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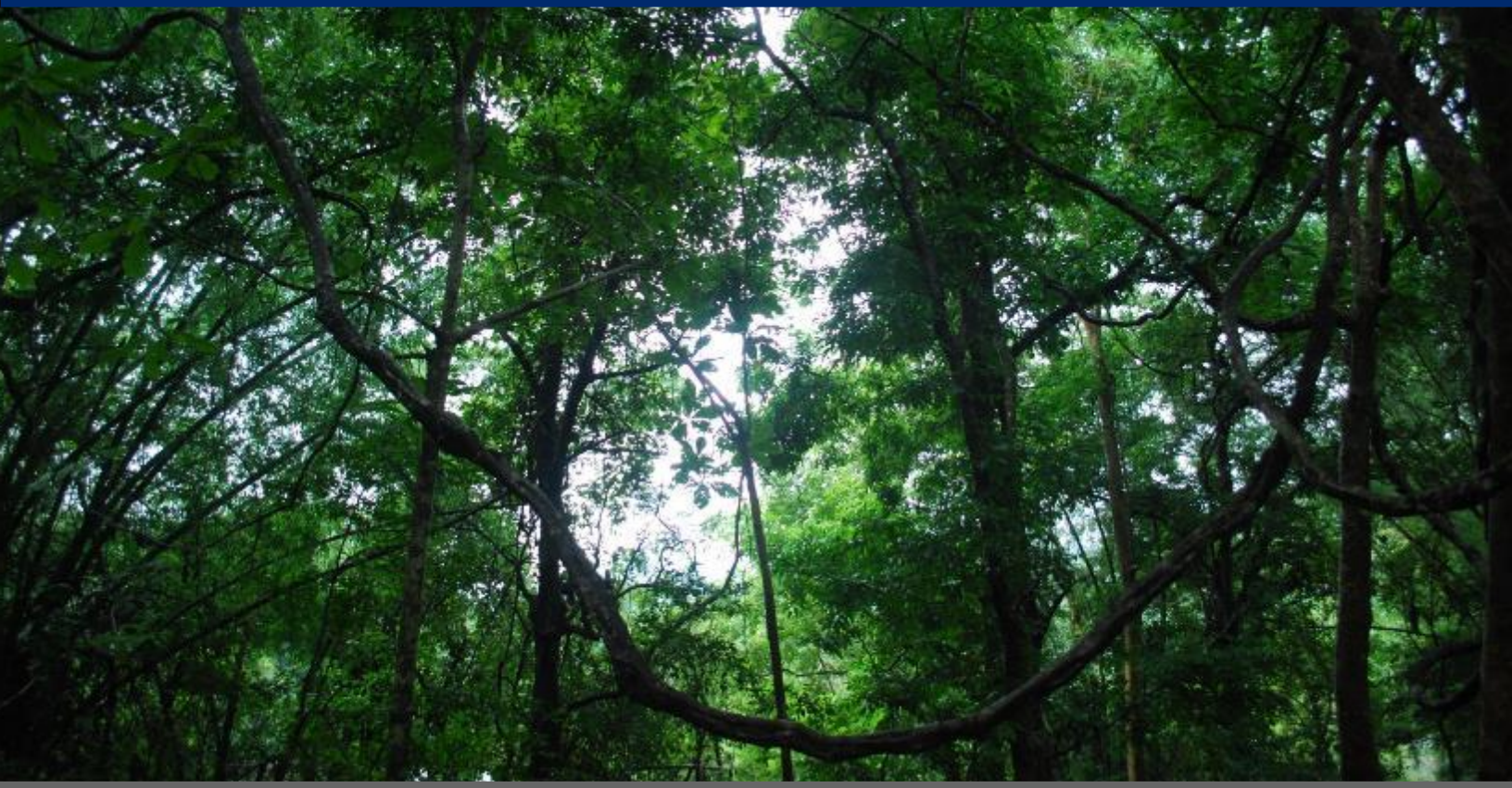
TRAINING MANUAL FOR SUSTAINABLE MANAGEMENT OF NON-TIMBER FOREST PRODUCTS IN HIMACHAL PRADESH LANDSCAPE



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PARTNERSHIP FOR LAND USE SCIENCE (Forest-PLUS) PROGRAM

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ACRONYMS AND ABBREVIATIONS

CAMP	Conservation Assessment and Management Prioritization
FRLHT	Foundation for Revitalization of Local Health Traditions
HP	Himachal Pradesh
IUCN	International Union for Conservation of Nature
JFMC	Joint Forest Management Committee
JFPM	Joint Forest Planning and Management
LF	Large Farmer
LL	Landless Person
NGO	Nongovernmental organization
NTFP	Non-timber forest product
PFM	Participatory forest management
PRI	Panchayati Raj Institutions
SF	Small Farmer
VFC	Village Forest Committee

1.0 INTRODUCTION

This non-timber forest product (NTFP) training manual provides guidance and instructions for assessment, sustainable harvesting, nursery development, cultivation, and post-harvest management of selected, high-altitude, Himalayan non-timber forest products (NTFPs). NTFP species at high altitude are valued highly and demanded in trade; however, these undergo the least enrichment, do not propagate at high rates, and are depleting fast from their natural habitat because of destructive harvesting, habitat degradation, and changing global climatic factors. The following NTFPs subjected to vigorous trade are sourced from temperate forest, which characterizes maximum area of Forest-PLUS landscape in Himachal Pradesh (HP): *Abies spectabilis* (Brahmi tallish), *Angelica glauca* (Chora), *Aconitum ferox* (Vachnag), *Aconitum heterophyllum* (Atis), *Berberis aristata* (Daruhaldi), *Bergenia ciliate* (Pashanbheda), *Cinnamomum tamala* (Tejpata), *Ephedra gerardiana* (Somlata), *Juniperous communis* (Hauber), *Jurinea macrocephala* (Dhoop), *Nardostachys grandiflora* (Jatamansi), *Onosma hispidum* (Ratanjot), *Parmelia perlata* (Chadila), *Picrorhiza kurroa* (Kutaki), *Pistacia integerrima* (Kakarsingi), *Rheum austral* (Reveandchini), *Rhodendron anthopogon* (Talish patra), *Swertia Chirayita* (Chirata), *Taxus wallichiana* (Talish), *Paris polyphylla/Trillium govanianum* (Nagchatri), *Valeriana jatamansi* (Mushkbala), *Viola pilosa* (Banafasha), and species of morels (*Morchella*-Guchhi).

