INCENSE PLANTS, THEIR USES AND DIVERSITY IN UPPER MANANG, CENTRAL NEPAL

A Dissertation submitted for the partial fulfillment of the Master's Degree of Science in Botany

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September, 2013

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RECOMMENDATION

This is to certify that M. Sc. Dissertation work entitled "**Incense plants, their uses and diversity in upper Manang, Central Nepal**" has been carried out by Sita Karki under my supervision. The entire work is based on field study and lab work performed by the student and the same work has not been submitted for any other degree. I recommend this dissertation work to be accepted as a partial fulfillment for Master's Degree of Science in Botany, Tribhuvan University.

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LETTER OF APPROVAL

This dissertation work submitted by Sita Karki entitled "**Incense plants, their uses and diversity in upper Manang, Central Nepal**" has been accepted as a partial fulfillment of the requirements for Masters of Science in Botany (Plant Systematics and Biodiversity Unit).

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ACKNOWLEDGEMENT

I express so many debts and gratitude to all people and institutions that have contributed in this research endeavor. It is impossible to acknowledge my sincere gratitude to each of them because of limited space. Thank you all, but I would like to mention some of them who deserve the special acknowledgements.

First and foremost, I extend my sincere thanks to my supervisor Associate Professor Dr. Sangeeta Rajbhandary, Central Department of Botany (CDB), Tribhuvan University (TU) for her guidance, encouragement and efforts through the preparation of this dissertation.

I am tremendously grateful to Associate Professor Dr. Suresh Kumar Ghimire for his sharp insights, creative and constructive ideas and guidance at my field work. I deeply respect his ways to instruct me for his support.

I am thankful to Prof. Dr. Promod Kumar Jha, Head, CDB/TU and Prof. Dr. Krishna Kumar Shrestha, former Head, CDB/TU, for their incredible support throughout the completion of this study. I also like to thank Professor Dr. Mohan Siwakoti, Dr. Chitra Baniya for their help in different aspects of this research.

My heartfelt grateful goes to Gloria project (CDB/TU, MBG) that rendered my dream comes true with financial support for this study. I couldn't have been able to walk the long way research in this area of Nepal without the support of this project.

I would also express my sincere thanks to my friends and team members of Gloria project Mr. Laxmi Raj Joshi, Mr. Prem Upadhaye Subedi, Mr. Arjun Chapagain, Ms. Smriti Lo and Mrs Asha Poudel for their encouragements, interactions, suggestions, continuous help and good accompany during field work. I wish my thanks to all the assistants and local people for their help during my field work. My special thanks go to Mr. Sankar Panthi for guiding me in spite of his busy schedule in data analysis. I would also like to acknowledge Mr. Janardhan Mainali and whole the ReSoN team member for their continuous help during my writing and analysis.

I would also like to acknowledge my sisters Lila, Shanti and Mrs Bimala Karki for their continuous support and encourage during my thesis writing and analysis. I would also like to acknowledge my friends Dr. Subhadra Karki, Mr. Pramod Pandey, Mr. Rupesh Kumar Yadav, Mrs. Srijana Shah and other seniors who helped me during this work. I am also thankful to all my friends and staff of Central Department of Botany as well as other friends and peoples who directly or indirectly helped me during research period.

Finally, I am indebted to my family for their continuous support and encouragement in every turn of life and for the completion of my master degree but here I am unable to express my felling in words. I owe all my success to them forward in my life for their valuable suggestions.

September 2013 Sita Karki

ABSTRACT

This study aims to document the incense plants, their uses in other purposes and diversity along different elevation gradients in Upper Manang. The study area is very rich in terms of incense plants. The local people are highly knowledgeable and totally dependent on incense plants. Forty different household were surveyed from which a total of 31 plants were found to be used as incense. These incense plants were also found to be used in other purpose like medicine, fodder, fuel wood etc. Therefore, ethnobotanical study of incense plants was done. The ecological sampling was done an altitudinal gradient of 3200 to 4300 m asl and total of 66 plots (10m×10m) was taken. Latitude, longitude, altitude, aspects and grazing intensity were recorded in each plot. Total 24 incense plant species out of 31 species were recorded from different 66 plots among them 13 were herbaceous and 11 woody species. DCA was used to assess gradient in species composition. Incense species composition was heterogeneous which was reflected by longer gradient length. A Generalized linear model was used to elucidate the pattern of species richness. A quasi-Poison error distribution with F-test was used where the data showed the over dispersion. The incense plants with their life forms were also regressed against the altitude, RRI, and grazing.

Incense species showed a unimodel pattern with altitude whereas woody incense species showed a linear pattern but other life form did not show any significant relationship with altitude. Incense species did not show any relation with RRI but its life form showed linear relationship. A linear pattern of grazing was also observed with incense plants and its different life. Environmental variables play a dominant role to explain the pattern of richness at the local scale.

KEY WORDS: Incense plants, Ethnobotany, Species richness, DCA, GLM

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ACRONYMES AND ABBEREVIATIONS

^{O}C	Degree Celcius
Alt	Altitude
DCA	Detrended Correspondence Analysis
GLM	Generalized Linear Model
ITK	Indigenous Traditional Knowledge
ReSoN	Research Solution Nepal, Kirtipur
MBG	Missouri Botanical Garden, USA
CDB	Central Department of Botany
m	Meter
m asl	Meter above sea level
RRI	Relative Radiation Index
Spp.	Species
SD	Standard Deviation
TUCH	Tribhuvan University of Central Herbarium
VDC	Village development Committee

1. INTRODUCTION

1.1 Background

The Himalayan mountain region represents the longest altitudinal gradients, containing varied vegetation types and a wide range of eco-climatic zones which differs in altitude, topography, status of soil and climatic conditions that favours high species and thus supports different forest types (Dobremez, 1976). Nepal reflects its rich floral diversity due to its unique geographic, altitudinal and climatic variations, which varies from tropical lowland rain forest to temperate forests of oak and conifers in the mid hills to dwarf scrubs of *Rhododendron* and alpine meadows in the higher regions (Stainton, 1972). It is considered as a crossroad of plant migration in the Himalayan region, overlapping between eastern and western Himalayan elements that merge in Central Nepal (Shrestha & Joshi, 1996).

If the level of diversity were the same everywhere, the diversity would not be interesting. No single process or theory can explain a phenomenon as complex as biological diversity so it needs conceptual clarity to understand the phenomenon that is influenced by many different interacting factors and processes (Wilson, 1992). Many products and services derived from biodiversity are highly diverse with benefits that increase value at the local, national and global levels (Daily, 1997; Salick et al., 1999). Majority of the biological resources may be used directly by households in response to food insecurity and natural disasters or indirectly in the form of food, fuel, fibre, medicines and as raw materials for different household item. Biodiversity provides many products to sustain life and also performs many functions that maintain ecosystem integrity on the other hand (Daily, 1997).

The ability to measure biodiversity is critically important because it gives the soaring rates of species extinction and human alteration of natural habitats (Brown et al., 2007). The simplest and most frequently used measure of biological diversity is species richness which is the number of species per unit area. Each species has definite response towards particular environmental niche. Environmental factors severely affect the species having a narrow niche and govern the change in species composition. According to Salick et al. (2004) altitude is the predominant vegetational and ethnobotanical variable with aspect and slope that secondarily affects the plant species richness, diversity and distributions. Thus, an altitudinal gradient is a major factor that brings changes in a range of factors, responsible for affecting species diversity (Rahbek,1997; Grytnes and Vetaas,2002; Grytnes, 2003).

1.2 Ethnobotany

Ethnobotany is a branch of science that includes the beliefs, tradition, religion and culture of the particular community or area, refers to the study of the relationship between people and plants (Martin, 1995). The use of plants and their products for different purposes can be traced as far back as the beginning of human civilization so the interactions between people and plants have been established along with the evolution of human beings. Martin (1995) also defined ethnobotany as the relationship of the people with the surrounding environments. Ethnobotanical research is concerned with the use of plants by the local people in their daily life. It is well known that plants have been used in different purposes since ancient times. Biological resources are the key source of energy in all forms consumed by human beings for their survival. Plant species provide the majority of food, medicines, fibres, timber drugs, incense, items for decoration etc required for living beings.

All cultures like Hindu, Christian, Buddhist and Muslim around the world had access to various plants from which they develop a recipe for pleasing the nose and mind. They also provided us with instructions for using aromas that were pleasing not only to the senses of the human nose, but also to the senses of the divine forces in their lives (Carey, 2008). Many traditional communities with their own culture depend on the plant resources for their livelihood in terms of medicine, food, timber, incense, grazing and hunting (Salick & Byg, 2007). Traditional knowledge generally focuses on the relationship between plants and human throughout human history. It also helps to document the knowledge of plants that has come through generations (Sharma et al., 2009). Its importance has been realized because it brings light to numerous less known or unknown uses of plants, some of which have potential usage (Chaudhary, 1998).

Nepal, in terms of Indigenous Traditional Knowledge (ITK) is considered as one of the richest countries due to its geographical diversities and many ethnic communities. All communities have some kind of traditional knowledge associated with their life from time immemorial. It also provides invariable knowledge and aid in making best use of natural resources (Sharma et al., 2009).

1.3 Incense plants

The term incense refers to the substance itself, rather than to the odour it produces. Any plant having good aroma are used as incense. Because of its good odour, it is used in religious ceremonies, ritual purification and aromatherapy, medicine, for creating a spiritual atmosphere and for masking unpleasant odours. According to Manandhar (2004), incense is one of the items of puja. Different types of plants in different forms are used for this. Thus, the incense is an important item of puja so people keep it constantly in their houses. Generally, people try to use those plants which are available in their surrounding areas.

It has become very important from socio-cultural and economic point of view. Therefore, uses of incense plants are diverse. Usually, incense plant is burned to communicate with spiritual entities and for fumigations that enhance personal well-being. The locations where incense is burned for these communicative acts include graves, shrines, temples, and kitchen stoves (Staub et al., 2011). To perform pujas (religious worship) daily, seasonally, monthly, annually, periodically or on certain occasions, incense plants play an important role in procuring the ritual objects necessary for people. Many attempts have been made to return to the sources of traditional cultural value in order to record and document the treasured knowledge on incense plants that still exist with different caste and ethnic community (Pohle, 1990). However, these attempts have ignored detailed studies on spiritual and cultural values of plants in heterogeneous Hindu dominated Nepalese society that gives higher social recognition on it (Acharya, 2003).

Incense plants are one of the essential offerings during ritual and religious activities. According to Bhattacharya (1998), each of these offerings has symbolic spiritual significance and is offered to the divine in a particular order. Incense keeps the fractioned mind calm while performing ritual worship. It has been used for centuries for ceremonial purposes as well as fragrance to the environment, also conceals undesired ambient odours, or freshen clothing (Knight et al. (2001)). Acharya (2003) examined how the socio-cultural and spiritual values in Nepal influence the way of Nepalese communities perceive plants and found about 80 plant species that are used in socio-cultural festivals in Kusma, Parbat of Western Development Region of Nepal. Carey (2008) studied many flowers and plants with specific reference to incense in which whether from ancient knowledge or modern practice and also found that a great number of people use incense for the sake of appeasing the Divine Spirit in their culture or religion to attain favour or their own personal enlightenment.

Bhattacharya (1998) lended her knowledge to share insight in the use of incense plants in Hindu culture, where as Knight et al. (2001) studied some plants used for candle and incense as potential sources of indoor air pollution in which incense has been used for centuries for ceremonial purposes as well as to add fragrance to the environment. According to Packaged (1999), most of the incense is made from a combination of fragrant gums, resins, woods, and spices and one traditional method of making incense is to prepare a paste of pulverized botanicals, water, and charcoal and wrap the paste around a bamboo twig. After the twig dries, it is dipped into perfumed essential oils or powders. Incense is available in varied forms like sticks, cones, rods, coils, small blocks, wands, and powders. The history of incense in different cultures and religions come from several sources (Carey, 2008).

Staub et al. (2011) documented total 17 species for use in incense in Southeast China and also found that local people of the study area always used the mixtures of different plant species and are either burned in the form of powders in a censer or as joss sticks. They also found that incense is burned for communication with spiritual entities at graves, temples, and cooking stoves, as well as for personal well-being.

Manandhar (2004) identified 31 species of plants belonging to 11 families under 8 genera that have been used for incense purpose in Nepal. Among these family Asteraceae represented the maximum number of incense plant species in Nepal.

Bhattarai et al. (2008) recorded 27 ritual and religious plant species belonging to 11 families under 16 genera from Manang district of Nepal. Bhattarai (2009) also reported 19 incense plant species from Manang.

1.4 Species richness

Plant species richness means the overall number of plant species found at per unit area. It is most widely used measure of diversity which is assumed as a simple and easily interpretable indicator of biological diversity thus, the pattern of species richness changes with altitude characterizes the vegetation in a simple but powerful way (Peet, 1974; Whittakar, 1977).

Generally, species richness is lower at higher altitude because of the cooler environments as one ascends for mountains is that as the number of species decreases in progressively cooler climates moving from tropical to polar region (Ohlemuller and Wilson, 2000). On the basis of several reviewed papers, Rahbek (1995, 1997) came to the conclusion that, in general there are three main patterns of species richness as: a monotonic decline in species richness from low to high elevation; a hump shaped pattern with a maximum richness at mid-elevation or essentially a constant from the lowlands to mid-elevations followed by a strong decline further up.

Species richness is important to determine the pattern in species distribution along different parameter which may vary at local and broad scale study. Vetaas and Grytnes (2002) studied distribution of vascular plant species and endemic richness along the Himalayan elevation gradient in Nepal. They found that there was no statistically significant positive correlation between log-area, richness and the proportion of endemic species but it increases steadily from low to high elevations. Lesser number of species at lower and higher altitude and greater number of species richness along the mid altitude gradients are proved by various researches investigated on plants (Vetaas and Grytnes, 2002; Panthi et al. 2007; Bhatta and Chaudhary 2009; Baniya et al., 2012), orchid (Acharya et al., 2011) and lichen (Baniya et al., 2010).

Panthi (2006) studied plant diversity and resource utilization in Argakhanchi and Manang Districts of Nepal. He recorded 68 species under 50 genera from the Manang district. He also found the species composition, plant resource utilization pattern in Argakhanchi and Manang Districts.

Subedi (2006) studied the distribution pattern of plant species in Manang along the whole Himalayan elevation gradient of Nepal. He recorded three hundred three species using primary and secondary data. The study showed the hump shaped distribution with optimum species at 3500 m. According to Subedi et al. (2007), there is a hump shaped relationship between species richness and altitude in Manang along the whole Himalayan elevation gradient which is estimated by generalized linear model. Rijal (2007) also studied the plant species diversity and environmental justice of resource use in upper Manang. He recorded altogether one hundred eight species of vascular plant from three different sites. He selected three different sites with special reference to tree line ecotone and lower elevation near from goat-shed. His result did not show any significant correlation for natural resources and environmental justice.

Bhatta and Chaudhary (2009) collected altogether 600 specimens from the upper Manang area covering elevation gradients of 2600-5200 m above sea level and of which 220 species belonging to 138 genera and 50 families were identified up to species level and used to estimate species richness. A unimodal pattern of species was obtained along greatest elevation gradient between 3500-4000 m altitudes, whereas no any angiosperm species was encountered beyond 5100 m.

Environmental factors greatly affect the species diversity within a community. It includes both resource gradients such as water or soil nutrients for plants and gradients in conditions such as temperature and pH.

1.5 Justification of study

Due to great variations in the climate, altitude and aspect, Manang valley supports unique vegetation with high species diversity. Manang district is also rich in terms of socio-culture and indigenous knowledge related to the use of biodiversity. Most of the people of Manang use different types of incense plants daily for their religious purposes as well as in other uses. Therefore, this study will help to document the indigenous knowledge on the utilization pattern of incense plants used by local people. The area chosen is very rich in biodiversity and socio-culture thus this work would help to document the ethnobatanically important plants particularly used for incense.

1.6 Hypothesis

The hypotheses were generated during this study are

- The traditional knowledge on the use of incense plants may have significant role in religious rituals, medicinal, fodder, ornamental uses etc.

- Incense plants richness with their composition varies significantly along elevation gradient.

1.7 Research questions

- What are major incense plants used by local people?
- Is there any use of incense plants for other purpose?
- What is the general pattern between elevation and incense plant richness and its composition in the study area?
- Is there any role of environmental parameter like relative radiation index (RRI) and grazing on the incense plant richness pattern at high elevation?

1.8 Objectives

General objective of this research work is to document the indigenous knowledge on the incense plants used by local people and to find out the relation of incense species richness along the altitudinal gradient.

Specific objectives of this work are

- To document detail use of incense plants used by local people.
- To document the use frequency value of incense plants by the local people.
- To analyze the incense plant species richness pattern with the existing environmental variables.

