# *CHAPTER 1*

# INTRODUCTION

## 1.1 Background

Forests play a vital role in maintaining the ecological balance and economic development for a nation. From ancient time, human in every corner of the world are dependent upon forests and forest products to meet their daily needs and also to cure different ailments. The ancient people had good knowledge about traditional uses of forest resources which have been transmitted, in most cases orally and in few cases textually, from generation to generation. Forests provide a variety of products and services, including fodder, timber, fuel- wood and other Non-Timber Forest Products (NTFPs) (Springate-Baginski *et al*. 2003). NTFPs include all biological materials, excluding timber, derived from forests, pasturelands and other man-made and wild habitats and have socio-cultural, economic and other livelihood significance. These products include wild edible foods, medicinal and aromatic herbs, fibers, materials for handicrafts, spices, resins, gums, tannins, latexes, cosmetics, glues, aromatic oils, wildlife and their parts. In Nepal, forests and forest products have significant contribution to the peoples' livelihood and agriculture productivity. They have contributed significantly to the local and national economy. In Nepal, forestry sector has contributed about 15% of the total GDP and among which 5% is contributed by NTFPs (Ghimire *et al.* 2008a).

Nepal has been divided into striking vertical zonation in natural vegetation and diversity in flora, with 75 vegetation types and 35 forest types under six bioclimatic zones (tropical, subtropical, temperate, subalpine, alpine, and nivale) due to the presence of extreme ranges of altitude, climate and soil within a small geographical area (Stainton 1972; Shrestha and Joshi 1996). About 6500 species of flowering plants exist in Nepal (Hara *et al*. 1978, Press *et al*. 2000). Thus, Nepal has been ranked on the tenth highest flowering plant diversity in Asia (Chaudhary 1998).

## 1.2 Non-timber Forest Products (NTFPs)

### 1.2.1 General background

NTFPs are culturally important, cheap and often accessible to local people. NTFP harvesting can be both opportunistic and casual, or it may be included under alternatively planned expeditions. The rural people collect useful NTFP species from different habitats, such as forests, scrubs, grasslands, cultivated fields, wetlands and riverbanks and use those species following traditional practices. There has been increasing awareness about the importance of NTFPs because of the dependence of rural communities on those species, the increased urban and overseas market for natural products (including medicines), and the degradation of forests and ecosystem disturbance through unregulated collection.

Medicinal and aromatic plants, which represent a major part of NTFPs, are local heritage of global importance (Purohit and Vyas 2004). The people of both developing and developed countries depend upon traditional medicinal practices, mostly plant drugs, for their primary health care needs, using different plant products. Nepal is considered as an important place for the diversity of medicinal plants and other NTFP species. Medicinal plants of Nepal Himalaya have been documented in various literatures. The first attempt in the documentation of medicinal plant of Nepal was hand written encyclopedia 'Bir Nighantu', which was compiled at the end of $19^{th}$ century by Pandit Ghana Nath Devkota (Kanai 1971). The scientific study of medicinal plants in Nepal was begun with the establishment of the Department of Medicinal Plants (presently Department of Plant Resources) in 1961. Department of Medicinal Plants published its first volume 'Medicinal Plants of Nepal' in 1970, which included information of 393 species of medicinal plants with their therapeutic uses and distribution (DMP 1970). Its supplementary volume was published in 1984 with additional list of 178 species of medicinal plants (DMP 1984). Beside these, NTFPs including medicinal plants have been documented by many other studies (e.g., Banerji 1955; Manandhar 1971, 2002; Malla 1982; Bhattarai 1987; Rajbhandari 1989, 2001; Chaudhary 1993; Edward 1996; Olsen 1998; Shrestha *et al*. 2003a).

Despite various efforts in the compilation of useful plants of Nepal, the total number of NTFP species available in Nepal is not yet clearly known. However, it has been estimated that there are over 2000 species of useful plants in Nepal (Ghimire *et al.* 2008b). Malla and Shakya (1999) reported 630 species of medicinal plants from Nepal. Manandhar (2002) listed 1517 species of vascular plants (1434 flowering plants, 65 pteridophytes and 18 gymnosperms) having at least one documented ethnobotanical use, with 1002 species of medicinal, and 651 species of food plants. Regarding medicinal plant species diversity, Shrestha *et al*. (2000) documented 1624 species from Nepal. Baral and Kurmi (2006) listed 1792 species of plants being used in therapeutics in Nepal. Recently, Ghimire (2008) estimated 1950 species of medicinal plants in Nepal, including 1906 species of vascular species (with 1614 native, 192 introduced and/or cultivated, and 100 naturalized taxa).

Medicinal plants and other useful species are distributed throughout Nepal from lower Terai to the high Himalayas, with the greatest concentration of species in the tropical and subtropical zones (Bhattarai and Ghimire 2006; Ghimire *et al.* 2008b). However, endemic species and high-value products are concentrated in the High Mountain and High Himalayan physiographic zones (Shrestha and Joshi 1996; Malla and Shakya 1999; Joshi and Joshi 2001; Lama *et al*. 2001; Ghimire 2008).

### 1.2.2 Ethnobotany and use values of NTFPs

Harsberger (1896) for the first time defined ethnobotany as 'Plants used by primitive and aboriginal people'. Martin (1995) used the term ethnoecology which describes local peoples' interaction with natural environment that include sub-disciplines such as ethnobiology, ethnobotany, ethnoentomology and ethnozoology. Ethnobotany is a part of ethnoecology which concern plants. Ethnobotany documents the knowledge about plants that had come generation after generation and the knowledge is used for the benefit of the society (Chaudhary 1998). Ethnobotany is now recognized as a multidisciplinary science, which comprises many aspects of plant science, history, anthropology, culture, botany, ecology, literature, etc. Ethnobotany also plays a significant role in the development of agriculture, pharmaceutical industries, biotechnology, environment and conservation of biodiversity (Martin 1995).

Nepal is a multiethnic and multilingual country. There are altogether 102 ethnic/caste groups in Nepal speaking 92 mother tongues in different geographic belts (CBS 2005). The local people especially in rural areas belonging to different ethnic/caste groups have very rich indigenous knowledge about use and management of plant resources.

Ethnobotanical researches so far conducted in Nepal have documented the indigenous knowledge of Nepalese societies in the utilization of different plant resources in the form of medicines, drugs, foods, fibres, pesticides, chemicals and other products (Shrestha 1985; Manandhar 1990; Sapkota 1994; Mahato 1998; Malla *et al*. 1999; Devkota 2003; Gurung *et al*. 2007). Ethnobotanical studies have also focused on the knowledge variation among different societies in Nepal (Oli 2001; Ghimire *et al*. 2004). Among different plant resources, medicinal and aromatic plants play a vital role in the livelihood of Nepalese societies from local healthcare and socioeconomic prospects (Shrestha *et al*. 2003a). The rural people mostly depend on local plant-based therapy for their primary health care which is cheap and easily available.

Throughout their history Nepalese people have been using plants and plant products as a mainstay of everyday life. In course of their practice of using various vegetation resources for manifold purposes, local people have gained knowledge about the useful and harmful properties and other economic values of many plant species (Shrestha 1985; Manandhar 1990; Sapkota 1994). Such knowledge has been transmitted in most of the case orally for generation to generation. In recent years, great concern has been raised on the issue regarding the loss of indigenous knowledge on the utilization and management of such vital resources due to modernization of traditional culture and urbanization (Mujtaba and Khan 2007; Kunwar and Duwadee 2003). Although the indigenous knowledge about the use of plant resources is fast disappearing, there is still some scope for the use of available knowledge for the betterment of mankind in the global context. Immediate action is also needed for the proper documentation of available knowledge. In Nepal, attempts have been made to bridge traditional knowledge, science and modern technology to identify and protect the useful plants and indigenous knowledge before they become eradicated (Sapkota 1994; Lama *et al*. 2001).

### 1.2.3 Conservation status of NTFPs

NTFPs support livelihood and welfare of rural population by providing them with food, medicines, other material inputs and a source of income and employment. Harvesting of NTFPs for trade is one of the major activities of rural people to supplement their source of income (Yonzon 1994; Bhattarai 1995). In some mountain areas of Nepal, trade of NTFPs provides up to 50 percent of household income (Edwards 1996; Olsen and Helles 1997; Chhetry 1999; Olsen and Larsen 2003). In recent years, there is growing awareness for the establishment of NTFP-based enterprises in Nepal which can help in the value addition and to increase the price of the product (Bhattarai 1995; Achet and Shukla 1998; Ghimire *et al*. 2008a). Local value addition and processing of medicinal and aromatic plants and other NTFPs will assist the traditional users of forest resources to simultaneously conserve their forest and pasture habitats while enhancing the commercial return that these resources offer (Bhattarai 1995).

The demand of NTFPs is increasing day by day in domestic as well as in international markets. So the collection of NTFPs greatly supports in upgrading the rural livelihood. Exploitation of wild plants is therefore very high in rural areas. The unregulated harvesting of NTFPs (especially medicinal and aromatic plants) for trade without systematic management is of great concern. The other threats are deforestation, forest fire, soil erosion and overgrazing. NTFPs are also being degraded due to lack of local control over the resources, rural poverty and social and cultural transformation (Kunwar and Duwadee 2003). During recent years a large number of NTFP species are highly threatened throughout the globe and some are in the verge of extinction due to commercial harvesting (CAMP 2001; Dongol *et al.* 2002; Springate-Baginski *et al*. 2003; Ghimire *et al.* 2005; Sol-Sánchez 2007). In Nepal, the exact figure of threatened NTFP is not known. However a Conservation Assessment Management Plan Workshop held in Nepal identified 51 species of threatened medicinal plants (CAMP 2001). Government of Nepal has prioritized a total of 30 species of NTFPs for economic development and still 12 species are protected for harvesting under Forest Act of 1993 (Bhattarai and Ghimire 2006) and 13 species are included in CITES Appendices (II and III).

## 1.3 Community Forests and Management of NTFPs

### 1.3.1 Community forests

Forest Act (1993) of Nepal has recognized the following six categories of forests: (a) government managed forests, (b) protected forests, (c) community forests, (d) leasehold forests, (e) religious forests and (f) private forests. Community forest is a part of national forest which is handed over by District Forest Office (DFO) to legally established Community Forest User Group (CFUG) for the protection, management and use. CFUGs are the community institutions which represent the community of forest users and are legally authorised to take management decisions (Karki *et al.* 1994; Bartlett 1992). The community forestry programme was formally launched in Nepal 30 years ago in 1978 (Acharya 2002).

The history of Nepalese forestry has been studied by different workers including Messerschmidt *et al.* (1994), Hobley (1996) and Pokharel (1997). Although the community forestry program in Nepal was started in 1980s, the history of community participation in the management of forests and other natural resources is very old. Before the legal establishment of community forests, villagers managed their nearby forests to meet local demands of fuel, fodder, poles, timber and other NTFPs through customary systems. Their management practice was based on indigenous knowledge of protection and utilisation of resources. These practices were locally developed and regularly revised (Gautam 1987; Fisher 1990, 1991; Gilmour 1991).

The community forestry program was originally conceived to achieve two major objectives: (i) ensuring the protection and management of national forest by involving local community and (ii) meeting forest products (like firewood, fodder, leaf litter, etc.) need of local people. Since community forest program began in 1978, it has ever improved as new experience was gained; and many changes were made both in policy and program. The Forest Act (1993), the Forest Regulations (1995), the Community Forest Operation Guidelines (1992), the Community Forestry Directives (1996) and the Community Forestry Inventory Guidelines (2001) have recognized forest user group as manager of community forest (Acharya 2002). Community forest program is spreading widely all over the country. Many government managed forests have been handed over to community for their proper management, utilization and conservation. In Nepal, so far, 1,219,273 ha of forests have been handed over to 14,337 community forest user groups involving 1,647,717 households (CFD 2007).

Community forestry has been the focus of forestry extension for several years and studies contend that the community forestry program has been successful in Nepal in improving the socioeconomic conditions of the people (Agrawal and Ostrom 2001; Dongol *et al*. 2002; Acharya 2003) and the condition of forest itself (Chakraborty 2001; Webb and Gautam 2001). Community forestry program especially focuses on protection and production of forestry related needs for users rather than conserving existing life forms in the particular forest (Belbase 1999). More emphasis has been given to the protection of timber yielding species rather than lower herbs and shrubs in community managed forests. Generally, non-timber and low quality timber yielding species are indiscriminately removed during various management practices the major aims of such practices are to conserve potentially important plant products including high-valued timber species. Some NTFP species are even over exploited at the expense of conservation of dominant species, such as Sal (*Shorea robusta* Gaertn.) (Shrestha 2005). Such action results in increase in the number of individual plant/trees, simultaneously reducing the overall species diversity and negatively affecting the ecosystem balance. Forest community with low species diversity may be less stable (Chapman and Reiss 1995). Thus the major objective of community forest should be maintaining high species diversity.

### 1.3.2 Management of NTFPs: major issues and challenges

Forest Act of Nepal (1993) has focused on decentralization, and has recognized the participation of individuals and groups as the prime means of development process. The community forest policy and current rules and regulations are considered to be progressive. By law, FUGs are legal owner of any community forest of which they are member, and are allowed to sell and distribute forest products like firewood, fodder, timber poles, non-timber forest products (NTFPs), etc. independently. FUGs can generate group funds and utilize them in various ways. In the past, Master Plan for Forestry Sector had focussed only on the fulfilment of fuel wood, fodder and timber from the management of community forests giving less attention to enhance income and employment from high value NTFPs. However, recently revised Community Forest Operation Guidelines (2002) have clearly mentioned that the action plan of community forest should include information regarding NTFP (Kanel and Shrestha 2003).

The potential income from sustainable harvesting of NTFPs could be considerably higher than income from timber or agriculture or plantation uses of the forest sites (Peters *et al*. 1989; Balick and Mendelsohn 1992). Sustainability means to pay more attention to the needs of future generations and to the longer-term social and environmental ramifications of current production and consumption decisions (Ruitenbeek and Cartier 1998). Sustainable forest management is 'management of primary or secondary forests for the sustained production of timber or other products or both in which forest cover is maintained indefinitely' (Dickinson *et al*. 1996). Sustainable forest management offers the only chance of maintaining forests and biodiversity (Whitmore 1999). The sustainable collection and management of NTFPs can provide valuable cash for rural people therefore government should focus to this sector for research (Bhattarai and Ghimire 2007). Sustainable use of NTFPs becomes an essence need for biodiversity conservation. There may be different kinds of sustainability associated with NTFPs such as: (a) biological sustainability, (b) organizational sustainability, (c) economic sustainability, (d) political sustainability, (e) socio-cultural sustainability and (f) environmental sustainability (Cubberly 1995; Cunningham 2001).

Market of NTFPs is being expanded in these days and this is an opportunity as well as a challenge for a more sustainable, efficient and equitable management of NTFP resources. Several issues and challenges characterize the NTFP sector. Some of the major issues and challenges relating to NTFP management in Nepal, particularly in community forest, are:

1. NTFP resources are being declining due to over grazing, unsustainable harvesting practices, lack of transparency, awareness and marketing information, and inequitable sharing of benefits among the participating groups (Ojha 2000).
2. Due to planting of only high timber yielding tree and fodder species within community forest, for better support to local livelihood, the diversity of herbs and NTFPs is decreasing day by day.
3. Poor harvesting technologies and greater post harvest loss. The storage and safe preservation technique is lacking which causes loss of collected NTFPs.
4. Most of the NTFPs are exported in unprocessed form due to which the local people can not get proper benefit.
5. Very low payment is paid to local collectors and hence they are least interested for conservation of NTFPs.
6. Due to difficulties in geography of the country and also poor transportation facilities and less incentives to the workers, the local people are posing frustration.
7. The existing government policies on NTFPs are controversial and not updated as required.
8. Scientific research on NTFPs is greatly lacking. NTFP management requires detailed information on taxonomy, distribution, availability, population ecology, and plants' response to harvesting and other management regimes. Hardly a few species are scientifically studied to propose their sustainable management protocols (Ghimire *et al*. 2005, 2008c). NTFPs include diverse species with variety of life forms and growth strategies; therefore management system should be unique for each species. Management prescription of one species can not exactly work for another species.
9. The distribution pattern of NTFPs is not uniform in the country and they exist in varying life form which creates difficulty for inventory works and for suggesting sustainable harvesting guidelines.
10. Documentation of indigenous knowledge has not yet been completely done in NTFP sector.
11. In Nepal, there is no specific policy about how much area is to hand over as community forest to local forest user groups. The area of forest and species diversity has significant relationship (Hill and Curran 2001, see below). Thus the size of forest is also important factor to consider in maintaining the diversity of NTFP species.

## 1.4 Species Diversity

### 1.4.1 Factors affecting species diversity

Not all ecological communities contain the same numbers of species. Some ecological communities contain few species and some contain many species. A plant community may be mono- or multi-culture. Heterogeneity is higher in a community when there is more species belonging to different genera in a particular area. Tropical environments support more species diversity in almost all taxonomic ranks than any other part as temperate and polar areas (Krebs 1994; Odland and Birks 1999).

Species richness (number of species per unit area) is a simple, most widely used measure of diversity and easily interpretable indicator of biological diversity (Peet 1974; Whittaker 1977; Krebs 1994). Species richness in any particular area or in any ecological community is affected by many components of climate and local environments (e.g., temperature, precipitation, etc.) that vary along the elevation gradients (Lomoliono 2001). Krebs (1994) stated eight factors maintaining the species richness: (a) history, (b) spatial heterogeneity, (c) competition, (d) predation, (e) climate, (f) climatic variability, (g) productivity and (h) disturbance.

Variation in altitude, orientation of slope, habitat area, nature of soil and type and intensity of disturbance significantly affect species composition and diversity (Stainton 1972; Vetaas 2000). Diversities of many of the earth's remaining natural and semi-natural ecosystems have declined due to habitat fragmentation, grazing, unregulated forest management and nutrient deposition (Ehrlich and Ehrlich 1981; Aerts and Berendse 1988; Wilson 1988, 1992; Ehrlich and Daily 1993). Decreased diversity would lead to decreased ecological stability and functioning and would debalance the natural ecosystem.

Natural disturbances such as forest fire, landslide, volcanic activity and climate change, etc. determine forest dynamics and species diversity (Burslem and Whitmore 1999; Maski *et al.* 1999). They can also affect tree population and can modify interactions among species in plant communities (Connell 1978; Huston 1994). Anthropogenic disturbance may regulate the regeneration dynamics, structure and floristic composition of forest (Ewel *et al.* 1981; Hong *et al*. 1995). The anthropogenic factor may have both positive and negative impact on forest, depending upon the intensity of disturbance. Disturbance may increase species richness in old growth forest and may maintain species diversity (Huston 1979; Petraitis *et al*. 1989).

Frequent and low intensity disturbance (like grazing or extraction of firewood and fodder) strongly affects forest structure and succession of tree species in the forest (Ramirez-Marcial *et al*. 2001). However, such factors do not necessarily hamper a genuine old-growth forest (Phillips *et al*. 1997).

Trends of decreases in species richness with increasing altitude have been reported by several workers (Yoda 1967; Brown 1988; Gentry 1988; Bergon *et al*. 1996; Patterson *et al*. 1998; Odland and Birks 1999; Lomoliono 2001). But other studies showed a mid-altitude peak in species richness (Janzen 1973; Whittaker and Niering 1975; Rahbeck 1995; Liberman *et al*. 1996). Unimodal relationship between species richness and elevation has been also reported from Nepal Himalaya (Grytnes and Vetaas 2002; Vetaas and Grytnes 2002; Bhattarai *et al*. 2004; Carpenter 2005).

### 1.4.2 Community forests and species diversity

Species composition and diversity of forest ecosystems, including community forests, have been documented for Nepal over several decades (Hara 1966; Shrestha 1982; Kharal 2000; Stræde *et al*. 2002). Anthropogenic disturbances in the form of deforestation for diverse purposes (collection of timber and firewood, expansion of agriculture land and human settlement) have been a serious issue for sustainable development since 1970s (World Bank 1978; Bishop 1990).

The distribution and diversity of plant species in forests depend on the size of forest or habitat area along with different other factors. Species richness is linked to area-based increase in habitat heterogeneity (Mac-Arthur and Wilson 1967; Rosenzweig 1995). It is generally assumed that larger the size of the forest the more will be the number of species. However, impact of forest area on diversity of species is controversial. Hill and Curran (2001) studied species composition in fragmented forest and they proposed that large forests contain the greatest number of tree species; however, the proportion of rare tree species increases with forest area (Arrhenius 1921, 1922) but common species remain same. In Nepal, studies related to the effect of forest area and other ecological factors on the diversity and distribution of NTFP species in community forests is lacking.

## 1.5 Research Hypotheses and Objectives

Before the conduction of this study following hypotheses are formulated:

- Diversity, distribution and population parameters of NTFP species will depend on the size of the community forest, level of disturbance, degree of accessibility and management practices applied.
- Species richness is related to area-based increase in habitat heterogeneity.
- Diversity of NTFP species also depends upon overall species richness, i.e., overall species richness is the predictor of richness of NTFP species.
- Knowledge on the use pattern of NTFP species strongly vary in different ethnic/caste groups

This study aims to assess the utilization pattern, diversity and population status of NTFP species in community forests of different sizes using ecological and ethnobotanical approaches. The specific objectives are:

1. To document local knowledge and the pattern of utilization of NTFP species
2. To assess species composition and richness of total plant species and NTFP species in different community forests in relation to forest size, altitude, human disturbance and other physical factors
3. To assess population size, structure and abundance of some potential NTFP species in relation to forest size, altitude, human disturbance and other physical factors

## 1.6 Limitations

Due to lack of time, the ethnobotanical knowledge on utilisation of NTFP species could not be documented of all ethnic/caste groups within the study area. All the environmental variables could not be collected in this study which may give strong relationship with population structure of NTFPs. Only three community forests of different sizes were taken as specific study sites. Selection of more than one replicate site per size class of community forest was not possible due to time and monetary constraints.

*CHAPTER 2*

# STUDY AREA

## 2.1 Location and Physiography

The study area lies in Dovan VDC (latitudes: $27^{O}42^{'}$ N to $27^{O}49^{'}$ N, and longitudes: $83^{O}23^{'}$ E to $83^{O}35$' E) of Palpa district (latitudes: $27^{O}34^{'}$ N to $27^{O}57$' N, longitudes: $83^{O}15^{'}$ E to $84^{O}22$' E). The area falls under the Dovan Bottleneck Area of Terai Arc Landscape (TAL) (see below for detail information). Palpa is a hilly district situated in western Nepal bounded by Nawalparasi district towards east, Arghakhachi and Gulmi districts towards west, Syanja and Tanahu districts towards north and Nawalparasi and Rupandehi districts towards south. The altitude of the district ranges from the base of Churiya, approximately 200 m to Mahabharat range up to 2000 m. The district covers an area of 1,366 sq. km, with approximate length of 70 km and breadth of 20 km.

