Conservation and Management of Threatened Plant Species of Manang

Submitted to

Provincial Government

Ministry of Forest, Environment and Soil Conservation

Divisional Forest Office

Chame, Manang

Submitted by

Green Herald Environmental and Engineering Consult Pvt. Ltd.

Baneswor, Kathmandu

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EXECUTIVE SUMMARY

The number of threatened species is an important measure of the immediate need for conservation in an area. In spite of global and national level analyses of the status of threatened species for few groups of organisms; their assessments at local level have not been carried out yet. Realizing this fact of management hurdle due to taxonomic gap of the threatened floral species, this study was conducted in the jurisprudence of the division forest office of Manang district. Even though IUCN recognized "threatened" species as the sum of species enlisted in three 'Vulnerable', 'Endangered' and 'Critically Endangered' categories, this study added extra two elements of CITES appendix and threatened NTFPs through over collection for the export trade in Nepal. From the study, seven species were identified as the threatened species in four community forests and their habitat suitability were assessed. Among these species, Panchaule (574.26 ha), Okhar (126.34 ha), Satuwa (231.61 ha), Chiraito (185.46 ha), Lauthsalla (231.61 ha), Sugandhawal (62.86 ha) and Timur (206.75 ha) had their current suitable habitat. These suitable patches of threatened species should be incorporated into operational forest management plans of the four community forests of the district. An explicit guideline regarding conservation, cultivation, harvesting and processing of these species and the exploration, encouragement, and engagement of locals in cultivation and awareness creation is recommended. Divisional Forest Office should support in revision of operational plans, massive level cultivation of these species and creation of conservation awareness among concerned stakeholders in the district to preserve and promote these threatened species of the district.

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1. INTRODUCTION

1.1 Background

Nepal is richly endowed with natural resources across a variety of ecosystems. These ecosystems include forests, grasslands, wetlands, high mountains, the Himalayas and the lowland plains which provide invaluable habitats for flora and fauna, as well as goods and services to local people and the country as a whole. Because of numerous reasons such as deforestation, illegal felling, forest fires, haphazard infrastructure development, encroachment, unsustainable harvesting, climate change and so on; the floral and faunal species of Nepal are facing a chronic vulnerability. Gandaki province, a biodiversity hotspot of Nepal due to transition of two floristic regions of the world, is not untouched by all these problems and has been grieved from species lost. In the same way, Manang, a Himalayan district of Nepal, is also suffering from the above-mentioned chronic problems and is threatened by unprecedented species loss.

International Union on Conservation of Nature (IUCN) recognized "threatened" species as the sum of species enlisted in three 'Vulnerable', 'Endangered' and 'Critically Endangered' categories. The number of threatened species is an important measure of the immediate need for conservation in an area. Global and national level analyses of the status of threatened species have been carried out for few groups of organisms. Only for mammals, birds, and amphibians has the status of virtually all known species been assessed. As of September 2016, the IUCN listed 37 (0.17% of all evaluated plant species) species as extinct in the wild, 2493 (11% of all evaluated

plant species) species as critically endangered plant, 3,654 (17% of all evaluated plant species) species as endangered plant and 5430 (25% of all evaluated plant species) species as vulnerable plants. The IUCN Red List of Threatened Species is widely recognized as the most comprehensive, objective global approach for evaluating the conservation status of plant and animal species. The IUCN guides conservation activities of governments, non-government organisations and scientific institutions. The IUCN draws on and mobilizes a network of scientists and partner organizations working in almost every country in the world who collectively hold what is likely the most complete scientific knowledge base on the biology and conservation status of species. The plants and animals assessed for the IUCN Red List are the bearers of genetic diversity and the building blocks of ecosystems, and information on their conservation status and distribution provides the foundation for making informed decisions about conserving biodiversity from local, provincial, national and global levels. Only a small number of the world's plant and animal species have been assessed. In addition to the many thousands of species which have not yet been assessed so far, other species not included on the IUCN Red List are those that went extinct before 1500 AD and the "Least Concern" (plants that have been evaluated to have a low risk of extinction) species that have not yet been data based. Direct threats to species are the proximate human activities or processes that have impacted, are impacting, or may impact the status of the taxon being assessed. Direct threats are synonymous with sources of stress and proximate pressures. Threats can be past (historical, unlikely to return or historical, likely to return), ongoing, and/or likely to occur in the future.

Reporting the proportion of threatened species on the Red List is complicated by the fact that not all species groups have been fully evaluated, and also by the fact that some species have so little information available that they can only be assessed as Data Deficient (DD). For many of the incompletely evaluated groups, assessment efforts have focused on species that are likely to be threatened; therefore any percentage of threatened species reported for these groups would be heavily biased (i.e., the percentage of threatened species would likely be an overestimate). Although there are over 12,000 plant species on the IUCN Red List, fewer than one thousands of these are properly documented. To help address this gap, IUCN is pursuing global assessments of plant species of value to people including species of high economic value. The conifer and cycad species already on the IUCN Red List need to be fully documented. IUCN is also developing a tool to assist with preliminary assessments of plant species. Since IUCN has evaluated extinction risk for less than 5 percent of the world's described species, IUCN cannot provide an overall estimate for how many of the planet's species are threatened. For those groups that have been comprehensively evaluated, the proportion of threatened species can be calculated, but the number of threatened species is often uncertain because it is not known whether DD species are actually threatened or not. Due to variations in consistency and methods of collection, data quality is highly variable across countries. Some countries update their information more frequently than others, some have more accurate data on extent of coverage, and many underreport the number or extent of protected areas. Also, because of differences in definitions, reporting practices, and reporting periods, cross-country comparability of threatened species is limited. In order to ensure global uniformity when describing the habitat in which a taxon (a taxonomic group

of any rank) occurs, the threats to a taxon, what conservation actions are in place or are needed, and whether or not the taxon is utilized, a set of standard terms, called Classification Schemes, are being developed, for documenting taxonomy on the IUCN Red List.

IUCN Red List of Threatened Species collects and disseminates information on the global threated species. Proportion of threatened species is only reported for the more completely evaluated groups (i.e., >90% of species evaluated). Also, the reported percentage of threatened species for each group is presented as a best estimate within a range of possible values bounded by lower and upper estimates: Lower estimate = % threatened extant species if all Data Deficient species are not threatened, i.e., (CR + EN + VU) / (total assessed - EX) Best estimate = % threatened extant species if Data Deficient species are equally threatened as data sufficient species, i.e., (CR + EN + VU) / (total assessed - EX - DD) Upper estimate = % threatened extant species if all Data Deficient species are threatened, i.e., (CR + EN + VU + DD) / (total assessed - EX) Additional information on ecology and habitat preferences, threats, and conservation action are also collated and assessed as part of Red List process.

The problem of lack of reliable, accurate biodiversity data on the threatened plants of Nepal has been highlighted in the Nepal Biodiversity Strategy (NBS 2002). Many countries have now produced a Plant Red Data Book that includes information on their most threatened plants, but Nepal does not yet have this. The foundations for a Plant Red Data Book for Nepal were made in the mid 1980's when WWF-US funded

the project 'An Inventory on Endemic, Endangered and Threatened Plants of Nepal'. Ten years later, Shrestha et al. (1996) published these results in Rare, Endemic and Endangered Plants of Nepal. This very useful book details 246 endemic and 60 other threatened species of plants. 90% of the endemics are only known from their original type collection; about 75% of these are from the high mountains. They conclude that nine species of flowering plants are now suspected as being extinct from Nepal, including eight endemics. According to a recent report, Nepal hosts 22 threatened plant species (Royal Botanic Gardens Edinburgh, 2014).

Even though global and national level analyses of the status of threatened species have been carried out for few groups of organisms; their assessment at local level has not been done yet. Apart from IUCN definitions of threatened species, this study added extra two elements of CITES appendix and threatened NTFPs through over collection for the export trade in Nepal. The reason behind these added elements are the importance of all these factors in threatening floral species of Manang for management purpose. Hence, this study was conducted in the jurisprudence (four community forests) of the division forest office of Manang to explore threatened species for their appropriate management.

1.2 The CITES Lists

CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) is an international agreement between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten the survival of the species. CITES works by subjecting international trade in

specimens of selected species to certain controls. CITES is the most widely accepted international treaty on the conservation of biodiversity. All import, export, re-export and introduction from the sea of species covered by the convention has to be authorized through a licensing system. Each Party to the convention must designate one or more management authorities in charge of administering that licensing system and one or more scientific authorities to advise them on the effects of trade on the status of the species.

The Convention comprises 25 articles and 3 Annexes. The species covered by CITES are listed in three Appendices, according to the degree of protection they need. Appendix I lists species that are the most endangered among CITES-listed animals and plants. They are threatened with extinction and CITES prohibits international trade in specimens of these species except when the purpose of the import is not commercial, for instance for scientific research. In these exceptional cases, trade may take place provided it is authorized by the granting of both an import permit and an export permit (or re-export certificate). Article VII of the convention provides for a number of exemptions to this general prohibition.

Appendix II lists species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled. It also includes so-called "look-alike species", i.e. species whose specimens in trade look like those of species listed for conservation reasons. International trade in specimens of Appendix-II species may be authorized by the granting of an export permit or re-export certificate. No import permit is necessary for these species under CITES (although a permit is needed in some countries that have taken stricter measures than CITES requires).

Permits or certificates should only be granted if the relevant authorities are satisfied that certain conditions are met, above all that trade will not be detrimental to the survival of the species in the wild.

Appendix III is a list of species included at the request of a Party that already regulates trade in the species and that needs the cooperation of other countries to prevent unsustainable or illegal exploitation. International trade in specimens of species listed in this Appendix is allowed only on presentation of the appropriate permits or certificates.

CITES have listed more than 35,000 species of wild animals and plants and nearly 30,000 species of plants are protected by CITES against over-exploitation through international trade in the world (Joshi et al., 2017). These species may be added to or removed from Appendix I and II, or moved between them, only by the Conference of the Parties, either at its regular meetings or by postal procedures. But species may be added to or removed from Appendix III at any time and by any party unilaterally (although the Conference of the Parties has recommended that changes be timed to coincide with amendments to Appendices I and II).

The names of species in the Appendices may be annotated to qualify the listing. For example, separate populations of a species may have different conservation needs and be included in different Appendices (e.g. the wolf populations included in Appendix I are only those of Bhutan, India, Nepal and Pakistan, whereas all others are included in Appendix II). Such specifications can appear next to the species name

or in the interpretation section. For this reason, the Appendices should always be consulted alongside the interpretation with which they are presented.

1.3 IUCN Red Lists

The International Union for Conservation of Nature (IUCN)'s Red List of Threatened Species has evolved to become the world's most comprehensive information source on the global extinction risk status of animal, fungus and plant species. It is a critical indicator of the health of the world's biodiversity. Far more than a list of species and their status, it is a powerful tool to inform and catalyse action for biodiversity conservation and policy change, critical to protecting the natural resources we need to survive. It provides information about range, population size, habitat and ecology, use and/or trade, threats, and conservation actions that will help inform necessary conservation decisions. The IUCN Red List committee is responsible body for overseeing and guiding the work of the species survival commission on biodiversity assessments. This includes responsibility for The IUCN Red List of threatened species and advising on the functioning of the species information service, the system used to manage IUCN Red List data.