As constituents of forest ecosystems, NTFPs are naturally affected by habitat degradation because of biotic pressure and climate change (e.g., collection of fuel and fodder, grazing, floods, forest fire, untimely snowfall, and storms). Articulating a general conclusion regarding impacts of climate change on NTFPs is difficult because of the large and diverse variety of NTFPs. Climate-related effects on NTFPs can range from positive to negative, indicating need to assess and predict those effects in order to develop adaptive strategies, protect multifunctional ecosystems, and ensure sustainability of livelihoods.

This manual provides a basis for sustainable production and management of these NTFPs in general, and focuses on conservation of five species of commercial importance, considering recent harvesting and trade of those species. This manual will benefit local people, forest department field officials, conservation organizations, and commercial traders. Development of the manual has been based primarily on experiences from hands-on training in implementation of the Forest-PLUS Program on NTFP at the field level, and work regarding these species within the last decade in HP. Hence, the manual should be useful to those who want to conserve and manage these important NTFPs as a part of their conservation and development tasks.

1.1 MANUAL OBJECTIVES

This manual is an outcome of both theoretical and practical experience, and provides a practical path and tool for establishment, development, management, and care of NTFPs in general and selected species in particular via sustainable harvesting and agro-technology; post-harvest management also is addressed. Major objectives of the manual are to provide and disseminate practical methods of (1) development and management of sustainable harvesting, (2) nursery development, (3) transplantation and (4) agro techniques regarding five species identified under Forest-PLUS Program intervention. Intent is to encourage NTFP collectors, local farmers, and

Forest Department field officials to enrich and domesticate these species in natural habitat, and to undertake *ex-situ* cultivation.

1.2 NTFP SCENARIO IN HIMACHAL PRADESH

NTFPs are very important bases of sustained rural livelihoods. Uses of NTFPs to satisfy domestic needs and as a source of cash returns to the poor population are well recognized. Plants yielding NTFPs number 1489 species out of 3500 species recorded in the state of HP. Of those 1489 species, 758 are typically temperate, while the remaining 731 are usually representative of subtropical to tropical areas.

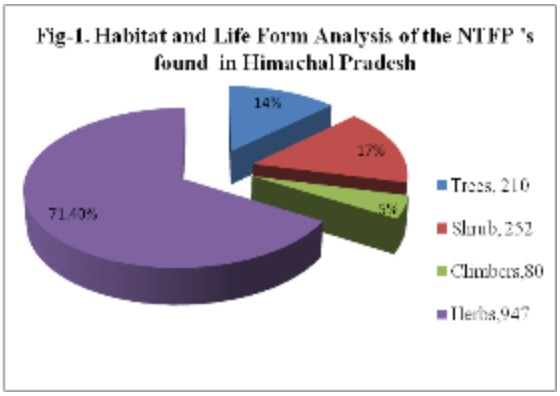


FIGURE 1: NTFP FOUND IN HP

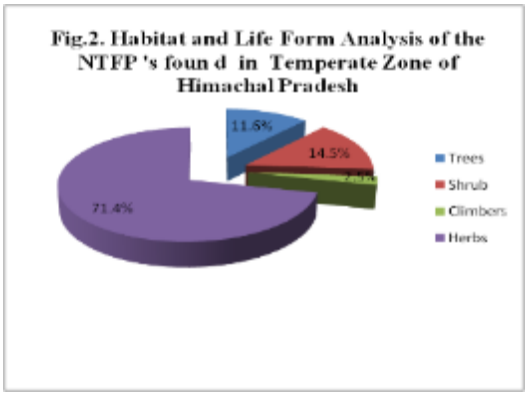


FIGURE 2: NTFP FOUND IN TEMPERATE ZONE OF HP

Further analysis of those 1489 NTFP-yielding species as to their habitats and life forms has revealed that 210 species (14%) are trees, 252 species (17%) are shrubs, 80 species (5%) are climbers, and 947 species (64%) are herbs (Figure 1). A similar habitat analysis of the subset of temperate species has revealed a still higher percentage of herbs (71.4%), and lower percentages of climbers (2.5%), trees (11.6%), and shrubs (14.5%) (Figure 2).

1.3 COMMUNITY DEPENDENCE ON NTFPS

Historically, communities residing within areas near forests depended on NTFPs in their day-to-day lives, and NTFPs were not commodities in the barter system for procuring necessary items not available locally. Subsequently, NTFPs became sources of income to people within the state. This is evident in the forest settlement reports of 1886 (Anderson Settlement Report. 1886). Local communities have been granted rights and privileges to harvest NTFPs. However, trade of listed NTFPs is regulated by “Transit Rules” whereby traders are obliged to apply for and obtain export permits after paying prescribed fees. Lately, the Panchayats have been vested with the power to grant trade permission and issue export permits regarding certain NTFPs. NTFPs, therefore, continue to exert significant influence on the lives of local people, especially those in rural communities.

1.4 CONSERVATION OF NTFPS

NTFP resources in the state, especially medicinal plants, are declining because of loss, degradation, or fragmentation of habitat; indiscriminate exploitation; and various anthropogenic

and developmental pressures. Evidences for this are declines in harvests of some species and subjective field assessments of species' population status by gatherers, traders, and forest field staff. The state government usually responds to this situation by temporarily banning collection of some species. For example, export of two species—Birmi (*Taxus wallichiana*) and Kashmal (*Berberis* spp.)—if collected from state forests, was terminated in 2001 for the ensuing five years.

A special exercise—Conservation Assessment and Management Prioritization (CAMP) Workshop—organized at Shimla during 2003, assessed conservation statuses of priority medicinal plants, a subset of the listed NTFPs of HP. The exercise revealed that 60 medicinal plant species of HP were facing various categories of threat as per International Union for Conservation of Nature (IUCN) guidelines and as compiled by a team of Foundation for Revitalisation of Local Health Traditions (FRLHT) Bangalore (Ved et al*.,* 2003). Twelve of these species have been assessed as "critically endangered," 21 species have been assessed as "endangered," and 27 species have been assessed as "vulnerable." During a CAMP workshop at Shimla in 2010 (with facilitation by FRLHT, Bangalore and HP Forest Department), statuses of 57 plants including most of those assessed in 2003 underwent scrutiny—11 species were categorized as critically endangered, 19 as endangered, 17 as vulnerable, and 5 near threatened; insufficient data were available regarding 1 plant, and 4 were not assessed. Details of plants with comparative threat statuses designated in 2003 and 2010 are listed in Annex 1**.**

1.5 CULTIVATION OF NTFP IN HIMACHAL PRADESH

Significantly varied agro-climatic conditions in HP render cultivation of many high-value NTFPs possible. The state has taken a lead in cultivation of some of the important NTFPs, and cultivated materials from these species satisfy a large part of national demand. However, initial high costs of cultivation, long gestation periods, and lack of assured marketing have restrained cultivation of many other promising species and limited activity in the state.