The study area covers three community forests: Khulkhule, Arghachhap and Hattikot of Dovan VDC located within the Dovan Bottleneck Area of Terai Arc Landscape. Dovan VDC covers an area of 79 sq km and is surrounded by Kachal, Palungmainadi, Timure, Masyam, Koldanda, Gothadi, Devdaha VDCs and Butwal Municipality.

## 2.2 Climate

The study area lies in Churiya hill (Siwalik) region and it has climate of tropical type. Typically four seasons are found in this region *viz*. pre-monsoon from March to May, monsoon from June to September, post monsoon from October to November and winter from December to February.

Climatic data of the nearest meteorological station (station: Butwal Municipality) for the last 3 years (2003-2005) was used to interpret climatic variations (Fig. 2.1). The temperature data of three years revealed the minimum temperature of $10.5^{O}$C in January 2004 and the maximum temperature of $38.6^{O}$C in July 2005. The precipitation data showed that the annual precipitation was 2024.3 mm and maximum precipitation was 792 mm in August 2005 during three years.

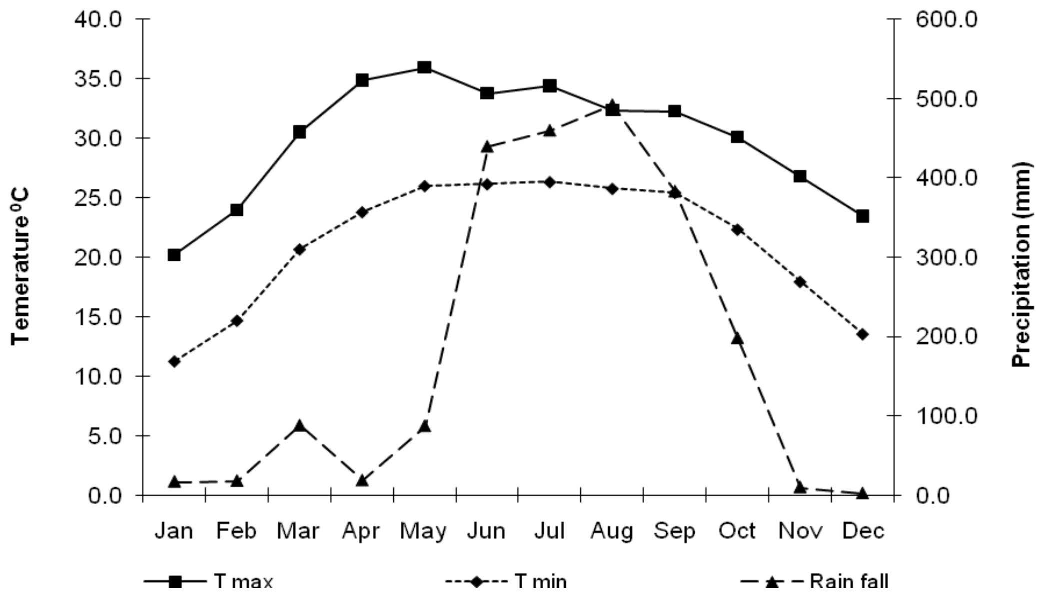


Figure 2.1: Climatic data of Butwal station (2003-2005). (*Source: Department of Hydrology and Meteorology, Kathmandu*)

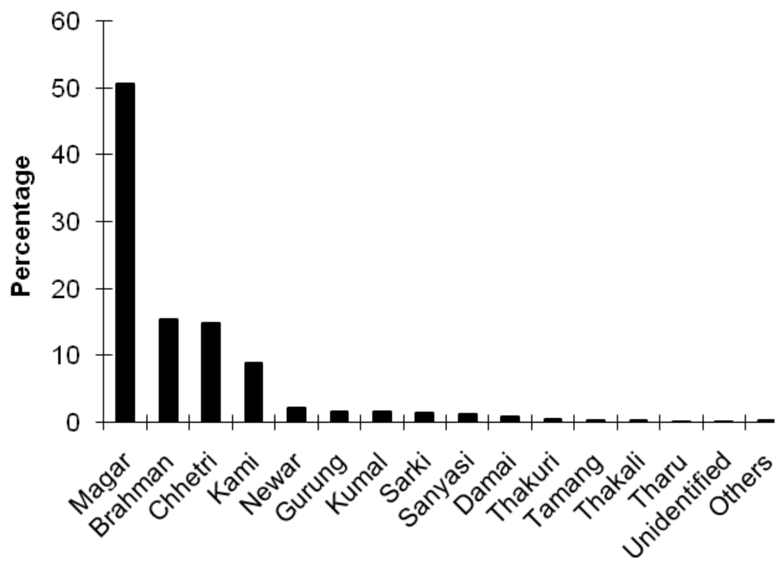


Figure 2.2: Ethnic/caste group composition in Dovan VDC (*Source: CBS 2002*)

## 2.3 Ethnic/Caste Group Composition and Local Economy

The major ethnic/caste groups of Dovan VDC are Magar, Brahman, Chhetri, Kami, Newar and Gurung. The total number of household in the Dovan VDC is 1226 with a total population of 6739, out of which Magar constitutes 50.72%, Brahman 15.40%, Chhetri 14.75%, Kami

8.93%, Newar 2.05%, and Gurung constitutes 1.63% (Fig. 2.2) (CBS 2002). Most of the people in the study area depend on agriculture as major occupation; “Tinahu” stream is passing almost at the centre of the Dovan VDC provides irrigation facility to agriculture. Some of the population is either engaged as permanent employ outside the VDC, teaching at local school, doing local business, wage-labor, abroad job, etc. In this study the Brahman and Chhetri caste group was considered as one caste group because of similar knowledge in use of NTFPs and the knowledge of Gurung and Magar were documented separately. Gurung had large number of cattle in comparison to the other Brahmin/Chhetri and Magar.

## 2.4 Vegetation Composition and NTFPs

About 71213 ha area (i.e. 52%) of Palpa district is covered by forest; and among total forest cover, 18% lies in Churiya range and remaining 82% lies in Mahabharat range (DFO 2007). The dominant forest types in the area are: *Shorea robusta* forest and mixed hardwood forest at lower altitudes, including Dovan VDC; and *Pinus roxburghii* forest and *Schima-Castanopsis* forests at higher altitudes. Only few studies analyzed the vegetation status of the area. For example, Bashyal (2005) studied the vegetation composition and regeneration of *Shorea robusta* and *Terminalia alata* in ‘Thulo ban forest’ (a government managed forest) in Dovan VDC.

The corridors and bottleneck regions of Terai Arc Landscape (TAL) are very rich in NTFPs along with various flora and fauna (Shrestha *et al*. 2003a, b). Over 200 species of NTFPs have been recorded from Palpa district (Bikaska Pailaharu 2004). Some of the high-valued medicinal plants are also reported from Dovan Bottleneck Area (Shrestha *et al*. 2003b; Aryal 2005). Bhandari (2006) reported 193 species of plants in a floristic study conducted in Dovan VDC. Overall distribution of NTFPs in Dovan Bottleneck Area has been studied by Shrestha *et al.* (2003a) and distribution of NTFPs in Matribhumi Community Forest in Dovan VDC has been documented by Aryal (2005) but comparative account of distribution and diversity of NTFPs in Khulkhule, Arghachhap and Hattikot Community Forests in Dovan VDC has not been studied yet.

Especially the NTFPs are traded from those villages which lie on southern side including Dovan VDC of Palpa district. Most of the NTFPs are collected from government and community managed forests, but *Cinnamomum tamala*, which is the most traded species in the area, is collected only from private forests. Especially the farmers and herdsman use to collect NTFPs for trade and household use during their leisure time.

## 2.5 Terai Arc Landscape (TAL) and Biodiversity Conservation

The Ministry of Forests and Soil Conservation of Government of Nepal and WWF Nepal have implemented the Terai Arc Landscape Program in July 2001 with the main objective of landscape level biodiversity conservation which involves linking network of protected areas with corridors in order to facilitate the long-term survival of endangered wildlife as well as to maintain the ecological integrity and sustainable livelihood of local people of the lowlands of Nepal (Gurung 2005; Surridge 2007). Terai Arc Landscape spans from the Bagmati River (Nepal) in the east to the Yamuna River (India) in the west, covering an area of 49,500 $km^2$ in the lowland Himalayas. Within Nepal, TAL extends from the Bagmati River in the east to the Mahakali River in the west, covering 14 districts including lowland forests of the Terai and foothills of the Churia. The Terai Arc Landscape connects 11 protected areas (such as national parks, wildlife reserves and buffer zones around them) of Nepal and India as well as non-protected areas between them. The non-protected areas include corridor and bottleneck areas which are critical areas to link two or more protected areas within or across the border. These areas are considered critical for the movement of large mammals, like tiger and elephant.

Restoration and community management of the forest has been considered as major interventions of Terai Arc Landscape project. Community based organizations (CBOs) most particularly Community Forest User Groups (CFUGs) and Community Forest Coordination Committees (CFCCs) are the focal points of TAL programs for program planning, implementation and monitoring at grass root level. Other interventions are reducing pressure in forest areas through the use of alternate energy, income generation activities and conservation education among others.

TAL is a biologically diverse habitat with 86 species of mammals, 550 species of birds, 47 species of herpeto-fauna, 126 species of fish, and over 2100 species of flowering plants (Flemming *et al.* 1975; Maskey 1992; Shah 1995; Basnet 2001).


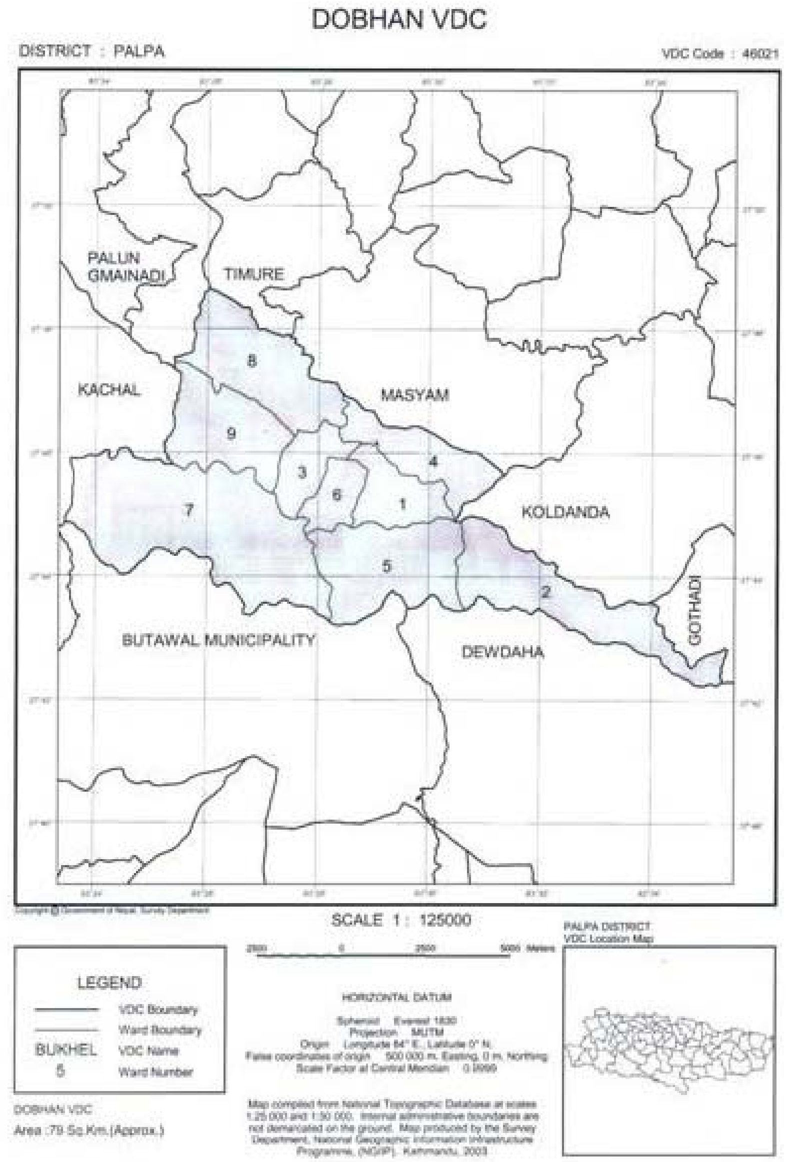


Figure 2.3: Map of the Study Area

# *CHAPTER 3*

# MATERIALS AND METHODS

## 3.1 Selection of Community Forests and Field Visits

Three community forests within Dovan Bottleneck Area were selected for research work. Basically they were selected on the basis of area that they cover. A large sized community forest, namely Khulkhule Community Forest, occupying an area of 590 hectare, a medium sized community forest, namely Arghachhap Community Forest, occupying an area of 94 hectare, and a small sized community forest, namely Hattikot Community Forest, occupying an area of 81.75 hectare were selected for study. But for ecological survey three forest patches of different sizes were taken to show the relationship between area of forest patches and species distribution. For this whole parts of Khulkhule and Arghachhap Community Forest were surveyed while for Hattikot Community Forest only one block i.e. block number 5, covering an area of 3.75 hectare was surveyed. The community forests were also selected on the basis of dominancy of caste/ethnicity of user groups, distance from nearest settlement and management practices that CFUGs are following.

The Khulkhule and Arghachhap community forests have a single forest patch whereas the Hattikot community forest is fragmented into three distinct patches. In Hattikot community forest, block 1, 2 and 3 represent a single patch whereas the block 4 and 5 are fragmented, forming separate patches lying far from each other. The lower belts of Khulkhule and Arghachhap community forest are touched by Siddhartha highway and they are facing opposite to each other, i.e. the Khulkhule community forest is facing south and the Arghachhap community forest is facing north. The Hattikot community forest facing north east direction is about 2 hours far from Siddhartha highway by foot. Most of the community forest user groups of the Khulkhule community forest belong to Brahman and Chhetri caste group, users of Arghachhap community forest belong to Magar ethnic group and users of Hattikot community forest belong to both Magar and Gurung ethnic groups. The characteristics of selected community forests are given in Table 3.1.

Altogether three field visits were made in the study area within the period between October 2006 and September 2007 with a total duration of 57 days (about 2 months). The

Table 3.1: Community forests selected for the present study

| Community Forests | Ward No. | Area in ha | Altitude range (m) | Village | Dominant Caste/ etnicity | DNS* | Management status[‡] | Dominant species[¥] |
|---|---|---|---|---|---|---|---|---|
| Khulkhule CF | 1 | 590 | 300-1100 | Jhumsa, Lagduwa, Panimil | Brahman & Chhetri | 5-120 | Fodder, fuel wood & timber collection after seeking permission from management committee. Grazing restricted. | Dominant canopy species: *Shorea robusta*, *Terminalia alata*; sub-canopy species: *Mallotus philippensis*, *Semecarpus anacardium*, *Bauhinia vahlii*, *Phoenix humilis*, *Lagerstroemia parviflora* |
| Arghachhap CF | 5 | 94 | 300-600 | Jhumsa, Bhutkhola | Magar | 5-60 | Fodder, fuel wood & timber collection after seeking permission from management committee. Scheduled grazing. | Dominant canopy species: *Shorea robusta*, *Terminalia alata*; sub-canopy species: *Semecarpus anacardium*, *Phoenix humilis*, *Mallotus philippensis, Bauhinia vahlii*, *Lagerstroemia parviflora* |
| Hattikot CF (Block - 5)[§] | 2 | 3.75 | 750-900 | Hattilek | Magar & Gurung | 5-30 | Fodder, fuel wood & timber collection after seeking permission from management committee. No restriction for grazing. | Dominant canopy species: *Shorea robusta*, *Terminalia alata*; sub-canopy species: *Lagerstroemia parviflora*, *Schima wallichii*, *Semecarpus anacardium* |

* Distance by foot from nearest settlement in minutes

[‡] Field survey

[¥] Species are arranged in order of dominance.

[§] Hattikot CF (actual are 81.75 ha) consists three distinct fragmented forest patches (block 1, 2 and 3 represent a single patch, and block 4 and 5 form separate patches) lying far from each other. Among these forest patches, the smallest one (designated as Block 5) has been taken as a representative site for this study.

first field visit was done from 12th to 18th October 2006. In this visit general information was collected from local informant. The second field visit was done from 10th June to 4th July 2007. In this visit ethnobotanical knowledge about use pattern of NTFPs was collected from local faith healers, elderly people, local informants, etc. The third field visit was done from 16th September to 10th October 2007. In this field visit ecological data about the distribution of NTFPs and associated species were collected from the community forests. Plant specimens were collected in each field visit.

## 3.2 Local Knowledge and the Patterns of Utilization of NTFPs

Standard methods prescribed for ethnobotanical study (Martin 1995; Cunningham 2001) were followed to document local knowledge on the use of NTFPs by the major ethnic/caste groups. In addition, local knowledge about the diversity and distributions of NTFP species in the study area was also collected following these references. The primary data about the use pattern of NTFP species were collected applying survey and inventory techniques (Martin 1995; Rastogi *et al*. 1998, Cunningham 2001). The survey technique included individual as well as group interviews, focus group discussion among local plant users, community forest user groups and traditional faith healers. The inventory technique included the collection of different plant specimens from the study area, noting down their taxonomic characters and other necessary information and identification of their local name, purpose of use, parts use, etc. exhibiting it with the help of key interviewees, local people as well as by transect walk (survey) method.

### 3.2.1 Distribution and diversity of NTFPs

Rapid Rural Appraisal (RRA) and household survey were conducted to assess local knowledge about the distribution and diversity of NTFP species in three community forests. In this process, people were asked to list freely the available NTFP species in the respective community forests and to provide local name and their use(s). During the transect walk the NTFP species growing in the forest were collected. A separate ecological study was carried out for the richness of NTFP species in different community forests. The name and number of species in each plot was counted and recorded (see Appendix 4).

### 3.2.2 Utilization pattern of NTFPs

RRA techniques (focus group discussion, key informant survey) were employed to gather primary information on use pattern (parts use, mode of use, etc.) and value of NTFP species. The truth of local information regarding the values, practices and use pattern of each species was confirmed by repeated informal and formal interviews with different users. In addition, herbarium specimens prepared during the field work were also placed in front of local people to confirm their identity, vernacular names, uses and other information. The participants of focus group discussion and key informant survey included local faith healers, elderly people, medicinal plant users and other knowledgeable people of the study area.

In addition, a standard questionnaire (Appendix 1) was used for interviewing the local people. In this process, a total of 39 people (among which 15 from Brahman/Chhetri, 13 from Magar and 11 from Gurung ethnic group of different age, gender and social status) were interviewed on a random basis in order to obtain local knowledge and practices regarding the use and values of NTFPs available in the study area, their parts use, purpose and mode of use, local preferences, etc.

## 3.3 Forest Sampling and Collection of Ecological Data

Ecological data from three different community forests were collected. Each community forest was divided into three horizontal transects on the basis of altitudinal variation. The altitudinal variation ranges from 50 m to 200m. Equal altitudinal variation could not be obtained due to differences in spatial area covered by different community forests, differences in altitudinal ranges and varying accessibility. The Khulkhule Community Forest ranges from about 300 to 1100 m asl. It was divided into three transects at about 400 m, 600 m and 800 m altitude respectively. Similarly the Arghachhap Community Forest ranges from about 300 to 600 m asl. It was also divided into three transects at about 350 m, 450 m and 550 m altitude respectively. The block 5 of the Hattikot Community Forest ranges from 750 to 900 m asl. It was again divided into three transects at about 770 m, 820 m and 870 m altitude respectively.

The systematic random sampling method was used for vegetation sampling. Square plots of 10 m × 10 m were sampled for trees and shrubs as determined by species area curve method following Mishra (1968), and 1 m × 1 m for herbaceous layer (including seedlings of tree species). Plots were located randomly along the three horizontal transects in each forest. Four sub-plots of 1 m × 1 m size were randomly located inside each 10 m × 10 m size plot. A total of 93 plots (10 m × 10 m size) among which 45 in Khulkhule CF, 30 in Arghachhap CF and 18 in Hattikot CF and 372 sub-plots (1 m × 1 m size) were surveyed in the three Community Forests.

In each 10 m × 10 m plot, all woody species (trees, tree saplings and shrubs) were recorded by their name and number of individuals present. In each 1 m × 1 m sub-plot, total number of individuals of each herbaceous/graminoid species and seedlings of woody species was recorded. Vegetation data of four sub-plots in each plot was pooled/averaged to represent a single sample. The vegetation data were analyzed separately for woody and herbaceous species in terms of density, frequency and species diversity (see section 3.6). The measure of density was compared separately for total plant species and total NTFP species. In addition, two tree species, *viz*., *Shorea robusta* and *Terminalia alata*, were selected for the analysis of other population parameters (such as population size and structure). In each plot all the individuals of these two species were measured for their circumference at breast height (cbh, 1.37 m above the ground level). Individuals having cbh greater than 30 cm were recorded as tree and cbh less than 30 cm and height above 1 m were recorded as saplings. These two tree species were selected on the basis of their greater abundance and value to the local people. Although there are many other highly valuable NTFP species (like *Phyllanthus emblica*, *Terminalia bellirica*, *T. chebula*, *Cinnamomum tamala*) but very scattered distribution of these species made difficulty in sampling and comparison among the three community forests. These species were studied for their seedling and adult densities.

Altitude, latitude and longitude were measured in each plot using altimeter and GPS, respectively. The aspect and slope of each plot was also recorded using clinometer. The percentage of rock cover, intensity of human disturbance, livestock disturbance and natural disturbance were also recorded by ranking in each plot.

## 3.4 Plant Collection, Herbarium Preparation and Identification

Most of the important plant species available in the area were collected for future reference. Collected plant samples were tagged, dried and mounted as voucher herbarium specimens following the standard technique (Lawrence 1967; Martin 1995). Collection of many plants species was impossible due to inaccessibility. Collection was not made for those species which were not in flowering/fruiting stage during the field visit. Similarly, common and most popular plant species were also not collected as voucher specimens. Almost all plant specimens collected and those which are common but not collected were photographed.