Considering the global population of a taxon, the IUCN Red List Categories and Criteria were developed for assessing extinction risk at the global level. Based on geographic range, population size and population decline/increase, probability of being extinction; the IUCN Red List consists of nine categories (**Figure 1**). They are a) Not Evaluated, b) Data Deficient, c) Least Concern, d) Near Threatened, e) Vulnerable, f) Endangered, g) Critically Endangered, h) Extinct in the Wild, and i)

Extinct (IUCN, 2021). For regional assessments, two additional categories are also available: 'Not Applicable' and 'Regionally Extinct'. The category Extinct (EX) involves species beyond reasonable doubt that the species is no longer extant while the Extinct in the wild (EW) represents species surviving only in captivity, cultivation and/or outside native range, as presumed after exhaustive surveys. Similarly, Critically endangered (CR) involves species in a particularly and extremely critical state and the Endangered (EN) involves species with very high risk of extinction in the wild. Also, Vulnerable (VU) involves those species meeting one of the 5 red list criteria and thus considered to be at high risk of unnatural (human-caused) extinction without further human intervention. In addition, Near threatened (NT) consists of species close to being at high risk of extinction in the near future while the Least concern (LC) category is unlikely to become extinct in the near future. Species in the ‘Vulnerable’, ‘Endangered’ and ‘Critically Endangered’ categories are collectively described as 'Threatened'.

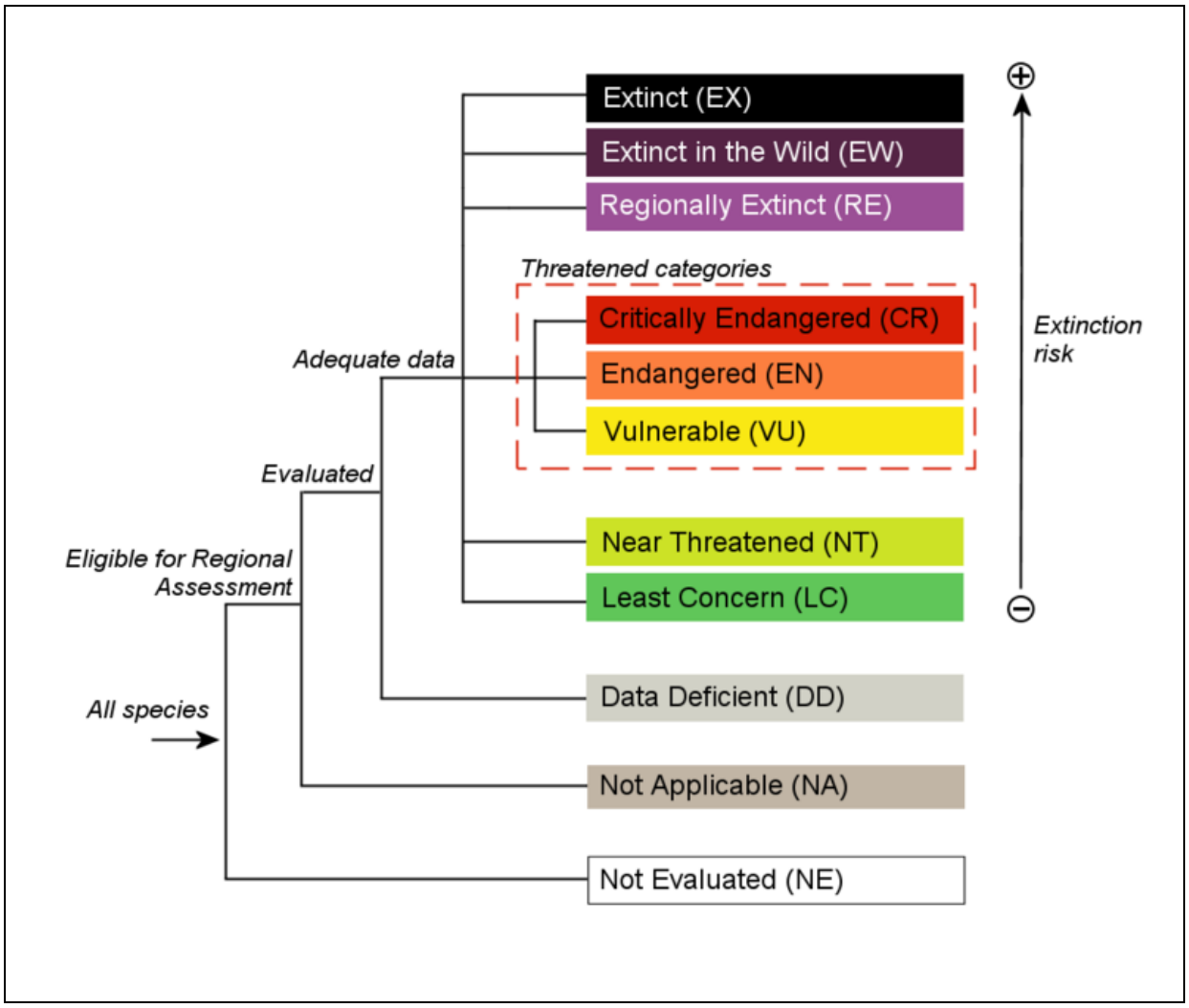

Figure 1. IUCN Red List categories.

The IUCN Red List is used by government agencies, wildlife departments, conservation-related non-governmental organisations, natural resource planners, educational organisations, students, and the business community. The Red List process has become a massive enterprise involving the IUCN Global Species Program

staff, partner organisations and experts in the IUCN Species Survival Commission and partner networks who compile the species information to make The IUCN Red List the indispensable product it is today.

The IUCN Red List is used to inform decisions taken by multilateral environmental agreements. It is often used as a guide to revise the annexes of some important international agreements, such as the Convention on International Trade in Endangered Species and the Convention on Migratory Species. Data from The IUCN Red List are used to calculate the Red List Index (RLI), which is one of the biodiversity indicators used by the Convention on Biological Diversity to monitor progress towards achieving the targets set out in the Strategic Plan for Biodiversity 2011-2020. It also provides data for the indicators needed to measure progress towards the achievement of the United Nations Sustainable development Goals. The IUCN Red List assessments of freshwater species have also contributed to the work of the Ramsar convention in selecting sites that are important for freshwater biodiversity. More importantly, it contributes to the function of the Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services to strengthen the science-policy interface on biodiversity and ecosystem services to improve decision making.

To date, many species groups including mammals, amphibians, birds, reef building corals and conifers have been comprehensively assessed. As well as assessing newly recognized species, the IUCN Red List also re-assesses the status of some existing species, sometimes with positive stories to tell. For example, good news such as the

down listing (i.e. improvement) of a number of species on the IUCN Red List categories scale, due to conservation efforts. The bad news, however, is that biodiversity is declining. Currently, there are more than 1,34,400 species on The IUCN Red List, with more than 37,400 species threatened with extinction, including 41% of amphibians, 34% of conifers, 33% of reef building corals, 26% of mammals and 14% of birds (IUCN, 2021).

There are some important limitations to the current dataset that need to be fully understood before any analysis based on Red List data can be undertaken. The species groups covered so far are biased towards terrestrial, and in particular forest, ecosystems. Among the better-documented species, there is also a strong bias towards animals, rather than plants or fungi; but steps are underway to rectify these biases.

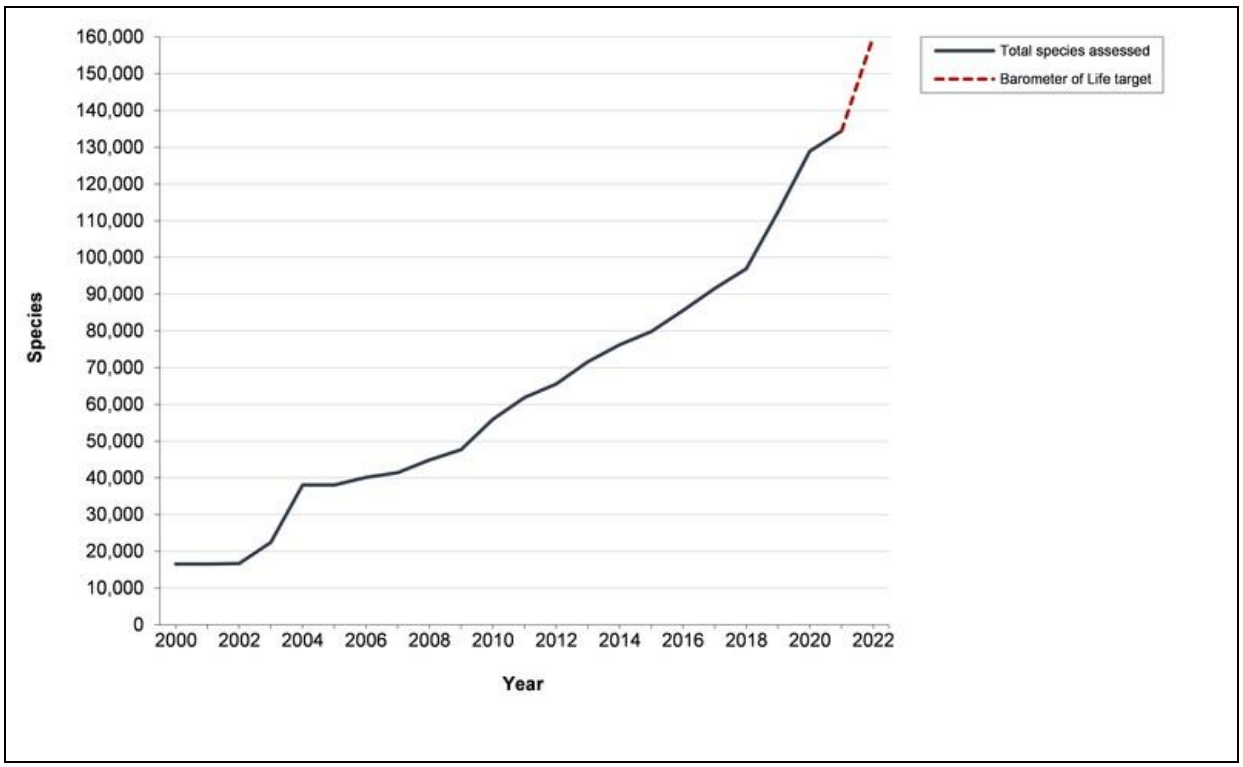

Figure 2. The IUCN Red List of threatened species and number of species still to assess to reach the target.

Despite the high proportions of threatened species, numerous attempts to reverse, or at least halt, the decline in biodiversity have been done. These include increased assessments of these threatened species to help to build The IUCN Red List into a more complete 'Barometer of Life'. Fungi being the vital components of ecosystems for nutrient recycling and the benefits to human lives, they are the most under-represented taxa on The IUCN Red List with fewer than 450 species assessments (IUCN, 2021). For this, IUCN is currently focusing on assessing a range of fungi groups, including selected groups of lichens, mushrooms, rusts, smuts, truffles, chytrids, slime moulds, and mildews. Also, around 54,000 plant species have been included in the IUCN Red lists now and this still represents a small proportion of the world's known plants (IUCN, 2021). To help address this taxonomic gap, IUCN is pursuing two assessment projects named the "Plants for People" and the "Global Tree Assessment" The former project will focus on assessing priority plant species in each of the following groups of wild crops, medicinal plants, timber trees and palms and the latter focuses on assessing the conservation status of every known tree species.

Realizing, the taxonomic gap of all flora and fauna, there is a need to increase the targeted number of species to be assessed to at least 1,60,000 (IUCN, 2021) (**Figure 2**). This will provide the most up-to-date information on the health of the world's

biodiversity, and thereby guide critical conservation actions. Also, it improves the global taxonomic coverage and thus provides a stronger base to enable better conservation and policy decisions. The IUCN Red List shows us where and what actions need to be taken to save the building blocks of nature from extinction. It provides a straightforward way to factor biodiversity needs into decision-making processes by providing a wealth of useful information on species. In addition, it helps identify Key Biodiversity Areas for conservation including Important Bird Areas, Important Plant Areas and Alliance for Zero Extinction sites. Also, it is crucial not only for helping to identify those species needing targeted recovery efforts, but also for focusing the conservation agenda by identifying the key sites and habitats that need to be protected. Ultimately, The IUCN Red List helps planners and concerned stakeholders to guide and inform future conservation and funding priorities.