Some NTFPs cultivated in HP are Kuth (*Saussurea costus,*), Pushkarmool (*Inula racemosa*), Hops (*Humulus lupulus*), and Chuli (*Prunus americana*). In lower temperate areas, previous and current efforts have been exerted to cultivate species of Kutki, (*Picrorhiza kurroa*), Chirayita (*Swertia chiraiyta* and *Swertia cordata*), and Mushkbala (*Valeriana jatamansii*) to meet large industrial demands for these species.

2.0 NTFP RESOURCES AND MONITORING OF THESE

To develop any plan for sustainable management of NTFP resources in the region, the first task before management is to gain knowledge of statuses of the resources, regeneration, existing practices of harvesting, usage, seed production, and value addition. This section describes in detail techniques for participatory resource assessment and monitoring.

2.1 PARTICIPATORY RESOURCE ASSESSMENT TECHNIQUES FOR NTFPS

Harvesting of species affects associated species and patterns of vegetation in natural forests. Monitoring harvesting and extent of harvesting is important to assess statuses of species for conservation. Methodologies should be designed to implement appropriate changes in monitoring and develop options of mitigation in order to re-establish natural statuses of species along with associated biodiversity. Also required are institutional mechanisms to ensure regular, periodic monitoring—with provision of necessary training and monetary support.

In Rampur Forest Circle, the Forest-PLUS program demonstrated tools and techniques for sustainable harvesting and general development of NTFPs, with special reference to selected, high-value, high-volume trade in HP. Efforts have been exerted to compile these methods for demonstration and training in order to achieve sustainable harvesting and development of NTFPs.

The study suggests that development of participatory NTFP monitoring should involve local communities, village forest councils (VFCs), and Panchayati Raj Institutions (PRI). Otherwise, studies of impacts will be limited only to the project period. Moreover, effects of harvesting on conservation and regeneration of selected NTFPs or associated biodiversity can be measured for the short term and long term—institutional structures are needed to extend monitoring of impacts beyond the project period.

Methods of monitoring have evolved during this study, and a field manual has been designed that describes quantitative and qualitative measurements of effects of sustainable harvesting promoted by enabled community institutions at the grassroots level. Periodic monitoring should be facilitated by the Forest Department and other technical organizations.

Before embarking on monitoring, it is important to identify the following key bases for implementation of sustainable harvesting of selected NTFPs:

- Sustainable forest development: Conservation must accompany forest development to meet needs of the present and future, as well as aspirations of the community. Forests provide sustenance (fuel wood, fodder, NTFPs, and small timber), and confer non-tangible environmental benefits.
- Monitoring should thus proceed in a manner satisfying criteria associated with health of forests, people's perception and participation, environmental indicators, and economic viability.

- Sustained and effective participation of local community: Participatory monitoring should include assessment of effectiveness and extent of participation by the community, and strategies should be developed to promote sustained participation of the community in monitoring.

2.2 OBJECTIVES OF PARTICIPATORY RESOURCE ASSESSMENT

The primary objective is to promote scientific management of forests and NTFPs by local communities, followed by sustainable utilization of resources to generate livelihood and resource security. Other objectives include:

- Enabling the local community to monitor the forest, vegetation, and ecological, social, and economic issues of managing NTFPs at the VFC and forest beat level.
- Building institutional structures within the VFC, capacity within the local community, and frontline forest staff to equip scientific monitoring.
- Facilitating adaptive management of selected NTFPs to improve biodiversity and flow of products, and to motivate the local community and sustain its interest.

2.3 APPROACH FOR PARTICIPATORY NTFP MONITORING

Participatory monitoring is a tool for adaptive forest management. Community and frontline forest staff have engaged in the important activity of measuring effects of sustainable harvesting. Thus, yearly or 2-year monitoring is reasonable, depending on type of forest and human resources available. Monitoring could occur at two levels: the village community level, with minimal observations; and the Forest Department level, with more emphasis on size class distribution, change in species number, regenerative capacity, etc.

2.3.1 Monitoring of Institutional, Social, Ecological, and Economic Issues

- ***Institutional issues:*** Institutional issues directly or indirectly pertaining to monitoring include: (1) structure and function of VFC, forest divisions, and state- and national-level institutions; (2) membership of various institutions, particularly VFC; (3) effectiveness of participation of local communities and Forest Department; (4) factors contributing to participation of communities; (5) role of Forest Department, non-governmental organizations (NGO), and other institutions; and (6) activities to build capacity and institutions.
- ***Social issues:*** Social issues pertaining to monitoring could include: (1) impacts of collection of NTFPs on different social groups in the village; (2) factors contributing to the effective participation of women, landless people, and artisans; (3) leadership development and awareness generation; (4) sharing of costs (of protection) and benefits among different social groups; and (5) effects on quality of life.
- ***Ecological and silvicultural issues:*** Ecological and silvicultural issues pertaining to monitoring studies could include: (1) forest regeneration model or the approach adopted; (2) biodiversity status; (3) species of community, species actually planted; (4) silvicultural practices adopted; (5) rate of growth and biomass production; (6) NTFP species' regeneration; (7) sustainability of regeneration; (8) grazing and harvesting practices adopted and impacts on sustained production; (9) species choice and silvicultural practices to be adopted for sustaining flow of forest products, and (10j) impacts on soil and water resources of the village.

- ***Economic issues***: Economic issues could include: (1) investment and operational costs; (2) opportunity cost to communities for participation; (3) economic values of different products (grass, fuel wood, NTFPs, timber); (4) cost-benefit analysis; (5) economic indicators to promote community participation; and (6) cost-effectiveness of afforestation.

Establishment of institutional mechanisms for participatory NTFP monitoring at the village level enables the local community to monitor statuses of resources over a period, because monitoring has to be a dynamic and continuous process. The ideal institutions are Joint Forest Management Committees (JFMC) initiated under the Joint Forest Planning and Management (JFPM) program in HP. Suggestion is to create teams under VFCs to ensure monitoring, and to involve them in planning and management of resources based on the monitoring process.