Most of the plant species were identified in the field. The unidentified specimens were later confirmed by consulting books and other standard taxonomic literatures (Hooker 1872-1897; Hara *et al*. 1978, 1979, 1982; Polunin and Stainton 1984; DMP 1986; Stainton 1988; Shrestha 1998; Siwakoti and Varma 1999) and comparing with specimens deposited at Tribhuvan University Central Herbarium (TUCH) and National Herbarium (KATH). The herbarium specimens were deposited at TUCH. Nomenclature of plant species follows Press *et al*. (2000).

## 3.5 Collection of Secondary Information

Secondary information related to this study was obtainded from several published as well as unpublished journals, research reports, records, documents, articles and websites related to ethnobotany and NTFPs. The information about area of community forest under study was obtained from District Forest Office, Palpa. The information about population distribution pattern of the study area was obtained from Central Bureau of Statistics, Kathmandu. The climatological and meteorological data of nearest base station (Butwal station) was obtained from Department of Hydrology and Meterology of Government of Nepal, Kathmandu.

## 3.6 Data Analysis

### 3.6.1 Ethnobotanical knowledge and utilization pattern

Field data was analyzed to assess the variation in local knowledge about the utilization of NTFPs among three major ethnic/caste groups *viz*. Brahman/Chhetri, Magar and Gurung. On the basis of this analysis comparative account of local knowledge of different ethnic/caste groups was presented. The information obtained from free listing exercises and from different interviews was analyzed to obtain a consolidated list of NTFP species for different community forests.

### 3.6.2 Ecological data analysis

The ecological data collected from field were analyzed as follows:

***i) Measurement of frequency***

Frequency is defined as the percentage of total number of quadrats studied in which the species occur and thus it expresses the distribution of various species in a community. It is expressed in percentage of the total number of species. The relative frequency is the frequency of one species as a percentage of total frequency. The frequency and relative frequency were calculated by using the following formula (Zobel *et al*. 1987):

$$\text{Frequency (\%)} = \frac{\text{Total number of plot in which ‘A’ species occurs}}{\text{Total number of plot studied}} \times 100$$

$$\text{Relative frequency (\%)} = \frac{\text{Frequency of individual species}}{\text{Total frequency of all species}} \times 100$$

***ii) Measurement of density***

Density of a species is defined as the number of individuals of the species present per unit area of the study area. It is usually expressed as number per hectare. Relative density is the density of one species as a percent of total plant density. The density and relative density were obtained by using the following formula (Zobel *et al*. 1987):

$$\text{Density (Pl/ha)} = \frac{\text{Total number of individuals of ‘A’ species in all plots}}{\text{Total number of plot studied} \times \text{Area of quadrat}} \times 100 \times 100$$

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

***iii) Vegetation environment relationships***

Ordination method was used to analyze the relationship between species, environmental variables and other attributes. All the disturbance variables were combined to an overall measure of disturbance (Dis-PCA) using principal component analysis (PCA), which was then used as a predictor variable in multivariate and regression analyses (see below). Detrended correspondence analysis (DCA) was performed in PC-ORD 4.25 (McCune and Mefford 1999) on the species abundance data to interpret gradients in vegetation composition and in environments. DCA is a widely used indirect ordination method (Økland and Eilertsen 1996; Exner *et al.* 2002; Lepš and Šmilauer 2003) and provides an effective approximation of the underlying environmental gradients (ter Braak 1995). Pearson correlation coefficients were calculated between scores of samples on DCA-axes and selected variables.

***iii) Species diversity***

Communities may contain a few or many species depending upon habitat and environment. Among different species occurring in a community relatively few are abundant and most of them are rare. The two factors, number of species and their relative importance, determine the species diversity of a community (Zobel *et al.* 1987). Species diversity is generally obtained by counting simply the number of species present in a unit area. Species diversity is the combination of species richness and species evenness. Species richness is the number of species per sampling area. According to Whittaker (1972), "diversity in the strict sense is richness in species and is appropriately measured as the number of species in sample of standard size." Species evenness is the distribution of individuals among the species. Species evenness will be high when all the species have same or nearly equal number of individuals (Kandel 2007). Species diversity has differentiated into alpha, beta, and gamma diversities (Whittaker 1972; for review see McCune *et* al. 2002).

- **Alpha Diversity:** Alpha diversity is simply the total number of species present in a unit area.
- **Beta Diversity:** Beta diversity is the amount of compositional variation in different sample.
- **Gamma Diversity:** Gamma diversity is the overall diversity in a collection of sampling units often at landscape level diversity.

In the present work alpha diversity was obtained by counting the total number of species per sampling area (i.e., per 10 × 10 m plot or 1 × 1 m subplot). Mean species richness was compared among the three community forests. Beta diversity was measured indirectly based on the length of gradient in the DCA first axis, which shows the amount of compositional variation in different sample (McCune *et al*. 2002). The axis length is measured in number of standard deviations. The lengths of axes in DCA are determined by Hill's scaling, and with this scaling, the average standard deviation of species turnover is used as a unit for scaling an ordination axis (McCune *et al*. 2002).

Gamma diversity was obtained by combining the species present in all plots as well as the species collected from outside the plots. Similarly consideration was also given to the species which the local people cited that the species is available in the forest, but in actual field work these species were not recorded in or outside the plot. Since my study did not cover whole of the forest area and seasonal variations, there might be high chance of missing a number of

NTFP species. Therefore, the local information was considered to be highly useful to measure the landscape level diversity of NTFP species.

### 3.6.3 Statistical analysis

Mean and standard deviation of the values of each attribute measured were determined separately for three community forests. The values of species richness, plant density and other variables in the three community forests were first checked for normality and homogeneity of variance. The mean values of different population and vegetation variables in the three community forests were later compared using either one way ANOVA or non-parametric tests (Kruskal-Wallis H or Mann-Whitney U tests). Pearson's correlation coefficients (parametric analysis) or Spearman's rho (non-parametric analysis) were determined among the different attributes of these community forests. Linear regression analysis was done to establish relationships among environmental variables and vegetation/population variables. The relevant and significant relations obtained by regression analysis were reported in the result. All statistical analyses were done using statistical package for social science (SPSS 2001 version 11.5).

# *CHAPTER 4*

# RESULTS

## 4.1 NTFPs: Utilization Pattern and Associated Ethnobotanical Knowledge

A total of 143 species of plants, belonging to 62 families and 118 genera (excluding 10 unknown species), were recorded in three community forests of Dovan Bottleneck Area (Appendix 2), out of which 114 species were found to be potentially useful (or NTFPs). Out of total NTFP species recorded from the study area, Leguminosae was found to be the largest family comprising eight genera and 11 species. The other larger families were Euphorbiaceae (5 genera and 5 species), Gramineae (5 genera and 5 species), Compositae (4 genera and 4 species) and Lauraceae (3 genera 4 species). According to life form categories, among total NTFP species, 36 species (31.58%) belong to herb, 21 species (18.42%) to shrub, 42 species (36.84%) belong to tree and 15 species (13.16%) belong to climber (Appendix 3).

Local people of the study area were found to have rich knowledge about the diversity and uses of NTFPs (Appendix 3). Most of the species (112 species, 98%) were reported to be used for medicinal purposes. Besides medicinal, a number of species had food (25 species), fodder (40 species), material (16 species, for the manufacture of different articles, such as handicraft), cultural (7 species), and miscellaneous (4 species) use values. Among the three ethnic/caste groups interviewed, the people belonging to Brahman/Chhetri and Magar ethnic/caste groups knew the uses of 100 species (88% of total species) of NTFPs. Similarly, people belonging to Gurung ethnic group described the uses of 83 species (73% of total species) of NTFPs. Magars and Brahman/Chhetri had comparatively high knowledge on the medicinal uses of NTFPs; they reported 90 and 88 species of medicinal plants, respectively. Gurungs were found to be using only 64 species of NTFP for medicinal purposes. Although the knowledge about the medicinal uses of NTFPs was comparatively low among Gurung community, they were found to have rich knowledge about the food, fodder and other uses of NTFPs (Fig. 4.1). Highest proportions of the species were used for their underground parts (roots/tubers/rhizomes) and lowest for flower and pulp (Fig. 4.2). The utilization pattern of different plant parts slightly varied among three ethnic/caste groups. Generally, use of root, seed and bark was more frequent among the Magar and Brahman/Chhetri communities as compared to Gurung community (Fig. 4.3).

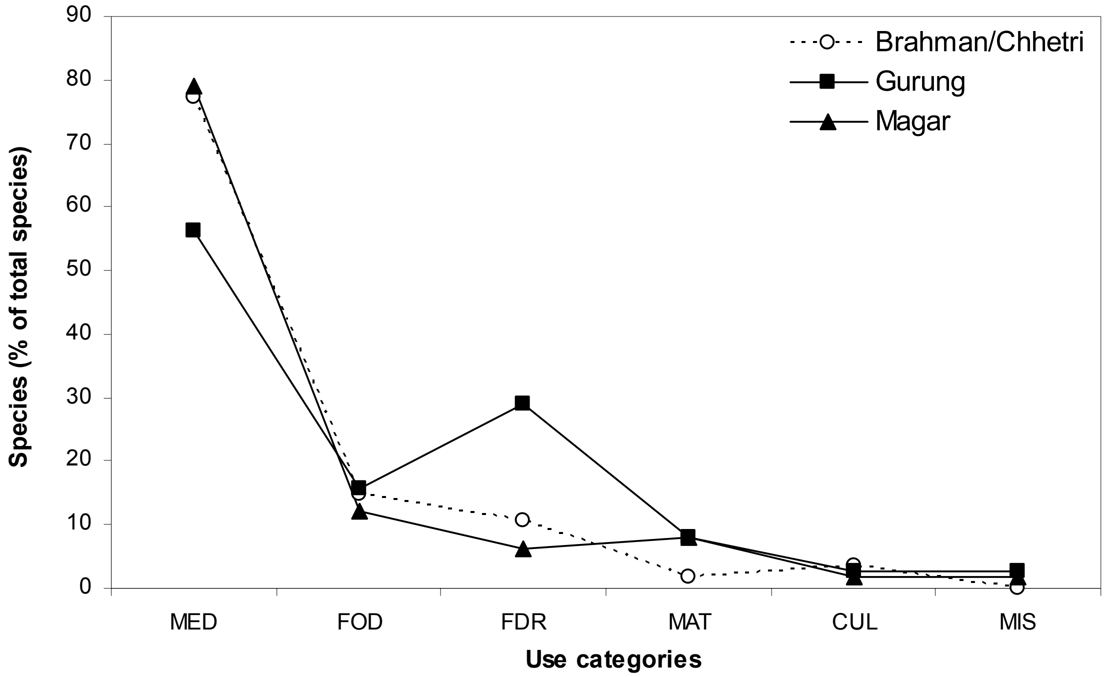


Figure 4.1 Use categories of NTFPs among three ethnic/caste groups (MED-Medicinal, FOD-Food, FDR-Fodder, MAT-Material (baskets, handicrafts), CUL-Cultural, MIS-Miscellaneous)

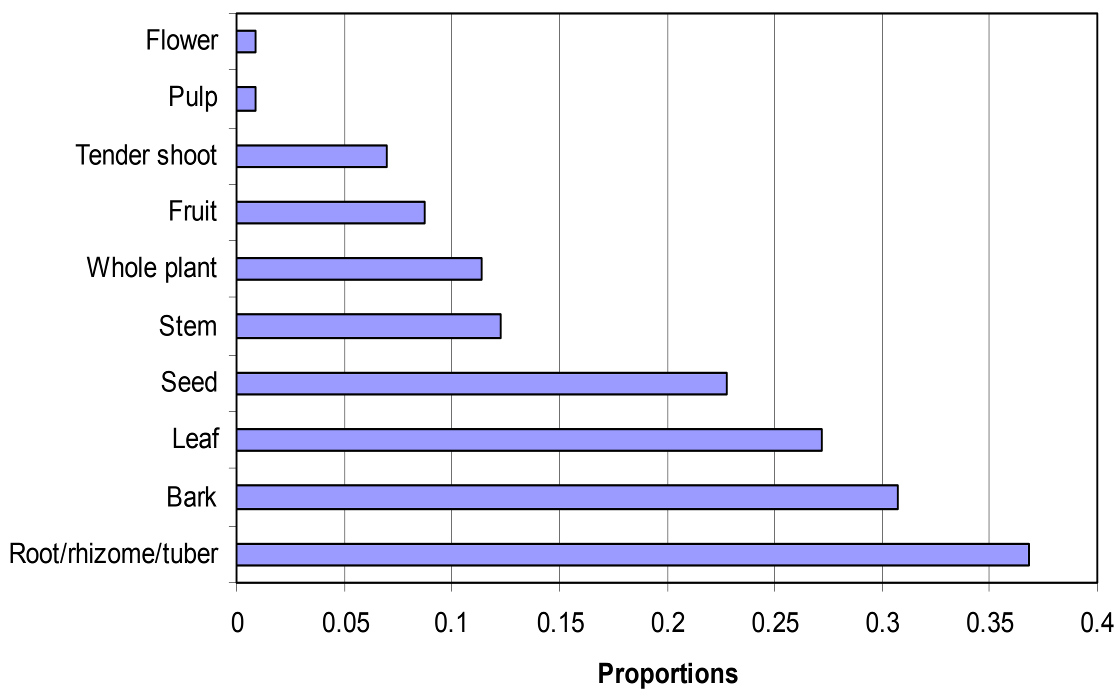


Figure 4.2 Parts use categories of NTFP

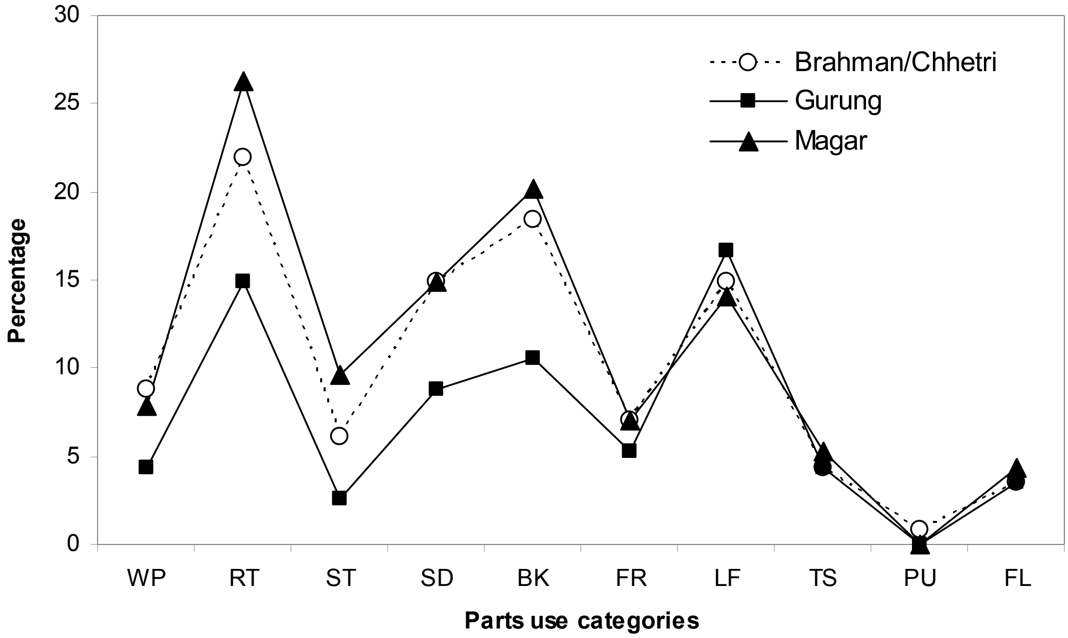


Figure 4.3 Utilization patterns of different plant parts among three ethnic/caste groups (WP-Whole plant, RT-Root/rhizome/tuber, ST-Stem, SD-Seed, BK-Bark, FR-Fruit, LF-Leaf, TS-Tender shoot, PU-Pulp, FL-Flower).

## 4.2 Species Composition and Environmental Relationships

### 4.2.1 Species composition in different community forests

All the three community forests showed more or less similar composition of woody vegetation, mainly dominated by *Shorea robusta* and *Terminalia alata*. In all the three community forests, *Shorea robusta* was the most common tree species with almost 100% frequency. *S. robusta* also showed highest density in all the three community forests (Appendix 4, see section 4.5). *Terminalia alata* was the second most common species with frequency of 88.89%, 83.33% and 84.44% in Hattikot, Arghachhap and Khulkhule CF, respectively. Among the other species, *Mallotus philippensis, Semecarpus anacardium* and *Phoenix humilis* were dominant sub-canopy species in Khulkhule CF and Arghachhap CF, and *Lagerstroemia parviflora* was the dominant sub-canopy species in Hattikot CF (Appendix 4).

The ground vegetation was mainly dominated by seedlings of *Shorea robusta* in all the three community forests, showing highest density and frequency values (Appendix 4, see section 4.5). *Cheilanthes anceps*, *Dryopteris* sp. and *Curculigo orchioides* were the most common herbaceous species showing comparatively higher frequency in all the three community forests. Among the other herbaceous flora, invasive species, such as *Eupatorium* sp., was most common in Khulkhule CF and Arghachhap CF. However, its density was higher in Khulkhule CF (10111.11 individuals per ha) than in Arghachhap CF (2666.67 individuals per ha). The other most important ground flora (in terms of both density and frequency) in Khulkhule and Arghachhap CF were an unidentified herbaceous species (locally known as 'Golaino'), denoted as 'Unknown 8', *Pogostemon benghalensis*, and seedlings of *Phoenix humilis* and *Bauhinia vahlii*. In addition, *Themeda triandra* was also very abundant in Khulkhule CF. Similarly, the other most important (in terms of both density and frequency) ground flora in Hattikot CF were *Begonia* sp., 'Unknown 8', and seedlings of *Melastoma melabathricum* and *Lagerstroemia parviflora* (Appendix 4).

### 4.2.2 Gradients in vegetation composition and in environments

The disturbance variables (harvesting intensity and grazing intensities) were reduced to an overall measure of human disturbance (PCA-Dis) through principal component analysis. One principal component, with an eigenvalue greater than one, could be extracted, as a combined measure of disturbance (PCA-Dis), explaining 82% of the variance in the disturbance variables. Intensities of human disturbance (livestock grazing and forest destruction) showed positive correlations with altitude, indicating higher human pressure at higher altitude and near to village area (Table 4.1). The majority of plots in Khulkhule CF (61%) showed low levels of disturbance; and 28% and 11% of plots in this CF showed sign of moderate and high levels of disturbance respectively. In Arghachhap CF, 43%, 38% and 18% of plots showed sign of low, moderate and high levels of disturbance, respectively. The majority of plots (74%) in Hattikot CF, on the other hand, showed signs of high level of disturbance (Fig. 4.4). The combined disturbance variable (PCA-Dis) was independent of most of the environmental variables, except altitude.

The result of DCA (detrendent correspondence analysis) ordination of forest vegetation data is presented in Fig. 4.5 and Table 4.2. The first two DCA axes cumulatively explained 48.4% of variance in species data. DCA axis 1 (eigenvalue 0.45) reflected disturbance and altitudinal gradients (Fig. 4.5a). This axis showed strong positive correlation with disturbance and altitude. The second DCA axis (eigenvalue 0.34) showed even stronger altitudinal gradient as this axis was more significantly correlated with altitude than did by axis 1 (Table 4.2). DCA axis 2 also

Table 4.1. (A) Major environmental (physical and disturbance) variables recorded in different community forests (mean, standard deviation and range of variables are shown); and (B) Spearman rank correlation coefficients between variables.

| **Variables** | **(A) Values of different variables in three community forests** | | | | **(B) Spearman rank correlation coefficients between variables**[§] | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Khulkhule** | **Arghachhap** | **Hattikot** | **Overall** | **Altitude** | **Aspect** | **Slope** | **Disturbance** | **Rock cover** |
| Altitude (m) | 596 ± 155 (380-830) | 460 ± 80 (360-570) | 822 ± 37 (770-870) | 596 ± 173 (360-870) | 1 | | | | |
| Aspect (degree) | 199 ± 38 (135-270) | 129 ± 126 (0-315) | 132 ± 137 (0-315) | 163 ± 102 (0-315) | ns | 1 | | | |
| Slope (degree) | 25.9 ± 8.9 (2-45) | 26.0 ± 8.6 (10-42) | 23.5 ± 6.2 (10-35) | 25.4 ± 8.4 (2-45) | 0.220 | ns | 1 | | |
| Disturbance[†] | -0.45 ± 0.80 (-1.14-0.84) | -0.12 ± 0.79 (-1.14-1.62) | 1.32 ± 0.53 (0.24-1.62) | -0.00 ± 1.00 (-1.14-1.62) | 0.239 | ns | ns | 1 | |
| Rock cover (%) | 11.9 ± 7.9 (5-30) | 26.2 ± 16.2 (10-65) | 26.1 ± 17.7 (0-60) | 19.2 ± 14.9 (0-65) | Ns | -0.297 | ns | 0.254 | 1 |
| Canopy cover (%) | 80-95 | 70-80 | 40-50 | 40-95 | - | - | - | - | - |
| Humus[‡] | Moderate-high | Moderate-high | Moderate | - | - | - | - | - | - |

[†]Combined human-impact variable (harvesting intensity and grazing intensities were reduced to an overall measure of human impact by extracting them in one principal component through principal component analysis).

[‡] Indirect qualitative observation based on litter content

[§] ns = not significant, all other coefficients in (B) are significant ($p<0.05$).

