Diversity of Medicinal Plant Species along Subalpine-Nival Gradient in Nyeshang Valley, Manang, Nepal

A Dissertation Submitted for Partial Fulfillment of the Requirements for the Master's Degree in Science, Central Department of Botany, Tribhuvan University, Kirtipur

Submitted by:

Smriti Lo

Plant Systematics and Biodiversity Unit

Exam Roll No.: 6272

T.U. Regd. No.: 5-2-3-1471-2005

Central Department of Botany

Tribhuvan University

Kathmandu, Nepal

Batch: 2009/2011

TRIBHUVAN UIVERSITY

INSTITUTE OF SCIENCE AND TECHNOLOGY

CENTRAL DEPARTMENT OF BOTANY

RECOMMENDATION

This is to certify Ms. Smriti Lo, a M.Sc Botany final year student at Tribhuvan University, Institute of Science and Technology, Kirtipur, Kathmandu has carried out research work entitled "**Diversity of Medicinal Plant Species along Sub-alpine Nival Gradient in Nyeshang valley, Manang, Nepal** under our supervision. This entire work has been accomplished on the basis of candidate's original research work under the GLORIA Nepal collaborative project of Central Department of Botany, TU and Missouri Botanical Garden, USA in the field of ethnobotany and biodiversity. To the best of my knowledge, the results of this work have not been submitted to any other academic degree.

It is hereby recommended for acceptance of this dissertation as a partial fulfillment of the requirement of Master's Degree in Botany at Institute of Science and Technology, Tribhuvan University.

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(Supervisor)

Suresh Kumar Ghimire, Ph.D.

Associate Professor

Central Department of Botany

Tribhuvan University, Nepal

Date: 24th March 2016

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LETTER OF APPROVAL

The M.Sc. dissertation entitled **"Diversity of Medicinal Plant Species along Sub-alpine Nival Gradient in Nyeshang valley, Manang, Nepal"** submitted by Ms. Smriti Lo has been accepted as partial fulfillment of the requirement of Master's Degree in Botany (Plant Systematics and Biodiversity).

EXPERT COMMITTEE

………………………………………

(Supervisor)
Suresh Kumar Ghimire, Ph. D
Associate Professor
Central Department of Botany
Tribhuvan University, Kathmandu

…………………………..

(Head of Department)
Mohan Siwakoti, Ph. D
Professor
Central Department of Botany
Tribhuvan University, Kathmandu

………………………………

(External Examiner)
Sheetal Vaidhya, Ph. D
Associate Professor
Tribhuvan University, Nepal

……………………………………

(Internal Examiner)
Bharat Babu Shrestha, Ph. D
Associate Professor
Central Department of Botany
Tribhuvan University, Kathmandu

Date: 11th April 2016

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Smriti Lo

ABBREVIATIONS AND ACRONYMS

ACA	Annapurna Conservation Area
asl	above sea level
CBS	Central Bureau of Statistics
CDB	Central Department of Botany
DMP	Department of Plant Resources
DNPWC	Department of National Park and Wildlife Conservation
DPR	Department of Plant Resources
ESON	Ethnobotanical Society of Nepal
et al.	and others
GLORIA	Global Observation Research Initiative in alpine Environment
ICIMOD	International Center for Integrated Mountain Development
IUCN	International Union for Nature Conservation
KATH	National Herbarium and Plant Laboratories, Kathmandu
m	metre
mm	millimeter
MO	Missouri Botanical Garden Herbarium
ppm	parts per million
sp.	species (singular=sp. and plural=spp.)
TUCH	Tribhuvan University Central Herbarium
VDC	Village Develpoment Committee
HSP	highest summit point
SAS	summit area section

ABSTRACT

This study examines the ethnomedicinally important plants extracted from the vulnerable sub nival zone in the Nyeshang Valley, Manang, Central Himalaya, Nepal. A list of medicinal plant species in Nyeshang valley was prepared through empirical ethnobotanical study and literature review. An ecological sampling was done along the subalpine- nival gradient by following the standard methodology of Global Research Initiative in Alpine Environments (GLORIA). Four mountain summits (SMA,SMB, SMC and SMD) were investigated along an elevation gradient of 4150-5005m asl (above sea level). Two measures of species diversity i.e. α and γ for both the overall plants and medicinal plants at all scales of measurement decreased along the elevation gradient with major influence of elevation, aspect and substrate type. However, the proportion of medicinal plant species remains almost similar among four elevation levels (summits). This implies that high altitude habitats provide unique sets of environment for the growth of diverse medicinal plant species. Therefore, landscape-level heterogeneity should be maintained for the preservation of medicinal plant species in the Himalaya.

The local inhabitants are highly knowledgeable but not as compared to their ancestors and dependent upon plant resources for their livelihood. A total of 97 plant species were found to have medicinal value on the basis of empirical ethnobotanical study and literature review. Out of this only 58 species were recorded as medicinal by local inhabitants and *Amchi* and the rest 39 species were found to have their use elsewhere in the country. Present study added 17 medicinally important species to the list of the Nyeshang valley and Jomsom valley as well as to the country. Intensity of utilization of local plant resources differed at different habitats, with more pressure towards the lower alpine region. Life form analysis revealed that the study area was characterized by harsh environmental climate with majority of taxa belonging to forbs. Himalayan mountain summits possess potential species with high local medicinal value. Therefore, management should be considered on landscape approach integrating different mountain summits, associated species and indigenous knowledge.

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CHAPTER ONE: INTRODUCTION

1.1 Background

1.1.1 Biological Diversity Resources

Biodiversity generally refers to the variation of life at all levels of biological organization (Gaston 2000). It is not evenly distributed, rather it varies greatly across the globe as well as within regions. The diversity of all things (biota) depends on temperature, precipitation, altitude, soil, geography and other existing species. At local, national and global levels, the products and services derived from biodiversity is highly diverse (Daily 1997; Salick *et al.* 1999). People are highly relied on the forest products for consumption, medication and narcotic stimulation such as fodder, timber and fuel, in rituals and other purposes. These products are also traded to supplement their household income (Shackleton and Shackleton 2004). Biodiversity being one of the major sources of natural resources helps them to sustain their life on one hand and at the same time maintains the ecosystem integrity (Daily 1997). Beside these, biodiversity also provides ecological services that regulate the earth's atmospheric, climatic, biogeochemical and hydrological cycles (Kunin and Lawton 1996).

Nepal is endowed with very high biodiversity due to varied climatic, physiographic condition, and presence of a great variety of ecosystems and habitats (Manadhar 1995, 2002). Due to its uniqueness in geophysical attributes and subsequent climatic variation, it has been recognized as biodiversity hotspot (Chaudhary 1998). It incorporates Palaearctic and Indo-Malayan biogeographic regions and major floristics of Asia, creating a unique and rich biodiversity. Although comprising only 0.09% of global land area, Nepal possesses a large diversity of flora at genetic, species and ecosystem levels (NBS 2002). More than 90% of the Nepalese people live in the interface between farmland and forest and are dependent on natural resources for their basic needs. In particular, people of the Himalayan areas are dependent on a combination of forest products, livestock and agricultural products for their sustainable livelihood (Manadhar 1995, 2002). Himalayan plant diversity is higher than the global average (Körner 1999; Vare *et.al.* 2003). However, biodiversity of the country is highly threatened due to environmentally destructive and exploitative practices. To overcome this threaten, scientific understanding of the resources and their ecological status must be upgraded. Moreover, systematic documentation of the associated indigenous knowledge prevailed within the society is necessitance.

1.1.2 Ethnobotany

The use of plants and its product as medicine has been one of the most important sources since the dawn of human civilization. Archaeological evidences of 60,000 year old Neanderthal burial grounds in Shanidar, Iraq, pointed the uses of plants like Marshmallow and Groundsel, which are still used in contemporary folk medicine (Lietava 1992). Concurrently, the earliest written record of plants used as medicine originating from the Himalayas are found in the 6,500 years old text of *Rigveda* followed by *Atharveveda*, *Aayurveda* (the foundation of science of life and art of healing of the Hindu culture) that describes the medicinal importance of 1,200 plants. Not only this, they enumerated the art of surgery, therapeutics and medicine in detail (Malla and Shakya 1984; Lewington 1990; Nambier 2002).

The term Ethnobotany was first coined by an American Botanist J.W. Harshberger in 1896 as the study of plants used by primitive and aboriginal people. Later the term was redefined and broadened by many scientists. Since then, the interest in this field has been growing and is now considered as multidisciplinary science of applied botany. Martin (1995) a renowned ethnobotanist and conservationist has critically analyzed and fully broadened this discipline in his book "Ethnobotany- a method manual". Ethnobotany is a multi-disciplinary science comprising many aspects of plant science, history, culture, anthropology, botany, ecology, literature etc. that deals with the documentation of traditional knowledge of the use of plants by indigenous people. It finds out the interaction of human with plants and this ecosystem. In fact, it plays a vital role in development of agriculture, pharmaceuticals industries, biostatistics, environment and conservation of biodiversity.

In Nepal, the published work of Banerji (1955) commenced milestone for the study of ethnobotany which deals with the medicine and some edible plants from East Nepal. Since than many scientist have covered different topics, focusing on ethnic caste group and geographical area (Pandey 1964; Adhikari and Shakya 1977; Manandhar 1980, 1985, 1986, 1990, 2002; Malla and Shakya 1984; Shrestha and Pradhan 1986; Shrestha *et al.* 1998; Shakya *et al.* 1999; Ghimire *et al.* 2000; IUCN 2000; Rajbhandari 2001; Mahato and Chaudhary 2005; Ghimire *et al.* 2008) unveiling knowledge regarding the use of diverse plant species. Likewise, a number of institutions are involved in ethnobotanical work including CDB (TU), DPR, ESON, WWF Nepal, ICIMOD etc. Chaudhary (1989) presented information about the medicinal plants and traditional medicine practices in Nepalese context and emphasized the scope of medicinal plants and its importance which fills up the gap of knowledge of the existing plant wealth and uplifts the economy of the country. If ethnobotanical studies are done regularly in different regions among tribes, most valuable plants can be identified and preserved for future. This empirical knowledge is accumulated either by self-experience or handed down over generation. In this way, indigenous knowledge regarding the use of plant resources is deeply rooted in the tradition and culture of Nepalese people.

Over 20,000 species of medicinal plants from the world and about 80% of the total human population depend upon traditional system of medicine as per listed by World Health Organization (WHO) . Adhikari and Shakya (1977) listed 217 species of MAPs of Nepal and studied pharmacological screening of some medicinal plants having traditional use. Shrestha et al. (2002) reported more than 2,000 plant species from Nepal having ethnobotanical values, out of which 1,600 were used as basic raw materials for medicinal practices in the country. A tentative list of alpine flora of Nepal Himalaya consist of 1227 species in 317 genera (Obha 1988) including 114 and 45 medicinal plants respectively from sub-alpine and alpine zones (Malla *et al. 1*984).

In Hills and Himalayan tribe of remote areas in Nepal, wild plants are used as a means of combating diseases as well as to meet daily requirements for subsistence. Despite of such vital values due to various social, ecological and economic factors, the indigenous knowledge is under threat. Likewise, plant resources of the study area are also highly threatened due to various human activities. To overcome these threaten, conservation of natural resources and preservation of indigenous knowledge is necessitance (Devkota 2003). However due to changing life, perception and lifestyle changes of the forest dwellers, as well as commercialization and socio-economic transformation on a global scale, there is a general observation that the plants are exacerbated and that indigenous knowledge on resource use is being degraded severely (Gadgil 1993, Silori 2000).

Unfortunately, at this era indigenous knowledge is under threat as traditional cultures are being eroded. Ethnobotanist plays an important role in conserving threatened knowledge and returning it back to the local residents. This way, indigenous knowledge can be conserved as part of living cultural-ecological system, helping to maintain a sense of pride in local cultural knowledge and practices, and reinforcing links between communities and environment.

(Cunningham 2001) The present study aims at highlighting the ethnomedicinal uses of plant resources of the Himalayan regions, their recent status and possible threats to their use.

1.1.3 Useful plant species diversity and their distribution

Breathtaking topography in the Himalaya, not only provides drastic gradient in elevation but also steep transaction in temperature, precipitation and natural habitats (Konchar *et al.* 2015). These are the major factors for the diversity patterns of species in the Himalayas because it provides different measures of resources such as water, heat and land area (Barry 1992; Körner 2000). Variation in species richness along elevation gradient has been known for over a century (Wallace 1878; Pianka 1966; Lomolino 2001). Several studies have found that species diversity tends to decrease with increasing elevation (Yoda 1967; Stevens 1992; Brown and Lomolino 1998; Körner 2002), whereas others have found a unimodal (hump shaped) relationship between species richness and elevation (Rahbek 1995, 2005; Odland and Birks 1999; Grytnes and Vetaas 2002; Bhattarai and Vetaas 2003; Carpenter 2005; Baniya *et al* 2010; Rokaya *et al*. 2012).

In Nepal, some researchers interpolated the previous findings and conducted work in relation to elevation and useful plants are reported unimodal pattern (Bhattarai and Ghimire 2006; Ghimire 2008; Baniya *et al.* 2010; Rokaya *et al.* 2012). Ghimire *et al.* (2006) while conducting empirical study in Dolpo, found an significant unimodal (hump shaped) pattern for species richness of both rare and CTMP (commercially threatened medicinal plant) species along elevation gradient and reported richer plant species in sub alpine meadows than alpine meadows. Studies in the Eastern Himalayas have confirmed that the highest plant diversity and richness is found in Alpine environment between 4200 and 4500m (Salick *et al*. 2004). Furthermore, useful plants are most frequent in Alpine meadows.

Alpine region being biodiversity hotspot are inhabitated by substantial number of endemic species (Körner 2003). Vegetation in typical alpine region consists of grasses, sedges, herbaceous perennials, woody shrubs, lichen etc. In alpine ecosystem, geographical isolation, tectonic lift, glaciation, climatic changes, strong micro habitat differentiation and a varied history of migration and/or evolution led to a high degree of taxonomic richness (Körner 2003). About 1.5% of total species (25 species) have been reported to be endemic to Nepal Himalaya. The Himalayan region shows the highest richness for endemic species and medicinal herbs (Kunwar *et al.* 2003). Most of these endemic species have small population size, narrow distribution range and high habitat specificity (Shrestha and Joshi 1996; Ghimire *et al.* 2006). Himalayan ranges, where large number of endemic species are distributed, are likely to suffer critical species loss **(**Theurillat and Guisan 2001; Halloy and Mark 2003; Pauli *et al.* 2003; Pickering and Armstrong 2003**)** due to various anthropogenic disturbance.

