ASSESSMENT OF THREATENED MEDICINAL PLANTS IN LANGTANG NATIONAL PARK CENTRAL NEPAL

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Submitted By

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CERTIFICATE

This is to certify that the dissertation work entitled **"ASSESSMENT OF THREATENED MEDICINAL PLANTS IN LANGTANG NATIONAL PARK, CENTRAL NEPAL"** submitted by **Mr. Nawal Shrestha** has been carried out under my supervision. The entire work is based on the results of his research work and has not been submitted for any other degrees to the best of my knowledge. I recommend this dissertation work to be accepted for partial fulfillments of Master of Science in Botany (Plant Systematics), Tribhuvan University, Kirtipur, Kathmandu.

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LETTER OF APPROVAL

The dissertation paper submitted by **Mr. Nawal Shrestha** entitled **"ASSESSMENT OF THREATENED MEDICINAL PLANTS IN LANGTANG NATIONAL PARK, CENTRAL NEPAL"** has been accepted as a partial fulfillment of Master of Science in Botany (Plant Systematics).

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Apr 28, 2007 **Nawal Shrestha**

List of Acronyms

ACAP	Annapurna Conservation Area Project
ANSAB	Asia Network for Sustainable Agriculture and Bioresources
BZ	Buffer Zone
CAMP	Conservation Assessment and Management Planning
CBD	Convention on Biological Diversity
CCO	Canadian Co-operation Office
CITES	Convention on International Trade in Endangered Species of wild flora and fauna
Cov.	Coverage
D	Density
DDC	District Development Committee
DFO	District Forest Office
DoF	Department of Forests
DPR	Department of Plant Resources
F	Frequency
FORESC	Forest Research and Survey Centre
FRLHT	Foundation for Revitalization of Local Health Traditions
GoN	Government of Nepal
GPS	Global Positioning System
HNCC	Herbs and NTFP Co-ordination Committee
HPPCL	Herbs Production and Processing Company Ltd.
ICIMOD	International Centre for Integrated Mountain Development
IDRC	International Development Research Centre
IUCN	The World Conservation Union
IVI	Importance Value Index
KCAP	Kangchenjunga Conservation Area Project

LNP	Langtang National Park
MAP	Medicinal and Aromatic Plant
MAPPA	Medicinal and Aromatic Plants Programme in Asia
MAPDON	Medicinal and Aromatic Plant Database of Nepal
MOFSC	Ministry of Forests and Soil Conservation
NTFP	Non-Timber Forest Product
RC	Relative Coverage
RD	Relative Density
RF	Relative Frequency
RVA	Rapid Vulnerability Assessment
SHL	Sacred Himalayan Landscape
TAL	Terai Arc Landscape
TRAFFIC	The Wildlife Trade Monitoring Network
TU	Tribhuvan University
UNESCO	United Nations Educational, Scientific and Cultural Organization
URL	Uniform Resource Locator
VDC	Village Development Committee
WHO	World Health Organization
WWF	World Wide Fund for nature

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ABSTRACT

Langtang National Park is a unique habitat for a number of highly valuable medicinal and aromatic plants (MAPs). Of the 51 species of MAPs prioritized by CAMP workshop, 20 species are found in the area. This includes 11 species under IUCN threat category, 4 species under CITES Appendix II, 8 species under DPR prioritization and 18 species under HNCC prioritization. The area also harbors many threatened and endemic plants like *Jurinea dolomiaea, Meconopsis dhwojii, Heracleum lalli,* etc. The present study is an endeavor to document information on their status, distribution and assess their extent of threat. The study encompasses two field visits during the pre-monsoon and post monsoon seasons. Ecological tools have been used to assess population status of threatened species in the area. Rapid Vulnerability Assessment of threatened species was made to assess their resilience to human use.

The species are concentrated to two main hotspot areas: Cholangpati-Gosainkunda sector in the south-west and Langtang-Kyanjin sector in the north-east. These areas are rich in threatened and endemic species as well as high valued medicinal plants. Collection of MAPs for local use as well as large scale collection for trade is prevalent in the area. The species that are in trade includes *Swertia chirayita, Nardostachys grandiflora* and *Valeriana jatamansii*. The total amount of NTFPs traded from Rasuwa district in the fiscal year 2062/63 was about 91,000 kg with revenue collection of NRs. 390,000. A small number of households have started cultivation of MAPs in their farm lands. The cultivated species include *Swertia chirayita, Paris polyphylla, Valeriana jatamansii,* etc. Many species in the area are threatened due to unsustainable harvesting to meet the increasing demand by trade. Study shows that *Dactylorhiza hatagirea, Neopicrorhiza scrophulariiflora* and *Nardostachys grandiflora* are the most vulnerable species that are subjected to high threat risk. The vulnerability score placed *Neopicrorhiza scrophulariiflora* in threat category I, representing highest vulnerability. Six species of MAPs, namely *Aconitum spicatum, Dactylorhiza hatagirea, Jurinea dolomiaea, Meconopsis dhwojii, Nardostachys grandiflora* and *Swertia angustifolia* belonged to threat category II. Similarly, 3 species belonged to threat category III. This includes *Fritillaria cirrhosa, Rheum australe* and *Valeriana jatamansii*. Sustainable harvest and promotion of these species into cultivation can enhance the natural resource base of the area.

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1. INTRODUCTION

1.1 Background

A large number of world's population depends on traditional herbal medicine to meet their primary health care needs. It is estimated that 70-80% of people worldwide rely chiefly on traditional, largely herbal medicines (Fansworth and Soejarto, 1991; Shengji, 2001). Medicinal plants constitute 80% of raw materials for preparation of traditional drugs. They also contribute at least 25% in modern drug industry (Rawat and Karki, 2004). There is no reliable figure for the total number of medicinal plants on earth but an estimate of about 50,000 species (10-18% of the global flora) is provided by Schippmann *et al.* (2002). Globally, the two countries with the highest numbers of medicinal plants are China with 10,027 species (41% of its angiosperm flora) and India with 7500 species (44% of its vascular flora) (Shiva, 1996; Xiao and Peng, 1998). More than 6500 species of flowering plants have been recorded from Nepal (Press *et al.*, 2000; HMG Nepal, 2002) and an estimated 1700 species of plants are considered having medicinal properties (Shrestha *et al.*, 2000; Rawal, 2004; Sharma and Das, 2004; Baral and Kurmi, 2006). This comprises about 25 percent of the total number of flowering plants occurring in Nepal.

In Nepal, like in most other developing countries, non-timber forest products (NTFPs), especially medicinal and aromatic plants (MAPs), are vital to the rural people providing major support to the livelihoods. It is estimated that about 20 percent of the medicinal and aromatic plants in Nepal are commercially utilized (Edwards, 1996). High value but low volume MAPs are mainly found in wild in the mountains and substantial proportion of the local peoples' livelihood depends on the collection and sale of these products. About 100 species of NTFPs including about 70 species of MAPs are currently traded from Nepal. About 10 to 15 thousand tons of MAPs are exported every year from the country (Bhattarai and Maharjan, 2001). India is by far the dominant export trade destination of MAPs and there is very low domestic demand for raw plant materials in Nepal. *Nardostachys grandiflora*, *Swertia chirayita*, *Neopicrorhiza scrophulariiflora*, *Zanthoxylum armatum* and *Sapindus mukorosii* are the top five species of NTFPs currently in trade (Olsen, 2005a).

The collection and trade of medicinal plants have remained one of the sources of rural livelihood. The data of Department of Forests shows that 3,200 tons of NTFPs were exported from Nepal contributing NRs. 14.9 million as revenue in the fiscal year

2000/2001. Lack of proper management has rendered plants of high commercial value in a state of threat. This is prevalent throughout the country. Fifty one medicinal plants have entered into different threat categories such as rare, endangered, vulnerable and commercially threatened (Bhattarai *et al.*, 2002). For this reason, conservation and sustainable utilization of medicinal plants have been identified as the key issues for Nepal. Government of Nepal, in the recent time, has given this matter a high priority and adopted Herbs and NTFPs Development policy to develop this sub-sector for the benefit of rural people in general.

The present study area, Langtang National Park (LNP) which is the second largest national park in the country is a habitat for a large number of vascular plant species (Malla *et al.*, 1976; Shrestha and Shrestha, 2000). Majority of these species are medicinal and aromatic plants (Shrestha *et al.*, 2002; Dangol, 2002). LNP has been identified as the chief hotspot area in central Nepal in terms of biodiversity. It harbors many endemic as well as locally and globally threatened species (Shrestha and Joshi, 1996). The species are subjected to high collection pressure due to growing trade demand. In addition, higher dependency of the local people on the resources and unsustainable harvesting has greatly increased the vulnerability of the species (Yonzon, 1993).

Although this trend of collection, transportation and trade of medicinal and aromatic plants has remained functional for a long time, it cannot always serve as a model for the future. Hence, it is not only necessary but also logical to develop and manage this sub-sector of renewable natural resource or biodiversity, taking into prudent consideration of the age-old local traditions, indigenous knowledge systems and wise practices for developing and implementing sustainable livelihoods and biodiversity conservation.

1.2 Distribution of medicinal plants in Nepal

The MAPs are found growing between 100 m to 5,500 m along the elevational gradient in Nepal. The uppermost range of distribution is different for different life forms groups. The MAPs belonging to trees life form group are found up to 4,400 m but the MAPs species belonging to shrub life forms group are found up to 5,100 m. Similarly climbers are found up to 3,200 m and herbaceous MAPs are found up to 5,500 m (Bhattarai and Ghimire, 2006).

Looking at the horizontal distribution, central Nepal is the region from where maximum number of species, 540 (85%) has been recorded. The numbers from western

and eastern regions are 424 (67.3%) and 512 (81.27 %) respectively. It is the sub-tropical region of the country that harbors the maximum number of indigenous species 340 (53 %). Next comes the tropical zone that lodges 310 species (49 %) followed by temperate, sub-alpine and alpine zones with 225 species (35.7 %), 144 species (18.09 %) and 45 species (7.14 %) respectively (Malla and Shakya, 1984).

1.3 Existing policies and conservation strategies

The Master Plan for Forestry Sector (1989-2010) of Government of Nepal has recognized the role of MAPs to uplift the socio-economic condition of the local people. The current Tenth Five Year (2003-2008) has given emphasis to the development of MAPs as a priority program alleviating poverty. Rare and high priced medicinal herbs are on top priority for domestication, research and cultivation, processing and marketing. In order to conserve and manage wild NTFPs, including medicinal and aromatic plants in sustainable way, the Government of Nepal has given various modes of protection; some plants are totally banned, while others can be harvested but must be processed before export.

A national level Herbs and NTFP Coordination Committee (HNCC) has been formed under the chairmanship of Minister of Forests and Soil Conservation in the year 2002. It aims to create legislative and other enabling environment in which Herbs and NTFPs, in general, are conserved, sustainably harvested and benefits shared equally among the rural communities.

The Government has recently approved policy on NTFP development. The implementation of this policy will help in conservation, management, utilization, marketing, trade and export promotion, simplification of taxation and certification, and various other activities that are essential to develop herbs and NTFPs as a new sector. It will also help resolve different constraints and issues present in herbs and NTFP development.

Fourth amendment of the National Parks and Wildlife Conservation Act 2029 and the enactment of Buffer Zone Management Regulation 2052 opened avenue for local people's participation in carrying out integrated conservation and development activities to meet the needs of local residents and maintain the natural biodiversity to future generation intact. In Baisakh 14, 2055 (April 27, 1998) settlements inside the Langtang National park areas as well as 418.3 sq. km of adjoining areas were declared as a buffer zone (BZ) of the park (LNP, 2001). The declaration of LNP's BZ, provided an unique

opportunity as well as a monumental challenge to maintain biodiversity incorporating integrated conservation and sustainable development programs.

The community forestry program has been found to be very reliable for effective management of forest resources, in different parts of the country. This program has been practiced in LNP as well. LNP encompasses three districts in Central Nepal. They include Rasuwa, Sindhupalchowk and Nuwakot. The District Forest Offices of these districts have already handed over 78 forest patches to local users as community forest outside the core park area. This includes 53 in Rasuwa, 12 in Nuwakot and 13 in Sindhupalchowk, totaling 11,132.61 hectares (11.13 sq. km). From this program, 9,105 households have been benefited (LNP, 2001). This has considerably decreased dependency of the local people on park resources.

1.4 Threatened and protected MAPs of Nepal

In many parts of Nepal, MAPs in the wild are depleting due to continuous harvests without any plan to regenerate and sustain them. These plants occur even now in good density in national parks and reserves, where harvest is prohibited or restricted. Over-harvesting of resources in many cases has made them rare in the wild, in some cases threatening or even endangering their status (Sharma *et al.*, 2005). Currently 60 species of non-endemic plants of Nepal are considered as threatened (Shrestha and Joshi, 1996) based on IUCN threat categories. Among them, 29 species are medicinal and aromatic plants.

The International Development Research Center (IDRC)-funded Conservation Assessment and Management Planning (CAMP) workshop was held in Pokhara in 2001. The workshop attempted to assess the conservation and management status of MAPs of Nepal using IUCN guidelines. Fifty-one MAP species have been assigned to various categories: 3 taxa were classified as ‘Critically Endangered”, 14 as ‘Endangered’, 23 as ‘Vulnerable’, 3 ‘Nearly Threatened’, 1 Taxon as of ‘Least Concern’, and 7 taxa as having ‘Data Deficient’. This analysis gives clear warning bells to act immediately to halt or reverse the current trend of degradation so that a healthy resource base of these plants could be maintained (Bhattarai *et al.*, 2002).

Currently 30 species of NTFPs have been prioritized by Herbs and NTFP Co-ordination Committee (HNCC) for further research and promotion and those 12 species have been identified for agro-technology development by DPR. The medicinal plants that

have been prioritized for agro-technology development are: *Dactylorhiza hatagirea* (Paanchaunle), *Neopicrorhiza scrophulariiflora* (Kutki), *Swertia chirayita* (Chirayito), *Nardostachys grandiflora* (Jatamansi), *Valeriana jatamansii* (Sugandhawal), *Taxus wallichiana* (Lauth salla), *Zanthoxylum armatum* (Timur), *Rauvolfia serpentina* (Sarpagandha), *Asparagus racemosus* (Satawari), *Piper longum* (Pipla), *Cinnamomum glaucescens* (Sugandha kokila), and *Tinospora sinensis* (Gurjo).

1.5 Threats to medicinal plants

Species of medicinal plants occur at all altitudes. However, the greatest number of species of medicinal plants is found in central Nepal and, in particular, in the sub-tropical zone (Malla and Shakya, 1984). As reported for India and Nepal, the majority of traded medicinal plants originate from lower altitudes (Olsen, 2005b). On the other hand, the great diversity of herbs and shrubs found in Alpine meadows is of great importance in Tibetan medicine. Himalayas are home to four of the world's great medical traditions – Ayurveda, Chinese, Tibetan and Unani. All of these are very extensively used also outside the Himalayas, which is one reason why so much collection pressure is placed on Himalayan plants. Millions of Himalayan residents depend on the harvesting of wild medicinal plants for an income. There is generally very little cultivation (Larsen *et al.*, 2000). High collection pressure on these medicinal herbs has put them under high threat risk. Higher altitude plants are considered to be particularly at risk because of their often sparse occurrence, slow growth, large number of households involved in commercial collection, the tendency of these households to be strongly reliant on the income so received and the relatively high number of local endemics sought by collectors (Olsen, 2005b). Generally, it is the roots or other underground organs of these mainly herbaceous species that are sought for collection, contributing to its destructiveness.

The major direct threats to medicinal plants across the Himalaya are generally agreed to be habitat loss (including deforestation), habitat fragmentation, overgrazing by domestic stock, burning and unsustainable harvesting. More local direct threats include pressures from tourism, mining and construction.

1.6 Literature review

1.6.1 Enumeration of medicinal plants

The earliest publication on medicinal plants of Nepal was that of Banerjee (1955) who studied edible and medicinal plants from East Nepal. There are several pre-historical manuscripts on utilization of plant resources available from seventh century, that are published in different scripts. This could be justified by the publication of "Chandra Nighantu" (Kanai, 1971), a hand written herbal encyclopaedia with 750 coloured plates of plants and its medicinal uses in 8 volumes at the end of 19th century.

Many works has been done throughout the country on enumeration of medicinal plants and their therapeutic uses (Manandhar, 1980a, 1980b, 1989a, 1989b, 1992, 1993, 1998; Bhattarai, 1990; Basnet, 1998; Bohra, 1998; Sharma, 2000; Regmi *et al.*, 2000; Shrestha and Dhillion, 2003). A large number of plants have been described from different parts of the country used by various ethnic groups.

The book "Medicinal plants of Nepal" first published in 1970 by the Department of Medicinal Plants (currently Department of Plant Resources) provides comprehensive information on 393 species, their therapeutic uses, distribution, etc. (HMG Nepal, 1970). It was supplemented by another volume in 1984 with additional 178 species of plants (HMG Nepal, 1984).

Malla and Shakya (1984) have listed 630 species of plants of possible medicinal uses constituting about 12% of the country's known vascular flora. Of these species, 120 are either exotic or indigenous that are naturalized or cultivated since long.

The medicinal and aromatic plant database of Nepal (MAPDON) has listed 1,624 medicinal and aromatic plants, which are commonly available in crude drug market, under cultivation and in wild from (Shrestha *et al.*, 2000).

IUCN Nepal published a national register of medicinal plants in 2000 (IUCN, 2000). This publication has been revised and updated in 2004 which describes 187 species of medicinal plants (IUCN, 2004).

Rajbhandari (2001) compiled 562 species of plants from Nepal with ethnobotanical uses. Most of the species are medicinal and aromatic plants and is widely used by various ethnic communities and tribes of Nepal.

Shrestha *et al.* (2003) reported 270 species of NTFPs from western TAL region (Dang to Kailali), of which nearly 70 % species are medicinal and aromatic plants.

Watanabe *et al.* (2005) published "A Handbook of Medicinal Plants" in 2005. The book includes description of 108 important medicinal plants of Nepal along with their chemical constituents.

Baral and Kurmi (2006) in their "Compendium of Medicinal Plants in Nepal" have compiled 1,792 species of medicinal plants being used in Nepal.

1.6.2 MAPs of Langtang National Park

Malla *et al.* (1976) reported 911 species of vascular plants from the Langtang National Park and adjoining areas. Of these, about 132 species have been reported to have medicinal value.

Manandhar (1980a) described 43 species of less known and more important medicinal plants of Rasuwa district along with their specific uses, dose and mode of preparation.

Bhandary and Shrestha (1982) reported the uses of 15 poisonous plant species from Annapurna and Langtang Himal area.

Joshi and Edington (1990) reported 66 species of medicinal plants belonging to 46 families from two VDCs (Chaubas and Syabru) of Rasuwa district, Central Development Region.

Yonzon (1993) published 90 species of plants with medicinal value from Langtang area. He studied the availability of jaributi in the Langtang area and impact of local people on the jaributi as well as their future challenges. He found that, exploitation of medicinal plants from Langtang National Park is creating havoc in maintaining ecological integrity in the park. He felt the need of an inventory to be conducted of all medicinal plants to determine which products are present in sufficient quantities to permit collection.

Shrestha and Shrestha (2000) reported 82 species of ethno-medicinal plants of Langtang National Park, which have been used to cure 32 types of diseases.

Shrestha *et al.* (2002) documented and mapped medicinal plants of Langtang National Park. They found some 95 species of medicinal plants belonging to 52 families

in the region which were widely used by the local Tamang communities for treating up to 40 different types of diseases.

Dangol (2002) assessed the forest community diversity and associated medicinal plants in Langtang National Park and reported a total of 85 species of medicinal plants in the 8 vegetation communities. He felt that main issues of the conservation of biodiversity in Langtang National Park are forest degradation and habitat fragmentation owing to the over exploitation of natural resources.

1.6.3 Trade of medicinal plants

Himalayan medicinal plants appear to have been traded for millennia (Jacob and Jacob, 1993). However, only in recent years, commercially traded Himalayan plant species have received scientific attention and their potential for contributing to rural livelihoods and their conservation consequences of harvest and trade are highly discussed. Various studies have been made on identifying the species and products in trade (Manandhar, 1980b; Murty, 1993), outlining trade patterns (Farooquee and Saxena, 1996; Olsen, 1998; Mulliken, 2000) and estimating the importance of trade to rural harvesters (Olsen and Larsen, 2003).

Malla *et al.* (1995) reported an average annual licensed collection of Kutki in Nepal of approximately 25 tonnes and a trader estimate of annual national trade of 98 tonnes from 1989 to 1992.

Edwards (1996) reported that, every year about 10,000 to 15,000 tons of non-timber forest products (NTFPs) are harvested from forest land in the Middle Hills and High Mountains of Nepal and traded to India. Several road head towns, often district headquarters are important collection points for these products. He estimated an export of 24 tonnes of Kutki from five districts in eastern Nepal in 1991/92.

Olsen and Helles (1997) investigated the trade in medicinal and aromatic products from the rural area of Gorkha district in Central Nepal to the wholesale markets in India over a two-year period. They found that approximately 98 percent of the products are exported unprocessed to India. They emphasized that the government should focus on provision of public goods, such as dissemination of price information and developing physical infrastructure. They also felt the need of review of bans on collection and trade and a restructuring of current approaches.

Olsen (1999) estimated that Nepal's annual export to India of dried unprocessed rhizomes of *Nardostachys grandiflora* involves approximately 1,000 tons per year. *N. grandiflora* is one of the two most important species traded from Nepal.

Chhetri (1999) assessed the diversity of medicinal and aromatic plants (MAPs) in the lower valleys of Manang District and evaluated the status of commercially potential MAPs in terms of availability, trade and value to the local people. He reported 12 species of MAPs from the area which falls under the threatened and protected lists. He also showed that large quantities of MAPs are illegally traded from the area.

Gahire (2003) reported that the DFO records show only 9.5 % of total amount of kutki legally traded from Manang district and the remaining 90.5 % was harvested, collected and shipped illegally from the district.

Das (2005) reported that of about 7,000 species of plants in Nepal, 165 species are currently in trade, 20 species cover over 80 percent of volume and value of commerce and 250 species have high potential for marketing. He felt that NTFP sub-sector is under utilized in Nepal and a lot of coordinated efforts are required on research for commercialization of NTFPs and sustainable management of resources.

1.6.4 Conservation/ Management

Farooquee and Saxena (1996) conducted a survey of two villages inhabited by Bhotiya tribal people in Uttar Pradesh, India and found that medicinal herbs constitute about 12-13 percent of total income to the villages. Higher dependency of the villages has increased the pressure on plant populations giving clear indication on decline of these resources. They are in a view that cultivation is the only viable option for the resource and for the income of the local people who depend on it.

Cameron (1996) facilitated a biodiversity conservation project in the vicinity of Khaptad National Park in the Seti zone, linking conservation with the marketing of high-altitude medicinal plants. She found that the unit of biodiversity conservation and preliminary marketing activities should be the village and employing a specific group of people i.e. untouchables, produces the greatest amount of benefit for the greatest number of people.

Lama *et al.* (2001) analyzed the concepts, approaches and results of developing a model for strengthening community based management of medicinal plants in Shey Phoksundo National Park and its buffer zone in Dolpa district. They found that integrating local indicators for the monitoring of ecological plots will benefit both local communities and science. They suggested that long term research (such as ecological monitoring) as well as short term assessment (Rapid Vulnerability Assessment) is necessary to assess the level of threat for a species.

Gahire (2003) studied the ecology, distribution and trade of *Neopicrorhiza scrophulariiflora* (Kutki) in Manang district. He found that Kutki grows in soil with high nutrient content, associated with the species like *Carex* sp., *Viola biflora, Delphinium denudatum* and *Dactylorhiza hatagirea*.

Shrestha (2003) reported that most of the traded species of medicinal plants in Nepal are collected from the wild. Over harvesting and destructive collection techniques have put many of the valuable herbs in the verge of extinction. He recommended the cultivation and domestication as the most effective solution for the conservation of these species.

The workshop on Organic Production and Management of MAPs and NTFPs in Nepal jointly organized by International Development Research Centre (IDRC), Medicinal and Aromatic Plants Programme in Asia (MAPPA) and Canadian Co-operation Office (CCO) in February 2004, came up with a set of recommendations for quantitative resource assessment, conservation and sustainable management of important MAPs and NTFPs. It was felt that, policy on MAPs and NTFPs should address the threat status and conservation needs of plant species appended in CBD and CITES, through threat assessments, periodic monitoring and adequate conservation programs (IDRC/MAPPA/CCO, 2004).

Ghimire *et al.* (2005) analyzed the effects of different harvesting patterns on the population ecology of two highly threatened Himalayan medicinal plants, *Nardostachys grandiflora* and *Neopicrorhiza scrophulariiflora*, in Shey Phoksundo National Park and its buffer zone in northwestern Nepal. They found a positive effect of low harvesting levels on plant density and a decreased survival rates with increasing harvesting levels. They also inferred that *Nardostachys grandiflora* is more vulnerable to harvesting than *Neopicrorhiza scrophulariiflora*.