1.4 Compilation of Nepalese floral plants as in IUCN, CITES appendix and threatened through over-collection for the export trade

Nepal has a slew of species enlisted both in CITED lists and IUCN Red Lists. A total of 154 plant species including one species (*Paphiopedilum venustum* (Wall. ex Sims) Pfitzer) in Appendix I; 149 species in Appendix II including *Cyathea* four spp., *Euphorbia* four spp., *Dalbergia* four spp., Orchids 131 species, *Taxus* 2 spp.; and four species (*Gnetum montanum, Meconopsis regia, Podocarpus Neriifolius and Tetracentron sínense*) were enlisted in Appendix III in Nepal (Joshi et al., 2017). Also, *Nardostachys grandiflora* (IUCN vulnerable lists), *Rauvolfia serpentina* (IUCN endangered lists and CITES II) and *Taxus baccata subsp. wallichiana* (CITES

II) are listed in national list of plants banned species for export (Royal Botanic Gardens Edinburgh, 2014). Similarly, *Acacia catechu* (IUCN threatened lists), *Michelia champaca* (IUCN endangered lists) are listed in national list of timber trees banned for felling, transportation or export (Royal Botanic Gardens Edinburgh, 2014). Also, *Dactylorhiza hatagirea* (CITES II), *Picrorbiza scrophulariflora* and *Juglans regia* are listed in national list of plants banned for collection, use, sale, distribution, transportation and export (Royal Botanic Gardens Edinburgh, 2014).

Apart from these species, *Acontium heterophyllum, Aconitum spicatum, Acorus calamus, Dactylorhiza hatagirea, Ephedra gerardiana, Gentiana kurrooa, Nardostachys grandiflora* (IUCN Vulnerable lists), *Paris polyphylla* (IUCN Vulnerable lists), *Picrorhiza kurroa* (IUCN Vulnerable lists), *Piper longum, Podophyllum hexandrum* (IUCN Vulnerable lists), *Potentilla fulgens, Rauvolfia serpentine, Rheum australe, Rheum nobile, Swertia chirayita, Terminalia chebula, Terminalia bellirica, Valeriana wallichii* and *Zanthoxylum armatum* are the 20 species of medicinal plants threatened through over-collection for the export trade in Nepal (Royal Botanic Gardens Edinburgh, 2014). While combining these species of three categories, 18 species are found in temperate and sub-alpine climate of Nepal. These species were further selected in broad consultation with the forest officials and concerned stakeholders to segregate local species of interest for the study.

1.5 Study area

Manang district is one of the Himalayan districts of Gandaki province of federal democratic republic Nepal (**Figure 3**). Geographically the district is located between 28°27' to 28°28' N latitude and 83°40' to 84°34‘ E longitude covering an area of

2,246 km² from 1,680 m to 8,163 m above mean sea level. Situated between middle mountain to nival eco-zone areas of Nepal, it is bordered by Gorkha in the east, Mustang and Myagdi in the west, the dry alpine desert of Mustang and Tibet (China) in the north and Lamjung and Kaski in the south. Manang district gets least amount of rainfall among districts of Nepal as it lies to the north of the Himalayas which blocks monsoon air. The northern parts of Manang Valley are dry, brown and desolate places. Its district headquarter is Chame with its four rural municipalities, 28 wards and more than 35 settlements. Chame, Nason, Narpa Bhumi and Manang Ngisyang are the rural municipalities of the district. At the time of the 2011 Nepal census, Manang district had a population of 6,538. Of these, 56.9% spoke Gurung, 21.0% Nepali, 8.5% Tamang, 7.3% Sherpa, 1.7% Magar, 1.1% Newari and 0.8% Thakali as their first language. 76.9% of the population in the district speaks Nepali and 0.6% Sherpa as their second language.

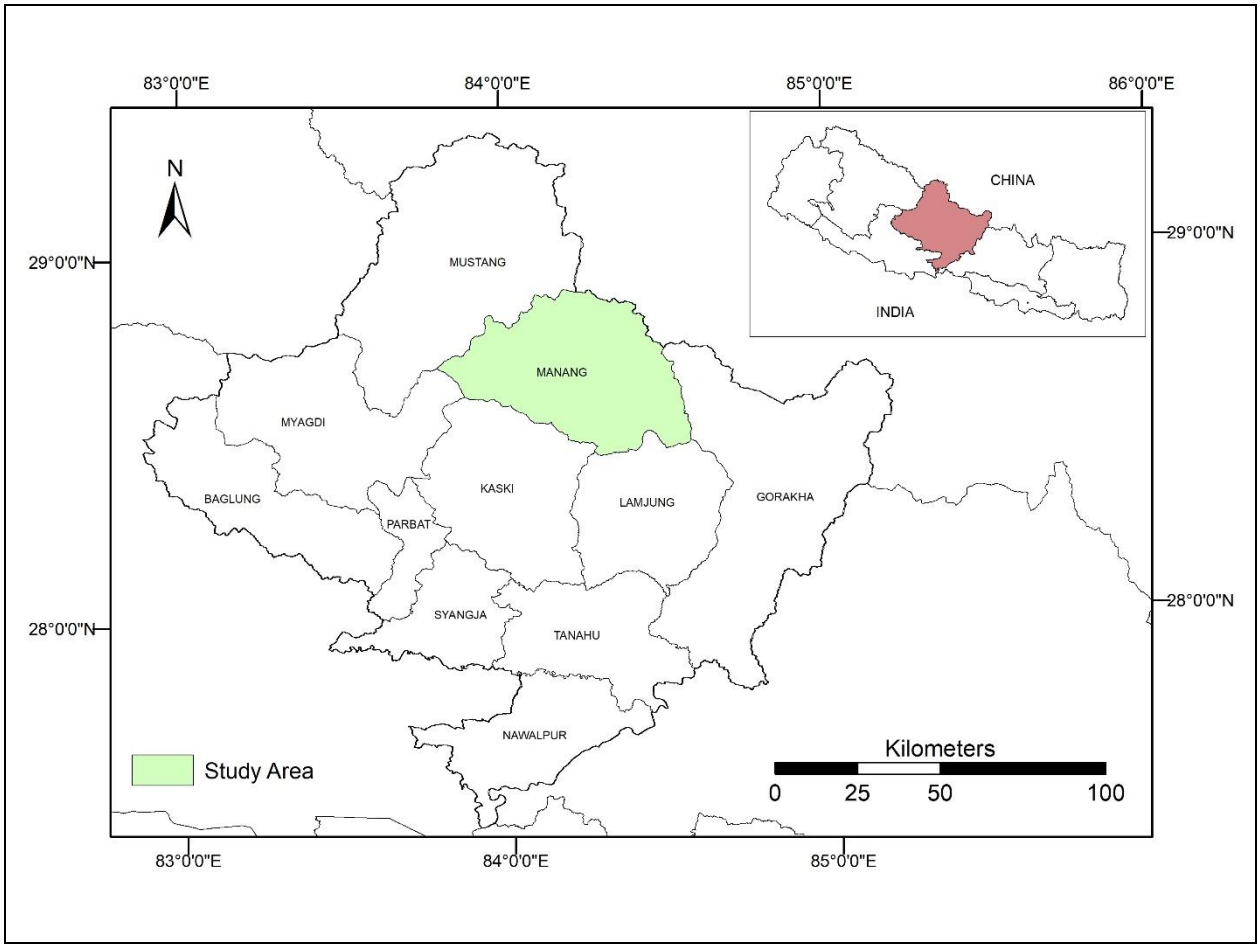

Figure 3. Study area.

This study was conducted in Nason rural municipality of Manang district outside the area of Annapurna Conservation Area with a view to conserving threatened plant species in and around four community forests (jurisprudence of Division Forest Office) namely Tal community forest, Tiliche community forest, Thonche community forest and Nanche community forest. Tal community forest was located in Nason rural municipality ward number 1 of Manang covering an area of 489.07 ha and has a mixed natural forest of Pine, Gurans, Dhupi, Oak and Bhojpatra. This consists of MAPs such as Nirmansi, Pakhanved, Jatamansi, Padamchal, Bish, Sugandhawal, Yarshagumba and Paanchaaule. Nanche community forest was also located in Nason rural municipality ward number 2

of Manang covering an area of 497.08 ha and has a mixed natural forest of Pine, Uttis, Gurans, Dhupi, Oak and Bhojpatra. Nirmansi, Padamchal, Satuwa, Banlasun, Sugandhawal, Pakhanved, Guchchi Chyau are some of the MAPs of the community forest. Tilche community forest was also located in Nason rural municipality ward number 6 and 7 of Manang covering an area of 2265.64 ha and has a mixed natural forest of Pine, Bhotepipal, Uttis, Gurans, Dhupi, Oak and Bhojpatra. Chiraito, Kurilo, Nirmansi, Jatamansi, Satuwa, Banlasun, Sugandhawal, Pakhanved and Yarsagumba are some of the MAPs of the community forest. Thonche community forest was located in Nason rural municipality ward number 5 of Manang covering an area of 325 ha and has a mixed natural forest of Pine, Gurans, Uttis, Dhupi, Okhar, Katus and Bhojpatra. This consists of MAPs such as Satuwa, Kurilo, Chiraito, Pakhanved and Guchchi chyau.

2. METHODOLOGY

2.1 Data preparation

Administrative data such as district boundary and community forest were gathered from divisional forest office Manang. The shapefile of paths and motor roads inside the study area was obtained from the Geofabrik (https://www.geofabrik.de/data/shapefiles.html) website. Settlement locations were available from Department of Survey, Nepal. Distance raster files of paths and settlements were created by using ArcGIS (ESRI, 2017). Land cover and land use data were downloaded from the website of International Centre for Integrated Mountain Development website (ICIMOD; http://www.icimod.org) (Uddin et al., 2015). Digital Elevation Model (DEM) of 30 m resolution was downloaded from USGS website (https://earthexplorer.usgs.gov/), and slope was calculated from the DEM using ArcGIS software (ESRI, 2017). Enhanced Vegetation Index (EVI) time series data (2015-2017) were downloaded from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor from the website of USGS. From this, we calculated mean and standard deviation of EVI.

2.2 Format design and field orientation

Checklists and data collection sheets were prepared by the study team. These were used to collect both primary and secondary data through office visit, consultation with users and field work. Prior moving to the field, a brief orientation was conducted for the field staff. The main objective of the orientation was to ensure that

they could easily collect required dataset following uniform formats and conduct field work easily.

2.3 Data collection and compilation

At first, desktop study was done in the office to gather information related to threatened floral species of Nepal which were then limited to the species of Manang. From the detailed literature review of those species, 18 suitable species of temperate and sub-alpine climate were selected. Among these species, seven species of were selected for the field level data collection in broad consultation with government officials of the district and the users of the community forests and their cultivation potentialities. Then, field level staffs were deployed in the field to collect occurrence points of those species in specific formats. The study team visited all potential habitats of threatened species from March to May throughout the study area to search for these species. Then the team visited the habitat of threatened species of interests and collected occurrence points of those species in the study area. Grey literatures were collected from the published and unpublished official documents. All these data were compiled into a Microsoft Excel.