The perception and relative importance of useful plants is co-related to cultural factors such as human behaviours, social and economic constraints etc. (Pelto *et al.* 1989). The plant use pattern by human communities may depend on environmental constraints. For example: the use pattern can be related to local species richness or to the regional abundance of some useful plants. Studies carried out throughout the world shows that both the distribution of the knowledge of useful plant is not uniform with in population and that the pattern can also be better understood when cultural, historical, and environmental factors are considered (Benz *et al.* 2000; Hanazaki *et al.* 2000; Ladio 2001; Ladio and Lozado 2003, 2004; Arango Caro 2004; Pfeiffer and Butz 2005). Majority of the studies till date have focused on systematic documentation of useful plants but there is lack of quantitative studies on their distribution, specially within protected areas. Thus the study of relationship between species richness and elevation is important for conservation and management of species diversity (Grytnes 2003). Due to lack of detailed knowledge about distribution pattern of species and ecosystem, may lead to problem in conserving species (Hunter and Yonzon 1993).

Generally, species diversity tends to decrease with elevation gradient, but unimodal (hump shaped) pattern is highly dominant pattern along the elevation gradient. Thus, to find out the relation of plant species under different use categories with the elevation gradient, we forwarded the following objectives:

1.2 Objectives

- To document medicinally important plant species and their use in Nyeshang valley, Manang, Central Nepal.
- To study the diversity of medicinal plant species along elevation gradient.
- To analyse distribution pattern of medicinal species in relation with different environmental variables.

CHAPTER TWO: MATERIALS AND METHODS

2.1 Study Area

2.1.1 Physiography

The study was conducted in north-eastern part of Nyeshang valley in Manang district, within Annapurna Conservation Area, Nepal. The valley stretches between 28˚40ˈN latitude and 84˚01ˈE longitude with an elevation gradient of 3000m to 7555m above sea level (asl) in the Trans-Himalayan region between the Himalayan range and the Tibetean Plateau. It is a U-shaped valley extended from north-west to south-east, along the Marsyangdi river. Manang district which includes Manang and several other villages, is one of the least populated district of Nepal with a total population of 6,422 and a population density of 3 inhabitants/ km^2 (CBS 2012).

2.1.2 Climate

Manang district lies in the Central Himalaya, surrounded by Annapurna, Lamjung and Manaslu mountain series. Compared to other hilly areas of Nepal, the area is characterized by low annual precipitation (<400mm) (Bhattarai *et al.* 2004).

The mean maximum/minimum temperature recorded (Chame and Jomsom, nearest meterological station) are 16.73˚C and 17.01˚C/ 4.8˚C and 5.48˚C, and average annual precipitation of 948.73mm and 269.37mm in Chame and Jomsom respectively. Highest precipitation of 1053.8mm and 182mm in Chame and Jomsom station was recorded during monsoon season (Joshi 2013). Here snowfall is common during winter season.

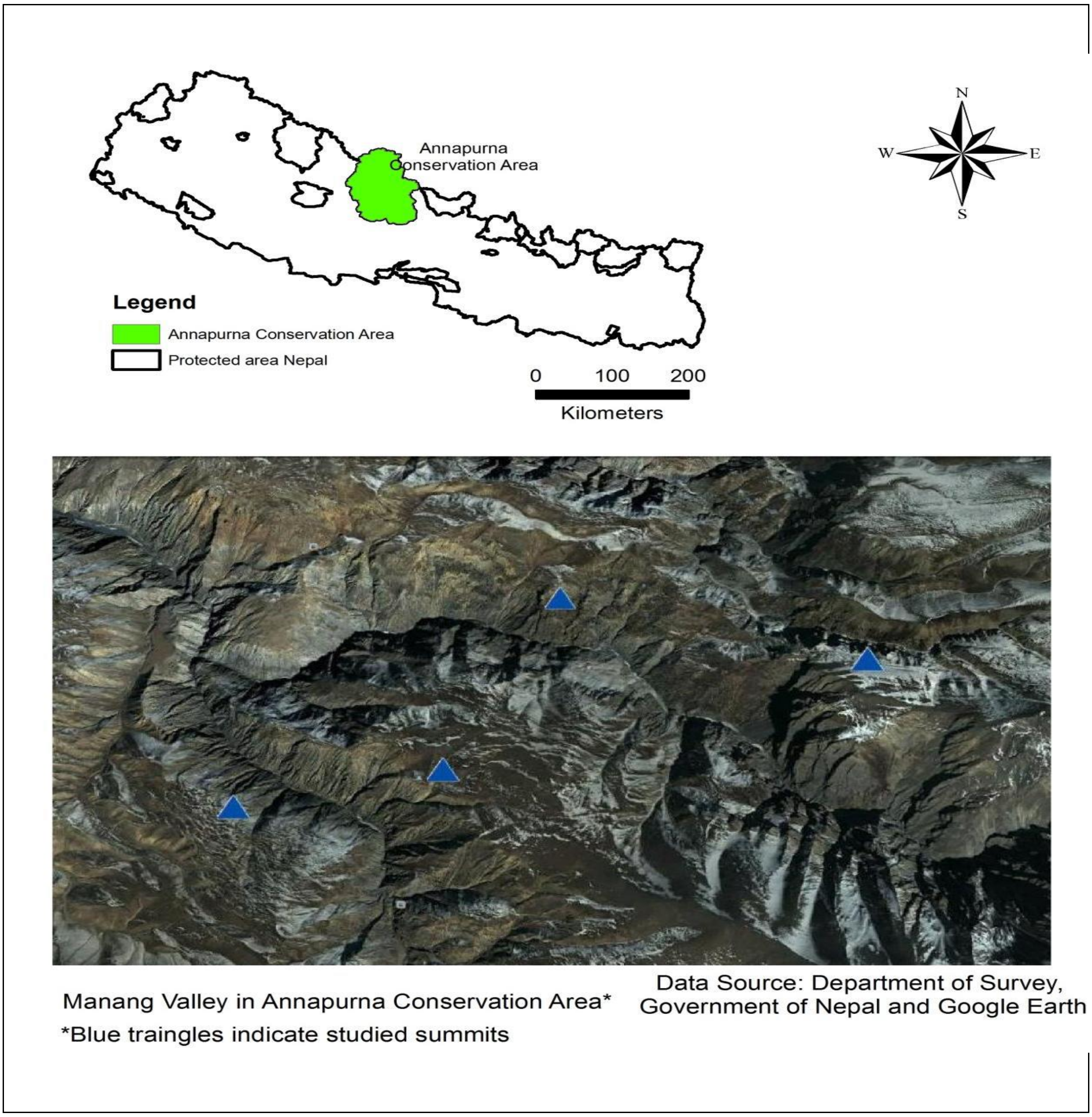


Fig 1. GIS map of the study area (map based on Arc GIS 9.3 and Google earth). Source: Joshi (2013)

2.1.3 Ethnicity

The inhabitants of the study area are known as “Nyeshanpa”, “Manangpa” or, more popularly known as “Manangi”. Manang district is one of the least populated districts of Nepal with 6538 people, 1480 households, a population density of three people per square kilometre (Gurung 1976; CBS 2012). In terms of number, the Nyeshang valley represents the largest ethnic group within Manang district comprising of approximately 3,500 residents. They are of Tibetan origin, speak Tibeto-Burman language closely related to Gurung, Tamang and Thakali. Majority of them practice Buddhism and their language, lifestyle, food habit, custom and culture resemble to those of Tibetans (Bhattarai *et al.* 2006).

2.1.4. Socio-economy

Local economy is based on traditional agriculture, animal husbandry, trade of non-timber forest products (mainly medicinal and aromatic plants) and tourism. Due to its extreme remoteness, the Manangi were given special privileges in 1789 and are well-known long distance traders throughout South-East Asia. Manang remains as an important centre of trade from Tibet via nearly high mountain passes (Konchar *et al.* 2015).

Traditionally, they grow wheat, barley and buckwheat during the summer season on limited arable land along the valley bottom. The cultivated crops are dependent on traditional practices of manuring for soil amendment as well as on irrigation from nearby glaciers and snowmelt water (Chaudhary *et al.* 2007; Aase *et al.* 2009). Land which are not suitable for agriculture are utilized for grazing and collection of fuel wood, fodder and Non- Timber Forest Products (Bhattarai *et al.* 2006; Salick *et al.* 2014). Globalization has significantly affected the livelihood of resident in Nyeshang valley. Large scale out-migration of village residents to the major cities in Nepal and start of tourism activities has significantly affected the livelihood of Nyeshanpa. However, the traditional agricultural practices contribute significantly in sustaining livelihood (Subedi 2007).

During off-farm season, the Nyeshanpa collect and trade medicinal plants for their sustainable livelihood. They do have rich indigenous knowledge regarding the use of plant species for various purposes (Bhattarai *et al.* 2006). Medicinal plants such as *Fritillaria cirrhosa, Hippophae tibetana, Juniperus indica, Nardostachys grandiflora, Ophiocordyceps sinensis* etc are reported to have immense livelihood oppurtunities for these local people (Joshi 2013). The district has a strong tradition of village governance which manages the agro-pastrol system, local natural resources and maintains village culture (NTNC 2008).

Manang was first opened for tourism in1977 and is reported as home to one of the World’s most popular trekking routes, the Annapurna Circuit, which receives more than seventy thousand tourist per year (NTNC 2008, 2009). The valley now host an average of thirteen thousand domestic and foreigner tourist per year (NTNC 2008).

2.1.5 Vegetation

Nyeshang valley lies in the arid zone north to Massif Himalayas, thus the flora of this region is quite similar to that of the Tibetaen Plateau (Chaudhary 1998). There is a decrease in moisture from east to west in the Nyeshang valley, and the south-facing slopes are significantly drier than those facing north, which is reflected in the vegetation and poor forest formation (Baniya *et al.* 2009). In Nyeshang valley, *Pinus wallichaina* forest is the mature vegetation where grazing and forest cutting is restricted. Here, shrubs of *Caragana spp, Juniperus squamata, Juniperus indica, Lonicera obovata, Rosa spp,* and *Rhododendron lepidotum* dominate the nearby landscape. At 3000m above sea level (asl) there is forest of *Picea smithiana, Quercus spp,* and *Tsuga dumosa.* At elevation above 3000m above sea level (asl), there is *Pinus wallichiana, Abies spectiabilis* and *Betula utilis* forest in the north-facing slopes and *Juniperus indica, Juniperus recurva* and *Rosa* spp. shrub on dry south-facing slopes.

On exposed slopes, the alpine meadows are dominated by *Anaphalis royleana, Bistorta macrophylla, Cicerbita macrorhiza var. saxatilis, Euphrasia himalayica, Galium megacyttarion, Gentiana depressa, Gentinella pedunculata, Gueldenstaedtia himalaica, Kobresia nepalensis, Lomatogonium himalayense, Persicaria glacialis, Polygonatum cirrhifolium, Potentilla argyrophylla var. atrosanguinea, P. forrestii, P. fruticosa, P. saudersiana, Trisetum spicatum* and *Veronica ciliata.* Area above timberline (4000-4300m above sea level) consists of harsh continental climate which allows only steppe vegetation similar to that of the Tibetean Plateau (Miehe 1982). The major species found in this zone are *Cortia depressa, Cremanthodium nepalense, Eriophyton wallichii, Gentiana algida var. przewalskii, Kobresia pygmaea, Leontopodium monocephallum, Nardostachys grandiflora, Potentilla eriocarpa, Saussurea graminifolia, S. leontodontoides, S. polystichoides, Saxifraga andersonii,* etc.

2.2 METHODS

2.2.1 Voucher specimen collection, herbarium preparation and identification

Voucher (at least 3 sets) of each species recorded in quadrats and summit area section (SAS) were collected from outside the summit area. Recorded plant species in each plot, were identified in the field with the help of standard floras (Plounin and Stainton 1984; Stainton 1988). However, unidentified species were collected, tagged, dried and brought to the herbaria (KATH and TUCH) for further identification. Moreover, standard taxonomic literature such as Hara *et al.* Vol.I (1978), Vol.II (1979) and Vol.III (1982), Grierson and Long 1983, 2001; Press *et al.* 2002; Zhang-Yi and Raven 1996, 2003; Ohba *et al.* 2008 were also followed. Voucher specimens were deposited at TUCH and in addition for future reference, digital photographs were also taken. Nomenclature of the plant species follows e-version of the Annotated Checklist of Flowering Plants of Nepal (Press *et al.* 2002) and Flora of China (Zhang-Yi and Raven 1996, 2003).

2.2.2 Collection of ethnomedicinal data and literature review

This work has been done in order to document the traditional knowledge on the use of plants being used as medicine by the local residents of the study area. A list of medicinal plant species was prepared through empirical ethnomedicinal study and literature survey. Ethnomedicinal study was made during September, 2011. This field work comprised the survey techniques and inventory techniques (Martin 1995; Cunningham 2001). Survey was conducted after obtaining prior information from local community of the village.

Participatory Rural Appraisal (PRA) method was employed to document ethnomedicinal data (Martin 1995) from local people having knowledge on the medicinal uses of plant species, location, seasonally growing condition and place of availability, state of collection, use form category and cultivation which included *Amchi* (traditional faith healers), village head and other key informants from different social and ethnic backgrounds, sex and age (range between 20-79). In total, 7 female and 18 male participants were interviewed displaying plant specimens (fresh, semi-dried and dried) to elicit the useful information about the plants in Nyeshang Valley, Manang. The key informants were again asked to freely list all the medicinal plants including their local name, parts use, purpose and mode of use. It ended up with varied range of information regarding plant use and other related topics. The major objective of PRA was to cross check the use of local plant mentioned by the local people regarding its correct local names, parts and form of use, purpose of use as well as availability. Secondly, personal interview were conducted using semi-structured questionnaire with the selected key informants such as *Amchi* in Jomsom valley. The questionnaire covered plant taxa, their localities, major use categories, parts use, mode of collection, trade status and livelihood strategy.