Larsen (2005) conducted a survey in Gorkha district to explore the impacts of replanting on regeneration of *Nardostachys grandiflora*. He found that harvesting 100% of the plants in plots followed by replanting of upper part and 2 cm of the rhizome provided the fastest regeneration and rhizome biomass growth.

Olsen (2005c) studied trade levels and conservation implications of two endangered Himalayan medicinal plants: *Nardostachys grandiflora* and *Neopicrorhiza scrophulariiflora*. He emphasized the importance of applying a regional approach to conservation of the species as well as the need for improved official trade monitoring by governments.

Paudel (2005), based on the experience of the last three decades of biodiversity conservation, suggested a shift in the management towards the ecosystem approach. He felt that for long-term existence of protected area, conservation efforts should be expanded into the areas beyond park boundaries for a greater stability. The BZ management may aid to ecosystem approach to sustain community development through self-reliance and continue to maintain key elements of landscape level conservation.

Sharma *et al.* (2005) studied the conservation and management efforts of medicinal and aromatic plants in Nepal. They inferred that medicinal plants of commercial value are in a state of threat due to deforestation and over harvesting. They suggested activities like threat assessment, cultivation practices and system regularization for conservation, management and sustainable utilization of medicinal plants in Nepal.

Bhattarai and Ghimire (2006) carried out a study to assess and evaluate the number of commercially important medicinal and aromatic plants (MAPs) found in the trade and explore their distribution pattern and conservation measures along the Himalayan elevation gradient of Nepal. They found that MAP species richness increases with increasing elevation up to 1,000 m then decreases with further increasing the elevation.

The Kangchenjunga Conservation Area Project (KCAP), a joint project of DNPWC and WWF Nepal which was launched in 2004 and still in action has identified and sufficiently addressed key conservation issues in the area such as overgrazing, destruction of alpine meadows, over harvesting, poaching, etc. through participatory management of natural resources (Parajuli, 2006).

The concept of Sacred Himalayan Landscape (SHL) was initiated to conserve a landscape that will preserve the ecological integrity of High Himalaya biodiversity. Major

part of the landscape (73.5 %) falls in Nepal extending from Langtang National Park in Central Nepal through the Kangchenjunga region in Sikkim and Darjeeling in India to Toorsa Strict Nature Reserve in Western Bhutan (Gurung *et al.*, 2006). The SHL lies within the Eastern Himalayan Hotspot and is a vision for a trans-boundary conservation of biological resources.

1.6.5 Threat assessment

In India, much work has been carried out in relation to threat assessment. Organizations and people involved in threat assessments in India include NGOs such as Foundation for Revitalization of Local Health Traditions (FRLHT) who has used the CAMP approach. The CAMP report for the Azad-Jammu and Kashmir and Himachal Pradesh is particularly relevant for the Western Indian Himalayan region (Ved and Tandon, 1998). Many researchers have also been engaged in conducting surveys on the endangered status of particular Himalayan plant groups (Jain, 1987; Kala, 2000).

In Nepal, besides a thorough review of rare, threatened and endemic species undertaken by Shrestha and Joshi (1996) which includes medicinal uses of plants as well as their conservation status, a CAMP workshop organized by IDRC-MAPPA was conducted in 2001 (Tandon *et al.*, 2001). The output of this workshop is of particular importance for setting priorities for the management and sustainable use of plants in Nepal.

Rapid Vulnerability Assessments, a method developed by Cunningham (1996) for the assessment of useful plants at Bwindi National Park in Uganda has been modified and applied to high altitude medicinal plants at Shey Phoksundo National Park by Tripathi and Schmitt (2001), Rokaya (2002) and Ghimire and Aumeeruddy-Thomas (2005). The method turns out to be a useful approach locally to integrate both ecological and social parameters such as type of user groups, methods of harvesting (parts collected), amount collected, level of social control on harvesting etc., in assessing the vulnerability of species to different harvesting patterns.

Ghimire and Aumeeruddy-Thomas (2005) assessed the vulnerability of 35 species of highly traded medicinal plants in Shey Phoksundo National Park. They identified 20 species of MAPs as potentially vulnerable. Among these, six species (*Nardostachys grandiflora, Dactylorhiza hatagirea, Neopicrorhiza scrophulariiflora, Delphinium* sp. and *Valeriana jatamansii*) fall under the high vulnerability category with threat scores

equal or greater than 25. Nine species were found with score between 21 and 24, and 5 species with vulnerability score of 20.

1.7 Rationale

Langtang National Park (LNP) has a rich natural resource base which potentially can contribute to rural development. The area is rich in medicinal plants along with various flora and fauna (Malla *et al.* 1976; Shrestha and Shrestha, 2000; Dangol, 2002; Shrestha *et al.*, 2002). High valued medicinal herbs are abundantly found in the park. However, there is no authentic data on the distribution and status of these commercially important plants. Furthermore, illegal and unsustainable harvest of these species has put them in dwindling condition, thereby questioning their very existence.

Of the 172 useful plant species (plus 32 species of edible mushrooms) recorded within the park, 91 are used for medicinal purposes. Of these, 43 are collected for their leaves, fruits or flowers; 15 for their bark; 27 for their roots; and 6 for the whole plant (Yonzon, 1993; Shrestha *et al.*, 2002). This means at least 36 % of the medicinal plant species in the Langtang area may be threatened by harvesting. Thus there is an urgent need for an inventory to be conducted of all medicinal plants both within and outside the park to determine which products are present in sufficient quantities to permit collection. Most of the previous works in the area have been focused on documenting ethnobotanical information (Manandhar, 1980a; Joshi and Edington, 1990; Shrestha and Shrestha, 2000; Shrestha *et al.*, 2002). No works has been done in quantifying and assessing the vulnerability of the threatened species. The present study, as such, is an endeavor to document data on the status, distribution, population ecology and trade of MAPs as well as socio-economic information on use patterns by the local people.

1.8 Objectives

The main objective of the present research is to assess the status and distribution pattern of commercially valuable medicinal plants and threatened/endemic species in LNP. The specific objectives of the present research are as follows.

- Assessment of the high-value MAPs in LNP in terms of diversity, distribution, use, trade, cultivation and conservation.

- Identification of important plant areas within the park.
- Determination of the population status of major medicinal plants in terms of density, frequency, coverage and Importance Value Index.
- Assessment of the threat status of commercially valuable medicinal plants and of endemic species.

1.9 Limitations of the study

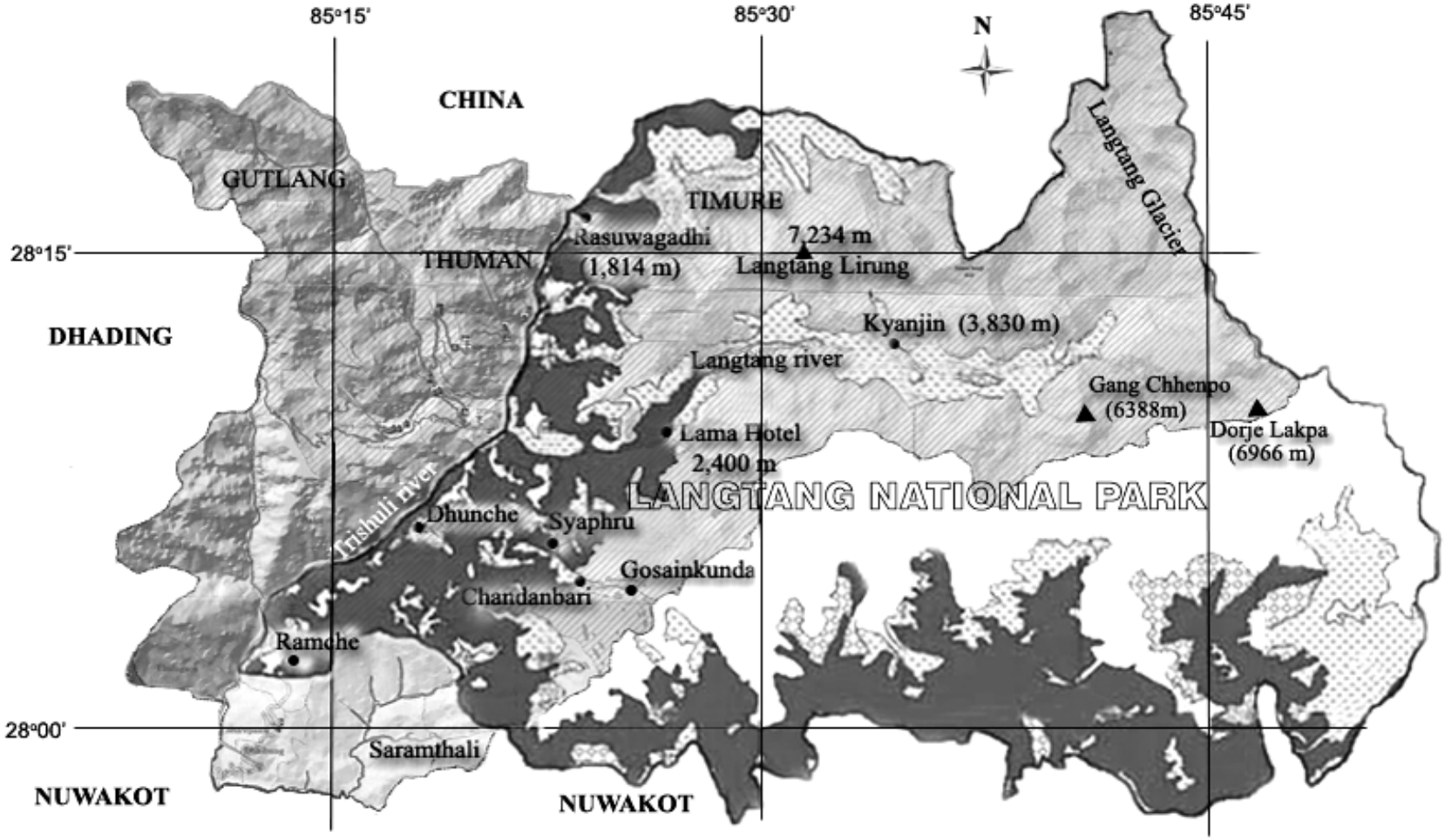
The study was carried out during short field trips (Jun 1, 2006 - Jun 15, 2006 and Aug 28, 2006 - Sep 10, 2006). So the present study does not cover all the aspects of MAPs issues in the area. Detailed study on these species could not be completed. The field visits could not be made during flowering and fruiting seasons of most of the species. For the same reason, specimens of some species were not collected. Due to adverse climatic condition in the area, the field study could not be made smoothly. As such, ecological analysis of some species is lacking. The study has been carried out in a small geographical area of the LNP, so the present findings cannot be generalized for the entire area of the park.

2. STUDY AREA

The study area includes Langtang National Park (LNP) which is the second largest among Nepal's nine national parks occupying 56% of the Rasuwa district and stretching up to the Tibetan border. It is the nearest park from Kathmandu situated directly to the north of Kathmandu in the Central Himalayan Region. Langtang National Park was established in 1976 to conserve the unique flora and fauna of the region. It has an area of 1,710 sq. km. and extends over parts of Nuwakot, Rasuwa and Sindhupalchowk districts in the southern mountainous terrain of the Nepal-China (Tibet) border. The elevation ranges from 792 m on the Bhote Koshi to the peak of Langtang Lirung at 7,245 m (Chaudhary, 1998; Shrestha *et al.,* 2002). The present study was undertaken in two major VDCs of Rasuwa district: Syaphru and Langtang. The areas surveyed under Syaphru VDC were Dhunche, Thulo Syaphru, Singompa, Cholangpati, Laurivinayak and Gosainkunda. Similarly, Lamahotel, Ghodatabela, Langtang village and Kyanjin were surveyed in Langtang VDC (Map 1).

2.1 Vegetation

LNP represents some of the best examples of graded climatic conditions in the Central Himalaya. Elevational gradients (ranging from mid-hills to alpine) coupled with complex topography and geology have produced a rich biodiversity unique patchwork of vegetation. Montane tropical forest (below 1,000 m) characterized by Sal (*Shorea robusta*) in the southern section of the park is gradually taken over by *Schima wallichii* and *Castanopsis indica* forest in the subtropical zone (1,000-2,000 m). Hill forest (2,000-2,600 m) consists of Chirpine (*Pinus wallichiana*), *Rhododendron arboreum* and Nepalese Alder (*Alnus nepalensis*). The temperate zone (2,600-3,000 m) is covered mainly by Oak (*Quercus semicarpifolia*) forest fading to old forest of Silver fir (*Abies spectabilis*), Hemlock (*Tsuga dumosa*) and Larch (*Larix himalaica*) in the lower sub-alpine zone (3,000-3,600 m). The upper sub-alpine zone (3,600-4,000 m) is characterized by Birch (*Betula utilis*) forest associated with species of Rhododendron such as *R. arboreum, R. barbatum, R. campanulatum* and *R. lepidotum.* Tree species such as *Betula utilis, Abies spectabilis, Sorbus macrophyla* are found near the tree line. Juniper (*Juniperus indica*) and Rhododendron shrubs (*R. anthopogon*) slowly dissolve into the expansive alpine grassland meadows at 4,000 m. The upper alpine zone between 4,500-5,500 m consists of diverse species composition like *Androsace tapete, Gentiana depressa, Pedicularis longiflora* and *Anemone demissa*. (Chaudhary, 1998).



Map 1: Location map of study area

2.2 Fauna

Langtang's expansive high meadows provide summer habitat for numerous ungulate species, such as Musk Deer (*Moschus chrysogaster*), Wild Boar (*Sus scrofa*) and Himalayan Thar (*Hemitragus jemlahicus*). The park is also well known for population of Red Panda (*Ailurus fulgens*), Himalayan Black Bear (*Selenarctos thibetanus*), Snow Leopard (*Panthera uncia*), Wild dog (*Cuon alpinus*), Ghoral (*Naemorhedus goral*) and Serow (*Capricornis sumatrensis*). Small animals include Royle's Pika (*Ochotona roylei*), orange-bellied Himalayan squirrel (*Dremomys lokriah*) and Indian porcupine (*Hystrix indica*). The park is rich in avifauna. More than 250 species of birds are found inside the park (DNPWC). Some of them are Dark-rumped Rosefinch (*Carpodacus edwardsii*), Satyr Tragopan (*Tragopan satyra*), Ibisbill (*Ibidorhyncha struthersii*), Bay woodpecker (*Blythipicus pyrrhotis*), Crimson-browed finch (*Propyrrhula subhimachala*) and Spot-winged grosbeak (*Mycerobas melanozanthos*) (Chaudhary, 1998).

2.3 Ethnic groups

The park also offers a rich cultural diversity. The main ethnic group in LNP is Tamang which is thought to have originated from Tibet. The Tamangs are traditional farmers and cattle herders of the region. Their farm lands and villages stretch south and west of the Bhote Koshi/Trishuli river. They are mostly Buddhists. Tamangs occupy about 65 percent of the total population of the park. Of the three districts, major settlements of Tamangs occur in Rasuwa district. Other hill tribes and castes such as Brahmin, Chhetri, Newar and Gurung inhabit lower elevational range along the edges of the park in the buffer zone (Fig. 1).

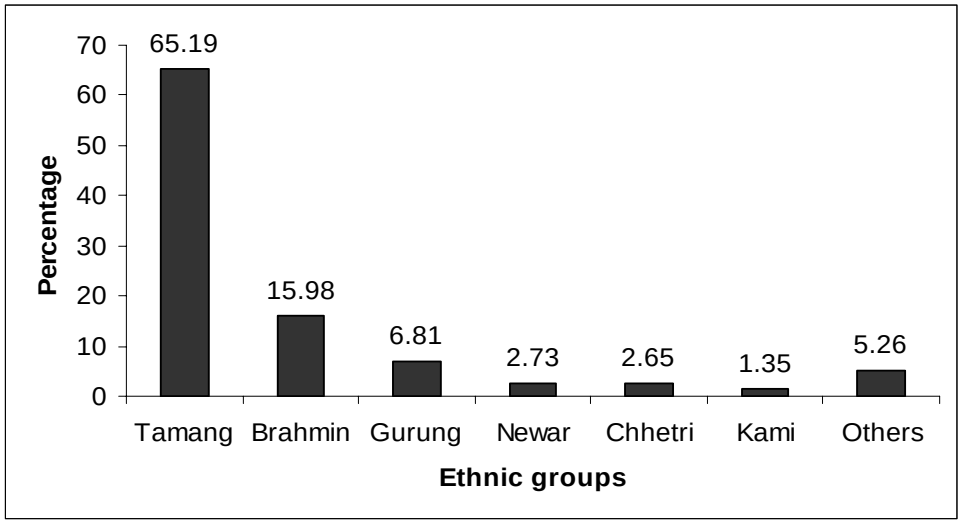


Fig. 1: Ethnic groups of LNP *(Source: DDC, Rasuwa, 2006)*

The people of the Langtang valley inside the park are mostly Bhotias with Tibetan origin, many have intermingled with local Tamangs. However, the cultures are discernible by language, house style, dress, ornaments and customs. The Yolmo people of the Helambu region are often referred to as "Sherpa". However their language and socio-cultural setup do not resemble the Solukhumbu Sherpa.

2.4 Economic characteristics

Agriculture is the chief occupation of the people of LNP. About 84 % of the people are engaged in agriculture (Fig. 2). The agricultural products include maize, rice, wheat, potatoes, millet and apple. Medicinal plants are cultivated at few places inside the park and its buffer zone. In addition to agriculture, a large number of people are engaged in collection of high altitude medicinal plants and other forest products. About 11 % of the people are engaged in occupations like business, hotels and restaurants, transportation, communication, education, health, etc. Similarly very few people (5 %) are engaged in occupations related to mining, production industries, electricity, water and gas production (Fig. 2).

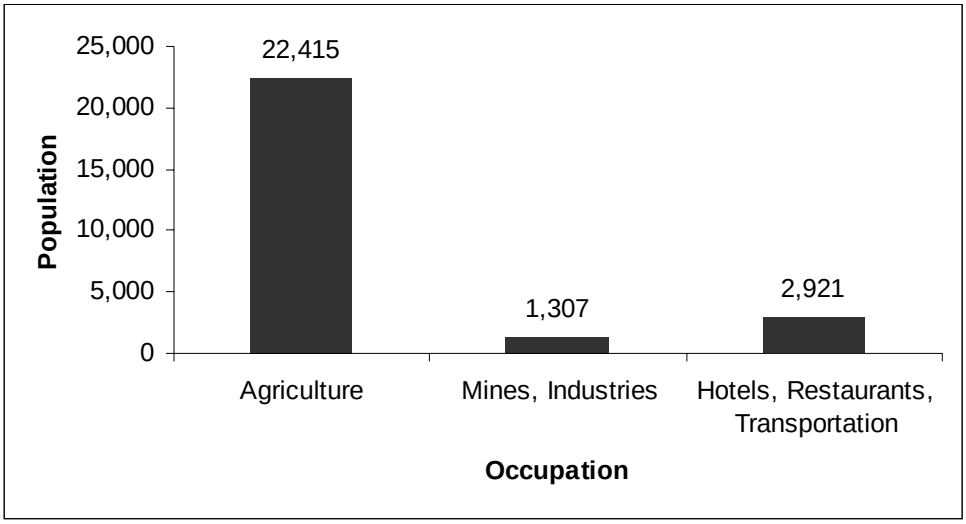
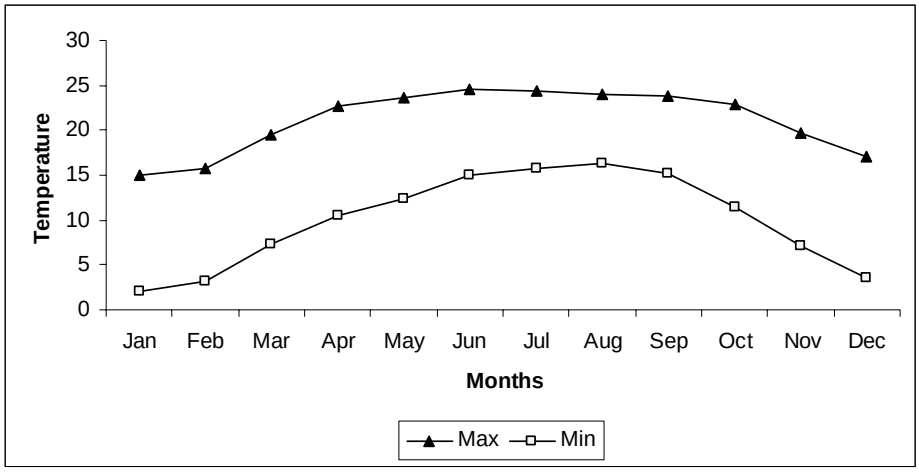


Fig. 2: Major occupations of the people of LNP *(Source: DDC, Rasuwa, 2006)*

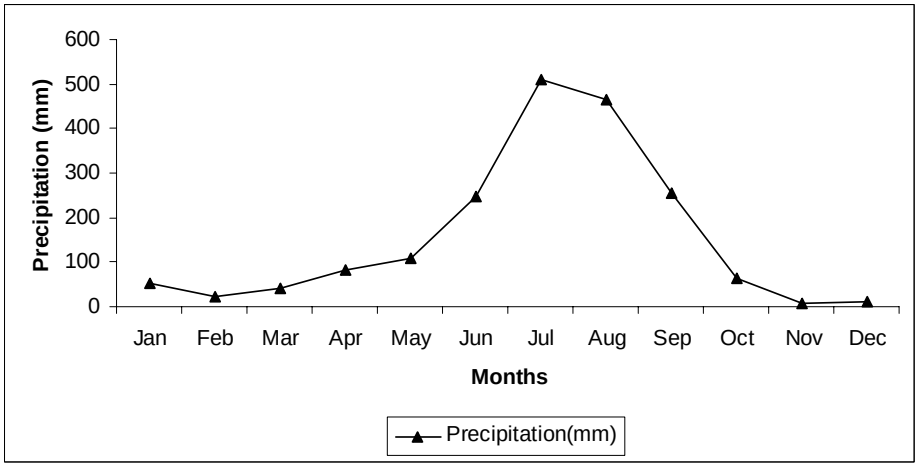
2.5 Climate

Climate varies from place to place depending upon the land structure and altitude of the area. Most of the upper part of park is covered with snow from September through May. The weather is dry except in January and February. The place receives heavy monsoon rain from June to August that is carried by the wind blowing from the south

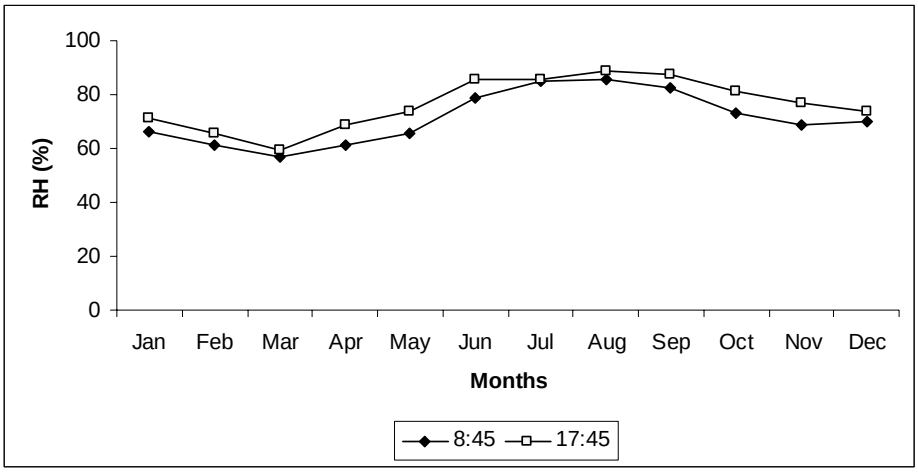
west. In winter, the area receives mild showers. Records of Department of Hydrology and Meteorology for the last 5 years (2001-2005) shows an average minimum temperature of 2.07°C in January and an average maximum temperature of 24.6°C in June (Fig. 3a). The maximum precipitation recorded during the five year period was 635 mm in July 2003 (Fig. 3b). The average total precipitation of the five years was 894 mm per annum. Relative Humidity (RH %) was highest in the month of August and lowest in the month of March (Fig. 3c).



a) Mean monthly maximum and minimum temperature



b) Mean monthly precipitation



c) Mean monthly relative humidity

Fig. 3: Climatic data of Rasuwa (2001-2005). Station: Dhunche, Rasuwa
Source: Department of Hydrology and Meteorology, Kathmandu (2007)

2.6 Land use pattern

The major portion of the park is covered by rock and ice (60 %), followed by forest land (30 %). Grassland and cultivation land occupies a minimal area (Fig. 4). Waste or degraded area, rocky area and river cover minimal part in the BZ compared to the park.