2.4 Identification of suitable habitat

We performed species distribution modeling in study area based on the geo-referenced presence points of the prioritized threatened speices of Manang. Environmental variables (elevation, slope, land use land cover, distance to path, distance to motor road, EVI, distance to water and land use land cover) were used as an input variable to the MaxEnt modeling to find out potential suitable habitat (Elith

et al., 2006; Phillips et al., 2017, 2006) in Manang district of Nepal. This model is widely used model to model the suitable habitat and to find out the important variables and their impact on the suitable habitat in Nepal (Panthi, 2018).The model was validated by the help of area under the receiver-operator curve (AUC) and evaluated by True Skill Statistics (TSS) (Merow et al., 2013; Phillips et al., 2006). The output of the model was further analyzed in ArcGIS and the potential suitability map was finally prepared.

3. RESULTS

3.1 PANCHAULE

3.1.1. Introduction

Panchaule (*Dactylorhiza hatagirea*) is a species of orchid generally found growing in the Himalayas, from Pakistan to SE Tibet, at altitudes of 2,800–4,000 metres (9,200–13,100 ft). It is locally called 'Salam Panja' or 'Hatta Haddi'. It is called 'Panchaule'in Nepali and Himalayan regions. The name 'Panchaule' (meaning 5 fingered hand) arises from its root resembling fingers of hand with around 3-5 fingers. It is an erect perennial herb with long flowering stems. The plant is well known for its medicinal value. The root has sweet taste. It is strictly prohibited for collection and sale, but can be found easily around Nepal. It costs around NRs. 10,000-15,000 per kilo as of late 2015.

3.1.2 Habitat and distribution

As it is highly traded in the name of 'Panchaule' or 'Salampanja' and found in wild, is being unscientifically collected for its commercial importance. *Dactylorhiza hatagirea* is native of the Himalaya. It is found throughout from west to east at temperate to subalpine bio climates within 2800 – 4000 m altitude. Flowers spotted rosy-purple in a terminal spike, borne on a robust leafy stem. It has palmately lobed root tubers, grows well in moist places, open areas, shrub land and open meadows. *Dactylorhiza hatagirea* is endemic to the Hindu- Kush Himalaya. It is categorized as endangered in CAMP Pokhara (2001) conservation list, and strictly banned for collection, utilization and sale (strictly protected species list I GoN, 2001, 2005), and

listed in appendix II for control trading. This study has identified 574.26 ha suitable habitats for Panchaule in Manang district (**Figure 4**).

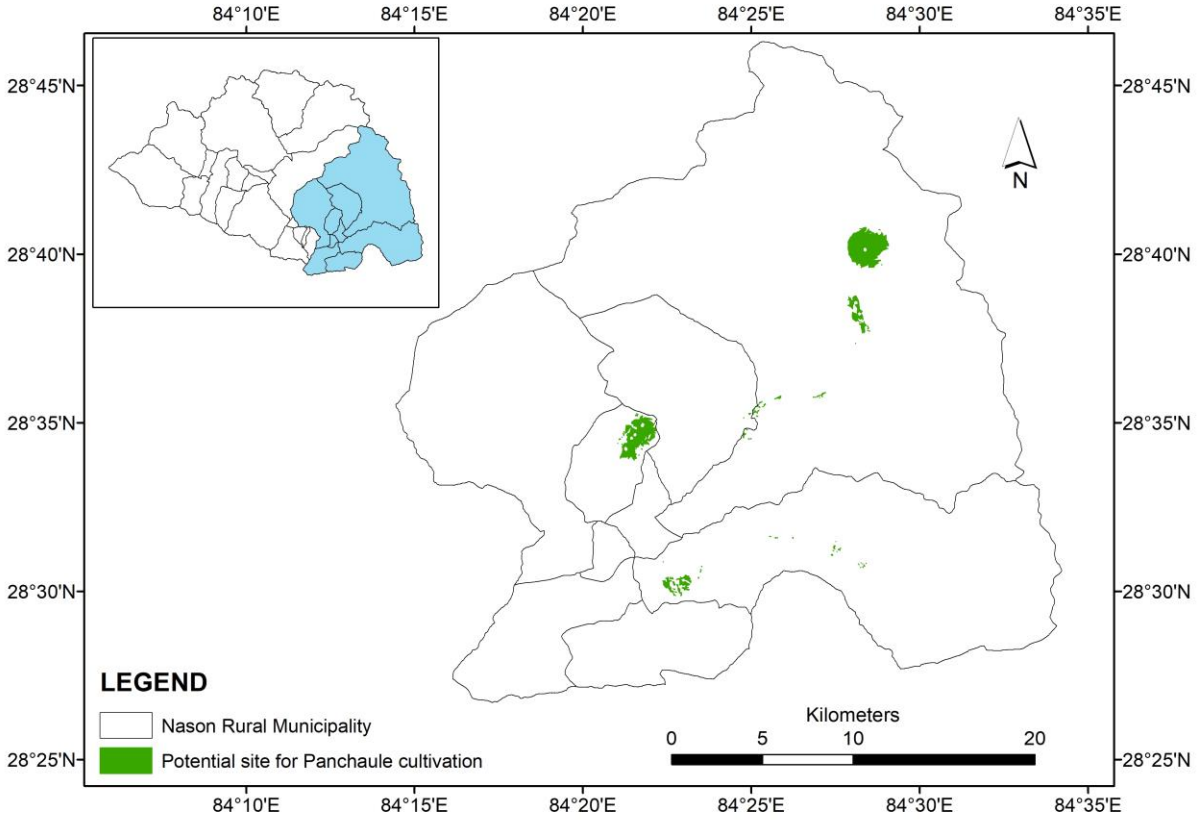

Figure 4. Potential cultivation site for Panchaule.

3.1.3 Uses

The Juice extracted from tuber is used as tonic and also used for the treatment of pyorrhea (inflammation of the gum & teeth). Root paste is externally applied as poultice on cuts and wounds and extract is given in intestinal disorders. The term Hatta Haddi is probably coined because it is used for treating bone fractures.

3.1.4 Cultivation

The materials for propagation of Panchaule are seeds and tuber cuttings. Plants can be grown by splitting the sprouting tubers. Collected seeds did not show germination at controlled temperature and moisture (temp. 10-15^{o}C; humidity 90+5%) conditions. It probably requires thawing under the snow for about 4-5 months and mycorrhizal association for germination. It is reported to be an inherently slow growing and poorly regenerating species because of pollinator specificity.

3.2 OKHAR

3.2.1 Introduction

Juglans regia is a large deciduous tree, attaining heights of 25–35 m (80 to 120 ft), and a trunk up to 2 m (6 ft) in diameter, commonly with a short trunk and broad crown, though taller and narrower in dense forest competition. It is a light-demanding species, requiring full sun to grow well. The bark is smooth, olive-brown when young and silvery-grey on older branches, and features scattered broad fissures with a rougher texture. Like all walnuts, the pith of the twigs contains air spaces; this chambered pith is brownish in color. The leaves are alternately arranged, 25–40 cm (10 to 16 in) long, odd-pinnate with 5–9 leaflets, paired alternately with one terminal leaflet. The largest leaflets are the three at the apex, 10–18 cm (4 to 7 in) long and 6–8 cm (2 to 3 in) broad; the basal pair of leaflets are much smaller, 5–8 cm (2 to 3 in) long, with the margins of the leaflets entire. The male flowers are in drooping catkins 5–10 cm (2 to 4 in) long, and the female flowers are terminal, in clusters of two to five, ripening in the autumn into a fruit with a green, semi-fleshy

husk and a brown, corrugated nut. The whole fruit, including the husk, falls in autumn; the seed is large, with a relatively thin shell, and edible, with a rich flavour.

3.2.2 Habitat and distribution

One of the centers of origin and diversity of *Juglans regia* is Iran. However, as with other old and widespread cultivated plants, it is not easy to reconstruct the original distribution and determine the borders of the past natural ranges. There are many reports concerning the earliest fossil pollen and nuts of *J. regia*, and the conclusions that various authors draw are somewhat contradictory. Taken together these finds suggest that *J. regia* possibly survived the last glaciations in several refugia, as the compilation of the data shows most likely southern Europe, the Near East, China, and the Himalaya. This study has identified 126.34 ha suitable habitats for Okhar in Manang district (**Figure 5**).

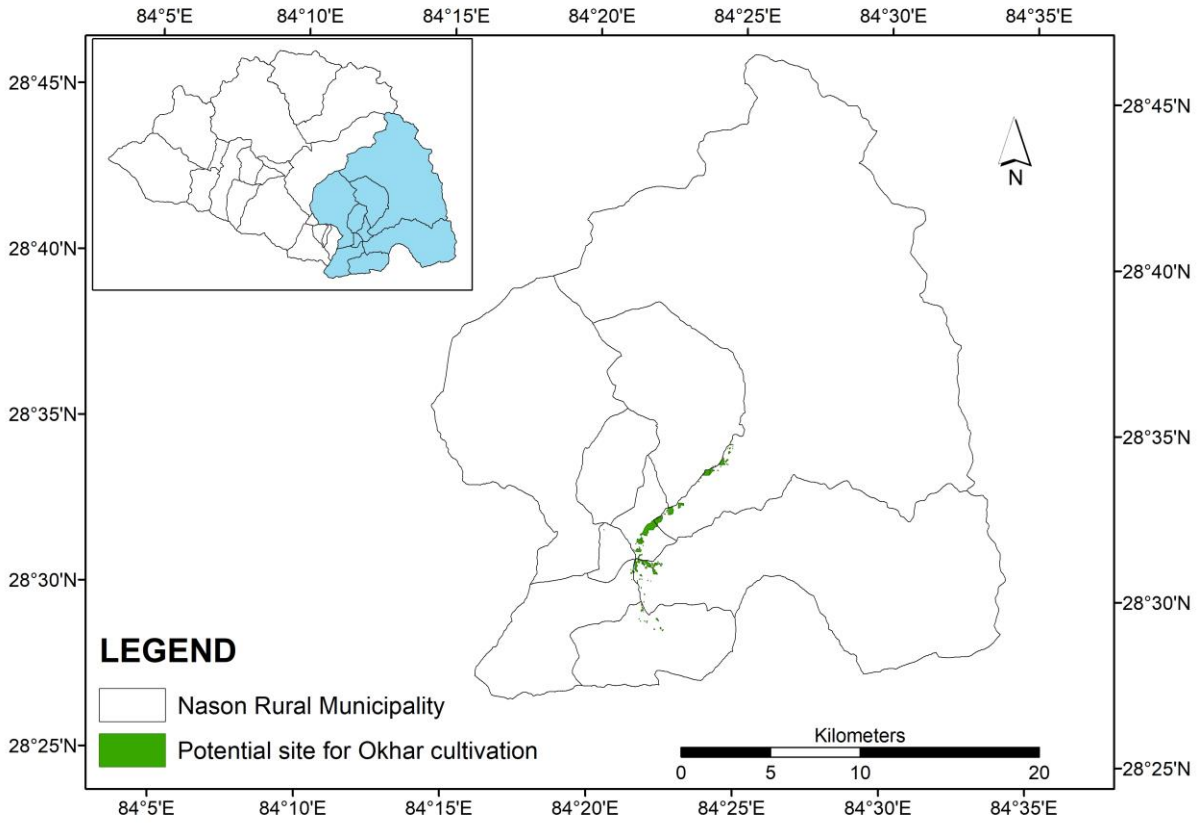

Figure 5. Potential cultivation site for Okhar.