The time spent in the field was probably too short to accumulate sufficient information on the medicinal plant diversity, so a thorough literature survey which focused on the literature of Manang (Nyeshang Valley) and Mustang (Jomsom valley) was consulted to enlist the other medicinal plant species, not cited by local people during the present study. Useful floras of Nepal (e.g., Rajbhandhari 2001; Manandhar 2002; Baral and Kurmi 2006; Bhattarai *et al.* 2006, 2010; Ghimire *et al.* 2008) were also consulted to compare the plant use. Moreover, secondary data were collected from published books and journals, different NGOs and INGOs, Department of Hydrology and Meteorology, Nepal Academy of Science and Technology (NAST), International Union for Conservation of Nature (IUCN), National Herbarium Centre (KATH) and Department of National Park and Wildlife Conservation (DNPWC).

2.2.3 Ecological study: sampling technique and data collection

Sampling was carried out during the month of September, 2011 following the GLORIA protocol (GLORIA 2009). Four summits were chosen along an elevation gradient between treeline and permanent snowline representing four ecotones: sub alpine-lower alpine, lower alpine- upper alpine, upper alpine- sub nival and sub nival- nival. The selected summits represented the characteristic vegetation of the respective elevation level. All the summits comprised of similar bedrock and were not affected by heavy pastures from human land use and grazing.

Each summit was divided into eight summit area section (SAS) facing the cardinal direction (N, S, E & W) from the highest summit point (HSP) with four sections ranging from the summit down 5m in vertical elevation and another 4 sections ranging from 5 to 10m vertical elevation. At the cardinal direction corner down 5m elevation from the highest summit point (HSP), a cluster of four 1 m^2 plots (at the corner of a 3m X 3m grids with temperature data logger buried 10cm down in the middle) were intensively sampled in 10cm X 10cm grids using a plastic pipe. Altogether, sixteen 1m X 1m quadrats were sampled in each summit. Within summit area section (SAS), species, frequency, cover and human disturbance was estimated. The presence/absence of vascular plants, including useful ones was recorded in each grid cell. The environmental parameters recorded in each plot included latitude, longitude, elevation, aspect, precipitation and temperature. Latitude, longitude and elevation was recorded using GPS device (eTrex Garmin), while slope and aspect for each quadrat was recorded with the help of clinometer. Annual precipitation and temperature was also recorded from the nearby meterological stations (Chame and Jomsom).

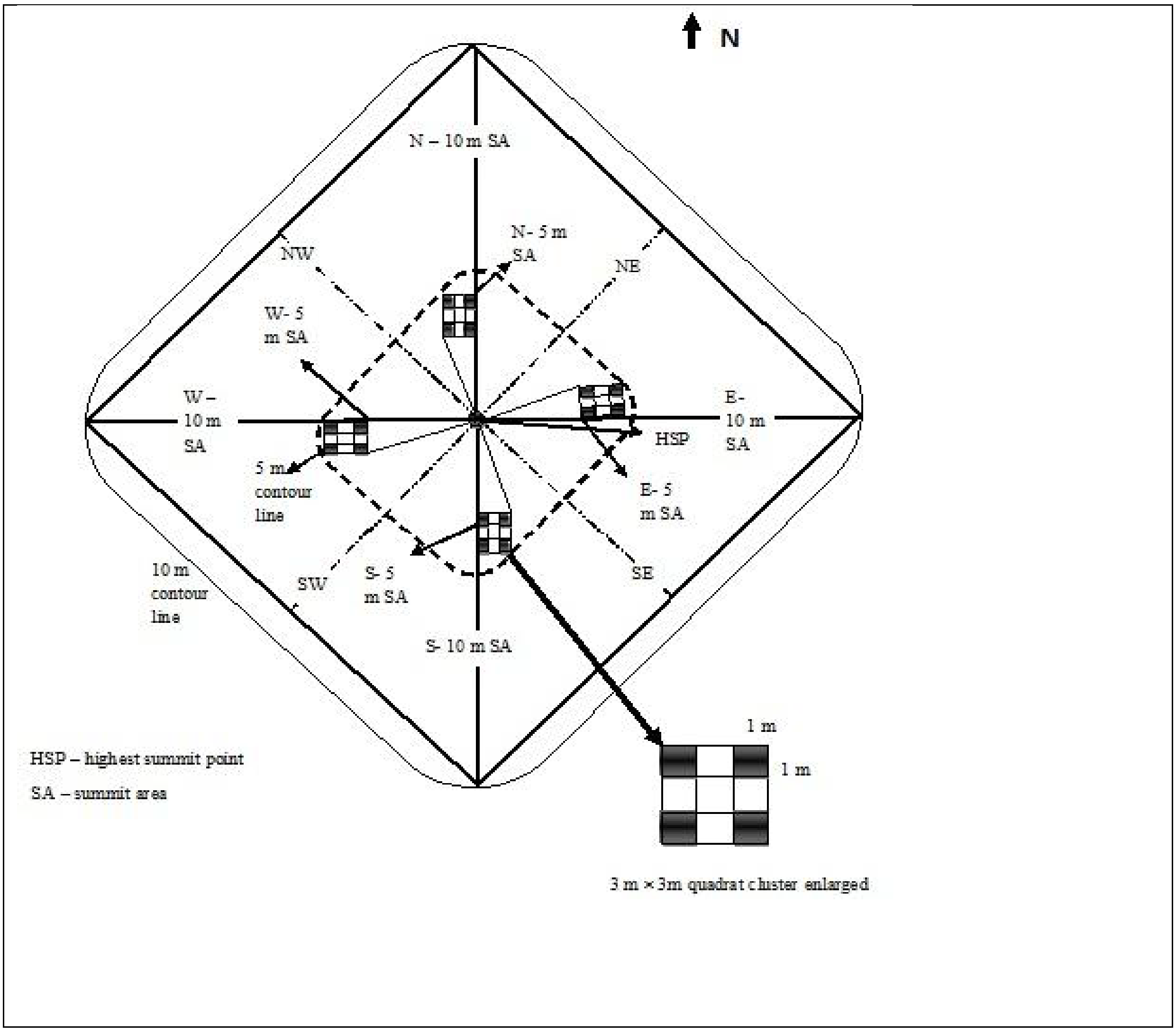


Figure 2: Field sampling technique (source: www. gloria.ac.at, modified by Joshi 2013)

2.2.4 Data analysis

The ethnomedicinal data was analysed to calculate the total number of medicinal plant species in different categories of use, parts use and life forms. All vascular plant species, including ferns and fern allies, was recorded and assigned to five life forms, such as forbs, graminoid, fern, shrub and sub-shrub using the method of Sarmiento *et al.* (2003). Here, medicinal plant species were analysed under three different categories (a) medicinally important only in the study area (b) medicinal in the study area as well as other parts of the country and (c) not used in the study area but cited as medicinal in other parts of the country.

However, the analysis of diversity (α and γ diversity) pattern of medicinal plant species was based on empirical data recorded as medicinal by local people and *Amchi* from the Nyeshang valley and Jomsom valley respectively. Mean species richness (α diversity) is the principle measure of diversity considered in this study to calculate all plant species and for plants under major use categories in each summit level and elevation band. As most of the species reported were for medicine, so our analysis was restricted for this category only.

Species richness is defined as total number of species per unit area (*sensu* Whittaker 1972), was obtained at the level of 1m X 1m quadrat. Total number of species from all sampling plots and quadrats per summit is defined as landscape level diversity (i.e. γ diversity; Whittaker 1972). One way ANOVA was accessed to compare total mean species richness and medicinally important plant species richness among four summits followed by Bonferroni multiple range test. Using SPSS Version 16 (SPSS Inc) normality and equal variance was tested; non-parametric data sets were log transformed to active normality and equal variance before analysis.

We used multivariate ordination techniques to understand the pattern of species-environment relationships. A preliminary analysis of presence/absence species data combining all summits through detrended correspondence analysis (DCA), an unconstrained (indirect) gradient analysis (Hill and Gauch 1980), revealed a gradient length of 5.56 in terms of SD units indicating a high species turnover along the gradient. In such situation, use of constraint (direct) ordination method, such as Canonical correspondence analysis (CCA) is appropriate for the analysis of species-environment relationships (ter Braak 1986).

DCA is perhaps the most widely used method of indirect gradient analysis which ordinates both species units simultaneously. This is an eigen vector ordination technique based on correspondence analysis (McCune and Grace 2002). DCA is used to impose assumptions about distribution of sample units and species in environmental phase, thus a pattern could be observed. Species turnover in the first DCA axis, obtained in terms of gradient length of SD unit, is used as a measure of β diversity (Hill and Gauch 1980).

CCA, on the other hand, is a direct gradient analysis that displays the variation of vegetation in relation to the included environmental factors using environmental data to order samples (ter Braak 1986; ter Braak and Verdonschot 1995). Here CCA ordination technique was applied to access the species-environment relationship. Monte Carlo permutation test were subsequently used within CCA to determine the significance of relation between species distribution along the gradient and environmental variables such as altitude, substrate type and vegetation cover at significant level $p<0.05$. CANACO version 4.5 (ter Brakk 2002) was used for DCA and CCA ordinations.

CHAPTER THREE: RESULTS

3.1 Ethnomedicinal Plant Species

A total of 176 species of vascular plants, belonging to 49 families and 69 genera, were collected from the study area and identified (Appendix 1), which comprised 97 species as medicinal, based on empirical ethnomedicinal study (Appendix 2) and literature review (Appendix 3). Out of 176 species, medicinal uses of only 58 species were cited by local inhabitants and *Amchi*, the rest of the species (n=39) not reported by local inhabitants and *Amchi* were found to be medicinally important elsewhere in the country. Present study added 19 medicinally important species to the list which were not mentioned in the literature I reviewed and may be new record for Nyeshang valley and Jomsom valley as well as for the country. The plant parts used for treating different ailments were underground parts (root, rhizome), young shoot (i.e. everything above ground), stem/barks, leaves/petiole, flower/fruits and seeds. The whole plant was also used mostly in case of herbs. Some 28.24% of the species were valued for their leaf parts followed by whole plant 23%, flower, root and rhizome 10.59%, shoot 9.41%, seed and stem 4.71%, fruit 3.53% and least used was petiole 1.18%.

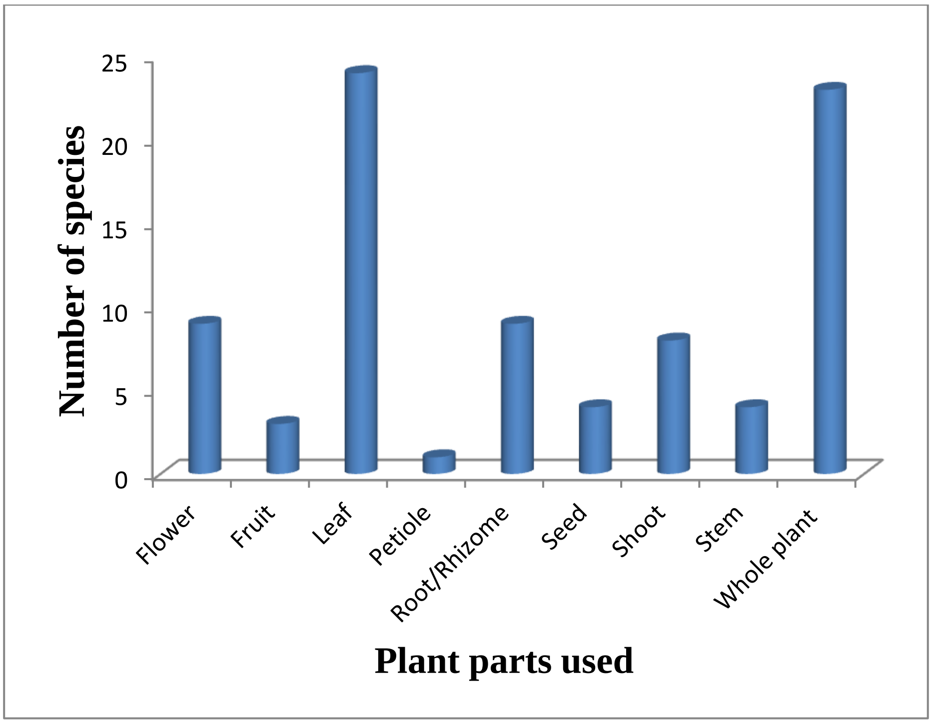


Fig 3: Plant parts used categories based upon local inhabitants.

Nine different plant parts were used medicinally to cure 32 different types of disease/disorders. The present study has documented at least 13 different body ailment categories and the highest proportions of species were cited for circulatory system disorders (21.11 %).

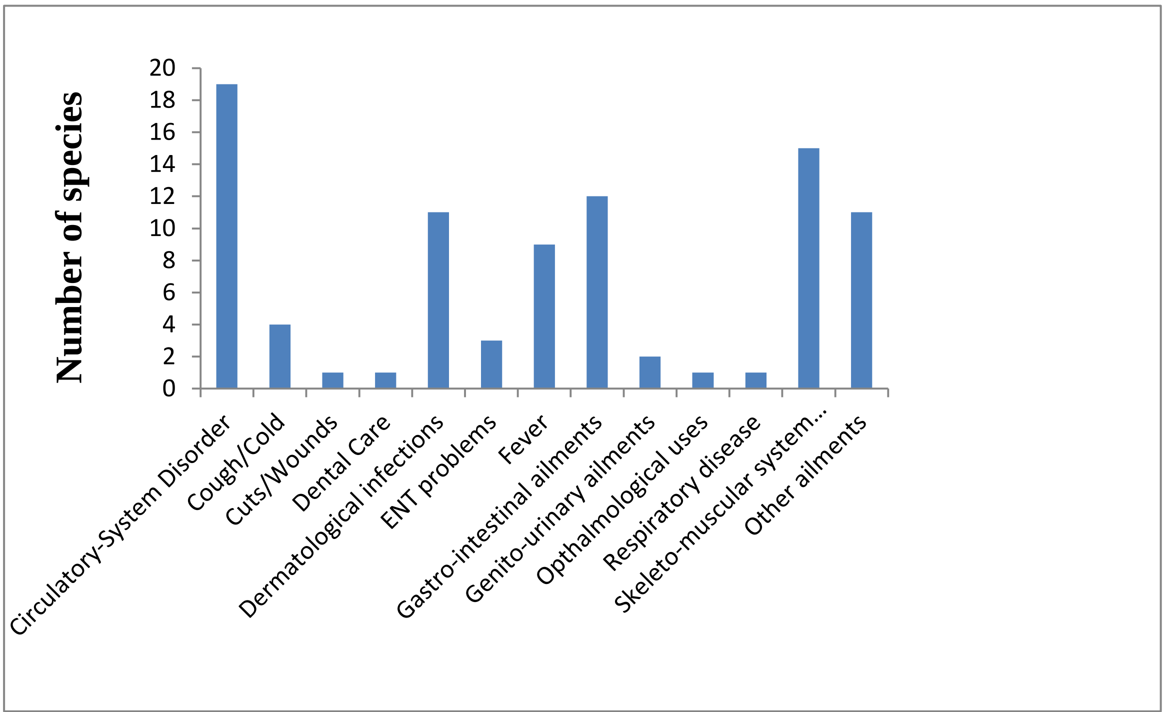


Fig 4: Medicinal plant use according to the types of ailment categories.