2.4 STRATEGY FOR PARTICIPATORY NTFP RESOURCE ASSESSMENT

The rationale for developing resource assessment systems through participatory means is that it enables active involvement of local institutions and communities in proper management of forests. The Forest Department, PRIs, and local NGOs are expected to facilitate the process.

Any design for use of biological elements must incorporate a system sustainable in several senses—biologically, ecologically, economically, and socially appropriate. The basic idea behind monitoring is competent management and sustainable utilization of NTFP resources. Sustainable use has been defined as use of resources in a way and at a rate that do not lead to long-term decline of biological diversity, thereby maintaining potential of those resources to meet needs and aspirations of present and future generations.

The central strategy of this assessment is to focus on scientific management of forests by developing participatory steps. This includes local knowledge and understanding of resource management, which are essential for establishing viable participatory adaptive management.

2.5 GENERATION OF BASELINE INFORMATION FOR PLANNING AND MONITORING NTFPS

The prerequisite for monitoring resources over extended periods is generation of baseline data/information. Data acquired regarding ecological, social, personal, and economic parameters during the first year can be considered baseline information, to which monitoring data of subsequent years will be added to increase understanding of changes in improvement.

Continual comparisons of changes to original conditions is vital; again, the purpose of generating baseline data via monitoring is to provide direction for changes anticipated in adaptive management of forests and NTFPs.

Local frontline forest staff, PRIs, and NGOs collectively may have to convince local communities about the value of gathering baseline data. However, over the long term, local communities will recognize the usefulness of that information for checking progress.

During establishment of a baseline scenario, forest staff, PRIs, and NGOs can assume leadership in collection of relevant information, with the help of local communities and the Forest Department. It is essential to properly record and document data acquired via field investigation.

All possibly relevant information should be acquired, because it could have current or future implications. Documentation and sharing of such information with PRIs, VFCs, and the Forest Department is essential to establish its validity and role in future applications.

2.6 CAPACITY ENHANCEMENT FOR HUMAN RESOURCES FOR NTFP RESOURCE ASSESSMENT

- Sensitization of the village community

  PRIs and NGO, with active involvement of local staff of the Forest Department, can brief the community about the aim and importance of monitoring NTFPs, methodology to be adopted, and results of analysis of data. All aspects of monitoring should be explained to the community, with examples provided to increase understanding.

- Training

  VFCs, PRIs, frontline forest staff, and the community require training on techniques applied in NTFP monitoring. Simple parameters have to be selected for the purpose. Normally, villagers can identify almost all trees, shrubs, and herbs in their forests by local names. They are also knowledgeable about the economic importance of species, their usefulness, etc. However, they require minimal training and demonstration in recording these parameters and undertaking simple analysis. A team of at least 10 members, composed of representatives from different stakeholder groups and approved by the community and Forest Department, can be trained for an intensive monitoring process.

- Field Methods

  Standard ecological methods, and social and economic index method, can be adopted for studying various ecological, social-personal, and economic parameters. For example, regarding ecological monitoring, measurements of tree girth, height, regeneration status, etc., can be recorded. The number of quadrates and replicates can be based on the type of vegetation sampled.

- Relevance of Data and Analysis

  Success and performance of natural protection and plantations are important in this context. Various factors influence performance, such as protection, grazing, and fire. Changes in these must be recorded in terms of number of species, density, etc., to understand growth and development of plantations. This information also could help in adoption of suitable management strategies suitable to local needs and environment. Regarding socio-economic data, generation of baseline data will indicate performance/progress of social and economic development among VFC members and the village as a whole by reference to the socio-economic index. Table 1 lists steps involved in participatory assessment of NTFPs.

TABLE 1: DIFFERENT STEPS OF PARTICIPATORY NTFP ASSESSMENT PROCESS AT COMMUNITY LEVEL

Stage	Step	Objective/output	By whom
Pre-monitoring stage	Select VFC	A selected VFC for monitoring	Local NGO and Forest Department, PRIs
Stage I: Constitution of monitoring team	VFC meeting	To explain purpose and process of participatory NTFP monitoring at VFC level To prepare adaptive management plan for selected NTFPs	Local NGO with Forest Department, PRIs
	Stakeholder group meeting	To select representatives for the team	VFC and Forest Department, PRIs
	Participatory Forest Management (PFM) team meeting	To train for monitoring process To monitor, document, and analyze	Local NGO and monitoring team, PRIs
Stage II: Generation of baseline data/information	Forest, vegetation, and ecology related	To understand vegetation status To prepare forest management plan	Monitoring team and VFC
Stage III: Monitoring of parameters	Field measurements	To arrive at quantity and quality of data	Monitoring team
	Recording	To use for present and future reference	Monitoring team and VFC
	Analysis	Interpretation of data	Monitoring team and VFC
Stage IV: Decision making process and adaptive management	Team meeting	To prepare inputs for decision making process	Monitoring team
	VFC meeting	To discuss and consider inputs for adaptive management of forest	Monitoring team, VFC, Forest Department. PRIs, and local NGO

2.7 QUANTIFICATION TECHNIQUES FOR NTFPS

- Transact walk

  The transact walk can be carried out by community members, PRIs, representatives, and forest department staff members to discern the present status of the forest/NTFPs. During the transact walk, different plant species, water storage structures, paths, plantations created, cultural properties, etc., will be identified. The important NTFP species will also be identified.

TABLE 2: OBSERVATIONS DURING TRANSACT WALK

Issues for monitoring	Observations in the field
Landscape and land use pattern	
Forest patches and vegetation status	
List of trees/NTFPs	
List of NTFP shrubs and herbs	
Animals and birds	
Water bodies, tanks, and rivers	
Watershed area, check dams, etc.	

- Trend analysis map (NTFP species present in previous and current status):

  Assess condition of NTFPs in the village by having trend data:

  Name of the forest patch:

  Approximate area:

  Local name of the patch:

TABLE 3: HISTORY AND CURRENT CONDITION

25 years ago	10 years ago	Current status

- Quadrate sample technique

  During the transact walk, the NTFP collection area will be identified for laying out quadrates to measure biophysical and biodiversity parameters of selected NTFPs.