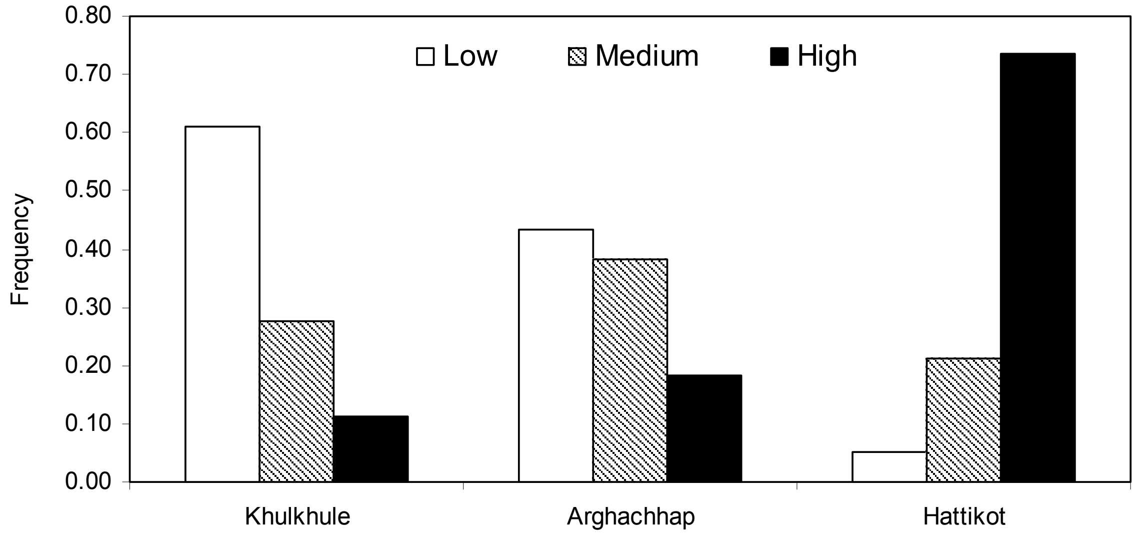


Figure 4.4 Frequency of different classes of intensity of human impact (mean of grazing and harvesting intensity) in different community forests.

reflected edaphic and moisture gradients, as this axis was correlated with humus, slope and aspect, but correlations of this axis with other variables were less stronger than the correlation with altitude. Along the first axis most of the plots of Arghachhap CF and plots located in transect 1 and 2 of Khulkhule CF all lying at lower altitude and receiving lower disturbance formed distinct cluster at the negative end, and plots of Hattikot CF all lying at comparatively high altitude and receiving high disturbance formed distinct cluster at the positive end. As already mentioned most of the plots in Hattikot CF received high level of human disturbance.

Distributions of many NTFP species of woody habit were associated with a particular environmental gradient and community forest (Fig. 4.5b). However, species such as *Mallotus phillipensis*, *Bauhinia variegata*, *Semecarpus anacardium*, *Terminalia alata* and *Shorea robusta*, the position of which lie at the centre in the ordination space, showed little affinity with any gradients. Only few NTFP species (e.g., *Cinnamomum tamala*) showed greater association with highly disturbed sites (positive end of DCA axis 1, in Fig. 4.5b). Species such as *Thespepsia lampas*, *Phylanthus emblica*, *Woodfordia fruticosa* and *Terminalia bellirica* were associated with less disturbed and comparatively high-altitude sites. Similarly, *Ficus hispida*, *Terminalia chebula* and *Syzygium cumini* were associated with less disturbed and comparatively lower altitude sites.

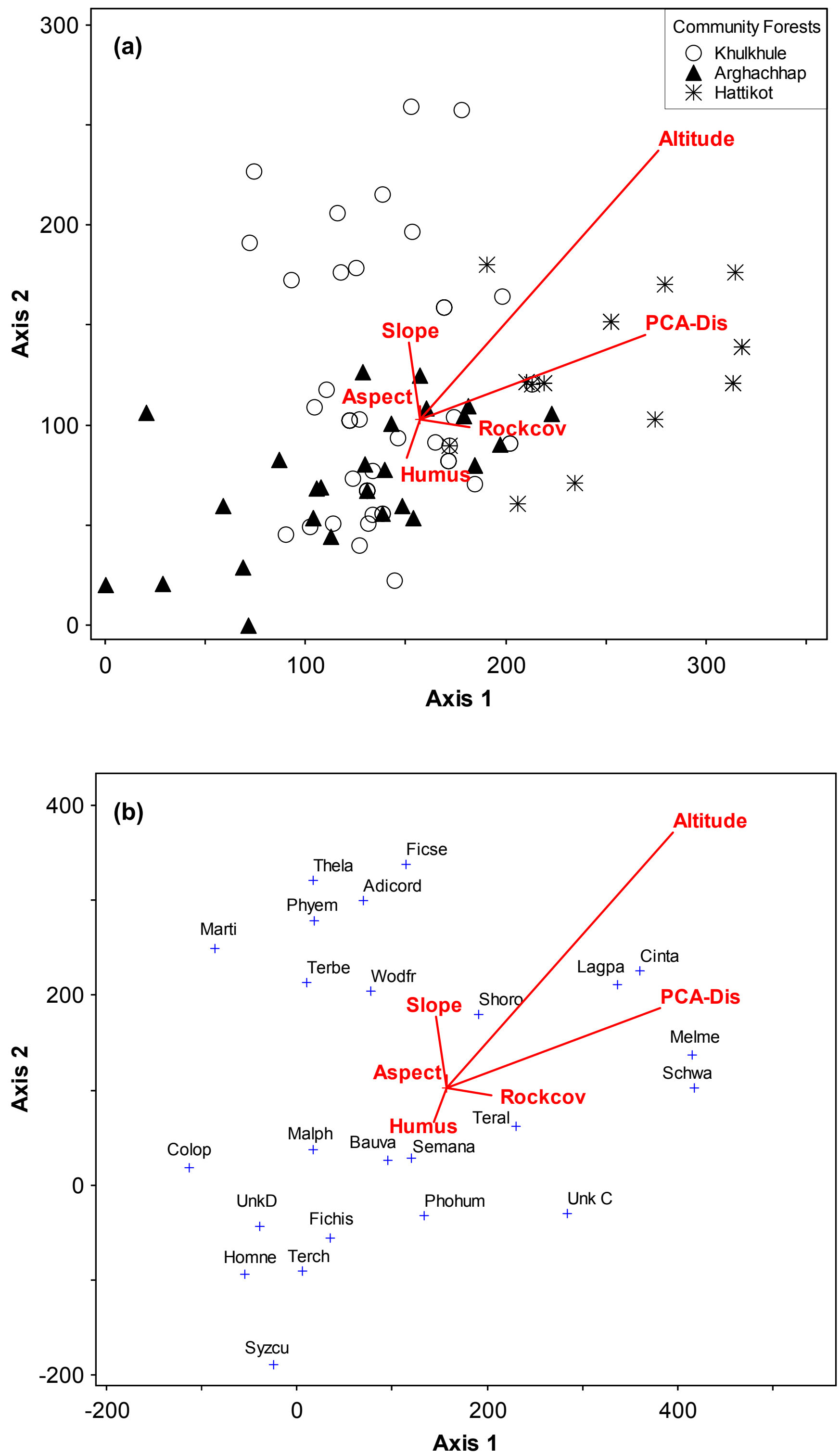


Figure 4.5 DCA ordination: (a) sample (plot) ordination, and (b) species ordination. In (a) symbols refer to sample plots from different community forests. The species abbreviations presented in (b) are derived from the first three letters of the generic name followed by the first two letters of the specific epithet (see Appendix 5). Environmental variables correlated with the ordination axes are shown as biplot vectors.

Table 4.2 Summary of DCA ordination results on compositional data. The second, third and fourth columns show Eigenvalues and Pearson correlation coefficients between variables and the three DCA axes.

| Variables | DCA axes‡ | | |
|---|---|---|---|
| | Axis 1 | Axis 2 | Axis 3 |
| Eigenvalue | 0.45 | 0.34 | 0.24 |
| Altitude | 0.497 | 0.570 | ns |
| Aspect | ns | 0.204 | ns |
| Slope | ns | 0.331 | ns |
| Rock cover | 0.240 | ns | ns |
| Humus | ns | -0.225 | ns |
| PCA-Dis (Disturbance)† | 0.504 | 0.273 | ns |

†Combined human-impact variable (harvesting intensity and grazing intensities were reduced to an overall measure of human impact by extracting them in one principal component through principal component analysis).

‡ns = not significant, all other coefficients are significant ($p<0.05$).

## 4.3 Diversity and Distribution of NTFPs in Community Forests

Altogether, 114 plant species were documented as potentially useful NTFPs, which are harvested for their different products. Detail uses of NTFP species is given in Appendix 3. The gamma diversity of all woody as well as all herbaceous species was found to be higher in Khulkhule CF, which was the largest (in term of area) community forest sampled in this study. Second highest diversity was found in the medium-sized community forest (Arghachhap CF). Gamma diversity was lowest in the smaller-sized community forest (i.e., Hattikot CF). Gamma diversity of overall NTFP species also showed similar pattern. However, gamma diversity of herbaceous NTFP species did not vary much in Arghachhap and Hattikot CF (Table 4.3). Among the total NTFPs, 111 species (97.37%) were present in Khulkhule CF, 98 species (85.96%) in Arghachhap CF and 88 species (77.19%) in Hattikot CF (Fig. 4.6).

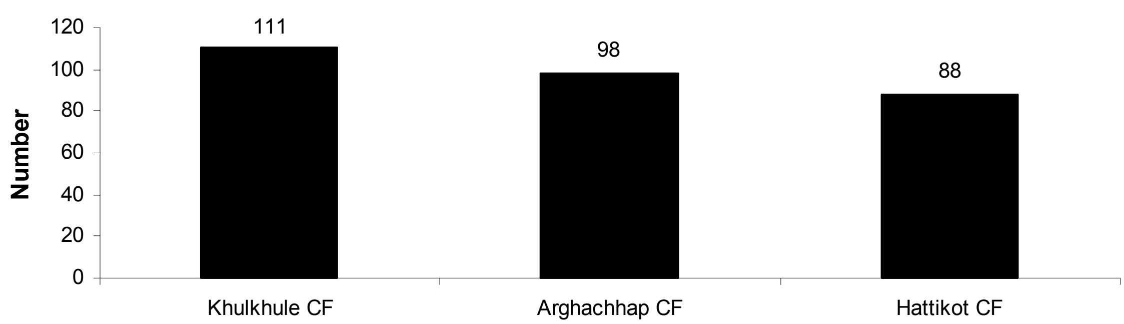


Figure 4.6 Total number of NTFP species in three community forests

Table 4.3 Total number of plant species (including NTFPs) in the three community forests (overall forest level diversity, considered here as gamma diversity), species richness (alpha diversity) at the level of 100 $m^2$ plots (for woody species) and at the level of four 1 $m^2$ plots (for herbaceous species) and compositional variation (as a measure of beta diversity) in three community forests.

| **Diversity measures** | | **Community forests** | | | **Total** |
|---|---|---|---|---|---|
| | | **Khulkhule** | **Arghachhap** | **Hattikot** | |
| ***Gamma*** | | | | | |
| All woody species | Total in the forest | 76 | 71 | 63 | 85 |
| All herbaceous species | Total in the forest | 51 | 47 | 34 | 58 |
| All woody NTFP species | Total in the forest | 70 | 64 | 57 | 72 |
| All herbaceous NTFP species | Total in the forest | 41 | 34 | 31 | 42 |
| ***Alpha*** | | | | | |
| All woody species | in 100 $m^2$ plot | $4.82 \pm 1.05^a$ | $5.20 \pm 0.85^a$ | $3.50 \pm 1.10^b$ | $4.69 \pm 1.16$ |
| All herbaceous species | in four $1m^2$ plot | $2.44 \pm 0.84^a$ | $3.47 \pm 1.25^b$ | $2.77 \pm 0.96^a$ | $2.83 \pm 1.10$ |
| All woody NTFP species | in 100 $m^2$ plot | $4.20 \pm 1.27^a$ | $4.30 \pm 1.12^a$ | $2.28 \pm 0.67^b$ | $3.86 \pm 1.36$ |
| All herbaceous NTFP species | in four $1m^2$ plot | $0.67 \pm 0.76^a$ | $1.40 \pm 0.89^b$ | $1.33 \pm 0.48^b$ | $1.03 \pm 0.84$ |
| ***Beta*** | | | | | |
| Compositional variation | Length of gradient | 4.70 | 4.52 | 3.34 | 5.30 |

Means in the same row with the same superscript letter are not significantly different at the 0.05 level (one way ANOVA with pairwise comparisons by Bonferroni multiple comparison test).

Table 4.4 Relationships between NTFP species richness and vegetation, topographic and disturbance variables based on linear and quadratic regression models. Only those variables which showed significant relationships either with woody or herbaceous species are presented.

| **Variables** | **Order** | $R^2$ | **F** | **P** |
|---|---|---|---|---|
| ***Woody NTFP*** | | | | |
| Total woody species richness | 1 | 0.644 | 164.99 | <0.0001 |
| Total number of individuals | 2 | 0.141 | 7.38 | 0.0011 |
| Altitude | 2 | 0.479 | 41.40 | <0.0001 |
| Slope | 2 | 0.074 | 3.61 | 0.031 |
| PCA-Dis (Disturbance)[†] | 1 | 0.237 | 28.02 | <0.0001 |
| ***Herbaceous NTFP*** | | | | |
| Total herbaceous species richness | 1 | 0.338 | 46.54 | <0.0001 |
| Altitude | 1 | 0.019 | 1.76 | ns |
| Slope | 1 | 0.002 | 0.201 | ns |
| PCA-Dis (Disturbance)[†] | 1 | 0.002 | 0.198 | ns |

[†]Combined human-impact variable (harvesting intensity and grazing intensities were reduced to an overall measure of human impact by extracting them in one principal component through principal component analysis).

Pattern of alpha diversity (species richness) was different than that of gamma diversity (Table 4.3). The value of species richness of all woody species and woody NTFP species at the level of 100 $m^2$ plots tended to be high in the medium-sized community forest (Arghachhap) followed by large-sized community forest (Khulkhule) (although the difference between these two forests was insignificant), and the value was significantly low in the smaller-sized community forest (Hattikot CF) (one way ANOVA $F_{2,90} = 15.40$, $P < 0.001$ for all woody species richness; $F_{2,90} = 21.92$, $P < 0.001$ for richness of woody NTFP species). Species richness of all herbaceous species at the level of four 1 $m^2$ plots was high in Arghachhap CF (medium-sized community forests) than in other two community forests ($F_{2,90} = 9.15$, $P < 0.001$). Unlike woody NTFP species, richness of herbaceous NTFP species was high in medium-sized (Arghachhap CF) and smaller-sized (Hattikot CF) community forests than in largest-sized community forest (i.e., Khulkhule CF) ($F_{2,90} = 9.10$, $P < 0.001$). The beta diversity showed pattern similar to gamma diversity with highest value for Khulkhule CF and lowest for Hattikot CF.

## 4.4 Relationships Between Species Richness and Environmental Variables

Significant relationships were observed between the richness of woody NTFP species and total woody species, total number of individuals, altitude, slope and disturbance (Table 4.4, Fig. 4.7). Richness of woody NTFP species showed strong positive linear relationship with the richness of total woody species and weak negative linear relationship with disturbance. But with plant density (total number of individuals per plot) and altitude the richness of woody NTFP species showed unimodal response (Table 4.4, Fig. 4.7). Thus the result revealed higher richness of woody NTFP species in plots located at middle altitude and having moderate level of plant density. The richness of herbaceous NTFP species, on the other hand, showed significant positive relationship only with total herbaceous species richness. Here the relationship was linear, in other words the richness of herbaceous NTFP species increased with the increase in the total number of herbaceous species per plot. The relationships between herbaceous NTFP species and other environmental variables were insignificant (Table 4.4).

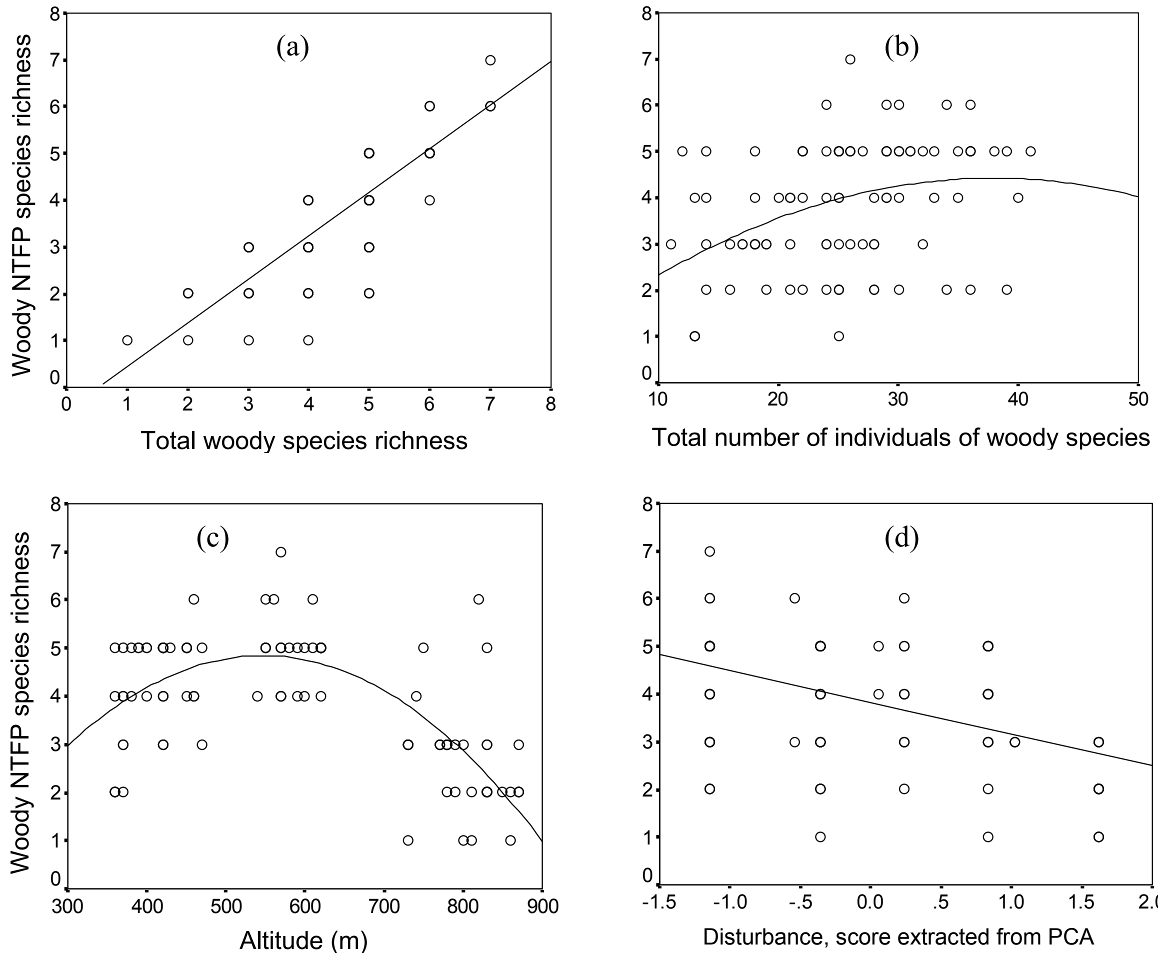


Figure 4.7 Scatter plots of woody NTFP species richness per 100 m² plot in relation to (a) total woody species richness, (b) total number of individuals of woody species, (c) altitude and (d) disturbance. In (d) the disturbance represents factor scores derived from Principal Component Analysis (PCA); by this analysis all the variables related to human disturbance (such as grazing, plant harvesting) were combined to an overall measure of human impact. The fitted lines in each figure are based on linear or quadratic regression model.

## 4.5 Population Size, Structure and Abundance of NTFP

### 4.5.1 Density of NTFP and other plant species in different community forests

Density of all woody species at the level of 100 $m^2$ plots and all herbaceous species at the level of four 1 $m^2$ plots tended to be high in the medium-sized community forest (Arghachhap CF), followed by large-sized community forest (Khulkhule CF) and low in smaller-sized community forest (Hattikot CF) (Table 4.5). Density of woody NTFP species also showed similar pattern, with high values in large- and medium-sized community forests (Khulkhule and Arghachhap) and low in smaller-sized community forest (Hattikot), while the density of herbaceous NTFP species was high in medium- and small-sized community forests (Arghachhap and Hattikot) and low in large-sized community forest (Table 4.5).

Table 4.5 Overall densities (number of individuals per 100 $m^2$ plot for woody species and per 1 $m^2$ plot for herbaceous species) of total plant species and all NTFP species in three community forests.

| Parameters | Plant density in | | | Total density | Significance‡ | |
|---|---|---|---|---|---|---|
| | Khulkhule | Arghachhap | Hattikot | | $\chi^2$ | *P* |
| Density of all woody species | 25.01 ± 6.98[ab] | 27.33 ± 7.36[b] | 22.50 ± 6.90[a] | 25.31 ± 7.22 | 6.66 | 0.036 |
| Density of woody NTFP species | 23.24 ± 7.40[a] | 23.20 ± 8.35[a] | 18.83 ± 6.42[b] | 22.38 ± 7.67 | 5.32 | 0.070 |
| Density of all herbaceous species | 3.72 ± 1.27[ab] | 4.37 ± 1.42[b] | 3.24 ± 0.89[a] | 3.83 ± 1.31 | 8.64 | 0.013 |
| Density of herbaceous NTFP species | 0.91 ± 1.22[a] | 2.02 ± 1.47[b] | 1.89 ± 0.76[b] | 1.46 ± 1.33 | 19.29 | <0.001 |

‡Kruskal-Wallis one-way analysis of variance, df = 2. Means in the same row with the same superscript letter are not significantly different at the 0.05 level (pairwise comparisons by Mann-Whitney U tests).

### 4.5.2 Population size and structure of most potential NTFP species

Out of 114 NTFP species, 12 species have been identified as most potential in terms of their socio-cultural and medicinal use values. Population densities of the 12 most potential NTFP species are separately given in Table 4.6. Out of 12 most potential NTFPs, *Shorea robusta* and *Terminalia alata* among the trees and *Curculigo orchioides* among the herbs were most common NTFP species with high density in all the three community forests. *Asparagus racemosus, Cinnamomum tamala, Phyllanthus emblica, Syzygium cumini, Terminalia bellirica* and *Terminalia chebula* were less common species occurring within only one or two community forests and with fairly low densities. Regeneration of most NTFP species was very poor, except *Shorea robusta*, *Terminalia alata, Bauhinia vahlii, Mallotus philippensis* and *Woodfordia fruticosa*.

In general, densities of seedling, juvenile and adult individuals of most of the NTFP species were comparatively high in large and medium-sized community forests, except for some light demanding species, such as *Shorea robusta* and *Terminalia alata*, the densities of seedling and juvenile individuals of these latter species were high in medium or small-sized community forests, which are experiencing considerable disturbances (Table 4.6 & Table 4.7).