Table 1: Number of medicinal plant species with single or multiple use categories based on the empirical data.

Ailments Categories	Bio-medical terms according to the interview	No. of species
Circulatory system disorder	bile, liver problem, blood disorder, jaundice	19
Cough/Cold	cough and cold	4
Cuts/Wounds	antiseptic, cuts and wounds	1
Dental Care	gums disease and tootache	1
Dermatological infections	allergy, skin disease, scabies	11
ENT problems	sinusitis, tonsil, ear problems	3
Fever	fever	9
Gastro-intestinal	Stomach-ache	12
Genito-urinary	aphrodiasic, kidney problems	2
Opthalmological	eye disease	1
Respiratory	bronchitis, chest pain, lung disorder	1
Skeleto-muscular system	body pain, headache, inflammation	15
Other ailments	tonic, anti-poison, sleeping tablets, antiseptic	11

The medicinal remedies were based on many kind of preparation ranging from a preparation made out of a single plant for a single ailment to use of a plant in combination. The most frequently used mode of preparation were paste (39.51%) followed by juice (23.26%), powder (13.58%), decoction (12.35%), chewed form (6.17%) and herbal bath (4.96%).

3.2 Ecological Study

3.2.1 Life form diversity:

Life form classification was made for 172 species identified for up to the species level (Appendix 1). The richness of species categorized into different life form at landscape level showed that the habitat was dominated by forb. The forb represented 75% of the total species recorded in the 4 summits. The second largest group was shrub (16%), followed by graminoid (7%) and sub-shrub and fern (1%) (Fig 5).

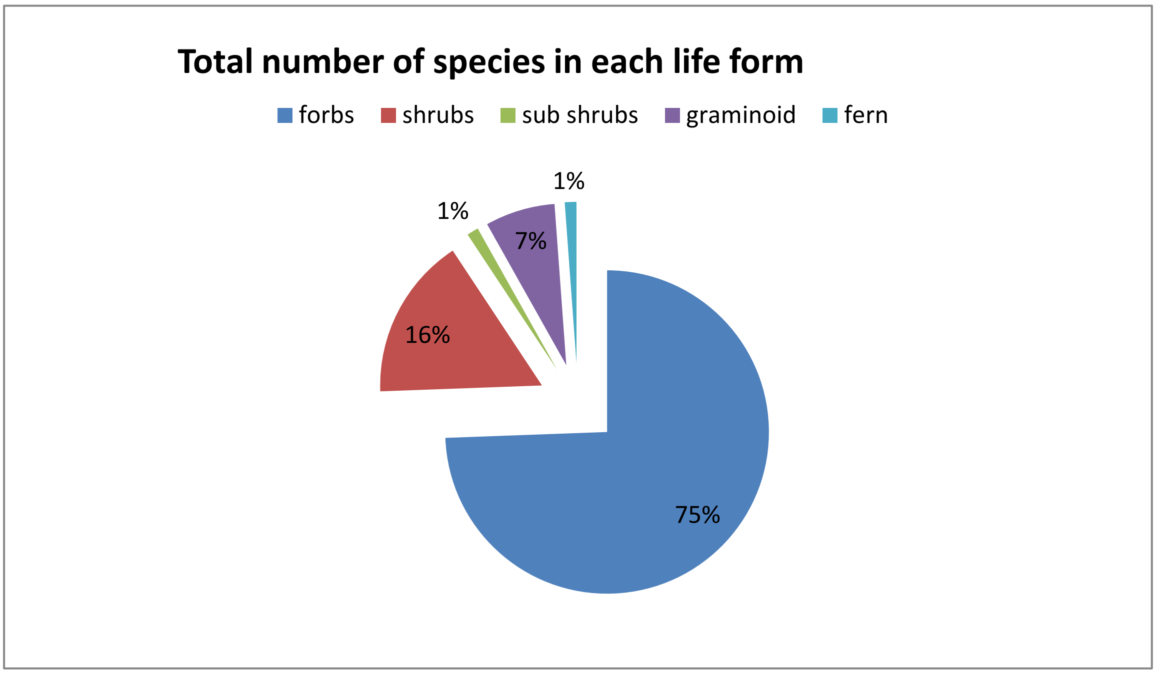


Fig 5: Life form of all recorded plant species

Analysis of life form data at the landscape level clearly showed that the forb and shrub is inversely proportional to the increase in elevation but we can observe a bit increase in number of forbs from subalpine-lower alpine (SMA) to lower alpine-upper alpine (SMB). (Fig 6). Only forb (88%) and shrub (12%) were medicinally important in the present study.

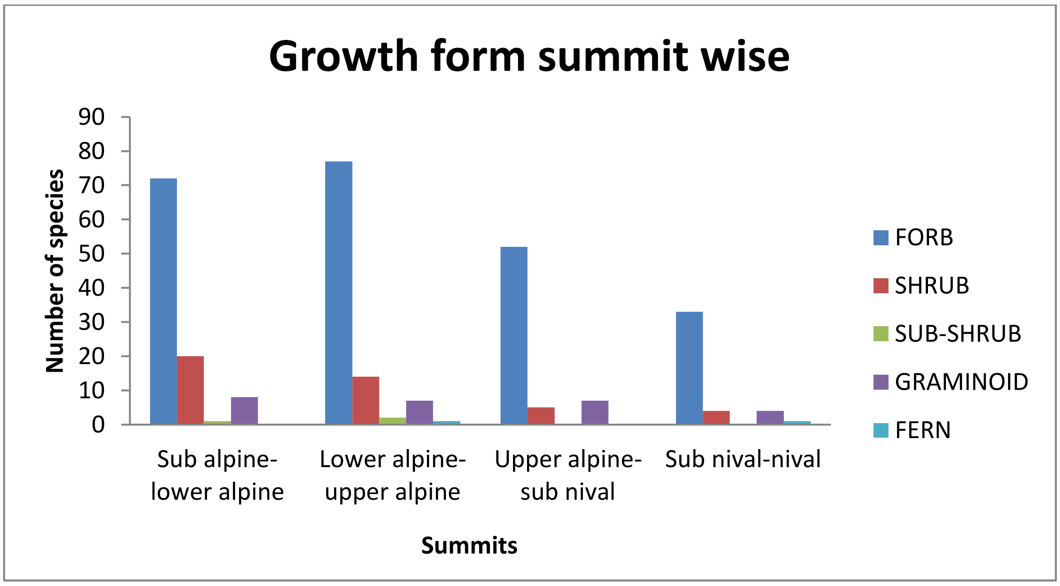


Fig 6: Growth form of species recorded in quadrats among four summits.

3.2.2 Species diversity measures

Altogether, 176 species of vascular plants belonging to 49 families and 96 genera were recorded in the present study. The largest family recorded was Asteraceae with 28 genera and the largest genus was *Potentilla* belonging to Rosaceae family with 10 species (Appendix 1). The landscape level diversity (γ diversity, total 176 from all summit) decrease in the summit representing different ecotones from the lower to higher elevation (Table 2). However, the two lower elevation summit of subalpine-lower alpine (SMA) and lower alpine- middle alpine (SMB) ecotone did not vary much in total species occurrence, but than a sharp decline in total number of species was observed from lower alpine- middle alpine (SMB) to middle alpine- upper alpine (SMC) and gradually decline upto upper alpine- sub nival (SMD) ecotone. On contrary, at quadrat cluster level the species richness was observed to decline gradually from SMA (lowest summit) to SMD (highest summit). One way Anova test showed that the value of species richness at the level of 3m X 3m plot was significantly higher in two lower elevation summit than in the summit at higher elevation (Table 2). Contrary to these findings, species richness at quadrat level didn't reflect a sharp trend, except the value was significantly low for the summit at highest elevation (SMD, Table 2).

Table 2: Species diversity measures at different spatial scales in summits representing different ecotones along elevation gradient.

Diversity measures	SMA	SMB	SMC	SMD	Overall	F	*p*
γ-diversity at summit level	103	102	65	41	176		
α-diversity (quadrat-cluster level)	32.75±3.30	27.50±1.19	25.25±1.03	17.33±2.33	26.26±1.70	7.93	0.004
α-diversity (quadrat level)	14.18±1.02	13.37±0.92	14.87±0.56	8±1.00	12.91±0.54	10.6	<0.001

SMA= subalpine-lower alpine (4150m); SMB= lower alpine-middle alpine (4575m), SMC= middle alpine-upper alpine (4835m), SMD= upper alpine-subnival (5005). The different superscript letters in each category of diversity measures represent significant difference (at p<0.05 level) based on one way Anova.

However, landscape level diversity for medicinal plants (γ diversity, total 58 from all summit) decrease in summit representing different ecotone from lower to higher elevation (Table 3). Decline in total number of medicinal plants can be observed from SMA to SMD. Similar trend was observed for richness of medicinal plant species at level of quadrat cluster

(Table 3). One way Anova tests for medicinal plants showed the same trend like that of overall species.

Table 3: Medicinal plant species diversity measures at different spatial scales in summits representing different ecotones along elevation gradient.

Diversity measures	SMA	SMB	SMC	SMD	Overall	F	*p*
γ-diversity at summit level	24	14	12	7	58		
α-diversity (quadrat-cluster level)	10.25±1.31	7.25±1.65	6.75±0.47	3.66±0.66	7.20±0.80	4.69	0.02
α-diversity at quadrat level	3.93±0.46	3.56±0.36	4.81±0.27	1.58±0.33	3.60±0.23	11.91	<0.001

SMA= subalpine-lower alpine (4150m); SMB= lower alpine-middle alpine (4575m), SMC= middle alpine-upper alpine (4835m), SMD= upper alpine-subnival (5005). The different superscript letters in each category of diversity measures represent significant difference (at $p<0.05$ level) based on one way Anova.

On contrary, the proportion of medicinal plant species remains almost similar among four elevation levels (summits). This implies that high altitude habitats provide unique sets of environment for the growth of diverse medicinal plant species.

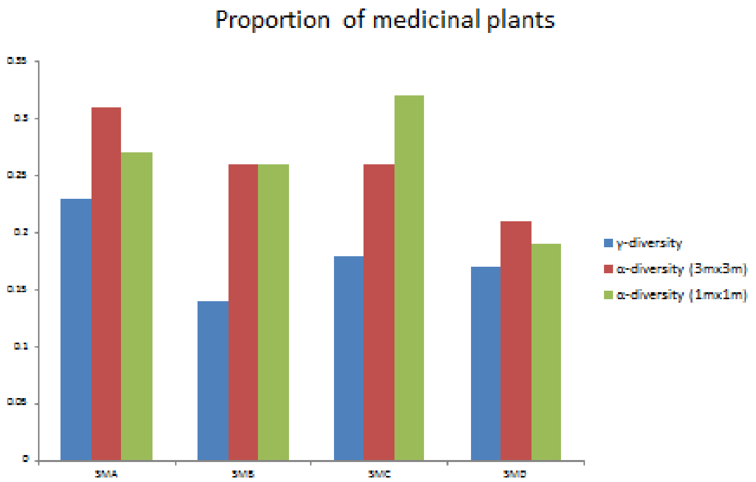


Fig 7: Proportion of medicinal plants along four summit.

3.2.3 Medicinal plants distribution patterns: along major elevation gradients

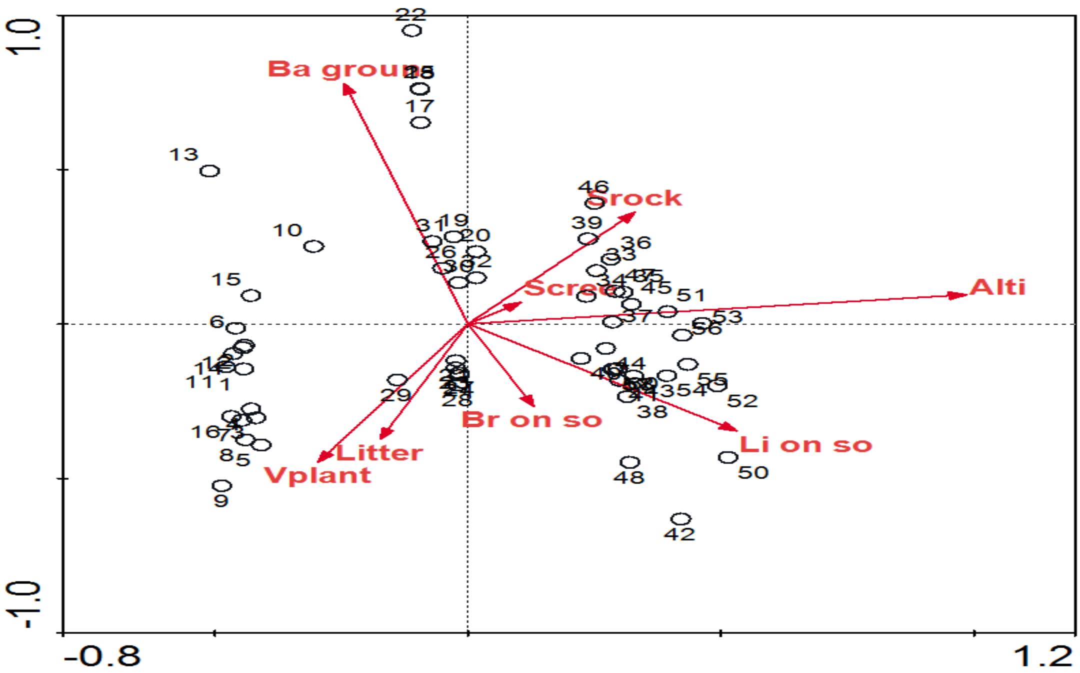
The CCA ordination explained the relationship between quadrats, medicinal plants and different environmental variables (Table 4). It showed that the medicinal plant species composition was governed most importantly by elevation. Forward selection and Monte Carlo permutation tests further revealed scree as substrate type (p=<0.01) to be the second most significant variable, followed by bare ground (p=0.002) in influencing the species composition at the local scale (Table 4).