  Technique of sampling: Plot will be selected where selected NTFPs are collected

  Technique: Quadrate technique

  Area:

  25 x 25 meters: Matured trees

  5 x 5 meters: Regenerating trees

  1 x 1 meter: Seedlings

FIGURE 3: MODEL OF QUADRATE SAMPLING TECHNIQUE

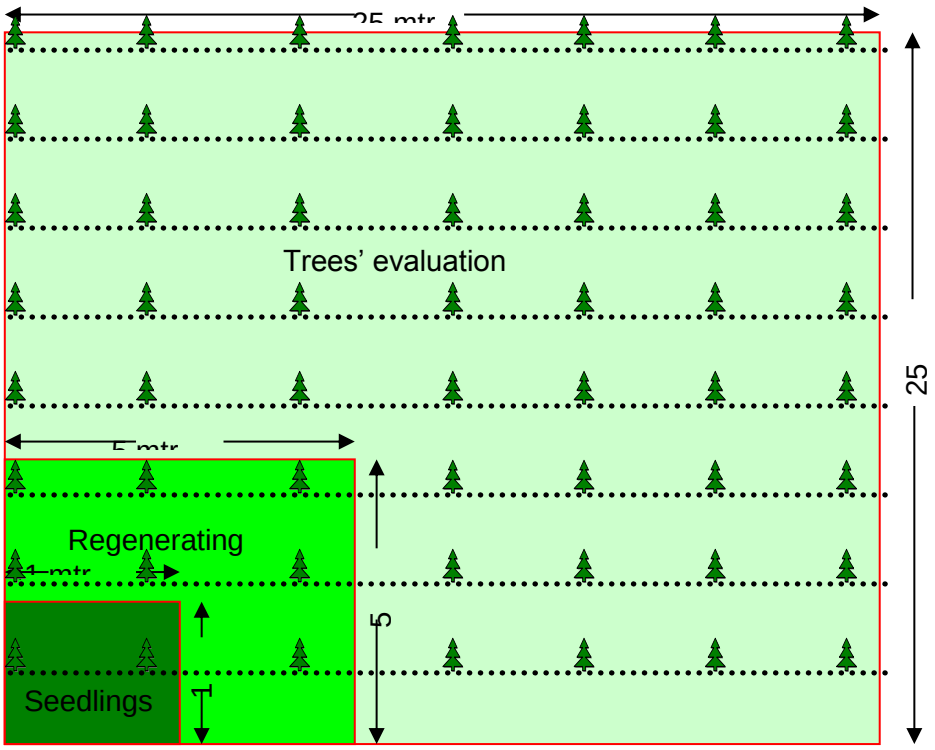


TABLE 4: ENUMERATION OF SELECTED NTFP SPECIES

Sample (Sl) number	Name of selected NTFPs	Height (meters [m])	Girth (centimeters [cm])	Remarks
1.				
2.				
3.				

TABLE 5: ENUMERATION OF ASSOCIATED HERBAL SPECIES OF NTFPS

Sl number	Name of species	Remarks
1.		
2.		
3.		
4.		
5.		

TABLE 6: REGENERATION OF SELECTED NTFP SPECIES

Sl number	Name of species	Number in each quadrate	Remarks
1.			
2.			
3.			

Quantification of data:

TABLE 7: QUANTIFICATION OF MATURE NTFP TREE SPECIES

Sl number	Name of species	Height (m.)			Girth (cm.)		
		Max.	Min.	Avg.	Max.	Min.	Avg.
1.							
2.							
3.							

TABLE 8: QUANTIFICATION OF HERBAL NTFPS SPECIES

Sl number	Name of species	Number
1.		
2.		
3.		

TABLE 9: QUANTIFICATION OF SHRUB NTFPS SPECIES

Sl number	Name of species	Number
1.		
2.		
3.		

2.8 MEASURING BIOPHYSICAL AND BIODIVERSITY INFORMATION REGARDING SELECTED NTFPS SPECIES

2.8.1 Indicators for biophysical and biodiversity information

- Species diversity and density—across plots for NTFP species
- Species survival and growth rate
- Current use of resource and its economic value
- Demand and supply status of forest resources with future projects
- Regeneration status
- Biodiversity associated with selected NTFP species.

2.8.2 Indicators for conservation and maintenance of selected NTFPs and biodiversity

- Growth of trees, flowering, and fruiting

- Improved species richness and density
- Improved harvest methods
- Natural regeneration status
- Rainfall
- Extent of weeds, pests, diseases, grazing, fire, etc.
- Availability of food to animals and birds
- Change in number of trees planted on private lands
- Community composting
- Improvement of family economic conditions and quality of life
- Continuous availability of NTFP produce
- Increased employment opportunities
- Increase in availability of NTFPs for sustenance and sale.

2.8.3 Format for Collection of Baseline Data/Information

TABLE 10: FOREST TYPES

Forest class	Area (hectares [ha])	Plantation, if any
Natural forest		
Reserve forest		
Area under JFPM		
Area under FDA		

TABLE 11: AFFORESTATION UNDER DIFFERENT LANDS

Scheme and model of the plantation	Year	Area	Species
Enrichment plantation			
Natural protection			
Fuel wood plantation			
NTFP plantation			
Multipurpose plantation			

TABLE 12: COLLECTION OF NTFP RESOURCES IN THE VILLAGE

Resource/stakeholder group	Number of families collecting	Quantity gathered (per family in kilograms [kg])	Frequency	Season of collection
NTFPs 1. LF 2. SF 3. LL 4. Women & children				

Notes:

LF Large farmers
SF Small farmers
LL Landless people

TABLE 13: NTFPS RESOURCE NEEDS MET (% COLLECTION TO MEET THE VILLAGE NEEDS)

	Forests	Agricultural lands	Plantations	Buy from market
NTFPs 1. 2. 3. 4. 5.				

TABLE 14: NTFPS RESOURCE BASE

	Area	Dominant species
Natural forest (area)		
Plantation I (area)		
Plantation II (area)		
Plantation IIII (area)		

TABLE 15: STATUS OF NTFP RESOURCES (NATURAL FORESTS AND PLANTATIONS)

Density of forest	Area	Dominant species	NTFPs extracted			
			NTFP 1	NTFP 2	NTFP 3	NTFP 4
Natural forest						
Dense forest						
Moderately dense						
Open forest						
Degraded forest						
Plantations						
Plantation 1						
Plantation 2						
Plantation 3						
Plantation 4						

3.0 EX-SITU AND IN-SITU PROPAGATION TECHNIQUES FOR SELECTED NTFPS

Selected species of NTFP's are high in demand and collected from their natural habitats in the Himalayan region for trade and industrial utilization. Long life cycles of these species ranging from 3-4 years is a major constraint to cultivation of them. NTFP collectors have observed these plants growing in nature only, and no research and development organization or institute has demonstrated successful *ex situ* propagation of these species. Sustainable harvesting can be achieved either through effective control on harvesting or large-scale *ex-situ* propagation for commercial utilization. Therefore, efforts should include techniques for *ex-situ* propagation of these species involving harvesters in nursery and agriculture fields to augment supply of selected species.