2. MATERIALS AND METHODS

2.1 Study area

2.1.1 Location and physiography

Manang district is located in the extreme northern side of Gandaki zone in the north-central part of Nepal, with an area of 2,246 square km at 28^{0}27'N to 28^{0}54'N latitudes and 83^{0}50'E to 85^{0}34'E longitude. This district is a part of Trans-Himalayan zone of Nepal having semi-arid type of climate and phytogeography. It is situated entirely within the Annapurna Conservation Area Project (ACAP). Its unique geographical terrain is bounded by the Tibet to the north and high mountain chains to the west, south and east. High mountains occupy most of the surface area of this region. Nearly 84 percentage of the total area of Manang district is composed of high mountains and hills and only 4.5 percent of total land area is covered by forest and shrubs (Shrestha et al.1995). The altitude of this region varies from 1600 to 8150 m asl. The district headquarter is Chame which is located at an altitude of 2660 m asl.

The specific study area includes Bhraka (3435 m) and Manang (3535m) VDCs.

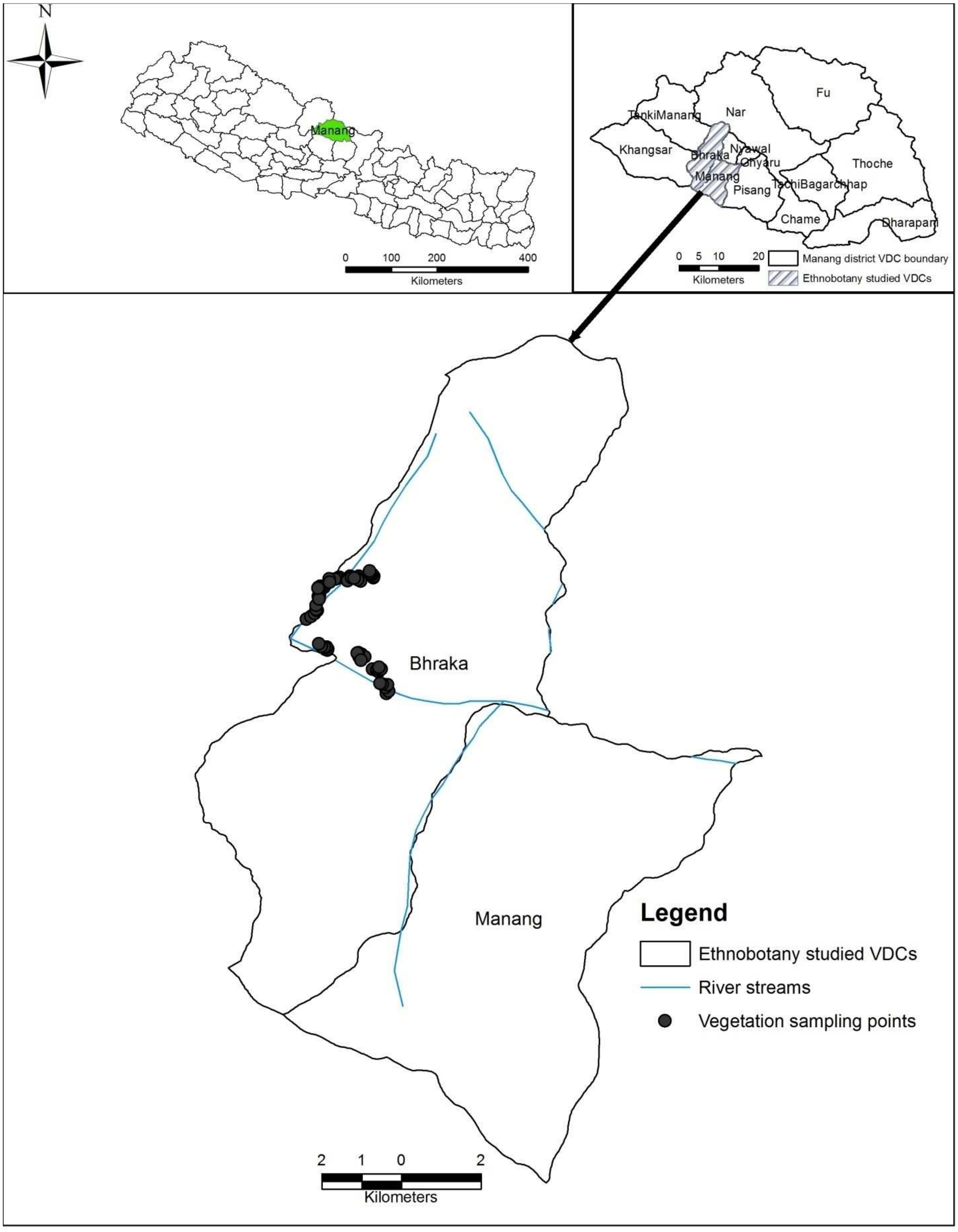


Fig.1: Map of study area

2.1.2 Vegetation

Manang is a ‘U’ shaped valley that runs northwest to southeast. Corresponding to the climate and altitude, there is change in vegetation types (Pohle, 1990). This can be noticed from subtropical to temperate, xerophilous to alpine formations. Tree line position in Nepal ranges from 3650 to 4000 m (Stainton, 1972) but in Manang tree line reaches up to 4300 m (Shrestha et al., 1995).

The vegetation of South facing slope is totally different from North facing slope. In the South facing slope tree species like *Betula utilis* and *Abies spectabilis* are found only at lower elevation on moist gullies. Tree line also lies at lower altitude in comparison to northern slope. In the higher elevation of South facing slope, patches of bushy shrubs and different species of herbs and grasses are found so, the southern slopes have sparse grass vegetation because of much drier than the northern slopes.

The Manang district possesses five types of vegetation like Dry Alpine Scrub, Moist Alpine scrub, Birch-Rhododendron forest, Fir forest and Temperate forest (Anonymous, 2002). Dry alpine scrub is characterized by the occurrence of dwarf prostrate *Juniperus* species namely *Juniperus indica, J. squamata, J. recurva, Ephedra gerardiana, Potentilla fruticosa.* The moist alpine scrub contains *Rhododendron* and a number dwarf scrub, such as *Juniperus indica, Lonicera ovobata* and other associated plants are *Astragalus, Berberis, Caragana, Lonicera* spp., *Hippophae tibetana* etc. Birch forest often mixed with *Abies spectabilis* are found on north facing shady slopes and ravines with an understory of *Rhododendrons* and *Sorbus* spp. The extensive grasslands in Manang are found only above 4500 m in north facing as well as south facing slopes in the Nyeshang as well as Nar-Phu area.

2.1.3 Climate

There is a great variation in the climate of Manang due to the extreme variation in the altitude and aspect with different landscape. It has a temperate, cool temperate and alpine type of climate. Lamjung and Manaslu separate humid outer Himalaya from dry inner and continental Tibetan Himalayan (Pohle, 1990; Kitamura, 1995). There is no climatic station in upper Manang. However, the climate of upper Manang more or less resembles with that Jomsom (Rijal, 2007). Annual precipitation of Gyasumdo is influenced by summer monsoon, while Nyeshang and Nar-Phu are beyond the reach of monsoon. From mid October to mid March, Nyeshang and Nar valleys remains covered with snow and after that snow begins to melt and the area receives little rainfall. The mean annual precipitation in Gyasumdo accounts 102.91 mm from Chame station (2011). Average maximum temperature of 17.36^{0}C and average minimum temperature of 2.6^{0}C.were recorded in Chame station (2011).The average minimum and maximum temperature recorded in Jomsom were 5.71 and 18.44 respectively (Jomsom station, 2011). The mean annual rainfall in Jomsom accounts 23.85 mm. Climate data of Jomsom (2010) is given below.

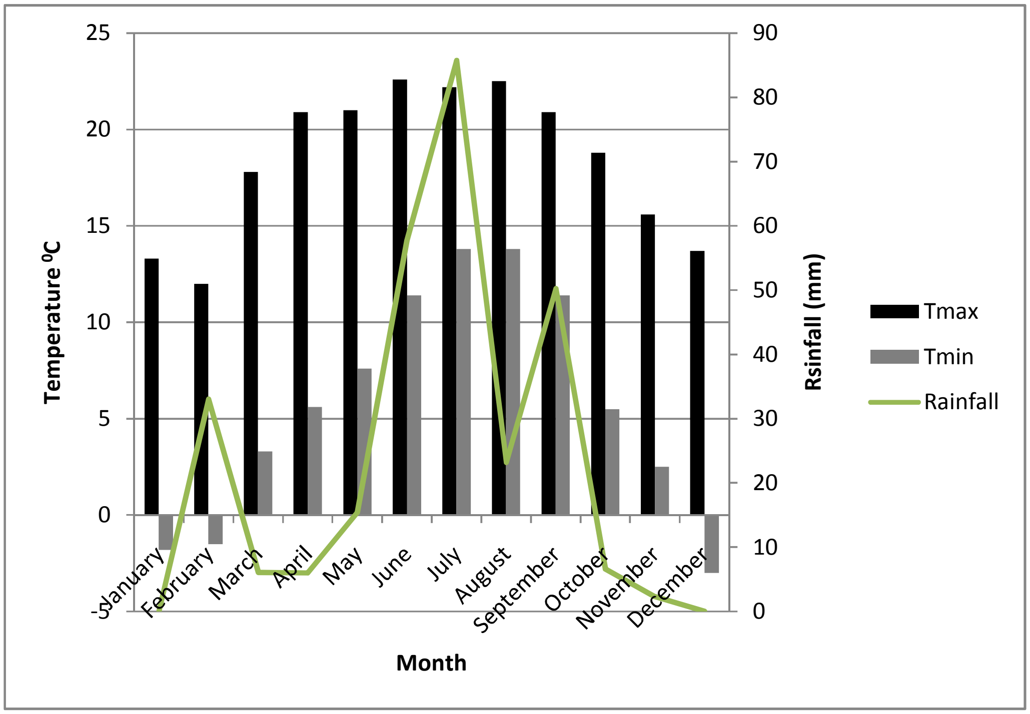


Fig.2: Average Meteorological Records of Jomsom station (2744 m).

Tmax-maximum temperature, Tmin-minimum temperature. Source: Department of Hydrological and Meterological, Babarmahal, Government of Nepal (2010)

2.1.4 People and land use pattern

People of Manang are generally known as 'Manangi' but are composed of diverse group of people. Inhabitants residing in different ecological zones are also distinct in their cultural way of living. The Nyeshang and Nar-Phu valleys are occupied by

Buddhist people. The people of Nyeshang are called Manangi or Nyeshangba (Gurung) whereas the Nar and Phu people are called *Narba* and *Phoobha* respectively, and both of them are Lamas. In Gyasumdo, two distinct clans inhabit—the Lamas (Gyasumdopa) and Gurungs, who are said to have migrated from Nyeshang (NTNC, 2008).

According to CBS (2011) the total population of Manang is 6,527 among them male population is 3,664 and female population is 2,863. The annual growth rate is negative (3.84%).The total number of households are 1,495. The average household size is 4.37. The population density is 3 person/sq. km, which is the least populated district of Nepal. Regarding the ethnic composition of the population of Manang district, there are four ethnic groups: the Gurungs, the Narpas, the Gyasumdopas and Manangis (NTNC, 2008). The major inhabitants fall under the Ghale or Gurung cast groups.

Pastoral agriculture is the main occupation of the people of upper Manang supporting a single seasonal crop per year. The main crops are wheat (*Triticum aestivum*), buckwheat (*Fagopyrum esculentum*), potato (*Solanum tuberosum*) and barley (*Hordeum vulgare*). Their main income sources are animal husbandry, agriculture, hotels & lodge, trade and tourism. Manangis have their own system for using the pasture. They always solve their problems or disputes by themselves. Each VDC has its own boundary up to which people and cattle of that VDC can inter to use forest products. If cattle of one VDC cross the boundary of another VDC then cattle owner has to pay the fine. Similarly, people of one VDC cannot collect the forest product of another VDC and vice versa. They have established goat-shed within the boundary of their respective villages.

2.1.5 Culture and cultural heritage

Most of the local inhabitants of Manang use 'Gurung' as their surname but they are also popularly known as Manangi. However, local communities of Gyasumdo and Nyeshang valleys see themselves different from people of Nar and Phu, and traditionally they refrain from inter-marriages between the people of two valleys (Phole, 1090). Ethnically, Gurung (including Ghale), is the dominant group in Manang. Besides this, there are other inhabitants such as Lama (immigrants from Tibet but settled in Manang for two to three generations) and Bishwakarmas, but their numbers are insignificant.

Culturally, Manangi belongs to the Tibetan sphere and their language traces back from the Tibeto-Burman origin (NTNC, 2008). Manang has very strong and effective traditional system of village governance managing natural resources and maintain cultural and social fabrics. Despite political changes, the traditional 'Khamb-Ngerbia' or mukhiya system is still in practice in most of the villages (NTNC, 2008). All people of Manang are Buddhist.

Every morning sometimes evening, Manangi use incense plants (by drying, crushing, mixing and adding ghee) to enhance the spiritual atmosphere and general well being of family. While lighting the incense plants in a glowing ember, a person from the family/usually a young and older member says confidential prayers in their local language.

2.2 Ethnobotanical study

The ethnobotanical study was conducted to document the indigenous knowledge on the incense plants. For this, primary data was collected from local people. Semi-structured questionnaires were presented by following the guidelines of Martin (1995) (Appendix 1). The primary information regarding the use, values and amount of incense plants were collected with the help of interviews with general public and focus group discussions with specific knowledgeable people by using semi-structured questionnaire. Information given by an informer was cross checked repeatedly by asking with several others users. Along with the information provided by local people, the voucher specimens were also collected. The identification in terms of vernacular names and uses was reconfirmed with strong participations of the local people.

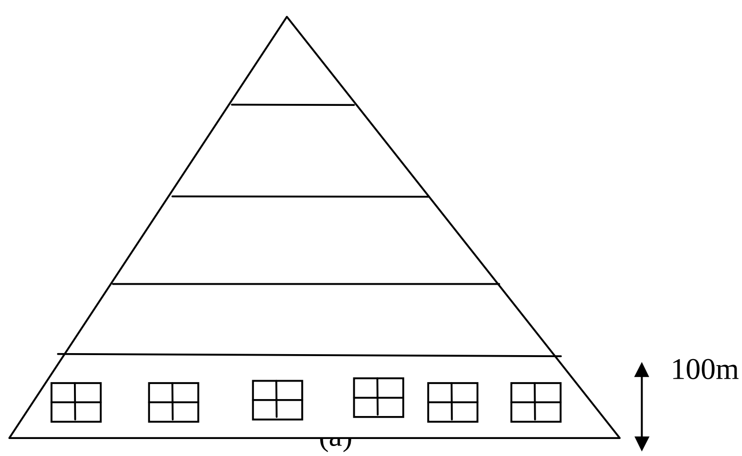
Altogether forty different households were interviewed. The plants used in incense were documented from each household. The total use of each incense plants were also documented from studied household. The frequency value of each incense plant was calculated to get final use frequency value which ranged from 1 to 40. It was again categorized into use frequency index ranging from 0-20%, 21-40%, 41-60%, 61-80%

and 81 to 100%. Incense species use value was categorized on the basis of final use frequency index.

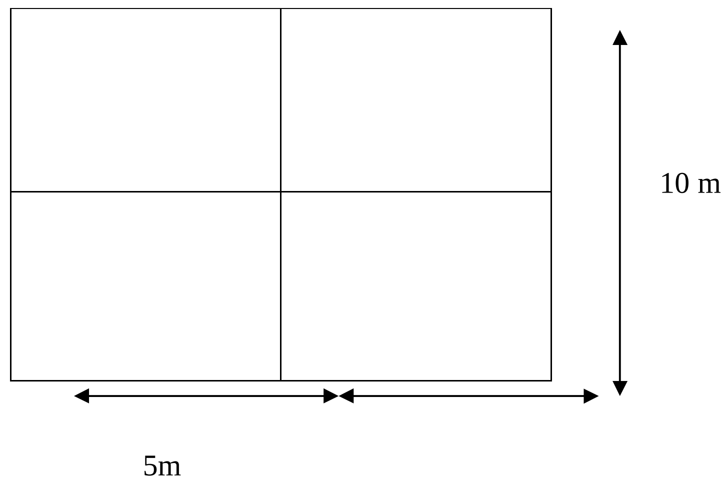
2.3 Sampling

2.3.1 Sampling techniques and data collection

Research was conducted in the month of September, 2011. All the necessary primary data was collected from the field by using semi systematic sampling method. A semi systematic representative sampling method was used for data collection to cover all the possible habitat and vegetation types. This sampling method was designed to include all the life form types and vegetation zones within 3200m to 4300m. Six plots of $10\times10m^2$, each were sampled in each 100m elevation band i.e. a total of 66 plots between 3200 m to 4300 m to include tree and shrub (woody) and herb incense plant species. Each plot was subdivided into four sub-plot of $5\times5\ m^2$ size and species presence was recorded for each subplot separately. This subdivision was done only to make easier to count the presence/absence data. The first plot was laid below the road which was near to river. The distance between two plots was not less than 50 m (walking distance) so that clustering of plots may not occur within the 100m altitudinal range. The direction of next plot from earlier plot was determined by tossing a coin to avoid biasness. Longitude, latitude and elevation of each sample plot were recorded by Global Positioning System (GPS) and elevation was cross checked with a standardized altimeter, slope and aspect of each plot were also recorded by a clinometers compass.



(a)



(b)Fig.3: Sampling design in a hypothetical mountain slope; (a) Sampling strategy for each 100m belt and (b) Sampling strategy for each plot (10m).