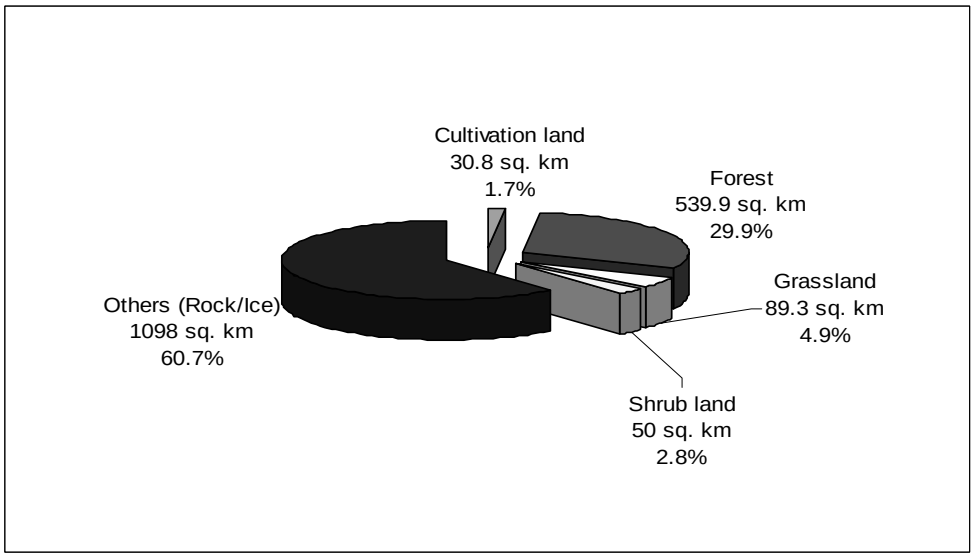


Fig. 4: Land use pattern in the Park (*Source: LNP*)

Box 1: District profile of Rasuwa

Area	:	1,544 sq. km
Location	:	27º2'-27º10' N; 85º45'-85º88' E
Elevation	:	792m (Bhote Koshi)-7,245m (Langtang Lirung)
Population	:	44,731 (2001 Census)
VDCs	:	18
Literacy	:	34.3 % (male – 42.8 % and female – 24.8 %)
Ethnic groups	:	Tamang (65%), Brahmin, Gurung, Sherpa, Chhetri, Kami and Newars.
Economic occupation	:	83 % Agriculture, less than 5 % in service sector.
Boundary		
East	:	Sindhupalchowk and China
West	:	Dhading and Nuwakot
North	:	China
South	:	Nuwakot and Sindhupalchowk
Mountain peaks		
1) Langtang Lirung (7245 m)		
2) Ganesh Himal mountain ranges		
Rivers		
1) Bhote koshi	2) Langtang	3) Chilime
4) Trishuli	5) Falakhu	6) Mailung
Major lakes (Kunda)		
1) Gosain kunda	2) Bhairav kunda	3) Saraswoti kunda
4) Dudh kunda	5) Ama kunda	6) Surya kunda
Climate		
Up to 2000 m	:	warm temperate climate
2000-3000 m	:	cool temperate climate
Above 3000 m	:	alpine humid climate
Major crops		
Rice, Maize, Wheat, Millet, Barley and Potato		
Major vegetation		
Sub-tropical	:	Sal, Alder
Temperate	:	Oak
Sub-alpine	:	Silver fir, Hemlock and Larch

3. MATERIALS AND METHODS

The present study is based on primary data collected from field visits during two seasons of the year. Some secondary information has also been used to accomplish this study. A total of two field visits were made during the year 2006. The first visit was made in June 2006. During this visit, general survey of the area was conducted to locate the potential sites of MAP distribution. The availability of MAPs and their localities were assessed during the visit. Cultivation practices and socio-economic status of local people were also studied. The second visit was carried out in August 2006. Ecological study of some selected species was made. The secondary data, like trade of MAPs from the district, population and climatic data were obtained from concerned offices and organizations.

3.1 Literature review

All the available literatures and research papers related to MAPs and NTFP, their conservation and trade issues was reviewed prior to field visit so as to identify the gaps and issues to be focused in the present study. Emphasis was given to screen literatures pertaining to Rasuwa and medicinal plants.

3.2 Questionnaire/ Interviews

A semi-structured questionnaire was used to obtain information from local people about the status of MAPs in the area, locality of their occurrences, trade issues, market linkage, cultivation practices and socio-economic issues. Altogether, 24 key persons were interviewed from Syaphru VDC (Appendix-6) and about 10 from Langtang VDC. The key persons interviewed were mainly hotel owners and villagers from Tamang community of Rasuwa district, belonging to age group 30-50. Of the interviewed locals, 70 % were male and the remaining 30 % were female. Various organizations (DDC, DFO, DNPWC, DoF) and individuals were also contacted and interviewed to obtain information related to NTFPs trade, government policies, revenue collection and prioritized MAPs for agro-technology.

3.3 Selection of target species

The MAPs belonging to IUCN/CAMP threat categories that were widely used by the locals and in high trade demand were selected for ecological study and to assess their vulnerability in the area. The study was also focused on some threatened and endemic species. The status of these species in the study area was assessed using ecological tools.

The threat value and threat category of these species was then determined using Rapid Vulnerability Assessment.

3.4 Selection of sampling sites

Sampling sites for the study was chosen based on previous literatures and general survey of the area which was made during the first field visit (Jun 2006). Based on local people's information, the potential sites were located. Sites that were rich in threatened and endemic species were chosen for study. The focused species were *Neopicrorhiza scrophulariiflora, Nardostachys grandiflora, Rheum australe, Swertia angustifolia, Jurinea dolomiaea*, etc. Altogether six sampling sites were selected at different elevation gradient (Table 1). The sites were chosen so as to cover the threatened and traded MAPs and hence study their status in the area.

Table 1: Sampling sites and sampled species in different localities

S.N.	Sampling sites	Elevation	Latitude/ Longitude	pH of soil	Dominant Vegetation
1)	Cholangpati	3,620 m	28º 06' 04.0" N 85º 22' 12.0" E	6.8	*Rhododendron campanulatum, Abies spectabilis*
2)	Cholangpati-Laurivinayak	3,739 m	28º 05' 46.0" N 85º 22' 27.5" E	6.9	*Rhododendron anthopogon, Berberis aristata*
3)	Laurivinayak I (North West Slope)	3,892 m	28º 05' 25.7" N 85º 22' 47.8" E	6.5	*Juniperus indica, Berberis aristata*
4)	Laurivinayak II (North East Slope)	3,887 m	28º 05' 37.9" N 85º 22' 57.6" E	4.8	*Rhododendron anthopogon, Fragaria nubicola*
5)	South of Gosainkunda lake	4,430 m	28º 04' 30.9" N 85º 25' 09.0" E	5.9	*Neopicrorhiza scrophulariiflora, Cremanthodium retusum*
6)	North of Saraswoti kunda	4,267 m	28º 05' 00.8" N 85º 24' 05.0" E	6.2	*Potentilla fruticosa, Leontopodium alpinum*

3.5 Ecological study

The ecological study of high valued MAPs was undertaken in the specified sites. The geographical coordinates of each plot were taken with the help of a GPS. The environmental variables, like slope and altitude were also noted in each plot. The pH of soil was measured with the help of a pH meter.

The ecological study was done in six different sites at various elevation gradients. In each site, 3-4 plots of 10m x 10m were laid along the vertical line at an interval of about 5m. Each 10m x 10m plot was further subdivided into 25 sub-plots each of 2m x 2m, out of which 10 sub-plots were chosen randomly (Fig. 5). The methodology has been used by Shrestha *et al.* (1998) in Shey Phoksundo National Park, and Sherpa (2002) and Oli and Nepal (2003) in Kangchenjunga Conservation Area. In each sub-plots, the individual plant was counted while the percentage coverage was estimated by employing visual assumption method. Associated plant species of the focused MAPs were also considered and counted.

For the calculation of frequency, relative frequency, density and relative density, relative coverage following formulae were used (Zobel *et al.*, 1987). Importance Value Index (IVI) was obtained by the summation of relative frequency, relative density and relative coverage.

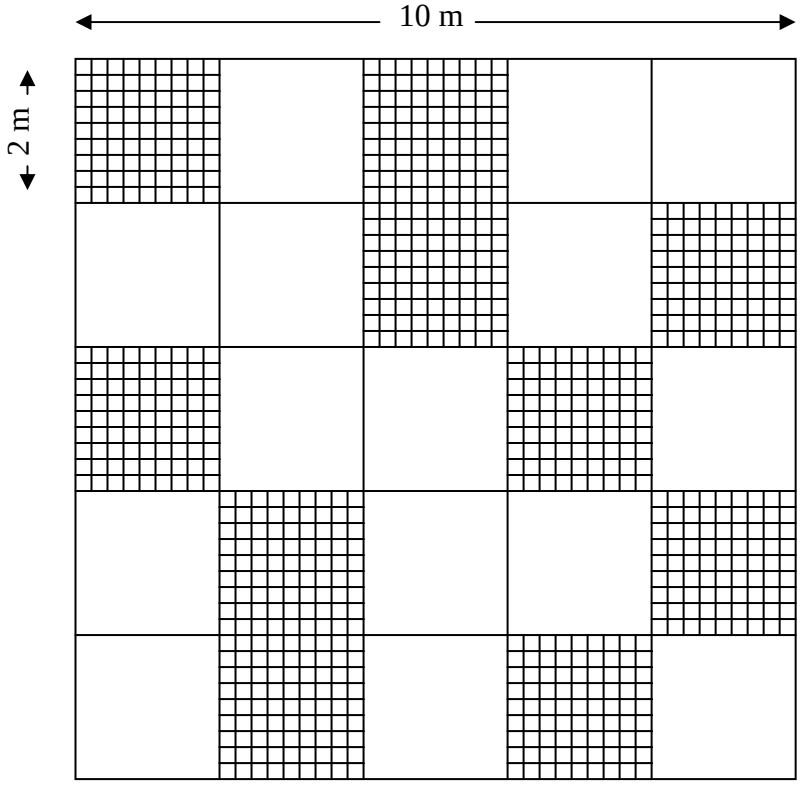


Fig. 5: Layout of sampling plot and sub-plots

3.5.1 Frequency and Relative frequency

The frequency of occurrence of medicinal plants was determined to assess the distribution pattern of the species.

$$\text{Frequency (F)} = \frac{\text{Number of quadrats in which species occur}}{\text{Total number of quadrats}} \text{ X } 100$$

$$\text{Relative Frequency (RF)} = \frac{\text{Frequency of 'A' species}}{\text{Sum of all frequency}} \text{ X } 100$$

3.5.2 Density and Relative density

Density is the number of individual per unit area, which gives the numerical strength of species. In general density is the total number of individuals of a species relative to total area studied and is calculated by following formula.

$$\text{Density (Individuals per } m^2\text{)} = \frac{\text{Number of individuals of species 'A' in all quadrats}}{\text{Total number of quadrats X size of the quadrat}}$$

$$\text{Relative Density (RD)} = \frac{\text{Density of species 'A'}}{\text{Total density of all species}} \text{ X } 100$$

3.5.3 Cover and Relative cover

Cover (also called coverage) is the percentage of quadrat area covered by a given species. Cover was estimated visually with the help of following scale (Daubeumire, 1968).

Table 2: Scale value, range and mid-point value of the estimate of plant cover

Scale value	Range of coverage (%)	Mid-point value
1	0-5	2.5
2	5-25	15.0
3	25-50	37.5
4	50-75	62.5
5	75-95	85.0
6	95-100	97.5

Average cover of a species was calculated by taking average of the values for all quadrats. Relative cover is the cover a particular species as a percentage of total plant cover. It is calculated by the following formula.

$$\text{Relative Cover (RC)} = \frac{\text{Cover of particular species}}{\text{Total cover of all species}} \times 100$$

3.5.4 Importance Value Index (IVI)

IVI refers to the relative contribution of a species to the entire community. It is a measure of dominance and ecological success of a species. The dominance and ecological status of the species in the studied sites were assessed using IVI. It takes into consideration relative frequency, relative density and relative cover. It was calculated as follows.

Importance Value Index (IVI) = RF + RD + RC

3.6 Plant collection, documentation and identification.

Different MAPs encountered during the field visits including associated species were collected from different sites. The rare and threatened species were not collected. They were only photographed. Collected species were identified with the help of standard literatures (Polunin and Stainton, 1987; Malla *et al.*, 1976; Grierson and Long, 1984-1999) and consultation with different plant taxonomists at Tribhuvan University, Kathmandu. The nomenclature of plants follows Press *et al.* (2000). The collected specimens were deposited at Tribhuvan University Central Herbarium (TUCH).

3.7 Rapid Vulnerability Assessment

Rapid Vulnerability Assessment (RVA) was carried out only for those species which were highly exploited and traded from the area. RVA was carried out for highly traded and threatened/endemic MAPs following the methods developed by Cunningham (1996) and used by Tripathi and Schmitt (2001), Rokaya (2002) and Ghimire and Aumeeruddy-Thomas (2005). A total of eight vulnerability criteria were used for each species (Table 3), which are 1) plant parts used, 2) life forms, 3) habitat, 4) geographical distribution, 5) habitat specificity and local population size, 6) amount traded, 7) official conservation/threat designation and 8) user group. The information on these criteria was mostly obtained from local resource users. The plant parts utilized in the area was known

by interviewing the local people. Life forms were assessed from secondary literatures. Survey was conducted during field visits and secondary literatures were consulted to assess the habitat of the species. Information on geographical distribution and official conservation threats was obtained from Shrestha and Joshi (1996) and Press *et al.* (2000). Habitat specificity was determined from secondary literatures as well from field survey (Jun/Aug 2006). The local population size was mainly based on the information provided by local people and field survey (Jun/ Aug 2006). The local perception of distribution and abundance of plant species were assessed and the provided information was validated by surveying MAP rich areas. This parameter requires intensive study and thorough observation of their population structure. Efforts have been made to document relevant information. However, a detailed study in this parameter is felt necessary to obtain a real figure. The species involved in trade from Rasuwa including their amount and frequency of trade, were collected from District Forest Office (DFO) Rasuwa, and by interviewing the traders at village and district level. Finally user groups were assessed from the local knowledge. For each of the eight predictors of vulnerability a score ranging from 1 to 4 (depending upon the parameters, 1 being low and 4 being high vulnerability) were questioned for each species (Ghimire *et al.*, 2001).

The species whose roots and rhizomes are utilized are more vulnerable as the entire plant has to be destructed to collect those parts. Similarly long lived perennial species are more vulnerable because they have to rely entirely upon their underground parts for perennation and destruction of these parts can seriously affect their number. Likewise, gravel and rocky slopes are very fragile habitats and there is very less human interference in these places. The presence of a species in this kind of habitat denotes that, very slight interference by human can destruct the species. On the other hand, the occurrence of species in grassland, pastureland and meadow where there is great human interferences shows that, the species have well adapted in these areas. Hence the species growing in grasslands are less vulnerable. The assignment of values to particular category was done based on their vulnerability. After completing the checklist for individual species, total threat values were calculated by adding all the values assigned for each parameter. Based on this information, the medicinal plants were divided into different categories of vulnerability. The minimum threat value was 8 and the maximum was 32. The table below summarizes 8 criteria and their categories and corresponding scores.

Table 3: Vulnerability criteria, categories and score

Criteria	Categories	Score
Plant parts use	Rhizome/Root/ Whole plant	4
	Bark, Stem	3
	Inflorescence, Flower, Fruit, Seed	2
	Leaves	1
Life Forms	Long lived perennial	4
	Short lived perennial	3
	Multi year	2
	Annual	1
Habitat	Gravel/Soil, Rocky/Stony slopes	4
	Moist, Marshy, Permanent snow melting zone	3
	Forests, Shrubberies, Agricultural land	2
	Grassland/Pastureland/Meadow	1
Geographical Distribution	Nepal endemic	4
	Himalaya endemic	3
	Himalaya + surrounding	2
	Cosmopolitan	1
Habitat specificity and local population size	Few places sparse	4
	Few places thin	3
	Many places thick or thin	2
	Everywhere thick or thin	1
Amount traded	>5,000 kg	4
	3,000-5,000 kg	3
	1,000-3,000 kg	2
	<1,000 kg	1
Official conservation/threat designation	Status in 3 categories or more	4
	Status in 2 categories	3
	Status in 1 category	2
	Not assigned	1
User group	Local people + Local exchange + Trade	4
	Local people + Trade	3
	Local people + Local exchange	2
	Local people	1

The total scores were summed up to obtain threat value for that species. Species that scored value equal to or greater than 25 were placed in Threat category I, representing most vulnerable species. Similarly, other 3 categories were assigned as shown below.

Threat Category I	>= 25
Threat Category II	20-24
Threat Category III	15-19
Threat Category IV	<=14

4. RESULTS

4.1 Medicinal plants occurring in LNP

The present study has identified 44 species of medicinal plants that are of high utilization in the area and in high trade demand. The species are widely distributed throughout the park. However, some high value medicinal plants occur in the sub-alpine and alpine meadows with altitudinal elevation ranging from 3,000-4,500m. The species like *Neopricrorhiza scrophulariiflora* (Kutki), *Rheum australe* (Padamchal), *Swertia chirayita* (Chiraito) and *Cordyceps sinesis* (Yarsagomba) are highly utilized in the area.

4.2 Trade of MAPs

The MAPs that are highly traded in the area includes *Neopicrorhiza scrophulariiflora* that is collected from the Gosainkunda region and traded via Sindhupalchowk to Kathmandu. However there is no authentic data on traded amount of this species. Similarly *Cordyceps sinensis* that are found abundantly in Kyanjin are traded to China via Rasuwagadhi. The price of *Cordyceps* in Kyanjin during 2006 was NRs 40-50 per piece. The collection of the species is intensive during June-July. Other traded species include *Swertia chirayita, Nardostachys grandiflora* and *Valeriana jatamansii* that are brought to Kathmandu via Dhunche.

4.2.1 Amounts of MAPs collected from Rasuwa

DFO records show an average collection of 1,000 kg of *Swertia* sp. from Rasuwa annually. The collection of *Nardostachys grandiflora* from the district amounts to 500 kg per year (DFO, Rasuwa). The other collected species include *Neopicrorhiza scrophulariiflora, Valeriana jatamansii* and *Rheum australe*. Most of these species are either collected in wild form or from community forests and only few are cultivated in private lands.

The data shows highest collection of MAPs during the year 2002 (Fig. 6). The amount of Chirayita collected during the year 2002 amounts to 1,400 kg which has considerably reduced by 50% in the year 2003. The year 2004 observes a rise in collection and is further decreased in the year 2005. The collection of Padamchal and Jatamansi has considerably increased during the year 2005. The records of DFO shows trade data for 35 species of NTFPs in the fiscal year 2062/63 constituting about 91,000 kg of NTFPs (Table 4). More than 20 species are medicinal and aromatic plants.

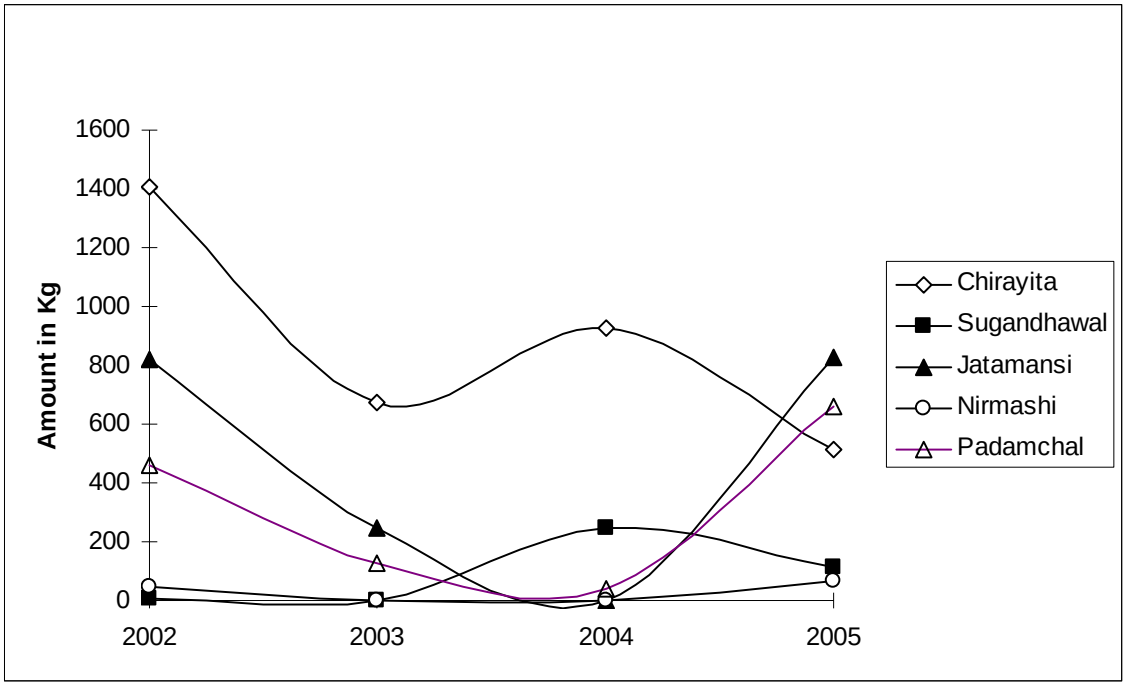


Fig. 6: MAPs collected from Rasuwa district (2002-2005)

(*Source: DFO, Rasuwa, 2006)*

Table 4: NTFPs traded from Rasuwa district (2062/63)

S.N.	Species	Amount Traded (Kg)	Revenue (NRs)
1)	Honey	3,440	34,400
2)	Nigalo gota	12,000	1,800
3)	Sunpati	4,575	13,725
4)	Dhupi paat	760	1,520
5)	Nirmashi	65	3,250
6)	Chirayito	515	7,725
7)	Lokhta	3,000	6,000
8)	Majitho	3,050	9,150
9)	Atis jara	100	1,500
10)	Kurilo	4,200	21,000
11)	Ban Karela	200	200
12)	Nagbeli	200	1,000
13)	Bish jara	200	2,000
14)	Bishphej	4,450	22,250
15)	Padamchal	660	3,300
16)	Pakhanved	4,700	9,400
17)	Jhyau	10,175	152,625
18)	Jatamansi	825	12,375

19)	Bojho	3,750	11,250
20)	Sugandhawal	115	1,725
21)	Dhupi bokro	25	625
22)	Pawan ko bokra	2,000	10,000
23)	Daar ko bokra	2,000	10,000
24)	Gamdol	150	1,500
25)	Ban lasoon	600	6,000
26)	Budhune jhayu	5,500	16,500
27)	Bhorla	7,500	7,500
28)	Tejpat	5,000	1,000
29)	Dhasingre	5,000	1,250
30)	Alllo	350	1,050
31)	Ritha	900	1,800
32)	Nundhiki	3,500	3,500
33)	Indrayani paat	100	800
34)	Pipla	300	3,000
35)	Kalo musli	1,000	6,000
	Total	**90,905**	**386,720**

Source: DFO, Rasuwa, 2006

4.2.2 Revenue collected from MAPs from Rasuwa district

The average revenue collection from some of the commercially important MAPs from Rasuwa district is shown in the chart below (Fig. 7). The revenue collected from Chirayita in year 2002 was NRs. 36,977 and has subsequently decreased to NRs. 2,790 in the year 2005. The average revenue collected during this period amounts to NRs. 11,505.5 from the trade of Chirayita. Jatamansi contributed average revenue of NRs. 4,362.5 during the year 2002-2005. The figure shows very poor collection and trade of Nirmashi. The data shows a collection of only 65 kg of Nirmashi during the year 2005 generating average revenue of about NRs. 610 (2002-2005). The total amount of NTFPs traded from Rasuwa district in the fiscal year 2062/63 was 90,905 kg with revenue collection of NRs. 3,86,720.