3.1 ACONITUM HETEROPHYLLUM LINN

Common Name: Atees, Patish, Ativisha, Shuklakanda, Indian Atees

3.1.1 Habit and habitat

Aconitum heterophyllum is found on slopes at altitudes between 3000 and 4000 meters in alpine regions of the Himalayas. Plant has erect stem with few or no branches. Leaves are more or less heteromorphous and glabrous. Inflorescence is a slender raceme. Seeds are black or dark brown obpyramidal in shape. Roots are biennial, paired, and tuberous. Product graded on the basis of root, which can be white, yellow, red, or black—white variety is preferred in trade and is of high value. Photograph 1 shows plant of *Aconitum heterophyllum*.

PHOTOGRAPH 1: *ACONITUM HETEROPHYLLUM*

3.1.2 Active ingredients and uses

Aconitum heterophyllum tubers contain a non-crystalline, non-toxic alkaloid atisine, dehydrosatisine, heteratisine and hetusube, aconitic acid, tannic acid, pectin, and starch. Nonpoisonous, antiperiodic, anti-inflammatory, astringent used for cough, diarrhea, dyspepsia, tonic (used after fevers), febrifuge, antispasmodic (used in irritability of stomach and abdominal pains). Aconitic acid; tannic acid; and a mixture of oleic, palmitic, stearic glycerides, and vegetable mucilage are also present in addition to starch and sugars. The tuber is used as febrifuge especially for poisoning from scorpion or snakebite and fever from contagious

diseases. *Aconitum heterophyllum* tubers are also used in many Ayurvedic preparations, some of which include Mahasudarsan Churna, Chandraprabha bati, Yograj Gullulu, Majun Bawasir, and Majun Yograj Guggulu used to control many human ailments.

3.1.3 Seed production

Aconitum heterophyllum life cycle is complex, as survival of seedlings is very poor, and until plant maturation in the third year, only few plants survive—rendering survival of this species vulnerable. The plant grows in vegetative phase for 3-4 years, and flowers in the fourth year. Until this stage, maximum mortality of plants occurs year after year. In the third or fourth year, some plants take lead in spring season with rapid growth of leaf and bolting. Growth is reduced after 2-3 months, and flowers start appearing in August. Growth stops with seed setting in September, which mature in October. Follicle containing seeds can be collected in October and November. Seeds germinate immediately after harvest under suitable environmental conditions of moisture in soil. Seeds stored at room temperature germinate during the first 7 months of storage, and subsequently lose viability (i.e., capacity to geminate) due to increase in temperature. Seeds stored at low temperature in a refrigerator at 4 degrees Celsius (^{o}C), however, retain viability throughout the year.

3.1.4 Agro-techniques

Propagation

Aconitum heterophyllum is propagated mainly through seed. In some studies, multiplication through tuber and stem cuttings is also explained, but these methods are not suitable in the field for large-scale propagation.

Soil Requirements

Aconitum heterophyllum is native of temperate and cold climate. Germination and growth of this plant are favored in sandy soil with rich organic matter. Addition of broad-leaf species litter is necessary to maintain moisture and porosity of soil. Fields must be well ploughed following removal of unwanted roots and debris. Spread layer of 300-400 kg of vermin-compost prepared from animal excreta per Bigha (12.5 *Bigha* = 1 ha) in the field to increase organic carbon level and render soil porous. Addition of forest litter is recommended to further achieve these soil characteristics. Mix the vermicompost and litter thoroughly either by ploughing or digging manually with hand tools. Make raised beds 150 cm width with deep passage on both sides for