2.3.2 Plant collection and identification

Most of the plant species were identified in the field by using the field guides like Polunin and Stainton (1994), Stainton (1988), Grierson and Long (1983-2001). Species that could not be identified in the field were collected, tagged, dried and brought to Central Department of Botany, Tribhuvan University for further identification. Digital photographs of live plant species were also taken in the field and then photo number and tag number was noted. The unidentified specimens were confirmed by comparing the specimen's deposited at Tribhuvan University Central herbarium (TUCH). Press et al. (2000) was followed for the nomenclature. Voucher specimens are housed at TUCH.

2.3.3 Data preparation and numerical analysis

The field data sheets were further elaborated and made reliable for the numerical analysis. Incense plants were categorized into herb incense and woody incense. In this study, altitude is mainly considered as main environmental variable. Other environmental variables are relative radiation index (RRI) and grazing.

2.3.3.1 Species richness

Species richness is the number of species in a given area. Here, species richness is defined as the total number of incense species encountered within $10\times10m^2$ plots. Incense species were first of all documented by local people through interviews and focus group discussion and then sampling was done for species richness. $10\times10m^2$ plots were taken because study area included tree, shrub and herbs. Species richness of the landscape comprises both the species richness in individual habitat and the degree of variation in species composition among the different habitat. It is one of the most interpretable fundamental measurements of community and region diversity and it is applicable to standardize and non- standardize plot (Bhattarai, 2003).

2.3.3.2 Relative Radiation index (RRI)

Radiation is one of the important primary factors that influences on vegetation composition and spatial pattern. Topographic orientation is often used as a proxy for relative radiation load due to its effects on evaporation demand and local temperature (Kenneth et al, 2005). The relative radiation index (RRI) gives a relative value of how much solar radiation of a particular spot receives at noon at equinox. It was calculated by using the formula given by Ôke (1987) which is the composite value of the measurement of slope, aspect and latitudes whose value ranges from +1 to -1 (Baniya, 2004).

$$RRI = \cos(180^0-\Omega).\sin\beta.\sin\Phi+\cos\beta.\cos\Phi$$

Where, Ω is aspect, β is the slope and Φ is the latitude of each plot.

2.3.3.3 Generalized linear model (GLM)

GLM is a parametric model which is used to relate the species richness to the environmental variables. GLMs were used to elucidate the relationship between the species richness and elevation. Along with this, it was also used to elucidate the relationship between species richness with RRI and grazing respectively. Species richness was used as the response variable and others like elevation, RRI and grazing as the explanatory variables. The response variable i.e, species richness is discrete data (counts) that expected to have a Poisson distribution of error ((Mc cullagh and Nelder, 1989). GLM is able to link the response variable to the explanatory variables with a log-link function (Mc cullagh & Nelder, 1989; Hastie & Pregibon, 1993). The over dispersion of deviance was observed thus an F- test statistics with a quasi-poisson distribution of error was used to normalize the data (Hastie & Pregibon 1993; Crawley, 2007).

Environmental variables were tested up to third order to evaluate the significance of additional device and monotonic versus unimodel trend (i.e. unimodality was evaluated by testing the significance of the model including a second order polynomial term against a linear model). Most parsimonious model of response and prediction and model with the best fit were selected (by evaluating the F-value). Here, GLM was used to relate the species richness and to the environmental variables like elevation, RRI (relative radiation index) and grazing.

2.3.3.4 Detrended Correspondence Analysis (DCA)

DCA is one of the most popular robust indirect gradient analyses, which was used to explore the main trend between species and samples. It is suitable for displaying floristic gradients and is free from distortion at gradient ends and eliminates arch effect after detrending into 0 mean and 1 standard deviation (Hill and Gauch, 1980).

The first two axes were then correlated with the explanatory variables. Beta diversity of community composition was measured by estimating the length of gradients i.e. the extent of species turns over in standard deviation (SD) units (Hill and Gauch, 1980; Hugh, 1995). The SD units of first two ordination axis (axis I and axis II) together with the eigenvalues (total inertia) were used to evaluate the dispersion and heterogeneity pattern of species. Eigenvalues are the shrinkage values in weighted averages (Oksanen, 2011). The axis explains percentage of the variance in the species data whereas eigenvalues are good measurement of the main variation in samples and species along the ordination axis (Jonfman et al., 1995).

Software used

R Console version 2.15.1 (R Development Core Team, 2012) was used to analyze the relationship between variation in species richness and its graphics, for correlation and regression analysis. The species composition pattern was carried out through vegan package (Oksanen, 2011).

3. RESULTS

3.1 Ethnobotanical study of Incense plant

Manangi are found to use fairly large number of incense plant. From the present study altogether 31 incense plant species were recorded belonging to 14 families with 20 genera (Appendix5). Asteraceae is the largest family having 11 species (Fig.4) followed by Cupressaceae (3 species), Salicaceae (3 species), Pinaceae (2 species), and Valerianaceae (2 species). While other remaining nine families hold single species each (Fig.4).

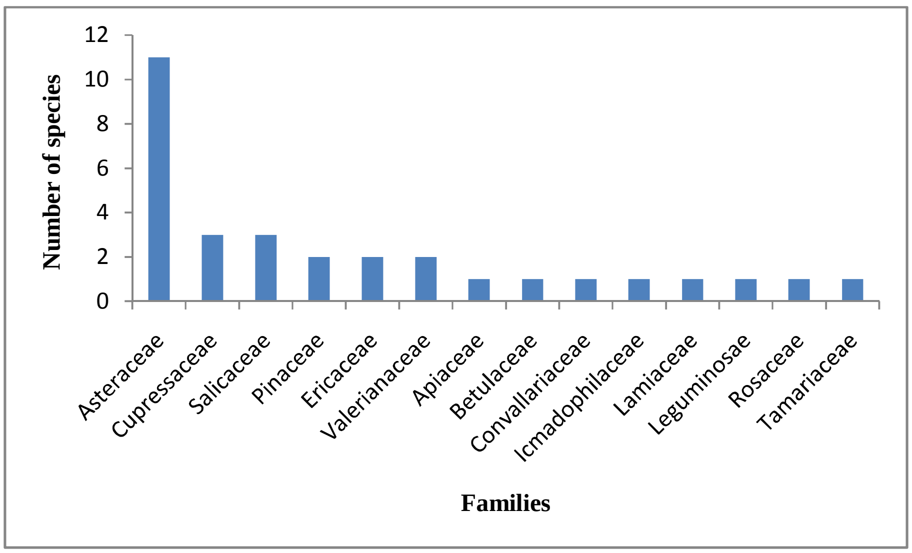


Fig.4: Incense species composition by families.

The number of incense plants, their local name and some information on incense plants from different households of the study area are given in Table 1.

Table1: Information on Incense Plants collected by local people

S. N.	Name of species	Family	local name	Parts used	C.N.	Used	Remarks
1	*Abies spectabilis* (D. Don) Mirb.	Pinaceae	Kye(n)/gobresalla (N)	Leaves	-	RS	Collected from lower Manang for incense, only used in the shortage of others
2	*Ajania gracilis* (Hook.f. & Thomson) Poljakov	Asteraceae	Khamsan (n)/dhup (N)	Whole plant	11	VC	More incense value, Easily available, highly used.
3	*Anaphalis contorta* (D. Don) Hook.f	Asteraceae	Pansan (n)/Bukhi Phool (N)	Small branches(Leaves &flower)	69	VRS	Easily available but mainly used in decoration than incense
4	*Anaphalis xylorhiza* Sch.Bip. ex Hook.f.	Asteraceae	Bukhiphool (N)	Small branches(Leaves &flower)	03	VRS	Easily available but mainly used in decoration than incense
5	*Anaphalis triplinervis* (Sims) C.B. Clarke	Asteraceae	Fojormindo (n)/phosorsan (n)	Small branches(Leaves &flower)	07	VRS	Easily available but mainly used in decoration than incense
6	*Artemisia biennis* Willd.	Asteraceae	Fojormendho(n)	Small branches	74	RS	Easily available, Mainly used for fodder
7	*Artemisia caruifolia* Buch.-Ham.	Asteraceae	Chaphong (n),serphang (n)/titepaati (N)	Small branches	73	RS	Easily available, Mainly used for fodder
8	*Artemisia dubia* Wall. ex Besser	Asteraceae	Khangkhar (n)	Small branches	72	RS	Easily available, Mainly used for fodder
9	*Artemisia gmelinii* Weber ex Stechm.	Asteraceae	Bajha(n)/Fumungh (n)	Small branches	14	RS	Easily available , Mainly used for fodder
10	*Artemisia vestita* Wall. ex Besser	Asteraceae	Tamboi(n)/paaati (N)	Small branches	52	RS	Easily available , Mainly used for fodder
11	*Artemisia siversiana* Willd.	Asteraceae	Tompe(n)/paati (N)	Small branches	51	RS	Easily available ,Mainly used for fodder
12	*Betula utilis* D.Don	Betulaceae	Bushpath (n)	Leaves	15	VC	Far available, Good source of fuel wood
13	*Populus ciliata* Wall. ex Royle	Salicaceae	Cheltung (n)/Bhote papal (N)	Leaves	-	VRS	Cultivated plant, sometimes leaves are used in incense in the shortage of others by mixing with *Juniperus indica*
14	*Juniperus communis* L.	Cupressaceae	Phar (n)	Leaves	30	VC	Easily available, Used in the shortage of *Juniperus indica*
15	*Juniperus indica* Bertol.	Cupressaceae	Sukpha (n)	Leaves	28	HVC	Highly used plant for incense, Easily available
16	*Juniperus squamata* Buch-Ham.ex D.Don	Cupressaceae	Sukri (n)	Leaves	29	VC	Used in the shortage of *Juniperus indica*
17	*Leontopodium stacheyi* (Hook. f.) C.B.Clarke ex Hemsley	Asteraceae	Bukhi phool (N)	Whole plant	67	C	Found in Bhraka
18	*Myricaria rosea*	Tamaricaceae	Angmaa	Leaves	02	C	Found in Manang, mainly found near

	W.W.Smith		(n)				the bank of river
19	*Nardostachys grandiflora* DC.	Valerianaceae	Pangphoie (n)	Whole plant	79	VC	Far available ,Collected from Ice lake
20	*Origanum vulgare* L.	Labiatae	Akhebobo (n)/ Ghoodhaamarcha (n)	Leaves	34	RS	Mainly used in medicine
21	*Oxytropis williamsii* Vassilcz	Leguminosae	Sinshi (n)	Leaves	80	RS	Mainly used for fodder, this is not commonly used as incense because it is perceived to be an inferior quality when compared to other incense plants
22	*Pinus wallichiana* A.B.Jackson	Pinaceae	Thangsin (n)	Leaves	68	RS	Found in Bhraka,used more in Bhraka than Manang
23	*Polygonatum cirrhifolium* (Wall.) Royle	Convallariaceae	Gomesha (n)	Whole plant	16	VRS	Rarely used, only used by mixing with Juniperus indica in the shortage of others
24	*Potentilla fruticosa* L.	Rosaceae	Teba (n)	Leaves	53	VRS	Rarely leaves are used in incense, only used by mixing with *Juniperus indica* in the shortage of others in winter season
25	*Rhododendron anthopogon* D. Don	Ericaceae	Pallu (n)	Leaves	55	VC	Found far from the village, near Ice lake
26	*Rhododendron lapidotum* Wall.ex D.Don	Ericaceae	Bhaiunakpo (n)	Leaves	81	C	Found far from the village, near Ice lake
27	*Salix babylonica* L.	Salicaceae	Chayanghma (n)	Leaves	13	C	Also cultivated for fodder
28	*Salix lindleyana* Wall.ex Andersson	Salicaceae	Langhma (n)	Leaves	07	C	Also cultivated for other purpose
29	*Selinum wallichianum* (DC.) Rhizada & H.O. Saxena	Apiaceae	Bhutkesh (n)	Leaves		RS	Religious and ritual plant
30	*Thamnolia vermicularis* (Sw.) Ach. ex Schaer	Icmadophilaceae	Syaurujhung (n)/snow tea	Whole plant	81	C	It is Lichen, mainly collected Ice lake
31	*Valeriana jatamansii* Jones	Valerianaceae	Nappu (n) / Ghyapoo (n)	Leaves	82	VRS	Mainly used in medicine ,leaves are also used in incense by mixing with others

*n=Local name, *N=Common name

*HVC=highly used, *VC= Very Common, *C= Common *C.N. = Collection number (TUCH)

*RS= Rarely used in the shortage of others, used by mixing with highly incense plants

*VRS=Very rarely used in the shortage of others, used by mixing with highly incense plants

From the study area, it was found that *Juniperus indica* is used to be highly for incense than others. *Juniperus squamata, J.communis, Ajania gracilis, Nardostachys grandiflora, Rhododendron anthopogon* and *Betula utilis* were found to be used very commonly where as *Myricaria rosea, Rhododendron lapidotum, Salix babylonica, Salix lindleyana, Thamnolia vermicularis* were found to used commonly used but it was found that less quantity of *Thamnolia vermicularis* than other is used due to its faraway availability. *Selinum wallichianum, Pinus wallichiana, Origanum vulgare, Oxytropis williamsii, Artemisia siversiana, A. biennis, A. caruifolia, A. Dubia, A gmelinii* and *A. vestita* were found to be rarely used for incense where as some plants like *Valeriana jatamansii, Potentilla fruticosa, Polygonatum cirrhifolium, Populus ciliata, Anaphalis xylorhiza* were found to be very rarely used.

It was found that the local people of the study area do not use only one incense plant but the mixtures of incense plants were used while burning on a glowing ember in container. The container is usually an open tin box or a small box or a small clay pot (Plate 1). Sometimes ghee is also added separately on a glowing ember to get more fragrance. While lighting the incense, it was found that a person from the family/usually a young and older member always says confidential prayers in their local language. The incense plants were found to be used daily especially in the morning and sometimes in the evening for puja.

The container is placed in the kitchen, on top of the roof or most often in the living area of the house. They acquire most of the incense plants from vicinity of their locality. After harvesting the incense plants depending on the nature are dried wholly or as small pieces, which are then use later after complete drying.

However, it was found that mature small branches and leaves of *Juniperus indica, Ajania gracilis, Rhododendron anthopogon, Nardostachys grandiflora, Thamnolia vermicularis* and *Betula utilis* were used as the most popular source of incense for religious purpose in study area. But it was found that only *Juniperus indica* is used in higher amount in each household in comparison to others because of its wide availability near the villages, which could be easily collected and stored for a longer duration (one week to six month). Because of high fragrance and availability, this plant has been top ranked. From the present study, it was found that some incense plants like *Nardostachys grandiflora, Rhododendron anthopogon* have high incense value but they are less used than *Juniperus indica* because of their less availability and more use in medicine and for other purposes.

The major festivals of Manangi where incense plants are widely used includes Metha (arrow competition), Yartung (Hoarse race), Purnima (Full moon day), Bade (a special festival observed once in every 3 years) and Tarakya (worships at gumba). During these occasions mainly *Juniperus indica* is used for incense. It was found that not only *Juniperus indica* is used but mixtures of dried form of other very common incense plants like *Ajania gracilis, Rhododendron anthopogon, Nardostachys grandiflora, Thamnolia vermicularis* also used.

On the basis of parts used in incense, they were grouped into three main categories (Fig.5)

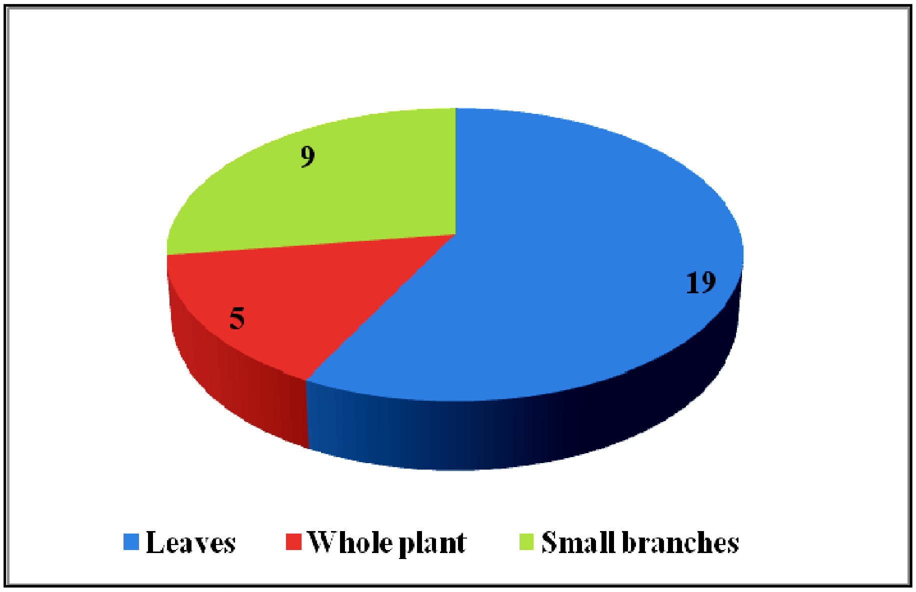


Fig.5: Parts of plants used in incense

Detail ethnobotanical information on medicine, fodder, and ornamental value for 31 incense plants mentioned above were also collected from different households of the study area (Table 2).