Table 4: Relative importance of environmental variable on species composition analysed based on CCA. The statistical significance (p-value) of variables was derived using a Monte Carlo permutation test with 1000 replicates.

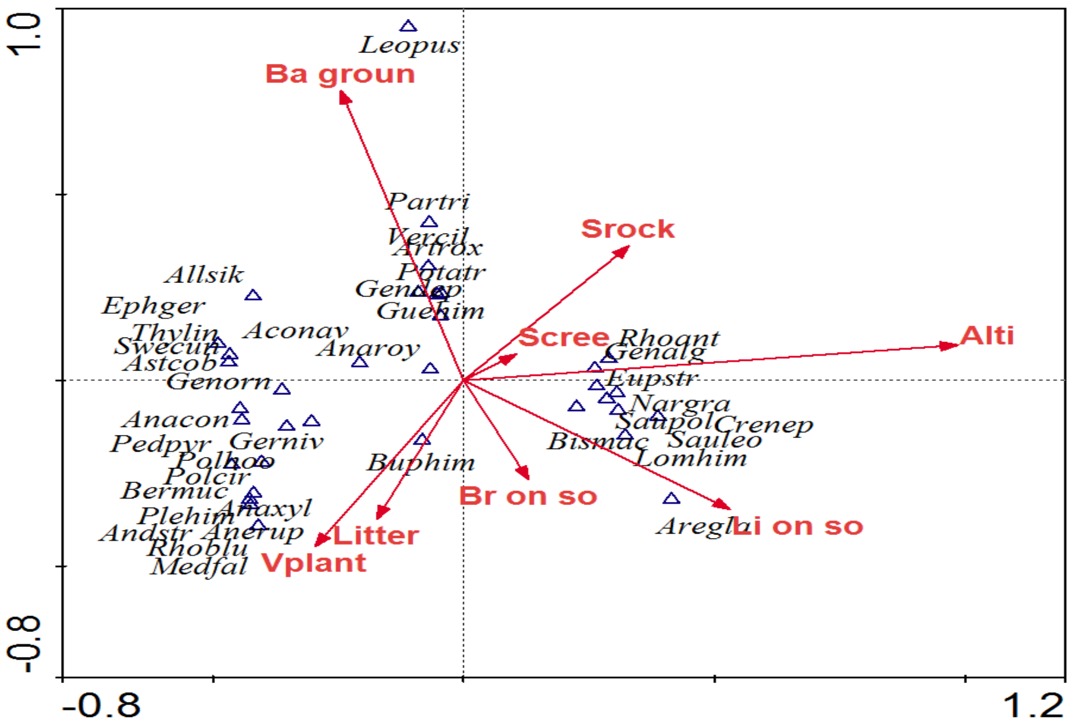
Environmental variable	Abbreviation	Variance explained	F	*p*
Altitude (m)	Alti	0.63	5.04	0.001
Scree cover %	Scree	0.24	1.98	0.001
Bare ground %	Ba groun	0.20	1.67	0.002
Litter cover %	Litter	0.18	1.51	0.052
Lichen on soil %	Li on so	0.16	1.37	0.053
Bryophyte on soil %	Br on soil	0.14	1.18	0.153
Solid rock %	Srock	0.11	0.98	0.478

Table 5: CCA ordination summary (total inertia= 7.609, sum of all canonical values= 1.544)

Axes	1	2
Eigen values	0.73	0.51
Species-environment correlations	0.52	0.35
Cumulative percentage variance		
of species data	9.6	16.4
of species-environment data	12.0	16.2



(a)



(b)

Fig 7: CCA biplot for (a) sample quadrats and (b) medicinal species along gradient with environmental variables. Abbreviation for environmental variables are given in Table 4 and those for species are given in Appendix 1. Species abbreviation represent first three letters of generic name and specific epithet.

CCA axis 1 clearly represent altitudinal gradient (Figure 7). This axis separated samples (quadrats, Fig 7a) and medicinal plants (fig 7b) from lowest to highest elevation summits. A preliminary DCA showed highest gradient length (5.56) for the first axis indicating high compositional turnover along this main gradient. The high eigen value of the CCA first axis (0.73) indicateds effective separation of species along the main gradient (Table 5). Almost 9.6% variance in species composition data and 12.0% variance species environment data were explained for by the first axis. The second CCA axis, which explained 6.8% variation in the species data reflected a complex gradient related to topography, substrate type and edaphic properties. The moderate eigen value for the second axis (0.51) also indicated substantial separation of species along this complex gradient representing moist and rich substrate with high bryophytes and litter cover at the negative end and scree and bare ground in slopes at the positive end of the second axis.

Medicago falcata (Medfal), *Androsace strigillosa* (Andstr), *Anemone rupicola (*Anerup), *Anaphalis xylorhiza* (Anaxyl), *Berberis mucrifolia* (Bermuc), *Polygonatum hookeri* (Polhoo), *Pedicularis pyramidata* (Pedpyr), *Gerbera nivea* (Gerniv), *Anaphalis contorta* (Anacon) had strong affinity for lower elevation moist substrate with high litter content and nutrient rich soil whereas *Rhododendron anthopogan* (Rhoant) and *Gentiana algida* (Genalg) were confined almost exclusively to high elevation scree substrate with dry and poor soil. Species such as *Arenaria glanduligera* (Aregla), *Lomatogonium himalayense* (Lomhim), *Bistorta macrophylla* (Bismac), *Saussurea leontodontoides* (Sauleo), *Cremanthodium nepalense* (Crenep), *Saussurea polystichoides* (Saupol), *Nardostachys grandiflora* (Nargra) were confined to the moist habitat bryophyte rich soil whereas *Leontopodium pusillum* (Leopus), *Allium sikkimense* (Allsik), *Veronica ciliata* (Vercil), *Ephedra gerardiana* (Ephger), *Aconitum naviculare* (Aconav), *Gentiana depressa* (Gendep) were confined to the dry and open substrate (Bare ground).

CHAPTER FOUR: DISCUSSIONS

Annapurna region in Central Nepal, with the complex topography and varied ecosystems, harbours a wide range of floral diversity with high percentage of endemism. The inhabitants of Nyeshang (Upper Manang) are ethnobotanically rich possessing wide knowledge on the use of plant species for various purposes (Bhattarai et al. 2006). Plant resources and traditional knowledge on their uses are the important heritage of Manang that provide livelihood to the people of Nepal and adjoining areas. The local traditional healers such as *Amchis* (traditional Tibetan doctor) and elderly people were very much knowledgeable on the plants used for medicinal purposes (Bhattarai *et al.* 2006).

Nyeshang valley of Manang district is one of the remotest area of Nepal. This region is bestowed with the diversity of wild plant resources, comprising medicinally valued species. So far, Bhattarai et al. (2006) reported 91 plant species belonging to 40 families and 73 genera from Upper Manang. Likewise, Manandhar (1987) documented 81 species of plants under 75 genera of 32 families and Pohle (1990) documented 239 species of plants, of which 66 species of plants were used ethnomedicinally. Present study reveals the presence of 176 vascular plant species belonging to 49 families and 69 genera (Appendix 1), which comprised 97 medicinal plant species. Out of 176 species, medicinal uses of only 58 species were cited by local inhabitants and *Amchi* (Appendix II), the rest of the species (n=39) not reported by local inhabitants and *Amchi* (Appendix III) were found to be medicinally important elsewhere in the country. Present study added 19 medicinally important species to the list which were not mentioned in the literature I reviewed and may be new record for Nyeshang and Jomsom valley as well as for the country.

The variation in the number of medicinal plants in different studies may be due to differing in specific study sites in Manang. For example, other studies were focussed either in whole Manang area (Manandhar 1987, Pohle 1990) or Nyeshang valley and nearby areas (Bhattarai *et al.* 2006). But the present study is focussed only in Nyeshang valley which recorded only 58 medicinal plant species cited by local inhabitants and *Amchi*. As the research work based on ethnomedicinally important plant species focussed only in Nyeshang valley were not found to be conducted before, so the present findings may support the possibility of recording new information. It is hoped that these newly documented plants may be valuable for future research work.

On the basis of life form, forbs (88%) were the primary source of plant use in comparison to shrub (12%). Highest proportion of ethnomedicinally important plants were forbs because the study area was located at higher elevation which favours herbaceous species. Habitat heterogeneity associated with topographic and climatic variabilities have supported diversity of useful species in the Himalaya (Ghimire and Thomas 2002) and there is high possibility of recording new uses through extensive ethnobotanical study. Over exploitation of medicinal and food plants has posed great conservation challenge in the Himalaya (Olsen and Helles 1997). The present study documented the plant parts used for treating different ailments as underground parts (root, rhizome), young shoot (i.e. everything above ground), stem/barks, leaves/petiole, flower/fruits and seeds. In some cases the whole plant was utilized. The most frequently utilized plant part was leaf (28.24%) followed by whole plant 23%, flower, root and rhizome 10.59%, shoot 9.41%, seed and stem 4.71%, fruit 3.53% and least used was petiole 1.18%. Leaf, flower and root contain more active principles in comparison to stem, seed and flower and are physically more vulnerable (Bhattarai *et al.* 2006). Harvesting of whole plant or underground parts is the main issue for the conservation of Himalayan medicinal plants (Lama et al. 2001; Ghimire 2006). Therefore, development of knowledge on sustainable use of such plant species is crucial for long-term maintenance of their populations.

The present study showed nine different plant parts used medicinally to cure 32 different types of disease/disorders. The study also documented at least 13 different body ailment categories and the largest number of remedies (21.11 %) were used to treat circulatory system disorders followed by dermatological infections and other ailments. The medicinal remedies were based on many kind of preparation ranging from a preparation made out of a single plant for a single ailment to use of a plant in combination. In this study, the most frequently used mode of preparation were juice and paste in comparison to decoction, herbal bath and chewed form.

Altogether, 176 species of vascular plants belonging to 49 families and 96 genera were recorded in the present study. The largest family recorded was Asteraceae with 28 genera and the largest genus was *Potentilla* belonging to Rosaceae family with 10 species (Appendix 1). Studies on species composition in the subalpine forests of upper Manang valley by several workers (e.g., Baniya *et al.* 2009; Ghimire B.K. *et al.* 2008; Panthi *et al.* 2007) also found Asteraceae was the largest family.

General theory of species richness along the alpine-nival gradient predicts that the species richness decreases with the increase in elevation (Brown and Lomolino 1998; Körner 2002; Baniya *et al.* 2010). Previous studies conducted in the Himalaya and the other mountain ranges also shows a linear decrease in species richness after reaching its peak (Grytness and Vetaas 2002; Ghimire *et al.*2006). This study also shows the similar pattern that the species richness in alpine –nival gradient decreases with increasing elevation. The landscape level diversity (γ diversity, total 176 from all summits) decrease in the summit representing different ecotones from the lower to higher elevation. However, the two lower elevation summit of subalpine-lower alpine (SMA) and lower alpine- middle alpine (SMB) ecotone did not vary much in total species occurrence, but than a sharp decline in total number of species was observed from middle alpine- upper alpine (SMC) to upper alpine- sub nival (SMD) ecotone. Similar trend was observed for richness of species at quadrat cluster. Result showed that the value of species richness at the level of 3m X 3m plot was significantly higher in two lower elevation summits than in the summit at higher elevation. Several studies have found that species diversity tends to decrease with increasing elevation (Yoda 1967; Hamilton 1975; Stevens 1992; Brown and Lomolino 1998; Körner 2002). Contrary to these findings, species richness at quadrat level didn't reflect a sharp trend, except the value was significantly low for the summit at highest elevation.

This study showed landscape level diversity for medicinal plants (γ diversity, total 58 from all summit) decreased in summit representing different ecotone from lower to higher elevation. Decline in total number of medicinal plants can be observed from SMA to SMD. Similar trend was observed for richness of medicinal plant species at level of quadrat cluster. Results for medicinal plants showed the same trend like that of overall species. Species richness is highly correlated with the elevation gradient. The area tends to decrease along the mountain slopes. Likewise, species diversity decrease along the elevation due to decrease in moisture, temperature and reduced growing season. However, the proportion of medicinal plant species remains almost similar among four elevation levels (summits). This implies that high altitude habitats provide unique sets of environment for the growth of diverse medicinal plant species. Therefore, landscape-level heterogeneity should be maintained for the preservation of medicinal plant species in the Himalaya.

A preliminary DCA showed highest gradient length (5.56) for the first axis indicating high compositional turnover along the main gradient. In such situation, use of constraint (direct) ordination method, such as Canonical correspondence analysis (CCA) is appropriate for the analysis of species-environment relationships (ter Braak 1986). The CCA ordination explained the relationship between quadrats, medicinal plants and different environmental variables (Table 4). It showed that the medicinal plant species composition was governed most importantly by elevation. CCA axis 1 clearly represent altitudinal gradient (Figure 7) and separate samples (quadrats, Fig 7a) and medicinal plants (fig 7b) from lowest to highest elevation summits. The high eigen value of the CCA first axis (0.73) indicated effective separation of species along the main gradient (Table 5). Almost 9.6% variance in species composition data and 12.0% variance species environment data were explained for by the first axis. Likewise, second CCA axis, explained 6.8% variation in the species data which reflected a complex gradient related to topography, substrate type and edaphic properties. The moderate eigen value for the second axis (0.51) also indicated substantial separation of species along this complex gradient representing moist and rich substrate with high bryophytes and litter cover at the negative end and scree and bare ground in slopes at the positive end of the second axis.