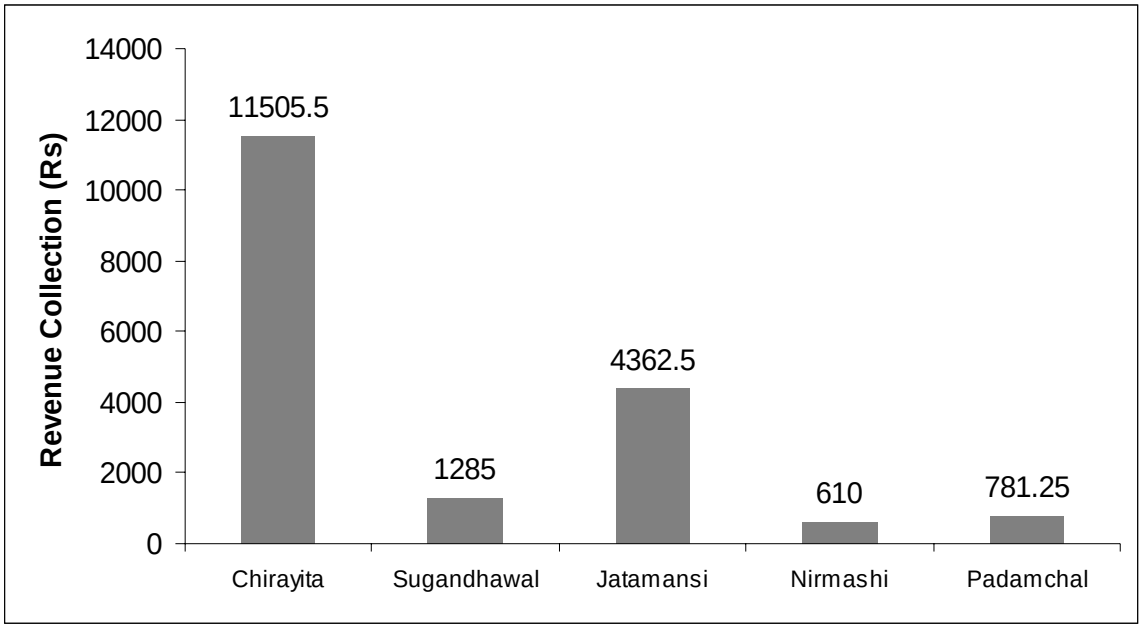
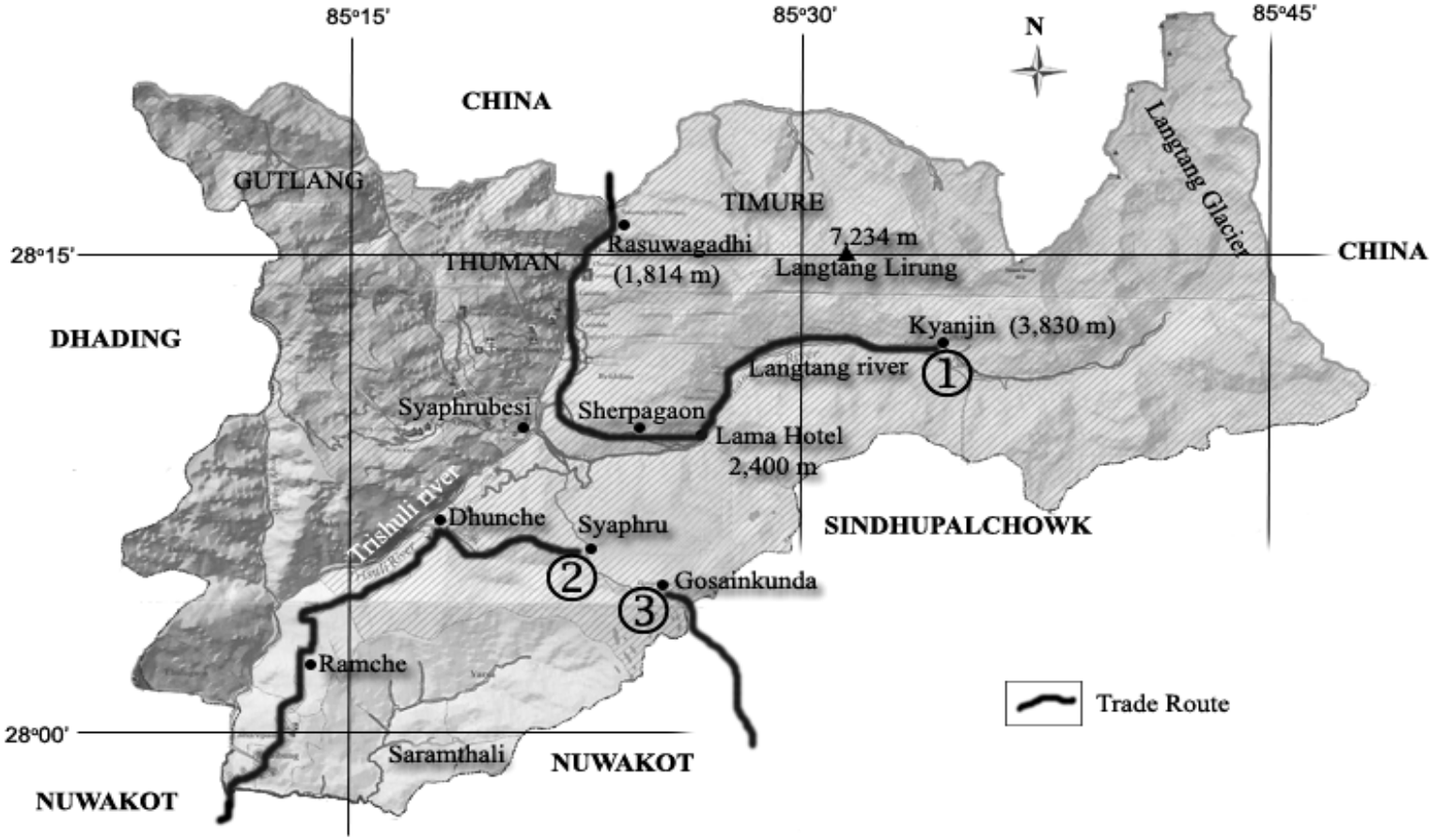


Fig. 7: Average revenue collected from MAPs from Rasuwa (2002-2005)

(Source: DFO, Rasuwa, 2006)

4.2.3 Trade channel

Large amount of medicinal plants are traded from the area. The trade follows both legal and illegal routes. Three major trade routes have been identified in the study (Map 2). The first route encompasses Kyanjin through LamaHotel, Sherpagaon, Rasuwagarhi to Tibet. A high-valued Himalayan herb, *Cordyceps sinensis* is exported to Tibet via this route. The second route follows the park headquarter, Dhunche to Kathmandu. Cultivated products and sustainably harvested products from community forests outside the park follow this route. The third route includes south of Gosainkunda to Sindhupalchowk. One of the threatened medicinal plants, *Neopicrorhiza scrophulariiflora,* which is abundantly found in the Gosainkunda region, is traded from this route.



Map 2: Trade route of MAPs in LNP

4.3 Threatened MAPs

A number of high valued medicinal plants occur inside the park. The region harbors many endemic as well as threatened species. One of the highly threatened species *Dactylorhiza hatagirea* is found in Laurivinayak. *Neopicrorhiza scrophulariiflora* is the most utilized species in the region and is found in Gosainkunda. The species are subjected to high threat risk due to higher demand, habitat degradation and unsustainable harvesting.

4.3.1 Threatened MAPs occurring in LNP

Langtang National Park represents a unique habitat for a number of highly valuable medicinal and aromatic plants. Twenty species of threatened medicinal plants prioritized by CAMP were recorded (Table 5). These includes *Aconitum spicatum, Dactylorhiza hatagirea, Ephedra gerardiana, Fritillaria cirrhosa, Maharanga emodi, Nardostachys grandiflora, Neopicrorhiza scrophulariiflora, Rheum australe* and many other threatened species. The species like *Meconopsis dhwojii* is endemic to LNP.

Thirteen species of medicinal plants are threatened due to excessive utilization by the local people. Similarly, 8 species are threatened due to high trade demand. Ten species are threatened possibly due to unfavourable natural conditions (Table 5).

Table 5: Threatened medicinal and aromatic plants occurring in LNP

S.N.	Plant species	Local name	Locality	Altitude (m)	Causes of threat
1.	*Aconitum spicatum* (Bruhl) Stapf	Bikh	Laurivinayak	3800	H_L, H_T
2.	*Asparagus racemosus* Willd.	Satawari (Kobi)	Syaprubensi	1600	H_L, H_T
3.	*Bergenia ciliata* (Haw.) Stearnb.	Pakhanved	Brabal, Thulo Syapru	2000-2200	H_L, H_T
4.	*Dactylorhiza hatagirea* (D. Don) Soo	Paanchaunle (Ompolakpa)	Laurivinayak	3800	H_L, N
5.	*Ephedra gerardiana* Wall. ex Stapf	Somlata	Langtang-Kyanjin	3400-3700	H_L, N
6.	*Fritillaria cirrhosa* D.Don	Kaakoli	Langtang, Cholangpati Gosainkunda	3600-4400	H_L, N
7.	*Jurinea dolomiaea* Boiss.	Dhupjadi	Gosainkunda	4300	H_L, N
8.	*Maharanga bicolor* (Wall. ex G. Don) A. DC.	Mahaarangi	Langtang	3300	N
9.	*Maharanga emodi* (Wall.) A. DC.	Mahaarangi	Langtang	3300	N
10.	[2]*Meconopsis dhwojii* G.Taylor ex Hay	-	Laurivinayak-Gosainkunda, Langtang	3800-4300	N

11.	[1]*Nardostachys grandiflora* DC.	Jatamansi	Laurivinayak-Gosainkunda	3900	H_L, H_T
12.	*Neopicrorhiza scrophulariiflora* (Pennell) Hong	Kutki	Laurivinayak-Gosainkunda	3800-4400	H_L, H_T
13.	*Paris polyphylla* Sm.	Satuwa	Syapru	2200	H_L
14.	*Rheum australe* D. Don	Padamchal (Chhurcha)	Laurivinayak, Langtang	3800	H_L, H_T
15.	*Rheum nobile* Hook.f. & Thoms.	Amalbetas (Yayuchawa)	Gosainkunda	4500	N
16.	*Rubia manjith* Roxb.	Majitho (Tiru)	Dhunche Syapru	2000-2200	N
17.	*Swertia angustifolia* Buch.-Ham ex D. Don	Bhale chiraaito (Timda)	Singompa Cholangpati, Laurivinayak	3500-3800	H_T
18.	*Swertia chirayita* (Roxb. ex Flem.) Karstn.	Chiraaito	Thulo Syapru	2200	H_L, H_T
19.	*Swertia multicaulis* D. Don	Sharma guru	Gosainkunda	4400	N
20.	*Valeriana jatamansii* Jones	Sugandhawal (Pe)	Brabal, Langtang	2200-3300	H_L, H_T

H_L: Local utilization; H_T: Trade; N: Natural causes.
[1]MAPs under CITES Appendix II
[2]Endemic to the region

4.3.2 Hotspot areas in LNP

The MAPs are widespread and occur throughout the park. However the threatened species are concentrated to few areas, the areas that show higher endemism and diversity. These areas include Syaphru, Brabal, Cholangpati, Laurivinayak, and the famous pilgrimage site Gosainkunda in the south-western region and Langtang village and Kyanjin in the Tibetan border towards the north-east. Of the 20 species of threatened MAPs, 5 species (13 %) are found in Langtang village. Six species (16 %) occur in Syaphru/Brabal, Cholangpati and Gosainkunda area. Seven species (18 %) are found in Kyanjin area. The highest number of species is found in Laurivinayak, covering 21 percent of the threatened MAPs occurring in Langtang National Park (Fig. 8). The species are sparsely distributed and occur only in few localized areas. Some species like *Jurinea dolomiaea* occur in specific habitat. The species is found only in Saraswati kunda area. Similarly, one of the highly threatened species, *Dactylorhiza hatagirea* is found in Laurivinayak. The endemic species of Langtang, *Meconopsis dhwojii* is found on rocky slopes in Langtang valley and Gosainkunda area. Cholangpati area shows richness in

species like *Rheum australe* and *Swertia angustifolia*. *Bergenia ciliata* and *Astilbe rivularis* occur at low altitudes in Syabru/Brabal village.

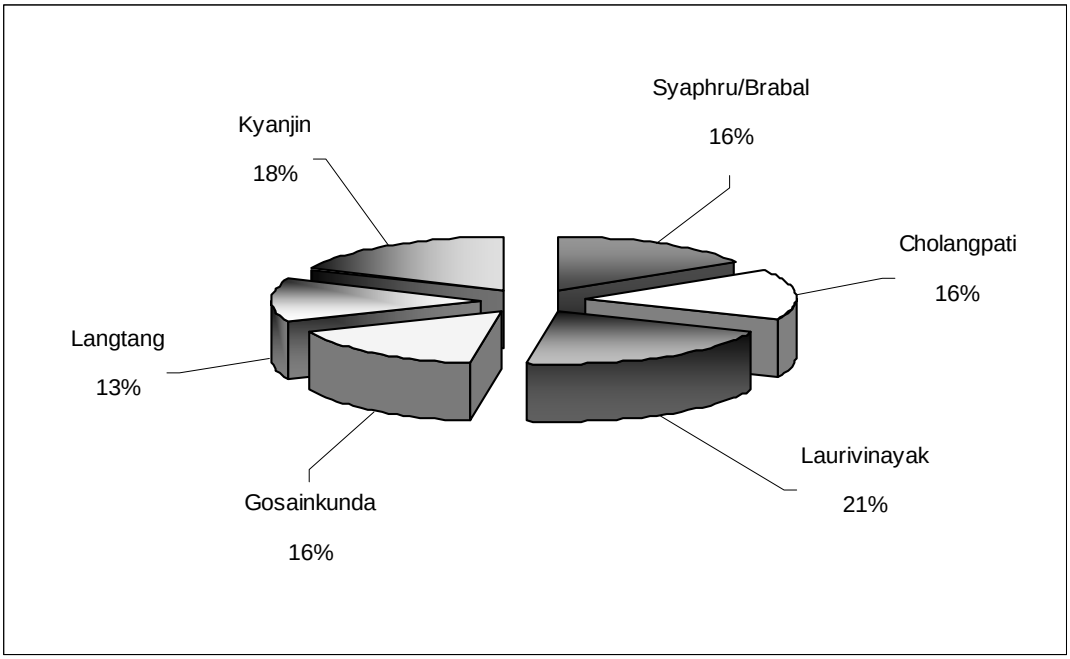
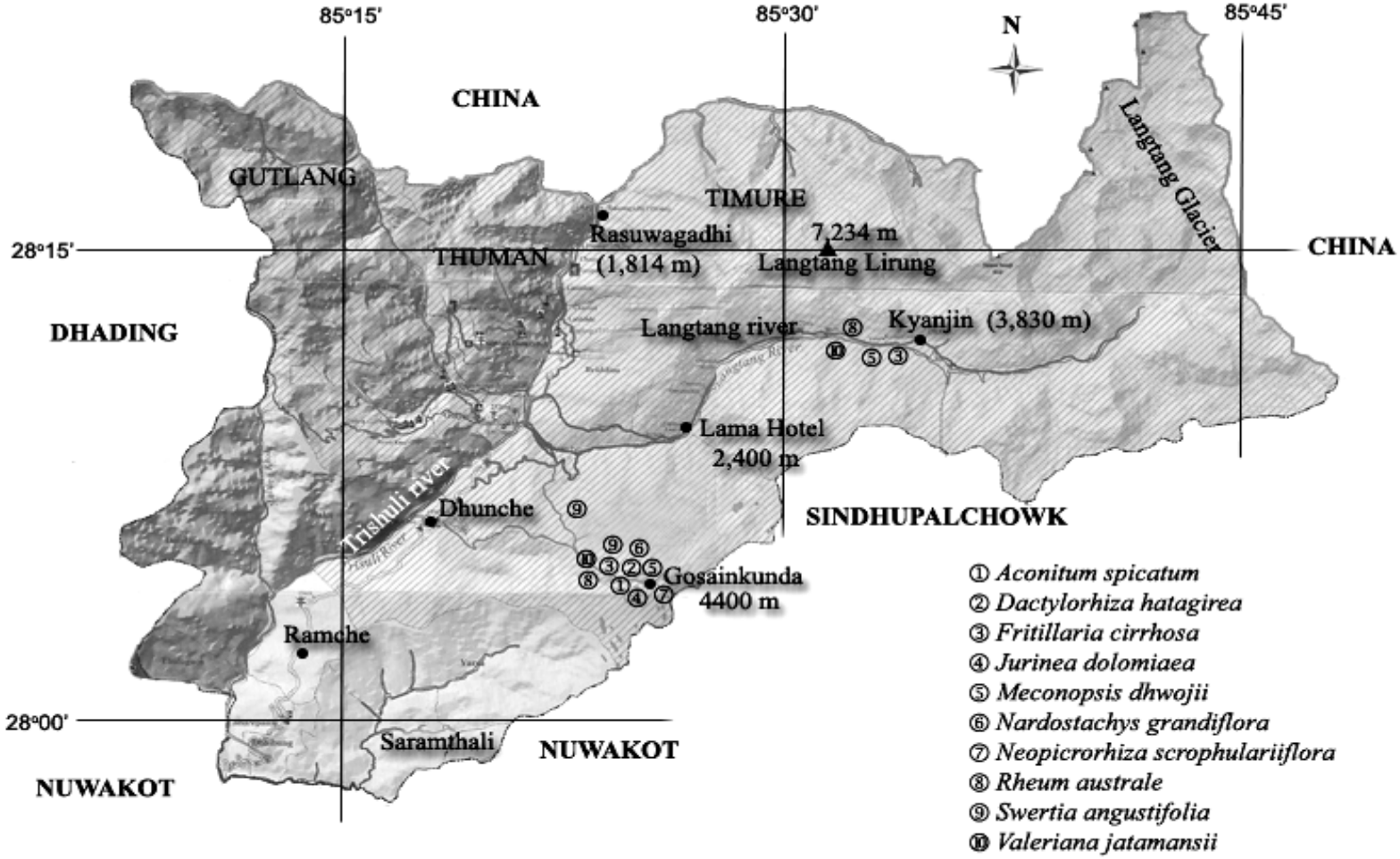
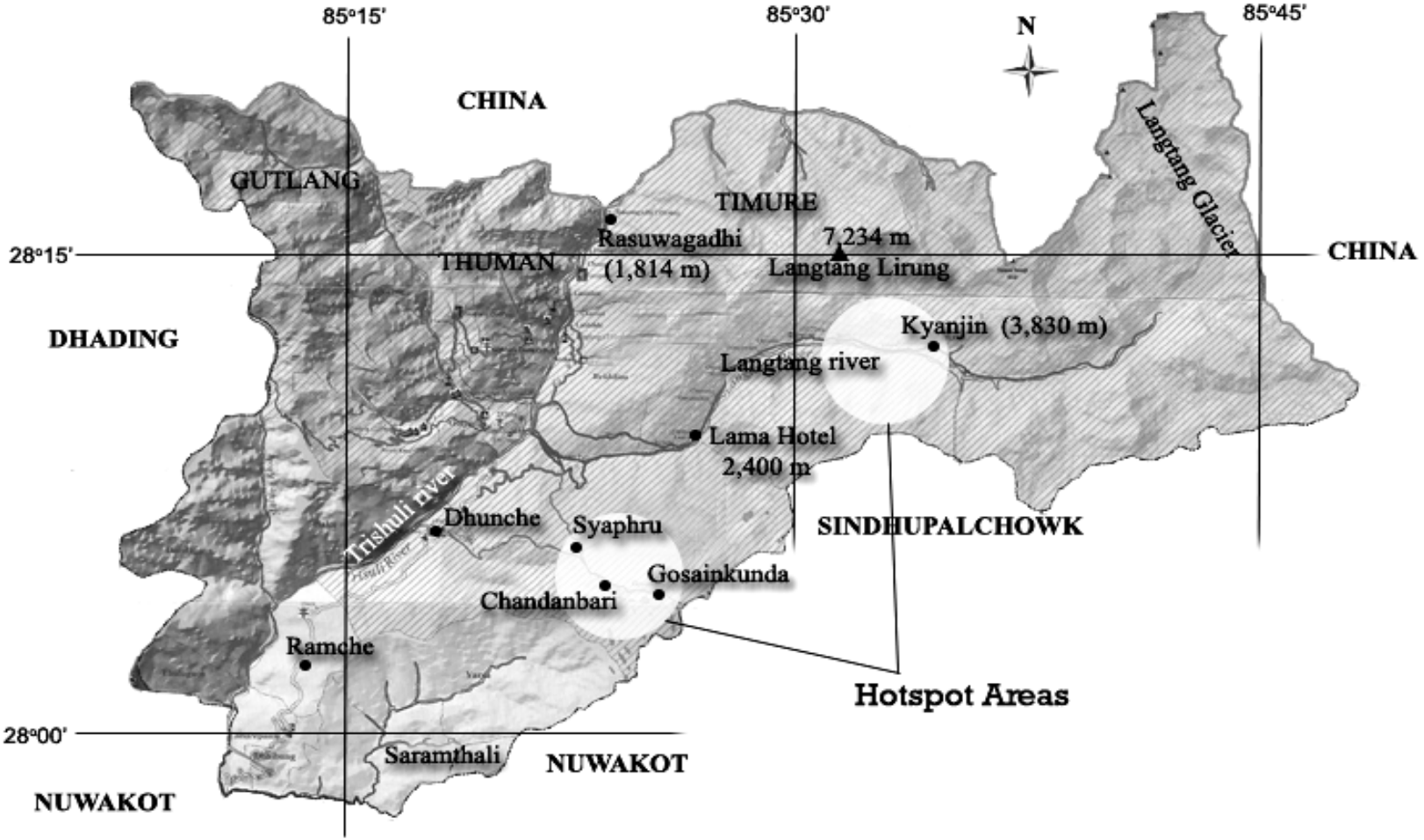


Fig. 8: Percentage of threatened medicinal plant species occurring in LNP

Important Plant Areas (IPAs) are sites of international significance for the conservation of global plant diversity that are recognized at a national level. Their recognition is based on three standard criteria (presence of threatened species, species richness, present of threatened habitats). Based on present study and previous literatures, two major sites have been identified as important plant areas in the park. These include Langtang valley in the north-east and Cholangpati-Gosainkunda sector in the south west. These areas are the potential hotspot areas that are inhabited by a number of high valued, threatened and medicinal and aromatic plants and endemic species. The altitudinal elevation of these places ranges from 3,000 to 4,500 m. The threatened species occurring in these regions are *Aconitum spicatum, Dactylorhiza hatagirea, Fritillaria cirrhosa, Jurinea dolomiaea, Meconopsis dhwojii, Nardostachys grandiflora, Neopicrorhiza scrophulariiflora, Rheum australe, Swertia angustifolia* and *Valeriana jatamansii.*



Map 3: Distribution of the high-value MAPs in LNP



Map 4: Hotspot areas in LNP

4.4 Cultivation Practices

4.4.1 MAPs in cultivation

A small number of populations have started cultivation of MAPs in LNP and its buffer zone. The cultivation is in preliminary phase and needs considerable technical expertise and opportunities for generating higher economic incentives for the local people. The MAPs that are in cultivation within the park are *Swertia chirayita*, *Valeriana jatamansii, Rheum australe* and *Paris polyphylla* (Table 6). These species are cultivated in Syabru and Brabal villages under Syabru VDC. In Syabru, altogether six households (5 %) have adopted farming so far. They have been cultivating MAPs since last 5 years. In Brabal, the farming has been initiated just 2-3 years back. They get plantlets from Kathmandu and some of the pioneer farmers have started preparing seedlings on their own farms. They sell it to other growers at a cheaper rate. This has remarkably reduced the cost of growing MAPs.

However, there are a number of challenges faced by the local people in the cultivation and promotion of these species. The cultivated species are first destroyed by the wild animals from the nearby forests. Some agricultural fields away from the villages near to the forest area have been left fallow by the local people due to crop damage by wildlife. Secondly, there is lack of proper market channel due to which farmers have to face lots of problems selling their products. Either they don't get enough amounts for their production or they have to incur heavy costs to transport their products to the herbal companies. In addition, the farmers have been victimized by the illicit traders who collect MAPs illegally from the forest area and bring it in the market with considerable adulteration. This has strongly discouraged farmers to pursuit this occupation.

Table 6: Cultivated species of MAPs in LNP

Locality	Cultivated species	No. of Households	Cultivation scale
Thulo Syabru	*Swertia chirayita, Paris polyphylla Valeriana jatamansii*	6	Small scale
Brabal	*Swertia chirayita, Valeriana jatamansii, Rheum australe*	4	Small scale

4.4.2 Marketing channel

The MAPs in wild are collected by herders/ collectors. The collected species are either consumed for local use or sold to primary traders. The primary traders either sell these MAPs directly to wholesalers of China or are supplied to secondary traders. The

secondary traders get permission from DFO to take the Jaributi to other parts of the district after paying royalties Secondary traders sell these MAPs to retailers and wholesalers of Kathmandu. The wholesalers in Kathmandu supply the product to retailers as well as foreign traders. The MAPs that are cultivated in farm lands are sold to secondary traders and then brought to Kathmandu through Dhunche after seeking permission from the park. Small amount of cultivated products are utilized for local use. People from adjoining districts invade the park to collect these MAPs during the harvesting season. These MAPs are then brought to Kathmandu or traded to Tibet. The collection and trade of *Cordyceps* is highest in the northern boundary of the park. High value and high market demand of the species has encouraged people to resort to this occupation.