Table 2: Incense Plants and their uses for various purposes

S. N.	Name of species	Parts used	Uses
1	*Abies spectabilis* (D. Don) Mirb.	Leaves, small branches, stem &cone (inflorescence)	To heal broken bone , fence, fuel wood & furniture, leaves with cones are used as a decoration also used in fence and fuel wood

2	*Ajania gracilis* (Hook.f. & Thomson) Poljakov	Whole plant	Fodder
3	*Anaphalis contorta* (D. Don) Hook.f	Root & inflorescence	Root liquid is used for diarrhoea, Inflorescence for decorating
4	*Anaphalis xylorhiza* Sch.Bip. ex Hook.f.	Inflorescence	Inflorescence for decorating
5	*Anaphalis triplinervis* (Sims) C.B. Clarke	Whole plant	Cough, cold, tonsillitis and fever, menstrual disorders and edema
6	*Artemisia biennis* Willd.	Whole plant	Fever, fodder in the colder season
7	*Artemisia caruifolia* Buch.-Ham.	Leaves & stem	Allergies of the skin and fodder in the colder season
8	*Artemisia dubia* Wall. ex Besser	Whole plant	Backbone pain, allergies and skin wounds, fodder in the colder season
9	*Artemisia gmelinii* Weber ex Stechm.	leaves, stem and flowers	Fever, cold and sore throat recovery. Also used fodder in the colder seasons
10	*Artemisia vestita* Wall. ex Besser	Leaves &stem	Fodder
11	*Artemisia siversiana* Willd.	Leaves & stem	Fodder
12	*Betula utilis* D. Don	Bark, leaves &stem	Fever, bark to write chena, used as buti, good source of fuel wood
13	*Populus ciliata* Wall. ex Royle	Leaves, stem & Bark	Fodder, fuel wood, Timber & bark as medicine
14	*Juniperus communis* L.	Leaves, stem &fruits	Respiratory complaints, chest pains, lung infection, bronchitis &other infections of upper respiratory tract, decorating material, fuel wood, branches as fence
15	*Juniperus indica* Bertol.	Leaves, stem & fruits	Cough, cold, tonsillitis and malarial fever, neck pain &to reduce blood pressure, branches are also used as manure, fence &fruit as decorating material
16	*Juniperus squamata* Buch-Ham.ex D.Don	Leaves, stem & fruits	Used for animal when they are affected by different kinds of insects, scabies & wounds, also used as fuel wood, manure & decoration
17	*Leontopodium stacheyi* (Hook. f.) C.B.Clarke ex Hemsley	Whole plant	Dried plant is used to ignite the fire(fuel wood)
18	*Myricaria rosea* W.W.Smith	Leaves, stem & flower	For respiratory disease
19	*Nardostachys grandiflora* DC.	Whole plant	Diarrhoea, fever, conjunctivitis, gastritis, headache, anthelmintic, edema, dyspepsia & rib pain.
20	*Origanum vulgare* L.	Whole plant	High blood pressure, cough, cold, heart diseases and fever
21	*Oxytropis williamsii* Vassilcz	Whole plant	Used as fodder for horse
22	*Pinus wallichiana* A.B.Jackson	Bark, latex, Leaves &stem	Used on fractured part of the body, tuberculosis, also as a manure, decoration, household construction, fence & fuel wood
23	*Polygonatum cirrhifolium* (Wall.) Royle	Whole plant	Cough, cold and fever, also used with a cup of milk or boiled water to increase sexual power
24	*Potentilla fruticosa* L.	Stem & leaves	Used as an inner layer in roof construction (household construction)
25	*Rhododendron anthopogon* D. Don	Leaves & flower	To reduce blood pressure, paralysis, pains in limbs, waist &inflammation of limbs, fever

26	*Rhododendron lapidotum* Wall.ex D.Don	Leaves & flower	Fever, cough, cold, tonsillitis
27	*Salix babylonica* L.	Bark, stem &leaves	For body pain and excessive menstrual bleeding also used for ritual &religious purposes, fuel wood, household construction & cultivate to check soil erosion
28	*Salix lindleyana* Wall.ex Andersson	Leaves & stem	For stomach ache, diarrhoea and dysentery
29	*Selinum wallichianum* (DC.) Rhizada & H.O. Saxena	Whole plant	For stomach ache, cuts, wounds & also use against ghost attack
30	*Thamnolia vermicularis* (Sw.) Ach. ex Schaer	Whole plant	Used mainly in tea
31	*Valeriana jatamansii* Jones	Whole plant	For eye pain, conjunctivitis, wounds, fever

It was found that all the obtained incense plants were also used in other purposes. The incense plants used in other purposes were also grouped into different categories like medicine, fuel wood, fodder etc. The number of incense plant used in different categories was also calculated. Among 31 incense plant species it was found that 25 species were found to be used in medicine, 9 species in fuel wood, 7 species in decoration, 6 species in fodder and three species each for house hold construction and fence and one species each in tea and furniture (Fig. 6).

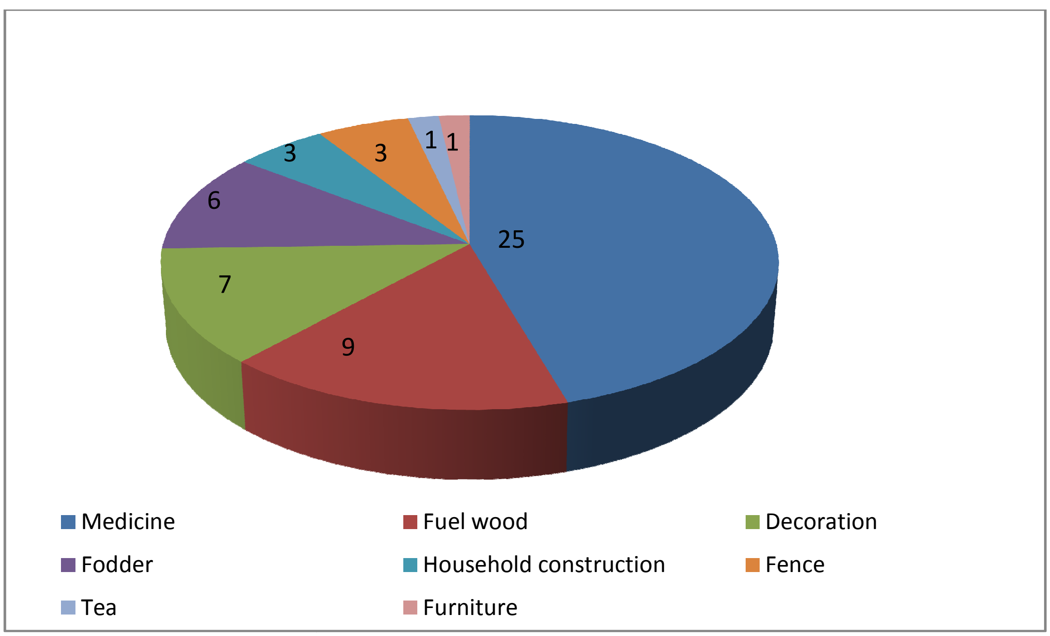


Fig. 6: incense plants used in for other purposes

All the collected incense plants used in other purposes were also categorized on the basis of different parts like root, stem, bark, leaves, inflorescence, fruit, whole plant and latex (Table 3 & Fig. 7).

Table 3: Different parts of incense plants used in different purposes.

Parts used	Number	Percent (%)
Root	2	3.03
Stem	16	24.24
Bark	4	6.06
Leaves	20	30.3
Inflorescence	7	10.6
Fruit	4	6.06
whole plant	12	18.18
Latex	1	1.51

It was found that leaves were used more frequently (30.03%) in incense as well as for other purposes like medicine, fodder. Followed by stem, whole plants and inflorescense having 24.24%, 18.18%&10.6% use respectively. Very less amount of latex is used in medicine i,e 1.51% but it is not use in incense.

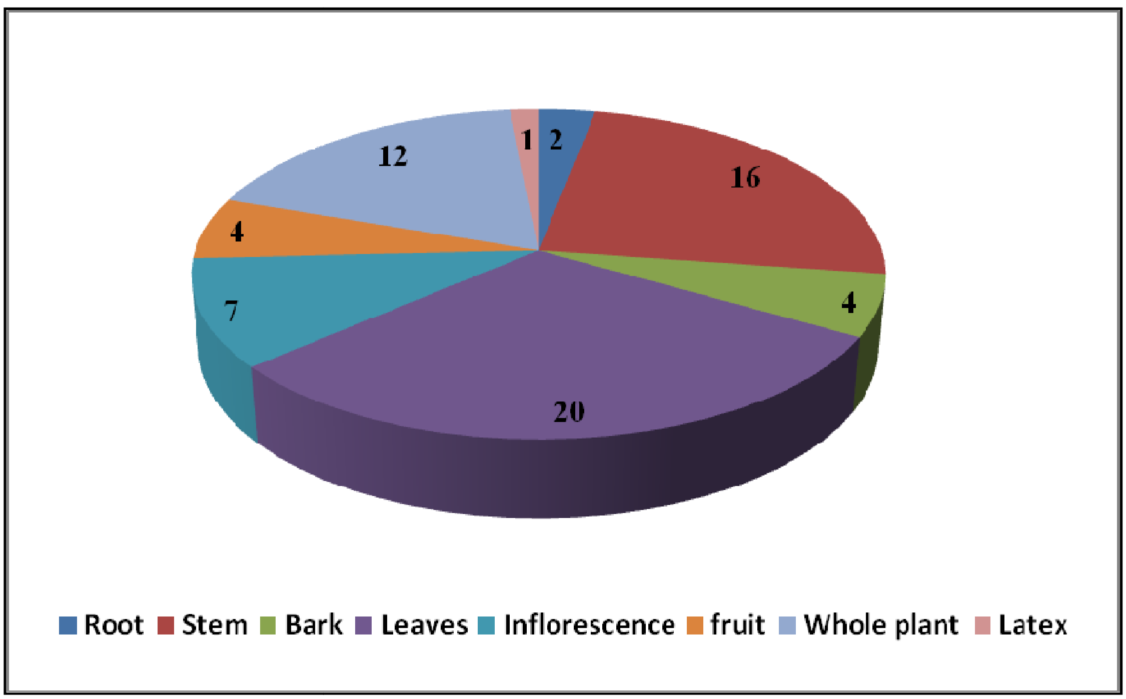


Fig.7: Parts of incense plants used in other purposes

After collecting all the information on incense plants from studied household, the use frequency value of each incense plant was calculated (appendix 8). It was found that the use frequency value of *Juniperus indica* is highest i.e. 40 than others. The use frequency value of *Ajania gracilis*, *Rhododendron anthopogon* and *Betula utilis* were found to be 32. It was found that the *Juniperus squamata* had 31 frequencies where as *Nardostachys grandiflora*, and *J. communis* had 29 and so on (Appendix8).

The use frequency index of total obtained incense species were also calculated from the use frequency value which are given below (Table 4)

Table 4: Total use frequency index of incense species

S. N.	Total Use Frequency	Name of Species
1	81-100%	*Juniperus indica* Bertol.
2.	61-80%	*Rhododendron anthopogon* D. Don, *Ajania gracilis* (Hook.f. & Thomson) Poljakov, *Juniperus communis* L., *Betula utilis* D. Don, *Nardostachys grandiflora* DC., *Juniperus squamata* Buch.-Ham. ex D. Don
3.	41-60%	*Thamnolia vermicularis* (Sw.) Ach.ex Schaer, *Salix babylonica* L., *Salix lindleyana* Wall. ex Andersson , *Myricaria rosea* W. W. Smith , *Leontopodium stracheyi* (Hook. f.) C.B. Clarke ex Hemsley, *Rhododendron lepidotum* Wall. D. Don
4.	21-40%	*Origanum vulgare* L., *Abies spectabilis* (D. Don) Mirb., *Selinum wallichianum* (DC.) Rhizada & H.O. Saxena, *Artemisia biennis* Willd, *Artemisia caruifolia* Buch.-Ham., *Artemisia gmelinii* Weber ex Stechm., *Oxytropis williamsii* Vassilcz, *Pinus wallichiana* A. B. Jackson, *Artemisia dubia* Wall. ex Besser, *Artemisia vestita* Wall. ex Besser, *Artemisia siversiana* Willd.
5.	Upto 20%	*Anaphalis contorta* (D. Don) Hook.f., *Anaphalis triplinervis* (Sims) C.B. Clarke, *Anaphalis xylorhiza* Sch. Bip.ex Hook. f., *Populus ciliata* (Wall.) ex Royle, *Valeriana jatamansii* Jones, *Polygonatum cirrhifolium* (Wall.) Royle, *Potentilla fruticosa* L.

From Table 4, & Fig. 8 Appendix 8, it was found that *Juniperus indica* (Plate 2) was found to be more used i.e. 100%, having very high quality of incense effects for their religious purpose due to their more fragrance and high availability. Then six very commonly used incense species about 61-80% are *Ajania gracilis* (Plate 2), *Juniperus communis, J. squamata, Betula utilis, Rhododendron anthopogon* (Plate 2), and *Nardostachys grandiflora.* Six species like *Thamnolia vernicularis, Salix babylonica, Salix lindleyana, Rhododendron lapidotum, Myricarea rosea* and *Leontopodium stracheyi* (Plate 2) were found to be common for about 41-60%, while 11 species *Origanum vulgare, Oxytropis williamsii, Artemisia biennis, A. caruifolia, A. gmelinii, A. dubia, A. vestita, A. Siversiana, Pinus wallichiana, Abies spectabilis* and *Selium wallichiana* were less commonly used because they were considered to be of lesser quality due to poor fragrance. Seven species like *Populus ciliata, Potentilla fruticosa, Polygonatum cirrhifolium, Valeriana jatamansii, Anaphalis contorta, A. triplinervis,* and *A. xylorhiza* were the least used incense plants due to their inferior quality. But these incense plants when used were mixed with other incense plants having higher quality fragrance. Those were used only by few household when there is shortage of important incense plants.

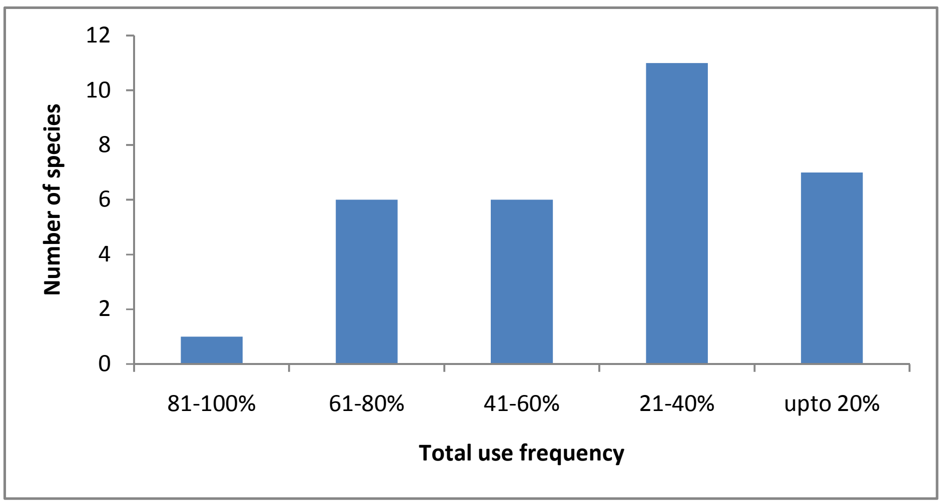


Fig.8: Number of locally used incense species with their used category

3.2 Species richness

Among total collected incense plants (31 species) from the study area only 24 incense plant species having 15 genera belonging to 12 families were recorded from 66 different sampling plots of the study area (Appendix 5).

By comparing the frequency of all recorded incense species from sampling plot (Appendix 8), *Juniperus indica* and *Ajania gracilis* were found dominant with highest frequency(84.85% and 77.27% respectively). Other most frequently occurring species were *Juniperus communis*, *Polygonatum cirrhifolium*, *Artemisia dubia* and *Anaphalis xylorhiza*, etc.

Incense species were further grouped into herb incense and woody incense species by field observation and literature. The numbers of herb incense plant species were found slightly dominant over the woody incense representing 13 species and 11 species respectively (Fig. 9).