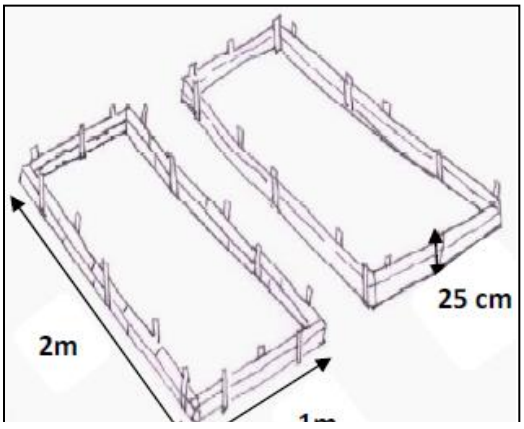


FIGURE 4: WOOD SIDINGS BEDS IN NURSERY

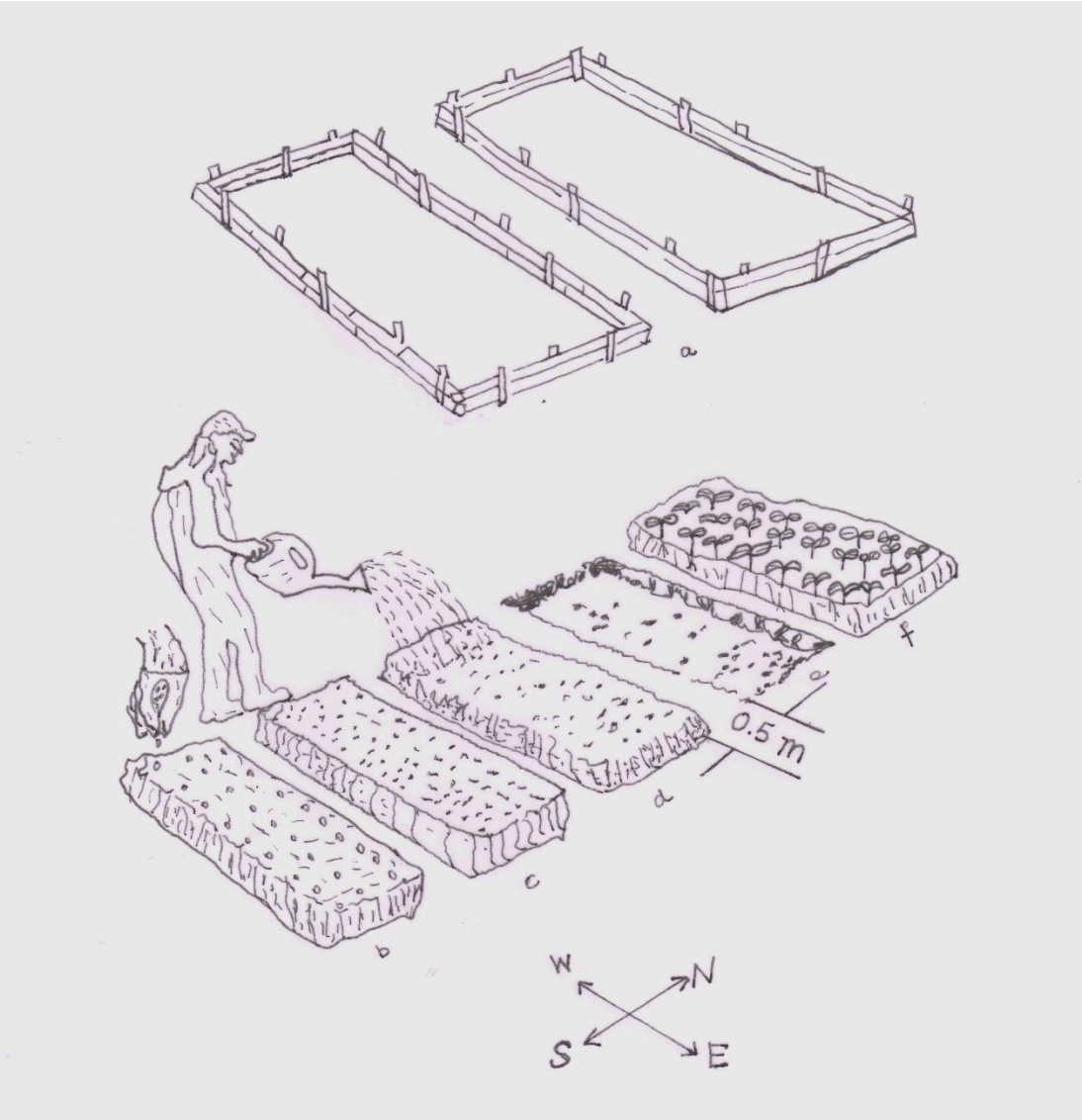
FIGURE 5: ILLUSTRATION OF WOOD SIDINGS BED

drainage of excess water and access for weeding and compost addition in later stages. Beds can also be made with wood sidings, as shown on Figures 4 and Figure 5 for germination of seeds and first year planting.

Time of seed sowing

Aconitum heterophyllum seeds germinate immediately after harvest under suitable environmental conditions such as soil moisture around 50% and soil temperature of about 10-12 ^{o}C, and are free of dormancy. Seeds germinate well after sowing in December in polyhouse in lower altitude to advance growing. In open, seeds are sown in April (after snow melting) in soil beds or beds with wood sidings (Figures 4 and 5). Germination of seeds outside poly-house is very low. Seed remains in initial form of two-leaf stage technically called cotyledonary stage for the first year, and growth is quite slow.

FIGURE 6: TECHNIQUES OF SEED SOWING, WATERING, AND GERMINATION IN RAISED NURSERY BED



Planting seedlings in the field out of the germination bed in the first year results in heavy mortality and is not advised. Seedlings should be shifted from germination bed to plantation in the third year, when leaf stage has arrived. When transport of a seedling occurs, necessary for its survival is to uproot it by use of a digging tool around the seedling with minimal damage to the roots, and lifting the seedling by use of a soil block. The planting site must have been prepared prior to uprooting of seedlings, and uprooted seedlings must be planted and irrigated immediately.

Tuber planting

Aconitum heterophyllum propagation through tuber top segmentation with growing bud has been found more successful, but availability of tubers for planting is limited. Tubers with top segment having growing bud are planted in nursery polybags filled with mixture of vermin-compost, sand, and forest soil (1:1:1), or in soil beds (prepared as explained earlier) in the field at a distance of 30 cm with regular irrigation in April-May (very successful). Top tuber segments with buds are collected during harvesting of mature tubers in November-December. Top tuber segment is removed with knife and planted in field or poly-house bed, and sprouts at onset of spring in April-May in the field at altitude of 2200 meters. In poly-house, this sprouts early in March and is planted in the field during rainy season.

Aconitum heterophyllum propagation through young stem cuttings at higher altitudes is described, but is not as successful as vegetative multiplication through tuber top with bud and seed multiplication. Vegetative growth phase lasts for 3 to 4 years before leading to the reproductive phase. Vegetative propagation is most suitable for propagation of this important Himalayan medicinal plant

Planting density

Aconitum heterophyllum seedling in leaf stage after one year or plants produced from tuber top planting are planted in the field, which has been prepared with addition of vermincompost and litter addition in the rainy season (July-August). Plants are planted at a distance of 30 cm, providing sufficient space for each plant for weeding and compost addition during 3-4 years. Planting of seedling in the first year at cotyledonary stage is not successful, and mortality is quite high.

Nutrient requirement

Aconitum heterophyllum cultivation requires high concentration of organic matter (3-5% in soil) and vermicompost (4000-5000 kg/ha) addition is recommended prior to planting or during rainy season in a 5- to 6-cm-deep trench around the plant. Soils containing good organic matter support higher seedling survival, growth, and yield. Addition of vermin-compost (2000-3000 kg/ha) or litter manure in the same proportion during the second and third years of plantation is recommended during months of July-August and November-December.

Irrigation and weed control

Aconitum heterophyllum needs high irrigation for survival of seedlings. Irrigation once in 24 hours is necessary in dry season, and in some fields irrigation is required even during rainy season. Water logging damages the plant root system and encourages development of leaf diseases, and hence should be avoided with proper drainage system in the field. Excessive moisture in the field from irrigation favors growth of weeds; and weeding occurs in weekly intervals. Excess growth of weeds turns the seedling leaves yellow because of nutrient

deficiency, and hinders normal plant growth. Timely weeding schedule is the remedy to facilitate proper plant growth and healthy looking leaves with green silvery luster.

Maturity and harvesting

Aconitum heterophyllum completes reproductive phase in the third or fourth year. Seed maturation is indicative of this stage. This stage at high altitude occurs in October. Mature follicles with seed are collected before harvesting of tuber for further multiplication. Roots are harvested via digging and uprooting of dry plants to extract tubers. This is also the period for removal of tuber top with crown for immediate plantation in the poly-house or field for future growth of the plant. The seedling is harvested in the fourth year. However, plants produced from tuber top via vegetative propagation complete their life-cycles in three years.