3.2.3 Uses

Walnut heartwood is a heavy, hard, open-grained hardwood. Freshly cut live wood may be Dijon-mustard colour, darkening to brown over a few days. The dried lumber is a rich chocolate-brown to black, with cream to tan sapwood, and may feature unusual figures, such as "curly", "bee's wing", "bird's eye", and "rat tail", among others. It is prized by fine woodworkers for its durability, lustre and chatoyance, and is used for high-end flooring, guitars, furniture, veneers, knobs and handles as well as gunstocks. Walnuts and other tree nuts are food allergen sources having potential to cause life-threatening, IgE-mediated allergic reactions in some individuals. *Juglans regia* is infested by *Rhagoletis juglandis*, commonly known as the walnut

husk fly, which lays its eggs in the husks of walnut fruit. Particular cultivars of *J. regia* may be more infested than others because of varying walnut husk softness or thickness. 'Eureka', 'Klondike', 'Payne', 'Franquette' and 'Ehrhardt' cultivars are among the most susceptible to infestation.

3.2.4 Cultivation

Walnut trees grow best in rich, deep soil with full sun and long summers, such as the California central valley. *Juglans hindsii and J. hindsii* × *J. regia* are often used as grafting stock for *J. regia*. Other plants often will not grow under walnut trees because the fallen leaves and husks contain juglone, a chemical which acts as a natural herbicide. Horses that eat walnut leaves may develop laminitis, a hoof ailment. Mature trees may reach 50 feet (15 m) in height and width, and live more than 200 years, developing massive trunks more than 8 feet (2.4 m) thick.

3.3 SATUWA

3.3.1 Introduction

Paris polyphylla Sm. (Common Name: Satuwa; English: Love Apple; Family: Trilliaceae) is an erect perennial herb distributed in temperate regions throughout Nepal. The name "*Paris*" comes from "Par," meaning equal, and it refers to the great symmetry of the flower. *Paris* is a very variable species, with many subspecies

recognized. Rhizomes and roots of *P. polyphylla* have medicinal and commercial value. The market of Satuwa rhizomes has boomed up for the last couple of years.

Paris polyphylla is about 40-70 cm high with herbaceous stem. Leaves 5-16 cm long by 1.5-4 cm wide, dark green in colour, stalked, 4-9 in number and arranged in a whorl at the top of the stem. Shape of the leaf is elliptic, oblong or lanceolate; surface glabrous; and acuminate tip. Rhizomes are somewhat bitter, stout and creeping. Flowers are yellowish green in colour with short stalk and borne solitary on terminal head. Perianth with 8-12 segments in two different whorls - the outer whorl with lanceolate, long, pointed, green leaf like segments; and the inner whorl with thread like yellow or purple segments. The individual flowers are very long-lived, lasting for up to three months. Fruits are globular. Flowering occurs in April- May and fruiting in July-September (Ghimire and Pyakurel, 2008; Polunin and Stainton, 1984).

3.3.2 Habitat and Distribution

There is confusion regarding the origin of *P. polyphylla*. It might be Sinu-Japanese or Eastern Asiatic element. It is distributed from NW India, WCE Nepal, Bhutan, Southern Tibet, Myanmar and mainland China. Though found throughout Nepal, it is fairly common in Central and Eastern Nepal within the altitudinal range of 1800-3300m. It prefers moist and swampy habitat and grows under dense forests, bamboo forests, thickets, grassy or rocky slopes, and on humus rich moist soil. The best place to found *P. polyphylla* within the altitudinal range prescribed is the north facing hills and near the streamside and swampy areas. It is often found in the broadleaved and dense woodland forest with *Rhododendron arboreum*, *Quercus lanata, Q.*

semecarpifolia, *Aesculus indica*, *Tsuga dumosa*, etc as major tree species (Pyakurel and Baniya, 2011). This study identified 231.61 ha potential habitats for Satuwa in Manang district (**Figure 6**).

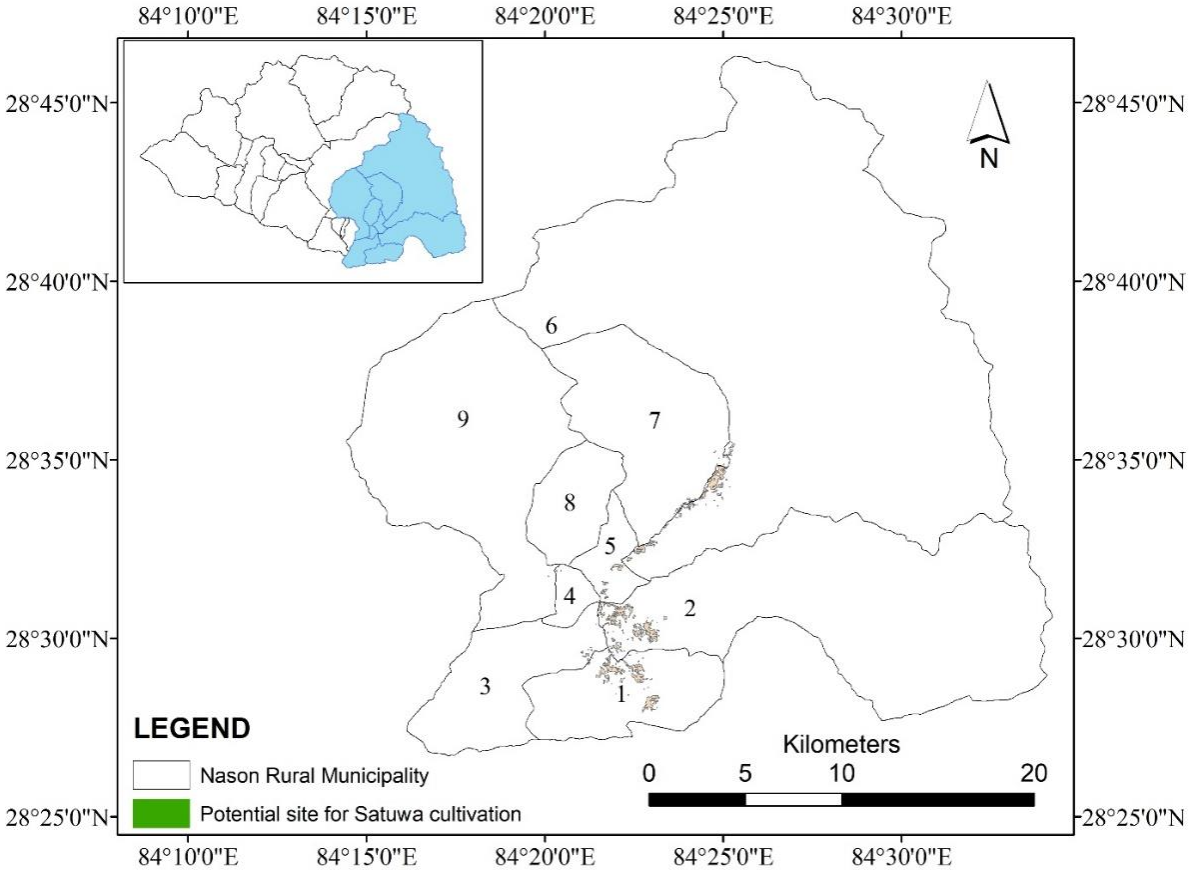

Figure 6. Potential cultivation site for Satuwa.

3.3.3 Uses

Rhizomes are used in stomachache, antispasmodic, digestive, vermifuge, anthelmintic, expectorant and tonic (Nepal, 2004). Root paste is applied as an antidote to the bite of poisonous insects and snake bite, root paste is taken to alleviate narcotic effects. Chewing a piece of root is believed to heal internal wounds below the throat (Rajbhandari, 2001). A paste of the root is applied to cuts and

wounds. Pieces of the root are fed to cattle with diarrhea and dysentery. Juice of the root or powder is taken as anthelmintic and in fever (Manandhar, 2002). Root extract is mixed with rhizome of *Dactylorhiza hatagirea* and applied on fresh cuts and wounds (Ghimire and Pyakurel, 2008). The rhizomes are uses as an alternative to drug Diosgenin.

3.3.4 Cultivation

Commercial cultivation of Satuwa is commenced in Nepal. It grows well in soil with *p*H ranged from 5.6-7.5, i.e. it prefers slightly acidic to neutral soil. The plant prefers light (sandy) and medium (loamy) soils). It can grow well in full shade (deep woodland). The plant requires moist humus rich soil and therefore watering is very essential (Brown et al., 2007). It can be cultivated in Baitadi, Darchula, Bajhang, Jajarkot, Rolpa, Rukum, Manang, Kaski, Parbat, Makawanpur, Gorkha, Dhading, Rasuwa, Dolakha, Solukhumbu, Tehrathum, Sankhuasabha, Panchthar and Taplajung districts. Besides from the above-mentioned district, it can be cultivated in all the districts which have temperate moist climate.

Seed are collected from healthy plant during July- August (*Shrawan-Bhadra*). Outer fleshy coating are removed, properly cleansed and well dried before storing. The seeds are sowed in the prepared nursery during September (*Ashwin*). Seeds are thinly sown so that the seedling can grow freely. It takes about six-seven months to produce a primary root. Satuwa being a shade loving plant, nursery beds should be

shaded with appropriate roofing. Regular watering is necessary for Satuwa. The plants are transferred to the prepared fields during May-June (*Baisakh-Jestha).*

Satuwa also propagates efficiently with underground rhizomes and is more prolific than propagation from seeds. The tubers are cut into small pieces ensuring that the growing bulbs are present in each piece. These rhizomes are grown in polybags during the rainy season. Leaf appears from the rhizomes in about 3-4 months' time. These are kept in the nursery in the first year and transplanted to prepared field during May-June next year.

3.4 CHIRAITO

3.4.1 Introduction

Swertia chirayita (Roxb. ex Fleming) Karsten, Chireeta in english and Tite/ Pothi Chiraito/ Tikta in Nepali, belongs to family Gentianaceae. This is a perennial herb of temperate regions of Nepal. Chiraito is one of the highest export revenues earning medicinal plants of Nepal. Chiraito is a biennial or perennial herb with seasonal growth. It mostly has a single stout elongated stem, size of which ranged from 60cm to 150cm with branching at tip. Colour of stem is greenish brown at young and turns light brown to light violet as the plant attains maturity. Stem is cylindrical at base, quadrangular upwards. Roots are generally small, 5-10cm long, light brown, somewhat twisted and gradually tapering, bearing a few rootlets or their remnants. Leaves are ovate, elliptic or broadly lanceolate, sessile, opposite, acute, 3-5 nerved, 1.6-10cm by 0.3- 3cm. Leaves grown near base are often larger than that grown near

tips. Flowers are greenish yellow borne in small clusters. Flowers contain numerous minute seeds. It is unable to exhibit thick stocking. Whole plant is intensely bitter in taste. Flowering takes place from July to October and fruiting from September to November (Dutta, 2007; Ghimire and Pyakurel, 2008; Polunin and Stainton, 1984).

3.4.2 Habitat and distribution

Chiraito grows in temperate Himalayas from Kashmir to Bhutan and in Khasia hills of Meghlaya. and is distributed within the altitude of 1,500m to 3,000m throughout Nepal. This species prefers North and North West facing moist habitat on forests, rangelands and around cultivated lands. But it is found mostly on South West facing slopes of mixed broad-leaved forest. Chiraito population mainly comprised of juveniles, followed by rosette stage and adults in wild. Major associates of Chiraito are Anaphalis sp, Desmodium sp, Anemone obtusiloba, Elsholtzia sp, Fragaria sp, Oxalis corniculata etc. (Ghimire and Pyakurel, 2008). This study identified 185.46 ha potential habitats for Chiraito in Manang district (**Figure 7**).