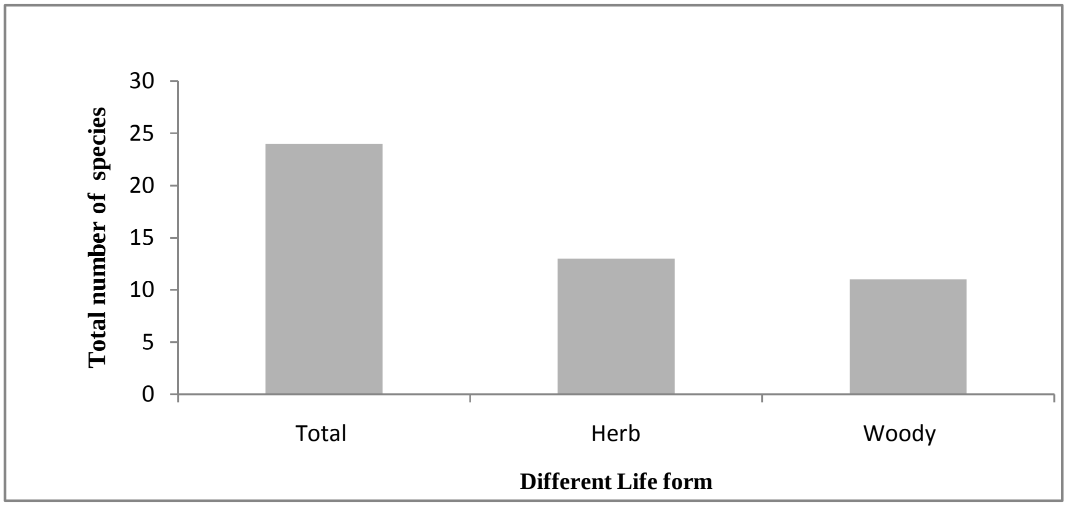


Fig.9: Diagram showing the total number of incense species with their different life form

3.3 Species composition

DCA on the total incense species abundance data showed strong gradient in species composition. Distributions of the species were found to be associated with particular environmental gradients. The gradient length and eigenvalue of the DCA first axis showed that the incense species composition along the first axis was heterogeneous in comparison to the second and third axis (Table 7). The eigenvalue of the DCA axis first was 0.4155 which fairly indicates the strong matrix analysis with significant dispersion of species along the first two axes (Table 5). The length of gradient along first axis is longest one (2.8336 SD units) than other axis that shows high beta diversity which indirectly supports the unimodal relationship of species with the altitude (Okansen, 1996). It explains that most of the species might show complete turnover in species composition and unimodal response with the measured environmental variables. The distribution of samples and species along the first two axes of the DCA diagrams (Fig.10) showed that incense species are found associated with environmental gradients for their distribution. Most of the species are distributed towards right and positive end of the both axis in DCA diagram.

Table 5: Summary of Detrended Correspondence Analysis

Axis	I	II	III	IV
Eigenvalues	0.4155	0.2439	0.1517	0.1690
Lengths of gradient	2.8336	2.4197	2.7350	1.9414

The species composition was found significantly influenced ($p \leq 0.05$) by elevation (altitude) and Grazing but RRI did not show significant influence on species composition (Table 8).

Table 6: Permutation test of different environmental variables with 1st and 2nd DCA axis

Variable		DCA1	DCA2	r^2	p(>r)
Altitude		0.896508	0.443028	0.1826	0.001998**
RRI		0.999906	-0.013733	0.0577	0.155844
	None	-0.9278	0.2011		
	Low	-0.2293	-0.0935		
Grazing	High	0.7994	0.1860	0.3305	0.000999***

The distribution of incense species along the first two axes of the DCA diagrams (Fig. 10) showed that incense species were found associated with environmental gradients for their distribution. Incense species composition is directly influenced by altitude and grazing but not by RRI (Table 6). Most of the species were distributed towards right and positive end of the both axis in DCA diagram. They are more common species found at the positive axis of DCA around right of DCA space. *Rhododendron* *anthopogon, Artemisia gmelinii* were found towards the positive end of DCA I axis whereas *Pinus wallichiana*, *Artemesia vestita* were found towards the left and negative end of DCA axis-I axis. *Juniperus indica, Myricarea rosea were* found towards the positive axis of DCA axis II where as *Ajania gracilis*, *Juniperus squamata* were found towards the positive axis of DCA axis II. Some species like *Potentilla fruticosa*, *Ajania gracilis, Leontopodium stracheyi*, *Juniperus communis* & *J.squamata* were widely distributed in the DCA space (Fig. 10).

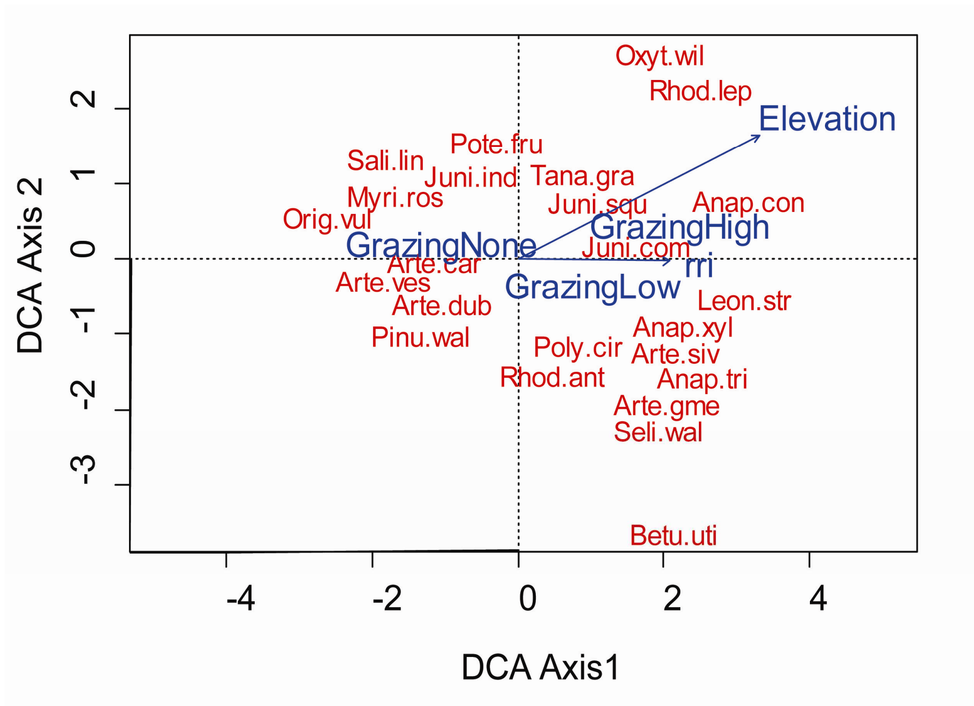


Fig.10: DCA diagram for Incense species distribution. Complete name of Incense species are given in Appendix 5.

3.4 Species Richness Pattern

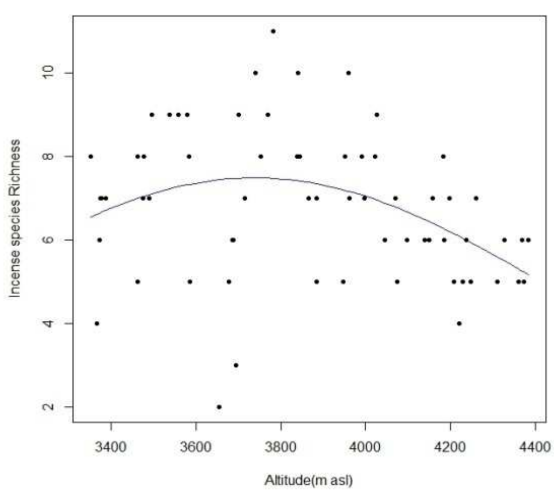
3.4.1 Species Richness and Environmental Correlation

Incense species showed statistically significant negative relation with elevation (r=-0.3) and grazing (r=-0.4) but it did not show any significant relation with RRI (Appendix 3).The incense species was grouped into 2 life form, they are herb incense, woody incense. The grouped species also showed statistically significant positive/negative relationship with environmental variables. Herb incense species showed a statistically positive significant relation with RRI (0.3) and grazing (r=0.4) but didn't show any significant relation with altitude. The woody incense species also showed statistically significant positive relation with altitude (r=0.4) and statistically significant negative relation with RRI (r=-0.2) but both herb incense and woody incense did not show statistically any significant relation with grazing (Appendix 3).

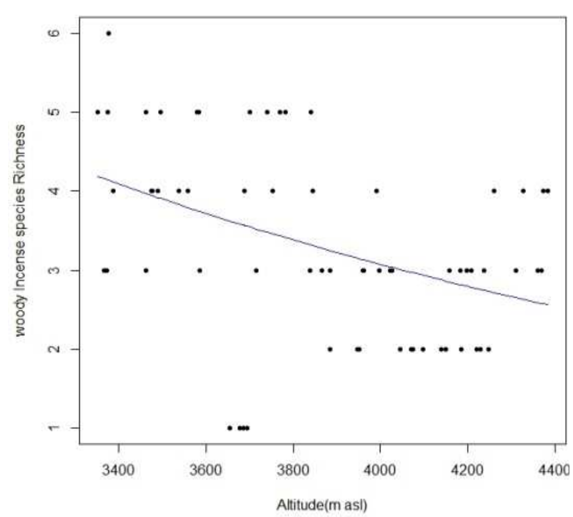
3.4.2 Species richness along altitudinal gradient

The relationship between Incense plant species richness and elevation (altitude) is shown in appendix 4a. A unimodal relationship was observed between incense species richness and altitude (Fig. 11a, Appendix 4a).The two different life form i.e. herb incense and woody incense were also tested with altitude, RRI and grazing.

Incense plant species also showed a statistically 2^{nd} order significant relationship with elevation over the GLM (Fig.11c, Appendix 4a). There is a hump-shaped pattern at the elevation gradient (3600-3900m) for incense plant species. Herb incense plant species did not show relationship with elevation which is statistic ally not significant over the polynomial order of GLM (Appendix 4a). A significant negative relationship (i.e. monotonically decreasing) was found between woody incense species richness and elevation in the 1^{st} order of GLM (Fig.11b, Appendix 4a).



a.

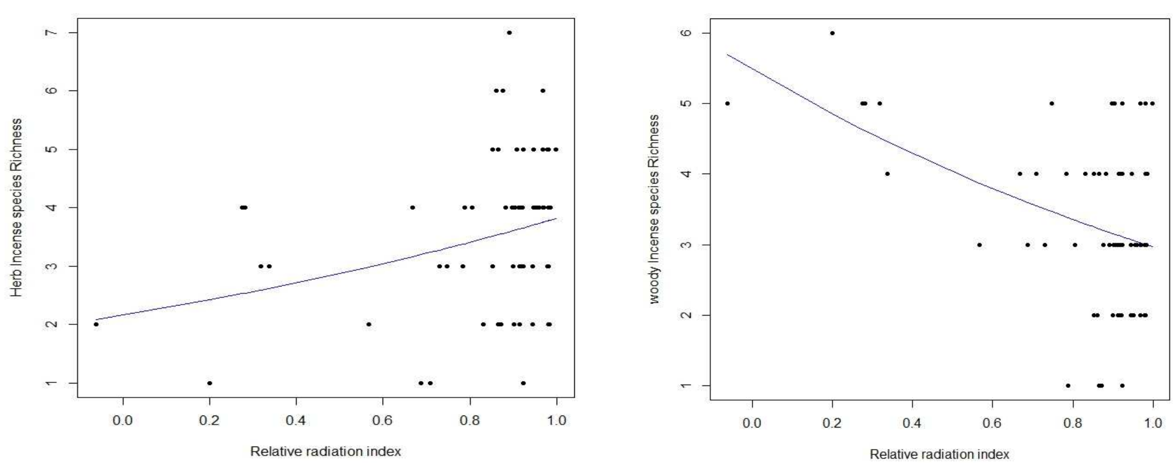


b.

Fig.11: The relationships between Incense species richness and its woody life forms with altitude. The fitted lines are based on generalized linear models (GLM) with a significant test. (Appendix4 for regression detail).

3.3.2 Incense species richness and relative radiation index (RRI)

Incense species did not show statistically any significant relationship with RRI (Appendix 4b) but its two different life forms i.e. herb incense and woody incense species showed statistically more significant with RRI (Appendix 4b & 4c respectively). There is a positive relationship (monotonically inclined) and negative relationship (monotonically declined) relationship between herb incense and woody incense richness with RRI respectively (Fig. 12a & 12b respectively).

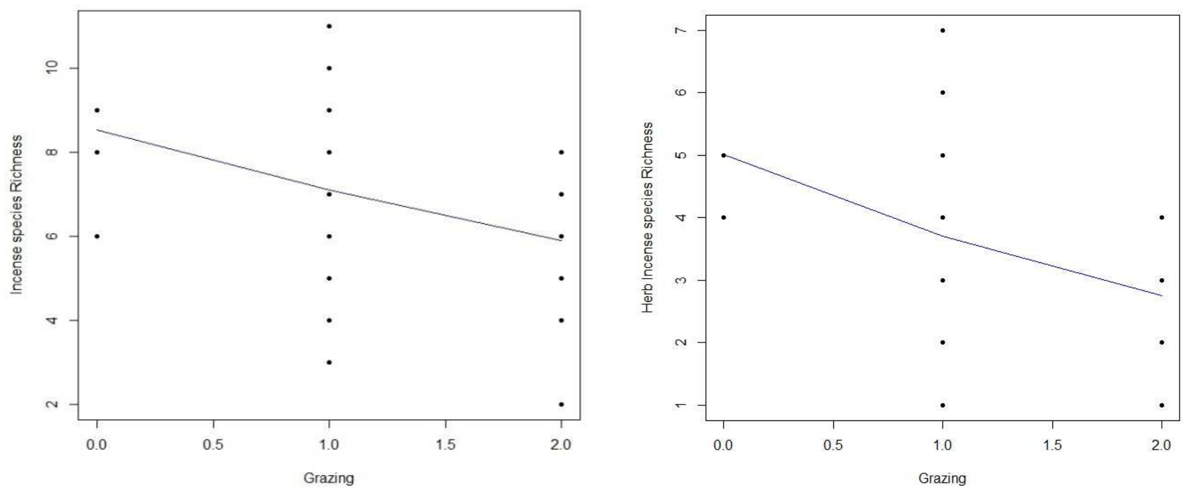


a. b.

Fig. 12: The relationship between herb Incense species woody Incense richness with RRI (relative radiation index).The fitted lines are based on generalized linear models (GLM) with a significant test.(Appendix 4 for regression details)

3.4.3 Species richness and Grazing

Incense species showed statistically more significant relationship with grazing (Fig. 13a, Appendix 4c). Herb incense species also showed a negative relationship with grazing (Fig. 13b, Appendix 4c) whereas woody incense species did not show statistically significant relationship with grazing.



a. b.

Fig.13: The relationships between Incense species richness and their herb life form with Grazing. The fitted lines are based on generalized linear models (GLM) with a significant test. (Appendix 4 for regression details)

4. DISCUSSIONS

4.1 Ethnobotanical study of Incense plant

Plant resources play a vital role in the life of rural people. There are different plant resources which are being utilized for various purposes by different ethnic groups. The local people have rich traditional knowledge on the utilization of different plant resources for their subsistence and livelihood. They have new and unique method using different parts of plant species. Among them, uses of incense plants play an important role for their religious purpose in their daily life. A large variety of incense plant species are also used for medicine, fodder, fuel wood and many other miscellaneous uses. They know the phenology, harvesting system and plantation period of plant. This knowledge is being transferred from generation to generation.

Thus, the present study was undertaken in Manang to explore the incense plant knowledge. This information presented here is primarily based on the field visit and by interviews with local people. About 40 different households were interviewed. Group discussion and cross checking at different places were also done for the specific identification of plant species in terms of the local name, parts used and mode of use.

Majupuria and Majupuria (1999) documented a list of 56 sacred and useful plants used for religious purpose in Nepal. Out of 56 collected religious plant species, only two species *Betula utilis* and *Populus ciliata* from the present study was mentioned.

Manandhar (2003) documented 31 incense plants from Nepal. Among them 15 incense plants were also found to be common in the study area, while 16 species can be considered new report as compared to Manandhar (2003).

Bhattarai et al. (2008) documented 27 ritual and religious plants from Manang. It was found that among 27 ritual and religious plants, 18 species like *Anaphalis triplinervis*, *Artemisia biennis*, *A. caruifolia*, *A. dubia*, *A. gmelinii*, *A. indica*, *Betula utilis*, *Juniperus communis*, *J. Indica*, *J. squamata*, *Myricaria rosea*, *Nardostachys grandiflora*, *Origanum vulgare*, *Oxytropis willamsii*, *Pinus wallichiana*, *Rhododendron anthopogon*, *R. lepidotum*, *Salix babylonica*, *Selinum wallichianum* were found to be used as incense plants in the present study. While 13 incense plants species were not reported by Bhattarai et al. (2008), which could be considered as new report as compared with ritual and religious plants from the study area.

Bhattarai (2009) reported 19 incense plant species from Manang. The present study has documented 31 species of incense plants used for religious purpose from the 40 different households. Except *Anaphalis nepalensis* and *Rhododendron campanulatum,* all 17 incense plants collected from Bhattarai et al. (2009) were also found in this study.

All the obtained incense plants after tallying with other incense, ritual and religious plants published in different articles, six of incense plant (*Ajania gracilis, Leontopodium strachyei, Artemesia siversiana, Anaphalis contorta, Polygonatum cirrhifolium* and *Potentilla fruticosa*) and one lichen (*Thamnolia vermicularis*), were found to be new record only for Manang. The six incense plants and one lichen from Manang was not previously documented by Manandhar (1987), Pohle (1990), Manandhar (2003), Bhattarai et al. (2008) & Bhattarai (2009). Among these seven incense plants, *Ajania gracilis* was found to be more commonly used from the entire studied household due to its high quality and easily availability where as *Artemesia siversiana, Anaphalis contorta, Polygonatum cirrhifolium* and *Potentilla fruticosa were* found to be very less used due to its inferior quality. It was found that such incense plants having inferior quality were used only at the shortening of other incense plants by mixing with higher quality incense plants like *Juniperus indica.* According to local people it was found that *Thamnolia vermicularis* is lichen belonging to family Icmadophilaceae, has also high incense quality. Whole plant of *Thamnolia vermicularis* is used in incense but it is very less commonly used due to its less availability and found in distance areas.