Medicago falcata (Medfal), *Berberis mucrifolia* (Bermuc), *Polygonatum hookeri* (Polhoo), *Pedicularis pyramidata* (Pedpyr), *Gerbera nivea* (Gerniv), *Anaphalis contorta* (Anacon) had strong affinity for lower elevation moist substrate with high litter content and nutrient rich soil whereas *Rhododendron anthopogan* (Rhoant) and *Gentiana algida* (Genalg) were confined almost exclusively to high elevation scree substrate with dry and poor soil. Species such as *Arenaria glanduligera* (Aregla), *Cremanthodium nepalense* (Crenep), *Saussurea polystichoides* (Saupol), *Nardostachys grandiflora* (Nargra) were confined to the moist habitat bryophyte rich soil whereas *Leontopodium pusillum* (Leopus), *Allium sikkimense* (Allsik), *Gentiana depressa* (Gendep) were confined to the dry and open substrate (Bare ground).

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

The Nyeshang valley, is very rich in biodiversity mainly comprising ethnomedicinally important plant species. A total of 176 vascular plant species belonging to 49 families and 69 genera were recorded in the present study comprising 97 medicinal plant species. Out of 176 species, medicinal uses of only 58 species were cited by local inhabitants and *Amchi*, the rest of the species (n=39) not reported by local inhabitants and *Amchi* were found to be medicinally important elsewhere in the country. Present study added 19 medicinally important species to the list which were not mentioned in the literature I reviewed and may be new record for Nyeshang and Jomsom valley as well as for the country. This study showed the possibility of recording new information of ethnomedicinal importance through extensive ethnomedicinal study. Present study indicates that local inhabitants in the highland are highly dependent on the forest sources not only for the medicinal purpose but also generates income from it. Thus, enhancing the sustainable use and conserving indigineous knowledge of medicinal plants may benefit and improve the living standard of poor people. The valuable information needs to be documented before it disappears. Therefore, it is strongly recommended to promote the documentation of indigenous uses and traditional knowledge and practices. Furthermore, research related to chemical screening should also be initiated to analyse the chemical contents of medicinal plants and their implication on health. In addition to medicinal use, plant resources can also be linked to the preservation of biodiversity and allevation of poverty.

Both the species diversity measured i.e.α and γ for overall and medicinal plant species differed in each summit level (SMA- SMD). In general, they show linear decreasing trend along the gradient at different scales of measurement. However, the proportion of medicinal plant species remains almost similar among four elevation levels (summits). This implies that high altitude habitats provide unique sets of environment for the growth of diverse medicinal plant species. Generally more species number are found in nutrient rich substrate than nutrient poor substrate. Forb is the dominant life form in the study area followed by shrub at higher elevation. Significant effects of aspect with respect to species richness were observed that reflected the consistent trend. Himalayan mountain summits possess potential species with high local medicinal value. Therefore, management should be considered on landscape approach integrating different mountain summits, associated species and indigenous knowledge.

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Appendix I. List of plant species recorded in all summits representing different ecotones along elevation gradients.

SN	Name of plant species with author citation	Abbreviation	Family	Life Form	Distribution (m) based on empirical data
1	*Aconitum naviculare* var. *leiocarpum* Tamura	Aconav	Ranunculaceae	forb	4110-4900
2	*Agrostis pilosula* Trin.	Agrpil	Poaceae	graminoid	2000-4600
3	*Ajuga lupulina* Maxim.	Ajulup	Labiatae	forb	2200-4500
4	*Allium sikkimense* Baker	Allsik	Amaryllidaceae	forb	3000-4800
5	*Anaphalis cavei* Chatterjee	Anacav	Asteraceae	forb	4100-5000
6	*Anaphalis contorta* (D. Don) Hook.f.	Anacon	Asteraceae	forb	1700-4500
7	*Anaphalis nepalensis var. nepalensis* (DC.) Airy	Ananep	Asteraceae	forb	2400-4500
8	*Anaphalis royleana* DC.	Anaroy	Asteraceae	forb	1200-4200
9	*Anaphalis triplinervis var. monocephala* (DC.) Airy Shaw	Anatri	Asteraceae	forb	3400-5500
10	*Anaphalis xylorhiza* Sch. Bip. ex Hook.f.	Anaxyl	Asteraceae	forb	3400-5000
11	*Androsace globifera* Duby	Anaglo	Primulaceae	forb	3200-4700
12	*Androsace lehmannii* Wall. Ex Duby	Analeh	Primulaceae	forb	3500-5300
13	*Androsace robusta* (Knuth) Hand.-Mazz	Androb	Primulaceae	forb	3100-5600
14	*Androsace strigillosa* Franch	Anastr	Primulaceae	forb	2400-4700
15	*Anemone demissa* Hook. f. & Thomson	Anedem	Ranunculaceae	forb	2700-5600
16	*Anemone rupicola* Cambess	Anarup	Ranunculaceae	forb	2400-4700
17	*Arabidopsis himalaica* (Edgew.) O. E. Schulz	Arahim	Cruciferae	forb	2600-4400
18	*Arenaria bryophylla* Fernald	Arebry	Caryophyllaceae	forb	4400-5900
19	*Arenaria glanduligera* Edgew. ex Edgew. & Hook	Aregla	Caryophyllaceae	forb	4100-5500
20	*Artemisia roxburghiana* Besser	Artrox	Asteraceae	sub shrub	2400-5600

21	*Artemisia subdigitata* Mattf	Artsub	Asteraceae	subshrub	2200-3000
22	*Aster ageratoides* subsp. alato-petiloata Kitam.	Astage	Asteraceae	forb	1800-3400
23	*Aster himalaicus* C. B. Clarke	Asthim	Asteraceae	forb	3500-5200
24	*Aster indamellus* Grierson	Astind	Asteraceae	forb	1900-4200
25	*Astragalus cf. acaulis* Baker	Astaca	Fabaceae	shrub	3300-5400
26	*Astragalus cobresiiphilus* Podlech & L. R. Xu	Astcob	Fabaceae	shrub	3300-5100
27	*Astragalus himalayanus* Klotzsch	Asthim	Fabaceae	shrub	3500-4500
28	*Astragalus oplites* Benth. ex R. Parker	Astopl	Fabaceae	shrub	3500-4100
29	*Athyrium wallichianum Ching*	Athwal	Athyriaceae	fern	2200-3000
30	*Berberis erythroclada* Ahrendt	Berery	Berberidaceae	shrub	3000-4300
31	*Berberis mucrifolia* Ahrendt	Bermuc	Berberidaceae	shrub	2100-4500
32	*Betula utilis* D. Don	Betuti	Betulaceae	shrub	2700-4300
33	*Bistorta affinis* (D. Don) Greene	Bisaff	Polygonaceae	forb	3500-4800
34	*Bistorta macrophylla* (D. Don) Sojak	Bismac	Polygonaceae	forb	2300-5000
35	Boraginaceae	Bor	Boraginaceae		
36	*Bromus himalaicus* Stapf apud Hook. f.	Brohim	Poaceae	graminoid	3500-3700
37	*Bupleurum falcatum* L.	Bupfal	Apiaceae	forb	1500-4200
38	*Bupleurum himalayense* Klotzsch	Buphim	Apiaceae	forb	4200-4600
39	*Calamagrostis pseudophragmites* (Haller f.) Koeler	Calpse	Poaceae	graminoid	1500-4600
40	*Chenopodium aristatum* L.	Cheari	Chenopodiaceae	Herb	2700-3600
41	*Chesneya nubigena* (D. Don) Ali	Chenub	Leguminosae	forb	3600-5200
42	*Cicerbita macrorhiza* var. *saxatilis* (Edgew.) P. Beauv	Cicmac	Asteraceae	forb	3300-4500
43	*Cortia depressa* (D. Don) C. Norman	Cordep	Apiaceae	forb	3500-4900
44	*Corydalis juncea* Wall.	Corjun	Papaveraceae	forb	2500-4400
45	*Cotoneaster ludlowii* Klotz	Cotlud	Rosaceae	shrub	1900-4000
46	*Cotoneaster microphyllus* Wall. ex Lindl.	Cotmic	Rosaceae	shrub	2000-5400

47	*Cremanthodium ellisii* (Hook. f.) Kitam. ex Kitam. & Gould	Creell	Asteraceae	forb	3400-5600
48	*Cremanthodium nepalense* Kitam.	Crenep	Asteraceae	forb	3600-4900
49	*Cremanthodium purpureifolium* Kitam.	Crepur	Asteraceae	forb	3800-4900
50	*Cyananthus himalaicus* K. K. Shrestha	Cyahim	Campanulaceae	forb	3400-3600
51	*Cynoglossum amabile* Stapf & Drumm.	Cynama	Boraginaceae	forb	2600-3800
52	*Delphinium glaciale* Hook. f. & Thomson	Delgla	Ranunculaceae	forb	5000-6500
53	*Delphinium kamaonense* Huth	Delkam	Ranunculaceae	forb	2500-4500
54	*Delphinium nepalense* Kitam. & Tamura	Delnep	Ranunculaceae	forb	3800-5500
55	*Dendranthema mutellina* (Hand.-Mazz.) Kitam. ex Kitam. & Gould	Denmut	Asteraceae	shrub	2500-5300
56	*Dendranthema nubigenum* (Wall. ex Dc.) Kitam. Ex Kitam. & Gould.	Dennub	Asteraceae	shrub	2800-4400
57	*Elsholtzia eriostachya* (Benth.) Benth.	Elseri	Lamiaceae	forb	3000-4800
58	*Elymus nutans* Griseb.	Elynut	Poaceae	graminoid	2800-4600
59	*Ephedra gerardiana* Wall. ex Stapf, Akad.	Ephger	Ephedraceae	shrub	2300-5300
60	*Epilobium brevifolium* D. Don	Epibre	Onagraceae	forb	1500-4000
61	*Eriophyton wallichii* Benth.	Eriwal	Lamiaceae	forb	4000-5400
62	*Eriotrichum* sp.	Erisp.	Amaranthaceae	forb	
63	*Euphorbia stracheyi* Boiss.	Eupstr	Euphorbiaceae	forb	2000-5000
64	*Euphrasia himalayica* Wettst.	Euphim	Orobanchaceae	forb	2500-4200
65	*Festuca polycolea* Stapf	Gespol	Poaceae	graminoid	3600-4700
66	*Galium megacyttarion* R. R. Mill	Galmeg	Rubiaceae	forb	2400-3600
67	*Gentiana algida* var. *przewalskii* (Maxim.) Kusn.	Genalg	Gentianaceae	forb	4200-5000
68	*Gentiana bryoides* Burkill	Genbry	Gentianaceae	forb	3000-4500
69	*Gentiana depressa* D. Don	Gendep	Gentianaceae	forb	2900-4300
70	*Gentiana himalayensis* T. N. Ho	Genhim	Gentianaceae	forb	4000-4900
71	*Gentiana ornata* (D. Don) Griseb.	Genorn	Gentianaceae	forb	3400-5500
72	*Gentiana robusta* King ex Hook. f.	Genrob	Gentianaceae	forb	3500-4800

73	*Gentianella pedunculata* (D. Don) H. Smith	Genped	Gentianaceae	forb	3000-5000
74	*Gentienella paludosa* (Hooker) H. Smith	Genpal	Gentianaceae	forb	3000-4900
75	*Gentinella stellariifolia* (Forbes & Hemsley) H. Smith	Genste	Gentianaceae	forb	4100-4300
76	*Geranium donianum* Sweet	Gerdon	Geraniaceae	forb	2500-4800
77	*Gerbera nivea* (Dc.) Sch.	Gerniv	Asteraceae	forb	2800-4500
78	*Geum elatum* Wall. ex G. Don	Geuala	Rosaceae	forb	3500-5400
79	*Gueldenstaedtia himalaica* Baker	Guehim	Leguminosae	forb	3000-5000
80	*Haplosphaera himalayensis* Ludlow	Haphim	Apiaceae		3900
81	*Heracleum sublineare* C. B. Clarke	Hersub	Apiaceae	forb	3600-3850
82	*Herminium lanceum* (Thunb.) Vuijk	Herlan	Orchidaceae	forb	1000-3600
83	*Iris kemaonensis* D. Don ex Royle	Irikem	Iridaceae	forb	2500-4300
84	*Juncus thomsonii* Buchenau	Juntho	Juncaceae	graminoid	2700-5200
85	*Juniperus indica* Bertol.	Junind	Cupressaceae	shrub	2600-5100
86	*Juniperus recurva* Buch.-Ham. ex D. Don	Junrec	Cupressaceae	shrub	3000-4600
87	*Juniperus squamata* Buch.-Ham. ex D. Don	Junsqu	Cupressaceae	shrub	3300-4600
88	*Kobresia nepalensis* (Nees) Kuk.	Kobnep	Cyperaceae	graminoid	2900-5700
89	*Kobresia pygmaea* (C. B. Clarke)	Kobpyg	Cyperaceae	graminoid	3100-5600
90	*Kobresia uncinoides* (Boott) C. B. Clarke	Kobunc	Cyperaceae	graminoid	3500-4600
91	*Kobresia williamsii* T. Koyama	Kobwil	Cyperaceae	graminoid	3600-4000
92	*Lagostis kunawurensis* (Royle ex Benth.) Rupr.	Lagkun	Scrophulariaceae	forb	3900-5600
93	*Leibnitzia nepalensis* (Kunze) Kitam	Leinep	Asteraceae	forb	3200-4600
94	*Leontopodium pusillum* (Beauverd) Handel-Mazzetti	Leopus	Asteraceae	forb	3500-5600
95	*Leontopodium stracheyi* (Hook. f.) C. B. Clarke ex Hemsl.	Leostr	Asteraceae	forb	2200-4500
96	*Lomatogonium himalayense* (Klotzsch) E. Aitken	Lomhim	Gentianaceae	forb	3500-4400
97	*Lonicera hispida* Pallas ex Schultes	Lonhis	Caprifoliaceae	shrub	1700-4200
98	*Lonicera minutifolia* Kitam	Lonmin	Caprifoliaceae	shrub	3300-4500