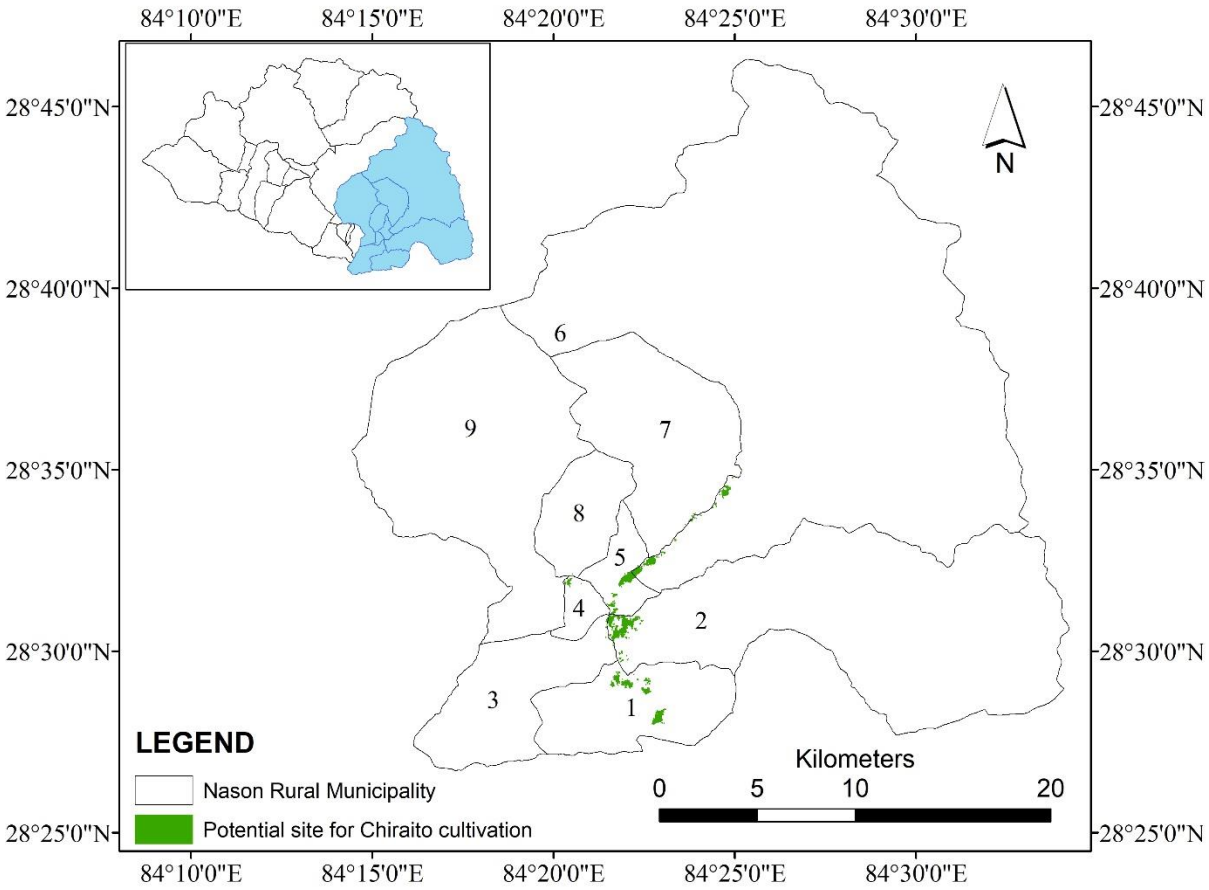

Figure 7. Potential cultivation site for Chiraito.

3.4.3 Uses

Chiraito is one of the most important medicinal plants of the mid-hills has historical, ethno-botanical, medical as well as economic values for the local communities. Chiraito is an integral part of Ayurved, Yunani, Chinese and Tibetan medication system. It is also used in herbal medication system in USA and UK (Joshi and Dhawan, 2005). Whole plant is intensely bitter in taste. Chiraito is useful to treat more than 15 diseases, disorders & ailments locally and through Ayurvedic & Allopathic medicines. Dried plant is soaked in a glass of water (150-200ml) overnight and the extract is taken orally to treat fever, asthma, cold and cough. Crushed seeds

are considered most effective to cure those ailments. Plant juice is taken with water to treat jaundice, headache, malarial fever, stomach disorder, gastric, ulcer and anthelmintic medicine. The plant is also used for the treatment of cuts and wounds (Ghimire and Pyakurel, 2008). Chiraito immersed in half glass of water overnight is taken twice a day to treat diabetes and 1 teaspoon decoction thrice a day is taken to treat fever in Nubri Valley, Gorkha (Gurung and Pyakurel, 2006). Paste of plant is used to treat various skin diseases (Manandhar, 2002). It is used as tonic, febrifuge, antidiarrhoetic and to cure various liver problems. The plant is used to control the sugar level in blood. The plant shows antipyretic, sudorific, antiperiodic, anthelmintic, antiinflammatory and hepatoprotective actions and used in urinary and liver disorders (Ambasta, 1986).

3.4.4 Cultivation

The natural regeneration of plant takes place by seeds, when the seeds become biologically mature having high potentiality of viability during November (Bhattarai and Acharya, 1996). The viability of seeds is very low if seeds are collected before November. The seeds stored in bad condition have no viability at all. The viability decreases after next October. If seeds are collected after November and cleaned properly, the percentage of germination is reported to be up to 90%.

Chiraito seeds from the forest should be collected to start a Chiraito nursery in November. The seeds collected should be sown within a year of collection. Before February, the soil is too cold to sow the seeds. It is better to sow between February

and April, into moist, fertile nursery beds. The seeds are covered with a thin layer of soil (depth twice the size of the seeds). Mulching is necessary for better germination. Frequent water spraying is done to maintain the moisture content of soil. When the seeds start to germinate, the mulching materials should be removed. After the seedlings attained the height of 6-8 cm, then they are ready for transplantation in field. Generally, 15 cm spacing between seedlings is needed for optimum production.

3.5 LAUTHSALLA

3.5.1 Introduction

Taxus wallichiana, the Himalayan yew, is a species of yew, native to the HImalaya and parts of south-east Asia. The species has a variety of uses in traditional medicine. It is currently classified as endangered by the IUCN. It is a medium-sized evergreen coniferous tree growing to 10 m tall, similar to *Taxus baccata* and sometimes treated as a subspecies of it. The shoots are green at first, becoming brown after three or four years. The leaves are thin, flat, slightly falcate (sickle-shaped), 1.5–2.7 cm long and 2 mm broad, with a softly mucronate apex; they are arranged spirally on the shoots but twisted at the base to appear in two horizontal ranks on all except for erect lead shoots. It is dioecious, with the male and female cones on separate plants; the seed cone is highly modified, berry-like, with a single scale developing into a soft, juicy red aril 1 cm diameter, containing a single dark brown seed 7 mm long. The pollen cones are globose, 4 mm diameter, produced on the undersides of the shoots in early spring.

3.5.2 Habitat and distribution

The species favours a reasonably wide range of habitats, growing in montane, temperate, warm temperate, and tropical submontane to high montane forests which may be deciduous, evergreen, or of mixed character. In forests, it tends to present as a low canopy tree; in open situations it usually forms a large, broadly spreading shrub. Elevation ranges from 900 m to 3,700 m. This study identified 231.61 ha potential cultivable area of Lauthsalla in 4 community forests of Nason rural municipality of Manang (**Figure 8**).

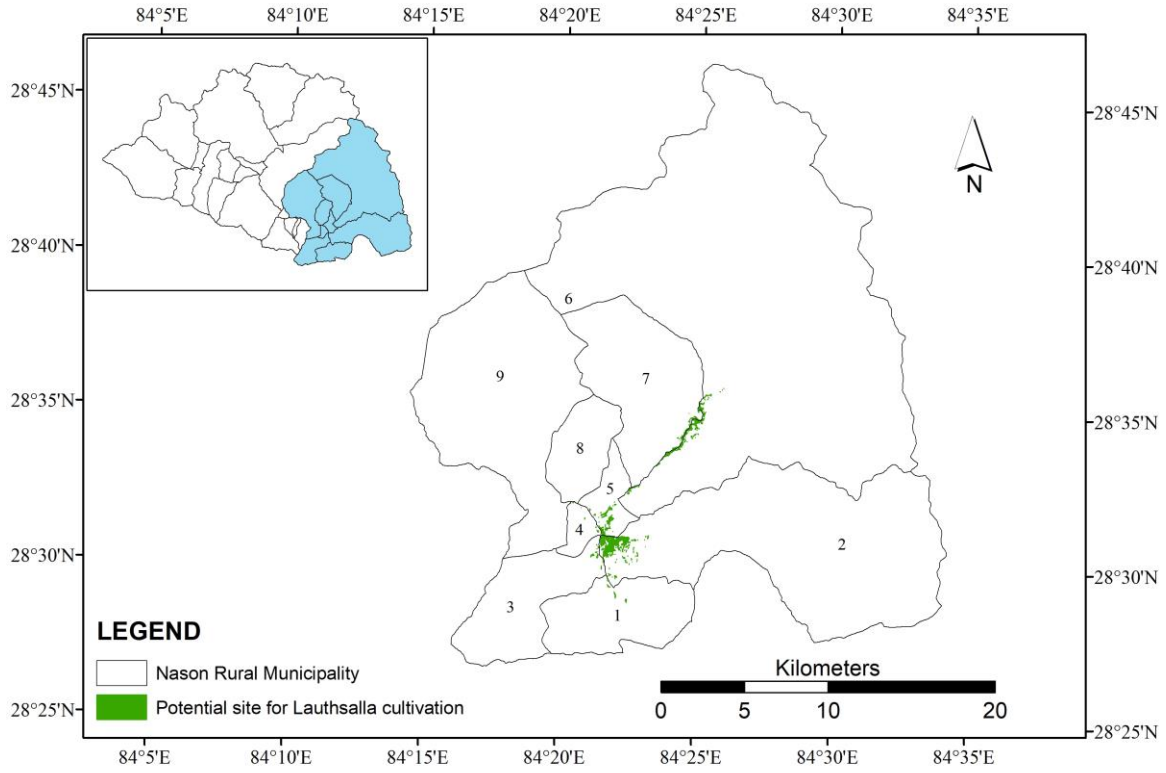

Figure 8. Potential cultivation site for Lauthsalla.

3.5.3 Uses

Taxus wallichiana has medicinal use in Ayurveda and Tibetan medicine. It is also a source of the chemical precursors to the anticancer drug paclitaxel. It is used for making tea by the Bhotiya tribal community in the Garhwal Himalaya. The stem bark of this species, which is locally known as thuner, is collected for this purpose. This species is also used as fuelwood by the local communities. In Himachal it is known to be medicine for some types of cancer.

3.5.4 Cultivation

The Himalayan yew has been subject to heavy exploitation for its leaves and bark across most of its range through the Himalayas and western China. Declines have been particularly heavy in India and Nepal, with losses of up to 90% having been reported. The degree of exploitation in other locations in its range is less well known, but is also assumed to be serious. It is present in several protected areas, and at least some conservation and propagation measures are underway, with an eye to its commercial value in the medicine trade.

3.6 SUGANDHAWAL

3.6.1 Introduction

Sugandhawal (*Valeriana jatamansi*) or samayo in Nepali and Mushkbala, Tagar in Hindi, Unani and trade, belongs to the valerianaceae family. This aromatic herb has a height upto 50 cm, thick rootstock of 6-10 cm length and long fibrous roots knotted by uneven circular ridges. It has 15–45 cm long several stems with radical and cauline leaves. Radical leaves are cordate–ovate, 2.5–8 cm, toothed or sinuate, long stalked, while cauline leaves are few, small, entire or lobulate. Flowers are white or tinged with pink and occur in flat-topped corymbose clusters on erect, nearly leafless peduncles. These flowers are unisexual means male and female flowers appear on different plants. Corolla is funnel shaped with five lobes and fruits are crowned with a persistent pappus-like calyx.