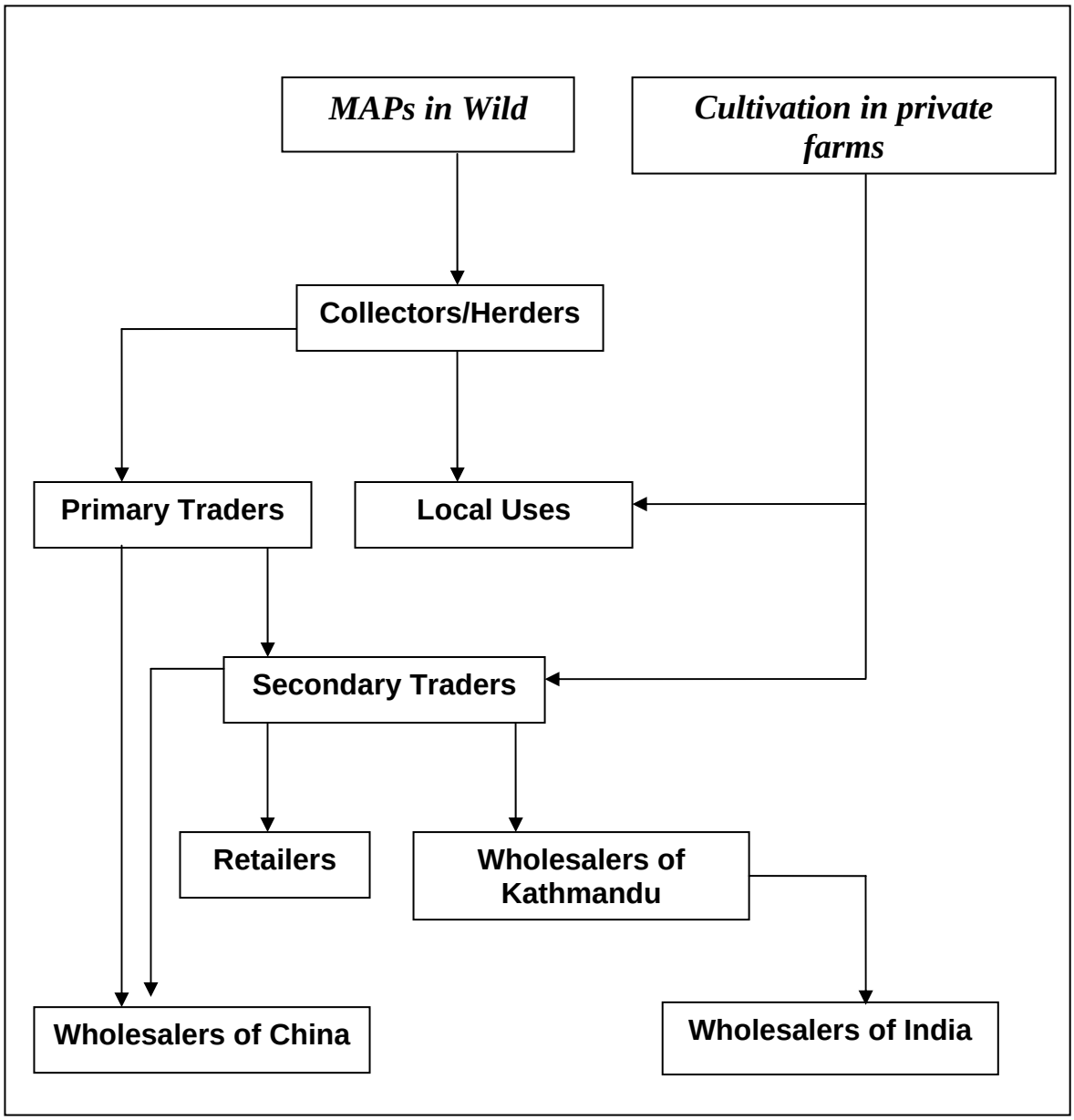


Fig. 9: Market channel of MAPs in LNP

4.4.3 Harvesting seasons

A large number of medicinal and aromatic plants are harvested during the post monsoon seasons (Table 7). The peak season is August to October. Few species like *Cordyceps sinensis* (Yarsagumba) is extensively collected during June-July. The harvesting method follows traditional techniques, uprooting, cutting, picking and cutting parts. The species like *Neopicrorhiza scrophulariiflora*, *Nardostachys grandiflora* are collected after flowering and seed formation. Most of the locals, however, collect these species before their maturity. *Rheum australe* is widely used as pickle in the area. The stem and petioles of *Rheum* is collected for this purpose. The cultivation of *Swertia chirayita* in the farm lands has prevented its wild harvesting. The cultivated species of *Swertia* sp. is harvested after three years of plantation. Harvesting of *Swertia* sp. is carried out in Oct-Dec after the flowering period is over.

Table 7: Harvesting seasons of some highly traded MAPs

S.N.	Species	Parts harvested	Flowering	Fruiting	Harvesting
1.	*Swertia chirayita*	Whole plant	Jun – Aug	Sep – Oct	Oct – Dec
2.	*Neopicrorhiza scrophulariiflora*	Root	Jun – Jul	Jul – Sep	Sep – Oct
3.	*Rheum australe*	Petiole	Jun – Jul	Sep – Oct	Sep – Oct
4.	*Valeriana jatamansii*	Root	May – Jun	Jul – Sep	Sep – Nov
5.	*Nardostachys grandiflora*	Rhizome	Jun – Aug	Sep – Oct	Aug – Oct

4.4.4 Local use of threatened MAPs

The area is largely dominated by Tamang communities. These people have rich indigenous knowledge on use of various plants. Most of the households depend upon traditional health care system for treating various medical ailments. *Neopicrorhiza scrophulariiflora* is the most preferred species in the area for treating fever. About 1-2 kg of the species is collected annually by each household for local health care. Similarly, the use of *Swertia chirayita, Nardostachys grandiflora, Aconitum spicatum* and *Dactylorhiza hatagirea* for local use is largely prevalent in the area. All the species are wild harvested during September-October. Table 8 summarizes local use of threatened species of MAPs occurring in the area.

Table 8: Local use of threatened species of MAPs

S.N.	species	Parts Used	Uses
1.	*Aconitum spicatum* (Bruhl) Stapf	Leaves	Fever *(Jworo)*
2.	*Asparagus racemosus* Willd.	Root	Gastritis (*Pet sunneko*)
3.	*Bergenia ciliata* (Haw.) Stearnb.	Stem	Pharynxitis (*Ghaanti dukheko*)
4.	*Dactylorhiza hatagirea* (D.Don) Soo	Root	Cuts (*Kateko*) and wounds (*Ghau*)
5.	*Ephedra gerardiana* Wall. ex Stapf	Stem	Asthma (*Dum*)
6.	*Fritillaria cirrhosa* D. Don	Whole plant	Stomach disorder (*Pet dukheko*)
7.	*Jurinea dolomiaea* Boiss.	Root	Diarrhoea *(Pakhala)*
8.	*Maharanga bicolor* (Wall. ex G. Don) A. DC.	NA	NA
9.	*Maharanga emodi* (Wall.) A. DC.	NA	NA
10.	*Meconopsis dhwojii* G.Taylor ex Hay	NA	NA
11.	*Nardostachys grandiflora* DC.	Rhizome	Epilepsy (*Chhare rog*)
12.	*Neopicrorhiza scrophulariiflora* (Pennell) Hong	Root	Fever (*Jworo*)
13.	*Paris polyphylla* Sm.	Rhizome	Fever (*Jworo*), Anthelmintic (*Pet ko juka marne*)
14.	*Rheum australe* D. Don	Root	Diarrhoea (*Pakhala*)
		Leaves, stem	Used as pickle (*Achar*)
15.	*Rheum nobile* Hook.f. & Thoms.	Leaves, stem	Used as pickle *(Achar)*
16.	*Rubia manjith* Roxb.	Root	Skin disease (*Chhala rog*)
			Dye (*Rangaune*)
17.	*Swertia angustifolia* Buch.-Ham ex D. Don	Leaves	Fever (*Jworo*)
18.	*Swertia chirayita* (Roxb. ex Flem.) Karstn.	Leaves	Fever *(Jworo)*
19.	*Swertia multicaulis* D. Don	Whole plant	Blood clotting in wounds (*Ghau ko ragat rokne*)
20.	*Valeriana jatamansii* Jones	Rhizome	Rheumatism (*Baath*)
		Root	Used as incense (*Dhoop*)

NA: Not Available

4.5 Ecological analysis

4.5.1 Cholangpati

Ecological analyses of the selected species were carried out at six different localities. The study was carried out in the hotspot areas within the park boundary in the Cholangpati - Gosainkunda sector. The study shows high IVI value of *Swertia angustifolia* in the Cholangpati (63.12) (Table 9). The other associated species with next largest IVI values include *Leontopodium alpinum, Fragaria nubicola* and *Parnassia nubicola* with IVI values 39.78, 31.53 and 27 respectively (Table 9). The site is characterized by dense forest of *Abies spectabilis* and *Rhododendron campanulatum*.

Table 9: Ecological status of species in Cholangpati

S.N.	Species	F	D	C	RF	RD	RC	IVI
1)	*Swertia angustifolia*	80	7.25	23.25	12.70	23.65	26.77	63.12
2)	*Leontopodium alpinum*	50	5.53	12.00	7.94	18.03	13.82	39.78
3)	*Parnassia nubicola*	50	1.93	11.10	7.94	6.28	12.78	27.00
4)	*Caltha palustris*	30	1.23	4.50	4.76	4.00	5.18	13.94
5)	*Parochetus communis*	30	1.55	4.50	4.76	5.06	5.18	15.00
6)	*Potentilla microphylla*	70	1.33	4.50	11.11	4.32	5.18	20.62
7)	*Geum elatum*	50	1.35	3.75	7.94	4.40	4.32	16.66
8)	*Pedicularis siphonantha*	30	1.13	4.50	4.76	3.67	5.18	13.61
9)	*Poa partensis*	20	0.30	0.50	3.17	0.98	0.58	4.73
10)	*Fragaria nubicola*	40	5.60	6.00	6.35	18.27	6.91	31.53
11)	*Primula glomerata*	30	0.23	0.75	4.76	0.73	0.86	6.36
12)	*Artemisia vulgaris*	30	0.95	4.50	4.76	3.10	5.18	13.04
13)	*Bistorta affinis*	30	0.75	1.00	4.76	2.45	1.15	8.36
14)	*Plantago major*	30	0.35	0.75	4.76	1.14	0.86	6.77
15)	*Geranium sp.*	20	0.40	1.75	3.17	1.31	2.01	6.49
16)	*Corydalis juncea*	20	0.18	0.50	3.17	0.57	0.58	4.32
17)	*Senecio graciliflorus*	20	0.63	3.00	3.17	2.04	3.45	8.67
	Total	**630**	**30.65**	**86.85**	**100.00**	**100.00**	**100.00**	**300.00**

F: Frequency %; D: Density (Individual/m^2); C: Cover %; RF: Relative frequency; RD: Relative density; RC: Relative cover; IVI: Importance Value Index.

4.5.2 Cholangpati-Laurivinayak

The Cholangpati-Laurivinayak sector showed very poor distribution of *Rheum australe* with frequency value of 30 % and IVI value of 8.17 (Table 10). *Fragaria nubicola* and *Parnassia nubicola* were the most dominant vegetation in the area showing IVI values 43.10 and 31.76 respectively. The highest value of frequency was shown by *Berberis aristata* (100 %). Density of *Fragaria nubicola* was the highest (12 plants/m^2) of all the species. The IVI value for *B. aristata* was 30.80. Altogether 19 plant species were

recorded from the area. The important medicinal plants occurring in the area were *Swertia angustifolia* and *Rheum australe*. The IVI value for *Swertia angustifolia* was 21.07.

Table 10: Ecological status of species in Cholangpati-Laurivinayak

S.N.	Species	F	D/m2	C	RF	RD	RC	IVI
1)	*Berberis aristata*	100	3.60	15.00	11.90	7.29	11.61	30.80
2)	*Fragaria nubicola*	80	12.00	12.00	9.52	24.29	9.28	43.10
3)	*Parnassia nubicola*	80	6.40	12.00	9.52	12.96	9.28	31.76
4)	*Leontopodium alpinum*	50	5.03	12.00	5.95	10.17	9.28	25.41
5)	*Swertia angustifolia*	50	4.60	7.50	5.95	9.31	5.80	21.07
6)	*Delphinium himalayi*	40	1.75	6.00	4.76	3.54	4.64	12.95
7)	*Bistorta affinis*	20	0.85	3.00	2.38	1.72	2.32	6.42
8)	*Rheum australe*	30	0.55	4.50	3.57	1.11	3.48	8.17
9)	*Arisaema nepenthoides*	10	0.15	0.25	1.19	0.30	0.19	1.69
10)	*Corydalis juncea*	10	0.45	1.50	1.19	0.91	1.16	3.26
11)	*Artemisia vulgaris*	10	0.53	1.50	1.19	1.06	1.16	3.41
20)	*Pedicularis siphonantha*	60	2.23	9.00	7.14	4.50	6.96	18.61
12)	*Commelina benghalensis*	20	0.65	3.00	2.38	1.32	2.32	6.02
13)	*Parnassia cabulica*	60	2.80	9.00	7.14	5.67	6.96	19.77
14)	*Agrimonia pilosa*	20	0.68	3.00	2.38	1.37	2.32	6.07
15)	*Cremanthodium reniforme*	40	1.00	6.00	4.76	2.02	4.64	11.43
16)	*Aster asteroids*	40	1.23	6.00	4.76	2.48	4.64	11.88
17)	*Bupleurum tenue*	50	1.93	7.50	5.95	3.90	5.80	15.65
18)	*Saxifraga parnassifolia*	50	2.65	7.50	5.95	5.36	5.80	17.12
19)	*Umbelliferae* (196)	20	0.35	3.00	2.38	0.71	2.32	5.41
	Total	**840**	**49.4**	**129.25**	**100.00**	**100.00**	**100.00**	**300.00**

F: Frequency %; D: Density (Individual/m^2); C: Cover %; RF: Relative frequency; RD: Relative density; RC: Relative cover; IVI: Importance Value Index.

4.5.3 Laurivinayak I

Dactylorhiza hatagirea, a highly threatened species, was reported from Laurivinayak showing poor distribution. The IVI value was only 13.55 (Table 11). The density of the species was 0.18 plants/m^2. It was found associated with other 11 species. *Berberis aristata* and *Cyananthus lobatus* were the most dominant vegetation in the area, showing IVI values of 40.60 and 56.71 respectively. *Swertia angustifolia* was another threatened species occurring in the area. The species showed IVI value of 21.07, which was 50 percent less in comparison to value recorded from Cholangpati.

Table 11: Ecological status of species in Laurivinayak I

S.N.	Species	F	D/m2	C	RF	RD	RC	IVI
1)	*Berberis aristata*	50	1.18	16.50	11.11	9.36	20.12	40.60
2)	*Morina* sp.	50	2.30	7.50	11.11	18.33	9.15	38.58
3)	*Euphorbia wallichii*	30	0.78	11.25	6.67	6.18	13.72	26.56
4)	*Potentilla microphylla*	50	2.10	7.50	11.11	16.73	9.15	36.99
5)	*Leontopodium alpinum*	30	0.68	3.25	6.67	5.38	3.96	16.01
6)	*Parnassia nubicola*	30	0.75	4.50	6.67	5.98	5.49	18.13
7)	*Swertia angustifolia*	30	0.85	4.50	6.67	6.77	5.49	18.93
8)	*Dactylorhiza hatagirea*	30	0.18	4.50	6.67	1.39	5.49	13.55
9)	*Rheum australe*	30	0.30	4.50	6.67	2.39	5.49	14.54
10)	*Juniperus indica*	40	0.40	6.00	8.89	3.19	7.32	19.39
11)	*Cyananthus lobatus*	80	3.05	12.00	17.78	24.30	14.63	56.71
	Total	**450**	**12.55**	**82**	**100.00**	**100.00**	**100.00**	**300.00**

F: Frequency %; D: Density (Individual/m^2); C: Cover %; RF: Relative frequency; RD: Relative density; RC: Relative cover; IVI: Importance Value Index.

4.5.4 Laurivinayak II

Laurivinayak sector II was dominated by *Delphinium himalayi*, *Fragaria nubicola* and *Cyananthus lobatus*. The IVI values for the species were 45.64, 41.25 and 39.94 respectively (Table 12). The threatened species occurring in the region were *Rheum australe* and *Aconitum spicatum*, which showed very poor distribution in the area. The frequency of *Rheum australe* was 50 % and the coverage value was 7.5 %. Density of the species was very low (2.68 plants/m^2). The frequency of *Aconitum spicatum* was found to be 30%. The density was 0.25 plants/m^2 and the coverage was very low with the value of 3.5.

Table 12: Ecological status of species in Laurivinayak II

S.N.	Species	F	D/m2	C	RF	RD	RC	IVI
1)	*Rhododendron anthopogon*	60	2.28	7.50	11.76	8.97	10.34	31.08
2)	*Rheum australe*	50	2.68	7.50	9.80	10.55	10.34	30.70
3)	*Delphinium himalayi*	50	5.68	9.75	9.80	22.39	13.45	45.64
4)	*Fragaria nubicola*	50	5.35	7.50	9.80	21.10	10.34	41.25
5)	*Pedicularis siphonantha*	20	1.50	3.00	3.92	5.92	4.14	13.98
6)	*Parnassia nubicola*	30	0.95	4.50	5.88	3.75	6.21	15.84
7)	"Mahaguru"	70	2.68	10.50	13.73	10.55	14.48	38.76
8)	*Taraxaccum* sp.	30	0.50	0.75	5.88	1.97	1.03	8.89
10)	*Cyanathus lobatus*	70	2.98	10.50	13.73	11.74	14.48	39.94
11)	*Aconitum spicatum*	30	0.25	3.50	5.88	0.99	4.83	11.70
12)	*Aconitum gammiei*	50	0.53	7.50	9.80	2.07	10.34	22.22
	Total	**510**	**25.35**	**72.5**	**100.00**	**100.00**	**100.00**	**300.00**

F: Frequency %; D: Density (Individual/m^2); C: Cover %; RF: Relative frequency; RD: Relative density; RC: Relative cover; IVI: Importance Value Index.

4.5.5 Gosainkunda

Neopicrorhiza scrophulariiflora in Gosainkunda showed high frequency (70 %) and density (17.50 plants/m^2) and was one of the dominant vegetation. The IVI value was 69.16 (Table 13). Poor distribution of *Swertia multicaulis* with IVI value of 9.62 was also recorded from the area. Altogether, 15 species were recorded from the site. Besides *N. scrophulariiflora*, the area was dominated by *Cremanthodium retusum* and "Mahaguru". The frequency of *Cremanthodium* was the highest (100 %). The density was 2.73 plants/m^2 and coverage value was 15 %. The frequency of "Mahaguru" was 80 %. The density value for the species was 7.45 plants/m^2 and the coverage was 14.25 %. *Bistorta amplexicaulis* was sparsely distributed in the area with frequency value of 50 %.

Table 13: Ecological status of species in Gosainkunda

S.N.	Species	F	D/m2	C	RF	RD	RC	IVI
1)	*Neopicrorhiza scrophulariiflora*	70	17.50	33.75	10.14	36.06	22.96	69.16
2)	*Arenaria globifera*	30	6.05	13.75	4.35	12.47	9.35	26.17
3)	"Mahaguru"	80	7.45	14.25	11.59	15.35	9.69	36.64
4)	*Bistorta amplexicaulis*	50	3.25	12.00	7.25	6.70	8.16	22.11
5)	*Cremanthodium retusum*	100	2.73	15.00	14.49	5.62	10.20	30.31
6)	*Rhododendron anthopogon*	40	1.35	12.75	5.80	2.78	8.67	17.25
7)	*Rhododendron lepidotum*	20	0.28	3.00	2.90	0.57	2.04	5.51
8)	*Geum elatum*	60	1.28	9.00	8.70	2.63	6.12	17.45
9)	*Swertia multicaulis*	30	1.08	4.50	4.35	2.22	3.06	9.62
10)	*Potentilla peduncularis*	50	1.10	6.25	7.25	2.27	4.25	13.76
11)	*Cortia depressa*	10	0.05	0.25	1.45	0.10	0.17	1.72
12)	*Lomatogonium carinthiacum*	30	0.43	4.50	4.35	0.88	3.06	8.28
13)	*Saxifraga brachypoda*	30	3.48	4.50	4.35	7.16	3.06	14.57
14)	*Leontopodium alpinum*	50	1.85	7.50	7.25	3.81	5.10	16.16
15)	*Leonotpodium stracheyi*	40	0.68	6.00	5.80	1.39	4.08	11.27
	Total	**690**	**48.53**	**147**	**100.00**	**99.99**	**100.00**	**299.99**

F: Frequency %; D: Density (Individual/m^2); C: Cover %; RF: Relative frequency; RD: Relative density; RC: Relative cover; IVI: Importance Value Index.

4.5.6 Saraswatikunda

Jurinea dolomiaea showed moderate distribution in the Saraswoti kunda region, towards the north of the lake with IVI value of 13.81. Frequency of *Jurinea dolomiaea* was 40 % (Table 14). *Potentilla peduncularis* was the most dominant vegetation in the region with high IVI value (75.54). The area was also dominated by *Leontopodium alpinum*, *Persicaria perfoliata* and *Geranium* sp. with IVI values of 38.53, 34.36 and 33.33 respectively. Other associated species occurring in the area were *Berberis aristata*,

Meconopsis paniculata, *Parnassia nubicola* and *Cyananthus lobatus*. The highest frequency was shown by *Potentilla peduncularis* (100 %). The density (40.98 plants/m^2) and coverage value (24 %) was also the highest for the species.

Table 14: Ecological status of species in Saraswatikunda

S.N.	Species	F	D/m2	C	RF	RD	RC	IVI
1)	*Potentilla peduncularis*	100	40.98	24.00	17.86	34.94	22.75	75.54
2)	*Leontopodium alpinum*	50	16.38	16.50	8.93	13.96	15.64	38.53
3)	*Geranium* sp.	50	20.28	7.50	8.93	17.29	7.11	33.33
4)	*Berberis aristata*	70	5.05	15.00	12.50	4.31	14.22	31.02
5)	*Jurinea dolomiaea*	40	1.15	6.00	7.14	0.98	5.69	13.81
6)	*Meconopsis paniculata*	30	0.40	3.50	5.36	0.34	3.32	9.02
7)	*Persicaria perfoliata*	60	17.73	9.00	10.71	15.11	8.53	34.36
8)	*Juniperus indica*	50	0.85	7.50	8.93	0.72	7.11	16.76
9)	*Parnassia nubicola*	40	4.03	6.00	7.14	3.43	5.69	16.26
10)	*Cyananthus lobatus*	70	10.45	10.50	12.50	8.91	9.95	31.36
	Total	**560**	**117.28**	**105.50**	**100.00**	**100.00**	**100.00**	**300.00**

F: Frequency %; D: Density (Individual/m^2); C: Cover %; RF: Relative frequency; RD: Relative density; RC: Relative cover; IVI: Importance Value Index.

Of all the sampled sites, *Swertia angustifolia* was found in 3 sites viz: Cholangpati, Cholangpati-Laurivinayak and Laurivinayak-I. The highest IVI value was reported from Cholangpati (63.12), followed by Cholangpati-Laurivinayak (21.07) and Laurivinayak (18.93). *Rheum australe* was reported from 3 sites. The highest IVI value was reported from Laurivinayak-II (30.70). The IVI values at Laurivinayak-I and Cholangpati-Laurivinayak were 14.54 and 8.17 respectively. The species like *Dactylorhiza hatagirea*, *Aconitum spicatum*, *Jurinea dolomiaea* and *Neopicrorhiza scrophulariiflora* were present only in single site. *Dactylorhiza hatagirea* was reported from Laurivinayak-I, with very poor IVI value (13.55). *Aconitum spicatum* was found in Laurivinayak-II with IVI value of 11.7. *Jurinea dolomiaea* was reported from Saraswatikunda region only. The species has very specific habitat and is not found elsewhere. The IVI value for the species was 13.81. *Neopicrorhiza scrophulariiflora* was reported from Gosainkunda region. The species was abundantly distributed in the area with high IVI value (69.16). Table 15 shows the IVI values for threatened species of MAPs recorded at different sampling sites.

Table 15: IVI of threatened species of MAPs

S.N.	Sampling Sites	Target Species	IVI	Associated species
1)	Cholangpati	a) *Swertia angustifolia*	63.12	16
2)	Cholangpati-Laurivinayak	a) *Swertia angustifolia* b) *Rheum australe*	21.07 8.17	17
3)	Laurivinayak-I	a) *Swertia angustifolia* b) *Dactylorhiza hatagirea* c) *Rheum australe*	18.93 13.55 14.54	8
4)	Laurivinayak-II	a) *Rheum australe* b) *Aconitum spicatum*	30.70 11.70	10
5)	Gosainkunda	a) *Neopicrorhiza scrophulariiflora*	69.16	14
6)	Saraswatikunda	a) *Jurinea dolomiaea*	13.81	9

4.6 Rapid Vulnerability Assessment

Rapid Vulnerability Assessment was carried out for ten species of threatened MAPs. Altogether 8 criteria were analyzed and the score summed up to get a final score (Appendix-3). Fig. 10 shows the total score and threat category of some of the threatened species. *Neopicrorhiza scrophulariiflora* showed the highest threat value of 25. Similarly, *Aconitum spicatum* and *Nardostachys grandiflora* showed threat value of 24 each. *Fritillaria cirrhosa* and *Valeriana jatamansii* showed least threat values (17). *Dactylorhiza hatagirea, Jurinea dolomiaea, Meconpsis dhwojii, Rheum australe, Swertia angustifolia, Valeriana jatamansii* and *Fritillaria cirrhosa* showed threat values of 23, 20, 20, 20, 19, 17 and 17 respectively.

Only one species, *Neopicrorhiza scrophulariiflora* belonged to threat category I, representing highest vulnerability. Six species viz: *Aconitum spicatum, Dactylorhiza hatagirea, Jurinea dolomiaea, Meconopsis dhwoji, Nardostachys grandiflora* and *Swertia angustifolia* belonged to threat category II. Similarly 3 species of MAPs belonged to threat category III. This includes *Fritillaria cirrhosa, Rheum australe* and *Valeriana jatamansii*.