Most used incense plants by the local people is *Juniperus indica* because it was easily available and highly valued as a religious plant. The present survey concludes that the local people of Manang district have fairly extensive and detailed knowledge regarding incense plants and their utility. Mature small branches and sometimes whole plants are also used as the most popular source of incense. *Juniperus indica* was found to be highly used incense plant because it almost always available near the village, have their high fragrance and can be stored in the rafter of the roof after drying in the sun for a long duration (one week to six months). During the shortage of *J. Indica*, *J. squamata* and *J. communis* were commonly used.

It was also found that the whole plant of *Nardostachys grandiflora, Ajania gracilis* small branches and flower of *Rhododendron anthopogon*, leaves of *Betula utilis* and lichen like *Thamnolia vermicularis* are also used as one of the major source of incense in the study area but they are used in low quantity than *Juniperus indica* due to its faraway availability and as these species are more used in medicine and for other purpose. Generally incense plants are used either in powder form or small branches, but sometimes whole plant is also used by lamas, amchi and local villagers. They give a pleasant smell when it is burnt. They also use ghee and other materials for more fragrance. They are generally found in higher altitudes (3200–5000 m), and because of this it is said to be ritually purer and have a nicer smell. They are ranked on top among incense in Manang but used less than *Juniperus indica* due to their distance (high altitude) availability. Even though they are less used, but at the time of ritual and religious ceremonies they are used for good fragrance.

Similarly, mature small branches of *Myricaria rosea, Salix* spp*. Anaphalis* spp*., Leontopodium strachei, Oxytropis vulgare,* and leaves of *Pinus wallichiana, Abies spectabilis* are used by mixing them with those aromatic plants having high incense quality or good fragrance and also used when other incense plants are not available. *Anaphalis contorta, A. triplinervis, A. xylorhiza, Populus ciliata, Polygonatum cirrhifolium* and *Potentilla fruticosa* were found to be very less used due to their less fragrance value. They are only used when the other important incense plants become shortage.

People from Manang, who now live in the larger cities of Nepal like Kathmandu, Pokhara carry incense plants even having mild fragrance like *Juniperus squamata, J. communis,* and *Artemisia* spp. for their use. As these less valued incense plants are used with high quality incense plants like *Juniperus indica*, *Ajania gracilis, Rhododendron anthopogon* etc to get good fragrance for their ritual, religious and daily use.

Incense plants were also found to be used in other purpose like medicine, fodder and also used as a main sources of income. According to Namgay et al.(2007), Incense plants contribute 14% of the total income of the Layaps. Of the 14 species of incense plants found in the Laya area, five common species contribute 94% of the income from the incense products. Which also supports the present findings as incense plants like *Rhododendron anthopogon, Juniperus* spp., *Nardostachys grandiflora* are not only used as incense but are also traded for other purpose to generate income.

All the obtained incense plants (31 species) from the study area were also found to be used for other purposes like medicine, food, fodder, fuel wood, decoration etc. Among them, 25 species were found to be used in medicine which supports the findings of different research. Five species were found to be new in medicine in comparison with Pohle (1990). Two species *Anaphailis contorta* and *Populus ciliata* are found to be new in the field of ethnomedicine in comparison with Bhattarai (2009). Ghimire et al. (1999) studied the ecology of some high altitude medicinal and aromatic plants in the Gyasumdo valley, Manang Nepal. Distribution pattern, population density, regeneration status and biomass production of five most important high altitude and aromatic plants were assessed in three different natural sites of the Gysumdo valley. It was found that *Nardostachys grandiflora* also occurred among five obtained most important and aromatic plants reported by Ghimire et al. (1999).

Bhattarai (2009) documented 29 plant species for fuel wood in Manang. Nine plant species were found to be used in fuel wood in the present study among them eight species were also found same as Bhattarai (2009). *Leontopodium stacheyi* was found to be new in the field of fuel wood in Manang.

It was found that among all the obtained incense species, seven species for decoration, six species for fodder, and three species each for fence and household construction and one species for furniture which supports the findings of Bhattarai (2009).

It was found that the use frequency value of *Juniperus indica* is highest i.e. 40 than others. It represents that all the local people of Manang use *Juniperus indica* in the field of incense. The use frequency value of *Ajania gracilis, Rhododendron anthopogon* and *Betula utilis* were found to be 32. It was found that the *Juniperus squamata* had 31 frequencies where as *Nardostachys grandiflora, and J. communis* had 29. *Anapalis contorta, A. triplinervis, A. xylorhiza, Populus ciliata, Valeriana jatamansii, Polygonatum cirrhifolium* and *Potentilla fruticosa* were occurred in use frequency index up to 20%. It represents that these plants were used by few household. This may be due to their less quality (fragrance) of incense.

4.2 Species composition and distribution

Researches on ecological drivers have often been used to determine the species composition and distribution within an ecosystem. The result of the present study indicated a variation in species distribution with respect to altitude. The DCA analysis explained the total variance in the species data. Along with this, it also explained the species dispersion and turnover.

Gradient length of total incense species was found to be 2.839 SD units. Along such a gradient length, a total turnover of species is expected (Hill and Gauch, 1980). Discrepancy in gradient length between different axes of total incense species richness is due to difference in the habitat heterogeneity. Longer gradient length corresponds to larger heterogeneity and shorter gradient length to smaller heterogeneity.

Incense plants were also scattered on the DCA axis. *Rhododendron anthopogon, Artemisia gmelinii* were found towards the positive end of DCA I axis whereas *Pinus wallichiana, Artemisia vestita* were found towards the left and negative end and *Origanum vulgare, Myricarea rosea* were towards the left and positive axis of DCA axis-II. Some species like *Potentilla fruticosa, Ajania gracilis, Leontopodium stracheyi, Juniperus communis, J. indica* & *J. squamata* were widely distributed in the DCA space. The total incense species were grouped into 2 different life forms i.e. herb incense and woody incense. The woody incense species like *Pinus wallichiana, Juniperus indica, Potentilla fruticosa* etc. were found more abundant at the lower altitude which suggest the decreasing trend of the woody species with increasing altitudes while the herb incense species like *Ajania gracilis, Leontopodium stracheyi* were found at the centre of DCA space and *Polygonatum cirrhifolium, Anaphalis xylorhiza* were found on the positive side of DCA-I axis.

Abundance of plants like *Juniperus communis, Ajania gracilis, Anaphalis contorta* etc. towards the positive ends of the DCA II axis well explained that the species distribution and composition of incense plants of higher altitudes. However, there are few species distributed towards the lower end, not showing significant relationship with altitude.

Such type of distribution may be due to other influencing factors like soil moisture or pH, RRI, anthropogenic disturbance (trampling, grazing, harvesting, looping and cut stumps of woody plants) which may collectively interact with altitudes to determine the distribution and composition.

Dominant species are regularly distributed along environmental gradients and less dominant species are distributed randomly which is similar to the findings of many researchers like Gauch and Whittaker (1972). Panthi (2006) found that moisture and indirect factors like canopy and aspects are the main environmental factors influence the species composition and richness in the dry inner of trans-Himalayan area. The present study reveals that species composition may be influenced not only by a single dominant environmental variable but complex factors. Species distribution along the main gradients is affected by small scale environmental variation.

4.3 Species richness pattern and environmental factors

In this study, incense species richness with altitude showed a hump shaped patterns across altitudinal range as shown the relationship between species richness and altitude by many authors (Rahbek, 1995, 1997; Brown, 2001; Lomolino, 2001; Grytnes and Vetaas, 2002; Carpenter, 2005; Panthi et al., 2007; Nogues-Bravo et al., 2008; Rijal, 2009; Baniya et al., 2010; Acharya et al. 2011; Baniya et al.2012 and others). This type of hump shaped species richness pattern across altitudinal gradient is reported from different studies (Grytnes, 2003; Bhattarai and Vetaas, 2004; Bhattarai et al., 2004; Fossa, 2004; Bhattarai, 2005; Hua and Saprunoff, 2005; Bhattarai and Vetaas, 2006; Subedi, 2006; Baniya et al., 2010). The optimum incense species richness was found in the middle of the gradient i.e. near 3800 m. This study is comparable with the estimates obtained by interpolation from elevation range data by Grytnes and Vetaas (2002); Bhattarai (2003); Bhattarai et al. (2003); Hua and Saprunoff (2005); Bhattarai and Vetaas (2005); Bhatt and Chaudhary (2009); Rowe and Lidgard (2009), Baniya et al., (2010), Baniya et al., (2012). They all came with similar conclusion that species richness has hump-shaped pattern along the elevation gradient.

Grytnes and Vetass (2002) found vascular plant species richness peak between 1500 m and 2000 m as well as observed plateau between 3000-4000 m in Nepal Himalayas. Bhatt and Chaudhary (2009) also found a hump shaped pattern of species with altitude having altitudinal range 2500-5000 m. The incense species richness optima found in this study is not totally but almost congruent to above studies. This discrepancy in optimum richness might be due to the fact that species considered in this study area reported from higher altitudes and only from small geographical area (Manang) was considered with smaller number of species (includes only primary data). This could also be due to ecophysiological constrains, such as reduced growing season and low ecosystem productivity in high elevation (Korner, 2002). The species optima found in study site is a local mid-elevation peak (Rahbek, 1995), since elevation gradient ranges from 3800 m to 4600 m, it includes both subalpine as well as alpine flora and there is a possibility of immigration of flora from both direction which increases species richness due to mass effect(Grytnes and Vetaas, 2002).

The incense species richness with different life forms like herb incense and woody incense were also tested and analyzed with altitude. The herb incense species did not show significant relationship with altitude. This is the similar finding with Ohlemüller & Wilson (2000) from New Zealand. It was expected that the altitudinal gradient should influence herbaceous species richness, as has been shown by Richerson & Lum (1980). However, several studies have shown that herbaceous patterns do not run parallel to those of trees and shrubs along the elevation energy gradient (Whittaker, 1956, 1972; Whittaker & Niering, 1965). According to the hierarchical theory of species diversity (Whittaker et al., 2001), the herbaceous species may be relatively more influenced by local factors, such as soil conditions, disturbance, and degrees of canopy cover in the landscape (Vetaas, 1997).

Woody incense species showed a significant negative relationship with altitude. A monotonic decline in the number of woody incense species with increasing elevation was observed in the study area. This finding is similar to the decline relationship of evergreen and deciduous dwarf shrubs with altitude given by Bruun et al. (2006) and the relationship between tropical land bird species richness with elevation by Rahbek (1997).

Incense species richness was also tested and analyzed with RRI. The total incense species did not show any significant relationship with RRI but the different life forms of incense plants showed significant relationship. Herb incense species showed an inclined relationship with RRI like Poudel (2005) but woody incense species showed negative correlation with RRI. This may be due to the less number of woody incense species in higher elevation. This finding is similar to decline pattern of total tree species to the mean monthly solar radiation in New South Wales by Pausas and Austin (2001).

According to Bakker et al. (2003), grazing has a clear positive effect on species richness in the permanent transects. It also affected the heterogeneity in the plant communities. The negative monotonic relationship of total incense species richness and its herbaceous life form along with the grazing was found in this study. This finding did not support the positive grazing effect on species richness by Bakker et al. (2003) and Bello et al. (2006). This may because of lower elevation is near from cattle-shed and there may be greater chance of higher grazing pressure. Distance from cattle-shed increased when elevation increased so decline pattern of grazing line was observed. Species of incense plants are higher in higher altitude. Thus, severe grazing pressure was observed towards lower elevation whereas grazing was less towards higher elevation. But woody incense species did not show any statistically significant relationship with grazing. That means woody incense species were not influenced by grazing. It also indicates that incense species are preferred by grazing.

5. CONCLUSIONS AND RECOMMENDATION

5.1 Conclusions

This study concludes with the result that total 31 species are being used as incense plant in Manang. *Juniperus indica* was found to be more used than others. Not only one plant was found to be used in incense but the mixture of other plants like *Rhododendron anthopogon, Nardostachys grandiflora, Ajania gracilis, Thamnolia vermicularis* were found to be used. Among total 31 obtained species, 6 incense plant species and one lichen (*Thamnolia vermicularis*)are concluded as new record in the field of incense for Manang. They are *Ajania gracilis, Anaphalis contorta, Artemesia siversiana, Polygonatum cirrhifolium* and *Potentilla fruticosa*. *Juniperus indica* and *Ajania gracilis* are found to be most used incense species where as *Rhododendron anthopogon, Nardostachys grandiflora, Juniperus squamata,* are found to be less used due to its distance availability and having used in other purposes, while *Origanum vulgare, Selinum wallichi, Leontopodium strachyei* are used when the above species are shortage.

Along with the above mentioned plants, the plants having less fragrance plants like *Potentilla fruticosa, Polygonatum cirrhifolium, and Populus ciliata* were found to be used by mixing with plants having high incense value. Mainly leaves were found to be used for incense then stem, inflorescence and whole plants. While stem, inflorescence, whole plants and leaves were found to be used for other purpose in medicine, fodder, ornamental, etc.

Some incense plants like *Nardostachys grandiflora, Juniperus indica* were also found to be used in the field of medicine. Similarly, *Abies* spectabilis, *Betula utilis,* were found to be used in fuel wood whereas *Artemisia vestita, Artemisia siversiana, Ajania gracilis* etc were found to be used in fodder. *Pinus wallichiana, Juniperus indica* were found to be used fence whereas *Thamnolia vermicularis* was found to be used in tea.

From the above result and discussions, the present study can be concluded that the local communities of Bhraka and Manang VDCs have wide knowledge about the use of incense plant resources for the various purposes such as religious purposes, medicinal values, timber, fodder, wild edible, fuel wood etc. Thus the assumed first hypothesis i.e. traditional knowledge on the use of incense plants have significant role in religious rituals, medicinal uses etc is true.

Species composition of incense species was heterogeneous which are indicated by the length of the gradients, which varied from 2.021-2.839 (SD Unit). Altitude, relative radiation index (RRI) is the environmental factors and grazing is anthropogenic factor governing the species composition in this study. The relationship between incense species diversity with altitude followed a unimodal pattern. Along with different life form, it has been concluded that the herb incense species did not show any relationship with altitude but declined relationship was found in between woody incense and altitude. The herb incense species showed monotonically inclined relationship with RRI and woody incense species showed monotonically declined relationship with RRI. But incense species did not show any relationship with RRI. This concludes that RRI directly correlates with incense species.

Similarly, incense species and its herb incense species showed a declined relationship with grazing but woody incense species did not showed any relationship with grazing. This shows that there is no any significant relationship in between incense plants and total species richness with grazing. Grazing does not affect the incense species as well as total species. So, the incense plants and total species richness with their composition vary significantly along elevation gradient.

Therefore, this study concludes that there is complex interaction of environmental factors which account for the species richness in Trans-Himalayan subalpine and alpine flora.

5.2 Recommendation

All the local people in Manang use incense plants directly or by drying and making them into small pieces. They do not use commercial products of incense from the market. They directly depend upon the local incense plants. Due to having other importance of incense plants like medicine, fodder etc, they may be threatened due to overharvesting. From the present study following recommendations are suggested for the conservation of traditional knowledge for incense plants.

Some incense plants may be threatened due to over grazing so over grazing should be controlled.

Due to multiple use of incense plants overharvesting may arise, therefore, overharvesting of important incense plant should be controlled through programs and awareness.

Acquaintance program: It is true that unless knowledge of the importance of plant species is infused to the people, no prevailing trend can be controlled. For this purpose, proper counseling awareness program on the conservation and importance of natural resources, sustainable utilization, management, harvesting and prevention of the valuable plant species at the local level need to be conducted.

Most of the plant species have multiple uses are comparatively more threatened from over exploitation. Therefore, these species should be focused as potential species and given priority for conservation.

Appropriate care and protection laws should be enacted by the local government, so that illegal collection and over exploitation may be checked to some extent,

Sustainable use of incense plants should be encouraged. For long term use cultivation of the incense plants should be promoted. Harvesting technology should be improved. Awareness should be created regarding the negative impact of overharvesting.

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Appendix 1: Questionnaire

S.N. Date: VDC: Ward no.: Tole:

Name or Respondent: Sex: Age/Occupation:

Education: illiterate/literate/1-5grade, 6-10 grade/Intermediate/more

Religious: Hindu/Buddhist/Muslim/Christian/other

Information on Incense Plants

S. N.	Local name	Scientific name	Common name	Incense category (HVC,VV,C,RS, CRS)	Parts used in Incense	Time duration to search	Ethno-botanical use	Remark
1								
2								
3								
4								
5								
6								
7								

*HVC=Highly used, *VC= Very Common, *C= Common
*RS= Rarely used in the shortage of others, used by mixing with highly incense plants
*VRS=Very rarely used in the shortage of others, used by mixing with highly incense plants

(1) How is the part used (directly or processed), if processed, how?

(2) What are the major incense plants?