Table 4.6 Seedling, juvenile and adult population densities (number of individuals per ha) of highly important NTFP species in three community forests.

| S. No. | Species Name | Adult and juvenile (sapling) | | | | | | Seedling[‡] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Frequency (%) | | | Density ($ha^{-1}$) | | | Frequency (%) | | | Density ($ha^{-1}$) | | |
| | | KCF | ACF | HCF | KCF | ACF | HCF | KCF | ACF | HCF | KCF | ACF | HCF |
| 1. | *Asparagus racemosus* L. | 2.22 | 0.00 | 0.00 | 277.78 | 0.00 | 0.00 | na | na | na | na | na | na |
| 2. | *Bauhinia vahlii* Wight & Arn. | 46.67 | 33.33 | 11.11 | 146.67 | 126.67 | 16.67 | 15.00 | 12.50 | 1.39 | 1833.33 | 1666.67 | 138.89 |
| 3. | *Cinnamomum tamala* (Buch.-Ham.) Nees & Eberm. | 0.00 | 0.00 | 5.56 | 0.00 | 0.00 | 5.56 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4. | *Curculigo orchioides* Gaertn. | 13.89 | 15.00 | 11.11 | 3388.89 | 2666.67 | 1250.00 | na | na | na | na | na | na |
| 5. | *Mallotus philippensis* (Lam.) Mull. | 64.44 | 53.33 | 0.00 | 224.44 | 170.00 | 0.00 | 7.22 | 0.83 | 2.78 | 1000.00 | 83.33 | 555.56 |
| 6. | *Phyllanthus emblica* L. | 15.56 | 6.67 | 0.00 | 35.56 | 6.67 | 0.00 | 3.89 | 0.00 | 0.00 | 444.44 | 0.00 | 0.00 |
| 7. | *Shorea robusta* Gaertn. | 97.78 | 100.00 | 100.00 | 1073.33 | 1273.33 | 1150.00 | 67.78 | 81.67 | 77.78 | 13000.00 | 24000.00 | 15555.56 |
| 8. | *Syzygium cumini* (L.) Skeels | 2.22 | 3.33 | 0.00 | 4.44 | 6.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 9. | *Terminalia alata* Heyne ex Roth | 84.44 | 83.33 | 88.89 | 417.78 | 216.67 | 661.11 | 25.00 | 17.50 | 48.61 | 3666.67 | 2916.67 | 6944.44 |
| 10. | *Terminalia bellirica* (Gaertn.) Roxb. | 2.22 | 16.67 | 0.00 | 2.22 | 30.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 11. | *Terminalia chebula* Retz. | 2.22 | 3.33 | 0.00 | 2.22 | 3.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 12. | *Woodfordia fruticosa* (L.) Kurz | 17.78 | 13.33 | 0.00 | 71.11 | 36.67 | 0.00 | 5.56 | 1.67 | 1.39 | 777.78 | 166.67 | 138.89 |

[‡] 'na' not assessed

In the case of *S. robusta*, the combined density of adults (trees) and juveniles (saplings) ranged 1073-1273 individuals per ha (trees: 338-372, sapling: 736-930 individuals per ha, Table 4.7) in the three community forests, with highest density recorded in Arghachhap CF and lowest in Khulkhule CF (Table 4.6 & 4.7). *Terminalia alata* was the second most common NTFP species. The density values of *T. alata* (total density including tree and saplings) ranged 217-661 individuals per ha in the three community forests, with highest density of saplings (594 individuals per ha) recorded in Hattikot CF and lowest in Arghachhap CF (127 individuals per ha). But the density of adult trees was highest in Khulkhule CF (156 individuals per ha) and lowest in Hattikot CF (67 individuals per ha). These results reflected species specific pattern of plant density of different life forms in different forests. Generally, the more light demanding species such as *Shorea robusta* had high seedling and juvenile densities in comparatively disturbed and smaller-sized community forests.

Table 4.7 Population size and structure of *Shorea robusta* and *Terminalia alata*: seedling, sapling and adult tree densities (individuals per ha) in three community forests.

| **Species** | **Community forests** | **Seedling density** | **Sapling (juvenile) density** | **Adult tree† density** | **Population size‡** |
|---|---|---|---|---|---|
| *Shorea robusta* | Khulkhule | 13000.00 | 735.56 | 337.78 | 79192 |
| | Arghachhap | 24000.00 | 930.00 | 343.33 | 18424 |
| | Hattikot | 15555.56 | 777.78 | 372.22 | 1164 |
| *Terminalia alata* | Khulkhule | 3666.67 | 262.22 | 155.56 | 23093 |
| | Arghachhap | 2916.67 | 126.67 | 96.67 | 2456 |
| | Hattikot | 6944.44 | 594.45 | 66.67 | 90 |

†Adult tree = tree with cbh >30 cm.

‡Population size was calculated as total number of adult tree in the entire forest area.

# CHAPTER 5

# DISCUSSION

## 5.1 NTFPs: Diversity and Utilization Pattern

The corridors and bottleneck areas of Terai Arc Landscape (TAL) are very rich in NTFPs along with various flora and fauna (Shrestha *et al*. 2003a, b). Over 200 species of NTFPs have been recorded from Palpa district (Bikaska Pailaharu 2004). Earlier floristic study by Bhandari (2006) identified 193 species of plants from Dovan VDC. In the present work, a total of 143 species of plants (belonging to 62 families and 118 genera) have been recorded from three community forests of Dovan VDC in Dovan Bottleneck Area of Terai Arc Landscape (TAL). Among total species recorded from the study area, 114 species were found as potentially useful NTFPs. As reported in the previous studies (Shrestha *et al*. 2003a, b; Aryal 2005) this study also identified some high-value medicinal plant species, in terms of subsistence and local economy, from Dovan Bottleneck area; the most important species being *Asparagus racemosus*, *Cinnamomum tamala*, *Curculigo orchioides*, *Phyllanthus emblica*, *Shorea robusta*, *Terminalia alata*, *T. bellirica*, *T. chebula* and *Woodfordia fruticosa*. Earlier studies have focused distribution of NTFPs mainly along the highways crossing the Dovan Bottleneck Area (Shrestha *et al.* 2003a, b) or in few community forests, such as Matribhumi Community Forest (Aryal 2005). Besides, preliminary lists of NTFPs are also available for some community forests in Dovan VDC based on inventories made during the preparation of action plan of these community forests (Community Forest Action Plan 2001, 2004, 2005a, b).

The present study has revealed that the local people of the study area had good knowledge about the utilization of plant resources. Among 114 species of NTFPs identified in the present work, 112 species were found to be used for medicinal purpose. These and several other species were also reported to be used for food, fodder, material, cultural, and miscellaneous purposes. The Brahman/Chhetri and Magar ethnic/caste groups had greater knowledge about the utilization of NTFPs in comparison to the Gurung. Knowledge of medicinal uses of plants was particularly high in Brahman/Chhetri and Magar communities, but Gurungs were much familiar with food, fodder and other uses of plants. Such cross-cultural variations in knowledge about plants have also been reported by various workers between geographically distinct groups as well as among local societies occupying the same geographical area (e.g., Ghimire *et al*. 2004, and references therein).

Several factors, including peoples' origin and history of attachment to the land, socio-cultural practices, etc. may explain such variation in knowledge and utilization pattern of NTFPs. Magar people are the ancient inhabitants of Nepal (Bista 2004; Pandey 2007) and of the study area. They were quite familiar to the surrounding environment and plant species around them. Palpa district and surrounding mountains have been considered as the centre of origin of Magar (Bista 2004; Pandey 2007). Brahman/Chhetri and Gurungs were immigrated in the study area from other parts of the country. According to local people, Brahman/Chhetri immigrated in the area very earlier than Gurungs and they were in continuous touch with local Magar people involving in different socio-cultural and economic activities sharing knowledge between each other. Several researchers in different parts of the world have suggested that the people migrated into new areas can show high levels of adaptation to local conditions and acquire high level knowledge about the local resources, especially regarding commercial products (e.g., Atran *et al*. 2002; cited in Ghimire *et al*. 2004). Particularly high knowledge of Gurungs about the use of fodder species could be explained by their agro-pastoral activities. Gurungs had high number of cattle in comparison to the Brahman/Chhetri and Magars. Among different plant parts, underground parts (roots/tubers/rhizomes) of plant were highly used by the local communities. The high importance of underground part may be attributed to the high concentration of bioactive compounds (Moore 1994).

## 5.2 Local Management Practices and Status of Vegetation in Different Community Forests

All the three community forests were handed over to the respective local communities very recently (Khulkhule and Arghachhap CF in 2000, and Hattikot in 2004). Before their formal recognition as community forests, these forests were mainly used as common property resources and there were no strict regulation and management, except for timber yielding species people required special permit from village committee. Elder people of the study area remembered that all the three community forests were very dense in the past, and some of these forests (e.g., Arghachhap CF) even provided good habitat for wild animals, like tiger and bear, the populations of which were quite high in the past. Human pressure around Khulkhule and Arghachhap forests especially increased after the construction of Siddhartha highway. The immigrant people also started to destroy the forest habitat for livelihood purposes. Illegal harvesting of trees like *Shorea robusta* and *Terminalia alata* were intensified for several years, before the legal establishment of community forests.

Now, after the formal recognition of the community forests, fodder and timber collection has been strictly regulated in all three community forests. Collection of fodder and timber is allowed to the forest users only after permission of the management committee of the respective community forests. Grazing is almost completely restricted in Khulkhule CF, but it is open in Hattikot CF, while in Arghachhap CF, schedule grazing has been allowed. Grazing has positive as well as negative impact on floral diversity (Huston 1979; Petraitis *et al*. 1989). In general intermediate grazing enhances species richness (Ramirez-Marcial *et al*. 2001). The intermediate grazing in Arghachhap CF may be the reason for high species richness.

DCA ordination of vegetation data revealed that altitude and disturbance are the major factors in explaining plant distribution patterns and vegetation composition in three community forests. Intensities of human disturbance showed positive correlations with altitude, indicating higher human pressure at higher altitude and close to village area. High altitude plots were highly disturbed especially in the small-sized community forest (i.e., Hattikot CF) as compared to the large- and medium-sized community forests (Khulkhule and Arghachhap CF). Hattikot CF is more close to Hattilek village which is located far away (2 hours walking distance) from the main high way, where alternatives to fuel wood is almost absent and local people are highly dependent on the forest resources putting high pressure in the forest. In addition, practice of open grazing within this community forest may reduce the ground vegetation and destroy the regenerating seedlings of grazing sensitive species. This is the reason why only few species of NTFPs (such as *Cinnamomum tamala*) showed high association with this forest (see Fig. 4.5b). On the other hand, most of the users of Arghachhap CF and some users of Khulkhule CF have good access to alternative sources of energy and other commodities as their settlements were linked to the Siddhartha high way. Therefore, these two forests showed comparatively low levels of human disturbance, and hence a number of high-value NTFP species (*Phylanthus emblica*, *Terminalia bellirica*, *T. chebula*, *Woodfordia fruticosa*) showed greater association with these two community forests. However, as compared to Khulkhule, Arghachhap CF was moderately disturbed. Furthermore, the practice of controlled grazing in Arghachhap CF would help to minimize competition between species and would favour species richness and coppicing capacity of ground vegetation (cf. Ramirez-Marcial *et al*. 2001).

## 5.3 Diversity and Distribution of NTFPs in Community Forests

The high gamma diversity in large-sized forest and low in small-sized forest may show the pattern related to area-based increase in habitat heterogeneity. Species diversity increases with the increase in the area of community forest. Area of forest and habitat heterogeneity is usually positively correlated (Mac-Arthur and Wilson 1967, Rosenzweig 1995). The habitat heterogeneity hypothesis predicts higher species richness because of the higher habitat heterogeneity of larger areas (Baldi 2008). Thus larger the area of community forest the higher would be the habitat heterogeneity and more species can be expected to occur in such forests. Among the total potentially useful NTFP species documented from the study area, the gamma diversities of all woody species, woody NTFP species, all herbaceous species, and herbaceous NTFP species were found higher in large-sized community forest (Khulkhule CF) and lowest in small-sized community forest (Hattikot CF). Hill and Curran (2001) studied the species composition (gamma diversity) of fragmented forest and observed that gamma diversity is positively correlated with the area of forest. However, impact of forest area on diversity of species is controversial, as Lawesson *et al.* (1998) observed negative relationship between area of forest and distribution of species. According to Honnay *et al.* (1999), a small forest fragments can be very important for maintaining plant diversity, at least if they are of high habitat quality and management of forest is appropriate. Since only three community forests of different sizes were taken as specific study sites in this study the result obtained may not be reliable as earlier findings. For good result there should be large number of patches of different sized community forest. If more community forest of different sizes were taken as specific study sites, then the result would be more reliable to interpret the distribution of species in relation to the area of forest.

Unlike gamma diversity, richness (alpha diversity) of all woody species, all herbaceous species, woody NTFP species and herbaceous NTFP species tended to be high in medium-sized community forest (Arghachhap CF) receiving moderate level of disturbance, suggesting the greater species richness in moderately disturbed community forest. Good management practices (scheduled plantation and controlled grazing and harvesting of forest products) followed by user communities of Arghachhap CF might contributed to the higher species richness in this forest. In human managed landscapes, moderate level of human disturbance creates small scale patchiness and habitat heterogeneity which enhances species richness by reducing the influence of more competitive species (Sullivan 1999). The high species richness in Arghachhap CF is also attributed to the presence of high moisture along with other supporting environmental factors (Panthi *et al.* 2007). In dry habitats, species number increases towards the relatively wetter areas as observed by Kassas and Zahran (1971) in Egypt and by Vetaas (1993) in Sudan. Total tree species richness was found to increase with soil and atmospheric moisture in New Zealand (Leathnick *et al.* 1998). In dry areas moisture is often the limiting factor and thus has a strong influence on species richness (Olsvig-Whittaker *et al*. 1983; Belsky *et al*. 1989). It can be concluded that good management practices along with moderate level of disturbance, optimum level of moisture with moderate canopy are some of the major factors influencing composition and richness of NTFP species.

In the entire data set, however, the richness of woody NTFP species showed weak negative linear relationship with disturbance and strong positive linear relationship with the richness of total woody species. Richness of woody NTFP species showed unimodal relationship with total plant density and altitude. This shows that the richness of woody NTFP species will increase with the increase in altitude and total density upto certain point and then the richness will decreases. In the case of Nepal Himalaya, Vetaas and Grytnes (2002) and Grytnes and Vetaas (2002) reported unimodal response of vascular plant species richness with a peak in richness at 2000 m. But the finding of unimodal relationship between species richness and altitude in the present study with a peak in richness at about 550 m is an artifact and not a natural phenomenon considering the level of altitudinal difference of the study plots (360-870 m). Within this level of altitude the expected tendency should be a monotonic increase in species richness but due to high human pressure particularly at high altitude areas (700-800 m) the richness of woody species showed unimodal relationship.

## 5.4 Population Size and Structure of Most Potential NTFP Species

Depending upon the socio-cultural and medicinal use values, out of 114 NTFP species, 12 species have been identified as most potential species. Out of 12 most potential NTFPs, *Shorea robusta* and *Terminalia alata* among the trees and *Curculigo orchioides* among the herbs were most common NTFP species with high density in all the three community forests. This may because the tree species, *Shorea robusta* and *Terminalia alata* were highly protected in the study area and great concern of community forest user groups (CFUGs) was mainly focused on conservation of such woody species. While in case of *Curculigo orchioides*, it is potential and highly preferred in other parts of the country for medicinal use but in the study area only the Magar people had idea about the use of this species as medicine which indicate low destruction. *Asparagus racemosus, Cinnamomum tamala, Phyllanthus emblica, Syzygium cumini, Terminalia bellirica* and *Terminalia chebula* were less common species occurring within only one or two community forests and with fairly low densities. *Asparagus racemosus, Cinnamomum tamala*, *Phyllanthus emblica, Syzygium cumini*, *Terminalia bellirica* and *Terminalia chebula* were popular among all ethnic/caste groups studied and used by them for their medicinal as well as food values. In the past, people had not given proper attention on the conservation of such NTFPs in the community forest, many valuable species might have been removed or destroyed during forest management activities (such as silviculture practices). Some species, once present in good abundance in the community forest, are now almost completely over exploited due to their high trade value. *Cinnamomum tamala*, for example, is now completely absent in most of the community forests due to excessive harvesting of its bark and leaves in the past. It is now restricted in the private plantation forests.

The results of the present study showed species specific pattern of plant density of different life forms in different community forests. The densities of seedling, juvenile and adult individuals of most of the NTFP species were comparatively high in large and medium-sized community forests. The more light demanding species such as *Shorea robusta* and *Terminalia alata* had high seedling and juvenile densities in comparatively disturbed and smaller-sized community forests (Jackson 1994). If the number of mature tree species is very low in an area as compared to the number of seedling, sapling and young trees of that species, it indicates very good natural regeneration; on the contrary, if the number of mature individuals is more than that of seedlings, saplings and young trees, it indicates poor natural regeneration (Singh and Singh 1992). Good regeneration was found in *Shorea robusta*, *Terminalia alata, Bauhinia vahlii, Mallotus philippensis* and *Woodfordia fruticosa.* Seed germination and seedling establishment is very important for the better regeneration of such plant species. Various environmental factors like temperature, soil moisture, light intensity and viability of seed affects germination of seed. High proportions of seeds and seedlings can not tolerate adverse environmental condition and many growing seedlings can not compete with other herbaceous flora.

# *CHAPTER 6*

# SUMMARY AND CONCLUSIONS

In this study, utilization pattern, diversity and population status of NTFP species were studied in three different community forests varying in size, level of disturbance and other factors in Dovan VDC of Palpa district. Data were collected using both ecological and ethnobotanical tools. The area is rich in plant species diversity including NTFPs. Local people are highly dependent on forest resources for various purposes. Majority of the NTFP species are used for medicinal purpose. The local people had sound knowledge about the utilization of NTFPs. Among three ethnic/caste groups interviewed, Magars and Brahman/Chhetri had comparatively high knowledge on the medicinal uses of NTFPs, while the Gurungs had high knowledge about the fodder value of NTFPs. Several factors, including peoples' origin and history of attachment to the land, socio-cultural practices, etc. have been attributed for such variation in knowledge and utilization pattern of NTFPs.

Habitat area, altitude and disturbance are the major factors affecting plant species (including NTFP species) distribution, vegetation composition and species diversity in three community forests. The gamma diversity of all species as well as NTFP species was high in large-sized community forest and low in smaller-sized community forest indicating area-based increase in habitat heterogeneity in maintaining overall landscape level species diversity. But species richness (alpha diversity) showed pattern related more with the level of human disturbance associated with the management practices. The results of the present study also showed species specific pattern of plant density of different life forms in different community forests. The densities of seedling, juvenile and adult individuals of most of the woody NTFP species were comparatively high in large and medium-sized community forests, except for more light demanding species, such as *Shorea robusta* and *Terminalia alata*, which showed high seedling and juvenile densities in comparatively disturbed and smaller-sized community forests. Among total 12 most potential NTFP species selected, the high density of woody species in almost all community forest showed that the CFUGs were only focusing on the management of timber yielding products rather than lower herbaceous NTFPs.

Based on the present study following recommendations are made:

- The local knowledge on utilization pattern of NTFPs should be properly documented for future reference.
- The CFUGs should not only focus on the timber yielding products but also on high-value NTFPs and medicinal/aromatic plants.
- Develop sustainable harvesting and community monitoring methods for highly valuable NTFPs integrating both scientific and indigenous knowledge.
- Destruction was found high in small sized community forest so small sized community forest should be properly conserved.
- Future handover of CF should also consider area based habitat heterogeneity.
- Management practices of NTFPs should include application of species-specific sustainable harvesting protocols and regular community monitoring for harvest adjustments.
- Control forest fire, over grazing and over harvesting of forest resources.
- Provide alternative sources energy, such as bio-gas, bio-fuel, etc. to reduce pressure on the forest resources.

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# *APPENDICES*

## APPENDIX 1

**Questionnaire**

1. Name of the informant: ..........................................................................................

2. Age: ............. 3. Sex: a. Male .................. b. Female......................

4. Do you use plant parts to cure illness? a. Yes.............. b. No.....................

5. What are the top three NTFPs in your use?

a. ............................ b. .................................... c. ............................

6. Do you collect them yourself? a. Yes ............ b. No..................

7. Do you grow these plants? a. Yes ............ b. No................

8. If yes,

i) What is the extent of collection? a. Small scale b. Large scale

ii) What plants have you cultivated? a................... b..................... c..........................

iii) Where do you sell them? a.................. b..................... c...........................

iv) What is the annual income from sale? ......................................................................

v) Where do you get the seedlings? ....................................................................................

9. What are the highly traded NTFPs in the area?

a.................................... b.................................... c....................................

10. What are the major localities of their occurrence?....................................................

11. Do outsiders come to collect NTFPs in this area ? a. Yes............ b. No............

12. How do you earn your livelihood?

a. Jobholder b. Agriculture c. Business d. Others

13. Do your earnings meet your household expenses? a. Yes............ b. No............

14. Do you think we should conserve the resources?

a. Yes.............. b. No.................. c. Don't know .......................

15. Can you give some idea about how to conserve resources?

a. .................................... b...................................... c.......................................