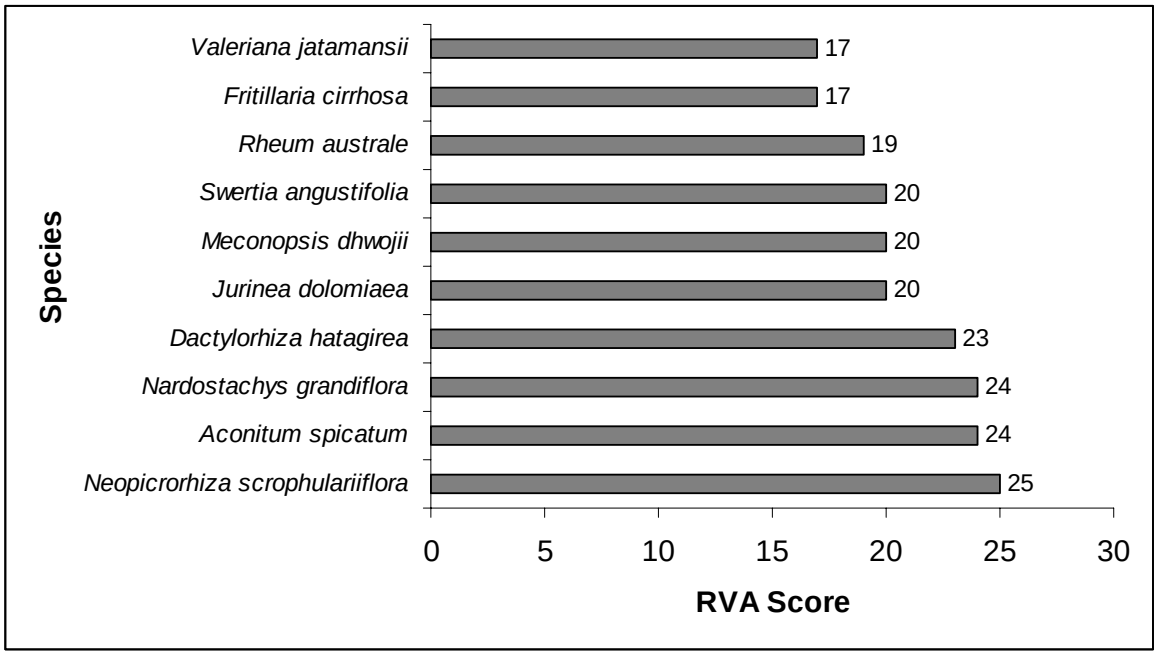


Fig. 10: RVA score of selected species of MAPs

The present study has assessed the vulnerability of following ten species of threatened MAPs (Table 16). All these species are under the CAMP priority and belong

to one of the threat categories (Vulnerable, Endangered and Nearly Threatened). Three species belong to IUCN Threat cateogory. They are *Aconitum spicatum* (T), *Nardostachys grandiflora* (V) and *Neopicrorhiza scrophulariiflora* (V). *Nardostachys grandiflora* has been recently added to CITES Appendix-II. Four species are under the government protection. They include *Dactylorhiza hatagirea* and *Neopicrorhiza scrophulariiflora* under Category 1 and *Nardostachys grandiflora* and *Valeriana jatamansii* under Category 2. *Neopicrorhiza scrophulariiflora* has been identified as the most vulnerable species in the area belonging to threat category I. The species is under high threat risk. The other vulnerable species were *Aconitum spicatum, Nardostachys grandiflora, Dactylorhiza hatagirea, Jurinea dolomiaea, Meconopsis dhwojii* and *Swertia angustifolia* belonging to threat category II. *Rheum australe, Valeriana jatamansii* and *Fritillaria cirrhosa* were least vulnerable and belonged to threat category III.

Table 16: Threat category of selected species of MAPs

S.N.	Plant species	CAMP	IUCN	Gov. N	Present Study
1.	*Aconitum spicatum*	V	T	-	II
2.	*Dactylorhiza hatagirea*	EN	-	1	II
3.	*Fritillaria cirrhosa*	V	-	-	III
4.	*Jurinea dolomiaea*	NT	-	-	II
5.	*Meconopsis dhwojii*	NT	-	-	II
6.	*Nardostachys grandiflora* [1]	V	V	2	II
7.	*Neopicrorhiza scrophulariiflora*	V	V	1	I
8.	*Rheum australe*	V	-	-	III
9.	*Swertia angustifolia*	EN	-	-	II
10.	*Valeriana jatamansii*	V	-	2	III

[1] Species under CITES Appendix-II

4.7 Profile of threatened species of MAPs

1) *Aconitum spicatum* (Bruhl) Stapf

Synonym: *Aconitum ferox* var. *spicata* Bruhl

Family: Ranunculaceae

Vernacular name: Bikh (Nep)

Description: Perennial erect herbs, 1-2 m, with large, tuberous roots. Leaves often softly hairy, deeply cut into ovate lobes; lobes further cut into toothed acute segments mostly more than 3 mm wide. Flowers purple to greenish white, 2-2.5 cm, in dense terminal spike, sometimes with lateral branches. Hood of flower about as long as broad.

Distribution: WCE (1800-4200m); Himalaya (Nepal to Bhutan), China (Xizang)

Local distribution: Laurivinayak (3800m)

Habitat: Sub-alpine scrubland.

Flowering: Aug-Sep

Indigenous uses: Leaf paste is applied in fever (*Jworo*) and headache (*Tauko dukheko*).

Other uses: Root paste is used as an arrow poison in Jumla district (Manandhar, 1986; Rajbhandari, 2001). Tincture of the drug from *Aconitum* is used as a heart and nervine sedative (Edwards, 1996). Root juice is used in cuts and wounds, cough and cold and liver problems in Dolpa (Kunwar and Adhikari, 2005).

Marketing information: The root of the plant is traded with the name "*Bish Jara*". The current market value of the species in Kathmandu is NRs 190 per kg.

Conservation status: Included in Threatened (T) category of IUCN. Included in Vulnerable (V) category of CAMP.

Voucher specimens: Laurivinayak, 3900m, 1st Sep 2006, *N. Shrestha, B. Karki & K. Homagain* 247 (TUCH); Laurivinayak, 3790m, Sep 10 & 11 1965, *Shrestha & Shakya* 3779 & 3795 (KATH).

2) *Dactylorhiza hatagirea* (D. Don) Soo

Synonym: *Orchis hatagirea* D. Don

Family: Orchidaceae

English name: Salep

Vernacular name: Paanchaunle (Nepali), Ompolakpa (Tamang)

Description: Terrestrial, erect herbs, occurring in subalpine and alpine zones. Stems robust, leafy, 30-90 cm, bearing terminal spike of many flowers. Leaves many, oblong-

lanceolate. Flowers rosy-purple, spotted, c. 1.8 cm long. Upper sepal and petals forming a hood, lateral sepals spreading; lip shallowly three-lobed, spotted dark purple; spur stout, curved.

Distribution: WCE (2800-3960m); Pakistan, Himalaya (Kashmir to Bhutan), China (Xizang).

Local distribution: Laurivinayak (3800m)

Habitat: Marshy shrubland, open places.

Flowering: Jun-Jul

Indigenous uses: Root paste is used in cuts (*Kateko*) and wounds (*Ghau*).

Other uses: Decoction of root is utilized in treating stomach troubles in Jumla district. Rhizomes are eaten raw or with milk or honey as a vital tonic (Manandhar, 1986; Bhattarai, 1992).

Marketing information: The species is strictly banned for collection and hence has no trade value. However, the tuber of the species is locally utilized.

Conservation status: Banned for collection, transportation and trade. Included in Endangered (EN) category of CAMP.

Voucher specimen: Laurivinayak, 3900m, 1st Sep 2006, *N. Shrestha, D. Prasai, B. Karki & K. Homagain* 244 (TUCH).

3) *Fritillaria cirrhosa* D.Don

Family: Liliaceae

Vernacular name: Kaakoli (Nepali)

Description: Perennial herbs, occurring in alpine zone, with subglobose bulb, whitish fleshy scales, covered with whitish, papery tunic. Leaves linear-lanceolate, opposite or in whorls of 3, apex filiform or cirrhose. Flowers single, usually drooping, subtended by a whorl of usually 3 leaf-like bracts, outside flushed tawny or olive-brown, inside yellowish-green.

Distribution: WCE (3000-4600m); Himalaya (Nepal to Bhutan), China (Xizang), N. Myanmar.

Local distribution: Cholangpati (3600m), Langtang (3600m), Kyanjin(3800m)

Habitat: Mountain slopes in alpine and sub-alpine meadows, sub-alpine scrubland, rock crevices, and forest floor.

Flowering: Apr-Jun

Indigenous uses: Plant is used in stomach disorder (*Pet dukheko*).

Other uses: Plant is eaten to reduce stomach pain at Rolwaling (Sacherer, 1979).

Marketing information: NA

Conservation status: Included in Vulnerable (V) category of CAMP.

Voucher specimens: Gosainkunda, 4400m, 31st Aug 2006, *N. Shrestha, D. Prasai & B. Karki* 225 (TUCH); Langtang valley, 4100m, Jun 25 & 28 1965, *Schilling, Sayers & Bista* 423 & 447 (KATH); Kyangjin Kharka, 3400m, Jul 16 1967, *Malla* 9153 (KATH).

4) *Jurinea dolomiaea* Boiss.

Synonyms: *Carduus macrocephalus* Wall., *Dolomiaea macrocephala* Royle, *Jurinea macrocephala* (Royle) C.B. Clarke

Family: Compositae

Vernacular name: Dhupjadi (Nepali)

Description: Stemless perennial herbs with rosette of prostrate leaves radiating to 30cm from stout taproot. Leaves oblong blunt, pinnate-lobed, with lobes toothed or shallowly lobed, often with purple mid-vein, woolly beneath, stalked. Flower-heads pinkish, very short-stalked, in dense domed central cluster to 10 cm across. Outer involucral bracts lanceolate, hairy; inner narrower, long pointed, dark red, papery.

Distribution: WCE (3200-4300m); Himalaya (Kashmir to Nepal), W. Asia (Turkey and Iran).

Habitat: Open, alpine steep slopes

Flowering: Jul-Sep

Indigenous uses: Root juice is used in diarrhoea (*Pakhala*).

Other uses: Plant is kept in the house to "ward off evil spirits" at Jumla district (Manandhar, 1986). The plant is used for incense and the juice of the roots is used in the treatment of fever (Manandhar, 2002). The root juice is used in diarrhoea and dysentery as well as in stomach pain in Dolpa (Kunwar and Adhikari, 2005).

Marketing information: NA

Conservation status: Included in Nearly Threatened (NT) category of CAMP.

Voucher specimen: Not collected

5) *Meconopsis dhwojii* G.Taylor ex Hay

Family: Papaveraceae

Description: Biennial herbs with branched flower bearing stems; lower branches 3-5 flowered; upper branches 1-flowered. Leaves twice pinnately lobed with long sparse

golden bristles, usually black-purple at base. Basal leaves petioled, c. 32.5 cm long including the petiole, 5 cm broad, bristly haired, leaflets 6-12, with rounded or obtuse or subacute lobes. Cauline leaves similar to basal leaves but minor. Sepals elliptic, densely hispid on the outerside. Petals 4, yellow, obovate-orbiculate, rounded, base broadly cuneate. Styles more or less slender; stigmas capitate, ovary globose or elliptic or ovoid, densely hispid. Capsules ellipsoid-oblong, 5-6 valved.

Distribution: CE (2950-5600m); Nepal.

Local distribution: Laurivinayak-Gosainkunda (3800m), Langtang (3600m)

Habitat: Open and steep sub-alpine slopes, open fields, rock crevice and slopes.

Flowering: Jun-Aug

Indigenous uses: No local use

Other uses: NA

Marketing information: NA

Conservation status: Included in Nearly Threatened (NT) category of CAMP.

Voucher specimens: Laurivinayak, 3900m, 28th Jul 1967, *Malla* 9526 & 9545 (KATH); Gosainkunda, 4570m, 13th Jun 1969, *Rajbhandari & Bista* 13147 (KATH); Gosainkunda, 4570m, 26th Aug 1969, *Kanai & Malla* 674903 (KATH); Gosainkunda, 4220m, 27th Aug 1969, *Kanai & Malla* 16241 (KATH); Langtang Valley, 3540m, 13th Jul 1970, *Kanai & Shakya* 218 (KATH); Dukpu, Helambu, 3960m, 11th Aug 1972, *Fleming* H12 (KATH).

6) *Nardostachys grandiflora* DC.

Synonyms: *Nardostachys gracilis* Kitam, *Nardostachys jatamansi* DC.

Family: Valerianaceae

English name: Spikenard

Vernacular name: Jatamansi, Bhulte (Nepali)

Description: Perennial herbs with spindle-shaped rootstock covered with fibres of old leaves, and flowering stems 5-30 cm. Leaves mostly basal, elliptic lanceolate or spoon-shaped. Flowers pruple to whitish, in heads borne in terminal often branched clusters. Calyx coloured, 5-lobed, the lobes enlarging in fruit and becoming papery. Corolla tube 6-20 mm long, with 5 rounded spreading lobes. The whole plant has a distinctive lingering smell.

Distribution: WCE (3200-5000); Himalaya (Uttar Pradesh to Bhutan), W. China.

Habitat: Rock ledges, open places

Flowering: Jun-Aug

Indigenous uses: Plant is used for making incense (*Dhoop*). Rhizome used in epilepsy (*Chhare rog*).

Other uses: Root paste is used as a tonic at Karnali zone. Rhizome paste is applied to treat piles at Jumla district (Manandhar, 1986; Bhattarai, 1992; Rajbhandari, 2001). An infusion of the rhizome is used in epilepsy, hysteria, palpitation of heart and chorea (Edwards, 1996).

Marketing information: The root of the plant is traded with the name "*Jatamansi*". The current market value of the species in Kathmandu is NRs. 180 per kg.

Conservation status: Banned for export outside the country without processing. Included in Vulnerability category of IUCN and CAMP. Included in Appendix II of CITES.

Voucher specimens: Gosainkunda, 3660m, 26th Jun 1962, *Suwal & A.B. Shrestha* 277 (KATH); Ghopte-Gosainkunda, 3660m, 9th Sep 1965, *Shrestha & Shakya* 3776 (KATH); Laurivinayak, 3900m, 27th Jul 1967, *Malla* 9247 (KATH); Geldangphu, Helambu, 4110m, 17th Aug 1972, *Fleming* H38 (KATH).

7) *Neopicrorhiza scrophulariiflora* (Pennell) Hong

Synonym: *Picrorhiza scrophulariiflora* Pennell

Family: Scrophulariaceae

English name: Gentian, Picrorhiza

Vernacular name: Kutki (Nepali)

Description: Perennial herbs with an elongate, stout, creeping rootstock found in the alpine Himalayas. Leaves almost radical, spathulate, sharply serrate. Flowers white or pale blue-purple, in a dense terminal spicate raceme; corolla about 1.5 cm across with a long, 3-lobed upper lip and short lower lip. Fruit an ovoid capsule, tip acute.

Distribution: WCE (3500-4800m); Himalaya (Uttar Pradesh to Bhutan), N. Myanmar, China (Sichuan, Xizang, Yunnan).

Local distribution: Gosainkunda (4400m).

Habitat: Rocky slopes and open alpine scree.

Flowering: Jun- Jul

Indigenous uses: Decoction of rhizome is used in fever (*Jworo*).

Other uses: Rhizome paste is taken to subside cough and colds in Jumla district. Plants are used as tonic. Root paste is used by the Sherpas of Helambu to heal wounds of cattle. Decoction of root is taken before bedtime to rid intestinal worms (Rajbhandari, 2001).

Marketing information: The root of the species is traded with the name "*Kutki*". The current market value of the species in Kathmandu is NRs. 250 per kg.

Conservation status: Banned for collection, transportation and trade. However, recently the ban has been lifted for products legally harvested from sustainably managed forests. Included in Vulnerability (V) category of IUCN and CAMP.

Voucher specimens: Gosainkunda, 4400m, 31st Aug 2006, *N. Shrestha, K. Homagain & B. Karki* 224 (TUCH); Gosainkunda, 4400m, 31st Aug 2006, *D. Prasai, N. Shrestha & K Homagain* 230 (TUCH); Laurivinayak, 3900m, 27th Jul 1967, *Malla* 9246 (KATH); Gosainkunda, 4270, 28th Aug 1969, *Kanai & Malla* 16257 (KATH).

8) *Rheum australe* D.Don

Synonym: *Rheum emodi* Wall. ex Meisn.

Family: Polygonaceae

English name: Rhubarb

Vernacular name: Padamchal (Nepali), Chhurcha (Tamang)

Description: Perennial herbs, up to 3 m high, occurring in alpine zone. Stems stout, streaked green and brown, 1.5-2 m. Leaves with rounded to broadly ovate blade with heart-shaped base, basal leaves to 60 cm across; leaf stalk very stout, to 45 cm; rootstock very stout. Flowers dark reddish-purple, in dense branched clusters, in a long inflorescence to 30 cm, which enlarges greatly in fruit. Corolla c. 3 mm across. Bracts minute papery. Nutlets ovoid, with narrow wings.

Distribution: CE (3200-4200); Himalaya (Himachal Pradesh to Nepal, Bhutan), China (Xizang)

Local distribution: Cholangpati (3600m), Laurivinayak (3900m), Langtang (3600m).

Habitat: Shrubberies and open slope

Flowering: Jun-Jul

Indigenous uses: Stem and leaves are used as pickle (*Achar*). Rhizome powder is used to treat diarrhoea (*Pakhala*).

Other uses: Rhizome paste is used as purgative in Jumla district. Petioles are eaten with common salt as an appetizer. Rhizome paste is used to treat rheumatism in Helambu (Manandhar, 1986; Bhattarai, 1989; Joshi and Edington, 1990).

Marketing information: The woody rhizome of the species is traded with the name "*Padamchal*". The current market value of the species in Kathmandu is NRs. 45 per kg.

Conservation status: Included in Vulnerability (V) category of CAMP.

Voucher specimens: Cholangpati, 3600m, 7th Jun 2005, N. Shrestha & D. Prasai 115 (TUCH); Thade, 3050m, 23rd Aug 1969, *Kanai & Malla* 16137 (KATH); Hilay Dhap-Mane, 3400m, 24th Aug 1969, *Kanai & Malla* 674748 (KATH).

9) *Swertia angustifolia* Buch.-Ham ex D. Don

Family: Gentianaceae

Vernacular name: Bhale Chirayito (Nepali)

Description: Annual herbs, 20-40 cm high, occurring in tropical and subtropical zones, with lanceolate to linear, rarely elliptic leaves, and white or bluish white flowers in panicles made up of cymes.

Distribution: WCE (600-2600m); Himalaya (Kashmir to Bhutan), N. India, Myanmar, S. China

Local distribution: Singompa (3500m), Cholangpati (3600m), Laurivinayak (3900m).

Habitat: Open rocky slopes, forest floor.

Flowering: Jul-Sep

Indigenous uses: Plant is used in fever (*Jworo*) as an antipyretic.

Other Uses: Plant is used for stomach disorder. Decoction of aerial parts is taken by the Sherpas of Helambu as an antipyretic and to treat body ache (Manandhar, 1986; Bhattarai, 1989; Rajbhandari, 2001).

Marketing information: The species is mixed with *Swertia chirayita* and is traded with the name "*Chirayito*". The current market value of the species in Kathmandu is NRs. 250 per kg.

Conservation status: Included in Endangered (EN) category of CAMP.

Voucher specimens: Cholangpati, 3600m, 31st Aug 2006, *N. Shrestha & D. Prasai* 215 (TUCH); Cholangpati, 3600m, 30th Aug 2006, N. Shrestha, D. Prasai & B. Karki 195 (TUCH); Shyapru-Sherpagaon, 1520m, 13th Sep 1965, *Shrestha & Shakya* 3818 (KATH); Beyond Dhunche, 1500m, 17th Sep 1966, *Nicholson* 2503 (KATH); Syaprubensi, 1450m 5th Sep 1971, *Dobremez* 961 (KATH).

10) *Valeriana jatamansii* Jones

Synonym: *Valeriana wallichii* DC.

Family: Valerianaceae

English name: Indian Valerian

Vernacular name: Sugandhawal (Nepali), Pe (Tamang)

Description: Perennial herbs, with thick horizontal rootstock and several erect stems 15-45 cm. Basal leaves ovate to heart-shaped, acute, toothed or wavy-margined, long stalked; stem leaves few, small, entire or pinnate-lobed. Flowers white or pink-tinged, to c. 5mm across, in clusters borne on nearly leafless stems. Corolla funnel-shaped, with 5 blunt spreading lobes.

Distribution: WCE (1500-3300m); Afganistan, Himalaya (Kashmir to Bhutan), NE India, Myanmar, W. and C. China

Local distribution: Brabal (2100m), Thulo Syabru (2200m)

Habitat: Marshy forest floor.

Flowering: Feb-Aug

Indigenous uses: Root is used as incense (*Dhoop*). Rhizome is used to treat rheumatism (*Baath*).

Other uses: Root past is applied to treat headache and eye problems in Jumla district. Oil of rhizome is used for rheumatism and dislocation of joints at Chaubas and Syabru villages. Plant paste is applied on boils. Root paste is applied to treat gout (Manandhar, 1986; Joshi and Edington, 1990; Rajbhandari, 2001).

Marketing information: The root of the species is traded with the name "*Sugandhawal*". The current market value of the species in Kathmandu is NRs. 110 per kg.

Conservation status: Included in Vulnerable (V) category of CAMP.

Voucher specimen: Langtang, 1500m, 26th Jun 1970, *Kanai & Shakya* 672036 (KATH).

5. DISCUSSION

5.1 Status of medicinal plants in LNP

The resource base of the Langtang National Park is very rich and a large number of plants have been reported to have medicinal value (Manandhar, 1980a; Bhandary and Shrestha, 1982; Joshi and Edington, 1990; Yonzon, 1993; Dangol, 2002). These species are widely used by ethnic Tamang communities for the treatment of various medical ailments (Shrestha and Shrestha, 2000; Shrestha *et al.*, 2002). The species ranges from commercially utilized to threatened, and species of high ethnomedicinal value. The medicinal plants reported from the area vary from 43 (Manandhar, 1980a) to 95 (Shrestha *et al.*, 2002). The present study has identified 44 species of medicinal plants that are highly utilized by local people and in high trade demand in the area. Of these species, medicinal value of 10 species of flowering plants has been newly reported from the area. However, their medicinal properties were reported from other parts of the country. One of the threatened species, *Jurinea dolomiaea* is used in Jumla to "ward off evil spirits" (Manandhar, 1986). In Dolpa, the root juice is used in diarrhoea and dysentery as well as in stomach pain (Kunwar and Adhikari, 2005). Root juice of the plant is used in diarrhoea in LNP. *Aconitum spicatum*, a poisonous plant which is used as an arrow poison in Jumla district (Manandhar, 1986; Rajbhandari, 2001), is used in fever and headache in LNP. Leaf paste is applied in forehead to reduce temperature of the body. The medicinal properties of these plants were not reported from previous studies in LNP. Other species of newly reported medicinal values are *Boschniakia himalaica* (Kangdol), *Fritillaria cirrhosa* (Kaakoli), *Lonicera myrtillus* (Taktak), etc.

5.2 Trade of MAPs

The trade of medicinal plant is highly prevalent in the area. The major traded species include *Neopicrorhiza scrophulaiiflora, Swertia chirayita, Cordyceps sinensis, Nardostachys grandiflora* and *Valeriana jatamansii*. DFO records show an average collection of 1000 kg of *Swertia* from Rasuwa annually. The collection of *Nardostachys grandiflora* (Jatamansi) from the district amounts to about 500 kg per year. The collection data for *N. grandiflora* is very poor. This is because the resource is very scanty and it is distributed at specific sites only. In addition, *Nardostachys grandiflora* is very vulnerable to harvesting (Ghimire *et al.*, 2005). Unsustainable harvesting and high collection pressure in the past has decreased the resources in the wild. *Nardostachys grandiflora* is

one of the two most important species traded from Nepal (Olsen, 1999, 2005c; Olsen and Larsen, 2003). Nepal's annual export to India of dried unprocessed rhizomes of *Nardostachys grandiflora* involves approximately 1000 tons per year (Olsen, 2005a). The trade of these species has contributed a lot to the harvesters' livelihood in the area. The records show very poor revenue collection from MAPs during 2002-2005 from Rasuwa. The average revenue collected from *N. grandiflora*, *Rheum emodi* and *Valeriana jatamansii* is very low. Most of the species are illegally shipped and very less revenue is collected from the legal trade. The records of DFO show no trade data for *Neopicrorhiza scrophulariiflora* and *Cordyceps sinensis*. This does not imply that trade of these species do not occur. These are the most commercially threatened species and a large volume is exported annually from the region. These species are illegally traded. The herders and traders from the adjoining districts invade the park during post monsoon seasons and harvest medicinal plants from the area. They are either brought to Kathmandu through Sindhupalchowk or traded to Tibet via Rasuwagarhi. Previous studies in Manang (Shrestha *et al.*, 1995; Gahire, 2003) shows that, only 9.5 % of total amount of kutki is legally traded and the remaining 90.5 % is shipped illegally from the district. Chhetri (1999) assessed the diversity of medicinal and aromatic plants (MAPs) in the lower valleys of Manang District and found that large quantities of MAPs are illegally traded from the area. The same trend is prevalent in Langtang National Park, with large amount of medicinal plants being traded illegally. Three major trade routes have been identified in the study. The first route encompasses Kyanjin through Lamahotel, Sherpagaon, Rasuwagarhi to Tibet. The second route follows the park headquarter, Dhunche to Kathmandu and the third route includes south of Gosainkunda to Sindhupalchowk. Legal as well as illegal trade of medicinal plants occurs through these routes. Lack of proper monitoring has fostered illegal and unsustainable harvesting of high-altitude medicinal plants in the area.