99	*Lonicera obovata* Royle ex Hook. f. & Thomson	Lonobo	Caprifoliaceae	shrub	3500-4400
100	*Meconopsis horridula* Hook. f. & Thomson	Mechor	Papaveraceae	forb	3000-5800
101	*Medicago falcata* L.	Medfal	Fabaceae	forb	2700-4000
102	*Nardostachys grandiflora* DC.	Nargra	Valerianaceae	forb	3600-5000
103	*Oxygraphis polypetala* (Royle) Hook. f. & Thomson	Oxypol	Ranunculaceae	forb	3000-5000
104	*Parnassia cf. trinervis* Drude	Partri	Celastraceae	forb	3100-4500
105	*Pedicularis cheilanthifolia* Schrenk	Pedche	Orobanchaceae	forb	4200-5200
106	*Pedicularis megalantha* D. Don	Pedmeg	Orobanchaceae	forb	3100-4300
107	*Pedicularis pyramidata* Royle. ex. Benth.	Pedpyr	Orobanchaceae	forb	2100-5000
108	*Pedicularis rhinanthoides* Schrenk	Pedrhi	Orobanchaceae	forb	2300-5000
109	*Persicaria glacialis* (Meisn.) H. Hara	Pergla	Polygonaceae	forb	3500-5000
110	*Pleurospermum album* C. B. Clarke ex H. Wolff	Plealb	Apiaceae	forb	3900-4900
111	*Pleurospermum apiolens C. B. Clarke*	Pleapi	Apiaceae	forb	3600-4700
112	*Poa annua* L.	Poaann	Poaceae	graminoid	2300-3500
113	*Polygonatum cirrhifolium* (Wall.) Royle	Polcir	Liliaceae	forb	3700-4600
114	*Polygonatum hookeri* Baker	Polhoo	Liliaceae	forb	2900-5000
115	*Polygonum tubulosum* Boiss.	Poltub	Liliaceae	forb	3000-3500
116	*Potentilla argyrophylla var. atrosanguinea* (Lodd.)	Potatr	Rosaceae	forb	3300-4600
117	*Potentilla caliginosa* Sojak	Potcal	Rosaceae	forb	4100-4700
118	*Potentilla eriocarpa* Wall. ex Lehm.	Poteri	Rosaceae	forb	3600-5050
119	*Potentilla exigua* Sojak	Potexi	Rosaceae	forb	3800-4500
120	*Potentilla forrestii* W. W. Sm.	Potfor	Rosaceae	forb	4100-4850
121	*Potentilla fruticosa* L.	Potfru	Rosaceae	shrub	2400-5400
122	*Potentilla microphylla* D. Don	Potmic	Rosaceae	forb	3400-5200
123	*Potentilla peduncularis* D. Don	Potped	Rosaceae	forb	3000-4800
124	*Potentilla plurijuga* Hand.-Mazz.	Potplu	Rosaceae	forb	1200-4300

125	*Potentilla saudersiana* Royle	Potsau	Rosaceae	forb	3100-4900
126	*Primula atrodentata* W. W. Sm.	Priatr	Primulaceae	forb	3500-4900
127	*Primula capitata* Hook. f.	Pricap	Primulaceae	forb	3800-5000
128	Primula minutissima Jacquem. ex Duby	Primin	Primulaceae	forb	3700-5200
129	*Primula primulina* (Spreng.)	Pripri	Primulaceae	forb	3400-5000
130	*Pterocephalus hookeri* (C. B. Clarke) Diels	Ptehoo	Dipsacaceae	forb	3000-4500
131	*Ranunculus brotherusii* Freyn	Ranbro	Ranunculaceae	forb	3000-5000
132	*Rheum moorcroftianum* Royle	Rhemoo	Polygonaceae	forb	3600-5300
133	*Rhodiola crenulata* (Hook. f. & Thomson) H. Ohba	Rhocre	Crassulaceae	forb	4800-5600
134	*Rhodiola bupleuroides* (Wall. ex Hook. f. & Thomson) S. H. Fu	Rhoblu	Crassulaceae	forb	2000-5100
135	*Rhodiola hemalensis* (D. Don) S. H. Fu	Rhohem	Crassulaceae	forb	3700-4600
136	*Rhodiola humilis* (Hook. f. & Thomson emend. Raym.-Hamet) S. H. Fu	Rhohum	Crassulaceae	forb	3600-4800
137	*Rhododendron anthopogon* D. Don	Rhoant	Ericaceae	shrub	3000-5000
138	*Rhododendron lepidotum* Wall. ex G. Don	Rholep	Ericaceae	shrub	3000-4700
139	*Rhododendron nivale* Hook. f.	Rhoniv	Ericaceae	shrub	4600-5800
140	*Rhododendron setosum* D. Don	Rhoset	Ericaceae	shrub	3700-5600
141	*Rosa sericea* Lindl.	Rosser	Rosaceae	shrub	3000-4600
142	*Salix calyculata* Hook. f. ex Andersson	Salcal	Salicaceae	shrub	3600-4500
143	*Salix lindleyana* Wall. ex Andersson	Sallin	Salicaceae	shrub	3800-5000
144	*Saussurea leontodontoides* (DC.) Sch. Bip.	Sauleo	Asteraceae	forb	4300-5100
145	*Saussurea nepalensis* Spreng.	Saunep	Asteraceae	forb	3200-4900
146	*Saussurea polystichoides* Hook. f.	Saupol	Asteraceae	forb	4000-4700
147	*Saussurea taraxacifolia* Wall. ex DC.	Sautar	Asteraceae	forb	3400-5600
148	*Saxifraga andersonii* Engl	Saxand	Saxifragaceae	forb	3400-5500
149	*Saxifraga hirculoides* Decne.	Saxhir	Saxifragaceae	forb	4000-5600
150	*Saxifraga mucronulata* Royle	Saxmuc	Saxifragaceae	forb	3800-5400

151	*Sedum ewersii* Ledeb.	Sedewe	Crassulaceae	forb	2700-4500
152	*Sedum gagei Raym.-Hamet*	Sedgag	Crassulaceae	forb	3900-5000
153	*Sibbaldia parviflora* Edgew	Sibpar	Rosaceae	forb	3000-4500
154	*Silene caespitella* F. N. Williams	Silcae	Caryophyllaceae	forb	2700-4800
155	*Silene gonosperma* (Rupr.) Bocquet	Silgon	Caryophyllaceae	forb	3000-5500
156	*Silene nigrescens* (Edgew.) Majumdar	Silnig	Caryophyllaceae	forb	4000-5000
157	*Soroseris hookeriana* (C. B. Clarke) Stebb.	Sorhoo	Asteraceae	forb	4100-5300
158	*Spiraea arcuata* Hook. f.	Spiarc	Rosaceae	shrub	3500-4900
159	*Stellaria congestiflora* H. Hara	Stecon	Caryophyllaceae	forb	4200-4700
160	*Swertia ciliata* (D. Don ex G. Don) B. L. Burtt	Swecil	Gentianaceae	forb	2800-4000
161	*Swertia cuneata* D. Don	Swecun	Gentianaceae	forb	3900-5000
162	*Swertia multicaulis* D. Don	Swemul	Gentianaceae	forb	4000-4900
163	*Taraxacum pseudostenoceras* Soest	Tarpse	Asteraceae	forb	4400-4500
164	*Thalictrum alpinum* L.	Thaalp	Ranunculaceae	forb	2400-5300
165	*Thalictrum alpinum var. minutissimum* H. Hara	Thamin	Ranunculaceae	forb	3800-5000
166	*Thesium himalense* Royle ex Edgew.	Thehim	Santalaceae	forb	2900-4000
167	*Thymus linearis* Benth.	Thylin	Labiatae	shrub	2400-4500
168	*Trisetum spicatum* (L.) K. Richt.	Trispi	Poaceae	graminoid	2500-5600
169	*Trollius pumilus* D. Don	Tropum	Ranunculaceae	forb	3500-4900
170	Unknown B	UnkB			
171	Unknown C	UnkC			
172	*Veronica cephaloides* Pennell	Vercep	Scrophulariaceae	forb	3600-4500
173	*Veronica ciliata* Fisch	Vercil	Scrophulariaceae	forb	2700-4700
174	*Viola biflora* L.	Viobif	Violaceae	forb	2100-4500
175	*Woodsia alpina (Bolton) Gray*	Wooalp	Dryopteridaceae	fern	
176	*Youngia gracilipes* (Hook. f.) Babc. & Stebb	Yougra	Asteraceae	forb	2700-4800

Appendix II: Medicinal plant species recorded in the study area (based on empirical data and previous findings)

Medicinal Plants	Empirical Data					Based on previous findings
	Vernacular name		Use categories	Parts Used	Use form	
	Tibetan	Gurung				
Aconitum naviculare var. *leiocarpum* Tamura	boongkar	ponkhar	Fever, Other ailments(T), Fever, Cough & Cold, Circulatory System Disorder (G)	rt, wp	decoction	wp:fever (1,6,11,12,13), bile fever, infection (1,6,15); rt,lf,st,fl: poisoning (6); wp,rt: jaundice and antibiotic (11,15); wp: headache, bile and liver idsease (12); tuber:gall bladder (13)
Allium sikkimense Baker	re gok	nach koko	Circulatory system disorder, Other ailments (T)	lf, rt	Chewed	
Anaphalis contorta (D. Don) Hook.f.	tracha	phosro mendo	Dermatological infections, Skeleto-muscular problems (T),(G)	lf, wp	Paste	wp: cough (5,6,7,15), rt: wounds and boils (5,6,7); wp: insect repellent (7)
Anaphalis royleana DC.	tracha	phosro mendo	Dermatological infections, Skeleto-muscular problems(T), (G)	lf, wp	paste	
Anaphalis xylorhiza Sch. Bip. ex Hook.f.		phosro mendo	Dermatological infections, Skeleto-muscular problems(G)	Wp	paste	
Androsace strigillosa Franch	chatik rig		Gastro-intestinal ailments(T)	Wp	chewed	rt,fl,lf: boils on tongue, fever, body sweeling (1,2,6) hot lympgh fluid disorder (2,6, 15); boils in tongue (7,10); edema and fever (11,15)
Anemone rupicola Cambess	subka		Gastro-intestinal ailments (T)	Sd	powder, paste	sd: indigestion, gastritis, liver disease, fever (5,15); fr,sd: lung, bile disorder, diarrhoea (15)
Arenaria glanduligera	nema		Other ailments (T)	Sh	paste	

Edgew. ex Edgew. & Hook						
Aster himalaicus C. B. Clarke	meto luk mik	kaar sang mendo	Circulatory system disorder, Gastro-intestinal disorder (T)	sh	juice	lf,fl: fever, headache, liver and stomach disorder, heals wound (15); fl: cough, cold and lung problem (13)
Aster indamellus Grierson	upal ralteema	kaar sang mendo	Circulatory system disorder, Gastro-intestinal disorder (T)	Sh	paste	fl: relief free (8)
Berberis mucrifolia Ahrendt	terwa	kyung puchu	Circulatory system disorder (T), Opthalmological uses (G)	sh, fr, rt	powder	wp: diarrhoea, dysentry, eye problems(5, 15); kidney and bile treatment (10,12)
Bistorta affinis (D. Don) Greene	pang ram	khalti	ENT problems (G)	sd	decoction	rt,fl: diarrhoea and dysentry, tonic (2,10,12,13,15); wp: blood deficiency, cold, sinusitis and fever (10,12,15)
Bistorta macrophylla (D. Don) Sojak	pang rambu	khalti	Gastro-intestinal ailments (T), ENT problems (G)	sd, rh, rt	powder, decoction	Rt: diarrhoea, dysentry, intestinal disorder (2,6,7, 15) / fr: increase blood (2,6)/ fr: lung and liver disorder (4,6); rt: typhoid (11) ; sd: blood dysentry (10)
Bupleurum himalayense Klotzsch	seera carpo		Gastro-intestinal ailments (T)	wp, sd	juice	
Chenopodium aristatum L.	new chung		Other ailments (T)	Wp	paste	
Cremanthodium nepalense Kitam.	somo		Dermatological infections(T)	wp	paste,herbal bath	
Cremanthodium purpureifolium Kitam.	ming chen serpo	yarcha	Fever(T)	Lf, fl, st	paste	
Delphinium glaciale Hook. f. & Thomson	jya kope	jawa thang	Dermatological infections(T)	wp	paste,powder	
Delphinium kamaonense Huth	meedok jayakang		Gastro-intestinal ailments(T)	fl, lf	decoction	wp: scabies (1,7)
Elsholtzia eriostachya (Benth.) Benth.	jiiruk serpo	thang khabamra	Cuts/Wounds, Other ailments(T)	Wp	powder, paste	sd: cough and cold (7); lf,st,fl: stomachache, wounds, boils, skin disease (11,15); wp: smoke inhaled (8)
Ephedra gerardiana Wall.	che	ra phanti,	Circulatory system disorder,	lf, fr	Juice,	wp: asthamatic problems, respiratory disease, circulatory system

ex Stapf, Akad.		raphani	Dermatological Infections, Skeleto-muscular system problems (T)		powder, decoction, paste	(2,7,9,10,11,12,15); st: bleeding problems, tonic (3); st, fr: cough and cold, fever,digestion, eye infection (6, 13)
Euphorbia stracheyi Boiss.	tha ra nu		Gastro-intestinal ailments(T)	Rt	juice	rt: bile disorder, diarhhoea, imrove digestive system, skin disease (15,1); rt: constipation, skin disease, bacterial infection (6)
Gentiana algida var. przewalskii (Maxim.) Kusn.	pang gen trobo		Other ailments (T)	Fl	juice	lf,fl: throat disease, chest pain, poor eye sight, blood disorder (1, 15); fl: cough (13)
Gentiana depressa D. Don	pang gen trabo		Circulatory system disorder (T)	Wp	juice	wp: cough and cold (1,7)
Gentiana robusta King ex Hook. f.	keche carpo	ana pung	Gastro-intestinal ailments, Fever (T)	st, lf, fl	juice, decoction	wp:infections, bloot clot/ rt: cough, cold and stomachache (5,6,7,10,11); wp: edema (7,10,11); fl: fever (13); rt.lf,fl: bile,liver,urinary system disorder, fever, headache (15)
Gerbera nivea (Dc.) Sch.	tracha		Skeleto-muscular system (T)	lf	Paste	lf:dries pus and water (5); lf: wounds and pains (8)
Gueldenstaedtia himalaica Baker	reeg		Circulatory sysytem disorder (T)	fl	paste	wp: vomiting, cough, fever, internal injuries and sweeling (15)
Haplosphaera cf. himalayensis Ludlow	tu rig	manj	Other ailments (T)	wp	paste	
Iris kemaonensis D. Don ex Royle	drema	chipla	Other ailments (T)	wp, rt	paste, decoction	Rt,Lf: Fever (1), wp: cough, cold and asthma (7,8); sd: anthelmitic disease (15); wp: appetite stimulant, diuretic (15)
Juniperus indica Bertol.			Skeleto-muscular system, Dermatological infections (T)	lf, fr	powder, paste, herbal bath	lf,fr: cough and cold, skin disease (5,6); lf,fr: kidney disorder, wounds (6); lf: female urinary system (13)
Juniperus recurva Buch.-Ham. ex D. Don			Skeleto-muscular system, Dermatological infections (T)	lf, fl	powder, herbal bath	lf,fr:diarrhoea, skin disease (5)
Juniperus squamata Buch.-			Skeleto-muscular system,	Lf	powder,	wp: skin disease (1,7,9,11); lf: fever, cuts and wounds (5); lf:

Ham. ex D. Don			Dermatological infections (T)		paste, herbal bath	kidney problems (13)
Lagostis kunawurensis (Royle ex Benth.) Rupr.	bebasaka		Cough/Cold, Fever, Circulatory system disorder (T)	Wp	paste	wp:inflammation of lung, liver and intestine (3); wp: blood purification (13)
Leontopodium pusillum (Beauverd) Handel-Mazzetti	tracha	phosro mendo	Skeleto-muscular system (T)	lf	paste	st, fl: anti-inflammatory, anti toxin, bleeding problems (3)
Leontopodium stracheyi (Hook. f.) C. B. Clarke ex Hemsl.	tracha		Skeleto-muscular system (T)	Lf	paste	lf,fl: heat therapy (6)
Lomatogonium himalayense (Klotzsch) E. Aitken	chhak tik		Circulatory sysytem disorder (T)	Wp	chewed	
Medicago falcata L.	busa wang	tanitha	Respiratory system disease, Cough/Cold (T)	Wp	juice	wp: fever, stomach disorder, skin disease; rt: cough, cold and fever (15)
Nardostachys grandiflora DC.	pang pong	pangpoe	Circulatory system disorder (T)	Sh	powder, paste, decoction	rt: antiseptic, digestion, epilepsy, menstrual problems (1,2,5) rt: tonic, stimulant, laxative (2,5); cough, cold, fever, food poisoning (5,6); rt: sweeling/ lf: high altitude sickness (6); rt: haemorrhoids (7,10); wp,rt: diarrhoea, fever, gastritis, headache, rheumatism (11,12); wp: paralysis (13)
Pedicularis pyramidata Royle. ex. Benth.	longma mukpo		Circulatory system disorder, fever (T)	Sh	juice, chewed, paste	wp: against retention, accumulation of fluids, inflammation of bones (3); removes excess body fluids, analgesic and repiration, asthma (6)
Pedicularis rhinanthoides Schrenk	longma mukpo		Circulatory system disorder, fever (T)	Sh	juice, chewed, paste	
Pleurospermum album C. B. Clarke ex H. Wolff	chya wa rig	syame	Other ailments (T), ENT problems (G)	lf, rt	juice	

Pleurospermum cf. apiolens C. B. Clarke	chawa rig		other ailments, Genito-urinary ailments (T)	Rt	juice	
Polygonatum hookeri Baker	raamu saayak	gomse	other ailments, Genito-urinary ailments (T)	lf	juice	Rt: burning sensation, skin disease, ulcers, tuberculosis, wounds, burns (1); rt: tonic (15)
Pterocephalus hookeri (C. B. Clarke) Diels	pang chi dobo		Skeleto-muscular system, Fever (T)	Wp	juice	rt: fever (7); fl,lf : alleviate cold, fever, diarrhoea (9,11); sh: bile disorder, jaundice, intestinal pain (15)
Rheum moorcroftianum Royle	chucha	kech	Gastro-intestinal ailments (T)	rt, lf, pt, rh	paste, decoction	rt: laxative (2); lf: sinusitis (7); stm : blood purifier (11)
Rhodiola himalensis (D. Don) S. H. Fu	solo mempa	kolte mindo	Dermatological infections (T)	rt,st	juice	rt: arthritis, fever, skin disease (15); wp: kidney disease, skin disease, asthma, lung infection (6)
Rhododendron anthopogan D. Don	ballu	ballu	Circulatory sysytem disorder, Dermatological infections, Skeleto-muscular system problems (T)	lf, fl	decoction	lf: cold,cough, chronic bronchitis (2,3,6,7,9,10,12)/ st,fl: promotes heart, digestion, appetizer, skin disease (5,6); lf,fl: reduces blood pressure, paralysis, pains in limbs (11,13)
Saussurea leontodontoides (DC.) Sch. Bip.	tracha		Skeleto-muscular system (T)	Lf	paste	
Saussurea nepalensis Spreng.	gangla medok		Circulatory system disorder (T)	Wp	paste	rt,wp: fever, cough, asthma, dysentry, appetizer (7); menstrual disorder, sinusitis, bone fracture, wounds, bleeding(8,10,12)
Saussurea polystichoides Hook. f.	tracha		Skeleto-muscular system (T)	Lf	paste	
Saussurea taraxacifolia Wall. ex DC.	tracha		Skeleto-muscular system (T)	Lf	paste	
Sedum cf. ewersii Ledeb.	draak ya habo		Gastro-intestinal ailments (T)	Wp	juice	
Soroseris hookeriana (C. B. Clarke) Stebb.	solo serpo		Circulatory system disorder (T)	Wp	paste	fl: fever, purgative, blood pressure (15,6)

Swertia cuneata D. Don	tikta rig	pang tikta	Fever, Cough & Cold, Circulatory System Disorder (G)	lf, st	powder, paste	wp: fever (5,6,15); wp: bile and liver disease, cough and cold, headache (6,15);
Taraxacum pseudostenoceras Soest	chathi		Skeleto-muscular system, Circulatory System disorder (T)	Wp	paste, juice	
Thymus linearis Benth.			Dental Care, Gastro-intestinal problems (T)	lf, fl, sh	decoction, powder	lf,fl:cough, cold, stomachache, diarrhoea, indigestion (5), lf,fl: stimulant, blood purifier, tootache (6,13); wp: eye infection, dyspepsia (15)
Veronica cephaloides Pennell	dhom nak dhom tea		Circulatory sysytem disorder (T)	wp, lf, fl	juice	wp: bile disease, high BP, bleeding problems (1)
Veronica ciliata Hong			Circulatory sysytem disorder, fever (T)	lf, fl	juice	lf,fl: wounds, bile disease, high blood pressure, malarial fever, stops bleeding (6)

Used form followed by superscript letter represent Tibetan (T) and Gurung (G)

Parts used: fl- flower, fr- fruit, lf- leaf, pt- petiole, rt- root, rh- rhizome, sh- shoot, sd- seed, st- stem and wp- whole plant.

Previous findings based on: 1- Baral and Kurmi (2006), 2- DPR (2007), 3- Tsarong (1994), 4- DPR (2008), 5- Rokaya *et al.* (2010), 6- Lama *et al.* (2001), 7- Manandhar (2002), 8- Phole (1990), 9- Stainton (1988), 10- Gautam (2012), 11- Bhattarai *et al.* (2006), 12- Bhattarai *et al.* (2010), 13- DPR (2009), 14- Thapa (2015) and 15- Ghimire *et al.* (2008)

Appendix III: Medicinal plant species not used by local inhabitants but found to be useful elsewhere in the country

Medicinal Plants	**Use based on secondary literature not found as useful by local inhabitants**
Ajuga lupulina Maxim.	lf, fl, sd: skin problem fever, sinusitis (4,8) , epilepsy, swelling, infection (4); wp: menstrual disorder, epilepsy, infection, fever and muscular swelling(8,9)
Anaphalis nepalensis var. nepalensis (DC.) Airy	fever, edema (12)
Anaphalis triplinervis var. monocephala (DC.) Airy Shaw	fl, lf: heat therapy (3,4) food poison (3); fl, lf, st: fever, chest pain, inner bleeding (4); wp: cold, cough, tonsilitis, menstrual disorder (10); wp: edema (12)
Artemisia roxburghiana Besser	wp: wounds, scabies (11)
Artemisia subdigitata Mattf	wp: swelling, intestinal disorder (3)
Berberis erythroclada Ahrendt	br: gall bladder (3), eye problem (3,5)
Betula utilis D.Don	br: cuts and wounds (2), antiseptic, diarrhoea, dysentery, appetizer, headache, insomnia(5); used as plaster on purulent swelling and boils, relieve neck pain (6) br, lf: fever (10)
Bistorta affinis (D. Don) Greene	br, resin: antiseptic (2,5), carminative, used in hysteria, cuts and wounds (2); br: diarrhoea, dysentery, appetizer, headache, insomnia (5); used as plaster on purulent swelling and boils, relieve neck pain (6,8); br, lf: fever (10)
Bupleurum cf. falcatum L.	sd, wp: ling disorder, indigestion, boils (8)
Cicerbita macrorhiza var. saxatilis (Edgew.) P. Beauv	lf, fl: liver, bile disorder (4); wp, rt: relieve fever (7,10); wp: headache (9)
Cortia depressa (D. Don) C. Norman	rt: food poisoning, swelling (5), rt: fever (9)
Cotoneaster ludlowii Klotz	fr: cough and cold (13)
Cotoneaster microphyllus Wall. ex Lindl.	fr: rheumatism, menstrual and lymph fluid disorder, check excess bleeding (8)
Cremanthodium ellisii (Hook. f.) Kitam. ex Kitam. & Gould	fl, lf: tonsilitis, sore throat, wounds, cough and bile disorder (8)
Dendranthema nubigenum (Wall. ex Dc.) Kitam. Ex Kitam. & Gould.	rt, wp: nose bleeding, swelling, liver disorder, cough and fever, indigestion (8)

Epilobium brevifolium D. Don	wp: muscular pain (13)
Eriophyton wallichii Benth.	wp: anti-inflammatory (1)
Gentienella paludosa (Hooker) H. Smith	rt: cold, fever, catarrh, hoarseness (6), headache (6,9), wound (9)
Geranium donianum Sweet	rt: fever, bile disorder, cough, intestinal disorder, joint pain (4,8); gingivitis, toothache (10)
Geum elatum Wall. ex G. Don	lf: wounds(13)
Meconopsis horridula Hook. f. & Thomson	wp: against blockage of menses, placenta, remove foreign material from body such as stones, bullets (1); antidote, lung and skin disease (2,4); wp: bone fracture, bile disease, sinusitis, wounds (4,8), rt: antiseptic, digestive, epilespsy, hysteria, urination and menstruation (9)
Pedicularis megalantha D. Don	wp: fever, bile and lymph disorder (8)
Polygonatum cirrhifolium (Wall.) Royle	rh: tonic, promotes bodily heat, carminative (1,2); pain in kidney and hips, dries serous fluids (2); rt: restore vitality (4,8), bile , generates stomach heat, increase regenerative fluids (4); rt: diarrhoea, menstruation problem (5,10), cough(5,8,10) and fever (5,7,8,10); wp: aphrodisiac (9,10), rt: emollient, tonic, skin disease, wound, ulcer, tuberculosis, cough, chest pain
Potentilla argyrophylla var. atrosanguinea (Lodd.)	rt: toothache (9)
Potentilla fruticosa L.	lf: astringent (2); wp: blood purifier (3); st, lf, fr: breast disease, stomach and lung disorder (4,8), indigestion (4,8,9); rt: back bone pain (5); cuts and wounds (6)
Potentilla peduncularis D. Don	rt, lf buds: profuse menstruation, fever (9)
Ranunculus brotherusii Freyn	lf, fl, st: indigestion, cell tumours (4)
Rhiodiola crenulata (Hook. f. & Thomson) H. Ohba	rt: dysentry (11)
Rhodiola blupleuroides (Wall. ex Hook. f. & Thomson) S. H. Fu	rh: fever (8)
Rhododendron lepidotum Wall. ex G. Don	br, lf, fl: purgative, headache, back pain (2,4), blood purifier (2,4,8) bile problem (2,4,8); lf, fl: lung disease, cold (4) appetizer (4,8); lf, fl: diarrhoea (5); lf, fl: purify blood, cough, cold (10), tonsillitis (8,10); lf, fl: bone disease (8)
Rosa sericea Lindl.	fl, lf, br: headache, liver, bile and lung disease, lymph disorder (2,4,8) menstrual disorder (4,5)); fl: gall bladder (3); lf, fl: jaundice (5); fl, rt: eye pain(7); fr: diarrhoea, dysentery, stomach ache, dyspepsia, bile disorder (10); sd: ulcers, rt: dysentery (11); wp: fatigue, BP, bile disorder (12)
Salix calyculata Hook. f. ex Andersson	wp: fever, joint pain, skin ailments, menstrual disorder (8)
Silene gonosperma (Rupr.) Bocquet	rt: cold (5)

Silene nigrescens (Edgew.) Majumdar	fl: used against blockage of auditory canal, promotes hearing (1); rt: cold (5); wp: appetizer, digestion (8)
Spiraea arcuarta Hook. f.	cold, cough (6)
Swertia ciliata (D. Don ex G. Don) B. L. Burtt	medicinal (not mentioned) (6); wp: cough, cold, fever (7,10), jaundice, malarial fever , diabetes (10); wp: liver, urinary system disorder, fever, headache and gastritis (8)
Swertia multicaulis D. Don	wp, rt: cold, cough, stomach ache, prevent infection (2); wp: prevents bleeding, cuts and wounds (8)
Thalictrum alpinum L.	wp: cough, cold, fever, food poisoning, joint swelling, back bone pain (12)
Viola biflora L.	wp: boils, vitamin, toothache (12), wounds, bone fracture (8,12), bile disorder (8)

Previous finding based on: 1- Tsarong (1994), 2- DPR (2007), 3- DPR (2008), 4- Lama *et al.* (2001), 5- Rokaya *et al.* (2010), 6- Phole (1996), 7- Gautam (2012), 8- Ghimire *et al.* (2008), 9- Baral and Kurmi (2006), 10- Bhattarai *et al.* (2006), 11- Thapa (2015), 12- Bhattarai *et al.*(2010) and 13- Manandhar (2002).