## APPENDIX 2

### Plant species recorded in three community forests

| S. No. | Family | Scientific Name | Local Name | Form | Category | Hattikot C.F | Arghachhap C.F. | Khulkhule C.F. |
|---|---|---|---|---|---|---|---|---|
| 1 | Acanthaceae | *Justicia adhatoda* L. | Asuro | S | NTFP | + | + | + |
| 2 | Agavaceae | *Agave cantula* Roxb. | Ketuki | H | NTFP | + | - | - |
| 3 | Amaranthaceae | *Achyranthes bidentata* Blume | Datiwan | H | NTFP | + | + | + |
| 4 | Amaranthaceae | *Amaranthus spinosus* L. | Banlunde | H | NTFP | + | + | + |
| 5 | Amaranthaceae | *Eclipta prostrata* (L.) L. | Bhirangi jhar/Bhirangiraj | H | NTFP | + | + | + |
| 6 | Anacardiaceae | *Mangifera indica* L. | Aap | T | N-NTFP | + | - | - |
| 7 | Anacardiaceae | *Rhus javanica* L. | Bhakimlo | T | NTFP | - | + | + |
| 8 | Anacardiaceae | *Semecarpus anacardium* L.f. | Bhalayo | T | NTFP | + | + | + |
| 9 | Apocynaceae | *Alstonia scholaris* (L.) R. Br. | Chhatiban | T | NTFP | + | + | + |
| 10 | Apocynaceae | *Holarrhena pubescens* (Buch.-Ham.) Wall. ex G. Don | Indrajau (Khirro) | T | NTFP | - | - | + |
| 11 | Apocynaceae | *Plumeria rubra* L. | Golaichi (Casva "N") | T | NTFP | + | + | + |
| 12 | Araceae | *Acorus calamus* L. | Bojho | H | NTFP | - | + | + |
| 13 | Araceae | *Colocasia esculenta* (L.) Schott | Karkalo | H | NTFP | + | + | + |
| 14 | Asclepiadaceae | *Calotropis gigantea* (L.) Dryand. | Aank | S | NTFP | + | + | + |
| 15 | Asclepiadaceae | *Marsdenia tinctoria* R. Br. | Kallahari | T | N-NTFP | - | + | - |
| 16 | Asclepiadaceae | *Periploca calophylla* (Wight) Falc. | Sikari laharo | CS | NTFP | + | + | + |
| 17 | Begoniaceae | *Begonia* sp. | Magarkachhi | H | N-NTFP | + | + | - |
| 18 | Berberidaceae | *Berberis asiatica* Roxb. ex DC. | Chutro (Birdi) | S | NTFP | - | - | + |
| 19 | Bignoniaceae | *Oroxylum indicum* (L.) Kurz | Tatelo (Suntata) | T | NTFP | + | + | + |
| 20 | Bombacaceae | *Bombax ceiba* L. | Simal | T | NTFP | + | + | + |
| 21 | Campanulaceae | *Lobelia pyramidalis* Wall. | Eklebir | H | NTFP | + | + | + |
| 22 | Combretaceae | *Terminalia alata* Heyne ex Roth | Saj | T | NTFP | + | + | + |
| 23 | Combretaceae | *Terminalia bellirica* (Gaertn.) Roxb. | Barro | T | NTFP | + | + | + |
| 24 | Combretaceae | *Terminalia chebula* Retz. | Harro | T | NTFP | + | + | + |
| 25 | Compositae | *Ageratum conyzoides* L. | Gandhe | H | N-NTFP | - | + | + |
| 26 | Compositae | *Artemisia indica* Willd. | Titepati | H | NTFP | + | + | + |
| 27 | Compositae | *Baccharoides anthelmintica* (L.) Moench. | Kalojira | H | NTFP | - | + | + |
| 28 | Compositae | *Bidens biternata* (Lour.) Merr. & Sherff | Kuro | H | N-NTFP | - | + | - |
| 29 | Compositae | *Eupatorium* sp. | Banmara | H | N-NTFP | - | + | + |
| 30 | Compositae | *Inula cappa* (Buch.-Ham. ex D. Don) DC. | Gaitihare | S | NTFP | + | + | + |
| 31 | Compositae | *Spilanthes calva* DC. | Latoghans (Marati) | H | NTFP | + | + | + |
| 32 | Convolvulaceae | *Cuscuta reflexa* Roxb. | Aakasbeli | HC | NTFP | + | + | + |
| 33 | Cucurbitaceae | *Mukia maderaspatana* (L.) Roem. | Golkakri | HC | NTFP | + | + | + |
| 34 | Cucurbitaceae | *Trichosanthes tricuspidata* Lour. | Indrayani | WC | NTFP | + | + | + |
| 35 | Cyperaceae | *Cyperus rotundus* L. | Mothe | H | N-NTFP | - | + | - |
| 36 | Cyperaceae | Cyperus sp. | Mothe | H | N-NTFP | - | - | + |
| 37 | Dioscoreaceae | *Dioscorea bulbifera* L. | Githa | HC | N-NTFP | - | + | + |

| S. No. | Family | Scientific Name | Local Name | Form | Category | Hattikot C.F | Arghachhap C.F. | Khulkhule C.F. |
|---|---|---|---|---|---|---|---|---|
| 38 | Dioscoreaceae | *Dioscorea deltoidea* Wall. ex. Griseb | Bhyakur | HC | NTFP | + | + | + |
| 39 | Dipterocarpaceae | *Shorea robusta* Gaertn. | Sal | T | NTFP | + | + | + |
| 40 | Dryopteridaceae | *Dryopteris* sp. | Unyu | H | N-NTFP | + | + | + |
| 41 | Dryopteridaceae | *Tectaria coadunata* (Wall. ex J. Sm.) C.Chr. | Kaloneuro | H | NTFP | + | + | + |
| 42 | Equisetaceae | *Equisetum ramosissmum* Desf. | Kurkure | H | NTFP | + | + | + |
| 43 | Ericaceae | *Lyonia ovalifolia* (Wall.) Drude | Ahero | S | NTFP | - | - | + |
| 44 | Euphorbiaceae | *Antidesma bunius* (L.) Spreng. | Archalo | T | N-NTFP | + | + | - |
| 45 | Euphorbiaceae | *Euphorbia royleana* Boiss. | Siudi | S | NTFP | + | + | + |
| 46 | Euphorbiaceae | *Jatropha curcus* L. | Sajiwan | T | NTFP | + | + | + |
| 47 | Euphorbiaceae | *Mallotus philippensis* (Lam.) Mull. | Rohini (Sindure) | T | NTFP | + | + | + |
| 48 | Euphorbiaceae | *Phyllanthus emblica* L. | Amala | T | NTFP | + | + | + |
| 49 | Euphorbiaceae | *Ricinus communis* L. | Ader (Redi) | S | NTFP | - | + | + |
| 50 | Flacourtiaceae | *Homalium napaulense* (DC.) Benth. | Phalame | S | N-NTFP | - | + | - |
| 51 | Gentianaceae | *Swertia chirayita* (Roxb. ex Fleming) H. Karst. | Chiraito (Tite) | H | NTFP | + | + | + |
| 52 | Gesneriaceae | *Didymocarpus albicalyx* C. B. Clarke | Kumkum | H | NTFP | + | + | + |
| 53 | Gramineae | *Cymbopogon citratus* (DC.) Stapf. | Kagati ghans | H | NTFP | + | - | + |
| 54 | Gramineae | *Dendrocalamus hamiltonii* Nees & Arn. ex Munro | Bans | T | NTFP | + | + | + |
| 55 | Gramineae | *Eulaliopsis binata* (Retz.) C.E. Hubb. | Babiyo | H | NTFP | + | + | + |
| 56 | Gramineae | *Imperata cylindrica* (L.) P. Beauv. | Siru | H | NTFP | + | + | + |
| 57 | Gramineae | *Themeda triandra* Forssk. | Khar | H | N-NTFP | - | - | + |
| 58 | Gramineae | Unknown 9 (Gramineae) | Ghans | H | N-NTFP | - | + | + |
| 59 | Gramineae | *Thysanolaena maxima* (Roxb.) Kuntze | Amriso | H | NTFP | + | + | + |
| 60 | Hypoxidaceae | *Curculigo orchioides* Gaertn. | Kalo musli (Musal ledi) | H | NTFP | + | + | + |
| 61 | Labiatae | *Colebrookea oppositifolia* Sm. | Dhurseli | S | N-NTFP | - | + | + |
| 62 | Labiatae | *Mentha spicata* L. | Pudina | H | NTFP | + | + | + |
| 63 | Labiatae | *Pogostemon benghalensis* (Burm. f.) Kuntze | Rudilo | H | NTFP | + | + | + |
| 64 | Lauraceae | *Cinnamomum glauscescens* (Nees) Hand.-Mazz. | Sugandhakokila | T | NTFP | - | - | + |
| 65 | Lauraceae | *Cinnamomum tamala* (Buch.-Ham.) Nees & Eberm. | Tejpat | T | NTFP | + | + | - |
| 66 | Lauraceae | *Litsea monopetala* (Roxb.) Pers. | Kutmero | T | NTFP | + | + | + |
| 67 | Lauraceae | *Persea odoratissima* (Nees) Kosterm. | Kaulo | T | NTFP | + | + | + |
| 68 | Leguminosae | *Acacia catechu* (L. f.) Willd. | Khayar | T | NTFP | + | + | + |
| 69 | Leguminosae | *Bauhinia purpurea* L. | Tanki | T | NTFP | + | + | + |
| 70 | Leguminosae | *Bauhinia vahlii* Wight & Arn. | Bhorla | WC | NTFP | + | + | + |
| 71 | Leguminosae | *Bauhinia variegata* L. | Koiralo | T | NTFP | + | + | + |
| 72 | Leguminosae | *Cassia fistula* L. | Rajbrikshya (Badar latthi) | T | NTFP | + | + | + |
| 73 | Leguminosae | *Entada phaseoloides* (L.) Merr. | Pangra | WC | NTFP | + | - | - |
| 74 | Leguminosae | *Mimosa pudica* L. | Lazzawati | S | NTFP | - | + | + |
| 75 | Leguminosae | *Mimosa rubicaulis*subsp. *himalayana* (Gamble) H. Ohashi | Areli | T | NTFP | - | + | + |
| 76 | Leguminosae | *Mucuna pruriens* L. DC. | Kauchho | HC | NTFP | + | + | + |
| 77 | Leguminosae | *Senna occidentalis* (L.) Link | Tapre | S | NTFP | - | + | + |
| 78 | Leguminosae | *Tamarindus indica* L. | Imili | T | NTFP | - | + | + |
| 79 | Liliaceae | *Aloe vera* (L.) Burm. f. | Ghiukumari | H | NTFP | + | + | + |
| 80 | Liliaceae | *Asparagus officinalis* L. | Kurilo | H | NTFP | + | + | + |

| S. No. | Family | Scientific Name | Local Name | Form | Category | Hattikot C.F | Arghachhap C.F. | Khulkhule C.F. |
|---|---|---|---|---|---|---|---|---|
| 81 | Liliaceae | *Asparagus racemosus* Willd. | Kurilo | H | NTFP | - | - | + |
| 82 | Liliaceae | *Smilax ovalifolia* Roxb. ex D. Don | Kukurdaino | CS | NTFP | + | + | + |
| 83 | Loranthaceae | *Viscum album* L. | Hadchur | S | NTFP | + | + | + |
| 84 | Lycopodiaceae | *Lycopodium japonicaum* Thunb. ex A. Murray | Nagbeli | CS | NTFP | + | + | + |
| 85 | Lycopodiaceae | *Lygodium japonicum* (Thumb.) Sw. | Janai laharo | H | N-NTFP | - | + | + |
| 86 | Lythraceae | *Lagerstroemia parviflora* Roxb. | Botdhayaro | T | N-NTFP | + | + | + |
| 87 | Lythraceae | *Lawsonia inermis* L. | Mehadi | S | NTFP | - | + | + |
| 88 | Lythraceae | *Woodfordia fruticosa* (L.) Kurz | Dhayaro (Jharyak) | S | NTFP | + | + | + |
| 89 | Malvaceae | *Thespesia lampas* (Cav.) Dalzell & Gibson | Bankapas | S | NTFP | + | + | + |
| 90 | Melastomataceae | *Melastoma melabathricum* L. | Angeri | S | N-NTFP | + | - | - |
| 91 | Meliaceae | *Azadirachta indica* A. Juss. | Nim | T | NTFP | + | - | + |
| 92 | Meliaceae | *Melia azedarach* L. | Bakaino | T | NTFP | - | + | + |
| 93 | Meliaceae | *Trichilia connaroides* (Wight & Arn.) Bentv. | Ankha Taruwa | T | NTFP | + | + | + |
| 94 | Menispermaceae | *Tinospora sinensis* (Lour.) Merr. | Gurjogano | CS | NTFP | + | + | + |
| 95 | Moraceae | *Ficus benghalensis* L. | Bar | T | NTFP | + | + | + |
| 96 | Moraceae | *Ficus hispida* L. f. | Totne | T | NTFP | - | + | + |
| 97 | Moraceae | *Ficus religiosa* L. | Pipal | T | NTFP | + | + | + |
| 98 | Moraceae | *Ficus semicordata* Buch.-Ham. ex Sm. | Khanayo | T | N-NTFP | - | - | + |
| 99 | Musaceae | *Musa balbisiana* Colla | Bankera | T | N-NTFP | - | - | + |
| 100 | Myricaceae | *Myrica esculenta* Buch.-Ham. ex D. Don | Kafal | T | NTFP | + | + | + |
| 101 | Myrsinaceae | *Embelia ribes* Burm. f. | Bayubidang | S | NTFP | - | - | + |
| 102 | Myrsinaceae | *Maesa chisia* Buch.-Ham. ex D. Don | Bilauni | S | NTFP | + | + | + |
| 103 | Myrtaceae | *Cleistocalyx operculatus* (Roxb.) Merr. & Perry | Kyamuna | T | NTFP | + | + | + |
| 104 | Myrtaceae | *Syzygium cumini* (L.) Skeels | Jamun | T | NTFP | + | + | + |
| 105 | Myrtaceae | *Syzygium* sp. | Bhadrejamun | T | NTFP | + | + | + |
| 106 | Nyctaginaceae | *Boerhavia diffusa* L. | Punarnarwa | H | NTFP | - | - | + |
| 107 | Oxalidaceae | *Oxalis corniculata* L. | Chariamilo | H | NTFP | + | + | + |
| 108 | Palmae | *Calamus* sp. | Bet | S | NTFP | + | + | + |
| 109 | Palmae | *Phoenix humilis* Royle ex Becc. & Hook. f. | Thakal | T | N-NTFP | - | + | + |
| 110 | Piperaceae | *Piper longum* L. | Pipala | WC | NTFP | + | + | + |
| 111 | Pontederiaceae | *Eichhornia crassipes* (Mart.) Solms | Jaluka | H | N-NTFP | - | + | - |
| 112 | Pteridaceae | *Cheilanthes anceps* Blanford | Ranisinka | H | NTFP | + | + | + |
| 113 | Punicaceae | *Punica granatum* L. | Darim | T | NTFP | + | + | + |
| 114 | Rhamnaceae | *Zizyphus mauritiana* Lam. | Bayar | T | NTFP | + | + | + |
| 115 | Rosaceae | *Rubus ellipticus* Sm. | Aiselu | S | NTFP | + | + | + |
| 116 | Rubiaceae | *Adina cordifolia* (Willd. ex Roxb.) Benth. & Hook. f. ex Brandis | Karam | T | N-NTFP | - | - | + |
| 117 | Rubiaceae | *Mussaenda frondosa* L. | Dhobini | CS | NTFP | + | + | + |
| 118 | Rubiaceae | *Rubia manjith* Roxb. ex Fleming | Majitho | HC | NTFP | - | - | + |
| 119 | Rutaceae | *Aegle marmelos* (L.) Correa | Bel | T | NTFP | + | + | + |
| 120 | Rutaceae | *Zanthoxylum armatum* DC. | Timur | T | NTFP | - | - | + |
| 121 | Sapotaceae | *Diploknema butyracea* (Roxb.) H. J. Lam | Chiuri | T | NTFP | + | + | + |
| 122 | Solanaceae | *Datura metel* L. | Dhatura | H | NTFP | + | + | + |
| 123 | Solanaceae | *Solanum anguivi* Lam. | Bihi (Gherena "M.") | S | NTFP | + | + | + |

| S. No. | Family | Scientific Name | Local Name | Form | Category | Hattikot C.F | Arghachhap C.F. | Khulkhule C.F. |
|---|---|---|---|---|---|---|---|---|
| 124 | Solanaceae | *Solanum nigrum* L. | Kumai | H | NTFP | - | + | + |
| 125 | Solanaceae | *Solanum virginianum* Dunal | Kantakari | S | NTFP | + | + | + |
| 126 | Theaceae | *Schima wallichii* (DC.) Korth. | Chilauni | T | N-NTFP | + | - | - |
| 127 | Umbelliferae | *Centella asiatica* (L.) Urb. | Ghodtapre | H | NTFP | + | + | + |
| 128 | Urticaceae | *Girardinia diversifolia* (Link.) Friis | Allo (chalne sisnu) | H | NTFP | - | - | + |
| 129 | Urticaceae | *Maoutia puya* (Hook.) Wedd. | Jankhi | S | NTFP | + | + | + |
| 130 | Verbenaceae | *Callicarpa macrophylla* Vahl | Dahichamle (Dayelo) | S | NTFP | + | + | + |
| 131 | Verbenaceae | *Premna barbata* Wall. ex Schauer | Gidari (Ginnari) | T | NTFP | + | + | + |
| 132 | Verbenaceae | *Vitex negundo* L. | Simali | T | NTFP | + | + | + |
| 133 | Zingiberaceae | *Curcuma caesia* Roxb. | Kalobesar | H | NTFP | + | + | + |
| 134 | Unknown 1 | Unknown 1 | Unknown 1 | H | N-NTFP | - | + | - |
| 135 | Unknown 2 | Unknown 2 | Unknown 2 | H | N-NTFP | - | + | - |
| 136 | Unknown 3 | Unknown 3 | Unknown 3 | S | N-NTFP | + | - | - |
| 137 | Unknown 4 | Unknown 4 (Asare) | Asare | S | N-NTFP | - | + | + |
| 138 | Unknown 5 | Unknown 5 (Bikhmari) | Bikhmari | H | NTFP | - | + | + |
| 139 | Unknown 6 | Unknown 6 (Chinilaharo) | Chinilaharo | HC | NTFP | + | + | + |
| 140 | Unknown 7 | Unknown 7 (Gajejhar) | Gajejhar | H | NTFP | - | + | + |
| 141 | Unknown 8 | Unknown 8 (Golaino) | Golaino | H | N-NTFP | + | + | + |
| 142 | Unknown 9 | Unknown 10 (Hiukanda) | Hiukanda | H | NTFP | - | - | + |
| 143 | Unknown 10 | Unknown 11 (Pehita) | Pehita | H | NTFP | - | - | + |

# APPENDIX 3

## Utilization pattern of non-timber forest products by three ethnic/caste groups

| S. No. | Scientific Name | Brahman/Chhetri | Magar | Gurung |
|---|---|---|---|---|
| 1 | *Acacia catechu* (L. f.) Willd. | Bark is used in making colours. | Boiled bark and stem is given to treat back bone pain. Bark is also used in making colours. | Plant is used as fodder. Timber is used in making handicrafts. |
| 2 | *Achyranthes bidentata* Blume | Juice of root is given to treat anorexia and marasmus. Stem is used as tooth brush. Plant is essential in 'Teej' for 'Panchami 'Pooja'. | Juice of root is given to treat anorexia and marasmus. | Juice of root is given to treat anorexia. Plant is used as fodder. Plant is essential in 'Panchami Pooja'. |
| 3 | *Acorus calamus* L. | Root is chewed to treat cough. | Root is chewed to treat cough. | Juice of root is given to treat body pain. |
| 4 | *Aegle marmelos* (L.) Correa | In juice of its fruit, powder of seed of *Trachyspermum ammi is mixed* and is given to treat indigestion and also given as cooling agent. Juice of fruit is given to treat gastritis. Only juice of fruit is also given as cooling agent. | Steam inhalation of boiled leaf is taken or boiled leaf is drunk to treat body pain. Plant is used to worship. | Fruit is given to treat cold. Plant is used as fodder. |
| 5 | *Agave cantula* Roxb. | Juice of root is given to treat gonorrhoea. | Juice of root is given to treat menstruation disorder. Leaves are used in making ropes. | |
| 6 | *Aloe vera* (L.) Burm. f. | Fluid of leaf is applied on burns. Fluid of leaf is also given to treat bile juice problem. | Fluid of leaf is given to treat diabetes and fever. Fluid of leaf is also given as cooling agent. Fluid of leaf is applied on burns. | Fluid of leaf mixed with water is given early in the morning as cooling agent in empty stomach. Fluid of leaf is applied on burns and headache. |
| 7 | *Alstonia scholaris* (L.) R. Br. | | Stem of plant is used to make 'Madal' | Juice of bark is given to treat anorexia. |
| 8 | *Amaranthus spinosus* L. | Juice of root is given to treat gonorrhoea. Juice of root is also given as cooling agent. Leaf is edible. | Juice of root is given to treat sinusitis. | Juice of root is given to treat retention of urine. Leaf is edible. |
| 9 | *Artemisia indica* Willd. | Juice of leaf is used in bathing to treat scabies. | Juice of leaf is given to treat gastritis. Boiled shoot apex is given as cooling agent. Juice of leaf is used in bathing to treat scabies. | Juice of leaf is given to treat gastritis. |
| 10 | *Asparagus officinalis* L. | Tender shoot is taken as vegetable. | | |
| 11 | *Asparagus racemosus* Willd. | Powder of root is mixed in water and given to treat breast engorged. Shoot apex is taken as vegetable. Root is used in making soap. | Shoot apex is taken as vegetable. Root is used in making soap. | Juice of root is given to domestic animals as cooling agent. Shoot apex is taken as vegetable. Root is used to make soap. |
| 12 | *Azadirachta indica* A. Juss. | Leaf is boiled and drunk to treat headache. Paste of bark or leaf is applied on boils. | Leaf is boiled and drunk to treat headache. | Paste of leaf is given to treat headache and fever. |
| 13 | *Baccharoides anthelmintica* (L.) Moench. | Paste of seed is applied on wounds and boils. | Powder of seed poured in water and is given to treat anorexia and marasmus. | |
| 14 | *Bauhinia purpurea* L. | Juice of bark is given to treat diarrhoea. Plant is used as fodder. | Juice of bark is given to treat stomach swelling. Plant is used as fodder. | Juice of root is given to treat stomach swelling. Flower is pickled. Plant is used as fodder. |
| 15 | *Bauhinia vahlii* Wight & Arn. | Powder of bark or root is mixed with powder of bark | Burnt seed is given to treat stomach pain. Flower | Plant is used to make rope. |