3.6.2 Habitat and distribution

Valeriana jatamansi is a perennial plant growing to 0.5 m (1ft 8in). It is slightly hairy, tufted herb, up to 45 cm in height, found in the temperate Himalayas at an altitude of 1,200-3,000 m. The species is dioecious (individual flowers are either male or female, but only one sex is to be found on any one plant so both male and female plants must be grown if seed is required). This species is pollinated by Insects. This study identified 62.86 ha potential cultivable area of Sugandhawal in 4 community forests of Nason rural municipality of Manang (**Figure 9**).

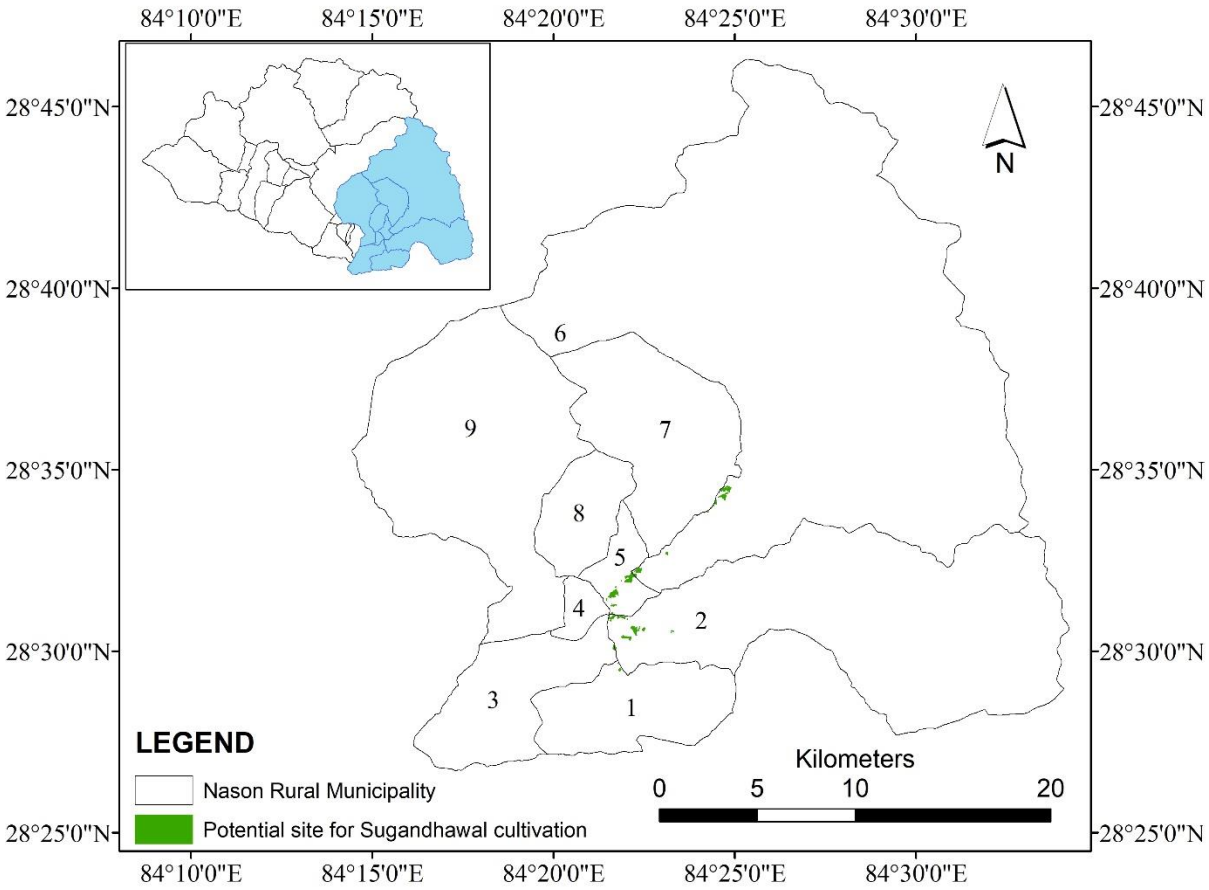

Figure 9. Potential cultivation site for Sugandhawal.

3.6.3 Uses

The root is antispasmodic, carminative and stimulant. It is employed as a nervine and sedative. In Nepal, It is to treat hysteria, insomna, nausea, pimples, rheumatism and cholera. The juice of the root is applied to the forehead in the treatment of headaches and is dripped into the eyes for treating eye problems. A paste of the plant is applied externally to boils. Valerian has been shown to encourage sleep, improve sleep quality and reduce blood pressure. It is also used internally in the treatment of painful menstruation, cramps, hypertension, irritable bowel syndrome etc. It should not be prescribed for patients with liver problems. Externally, it is used to treat

eczema, ulcers and minor injuries. The root is antispasmodic, carminative, diuretic, hypnotic, powerfully nervine, sedative and stimulant. The active ingredients are called valepotriates, research has confirmed that these have a calming effect on agitated people, but are also a stimulant in cases of fatigue. The fresh root is about 3 times as effective as roots dried at 40° (the report does not specify if this is centigrade or fahrenheit), whilst temperatures above 82° destroy the active principle in the root.

3.6.4 Cultivation

Cultivation of Sugandhawal is done through seed sowing spring in a cold frame and only just cover the seed because it requires light for germination. Prick out the seedlings into individual pots when they are large enough to handle and plant out into their permanent positions in the summer if sufficient growth has been made. If the plants are too small to plant out, grow them on in the greenhouse or frame for their first winter and plant them out early in the following summer. Larger divisions can be planted out direct into their permanent positions. It is found that it is best to pot up smaller divisions and grow them on in light shade in a greenhouse or cold frame until they are growing away well. Plant them out in the summer or the following spring.

3.7 TIMUR

3.7.1 Introduction

Timur (*Zanthoxylum armatum*), Nepalese pepper in English, belongs to the rutaceae family. It is a piny shrub or small tree about 3 m high with petiole odor. Leaves are alternate, slightly winged, with stipular spine at the base, odd pinnate, leaflets three to nine with red colored thrown. Flowers are small and whitish in loose inflorescence. Fruit are spherical, red when matured, splitting into two valves, 3 to 4 mm in fresh odor.

3.7.2 Habitat and distribution

Timur is widely distributed from 1000 to 2500 m in Hilly regions throughout east to west Nepal in natural conditions and edge of cultivated land. It is found in the warmer valleys and Eastern Ghats in Orissa and Andhra Pradesh at 1200m, and the lesser Himalayan ranges in the northeastern part of India (e.g., Naga Hills, Meghalaya, Mizoram, and Manipur). This study identified 206.75 ha potential cultivable area of Timur in 4 community forests of Nason rural municipality of Manang (**Figure**).

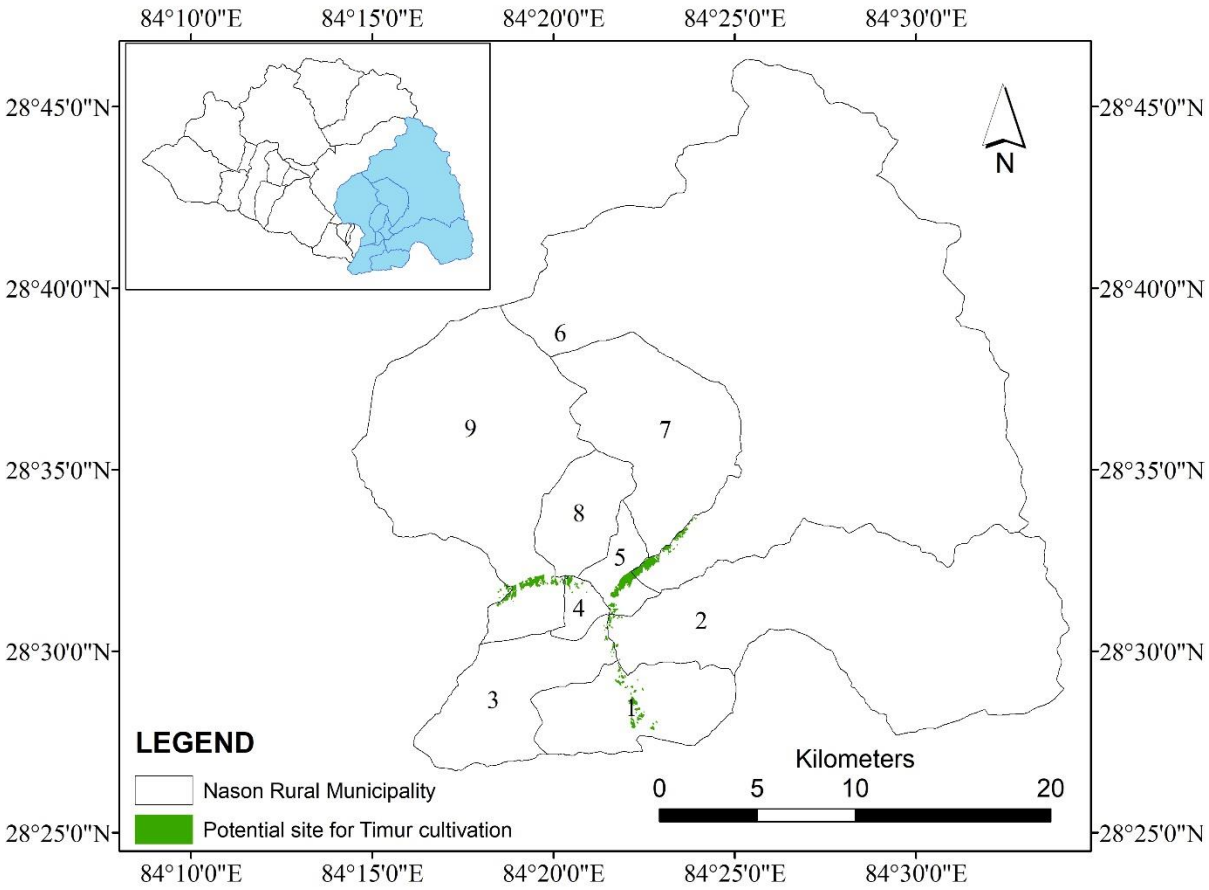

Figure 10. Potential cultivation site for Timur.

3.7.3 Uses

Fruits of Timur are used for headache, toothache in Ayurvedic Medicinal System. It is also used as spice and pesticide. Essential oil extracted from fruit is used for cosmetic materials, food materials and medicinal purposes. It is used in curing various common ailments such as toothache, common cold, cough, and fever, as it is believed to give warmth to the body. To cure toothache, a fresh or dry fruit is pressed over the affected tooth and is kept in position till it loses its pungency. Young shoots of Timur are used as toothbrushes. Recently people have also started to use powder made from the dried fruit for cleaning teeth. Common stomach complaints are

treated with Timur soup. The Bhotiya community also brew liquor from Timur, but the resulting liquor is palatable only to those highly addicted. Most members of the community consider the tree to have religious significance and magical properties.

3.7.4 Cultivation

Cultivation of Timur can be done both from seeds and stem cuttings. Freshly harvested seeds are best for the large-scale cultivation of *Zanthoxylum* species. Mature seeds can be collected in June–July. In the absence of sufficient seeds, terminal stem cuttings may be used as propagules. The crop can be raised by developing a nursery or by directly sowing in the main field. No seed treatment is necessary before sowing but stored seeds may require cold stratification for up to three months and may germinate in February– March. About 2–3 kg seeds are required to raise a nursery for plantation on 1 ha but about 30–50 kg seeds per hectare is required for direct sowing at a spacing of 50 cm × 50 cm. The seeds are sown in August– September in polybags (nursery) or main field. Stem cuttings may also be planted in the nursery during monsoon in July–August. The seeds germinate in 20–30 days after sowing and attain a height of 20–30 cm by June–July, when they can be transplanted to the main field.