5.3 Threatened MAPs

Langtang National Park provides a unique habitat for a number of commercially important and highly valuable medicinal plants. Of the 51 species of medicinal and aromatic plants prioritized by CAMP workshop (Tandon *et al.*, 2001), 20 species have been reported from the area. The area harbors 8 species of medicinal plants that has been prioritized by DPR for agro-technology development (Sharma *et al.*, 2005). High valued medicinal and aromatic plants like *Dactylorhiza hatagirea, Neopicrorhiza*

scrophulariiflora, Nardostachys grandiflora, Valeriana jatamansii, Rheum australe, Podophyllum hexandrum, Cordyceps sinensis, Swertia chirayita, Aconitum spicatum, Jurinea dolomiaea, etc. are found in the park. Four species of MAPs (*Dioscorea deltoidea, Nardostachys grandiflora, Podophyllum hexandrum* and *Taxus wallichiana*) are under CITES Appendix II. Of the 12 species of MAPs prioritized by DPR for agro-technology, 8 species are found in the area. Eighteen species of HNCC prioritized MAPs out of 30 species occur in the region. About 17 species of flowering plants are endemic to the region (Shrestha and Joshi, 1996). Langtang National Park has been identified as an important plant area in the Himalaya (Shrestha and Joshi, 1996; Gurung *et al.*, 2006). Two major areas inside the park have been identified as the potential sites for high valued medicinal plants and threatened/endemic species. It includes Langtang valley in the north-east and Cholangpati-Gosainkunda sector in the south-west. The altitudinal elevation of these areas ranges between 3000 and 4500 m. These areas are inhabited by many threatened species. Diverse elevation gradient of the area may be the reason of its rich biodiversity and endemism. Some of the species have high habitat specificity. These species are susceptible to high threat risk due to habitat destruction. Similarly fragile topography of the area, high utilization of species for local use and high trade demand has put the resources in dwindling condition. On the other hand, unsustainably harvesting has imposed serious threats to most of the medicinal plants in the area.

5.4 Cultivation practices

Cultivation and domestication of the threatened species has been identified as the most effective solution for conservation of these species (Farooquee and Saxena, 1996; Shrestha *et al.*, 2003; Sharma *et al.*, 2005). Cultivation is the only viable option for the resource and for the income of the traditional people who depend on it. Few species of medicinal plants have entered cultivation practices inside the park. The cultivated species include *Swertia chirayita, Paris polyphylla, Rheum australe* and *Valeriana jatamansii.* The cultivation is, however, limited to only few households due to lack of proper economic incentives and infrastructure. The cultivation of *Swertia chirayita* has largely prevented wild harvest of the species in the area. These practices should be expanded to other species as well to lower their depletion rate in the nature. The growers have to face lots of challenges selling their products. They have to incur heavy costs to transport their products to the market. In addition, they don’t get enough value for their products. This

has strongly discouraged farmers to pursuit this occupation. Hence, very few households are involved in medicinal plants cultivation in the area.

5.5 Harvesting seasons

The peak harvesting season for most medicinal plants is generally after the monsoon is over which normally occurs in September-October. The harvesting practice is traditional. Unsustainable harvesting practice is most prevalent in the area. This has seriously degraded the resources. Most of the species are harvested before their flowering and fruiting is over, which provides no chance for their regeneration. Similarly some of the species that propagate through their underground parts such as *Nardostachys grandiflora* and *Neopicrorhiza scrophulariiflora* are uprooted from the ground and no part is left for further regeneration. *Nardostachys grandiflora* is more vulnerable to harvesting than *Neopicrorhiza scrophulariiflora* (Ghimire *et al.*, 2005). The present harvesting practices has seriously affected the population of the species in the area. These species are in a state of serious threat due to such practices. Harvesting 100% of the *Nardostachys grandiflora* in plots followed by replanting of upper part and 2 cm of the rhizome provides the fastest regeneration and rhizome biomass growth (Larsen, 2006). However, no such practices are followed in the area. The harvesting is practiced on ad hoc basis and hence the resources are depleting day by day.

5.6 Ecological status

The ecological study of the selected species has revealed that the population density of most of the threatened species is very poor. The species like *Rheum australe*, which is largely utilized by the locals for preparing pickles, has seriously degraded. The density of the species was found to be 1.13 plants per m^2. The value is slightly lower than that the report of Kurumbang (2003) in Dolpa (2.16 plants per m^2). The species is highly utilized by the local people. Sometimes these are collected extensively without leaving any parts for regeneration. Hence, the population of the species is very poor. *Dactylorhiza hatagirea* is the most threatened species and needs serious conservation measures. The species was recorded only from Laurivinayak sector and the population was very poor. *Jurinea dolomiaea* grows in highly specific habitat (Ghimire and Aumeeruddy-Thomas, 2005). It is found in exposed rocky alpine slopes. Inside the park, it was found in Saraswati Kunda region associated with *Juniperus indica, Potentilla peduncularis* and *Berberis aristata*. The species has not been reported in Langtang National Park

previously. The species is localized in few areas only. The density of the species was found to be 1.15 plants per m^2 and frequency 40 %. The result is comparable to Kurumbang (2003). He obtained similar result in Shey Phoksundo National Park. The topography of the area is comparable to Langtang National Park. The density of the species was reported to be 2.31 plants per m^2 and frequency 70%. High habitat specificity of the species has made it very vulnerable in the area. *Neopicrorhiza scrophulariiflora*, one of the most traded species is abundantly found in areas around Gosainkunda. The density of the species was found to be 17.50 plants per m^2. The value is far more than reported by Gahire (2003) in Manang (4.57 plants per m^2). The climatic conditions, soil type and pH are highly favourable for the growth of *Neopicrorhiza scrophulariiflora* in Gosainkunda region. In addition, the place is not easily accessible. Hence the area has fairly large quantity of the resource. The species is, however, in high trade demand and it is the most preferred species for the treatment of fever in the area. The species are largely collected by the locals for primary health care. In addition, the harvesting method is traditional. Hence, high trade demand and present practices can seriously affect the density and population of the species in the near future.

5.7 Rapid Vulnerability Assessment

Short term assessment like Rapid Vulnerability Assessment, in addition to cultivation practices and system regularization, has been felt necessary for management and sustainable utilization of medicinal plants in Nepal (Lama *et al.*, 2001; Sharma *et al.*, 2005). In the present study, *Neopicrorhiza scrophulariiflora* scored the highest threat value, denoting highest vulnerability. The species belonged to threat category I. Six species were categorized under category II and 3 under category III based on RVA score. IUCN and CAMP have placed the species *N. scrophulariiflora* in vulnerable category and Government of Nepal in threat category I. The present finding adheres to the categorization by IUCN, CAMP and Government of Nepal (Sharma and Das, 2005; Sharma *et al.*, 2005). Likewise, the placement of *Dactylorhiza hatagirea, Swertia angustifolia, Aconitum spicatum, Nardostachys grandiflora*, *Jurinea dolomiaea* and *Meconopsis dhwojii* in threat category II is in accordance with the threat category assigned by CAMP and IUCN (Tandon *et al.*, 2001). The vulnerability assessment carried out by Ghimire and Aumeeruddy-Thomas (2005) in Shey Phoksundo National Park identified 20 species of MAPs as potentially vulnerable. Among these, six species

(*Nardostachys grandiflora, Dactylorhiza hatagirea, Neopicrorhiza scrophulariiflora, Delphinium* sp. and *Valeriana jatamansii*) fall under the high vulnerability category with threat scores equal or greater than 25. Nine species were found with score between 21 and 24, and 5 species with vulnerability score of 20. These species are vulnerable in Langtang National Park, as well and in all parts of the Himalaya (Mulliken, 2000; Lama *et al.*, 2001; Olsen, 2005c). The high utilization of parts, habitat specificity, life forms, high trade demand, excessive local utilization and unsustainable harvesting have made the species vulnerable in the area.

Some of the criteria of this assessment like habitat and local population size needs intensive study. The present study has been carried out in a short period (Jun-Sep 2006). So, it was not possible to cover entire area of the park. Hence the present finding is not comparable with that of Ghimire and Aumeeruddy-Thomas (2005) which was a long-term project in Dolpa. However, efforts have been made to collect enough information for assessing habitat and local population size. To sum up, the work cannot be generalized for the entire area of the park.

6. CONCLUSION

Langtang National Park represents one of the important cultural heritage site as well as a hotspot area in Central Nepal that harbors a wide variety of high valued medicinal plants, threatened and endemic species. The ethnic Tamang communities residing in the park have greater dependency upon the park resources for subsistence and livelihood. The utilization of medicinal plants in the local level is very high. A large number of plants are used for local health care for the treatment of various medical ailments. In addition, the species are in high trade demand. Illegal trade has fostered well in the park. *Neopicrorhiza scrophulariiflora* and *Cordyceps sinensis* are the two major medicinal plants that are highly traded from the area. Few species like *Meconopsis dhwojii* and *Heracleum lalli* are endemic to the region and do not occur beyond certain geographical boundary. The species are localized to few fragile habitats within the park. These species are gradually depleting due to habitat loss and competition by other invasive alien species. Traditional harvesting methods have further increased the vulnerability of the species. The species are collected without leaving any parts for regeneration. The Holy Gosainkunda Lake in the park is a famous pilgrimage site for Hindus and Buddhists. Every year thousands of devotees visit the area to pay offerings. High inflow of visitors during the peak flowering season has tremendously affected the natural environment of the area.

Higher utilization, high trade demand, less availability of the resources, habitat degradation and unsustainable harvesting has remarkably reduced the population density of the species. Most of the species have already entered different threat categories and continuation of the casual factors can put them under high extinction risk.

The management of park resources requires a lot of coordinated efforts between park authorities and local communities. The Kangchenjunga Conservation Area Project (KCAP), Annapurna Conservation Area Project (ACAP) provides some of the best example of participatory approach to management of natural resources (Parajuli, 2006). This work also contributes to an improvement of local livelihoods through integrated conservation and development. The Sacred Himalayan Landscape initiative of WWF is a vision for a transboundary landscape which encompasses Langtang National Park in Central Nepal. The initiative is an appreciative endeavor to conservation in the Himalayas.

7. RECOMMENDATIONS

Based on the present study following recommendations have been made for sustainable management of threatened species in the area.

- The present cultivation practice of medicinal plants is limited to few species only. The cultivation is in a very preliminary phase too. Training campaigns should be launched in the area to motivate people towards cultivation of threatened MAPs.
- The biology (pollination, fruit set) of the species has not been studied in detail. Researches should be focused on understanding the biology of the species so that proper measures could be taken to maintain their population in the area. Research should also be carried out to study the effect of invasive alien species on the growth of rare and endemic species.
- Participatory inventory and regular monitoring of plant resources should be done with the help of National Park authorities, researchers and local communities.
- Demand driven action plan should be prepared on resource utilization and medicinal plant conservation with the active participation of local communities. Government and National Park authorities should take initiatives in this regard.
- The resources should be handed over to local communities for conservation and sustainable utilization. This will not only prevent illegal harvesting by the invaders but also contribute to the upliftment of local economy.

8. REFERENCES

Banerjee, M.L. 1955. Some edible and medicinal plants from east Nepal. *J. Bomb. Nat. Hist. Soc.* **53:**153-155.

Baral, S.R. and Kurmi, P.P. 2006. *A Compendium of Medicinal Plants in Nepal*. Publisher: Rachana Sharma, Maijubahal, Kathmandu, Nepal.

Basnet, B.K. 1998. *Medicinal Plants in Sindhuli District: Utilization, Trade and Management Practices*. M. Sc. Dissertation, Central Department of Botany, Tribhuvan University, Kirtipur, Kathmandu, Nepal.

Bhandary, H.R. and Shrestha, P. 1982. Ethnobotanical approach on the poisonous plants of Annapurna and Langtang Himal area. *J. Nat. Hist. Museum.* **6**(1):125-135.

Bhattarai, D.R and Maharjan, P. 2001. Promotion of medicinal and aromatic plants by small farmers through training and capacity building: experience of HPPCL, Nepal. In: Bhattarai, N. and Karki, M. (eds.) *Sharing Local and National Experience in Conservation of Medicinal and Aromatic Plants in South Asia.* Proceedings of the Regional Workshop held at Pokhara, Nepal, 21-23 January 2001. MAPPA/IDRC, New Delhi, MOFSC, Kathmandu and IOF, Pokhara. pp. 185-187.

Bhattarai, K.R. and Ghimire, M. 2006. Commercially important medicinal and aromatic plants of Nepal and their distribution pattern and conservation measure along the elevation gradient of the Himalayas. *Ban ko Jankari.* **16** (1):3-13.

Bhattarai, N.K., Tandon, V. and Ved, D.K. 2002. Highlights and outcomes of the Conservation Assessment and Management Planning (CAMP) Workshop, Pokhara, Nepal. In: Bhattarai, K. and Karki, M. (eds.) *Sharing local and national experience in Conservation of Medicinal and Aromatic Plants in South Asia.* Proceedings of the Regional Workshop held at Pokhara, Nepal, 21-23 January 2001. MAPPA/IDRC, New Delhi, MOFSC, Kathmandu and IOF, Pokhara. pp. 46-53.

Bhattarai, N.K. 1989. Traditional phytotherapy among the Sherpas of Helambu, Central Nepal. *J. Ethnopharmacol***. 27**(1):45-54.

Bhattarai, N.K. 1990. Herbal folk medicines of Kavrepalanchowk district, Central Nepal. *Int. J. Cru. Drug Res.* **28**(3):225-231.

Bhattarai, N.K. 1992. Medical ethnobotany in the Karnali zone, Nepal. *Eco. Bot.* **46**(3): 257-261.

Bohara, G.B. 1998. *A Study on Traditional Medicinal Plants and its Knowledge Among People of Baglung District*. M. Ed. Thesis, Faculty of Education, Tribhuvan University, Kirtipur, Kathmandu, Nepal.

Cameron, M.M. 1996. Biodiversity and medicinal plants in Nepal: Involving untouchables in conservation and development. *Human Organization.* **55**(1):84-92.

Chaudhary, R.P. 1998. *Biodiversity in Nepal (Status and Conservation)*. S.Devi, Saharanpur, India and Tecpress Books, Bangkok, Thailand.

Chhetri, D.B. 1999. *Diversity of Medicinal and Aromatic Plants in Manang, Central Nepal with Emphasis on Ecology and Essential Oil Variation of Jatamansi* (*Nardostachys grandiflora* DC.). M. Sc. Thesis, Central Department of Botany, Tribhuvan University, Kirtipur, Kathmandu, Nepal.

Cunningham, A.B. 1996. *People, Park and Plant use: Recommendations for Multiple-use Zones and Development Alternatives Around Bwindi Impenetrable National Park, Uganda.* People and Plants working paper 4. UNESCO, Paris.

Dangol, B.R. 2002. *Forest Community Diversity and Associated Medicinal Plants in the Langtang National Park, Rasuwa*. M. Sc. Thesis, Central Department of Botany, Tribhuvan University, Kirtipur, Kathmandu, Nepal.

Das, P.K. 2005. *Status of Non-Timber Forest Products and Policy Initiatives in Nepal*. Synthesis of seminar on Herbs, Herbal products and Spices: 12-13 Nov, 2005, Nepalgunj. CECI, Kathmandu.

Daubeumire, R. 1968. *Plant Communities – A Text Book of Plant Synecology*. Harper and Row, New York.

Edwards, D.M. 1996. *Non-Timber Forest Products from Nepal: Aspects of the Trade in Medicinal and Aromatic Plants*. FORESC Monograph 1/96. Forest Research and Survey Center, Babarmahal, Kathmandu, Nepal.

Fansworth, N.R. and Soejarto, D.D. 1991. Global importance of medicinal plants. In: Akerele, O., Heywood, V. and Synge, H. (eds.) *The Conservation of Medicinal Plants*. Cambridge University Press, Cambridge, UK. pp. 25-51.

Farooquee, N.A. and Saxena, K.G. 1996. Conservation and utilization of medicinal plants in high hills of the Central Himalayas. *Environmental Conservation.* **23**(1):75-80.

Gahire, S. 2003. *Ecology, Distribution and Trade of Kutki (Neopicrorhiza scrophulariiflora (Pennell) Hong.) in Manang District, Nepal*. M.Sc. Thesis, Central Department of Botany, Tribhuvan University, Kirtipur, Kathmandu, Nepal.

Ghimire, S.K., Lama, Y.C., Tripathi, G.R., Schmitt, S. and Aumeeruddy-Thomas, Y. 2001. *Conservation of Plant Resources, Community Development and Training in Applied Ethnobotany at Shey Phoksundo National Park and its Buffer zone, Dolpa.* Fourth Year. Report Series No. 41. WWF Nepal Program, Kathmandu, Nepal.

Ghimire, S.K., McKey, D. and Ameeruddy-Thomas, Y. 2005. Conservation of Himalayan medicinal plants: Harvesting patterns and ecology of two threatened species, *Nardostachys grandiflora* DC. and *Neopicrorhiza scrophulariiflora* (Pennell) Hong. *Biological Conservation.* **124**:463-475.

Ghimire, S.K. and Ameeruddy-Thomas, Y. 2005. Approach to in-situ conservation of threatened Himalayan medicinal plants: A case study from Shey Phoksundo National Park, Dolpa. In: Aumeeruddy-Thomas, Y., Karki, M., Parajuli, D. and Gurung, K. (eds.) *Himalayan Medicinal and Aromatic Plants, Balancing Use and Conservation.* WWF-UNESCO, People and Plant Initiative/ WWF Nepal/ IDRC, Kathmandu, Nepal. pp. 209-234.

Grierson, A.J.C and Long, D.G., 1984-1999. *Flora of Bhutan*. Royal Botanic Garden, Edinburgh.

Gurung, C.P., Maskey, T.M., Poudel, N., Lama, Y., Wagley, M.P., Manandhar, A., Khaling, S., Thapa, G., Thapa, S. and Wikramanayake, E.D. 2006. The Sacred Himalayan Landscape: Conceptualizing, visioning and planning for conservation of biodiversity cultures and livelihoods in the eastern Himalayas. In: McNeely, J.A., McCarthy, T.M., Smith, A., Olsvig-Whittaker, L. and Wikramanayake, E.D. (eds.) *Conservation Biology in Asia*. Society for Conservation Biology Asia Section and Resources Himalaya Foundation, Kathmandu, Nepal. pp. 10-20.

HMG Nepal. 1970. *Medicinal Plants of Nepal*. Bulletin Dept. of Medicinal Plants No. 3. Department of Medicinal Plants, Thapathali, Kathmandu, Nepal.

HMG Nepal. 1984. *Medicinal Plants of Nepal*. Bulletin Dept. of Medicinal Plants No. 10. Department of Medicinal Plants, Thapathali, Kathmandu, Nepal.

HMG Nepal. 2002. *Nepal Biodiversity Strategy*. Ministry of Forests and Soil Conservation, Singha Durbar, Kathmandu.

IDRC/MAPPA/CCO. 2004. *Ouantitative Resource Assessment, Conservation and Sustainable Management of important MAPs/NTFPs*. Workshop on Local Experience-based National Strategy for Organic Production and Management of MAPs and NTFPs in Nepal. IDRC, MAPPA and CCO.

IUCN Nepal. 2000. *National Register of Medicinal Plants*. IUCN-the World Conservation Union, Kathmandu, Nepal.

IUCN Nepal. 2004. *National Register of Medicinal Plants (Revised and Updated)*. IUCN-The World Conservation Union, Kathmandu, Nepal.

Jacob, I. and Jacob, W. 1993. *The Healing Past: Pharmaceuticals in the Biblical and Rabbinic World*. E.J. Brill, Leiden.

Jain, S.K. 1987. Endangered species of medicinal herbs in India. *Medicinal Herbs in Indian Life*. **16**(1):44-53.

Joshi, A.R. and Edington, J.M. 1990. The use of medicinal plants by two village communities in Central Development Region of Nepal. *Economic Botany.* **44**(1):71-83.

Kala, C.P. 2000. Status and conservation of rare and endangered medicinal plants in the Indian trans-Himalaya. *Biological Conservation.* **93**:371-379.

Kanai, H. 1971. 'Bir Nighantu', A Nepalese Herbal Encyclopaedia. *J. Jap.* **46:**347-377.

Kunwar, R.M and Adhikari, N. 2005. Ethnomedicine of Dolpa district, Nepal: the plants, their vernacular names and uses. *Lyonia.* **8**(1):43-49. URL: http:// www.lyonia.org/ downloadPDF.php?pdfID=110.367.1.

Kurumbang, N. P. 2003. *Ecological study, Harvesting and Trade of some Medicinal Plants in Shey Phoksundo National Park and its Buffer zone, Dolpa, Nepal*. M.Sc. Thesis, Central Department of Botany, Tribhuvan University, Kirtipur, Kathmandu, Nepal.

Lama, Y.C., S.K. Ghimire and Y. Aumeeruddy-Thomas. 2001. *Medicinal Plants of Dolpo: Amchi's Knowledge and Conservation*. People and Plants Initiative, WWF Nepal Program, Kathmandu, Nepal.

Larsen, H. O., Olsen, C. S. and Boon, T. E. The non-timber forest policy process in Nepal: actors, objectives and power. *Forest Policy and Economics*. **1**:267-281.

Larsen, H.O. 2005. Impact of replanting on regeneration of the medicinal plant *Nardostachys grandiflora* DC. (Valerianaceae). *Economic Botany.* **59**(3):213-220.

LNP. 2001. *Langtang National Park Buffer Zone Management Plan*. Department of National Parks and Wildlife Conservation, Babarmahal, Kathmandu.

Malla, S.B. and Shakya, P.R. 1984. Medicinal plants. In: Majupuria, T. C. (ed.) *Nepal Nature's Paradise*. White Lotus Co. Ltd. Bangkok, Thailand. pp. 261-297.

Malla, S.B., Shakya, P.R., Rajbhandari, K.R., Bhattarai, N.K. and Subedi, N.N. 1995. *Minor Forest Products of Nepal*: *General Status and Trade.* FRIS Project Paper 4. Forest Resource Informat. System Project, Kathmandu.

Malla, S.B., Shrestha, A.B., Rajbhandari, S.B., Shrestha, T.B., Adhikari, P.M. and Adhikari, S.R. 1976. *Flora of Langtang and Cross Section Vegetation Survey (Central Zone)*. Bull. Dept. Med. Plants Nepal No. 6. Department of Medicinal Plants, Thapathali, Kathmandu, Nepal.

Manandhar, N.P. 1980a. Some less known medicinal plants of Rasuwa district. *Quart. J. Crude Drugs.* **18**(3):147-151.

Manandhar, N.P. 1980b. *Medicinal Plants of Nepal Himalaya*. Ratna Pustak Bhandar, Bhotahiti, Kathmandu, Nepal.

Manandhar, N.P. 1986. Ethnobotany of Jumla district, Nepal. *Int. J. Crude. Drug Res.* **24**(2):81-89.

Manandhar, N.P. 1989a. Folklore medicine of Chitwan district, Nepal. *Ethnobotany.* **2**(1):31-38.

Manandhar, N.P. 1989b. Medico-botany of Gorkha district, Nepal – An elucidation of medicinal plants. *Int. J. Crude Drug Res.* **28**(1):17-25.

Manandhar, N.P. 1992. Folklore medicine of Dhading district, Nepal. *Fitoterapia.* **63**(2):163-177.

Manandhar, N.P. 1993. Ethnobotanical notes on folklore remedies of Baglung district, Nepal. *Contribution to Nepalese Studies.* **20**(2):183-196.

Manandhar, N.P. 1998. Ethnobotanical census on herbal medicine of Banke district, Nepal. *Contribution to Nepalese Studies.* **25**:57-63.

Manandhar, N.P. 2002. *Plants and People of Nepal*. Timber Press, Oregon, USA.

Mulliken, T.A. 2000. Implementing CITES for Himalayan medicinal plants *Nardostachys grandifora* and *Picrorhiza kurrooa*. *TRAFFIC Bulletin.* **18**:63-72.

Murty, T.K., 1993. *Minor Forest Products of India*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India.