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| | | of *Mangifera indica*, *Terminalia alata* and urine of cow and is given to treat gastritis. Flower is pickled. Plant is used as fodder. | is pickled. Plant is used as fodder. Plant is also used to make rope. | |
| 16 | *Bauhinia variegata* L. | Powder of bark is applied on wound and boils. Flower is pickled. | Juice of bark is given to treat diarrhoea. Flower is pickled. | Boiled flower is given to treat diarrhoea. Flower is pickled. Plant is used as fodder. |
| 17 | *Berberis asiatica* Roxb. ex DC. | Powder of bark is mixed with milk of woman or juice of stem and is dropped in eyes to treat conjunctivitis. | Juice of bark is given to treat diabetes. | |
| 18 | *Boerhavia diffusa* L. | Juice of leaf or shoot apex is given to treat eye defect. | | |
| 19 | *Bombax ceiba* L. | Juice of root is given to treat gonorrhoea. Juice of root is also given as cooling agent. | Sticky fluid of stem is mixed in water and given to treat dysentery. Juice of bark is given as cooling agent. | Juice of root of juvenile is given to treat gonorrhoea. Plant is used as fodder and handicraft. |
| 20 | *Calamus* sp. | | Juice of root is given as cooling agent. Stem is used to make stick, handicraft, mat etc. | Juice of root is mixed with other medicinal plants and given to treat cold and hot. |
| 21 | *Callicarpa macrophylla* Vahl | Seed or juice of root or bark is given to treat stomatitis, throat pain, angina and cold. | Seed or juice of root is given to treat typhoid. Seed or juice of root or bark is given to treat stomatitis, throat pain, angina and cold. | Juice of root after rubbing is given to treat throat pain. |
| 22 | *Calotropis gigantea* (L.) Dryand. | Sticky fluid from stem is applied on sprains, headache, dropped on conjunctivitis. Dried stem is smoked to treat sinusitis. | Sticky fluid of stem or leaf is applied on sprains, headache, dropped on conjunctivitis. | Sticky fluid of leaf or stem is applied on sprains. |
| 23 | *Cassia fistula* L. | Powder of seed is given to treat retention of urine and diarrhoea. | Powder of seed is given to treat retention of urine and diarrhoea. | Juice of bark is given as cooling agent. Paste of bark or leaf is applied on ring worm. Plant is used as firewood. |
| 24 | *Centella asiatica* (L.) Urb. | Juice of whole part is given to treat fever. Juice of whole part is also given as cooling agent. | Juice of whole part is mixed with honey and given to treat typhoid and brain tumour. | Juice of whole part is given to treat headache. |
| 25 | *Cheilanthes anceps* Blanford | Juice of root is given to treat typhoid. Juice of three plants is given to treat dumbness. | Juice of whole part is given to treat gastritis, stomach pain and anorexia. Stem is worn in hole after piercing ear of child. | Juice of whole part is given to treat gastritis. |
| 26 | *Cinnamomum glauscescens* (Nees) Hand.-Mazz. | Powder of seed mixed in water and given to treat cold and cough. Plant is used as fodder. | Powder of seed is mixed in water and given to treat worm infestation. | Seed kept on teeth to treat toothache. |
| 27 | *Cinnamomum tamala* (Buch.-Ham.) Nees & Eberm. | Juice of bark is given to treat stomach pain. Bark or leaf is used as spices. | Juice of bark is given to treat gastritis. Bark or leaf is used as spices. | Juice of bark is given to treat diarrhoea. |
| 28 | *Cleistocalyx operculatus* (Roxb.) Merr. & Perry | | | Leaves are smoked to treat running nose. |
| 29 | *Colocasia esculenta* (L.) Schott | Cooked leaf is given to treat dysentery. Leaf is used as vegetable. | Leaf is used as vegetable. | Leaf is used as fodder. |
| 30 | *Curculigo orchioides* Gaertn. | | Juice of root is given to treat anorexia and marasmus. Paste of root is applied on cuts for tumour formation. Root is mixed with root of *Asparagus racemosus* and seed of *Holarrhena pubescens*, then it is dried and powdered and cooked with milk and given to treat anaemia. | |
| 31 | *Curcuma caesia* Roxb. | Juice of tuber is given to treat gastritis and stomach pain. | Juice of tuber is given to treat gastritis. | Juice of tuber is given to treat anorexia. |

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| 32 | *Cuscuta reflexa* Roxb. | Juice of whole part is given to treat jaundice. Juice of whole part is also applied to treat jaundice. | Juice of whole part is given to treat jaundice. Juice of whole part is also applied to treat jaundice. It is placed on bed for sleeping to treat jaundice. | Juice of whole part is given to treat anorexia. Juice of whole part is also given to domestic animals as cooling agent. |
| 33 | *Cymbopogon citratus* (DC.) Stapf. | Juice of leaf is given to treat gastritis. | Leaf is used in tea. | |
| 34 | *Datura metel* L. | | Seed is tempered in oil and the oil is given to treat anorexia and marasmus. | Very few amounts of seed are given to treat cold. |
| 35 | *Dendrocalamus hamiltonii* Nees & Arn. ex Munro | Young shoot apex is pickled. | Young shoot is used as vegetable. Plant is used as handicraft. | Water inside internodes is given to child who used to excrete urine on bed. Shoot is used as vegetable and pickled. Plant is used as fodder. |
| 36 | *Didymocarpus albicalyx* C. B. Clarke | Plant is used to treat worship. | Ash of whole part is mixed with mustard oil and dropped in ear to treat otitismedia. Juice of whole part is given to cows and buffaloes to treat uterus prolapse. | |
| 37 | *Dioscorea deltoidea* Wall. ex. Griseb | Tuber is taken as vegetable. | Boiled or burnt tuber is given to treat worm infestation. Tuber is taken as vegetable. | Tuber after cooking is given to treat worm infestation. Tuber is taken as vegetable. |
| 38 | *Diploknema butyracea* (Roxb.) H. J. Lam | Ghee prepared from seed is applied on cracks. | Ripe fruit is edible and also used to make alcoholic beverages. Plant is used as fodder. | Juice of bark is given to treat worm infestation. Ghee is extracted from seed. Plant is used as fodder and firewood. |
| 39 | *Eclipta prostrate* (L.) L. | Juice of whole part is given to treat jaundice. Juice of whole part is also applied on cuts to control bleeding. | Paste of root is applied on mud wound. | Paste of leaf is applied on mud wound. Plant is used as fodder. |
| 40 | *Embelia ribes* Burm. f. | Powder of bark or seed is given to treat gastritis. | | |
| 41 | *Entada rheedei* Spreng. | | Paste of rubbed seed is applied on extreme boils. | |
| 42 | *Equisetum ramosissmum* Desf. | Juice of whole part either boiled or unboiled is given as cooling agent. | Juice of whole part either boiled or unboiled is given as cooling agent. | |
| 43 | *Eulaliopsis binata* (Retz.) C.E. Hubb. | Plant is used as fodder. | Boiled root is given to treat cold and hot. Burnt root mixed with honey and given to treat asthma. It is used to make festoon. | Plant is used as fodder and handicraft. |
| 44 | *Euphorbia royleana* Boiss. | Sticky fluid of stem poured in water and drunk to treat anorexia and marasmus. Sticky fluid is marked to cows and buffaloes to treat cataract on the opposite eye (side head). | Sticky fluid of stem is poured in water and drunk to treat anorexia and marasmus. Sticky fluid after burning stem is given to treat gastritis. Sticky fluid of stem is applied on sprains. | Sticky fluid after burning stem is given to treat anorexia. |
| 45 | *Ficus benghalensis* L. | Paste of tip of accessory root is given to treat urinary problem. | Juice of bark is given to treat gastritis. | Plant is used as fodder. Plant is used to worship. |
| 46 | *Ficus hispida* L. f. | Plant is used as fodder. | Plant is used as fodder. | Juice of burnt leaf is dropped in ear to treat otitismedia. Plant is used as fodder. |
| 47 | *Ficus religiosa* L. | Juice of bark is given to treat diarrhoea. Plant is used to worship. | Powder of bark is applied on scabies. | Juice of bark is given to treat gonorrhoea. Plant is used to worship. |
| 48 | *Girardinia diversifolia* (Link.) Friis | Juice of root is given as cooling agent. Paste of root is applied on wounds and boils. | | |
| 49 | *Holarrhena pubescens* (Buch.-Ham.) Wall. ex G. Don | Seed mixed with root of *Asparagus racemosus* and seed of *Mucuna pruriens* and is boiled and is given | | Juice of bark is given to treat anorexia. Plant is used as fodder. |

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| | | to treat anaemia. | | |
| 50 | *Imperata cylindrica* (L.) P. Beauv. | Juice of root is given to treat worm infestation. Paste of root is applied on wound made by mud on foot. | Juice of root is given to treat worm infestation, anorexia and marasmus. | Juice of root is given to treat worm infestation. |
| 51 | *Inula cappa* (Buch.-Ham. ex D. Don) DC. | Juice of leaf is applied on cuts to control bleeding. | Juice of root is dropped in ear to treat otitismedia. | |
| 52 | *Jatropha curcus* L. | Stem is used as brush to treat gingivitis. | Sticky fluid of stem is applied on wounds. Sticky fluid of stem is applied on wound made by mud on foot. Stem is used as brush to treat gingivitis. | Sticky fluid of stem is applied on wound made by mud on foot, cuts and burns. |
| 53 | *Justicia adhatoda* L. | Its leaf is wrapped by leaf of *Shorea robusta*, then it is burnt or kept inside ash and then it is poured into the water and water is drunk as cooling agent. Thus prepared water is also given to treat cough. | Juice of shoot apex is given to treat cold, cough, fever, headache and sinusitis. | Juice of boiled shoot apex is given to treat fever and cough. |
| 54 | *Lawsonia inermis* L. | Paste of leaf is applied on head to treat headache. Juice of leaf is given as cooling agent. | Juice of leaf is given as cooling agent. Paste of leaf is applied on head to treat headache. | Paste of leaf is applied on wound made by mud on foot. |
| 55 | *Litsea monopetala* (Roxb.) Pers. | Juice of bark is given as cooling agent. Juice of bark is also given to treat knee pain and typhoid. Paste of bark is applied on sprains. | Powder of bark is mixed with powder of bark of *Oroxylum indicum* and mixing it in water. Then the water is given to cows and buffaloes to treat infertility. | Plant is used as fodder. |
| 56 | *Lobelia pyramidalis* Wall. | Juice of root is given to increase sexual desire. | Juice of root is given to treat sickness of domestic animals (cows and buffaloes). | |
| 57 | *Lycopodium japonicaum* Thunb. ex A. Murray | Juice of whole part is given to treat retention of urine. Plant is used as fodder. | It is believed that if trailer stem of it is hanged on doors the home will be safe from snakes. | It is believed that if trailer stem of it is hanged on doors the home will be safe from snakes. |
| 58 | *Lyonia ovalifolia* (Wall.) Drude | Paste of bark or seed is applied on scabies. | Paste of bark or seed is applied on scabies. | According to local people there are two types of 'Ahero'. The first type of plant bears rounded leaf and is considered to produce fruits which are slightly narcotic and are not edible. The second type of plant bears elongated leaves and non-narcotic edible fruits. |
| 59 | *Maesa chisia* Buch.-Ham. ex D. Don | | Bark or root is mixed with net of spider and nest of bird, paste is prepared after mixing all these and is given to treat infertility problem. Bark is used to make ink. | |
| 60 | *Mallotus philippensis* (Lam.) Mull. | Juice of bark is given to treat diarrhoea and gastritis. | Juice of bark is given to treat diarrhoea and gastritis. Paste of seed is given to treat worm infestation. | Leaf mixing with leaf of *Vitex negundo is boiled and juice is* given to treat gastritis. |
| 61 | *Maoutia puya* (Hook.) Wedd. | | Juice of root is given to treat typhoid and fever. | |
| 62 | *Melia azedarach* L. | Plant is used as fodder. | Plant is used as fodder. | Juice of bark is given to treat worm infestation. Plant is used as fodder. |
| 63 | *Mentha spicata* L. | Juice of whole part is given to treat stomach pain and insomnia. Juice of whole part is given as cooling agent. Leaf is pickled. | Juice of whole part is given as cooling agent. | Juice of whole part is given as cooling agent. Leaf is pickled. |
| 64 | *Mimosa pudica* L. | | Juice of whole part is given to babies to treat | Juice of root is given to treat anorexia. Plant |

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| | | | stomach pain and to cows and buffaloes to treat breast engorged. | is used as fodder. |
| 65 | *Mimosa rubicaulis*subsp. *himalayana* (Gamble) H. Ohashi | Juice of root is given to treat stomach pain. Juice of root is also applied on sprains. | Juice of root is given to control extreme bleeding (woman during menstruation). | Plant is used as fodder. |
| 66 | *Mucuna pruriens* L. DC. | Juice of root is given to treat sickness of domestic animal. | Juice of root is given to cows and buffaloes to treat infertility. | |
| 67 | *Mukia maderaspatana* (L.) Roem. | | Juice of root is given to treat gastritis. Root charged with 'Mantras' is hanged on neck or tied on arm or waist of child to treat psycho disorder. | Seed is given as cooling agent. Plant is used as fodder. |
| 68 | *Mussaenda macrophylla* Wall. | | Juice of root is given to treat gonorrhoea. | Plant is used as fodder. |
| 69 | *Myrica esculenta* Buch.-Ham. ex D. Don | | Powder of bark is given to treat gastritis. | |
| 70 | *Oroxylum indicum* (L.) Kurz | Pulp of seed is given to treat asthma. Plant is used as fodder. | Pulp of seed is given to treat anorexia and marasmus. | Juice of bark is applied on wounds (tumour formation occur). Plant is used as fodder. |
| 71 | *Oxalis corniculata* L. | Juice of whole part is given to treat anorexia. Juice of whole part is also given as cooling agent. | Juice of whole part is dropped in eyes to treat conjunctivitis and eye defect due to eclipse. Leaf is chewed to treat loss of enamel of tooth. | Boiled whole part is given to treat cold and hot. |
| 72 | *Periploca calophylla* (Wight) Falc. | Paste of leaf is applied on sprain and fracture. | Juice of whole part is given to treat waist pain and body pain. | Juice of leaf is given to treat sprain and fracture. Paste of root is applied on sprain and fracture. Plant is used as fodder. |
| 73 | *Persea odoratissima* (Nees) Kosterm. | Powder of bark is mixed in flour and used to make bread 'Sel'. Plant is used as fodder. | Powder of bark is given to treat gastritis and small pimples on body due to hot. | Paste of root is mixed with flour and used make bread ('Sel'). |
| 74 | *Phyllanthus emblica* L. | Ripe fruits are eaten raw or pickled. | Juice of bark is given to treat diarrhoea. Fruit powder is mixed with powder of seed of *Moringa oleifera* and is given to treat gastritis. Ripe fruits are eaten raw or pickled. | Juice of leaf is given to reduce burning sensation of chilli. Ripe fruits are edible. Plant is also used as fodder and firewood. |
| 75 | *Piper longum* L. | Burnt seed is given to treat cough. Juice of root is given to treat anorexia and marasmus. | Juice of stem is given to treat cough. Seed is used in making 'marcha'. | Powder of seed mixed with powder of seed of *Terminalia chebula* and *Terminalia bellirica* and given to treat gastritis. Plant is used as fodder. |
| 76 | *Plumeria rubra* L. | Juice of bark is given to treat anorexia, marasmus and worm infestation. | Juice of bark is given to treat anorexia and marasmus. | Juice of bark is given to treat anorexia. |
| 77 | *Pogostemon benghalensis* (Burm. f.) Kuntze | Paste of shoot apex is applied on forehead to treat fever. | Boiled leaf is given to treat fever, headache and cough. | Juice of leaf or shoot apex is given to treat running nose and headache. Paste of leaf is applied on nose and forehead to treat running nose and headache respectively. |
| 78 | *Premna barbata* Wall. ex Schauer | | Juice of bark is given as cooling agent. | Juice of bark is given as cooling agent. Plant is used as fodder. |
| 79 | *Punica granatum* L. | Fruit or paste of fruit bark is given to treat diarrhoea and dysentery. Fruit is given to increase blood level. | Fruit or paste of bark is given to treat diarrhoea. | Powder of fruit bark is given to increase blood level. |
| 80 | *Rhus javanica* L. | Seed is soaked in water and drunk as cooling agent. | Seed is given to treat dysentery. | |
| 81 | *Ricinus communis* L. | Paste of seed is applied on sprain and wounds. It is used to make 'Dalda Ghee' | | |

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| 82 | *Rubia manjith* Roxb. ex Fleming | Juice of root is given to treat diarrhoea. Plant is used as fodder. | | Juice of root is given to treat anorexia. |
| 83 | *Rubus ellipticus* Sm. | Juice of root is given to treat typhoid and gastritis. | Juice of shoot apex or root is given to treat throat pain and typhoid. Fruit is given to treat cold. | |
| 84 | *Semecarpus anacardium* L.f. | Juice after burning black seed is applied on cracked foot. Red seed is edible. | | Plant is used as fodder. Red seed is edible. |
| 85 | *Senna occidentalis* (L.) Link | Plant is used as fodder. | Paste of seed is applied on scabies. | Juice of leaf is given to treat cough. Plant is used as fodder. |
| 86 | *Shorea robusta* Gaertn. | Juice of bark is given to treat dysentery and gastritis. Powder of 'Sal' incense mixed with milk is given to treat cold and mixed with curd is given as cooling agent. | Juice of bark is given to treat dysentery, diarrhoea and gastritis. | Bark is boiled and juice is given to treat gastritis. Plant is used as fodder, handicraft and firewood. |
| 87 | *Smilax ovalifolia* Roxb. ex D. Don | Shoot apex is taken as vegetable. | Juice of root is given to treat marasmus and anorexia. Shoot apex is pickled and also taken as vegetable. | Shoot apex is taken as vegetable. Plant is also used as fodder. |
| 88 | *Solanum anguivi* Lam. | Juice of fruit is given as cooling agent. Paste of fruit is applied on head to treat headache. | Juice of fruit is given as cooling agent. Paste of fruit is applied on head to treat headache. | Seed is given to treat headache. |
| 89 | *Solanum nigrum* L. | Juice of root is given to treat gastritis. | Juice of root is given to hens for its sickness. | |
| 90 | *Solanum virginianum* Dunal | Burnt seed is kept on teeth to treat toothache. Seed is smoked to treat toothache. | Burnt seed keeping on cracked piece of pot is nosed to treat toothache. | Burnt seed is smoked to treat toothache. |
| 91 | *Spilanthes calva* DC. | Juice of flower is given to treat stomach pain. Flower is pickled. Dry flower is used as spices. | Juice of flower is given to treat toothache, cold, stomach pain. Flower is pickled. Dry flower is used as spices. Flower is also used in making 'marcha'. | Juice of flower is given to treat cold. Flower is placed on tooth to treat toothache. |
| 92 | *Swertia chirayita* (Roxb. ex Fleming) H. Karst. | Whole part kept in water and drunk to treat diabetes, eye defect and bile juice problem. | Flower soaked in water and drunk as cooling agent. | |
| 93 | *Syzygium cumini* (L.) Skeels | Juice of bark is given to treat fever. Ripe fruit is edible. | Ripe fruit is edible. | Ripe fruit is edible. |
| 94 | *Syzygium* sp. | Leaf is smoked to treat sinusitis and cold. Juice of bark is given to treat sinusitis. Fruit is edible. | Leaf is smoked to treat sinusitis and cold. Juice of bark is given to treat sinusitis. Fruit is edible. | |
| 95 | *Tamarindus indica* L. | Fruit is given to treat gastritis. | Fruit is pickled. | Fruit is pickled. Plant is used to make handicrafts. |
| 96 | *Tectaria coadunata* (Wall. ex J. Sm.) C.Chr. | Juice of root is given to treat dysentery and diarrhoea. | Juice of root is given to treat dysentery. | Juice of root is given to treat diarrhoea and stomach pain. Leaves are pickled or used as vegetable. Plant is also used as fodder. |
| 97 | *Terminalia alata* Heyne ex Roth | Juice of bark is given to treat gastritis and indigestion. | Grinded bark is boiled and juice is applied on wounds. Plant is used as fodder and handicraft. | Plant is used as fodder and firewood. |
| 98 | *Terminalia bellirica* (Gaertn.) Roxb. | Powder of fruit is mixed with fruit powder of *Terminalia chebula* and other medicinal plants and is given to treat gastritis. Plant is used as fodder. | | Fruit is given to treat gastritis. Plant is used as fodder. Plant is also used as firewood and handicraft. |
| 99 | *Terminalia chebula* Retz. | Burnt seed is given to treat cough and cold. | Burnt seed is given to treat cough and cold. | Seed is given to treat cough. Powder of seed is given to treat gastritis. |
| 100 | *Thespesia lampas* (Cav.) Dalzell & Gibson | Paste of root mixed with leaf paste of *Vitex negundo* and given to treat marasmus. | Juice of root is given as cooling agent. | Plant is used as fodder. |

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| 101 | *Thysanolaena maxima* (Roxb.) Kuntze | Plant is used as fodder. | Juice of root is given to treat typhoid. Paste of root is applied to pick out spine from skin. | Plant is used as fodder and handicraft. |
| 102 | *Tinospora sinensis* (Lour.) Merr. | Juice of tuber is given to treat gastritis. | Juice of tuber is given to treat gastritis. | Powder of dried rhizome is given as cooling agent. |
| 103 | *Trichilia connaroides* (Wight & Arn.) Bentv. | Oil obtained from seed is applied on wounds and boils. | Paste of seed mixed with mustard oil and applied on hairs to kill lice. It is used as a remedy of illness caused by spirit power (witches). | Juice of bark is given to treat anorexia. |
| 104 | *Trichosanthes tricuspidata* Lour. | Trailing stem is tied on waist to treat retention of placenta. | Juice of tuber is given to treat gastritis. | |
| 105 | *Viscum articulatum* Burm. f. | Powder of whole part or only stem is given to treat sprain and body pain. Juice of bark is given to treat sinusitis and sprain. | Juice of leaf or leaf mixed in bread is given to treat sprain, body pain and gastritis. | Powder or juice or paste of leaf is mixed with flour and after making bread is given to treat sprain. Plant is used as fodder. |
| 106 | *Vitex negundo* L. | Leaf is smoked to treat sinusitis. | Boiled leaf is drunk to treat sinusitis and headache. Leaf is smoked to treat sinusitis. | Leaf mixing with leaf of *Mallotus philippensis is boiled and juice is* given to treat gastritis. |
| 107 | *Woodfordia fruticosa* (L.) Kurz | Juice of flower or bark is mixed with hot water and given to treat diarrhoea and dysentery. | Juice of flower or bark is mixed with hot water and given to treat diarrhoea and dysentery. | Flower is given to treat dysentery. Plant is used as fodder. |
| 108 | *Zanthoxylum armatum* DC. | Powder of seed mixed with other medicinal plants and is given to treat gastritis. | Powder of seed mixed with paste of leaf of *Chenopodium album* and honey and is given to treat tuberculosis. | |
| 109 | *Zizyphus mauritiana* Lam. | Boiled pulp of seed is given to treat measles. Fruit is used as “Naibed”. | Pulp of seed, mixed with milk of black goat is given to treat measles. Paste of root mixed with soil of termite’s home and paddy, then cooked and given to treat measles. Paste of rubbed seed is given to treat typhoid. | Paste of seed and soil of termite's nest is cooked and given to treat measles. |
| 110 | Unknown 5 (Bikhmari) | Paste of leaf is applied on poisonous insect bites and snake bites. | Sticky fluid of leaf or stem is applied on burns. | |
| 111 | Unknown 6 (Chinilaharo) | Juice of trailer stem is given as cooling agent. | Sugar candy mixed with juice of trailer stem is given as cooling agent. | Plant is used as fodder. |
| 112 | Unknown 7 (Gajejhar) | Juice of leaf is applied on cuts to control bleeding. | | |
| 113 | Unknown 10 (Hiukanda) | Juice of root is given as cooling agent. | | |
| 114 | Unknown 11 (Pehita) | Powder of the seed mixed with salt and applied on boils. | | |