(3) What are the major festivals used incense plants?

(4) How do local people conserve the incense resources?

Appendix 2: **Villagers, Healers, Lama, Amchi, Dhami and Hotel owners of Manang district, Nepal, who contributed their knowledge regarding wild incense plants use. Only 40 households were taken from Bhraka and Manang VDC.**

S.N.	Name of villagers	Sex	Age(years)	Occupation
1	Chame Gurung	Female	44	Hotel owner
2	Nocho Ghale	Female	42	Job holder
3	Karma Chiring Ghale	Female	40	Hotel owner
4	Gamjo Gurung	Male	46	Hotel owner
5	Tashi Panchak Gurung	Male	50	Farmer

6	Karma Ghale	Female	50	Hotel owner
7	Chhiring Nisangba	Male	35	Job holder
8	Karma Gurung	Male	49	Farmer
9	Dolma Gurung	Female	60	Farmer/housewife
10	Galjen Gurung (Lama)	Male	68	Hotel owner
11	Samdu Gurung	Male	55	Shopkeeper
12	Karma Gurung	Male	63	Hotel owner
13	Chiring Gurung	Female	45	Hotel owner
14	Suk Bahadur Gurung	Male	55	Shopkeeper
15	Kumar Gurung	Male	40	Hotel owner
16	Tenjing Gurung	Male	51	Farmer
17	Kanchha Gurung	Male	65	Hotel owner
18	kanchha Ghale	Male	38	Porter
19	Nagkang Gurung	Female	48	Shopkeeper
20	Pemba Chhiring Gurung (Lama)	Male	66	Shopkeeper
21	Cheteng Gurung	Male	72	Farmer
22	Pemba Gurung	Male	40	Job holder
23	Anchale Gurung	Female	35	Hotel owner
24	Karma Dolma Gurung	Female	30	Health worker
25	Sonam Chhiring Gurung	Male	56	Job holder
26	Simi Samteng	Female	60	Farmer
27	Chongda Gurung	Female	61	Farmer
28	Champa Ghale	Female	53	Hotel owner
29	Sonam Chhiring Ghale	Male	51	Farmer
30	Topke Gurung	Male	36	Horse rider
31	Funja Ghale	Male	60	Farmer
32	Mengkhu Ghale	Male	31	Job holder
33	Tangla Gurung	Male	74	Healers
34	Lamchung Gurung	Female	37	Health worker
35	Tchhiring Lama	Female	37	Hotel owner
36	Kunchang Gurung	Male	41	Guide
37	Chetel Gurung	Male	38	Guide
38	Tchhiring Gurung	Male	38	Hotel owner
39	Dharma gurung	Male	37	Business
40	Maya gurung	Female	28	Hotel owner

Appendix 3: Environmental correlation coefficient matrix (Spearman's rank correlation) of explanatory variables for species richness

	Incesesp	hbincen	Wdyin	Alt	RRI	Gzing

Incensesp	1.000					
Hbincen	0.717	1.000				
Wdyincen	0.661	-0.009	1.000			
Alt	**-0.296***	0.017	**-0.409*****	1.000		
RRI	0.012	**0.276***	**-0.247***	0.410	1.00	
Gzing	**-0.416*****	**-0.457*****	-0.100	0.022	-0.0235	1.00

Where, incense sp=incense species, hbincen=herb incense, Wdyin=Woody incense, alt=altitude, RRI=Relative radiation index and gzing=Grazing

Bold entries are statistically significant correlation coefficients.

The asterisk sign represent the Significance level at * P<0.05, ** p<0.01, *** p<0.001

Appendix 4 Regression statistics

Appendix 4a: Regression statistics of Incense species regressed against environmental variables using generalized linear models (*GLMs*)

Explanatory variable	Polynomial order	Res.df	Res.dev	Df	Deviance	F-value	p (>F)
Elevation	0(Null)	65	31.248				
	1	64	29.426	1	1.822	4.209	0.04431*****
	2	63	26.953	2	4.2944	**5.5184**	0.006189******
	3	62	26.953	3	4.2951	3.6199	0.1785*
RRI	1	64	31.056	1	0.19192	0.4121	0.5232(NS)
	2	63	30.658	2	0.58969	0.6309	0.5354(NS)
	3	62	29.582	3	1.6653	**1.2064**	0.3149(NS)
Grazing	1	64	26.652	1	4.596	**11.592**	0.001148******
	2	63	26.159	2	5.0891	6.4801	0.002759**
	3	62	29.582	3	1.6653	1.2064	0.3149(NS)

Appendix 4b: Regression statistics of Herb incense species regressed against environmental variables using generalized linear models (*GLMs*)

Explanatory variable	Polynomial order	Res.df	Res.dev	Df	Deviance	F-value	p (>F)
Elevation	0	65	33.953				
	1	64	33.903	1	0.04982	0.0993	0.7537(NS)
	2	63	21.899	2	12.054	**18.613**	4.449e-07***
	3	62	21.051	3	12.902	13.512	6.898e-07***
RRI	1	64	31.138	1	2.8146	**6.072**	0.01643*
	2	63	30.928	2	3.0248	3.2126	0.04693*
	3	62	30.545	3	3.4085	2.3975	0.07653(NS)
Grazing	1	64	27.674	1	6.2792	**14.97**	0.0002567***
	2	63	26.785	2	7.1682	8.7401	0.0004467***
	3	62	30.545	3	3.4085	2.3975	0.07653 (NS)

Appendix 4c: Regression statistics of woody incense species regressed against environmental variables using generalized linear models (*GLMs*)

Explanatory variable	Polynomial order	Res.df	Res.dev	Df	Deviance	F-value	p (>F)
Elevation	0	65	30.113				
	1	64	24.421	1	4.6923	**13.068**	0.0005921***
	2	63	24.137	2	5.9757	8.4785	0.0005486***
	3	62	22.884	3	7.2291	7.3076	0.0002843***
RRI	1	64	25.458	1	4.6555	**12.385**	0.0008028***
	2	63	25.427	2	4.6859	6.1468	0.003642**
	3	62	24.800	3	5.3129	4.6591	0.005323**
Grazing	1	64	29.862	1	0.25078	0.5679	0.4538(NS)
	2	63	29.851	2	0.26214	0.2925	0.7474(NS)
	3	62	24.800	3	5.3129	**4.6591**	0.005323**

Bold entries are statistically significant

[NS- Not significant, Df- Degree of freedom, Res. Df- Residual degree of freedom, Res. dev- Residual deviance]

Signif. codes: '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 level of significance\

Appendix 5

List of incense species recorded by the empirical study within sampling plots and abbreviation used in ordination

S.N	Name of species (with author citation)	Family	Distribution (Press *et al.*, 2000)		Empirical data (range)	Abbreviation used in Ordination
			Regional	Altitudinal (m als)		
1	*Anaphalis contorta* D.Don	Asteraceae	WCE	1700-4500	3900	Anap.con
2	*Anaphalis triplinervis* (Sims)C.B.Clarke	Asteraceae	WCE	2900-4100	3800	Anap.tri
3	*Anaphalis xylorhiza* Sch.Bip.Ex Hook.	Asteraceae	WCE	3400-5000	3600	Anap.xyl
4	*Ajania gracilis* (Hook.f. & Thomson) Poljakov	Asteraceae	C	3600-3850	3300	Tana.gra
5	*Artemisia caruifolia* Buch.-Ham.	Asteraceae	WC	3900-4600	3500	Arte.car
6	*Artemisia dubia* Wall. ex Besser,	Asteraceae	WCE	1200-3400	3300	Arte.dub
7	*Artemisia gmelinii* Weber ex Stechm.	Asteraceae	WC	3800-4300	3600	Arte.gme
8	*Artemisia siversiana* Ehrh. ex Willd.	Asteraceae	WC	2100-4300	3600	Arte.siv
9	*Artemisia vestita* Wall. ex Bess	Asteraceae			3300	Arte.ves
10	*Betula utilis* D.Don	Betulaceae	WCE	2700-4300	3900	Berb. uti
11	*Juniperus communis* L.	Cupressaceae			3300	Juni.com
12	*Juniperus indica* Bertol.	Cupressaceae	WCE	3700-4100	3300	Juni.ind
13	*Juniperus squamata* Buch.-Hem.ex D.don	Cupressaceae	WCE	3300-4400	3300	Juni.sua
14	*Leontopodium stracheyi* (Hook.F)C.B.Clarke ex Hemsl.	Asteraceae	WC	2200-4500	4000	Leon.str
15	*Myricaria rosea* W.W.Smith	Tamaricaceae	C	3300-4500	3300	Myri.ros
16	*Origanum vulgare* L.	Labiatae	C	2500-	3600	Oxyt.mol
17	*Oxytropis williamsii* Vas.	Leguminosae	WC	2500-4400	4300	Oxyt.wil
18	*Pinus wallichiana* A.B.Jackson	Pinaceae	WCE	1800-4100	3300	Pinu.wal
19	*Polyganatum cirrhifolium* (Wall.) Royle	Liliaceae	WCE	1700-4600	3400	Poly.cir
20	*Potentilla fruticosa* Lindl.ex Lehm.	Rosaceae	WCE	3700-6000	3300	Pote. fru
21	*Rhododendron anthopogon* D.Don	Ericaceae	WCE	3300-5100	3300	Rhod.ant
22	*Rhododendron lapidotum* Wall.D.Don	Ericaceae	WCE	2100-4700	4200	Rhod.lep
23	*Salix lindleyana* Wall.	Salicaceae	CE	3000-4600	3400	Sali.lin
24	*Selinum wallichianum* (DC.)Raizata &Saxena.	Apiaceae	WCE	2700-4800	3800	Seli.wal

Appendix 6: List of species recorded by the empirical study within sampling plots

S.N	Name of species (with author citation)	Family	Distribution (Press et al., 2000)		Empirical Data (range)
			Regional	Altitudinal (m als)	
1	*Aconitum naviculare* Bruhl.	Ranunculaceae	WC	4100-4900	4300
2	*Ajania gracilis* (Hook.f. & Thomson) Poljakov	Asteraceae	C	3600-3850	3300
3	*Ajuga lupalina* Maxim.	Labiatae	WC	2200-4500	4300
4	*Allium wallichii* Kunth	Alliceae	WCE	2400-4650	3800
5	*Anaphalis cavei* Chatterjee	Asteraceae			4200
6	*Anaphalis contorta* D.Don	Asteraceae	WCE	1700-4500	3900
7	*Anaphalis triplinervis* (Sims)C.B.Clarke	Asteraceae	WCE	2900-4100	3800
8	*Anaphalis xylorhiza* Sch.Bip.Ex Hook.f.	Asteraceae	WCE	3400-5000	3600
9	*Androsace muscoidea* Duby	Primulaceae	WC	3300-5600	3800
10	*Androsace robusta* (Knuth)Hand.-Mazz.	Primulaceae	WC	3100-5600	4100
11	*Androsace strigillosa* Franch.	Primulaceae	WC	2400-4700	4100
12	*Androsace tapete* Maxima.	Primulaceae	WC	3800-5200	3800
13	*Anemone rivularis* Buch.-Hem.ex.DC	Ranunculaceae	WC	4100-4900	4000
14	*Anemone rupicola* cambess.	Ranunculaceae	WCE	2900-4700	4200
15	*Aradiopsis himalaica* (Edgew.) O. E. Schulz	Brassicaceae	WCE	3000-4100	3800
16	*Arisaema jaquemontii* Blume	Aracaceae	WCE	2700-4000	3700
17	*Artemisia caruifolia* Buch.-Ham.	Asteraceae	WC	3900-4600	3500
18	*Artemisia dubia* Wall. ex Besser,	Asteraceae	WCE	1200-3400	3300
19	*Artemisia gmelinii* Weber ex Stechm.	Asteraceae	WC	3800-4300	3600
20	*Artemisia siversiana* Willd.	Asteraceae	WC	2100-4300	3600
21	*Artemisia stricta* Edgew.	Asteraceae	WCE	2100-5000	3300
22	*Artemisia vestita* Wall. ex Besser	Asteraceae			3300
23	*Asparagus filicinus* Baum Buch.-Ham.exD.Don	Asparagaceae	WC	2100-2900	3300
24	*Asparagus tibeticus* F.T.Wang &S.C.Chen	Asparagaceae	C	3400	3400
25	*Aster albescens* (DC.)Hand.-Mazz	Asteraceae	WCE	1500-4200	3400
26	*Aster himalaicus* C.B.Clarke	Asteraceae	CE	3500-5200	3400
27	Aster indamelous Grierson	Asteraceae	CE	2200-4100	3500
28	*Astragalus candolleanus* Royle ex.Benth.	Leguminosae	WC	3500-4500	3700
29	*Astragalus clorostachys* Lindl.	leguminosae	CE	2100-3700	3600
30	*Astragalus multiceps* Wall	Leguminosae	C	3300-4400	3400
31	*Berberis aristata* DC.	Berbeidaceae	WCE	1200-2500	3300
32	*Betula utilis* D.Don	Betulaceae	WCE	2700-4300	3900
33	*Bistorta affinis* D.Don	Polygonaceae	WCE	3600-4800	3400

34	*Bistorta macrophylla* D.Don	Polygonaceae	WCE	2700-4500	3600
35	*Bistorta milletii* Lev.	Polygonaceae	WC	3000-3400	3900
36	*Bupleurum falcatum* L	Umbelliferae	WCE	3000-4900	3600
37	*Calendula officinalis* L.	Asteraceae	C	2600-4400	3400
38	*Caragana jubata* (Pall.)poir.	leguminosae	C	3300-4400	4100
39	*Carex hirtella* Drejer	Cyperacace	WC	2900-4900	3400
40	*Carex infuscata* Nees	Cyperacace	CE	3400-4100	3400
41	*Carex nubigena* D,Don	Cyperacace	C	2600-4400	3300
42	*Carum carvi* L.	Umbelliferae	WC	2500-5100	3800
43	*Chenopodium album* L.	Chenopodiaceae	WC	1800-4000	3400
44	*Chenopodium ambroisoides* L.	Chenopodiaceae	CE	300-2600	3300
45	*Chesnea nubigena* (D,Don)Ali	Leguminosae	WCE	3600-5200	4000
46	*Cicerbita machrorrhiza* (Royle) P. Beauv.	Asteraceae	WCE	1300-4500	3900
47	*Clematis buchananina* DC.	Ranunculaceae	CE	1800-3300	3400
48	*Conyza stricta* Willd.	Asteraceae	WCE	600-2000	3800
49	*Cortia depressa* (D. Don) C. Norman.	Apiaceae	WCE	3600-4900	4000
50	*Corydalis juncea* Wall	Fumariaceae	CE	2500-5100	3500
51	*Cotoneaster acuminatus* Lindl.	Rosaceae	WCE	2000-5400	3500
52	*Cotoneaster frigidus* Wall.ex Lindl.	Rosaceae	WC	2200-3400	3300
53	*Cotoneaster microphyllus* Wall.ex Lindl	Rosaceae	WCE	2000-5400	3300
54	*Cremanthodium arnicoides* (DC. ex Royle) R. Good	Asteraceae	WC	3100-4900	3900
55	*Crepis sancta* (L.) Babc.	Asteraceae	W	3200-4000	3300
56	*Cyananthes microphyllus* Edgew.	Campanulaceae	WCE	2900-4800	4100
57	*Cynoglossum zeylanicum* (Vahl ex Hornem.) Thunb. ex Lehm.	Boraginaceae	WCE	1200-4100	3300
58	*Delphinium brunonianum* Royle	Ranunculaceae	WC	3500-6000	3800
59	*Deyeuxia scrabescens* (Griseb.)Hook.f.	Gramineae	WCE	3000-4600	3300
60	*Elsholzia eriostachya* (Benth.)Benth.	Labiatae	WCE	3000-4800	3800
61	*Ephedra gerardiana* wall	Ephedraceae	WCE	2300-5200	3900
62	*Epipactis royleana* Lindl.	Orchidaceae	WC	1600-3500	3400
63	*Equisetum debile* Roxb.ex Vaucher	Equisetaceae	WCE	1000-3200	3300
64	*Euphorbia helioscopia* L.	Euphorbiaceae	WCE	3000-4100	3700
65	*Euphorbia stracheyi* Boiss.	Euphorbiaceae	WCE	2000-5000	3900
66	*Euphrasia himalayica* Wettst.	Scrophulariaceae	WCE	3200-4200	4100
67	*Fragaria nubicola* Lindl.ex Lacaita	Rosaceae	WCE	1600-4000	3400
68	*Galium asparine* L.	Rubiaceae	WC	2700-3600	3800
69	*Gentiana algida* Pall.	Gentianaceae	CE	4800	3800
70	*Gentiana bryoides* Burkill	Gentianaceae	WCE	3000-4500	3800
71	*Gentiana depressa* D.Don	Gentianaceae	CE	2900-4300	4000
72	*Gentiana robusta* King ex Hook.	Gentianaceae	C	3600-3900	3800
73	*Gentianella falcata* H.Sm	Gentianaceae	CE	4000-5200	4000
74	*Gentianella paludosa* (Hook.) H.Sm.	Gentianaceae	WCE	3000-4600	4200
75	*Gerbera nivea* (DC).Sch.Bip.	Asteraceae	WC	2800-4500	4000