Oli, B.R. and Nepal, B.K. 2003. *Non-timber Forest Products from the Kangchenjunga Conservation Area: Aspects of Trade and Market Opportunities.* A Report submitted to WWF Nepal Program.

Olsen, C.S. 1998. The Trade in medicinal and aromatic plants from Central Nepal to Northern India. *Economic Botany.* **52**:279–292.

Olsen, C.S. 1999. CITES Appendix II re-visited: Is the listing of *Nardostachys grandiflora* and *Picrorhiza kurrooa* appropriate? *Medicinal Plant Conservation.* **5**:8-10.

Olsen, C.S. 2005a. Quantification of the trade in medicinal and aromatic plants in and from Nepal. *Acta Horticulturae.* **678**:29-35.

Olsen, C. S. 2005b. Valuation of commercial Central Himalayan medicinal plants. *Ambio.* **34**:607-610.

Olsen, C.S. 2005c. Trade and conservation of Himalayan medicinal plants: *Nardostachys grandiflora* DC. and *Neopicrorhiza scrophulariiflora* (Pennell) Hong. *Biological Conservation.* **125**:505-514.

Olsen, C.S. and Helles, F. 1997. Medicinal plants, Markets and margins in the Nepal Himalaya: Trouble in paradise. *Mountain Research and Development.* **17**(4):363-374.

Olsen, C.S. and Larsen, H.O. 2003. Alpine medicinal plant trade and Himalayan mountain livelihood strategies. *The Geographical Journal***. 169**(3):243–254.

Parajuli, R.R. 2006. *Kangchejunga Conservation Area Project Details*. WWF Nepal Program, Kathmandu. URL: http://www.wwfnepal.org.

Paudel, N. 2005. Building capacity for effective protected area management in Nepal. In: Sharma, U.R. and Yonzon, P. (eds.) *People and Protected Areas of South Asia*. Resources Himalaya Foundation, Kathmandu and IUCN World Commission on Protected Areas, South Asia. pp. 46-49.

Polunin, O. and Stainton, A. 1987. *Flowers of the Himalaya*. Oxford University Press, New Delhi.

Press, J.R., Shrestha, K.K. and Sutton, D.A. 2000. *Annotated Checklist of the Flowering Plants of Nepal*. The Natural History Museum, London.

Rajbhandari, K.R. 2001. *Ethnobotany of Nepal.* Ethnobotanical Society of Nepal (ESON), Kathmandu, Nepal.

Rawal, R.B. 2004. Marketing Nepal's non-timber forest products, challenges and opportunities. In: Bhattarai, N.K. and Karki, M. (eds.) *Local Experience Based National Strategy for Organic Production and Management of MAPs/NTFPs in Nepal*. Proceedings of the National Workshop held at Kathmandu, Nepal, 27-28 February 2004. HMG Nepal, MAPPA/IDRC, New Delhi and CCO, Kathmandu. pp. 150-164.

Rawat, R.B.S. and Karki, M. 2004. Strategies for working together Nepal-India collaboration for the development of medicinal plants sector. In: Bhattarai, N. and Karki, M. (eds.) *Local Experience based National Strategy for Organic Production and Management of MAPs/NTFPs in Nepal*. Proceedings of the National Workshop held at Kathmandu, Nepal, 27-28 February 2004. HMG Nepal, MAPPA/IDRC, New Delhi and CCO, Kathmandu. pp. 42-54.

Regmi, S., Bista, S. and Casey, M. 2000. Conservation and sustainable use of high value medicinal and aromatic plants in Jumla district of Nepal. In: Watanabe, T., Takano, A., Bista, M.S. and Sainju, H.K. (eds.) *The Himalayan Plants, Can they save us?* Proceedings of Nepal-Japan Joint Symposium on Conservation and Utilization of Himalayan Medicinal Resources, 6-11 November 2000, Kathmandu, Nepal. Department of Plant Resources, HMG Nepal and Society for the Conservation and Development of Himalayan Medicinal Resources (SCDHMR), Japan. pp. 305-312.

Rokaya, M.B. 2002. *Ethnoecology of Medicinal Plants in Dho-Tarap area in Buffer zone of Shey Phoksundo National Park, Dolpa, Nepal.* M.Sc. Thesis, Central Department of Botany, Tribhuvan University, Kathmandu, Nepal.

Sacherer, J. 1979. The high altitude ethnobotany of the Rolwaling Sherpas. *Contribution to Nepalese Studies.* **4**(2):45-64.

Schippmann, U., Leaman, D. and Cunningham, A.B. 2002. *Impact of Cultivation and Gathering of Medicinal Plants on Biodiversity: Global Trends and Issues*. Inter Department Working Group on Biology Diversity for Food and Agriculture, FAO, Rome, Italy.

Sharma, D.K. 2000. *Distribution of Medicinal Plants in Ilam District of Nepal*. In: Watanabe, T., Takano, A., Bista, M.S. and Sainju, H.K. (eds.) *The Himalayan Plants, Can they save us?* Proceedings of Nepal-Japan Joint Symposium on Conservation and Utilization of Himalayan Medicinal Resources, 6-11 November 2000, Kathmandu, Nepal. Department of Plant Resources, HMG Nepal and Society for the Conservation and Development of Himalayan Medicinal Resources (SCDHMR), Japan. pp. 192-197.

Sharma, U.R. and Das, P.K. 2004. Reviewing current issues and prospects of Non-Timber Forest Product (NTFPs) sub-sector development in Nepal. In: Bhattarai, N. and Karki, M. (eds.) *Local Experience Based National Strategy for Organic Production and Management of MAPs/NTFPs in Nepal*. Proceedings of the National Workshop held at Kathmandu, Nepal, 27-28 February 2004. HMG Nepal, MAPPA/IDRC, New Delhi and CCO, Kathmandu. pp. 87-96.

Sharma, U.R., Malla, K.J. and Uprety, R.K. 2005. Conservation and management efforts of medicinal and aromatic plants in Nepal. *Banko Jankari.* **14**(2):3-11.

Sherpa, S. 2002. Sustainable Utilization and Management of High-Altitude Medicinal and Aromatic Plant Resources in Kangchenjunga Conservation Area. A Report submitted to WWF Nepal Program.

Shengji, P. 2001. Ethnobotanical approaches to traditional medicine studies: some experiences from Asia. *Pharmaceutical Botany.* **39**:74-79.

Shiva, V. 1996. *Protecting our Biological and Intellectual Heritage in the Age of Biopiracy*. The Research Foundation for Science, Technology and Natural Resources Policy, New Delhi, India.

Shrestha, I. and Shrestha, K. 2000. Ethnomedico-botanical studies of Langtang National Park, Nepal. In: Watanabe, T., Takano, A., Bista, M.S. and Sainju, H.K. (eds.) *The Himalayan Plants, Can they save us?* Proceedings of Nepal-Japan Joint Symposium on Conservation and Utilization of Himalayan Medicinal Resources, 6-11 November 2000, Kathmandu, Nepal. Department of Plant Resources, HMG

Nepal and Society for the Conservation and Development of Himalayan Medicinal Resources (SCDHMR), Japan. pp. 178-180.

Shrestha, I., Inglis, A. and Shrestha, K. 2002. Documentation and mapping medicinal plants of Langtang National Park. *Proceedings of International Seminar on Mountains*, 6-8 March 2002, Kathmandu, Nepal. pp. 361-371.

Shrestha, K.K., Ghimire, S.K., Gurung, T.N., Lama, Y.C. and Aumeeruddy, Y. 1998. *Conservation of Plant Resources, Community Development and Training in Applied Ethnobotany at Shey-Phoksundo National Park and its Buffer zone, Dolpa*. WWF Nepal Program, Report Series No. 33. WWF Nepal Program, Kathmandu.

Shrestha, K.K., Sah, J.P. and Ghimire, S.K. 1995. *Ecology, Exploitation Trend and Conservation of Potential High altitude Medicinal Plants in Gyasumdo Valley, Manang*. Report submitted to King Mahendra Trust for Nature Conservation (KMTNC), Kathmandu, Nepal.

Shrestha, K.K., Tiwari, N.N. and Ghimire, S.K. 2000. MAPDON-Medicinal and aromatic plant database of Nepal. In: Watanabe, T., Takano, A., Bista, M.S. and Sainju, H.K. (eds.) *The Himalayan Plants, Can they save us?* Proceedings of Nepal-Japan Joint Symposium on Conservation and Utilization of Himalayan Medicinal Resources, 6-11 November 2000, Kathmandu, Nepal. Department of Plant Resources, HMG Nepal and Society for the Conservation and Development of Himalayan Medicinal Resources (SCDHMR), Japan. pp. 53-74.

Shrestha, K.K.**,** Tiwari, N.N., Rajbhandary, S., Shrestha, S., Yadav, U. and Poudel, R.C. 2003. *Non Timber Forest Products (NTFPs) in the Critical Bottleneck and Corridors of Terai Arc Landscape Nepal (TAL) - Nepal: Documentation, Utilization, Trade and People's Livelihood*. WWF Nepal Program, Kathmandu, Nepal.

Shrestha, P.M. and Dhillion, S.S. 2003. Medicinal plant diversity and use in the highlands of Dolakha district, Nepal. *J. Ethnopharmacology*. **86**:81-96.

Shrestha, T.B. and Joshi, R.M. 1996. *Rare, Endemic and Endangered Plants of Nepal*. WWF Nepal Program, Kathmandu, Nepal.

Shrestha, U.B. 2003. Cultivation of medicinal and aromatic plants (MAPs): Tools for biodiversity conservation. Annual issue of *Botanica Orientalis – Journal of Plant Sciences*. Central Department of Botany, Kirtipur, Kathmandu, Nepal.

Tandon. V., Bhattarai, N.K. and Karki, M. 2001. *Conservation Assessment and Management Plan Workshop Report: Selected Medicinal Plants species of Nepal.* Medicinal and Aromatic Plants Program in Asia (MAPPA), International Development Research Centre (IDRC) and Ministry of Forest and Soil Conservation, Kathmandu.

Tripathi, G.R. and Schmitt, S. 2001. Rapid Vulnerability Assessment of Medicinal Plants. In: Ghimire, S.K., Lama, Y.C., Tripathi, G.R., Schmitt, S. and Aumeeruddy-Thomas, Y. (eds.) *Conservation of Plant Resources, Community Development and Training in Applied Ethnobotany at Shey Phoksundo National Park and its Buffer zone, Dolpa.* Fourth Year. Report Series No. 41. WWF Nepal Program, Kathmandu, Nepal.

Ved, D.K. and Tandon, V. 1998. *Conservation Assessment and Management Plan Workshop for High Altitude Medicinal Plants of Jammu-Kashmir and Himachal Pradesh, Kullu, Himachal Pradesh, 16-18 April, 1998.* FRLHT, Medicinal Plants Specialists Group, SSC-IUCN.

Watanabe, T., Rajbhandari, K.R., Malla, K.J. and Yahara, S. 2005. *A Handbook of Medicinal Plants of Nepal.* AYUR SEED, Life Environment Institute, Kamagawa, Japan.

Yonzon, P. 1993. Jaributi Exploitation from Langtang National Park. In: Edwards, D.M. and Bower, M.R. (eds.) *Focus on Jaributi*. FRSC Occasional Paper 2/93. Forest Research and Survey Center, Kathmandu, Nepal.

Xiao Pei-Gen and Peng Yong. 1998. Plants for Food and Medicine. In: Prendergast, H. D. V., Etkin, N. L., Harris, D. R. and Houghton, P.J. (eds.) *Proceedings of the Joint Conference of the Society for Economic Botany and the International Society for Ethnopharmacology*, London, 1-6 July, 1996. Royal Botanic Gardens, Kew, UK.

Zobel, D.B., Behen, M.J., Jha, P.K. and Yadav, U.K.R. 1987. *A Practical Manual for Ecology*. Ratna Book Distributors, Kathmandu, Nepal.

Appendix-1
Highly utilized medicinal plants of LNP

S.N.	Species	Local Name	Family
1.	*Aconitum spicatum* (Bruhl) Stapf	Bish	Ranunculaceae
2.	*Acorus calamus* L.	Bojho	Araceae
3.	*Artemisia vulgaris* L.	Chuwenti	Compositae
4.	*Asparagus racemosus* Willd.	Satawari	Liliaceae
5.	*Astilbe rivularis* Buch.-Ham ex D. Don	Thulo ausadhi	Saxifragaceae
6.	*Berberis asiatica* Roxb. ex DC.	Pichyar	Berberidaceae
7.	*Bergenia ciliata* (Haw.) Sternb	Bramendo	Saxifragaceae
8.	*Betula alnoides* Buch.-Ham ex D.Don	Takpa	Betulaceae
9.	*Boschniakia himalaica* Hook. & Thomson ex Hook. f.	Kangdol	Orobanchaceae
10.	*Cordyceps sinensis* (Berk) Sacc.	Yarshagomba	Hypocreaceae
11.	*Dactylorhiza hatagirea* (D.Don) Soo	Ompolakpa	Orchidaceae
12.	*Delphinium royle*	Bhongmar	Ranunculaceae
13.	*Ephedra gerardiana* Wall. ex Stapf	Somlata	Ephedraceae
14.	*Eupatorium adenophorum* Spreng.	Banmara	Compositae
15.	*Fragaria nubicola* Lindl. ex Lacaita	Palpapolang	Rosaceae
16.	*Fritillaria cirrhosa* D.Don	Kaakoli	Liliaceae
17.	*Hippophae salicifolia* D.Don	Govo, Taru	Elaegnaceae
18.	*Hippophae tibetana* Schlecht.	Taru	Elaegnaceae
19.	*Juniperus recurva* Buch.-Ham ex D. Don	Sukpa	Cupressaceae
20.	*Jurinea dolomiaea* Boiss.	-	Compositae
21.	*Lonicera myrtillus* Hook. f. & Thomson	Taktak	Caprifoliaceae
22.	*Lyonia ovalifolia* (Wall.) Drude	Tomasing	Ericaceae
23.	*Mahonia napaulensis* DC.	Kyarpa	Berberidaceae
24.	*Meconopsis dhwojii* G.Taylor ex Hay	-	Papaveraceae
25.	*Myrica esculenta* Buch.-Ham ex D. Don	Namin	Myricaceae
26.	*Nardostachys grandiflora* DC.	Jatamansi	Valerianaceae
27.	*Neopicrorhiza scrophulariiflora* (Pennell) Hong	Kutki	Scrophulariaceae
28.	*Paris polyhylla* J.E. Sm	Satuwa	Liliaceae
29.	*Pieris formosa* (Wall.) D.Don	Pra pra	Ericaceae
30.	*Potentilla peduncularis* D.Don	Pangthar	Rosaceae
31.	*Rheum australe* D.Don	Chhurcha	Polygonaceae
32.	*Rheum nobile* Hook.f. & Thoms.	Chhurcha	Polygonaceae
33.	*Rhododendron anthopogon* D.Don	Sunpati	Ericaceae
34.	*Rhododendron arboreum* J.E. Smith	Paramendo	Ericaceae
35.	*Rubia manjith* Roxb. ex Fleming	Tiru	Rubiaceae
36.	*Rumex nepalensis* Spreng	Alpibi	Polygonaceae
37.	*Saussurea gossypiphora* D.Don	Bhutkesh	Compositae
38.	*Swertia angustifolia* Buch.-Ham ex D. Don	Bhale Chiraito	Gentianaceae
39.	*Swertia chirayita* (Roxb. ex Fleming)	Timda	Gentianaceae
40.	*Swertia multicaulis* D.Don	Sharmaguru	Gentianaceae
41.	*Taxus wallichiana* Zucc.	Silding	Taxaceae
42.	*Thallictrum foliolosum* DC.	Bathuri	Ranunculaceae
43.	*Valeriana jatamansii* Jones	Sugandhwal, Pe	Valerianaceae
44.	*Zanthoxylum armatum* DC.	Timur	Rutaceae

Appendix-2

Endemic plants of LNP

SN	Scientific name	Family	Altitude(m)	Localities of Occurrence
1.	*Begonia flagellaris* H.Hara	Begoniaceae	2000-2900	Lingu, Tiblung
2.	*Carum carvi* L.	Umbelliferae	2500-5100	Langtang Valley
3.	*Cremanthodium nepalense* Kitam.	Compositae	2800-4000	Helambu
4.	*Delphinium walliamsii* Munz	Ranunculaceae	1500-2600	Before Langtang
5.	*Elaeagnus tricholepis* Momiy.	Elaegnaceae	1600-2500	Chilime, Langtang Valley
6.	*Heracleum lallii* C. Norman	Umbelliferae	3000-4400	Lauribinayak
7.	*Homalium napaulense* (DC.) Benth.	Flacourtiaceae	700-4500	Syaphru, Dhunche, Gosaikunda
8.	*Impatiens scullyi* Hook. f.	Balsaminaceae	1800-2630	Lingui, Tibling
9.	*Meconopsis dhwojii* G. Taylor ex Hay	Papaveraceae	3600-4570	Laurivinayak, Langtang
10.	*Meconopsis regia* G.Taylor	Papaveraceae	2700-4600	Sindhupalchowk
11.	*Meconopsis taylorii* L. H. J. Williams	Papaveraceae	3600-4570	Gosaikunda, Langtang
12.	*Micromeria nepalensis* Kitam. & Murata	Labiatae	1900-3600	Cheme, Rasuwa
13.	*Primula aureata* Fletcher	Primulaceae	c.4500	Gosaikunda
14.	*Primula sharmae* Fletcher	Primulaceae	2500-5300	Chandanbari
15.	*Rhododendron cowanianum* Davidian	Ericaceae	3000-3900	Langtang
16.	*Wendlandia appendiculata* Wall. ex Cowan	Rubiaceae	1000-1800	Dhunche, Syaphrubensi
17.	*Zanthoxyum nepalense* Babu	Rutaceae	2000-2850	Dhunche-Chandanbari

Source: Shrestha and Joshi (1996); DNPWC, Babarmahal, 2006.

Appendix-3

Rapid Vulnerability Assessment

S.N.	Species	Parts used	Life form	Habitat	Distr.	Local Pop	Trade	Threat	User Group	Total Score	Threat Category
1)	*Aconitum spicatum*	4	3	4	2	4	1	3	3	24	II
2)	*Dactylorhiza hatagirea*	4	4	4	2	4	0	3	2	23	II
3)	*Fritillaria cirrhosa*	4	3	2	2	3	0	2	1	17	III
4)	*Jurinea dolomiaea*	4	4	4	2	3	0	2	1	20	II
5)	*Meconopsis dhwojii*	4	3	4	3	3	0	2	1	20	II
6)	*Nardostachys grandiflora*	4	3	4	2	3	1	4	3	24	II
7)	*Neopicrorhiza scrophulariiflora*	4	3	4	2	3	1	4	4	25	I
8)	*Rheum australe*	3	4	2	2	2	1	2	3	19	III
9)	*Swertia angustifolia*	4	3	2	2	3	1	2	3	20	II
10)	*Valeriana jatamansii*	1	3	2	2	2	1	3	3	17	III

Appendix-4

Current Market price of various NTFPs (Falgun 2063)

Name of the Plants	Kathmandu	Nepalgunj	Tanakpur	Lucknow	Delhi	Kolkata
Alainchi	180	-	200	256	200	195
Amala	35	26	32	32	36	35
Amalbedh	-	88	70	96	112	96
Atis	-	780	720	800	936	650
Barro	18	12	13	-	15	10
Bhutkesh	-	145	-	-	264	-
Bishjara	190	180	195	-	272	-
Bojho	60	61	48	64	77	-
Chirayito	250	230	180	256	272	272
Dalchini	-	48	48	56	62	56
Guchhe-chyau	-	9000	8000	-	-	-
Harro	20	16	10	13	-	-
Jatamansi	180	140-165	176	224	264	288
Jhayu	65	80	112	136	168	128
Kakarsingi	80	85	80	136	122	128
Kutki	250	-	-	-	-	-
Majitho	40	38	72	64	72	61
Nirmasi	1150	1000	1600	1280	1640	-
Padamchal	45	50	67	64	72	70
Pakhanved	16	18	19	19	26	18
Pipla	135	110	256	240	240	210
Ritha	48	60	56	56	77	53
Satawari	240	260	280	240	160-320	288
Satuwa	350	390	352	480	520	-
Silajit	160	100-130	136	-	141	160
Sikakai	22	18	19	21	24	26
Sugandhawal	110	130	120	160	168	176
Sugandhakokila	75	80	112	112	120	-
Sutho	12022	57	104	67	66	80
Tejpat	95	23	32	32	38	-
Timur	-	50	72	58	62	77
Yarsagumba	-	-	-	-	2,40,000	-

Source: ANSAB, Bhimsengola, 2007

Appendix-5

Questionnaire applied to collect social data from Rasuwa district

Locality…… Date……..

1) Name of the informant……

2) Age……. 3) Sex: ☐ Male ☐ Female

4) Do you use plant parts to cure illness? ☐ Yes ☐ No

If yes, Is the use ☐ Self Administered or ☐ given by local healers?

6) Do you grow these plants? ☐ Yes ☐ No

7) If yes,

i) What is the extent of cultivation? ☐ Small scale ☐ Large scale

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

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

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

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

8) What are the important MAPs in the area?

a)……. b) ……. c)……..

9) What are the major localities of their occurrence?

a)……. b) ……. c)……..

10) Do outsiders come to collect MAPs in this area? ☐ Yes ☐ No

11) How do you earn your livelihood?

☐ Hotels ☐ Tourist guides / porter ☐ Agriculture ☐ Others

12) Do your earnings meet your household expenses? ☐ Yes ☐ No

13) Do you think we should conserve the resources?

☐ Yes ☐ No ☐ Don't know

Appendix-6

Key persons interviewed

A. Thulo Syabru

1) Lama Singi (President: Dudhkunda Menja Samiti / Hotel Yeti)
2) Lama Sonam (Hotel Lama)
3) Lama Temba
4) Wang di
5) Dorche Namgyal
6) Tenzin Tamang
7) Karma Dendhup

B. Brabal

1) Dendhup Tamang
2) Sonam Tamang
3) Karpu Sonam
4) Chhowang Dendhup
5) Sonam Tsering
6) Phurpu Gyalbo

C. Dhunche

1) Kami Tsering (Jhakri)
2) Karpu Sonam (Jhakri)
3) Dawa Pemba
4) Sukh Bahadur Tamang
5) Chhowang Tamang (Gosainkunda Medical)

D. Deurali

1) Tenzing Tamang

E. Dhimsa

1) Mr. Mingmar Tamang (Teashop owner)

F. Singompa

1) Subba Lama (Hotel Red Panda)

G. Cholangpati

1) Nima Singi Tamang (Hotel Langtang Lirung)

H. Laurivinayak

1) Tenzin Tamang (Hotel Mount Rest)

I. Gosainkunda

1) Urba Tamang (Hotel Peaceful Lake and Lodge)

Appendix-7

Itinerary of the field visit

First Field Visit (Jun 1, 2006 - Jun 15, 2006)

Jun 1, 2006	:	*Kathmandu - Dhunche*
Jun 2, 2006	:	*Dhunche*
Jun 3, 2006	:	*Singompa, Chandanbari*
Jun 4, 2006	:	*Cholangpati*
Jun 5-6, 2006	:	*Gosainkunda / Amakunda*
Jun 7-8, 2006	:	*Thulo Syabru / Brabal*
Jun 9, 2006	:	*Lama Hotel*
Jun 10, 2006	:	*Ghoda Tabela*
Jun 11-12, 2006	:	*Langtang Village*
Jun 13, 2006	:	*Kyanjin*
Jun 14, 2006	:	*Syaphru bensi*
Jun 15, 2006	:	*Syaphru bensi – Kathmandu*

Second Field Visit (Aug 28, 2006-Sep 10, 2006)

Aug 28, 2006	:	*Kathmandu-Dhunche*
Aug 29, 2006	:	*Singompa*
Aug 30, 2006	:	*Laurivinayak*
Aug 31, 2006	:	*Gosainkunda*
Sep 1, 2006	:	*Gosainkunda*
Sep 2, 2006	:	*Laurivinayak*
Sep 3, 2006	:	*Cholangpati*
Sep 4-6, 2006	:	*Thulo Syabru*
Sep 7-9, 2006	:	*Dhunche*
Sep 10, 2006	:	*Dhunche-Kathmandu*

Photo Plate 1

Dactylorhiza hatagirea (D.Don) Soo

Swertia chirayita (Roxb. ex Flem.) Karstn.

Rheum australe D.Don

Fritillaria cirrhosa D.Don

Photo Plate 2

Neopicrorhiza scrophulariiflora (Pennell) Hong

Aconitum spicatum (Bruhl) Stapf

Valeriana jatamansii Jones

Jurinea dolomiaea Boiss.

"Mahaguru"

Aconitum gammiei Stapf

Photo Plate 3

Working in the field (Above Cholangpati:3700m)

Team members with local healer of Dhunche (second from right)

Cultivation of Chirayita (Thulo Syabru:2200m)

Holy Gosainkunda lake (4400m)

South of Gosainkunda lake: 4400m (Potential site for *Neopicrorhiza scrophulariiflora*)

Cholangpati-Laurivinayak sector: 3700m (Potential site for MAPs)