# APPENDIX 4

## a. Frequency and density of woody species (trees, tree saplings, shrubs and woody climbers) in three community forests.

| S. No. | Species Name | Frequency (%) | | | Density ($ha^{-1}$) | | | Relative Frequency (%) | | | Relative Density (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | KCF | ACF | HCF | KCF | ACF | HCF | KCF | ACF | HCF | KCF | ACF | HCF |
| 1 | *Adina cordifolia* (Willd. ex Roxb.) Benth. & Hook. f. ex Brandis | 15.56 | 0.00 | 0.00 | 42.22 | 0.00 | 0.00 | 3.24 | 0.00 | 0.00 | 1.68 | 0.00 | 0.00 |
| 2 | *Bauhinia vahlii* Wight & Arn. | 46.67 | 33.33 | 11.11 | 146.67 | 126.67 | 16.67 | 9.72 | 6.45 | 3.17 | 5.85 | 4.63 | 0.74 |
| 3 | *Cinnamomum tamala* (Buch.-Ham.) Nees & Eberm. | 0.00 | 0.00 | 5.56 | 0.00 | 0.00 | 5.56 | 0.00 | 0.00 | 1.59 | 0.00 | 0.00 | 0.25 |
| 4 | *Colebrookea oppositifolia* Sm. | 0.00 | 3.33 | 0.00 | 0.00 | 16.67 | 0.00 | 0.00 | 0.65 | 0.00 | 0.00 | 0.61 | 0.00 |
| 5 | *Ficus hispida* L. f. | 2.22 | 0.00 | 0.00 | 8.89 | 0.00 | 0.00 | 0.46 | 0.00 | 0.00 | 0.35 | 0.00 | 0.00 |
| 6 | *Ficus semicordata* Buch.-Ham. ex Sm. | 13.33 | 0.00 | 0.00 | 37.78 | 0.00 | 0.00 | 2.78 | 0.00 | 0.00 | 1.51 | 0.00 | 0.00 |
| 7 | *Homalium napaulense* (DC.) Benth. | 0.00 | 20.00 | 0.00 | 0.00 | 100.00 | 0.00 | 0.00 | 3.87 | 0.00 | 0.00 | 3.66 | 0.00 |
| 8 | *Lagerstroemia parviflora* Roxb. | 26.67 | 33.33 | 50.00 | 91.11 | 83.33 | 122.22 | 5.56 | 6.45 | 14.29 | 3.63 | 3.05 | 5.43 |
| 9 | *Mallotus philippensis* (Lam.) Mull. | 64.44 | 53.33 | 0.00 | 224.44 | 170.00 | 0.00 | 13.43 | 10.32 | 0.00 | 8.95 | 6.22 | 0.00 |
| 10 | *Marsdenia tinctoria* R. Br. | 0.00 | 3.33 | 0.00 | 0.00 | 16.67 | 0.00 | 0.00 | 0.65 | 0.00 | 0.00 | 0.61 | 0.00 |
| 11 | *Melastoma melabathricum* L. | 0.00 | 0.00 | 33.33 | 0.00 | 0.00 | 150.00 | 0.00 | 0.00 | 9.52 | 0.00 | 0.00 | 6.67 |
| 12 | *Phoenix humilis* Royle ex Becc. & Hook. f. | 26.67 | 46.67 | 0.00 | 140.00 | 283.33 | 0.00 | 5.56 | 9.03 | 0.00 | 5.58 | 10.37 | 0.00 |
| 13 | *Phyllanthus emblica* L. | 15.56 | 6.67 | 0.00 | 35.56 | 6.67 | 0.00 | 3.24 | 1.29 | 0.00 | 1.42 | 0.24 | 0.00 |
| 14 | *Schima wallichii* (DC.) Korth. | 0.00 | 0.00 | 27.78 | 0.00 | 0.00 | 27.78 | 0.00 | 0.00 | 7.94 | 0.00 | 0.00 | 1.23 |
| 15 | *Semecarpus anacardium* L.f. | 48.89 | 70.00 | 22.22 | 153.33 | 166.67 | 50.00 | 10.19 | 13.55 | 6.35 | 6.11 | 6.10 | 2.22 |
| 16 | *Shorea robusta* Gaertn. | 97.78 | 100.00 | 100.00 | 1073.33 | 1273.33 | 1150.00 | 20.37 | 19.35 | 28.57 | 42.78 | 46.59 | 51.11 |
| 17 | *Syzygium cumini* (L.) Skeels | 2.22 | 3.33 | 0.00 | 4.44 | 6.67 | 0.00 | 0.46 | 0.65 | 0.00 | 0.18 | 0.24 | 0.00 |
| 18 | *Terminalia alata* Heyne ex Roth | 84.44 | 83.33 | 88.89 | 417.78 | 216.67 | 661.11 | 17.59 | 16.13 | 25.40 | 16.65 | 7.93 | 29.38 |
| 19 | *Terminalia bellirica* (Gaertn.) Roxb. | 2.22 | 16.67 | 0.00 | 2.22 | 30.00 | 0.00 | 0.46 | 3.23 | 0.00 | 0.09 | 1.10 | 0.00 |
| 20 | *Terminalia chebula* Retz. | 2.22 | 3.33 | 0.00 | 2.22 | 3.33 | 0.00 | 0.46 | 0.65 | 0.00 | 0.09 | 0.12 | 0.00 |
| 21 | *Thespesia lampas* (Cav.) Dalzell & Gibson | 8.89 | 0.00 | 0.00 | 44.44 | 0.00 | 0.00 | 1.85 | 0.00 | 0.00 | 1.77 | 0.00 | 0.00 |
| 22 | *Woodfordia fruticosa* (L.) Kurz | 17.78 | 13.33 | 0.00 | 71.11 | 36.67 | 0.00 | 3.70 | 2.58 | 0.00 | 2.83 | 1.34 | 0.00 |
| 23 | Unknown 3 | 0.00 | 0.00 | 11.11 | 0.00 | 0.00 | 66.67 | 0.00 | 0.00 | 3.17 | 0.00 | 0.00 | 2.96 |
| 24 | Unknown 4 (Asare) | 4.44 | 26.67 | 0.00 | 13.33 | 196.67 | 0.00 | 0.93 | 5.16 | 0.00 | 0.53 | 7.20 | 0.00 |

KCF = Khulkhule Community Forest ; ACF = Arghachhap Community Forest; HCF = Hattikot Community Forest

## b. Frequency and density of herbs and tree seedlings in three community forests.

| S. No. | Scientific Name | Frequency (%) | | | Density ($ha^{-1}$) | | | Relative frequency (%) | | | Relative density (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | KCF | ACF | HCF | KCF | ACF | HCF | KCF | ACF | HCF | KCF | ACF | HCF |
| 1 | *Ageratum conyzoides* L. | 4.44 | 5.00 | 0.00 | 944.44 | 1250.00 | 0.00 | 1.37 | 1.50 | 0.00 | 1.46 | 1.58 | 0.00 |
| 2 | *Antidesma bunius* (L.) Spreng. | 0.00 | 0.83 | 1.39 | 0.00 | 83.33 | 138.89 | 0.00 | 0.25 | 0.44 | 0.00 | 0.11 | 0.23 |
| 3 | *Asparagus officinalis* L. | 2.22 | 0.00 | 0.00 | 277.78 | 0.00 | 0.00 | 0.69 | 0.00 | 0.00 | 0.43 | 0.00 | 0.00 |
| 4 | *Bauhinia purpurea* L. | 0.56 | 0.00 | 0.00 | 55.56 | 0.00 | 0.00 | 0.17 | 0.00 | 0.00 | 0.09 | 0.00 | 0.00 |
| 5 | *Bauhinia vahlii* Wight & Arn. | 15.00 | 12.50 | 1.39 | 1833.33 | 1666.67 | 138.89 | 4.64 | 3.74 | 0.44 | 2.83 | 2.11 | 0.23 |
| 6 | *Begonia* sp. | 0.00 | 0.00 | 13.89 | 0.00 | 0.00 | 1666.67 | 0.00 | 0.00 | 4.39 | 0.00 | 0.00 | 2.76 |
| 7 | *Bidens biternata* (Lour.) Merr. & Sherff | 0.00 | 1.67 | 0.00 | 0.00 | 416.67 | 0.00 | 0.00 | 0.50 | 0.00 | 0.00 | 0.53 | 0.00 |
| 8 | *Cheilanthes anceps* Blanford | 14.44 | 43.33 | 73.61 | 3444.44 | 13583.33 | 17638.89 | 4.47 | 12.97 | 23.25 | 5.31 | 17.19 | 29.20 |
| 9 | *Colebrookea oppositifolia* Sm. | 5.00 | 5.83 | 0.00 | 1222.22 | 1333.33 | 0.00 | 1.55 | 1.75 | 0.00 | 1.88 | 1.69 | 0.00 |
| 10 | *Curculigo orchioides* Gaertn. | 13.89 | 15.00 | 11.11 | 3388.89 | 2666.67 | 1250.00 | 4.30 | 4.49 | 3.51 | 5.22 | 3.38 | 2.07 |
| 11 | *Cyperus rotundus* L. | 0.00 | 2.50 | 0.00 | 0.00 | 416.67 | 0.00 | 0.00 | 0.75 | 0.00 | 0.00 | 0.53 | 0.00 |
| 12 | *Cyperus* sp. | 1.67 | 0.00 | 0.00 | 444.44 | 0.00 | 0.00 | 0.52 | 0.00 | 0.00 | 0.68 | 0.00 | 0.00 |
| 13 | *Dioscorea bulbifera* L. | 1.67 | 4.17 | 0.00 | 277.78 | 583.33 | 0.00 | 0.52 | 1.25 | 0.00 | 0.43 | 0.74 | 0.00 |
| 14 | *Dryopteris* sp. | 8.33 | 18.33 | 15.28 | 2000.00 | 4833.33 | 3333.33 | 2.58 | 5.49 | 4.82 | 3.08 | 6.12 | 5.52 |
| 15 | *Eichhornia crassipes* (Mart.) Solms | 0.00 | 2.50 | 0.00 | 0.00 | 583.33 | 0.00 | 0.00 | 0.75 | 0.00 | 0.00 | 0.74 | 0.00 |
| 16 | *Eupatorium* sp. | 39.44 | 12.50 | 0.00 | 10111.11 | 2666.67 | 0.00 | 12.20 | 3.74 | 0.00 | 15.58 | 3.38 | 0.00 |
| 17 | *Lagerstroemia parviflora* Roxb. | 0.00 | 2.50 | 9.72 | 0.00 | 416.67 | 972.22 | 0.00 | 0.75 | 3.07 | 0.00 | 0.53 | 1.61 |
| 18 | *Lygodium japonicum* (Thumb.) Sw. | 3.33 | 0.83 | 0.00 | 555.56 | 83.33 | 0.00 | 1.03 | 0.25 | 0.00 | 0.86 | 0.11 | 0.00 |
| 19 | *Mallotus philippensis* (Lam.) Mull. | 7.22 | 0.83 | 2.78 | 1000.00 | 83.33 | 555.56 | 2.23 | 0.25 | 0.88 | 1.54 | 0.11 | 0.92 |
| 20 | *Mangifera indica* L. | 0.00 | 0.00 | 2.78 | 0.00 | 0.00 | 277.78 | 0.00 | 0.00 | 0.88 | 0.00 | 0.00 | 0.46 |
| 21 | *Melastoma melabathricum* L. | 0.00 | 0.00 | 15.28 | 0.00 | 0.00 | 3194.44 | 0.00 | 0.00 | 4.82 | 0.00 | 0.00 | 5.29 |
| 22 | *Musa balbisiana* Colla | 0.56 | 0.00 | 0.00 | 55.56 | 0.00 | 0.00 | 0.17 | 0.00 | 0.00 | 0.09 | 0.00 | 0.00 |
| 23 | *Phoenix humilis* Royle ex Becc. & Hook. f. | 16.67 | 14.17 | 0.00 | 2722.22 | 2666.67 | 0.00 | 5.16 | 4.24 | 0.00 | 4.20 | 3.38 | 0.00 |
| 24 | *Phyllanthus emblica* L. | 3.89 | 0.00 | 0.00 | 444.44 | 0.00 | 0.00 | 1.20 | 0.00 | 0.00 | 0.68 | 0.00 | 0.00 |
| 25 | *Pogostemon benghalensis* (Burm. f.) Kuntze | 6.67 | 17.50 | 0.00 | 1444.44 | 3916.67 | 0.00 | 2.06 | 5.24 | 0.00 | 2.23 | 4.96 | 0.00 |
| 26 | *Schima wallichii* (DC.) Korth. | 0.00 | 0.00 | 1.39 | 0.00 | 0.00 | 138.89 | 0.00 | 0.00 | 0.44 | 0.00 | 0.00 | 0.23 |

| S. No. | Scientific Name | Frequency (%) | | | Density ($ha^{-1}$) | | | Relative frequency (%) | | | Relative density (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | KCF | ACF | HCF | KCF | ACF | HCF | KCF | ACF | HCF | KCF | ACF | HCF |
| 27 | *Semecarpus anacardium* L.f. | 6.11 | 2.50 | 0.00 | 722.22 | 416.67 | 0.00 | 1.89 | 0.75 | 0.00 | 1.11 | 0.53 | 0.00 |
| 28 | *Shorea robusta* Gaertn. | 67.78 | 81.67 | 77.78 | 13000.00 | 24000.00 | 15555.56 | 20.96 | 24.44 | 24.56 | 20.03 | 30.38 | 25.75 |
| 29 | *Terminalia alata* Heyne ex Roth | 25.00 | 17.50 | 48.61 | 3666.67 | 2916.67 | 6944.44 | 7.73 | 5.24 | 15.35 | 5.65 | 3.69 | 11.49 |
| 30 | *Themeda triandra* Forssk. | 14.44 | 0.00 | 0.00 | 3833.33 | 0.00 | 0.00 | 4.47 | 0.00 | 0.00 | 5.91 | 0.00 | 0.00 |
| 31 | *Thespesia lampas* (Cav.) Dalzell & Gibson | 6.11 | 0.00 | 0.00 | 944.44 | 0.00 | 0.00 | 1.89 | 0.00 | 0.00 | 1.46 | 0.00 | 0.00 |
| 32 | *Woodfordia fruticosa* (L.) Kurz | 5.56 | 1.67 | 1.39 | 777.78 | 166.67 | 138.89 | 1.72 | 0.50 | 0.44 | 1.20 | 0.21 | 0.23 |
| 33 | Unknown 1 | 0.00 | 0.83 | 0.00 | 0.00 | 83.33 | 0.00 | 0.00 | 0.25 | 0.00 | 0.00 | 0.11 | 0.00 |
| 34 | Unknown 2 | 0.00 | 0.83 | 0.00 | 0.00 | 83.33 | 0.00 | 0.00 | 0.25 | 0.00 | 0.00 | 0.11 | 0.00 |
| 35 | Unknown 4 (Asare) | 6.67 | 9.17 | 0.00 | 1333.33 | 1583.33 | 0.00 | 2.06 | 2.74 | 0.00 | 2.05 | 2.00 | 0.00 |
| 36 | Unknown 8 (Golaino) | 46.11 | 54.17 | 40.28 | 10277.78 | 11250.00 | 8472.22 | 14.26 | 16.21 | 12.72 | 15.84 | 14.24 | 14.02 |
| 37 | Unknown 9 (Gramineae) | 0.56 | 5.83 | 0.00 | 111.11 | 1250.00 | 0.00 | 0.17 | 1.75 | 0.00 | 0.17 | 1.58 | 0.00 |

# APPENDIX 5

## Abbreviated forms of woody species as shown in Fig. 4.5 b.

| S. No. | Name of Species | Abbreviated form |
|---|---|---|
| 1 | *Adina cordifolia* (Willd. ex Roxb.) Benth. & Hook. f. ex Brandis | Adicord |
| 2 | *Bauhinia vahlii* Wight & Arn. | Bauva |
| 3 | *Cinnamomum tamala* (Buch.-Ham.) Nees & Eberm. | Cinta |
| 4 | *Colebrookea oppositifolia* Sm. | Colop |
| 6 | *Ficus hispida* L. f. | Fichis |
| 7 | *Ficus semicordata* Buch.-Ham. ex Sm. | Ficse |
| 8 | *Homalium napaulense* (DC.) Benth. | Homne |
| 9 | *Lagerstroemia parviflora* Roxb. | Lagpa |
| 10 | *Mallotus philippensis* (Lam.) Mull. | Malph |
| 11 | *Marsdenia tinctoria* R. Br. | Marti |
| 12 | *Melastoma melabathricum* L. | Melme |
| 14 | *Phoenix humilis* Royle ex Becc. & Hook. f. | Phohum |
| 15 | *Phyllanthus emblica* L. | Phyem |
| 16 | *Schima wallichii* (DC.) Korth. | Schwa |
| 17 | *Semecarpus anacardium* L.f. | Semana |
| 18 | *Shorea robusta* Gaertn. | Shoro |
| 19 | *Syzygium cumini* (L.) Skeels | Syzcu |
| 20 | *Terminalia alata* Heyne ex Roth | Teral |
| 21 | *Terminalia bellirica* (Gaertn.) Roxb. | Terbe |
| 22 | *Terminalia chebula* Retz. | Terch |
| 23 | *Thespesia lampas* (Cav.) Dalzell & Gibson | Thela |
| 24 | *Woodfordia fruticosa* (L.) Kurz | Woodfr |
| 25 | Unknown 3 | Unk C |
| 26 | Unknown 4 | Unk D |

# APPENDIX 6

## Terminologies used in describing medicinal uses of plants

| S. No. | English/Medicinal | Romanized Nepali | S. No. | English/Medicinal | Romanized Nepali |
|---|---|---|---|---|---|
| 1 | Anaemia | Rakta alpata | 38 | Insect bites | Kirale toknu |
| 2 | Angina | Ghantima ghau aaunu | 39 | Insomnia | Nidra naparnu |
| 3 | Anorexia | Bhok nalagnu | 40 | Jaundice | Pyale |
| 4 | Asthma | Dhamki , Dam | 41 | Kill lice | Jumra marnu |
| 5 | Back bone pain | Dhad dukhnu | 42 | Knee pain | Ghunda dukhnu |
| 6 | Bile juice problem | Pitta ras samasya | 43 | Loss of enamel of tooth | Datko rang janu |
| 7 | Body pain | Jiu dukhnu | 44 | Marasmus | Sukenas |
| 8 | Boils | Pilo, Khatira | 45 | Measles | Dadura |
| 9 | Brain tumour | Brain tumour | 46 | Menstruation disorder | Mainawari bigranu |
| 10 | Breast engorged | Thunilo | 47 | Mud wound | Hilole khutta khanu |
| 11 | Burn | Polnu | 48 | Otitismedia | Kan pakeko |
| 12 | Burning sensation of chilli | Khursani piro gadeko | 49 | Pimples | Dandifore |
| 13 | Cataract | Aakhama phula parnu | 50 | Psycho disorder | Sato janu |
| 14 | Cojunctivitis | Aankha paknu | 51 | Retention of placenta | Sal najharne |
| 15 | Cold | Sardi | 52 | Retention of urine | Pisab nahunu |
| 16 | Cold and hot | Sardi Garmi | 53 | Ring worm | Dad |
| 17 | Cooling agent | Chiso garauna | 54 | Running nose | Rugha |
| 18 | Cough | Khoki | 55 | Scabies | Luto |
| 19 | Cracked foot | Khutta phutnu | 56 | Sexual desire | Youn bardak |
| 20 | Cracks | Phuteko | 57 | Sickness of domestic animal | Bastu birami hunu |
| 21 | Cut | Katnu | 58 | Sinusitis | Pinas |
| 22 | Diabetes | Chini rog | 59 | Snake bites | Sarpale toknu |
| 23 | Diarrhoea | Pakhala lagnu | 60 | Sprain | Sarke markeko |
| 24 | Dumbness | Lato hunu | 61 | Stomach pain | Pet dukhnu |
| 25 | Dysentery | Ragatmasi | 62 | Stomach swelling | Pet dhadinu |
| 26 | Extreme bleeding (woman) | Dherai ragat aaunu | 63 | Stomatitis | Jibroma khatira aaunu |
| 27 | Eye defect | Aankha kamjor hunu | 64 | Throat pain | Ghanti dukhnu |
| 28 | Fever | Khadjuro, jwaro | 65 | Toothache | Dat dukhnu |
| 29 | Fracture | Bhachinu | 66 | Tuberculosis | Kshyarog |
| 30 | Gastritis | Gano, bayu gola, pet dhadinu | 67 | Tumour formation | Masu palaunu |
| 31 | Gingivitis | Harsa | 68 | Typhoid | Gadeko jwaro, kukhat |
| 32 | Gonorrhoea | Dhatu rog | 69 | Urinary problem | Pisabma samasya aaunu |
| 33 | Headache | Tauko dukhnu | 70 | Uterus prolapse | Aang khasnu |
| 34 | Hen's sickness | Kukhura birami hunu | 71 | Waist pain | Kammar dukhnu |
| 35 | Increase blood level | Ragat badaunu | 72 | Worm infestation | Churna, juka parnu, mate |
| 36 | Indigestion | Apach, tus | 73 | Wound | Ghau |
| 37 | Infertility | Bachcha nahunu | | | |

# PHOTO PLATE 1

*Bauhinia vahlii* Wight & Arn.

*Bauhinia purpurea* L.

*Begonia* sp.

*Colebrookea oppositifolia* Sm.

*Curculigo orchioides* Gaertn.

*Cuscuta reflexa* Roxb.

## PHOTO PLATE 2

*Datura metel* L.

*Ficus hispida* L. f.

*Lygodium japonicum* (Thumb.) Sw.

*Mallotus philippensis* (Lam.) Mull.

*Mimosa pudica* L.

*Mukia maderaspatana* (L.) Roem.

## PHOTO PLATE 3

*Phoenix humilis* Royle ex Becc. & Hook. f.

*Phyllanthus emblica* L.

*Plumeria rubra* L.

*Semecarpus anacardium* L.f.

*Senna occidentalis* (L.) Link

*Solanum nigrum* L.

# PHOTO PLATE 4

*Thespesia lampas* (Cav.) Dalzell & Gibson

*Zizyphus mauritiana* Lam.

Siddhartha Highway passing through study area

Community Forest User Groups of KCF in a meeting

Researcher with local Brahman people

Researcher with local Magar people