76	*Gueldenstaedtia himalaica* Baker	Fabaceae	WCE	3300-4600	3900
77	*Hedysarum manaslense (*Kitam) H.Ohashi	Leguminosae	C	3000-3500	4000
78	*Heracleum obtusifolium* wall.ex DC	Umbelliferae	C	2400-	3300
79	*Hippophe salicifolia* D.Don	Elaeagnaceae	WC	2200-3500	3300
80	*Iris kemaonensis* D.Don	Iridaceae	WCE	2500-4300	3900
81	*Juniperus communis* L.	Cupressaceae			3300
82	*Juniperus indica* Bertol.	Cupressaceae	WCE	3700-4100	3300
83	*Juniperus squamata* Buch.-Hem.ex D.don	Cupressaceae	WCE	3300-4400	3300
84	*Kobresia gammiei* C.B. Clarke	Cyperacace	C	3600-4000	3700
85	*Kobresia unicoides*(Boott)C.B.Clarke	Cyperacace	WCE	3500-4400	3500
86	*Leontopodium stracheyi* (Hook.F) C.B.Clarke ex Hemsi.	Asteraceae	WC	2200-4500	4000
87	*Ligustrum confusum* Decne.	Oleaceae	CE	800-2900	4000
88	*Lonicera hispida* Pall.Ex Wild	Caprifoliaceae	WCE	2900-4500	3900
89	*Lonicera hypoleuca* Decne.	Caprifoliaceae	WC	3000-4200	4100
90	*Lonicera purpurascens* Walp.	Caprifoliaceae	WC	3300-4000	3400
91	*Lonicera tomentella* Hook.	Caprifoliaceae	C	2400-3600	3600
92	*Maharanga emodi(*Wall) A.DC	Boraginaceae	WCE	2200-4500	3300
93	*Medicago falcata* L.	Fabaceae	C	2700-4000	3300
94	*Morina nepalensis* D.Don	Morinaceae	WCE	3000-4500	3300
95	*Myricaria rosea* W.W.Sm	Tamaricaceae	C	3300-4500	3300
96	*Origanum vulgare* L.	Labiatae	WC	600-4000	3300
97	*Oxytropis moliss* Royle	leguminosae	C	2500-	3600
98	*Oxytropis williamsii* Vas.	Leguminosae	WC	2500-4400	4300
99	*Pedicularis axillaries* Franchet ex Maximowicz	Scrophulariaceae	C	3200-3650	3800
100	*Pedicularis longiflora* Rudolph.	Scrophulariaceae	WCE	3300-5000	3600
101	*Pedicularis pectinata* wall.ex Benth.	Scrophulariaceae	WC	3000-4000	3800
102	*Pedicularis rhinanthoides* Schrenk	Scrophulariaceae	WCE	3300-4800	4000
103	*Pinus wallichiana* A.B.Jackson	Pinaceae	WCE	1800-4100	3300
104	*Plantago erosa* Wall.	Plantaginaceae	WCE	900-4100	4000
105	*Pleurospermum hookeri* C. B. Clarke	Apiaceae	WCE	900-4100	3900
106	*Polyganatum cirrhifolium* (Wall.) Royle	Liliaceae	WCE	1700-4600	3400
107	*Polygonatum hookeri* Baker.	Convallariaceae	WCE	2900-5000	4200
108	*Polygonatum verticillatum* (L.) All.	Convallariaceae	WCE	2400-4700	3800
109	*Potentilla eriocarpa* Wall.ex.Lehm	Rosaceae	WCE	3600-5050	3900
110	*Potentilla fruticosa* Lindl.ex Lehm.	Rosaceae	WCE	3700-60s00	3300
111	*Potentilla fulgens* Wall. ex Hook.	Rosaceae	C	2400-4150	3800
112	*Potentilla gelida* C.A.Mey.	Rosaceae	C	3000-4500	4000
113	*Potentilla microphylla* D.Don.	Rosaceae	WCE	3800-5100	3700
114	*Potentilla peduncularis* D.Don	Rosaceae	WCE	3000-4700	4100
115	*Primula capitata* Hook.	Primulaceae	E		3800
116	*Primula glomereta* Pax	Primulaceae	WCE	3100-5200	4100
117	*Pterocephalus hookeri* (C. B. Clarke) Diels	Dipsacaceae	WC	3000-4500	4100

118	*Rhododendron anthopogon* D.Don	Ericaceae	WCE	3300-5100	3300
119	*Rhododendron lapidotum* Wall.D.Don	Ericaceae	WCE	2100-4700	4200
120	*Rosa macrophylla* Lindley	Rosaceae	WCE	2100-3800	3300
121	*Rosa sericea* Lindl.	Rosaceae	WCE	2200-4600	3300
122	*Rumex nepalensis* Spreng.	Polygonaceae	WCE	1200-4200	3300
123	*Salix lindleyana* Wall.	Salicaceae	CE	3000-4600	3400
124	*Saussurea pachyneura* Franch.	Asteraceae	E	3800	4100
125	*Saxifraga parnassifolia* D.Don	Sxifragaceaea	WCE	1900-4900	4000
126	*Selinum wallichianum* (DC.)Raizata &Saxena.	Apiaceae	WCE	2700-4800	3800
127	*Silene nepalensis* Majumdar	Caryophyllaceae	WCE	3500-5000	3600
128	*Spiraea arcuata* Hook.	Rosaceae	WCE	3500-4900	4000
129	*Spiraea canescens* Hornem	Rosaceae	WCE	1500-3200	3300
130	*Stellaria congestiflora* Hara	Caryophyllaceae	CE	4200-4700	4200
131	*Stellaria patens* D.Don	Caryophyllaceae	CE	1300-4000	4200
132	*Swertia chirayita* (Roxb.ex Fleming)Karsten	Gentianaceae	CE	1500-2500	3900
133	*Swertia cuneata* D.Don	Gentianaceae	WCE	1700-5000	4100
134	*Taraxacum eriopodum* DC.	Asteraceae	WCE	3300-4600	3700
135	*Thalictrum alpinum* L.	Ranunculaceae	WCE	2800-5000	4300
136	*Thalictrum cultratum* Wall.	Ranunculaceae	WCE	2400-4200	3300
137	*Thesium chinense* Turcz.	Santalaceae	C	3100-4200	4000
138	*Thymus linearis* Benth.	Labiatae	WCE	2400-4500	3700
139	*Trigonella emodi* Benth.	Leguminosae	WCE	1300-4900	3800
140	*Verbescum thapsus* L.	Scrophulariaceae	WCE	1800-4000	3400
141	*Viola biflora* L.	Violaceae	WCE	2100-4500	
142	*Viola kunawarensis* Royle	Violaceae	WC	3600-3900	

Appendix 7: Plot wise species density along with environmental variables

Plot	Altitude	Species no.	Incense species	Herb incense	Woody incense	Relative radiation index	Grazing
1	3377	19	7	1	6	0.198848	2
2	3351	19	8	3	5	0.317433	1
3	3374	15	7	2	5	-0.06252	1
4	3387	17	7	3	4	0.784115	1
5	3371	14	6	3	3	0.729661	1
6	3365	21	4	1	3	0.687616	2
7	3475	22	7	3	4	0.336415	1
8	3490	28	7	3	4	0.915564	1
9	3495	20	9	4	5	0.281419	1
10	3477	24	8	4	4	0.921945	2
11	3462	27	8	3	5	0.981539	2
12	3461	21	5	2	3	0.982468	2
13	3584	20	8	3	5	0.747325	1
14	3585	15	5	2	3	0.56671	2
15	3580	20	9	4	5	0.904909	1
16	3538	21	9	5	4	0.852201	0
17	3559	24	9	5	4	0.946875	1
18	3580	23	9	4	5	0.274746	1
19	3687	22	6	2	4	0.831231	2
20	3688	19	6	2	4	0.831228	2
21	3655	17	2	1	1	0.922841	2
22	3694	15	3	2	1	0.871946	1
23	3677	22	5	4	1	0.786979	2
24	3686	26	6	5	1	0.864496	1
25	3753	23	8	4	4	0.667189	0
26	3715	25	7	4	3	0.921898	1
27	3701	26	9	4	5	0.898478	1
28	3741	25	10	5	5	0.922802	1
29	3769	23	9	4	5	0.898473	1
30	3782	42	11	6	5	0.969132	1
31	3885	27	7	4	3	0.959122	2
32	3866	26	7	4	3	0.805655	2
33	3885	16	5	3	2	0.852226	1
34	3839	39	8	5	3	0.980034	1
35	3840	44	10	5	5	0.999368	1
36	3845	40	8	4	4	0.986676	0
37	3992	31	8	4	4	0.882856	1
38	3997	33	7	4	3	0.982066	1
39	3961	35	7	4	3	0.955712	1

40	3952	35	8	6	2	0.861768	1
41	3959	44	10	7	3	0.890367	1
42	3947	32	5	3	2	0.978299	1
43	4098	35	6	4	2	0.951717	2
44	4071	44	7	5	2	0.98207	1
45	4075	36	5	3	2	0.945057	1
46	4022	32	8	5	3	0.907868	1
47	4046	35	6	4	2	0.946774	1
48	4026	34	9	6	3	0.876195	1
49	4184	40	8	5	3	0.968368	1
50	4185	38	6	4	2	0.912395	2
51	4197	32	7	4	3	0.915237	1
52	4159	32	7	4	3	0.971565	1
53	4150	30	6	4	2	0.98039	0
54	4140	26	6	4	2	0.968146	1
55	4237	29	6	3	3	0.921847	1
56	4261	32	7	3	4	0.922765	1
57	4248	27	5	3	2	0.899011	1
58	4229	29	5	3	2	0.921847	2
59	4220	30	4	2	2	0.91406	1
60	4209	28	5	2	3	0.913907	1
61	4385	32	6	2	4	0.98149	2
62	4370	36	6	3	3	0.92301	2
63	4373	31	5	1	4	0.70808	1
64	4361	35	5	2	3	0.944848	2
65	4327	30	6	2	4	0.865279	2
66	4310	22	5	2	3	0.900954	2

Appendix 8: Table showing use frequency value of different incense species

Name of incense plants	common name	Use frequency (%)	Number of household
Potentilla fruticosa L.	Teba(n)	2.5	1
Polygonatum cirrhifolium (Wall.) Royle	Gomesha(n)	7.5	3
Populus ciliata Wall.ex Royle	Teba(n)	7.5	3
Anaphalis xylorhiza Sch.Bip.ex Hook.f.	Bukhiphool(N)	15	6
Valeriana jatamansii Jones	Nappu(n)/Ghyapoo (n)	15	6
Anaphalis contorta (D.Don) Hook.f.	Pansan(n)/Bukhi Phool(N)	22.5	9
Anaphalis triplinervis (Sims) C.B. Clarke	Fojormindo(n)/phosorsan(n)	20	8
Artemisia biennis Willd.	Fojormendho(n)	25	10
Abies spectabilis (D. Don) Mirb.	Kye(n)/gobresalla (N)	27.5	11
Artemisia vestita Wall. ex Bess	Tamboi(n)/paaati(N)	27.5	11
Oxytropis williamsii Vassilcz	Sinshi(n)	30	12
Pinus wallichiana A.B.Jackson	Thangsin (n)	30	12
Artemisia siversiana Willd.	Tompe(n)/paati(N)	32.5	13
Artemisia caruifolia Buch.-Ham.	Chaphong(n),serphang(n)/titepaati(N)	35	14
Artemisia gmelinii Weber ex stechm.	Bajha(n)/Fumungh(n)	35	14
Selinum wallichianum (DC.) Rhizada & H.O. Saxena	Bhutkesh (n)	35	14
Origanum vulgare L.	Akhebobo(n)/ Ghoodhaamarcha(n)	37.5	15
Artemisia dubia Wall.ex Besser	Khangkhar (n)	40	16
Salix babylonica L.	Chayanghma(n)	42.5	17
Salix lindleyana Wall.ex Andersson	Langhma (n)	42.5	17
Leontopodium stacheyi (Hook.F) C.B.Clarke ex Hemsley	Bukhi phool(N)	47.5	19
Thamnolia vermicularis (Sw.)Ach.ex Schaerer	Syaurujhung (n)/snow tea	47.5	19
Rhododendron lepidotum Wall. ex D.Don	Bhaiunakpo(n)	50	20
*Myricaria rosea*W.W.Smith	Angmaa (n)	55	22
Nardostachys grandiflora DC.	Pangphoie(n)	72.5	29
Juniperus communis L.	Cheltung (n)/Bhote papal(N)	72.5	29
Juniperus squamata -Ham.ex D.Don	Sukppha (n)/Sukri(n)	77.5	31
Betula utilis D.Don	Bushpath (n)	80	32
Rhododendron anthopogon D.Don	Pallu(n)	80	32
Ajania gracilis (Hook.f. & Thomson) Poljakov	Khamsan (n)/dhup (N)	80	32
Juniperus indica Bertol.	Phar (n)	100	40

*n= Local name, *N=Common name

PLATE 1: Useful incense Plants of Manang District,Central Nepal

A. *Juniperus indica* Bertol. **B**. *Ajania gracilis* (Hook.f. & Thomson) **C**. *Leontopodium stacheyi* (Hook.F) C.B.Clarke ex Hemsi. **D**. *Rhododendron anthopogon* D.Don **E.**Collection of incense Plants **F**. Container used for burning incense plants

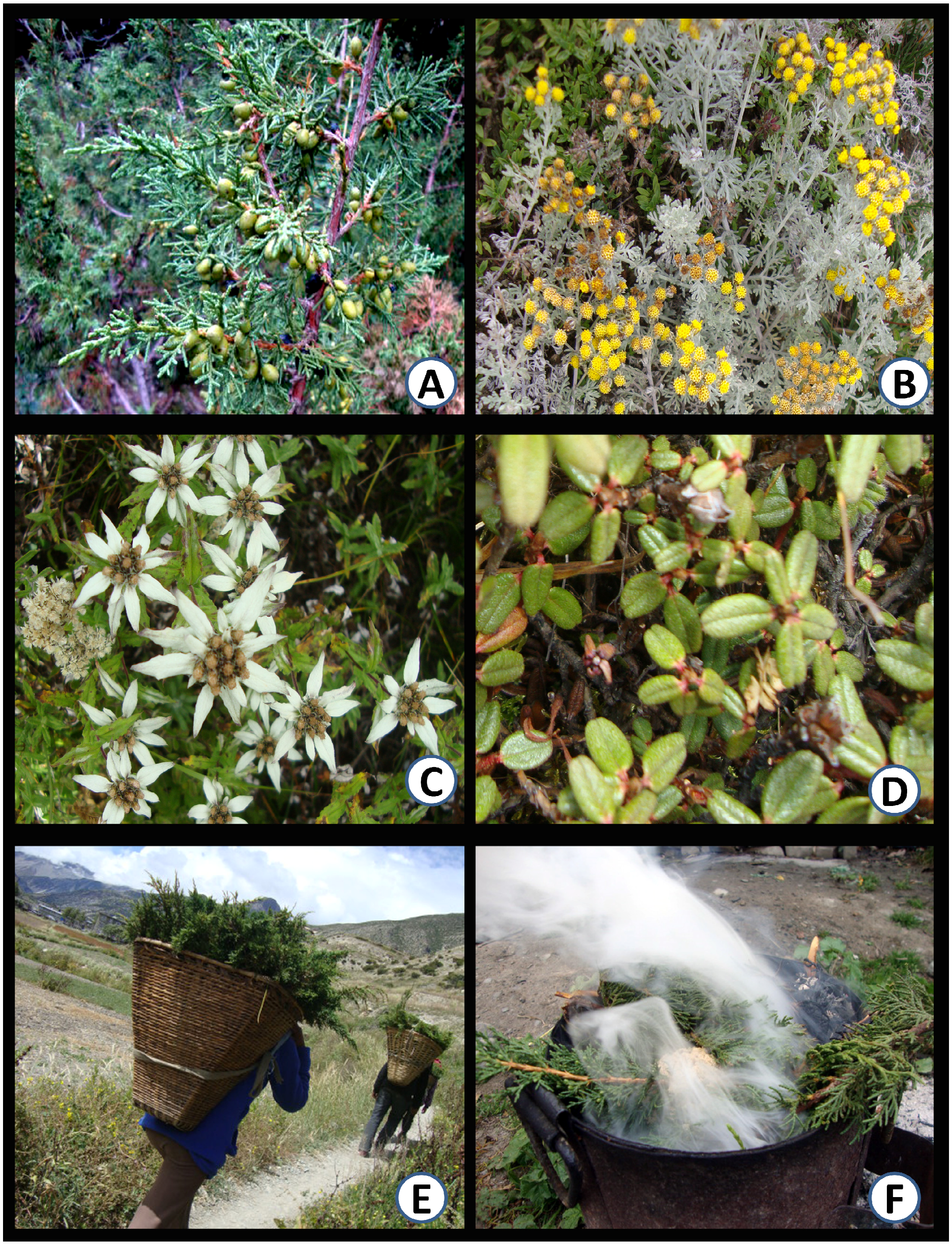

PLATE 2: A-B: Cropfield and Vegetation showing in Manang C-E: Interviews taking photographs with local people F: the photograph taking ecological sampling plot.