4. CONCLUSION AND MANAGEMENT IMPLICATION

This study identified seven threatened species in four community forests located in Nason rural municipality of Manang district. Out of 18 threatened species (based on IUCN Red List, CITES list, and threatened through over collection for the export trade) found in the temperate and sub-alpine region of Nepal, seven species were found threatened in the jurisprudence of Division Forest Office. They are Panchaule, Okhar, Satuwa, Chiraito, Lauthsalla, Sugandhawal and Timur with their current suitable habitat of 574.26 ha, 126.34 ha, 231.61 ha, 185.46 ha, 231.61 ha, 62.86 ha and 206.75 ha respectively. These suitable patches of threatened species should be incorporated into operational forest management plans of the four community forests of the district. An explicit guideline regarding conservation, cultivation, harvesting and processing of these species and the exploration, encouragement, and engagement of locals in cultivation and awareness creation is recommended. Divisional Forest Office should support in revision of operational plans, massive level plantation of these species and creation of conservation awareness among concerned stakeholders in the district to preserve and promote these threatened species of the district.

REFERENCES

Ambasta, S.S.P., 1986. The useful plants of India. Publications & Information Directorate CSIR, New Delhi, India.

Bhattarai, K.R., Acharya, N., 1996. Identification, qualitative assessment, trade & economic significance of Chiraito (Swertia Spp.) of Nepal. A Rep. Submitt. to ANSAB.

Brown, T.C., Bergstrom, J.C., Loomis, J.B., 2007. Defining, valuing and providing ecosystem goods and services. Nat. Resour. J. 47, 329–376. https://doi.org/10.1525/sp.2007.54.1.23.

Dutta, I.C., 2007. Non-timber forest products of Nepal: identification, classification, ethnic uses and cultivation, Institute of Forestry, PO Box-369, Pokhara, Nepal.

Elith, J., H. Graham, C., P. Anderson, R., Dudík, M., Ferrier, S., Guisan, A., J. Hijmans, R., Huettmann, F., R. Leathwick, J., Lehmann, A., Li, J., G. Lohmann, L., A. Loiselle, B., Manion, G., Moritz, C., Nakamura, M., Nakazawa, Y., McC. M. Overton, J., Townsend Peterson, A., J. Phillips, S., Richardson, K., Scachetti-Pereira, R., E. Schapire, R., Soberón, J., Williams, S., S. Wisz, M., E. Zimmermann, N., 2006. Novel methods improve prediction of species' distributions from occurrence data. Ecography (Cop.). 29, 129–151. https://doi.org/10.1111/j.2006.0906-7590.04596.x

ESRI, 2017. ArcGIS Desktop: Release 10.5, Environmental systems research Redlands, California, USA.

Ghimire, S.K., Pyakurel, D., 2008. A Manual of NTFPs of Nepal Himalaya (Gair

Kastha Ban Paidawar Digdarshan). WWF Nepal, Kathmandu, Nepal.

Gurung, K., Pyakurel, D., 2006. Identification and Inventory of Non-Timber Forest Products (NTFPS) of Manaslu Conservation Area. Kathmandu, Nepal Natl. Trust Nat. Conserv. Nepal.

IUCN, 2021. The IUCN Red List of Threatened Species [WWW Document]. URL https://www.iucnredlist.org/ (accessed 6.26.21).

Joshi, N., Dhakal, K.S., Saud, D.S., 2017. Checklist of CITES Listed Flora of Nepal, Department of Plant Resources (DPR), Thapathali, Kathmandu, Nepal.

Joshi, P., Dhawan, V., 2005. Swertia chirayita–an overview. Curr. Sci. 635–640.

Manandhar, N.P., 2002. Plants and people of Nepal. Timber press.

Merow, C., Smith, M.J., Silander, J.A., 2013. A practical guide to MaxEnt for modeling species' distributions: What it does, and why inputs and settings matter. Ecography (Cop.). 36, 1058–1069. https://doi.org/10.1111/j.1600-0587.2013.07872.x

MOITFE, 2019. Feasibility study on establishment of provincial level MAPs collection and processing centre. Ministry of Industry, Tourism, Forest and Environment, Gandaki Province, Pokhara, Nepal.

Nepal, I., 2004. National Register of Medicinal and Aromatic Plants (revised and updated). IUCN Nepal.

Panthi, S., 2018. Predicting current and future habitat suitability for red pandas in Nepal. MSc thesis. University of Twente,faculty of geoinformation and earth observation, Enschede, Netherlands.

Phillips, S.J., Anderson, R.P., DudÍk, M., Schapire, R.E., Blair, M.E., 2017. Opening the black box: an open-source release of Maxent. Ecography (Cop.). 40, 1–7.

https://doi.org/10.1111/ecog.03049

Phillips, S.J., Anderson, R.P., Schapire, R.E., 2006. Maximum entropy modelling of species geographic distributions. Ecol. Modell. 190, 231–259. https://doi.org/10.1016/j.ecolmodel.2005.03.026

Polunin, O., Stainton, A., 1984. Flowers of the Himalaya. Oxford University Press.

Pyakurel, D., Baniya, A., 2011. NTFPs, impetus for conservation and livelihood support in Nepal. WWF Nepal.

Rajbhandari, K.R., 2001. Ethnobotany of Nepal. Ethnobotanical society of Nepal.

Royal Botanic Gardens Edinburgh, 2014. Flora of Nepal [WWW Document]. URL http://www.floraofnepal.org/home (accessed 6.26.21).

Shrestha, T.B., Joshi, R.M., Program., W.W.F.N., 1996. Rare, endemic and endangered plants of Nepal. WWF Nepal Program, Kathmandu.

Uddin, K., Shrestha, H.L., Murthy, M.S.R., Bajracharya, B., Shrestha, B., Gilani, H., Pradhan, S., Dangol, B., 2015. Development of 2010 national land cover database for the Nepal. J. Environ. Manage. 148, 82–90. https://doi.org/10.1016/j.jenvman.2014.07.047

Appendix 1. Collection sheet of threatened plant species (Critically endangered, endangered & vulnerable) of Nepal.

SN	Vernacular name	Common name	Botanical name	IUCN category	CITES appendix	Threatened through over-collection for export trade	Remarks

Appendix 2. Selection of threatened plant species found in temperate and sub-alpine climate of Nepal.

SN	Scientific name	Common name
1	*Aconitum spicatum*	Bikh
2	*Acontium heterophyllum*	Atis
3	*Dactylorhiza hatagirea*	Panchaule
4	*Ephedra gerardiana*	Somlata
6	*Juglans regia*	Okhar
7	*Nardostachys grandiflora*	Jatamansi
8	*Paris polyphylla*	Satuwa
9	*Picrorhiza scrophulariflora*	Kutki
11	*Podophyllum hexandrum*	Himalayan may apple
12	*Potentilla fulgens*	Bajradanti
13	*Rheum austral*	Padamchal
14	*Rheum nobile*	Chulthi amilo
15	*Swertia chirayita*	Chiraito
16	*Taxus baccata subsp. Wallichiana*	Lauth salla
17	*Valeriana wallichii*	Sugandhawal
18	*Zanthoxylum armatum*	Timur

Appendix 3. Selection of threatened plant species from the study area with comprehensive discussion with locals and DFO officials.

SN	Scientific name	Common name
1	*Dactylorhiza hatagirea*	Panchaule
2	*Juglans regia*	Okhar
3	*Paris polyphylla*	Satuwa
4	*Swertia chirayita*	Chiraito
5	*Taxus baccata subsp. Wallichiana*	Lauth salla
6	*Valeriana wallichii*	Sugandhawal
7	*Zanthoxylum armatum*	Timur

Appendix 4. Occurrence points of threatened species of the study area.

SN	Name and address of CFUG	Name of threatened species	Latitude	Longitude	Altitude	Remarks

Appendix 5. List of 30 species of medicinal plants for research and development.

SN	Botanical Name	Common Name
1	*Aconitum heterophyllum*	Attis
2	*Aconitum spicatum*	Bish
3	*Acorus calamus*	Bojho
4	*Asparagus racemosus*	Kurilo/ Satavari
5	*Azadirachta indica*	Neem
6	*Bergenia ciliate*	Pakhanved
7	*Cinnamomum glaucescens*	Sugandha kokila
8	*Cinnamomum tamala*	Tejpat
9	*Ophiocordyceps sinensis*	Yarsagumba
10	*Dactylorhiza hatagirea*	Panch aaule
11	*Dioscorea deltoidea*	Vyakur
12	*Gaultheria fragrantissima*	Dhasingre, Patpate
13	*Juglans regia*	Okhar
14	*Morchella conica*	Guchi Chyau
15	*Nardostachys grandiflora*	Jatamansi
16	*Neopicrorhiza scrophulariiflora*	Kutki
17	Lichens	Jhyau
18	*Phyllanthus emblica*	Amala
19	*Piper longum*	Pipla
20	*Podophyllum hexandrum*	Laghu patra
21	*Rauvolfia serpentine*	Sarpagandha
22	*Rheum austral*	Padamchal
23	*Rubia manjith*	Majitho
24	*Sapindus mukorossi*	Rittha
25	*Swertia chirayita*	Chiraito, Tite
26	*Tagetes minuta*	Jangali Sayapatri
27	*Taxus wallichiana*	Lauth Salla
28	*Tinospora sinensis*	Gurjo
29	*Valeriana jatamansii*	Sugandhawal, Samayo
30	*Zanthoxylum armatum*	Timur

Appendix 6. Prioritized NTFPs for cultivation and research.

SN	Local Name	Scientific Name
1	Paanchaule	*Dactylorhiza hatagirea*
2	Kutki	*Neopicrorhiza scrophulariifolia*
3	Chiraito	*Swerita chirayita*
4	Jatamansi	*Nardostachys grandiflora*
5	Sugandhawal	*Valeriana jatamansi*
6	Lauth salla	*Taxus wallichiana*
7	Timur	*Zanthoxylum armatum*
8	Sarpagandha	*Rauvolfia serpentina*
9	Kurilo	*Asparagus racemosus*
10	Pipla	*Piper longum*
11	Sugandhakokila	*Cinnamomum glaucescens*
12	Gurjo	*Tinospora sinensis*

Appendix 7. Annual allowable quantity of NTFPs of Manang.

SN	NTFP	Annual Production (Kg)
1	Orchids	9286
2	Satuwa	14290
3	Sugandhawal	19718
4	Seabuckthron	1525
5	Attis	10145
6	Majitho	6265
7	Bhutkesh	9205
8	Bhyakur Ban Tarul	13220
9	Jatamansi	13330
10	Banmula	10145
11	Banlasun	43104
12	Pakhanved	43240
13	Bikhma	13525
14	Chiraito	10923
15	Lauthsalla	47727
16	Indreni	7887
17	Yarshagumba	128
18	Kutki	36966
19	Kurilo	8548
20	Dhupi	23875
	Total	**351414**

Appendix 8. Commercially important NTFPs of Manang.

SN	Local Name
1	Sugandhawal
2	Dalechuk
3	Okhar
4	Attis
5	Majitho
6	Bhutkesh
7	Bhojpatra
8	Bhyakur
9	Jatamansi
10	Sunagabha
11	Banmula
12	Banlasun
13	Bantarul
14	Padamchal
15	Pakhanved
16	Bishma
17	Chiraito
18	Lauthsalla
19	Yarshagumba
20	Indrajau
21	Kutki
22	Kurilo
23	okhKukur tarul
24	Dhupi
25	Timur

THE END