Best period of harvesting

Aconitum heterophyllum active ingredients maximize in concentration during July-August at the flowering stage. Harvesting at this stage will reduce availability of seed and germplasm for future growing. Therefore, harvesting is recommended after seed maturation in October only.

Crop production and commercial viability

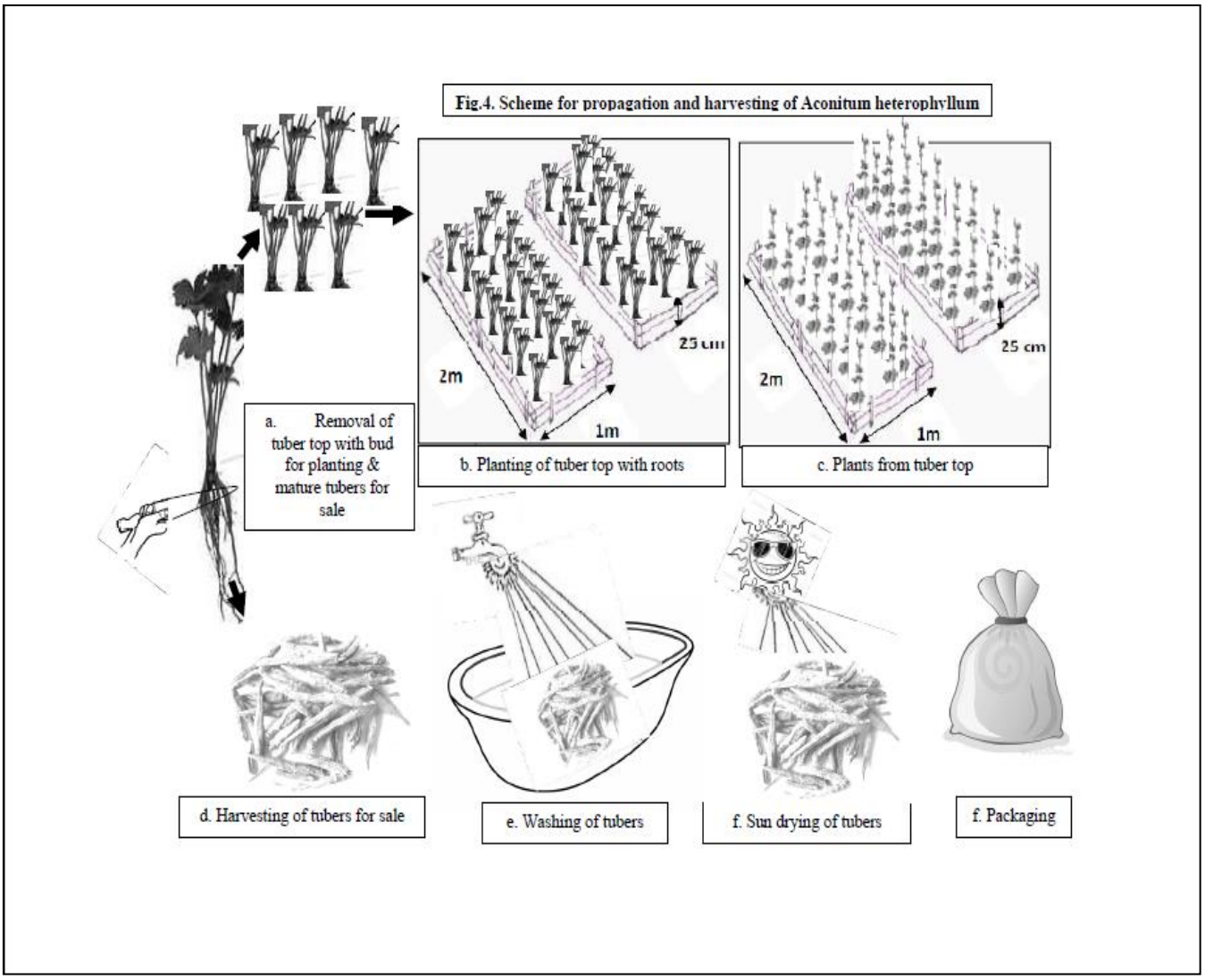
Aconitum heterophyllum production is difficult, and the plant requires a long period of 3-5 years to mature. This long duration and high mortality of 40-50% in open fields during the growing period render cultivation by farmers unviable. Studies in Uttarakhand suggest easy and successful cultivation in poly-house with high yield and commercial viability, but cultivation of the species on a commercial scale is yet to occur. Some studies project that monoculture of the species within approximately *5 bigha* (equivalent to 1 acre) will yield around 50 kg of dry roots. After establishment of first crop either from seeds or vegetative multiplication, successive crop management from apical segment or tuber top becomes easier and helps establish an annual harvesting cycle.

PHOTOGRAPH 2: DRY ROOTS OF ACONITUM HETEROPHYLLUM

Post-harvest management

Aconitum heterophyllum tubers should be washed thoroughly to remove soil particles. Tubers of different size and color should be separated, and kept for drying in diffuse sunlight. Drying in oven or direct sunlight reduces active contents of the tuber and thus efficacy of the formulation. Dried tubers are packed in gunny bags or cotton bags for marketing, and are stored under cold conditions. Complete details of the post-harvest activities are appear on Figure 7.

FIGURE 7: STEPS FOR PROPAGATION AND HARVESTING OF ACONITUM HETEROPHYLLUM



3.2 PROFILE OF *ANGELICA GLAUCA* EDGEW

Common Name: Smooth Angelica, Himalayan Angelica, Chorak, Gandhrayan, Chora

3.2.1 Habit and habitat

Angelica glauca is found in moist and shady alpine scrub and forest fringes between 2700 and 3400 meters elevation in the Indian Himalayas. It is an aromatic perennial or biennial herb with 3-6 feet plant height. Leaves 1-3 pinnate, ovateor lanceolate. Flowers white, yellowish, or purple in color, and the inflorescence compound umbel. Stem is hollow and roots are tuberous. Photograph of aneglica glauca is shown in Figure 8.

FIGURE 8: PLANT OF ANGELICA GLUACA

3.2.2 Active ingredients and uses

Angelica glauca roots contain volatile oil, valeric acid, angelic acid, and angelisine resin. Roots used as spice and also for flavoring confectionery, as well as liquors. Roots are used as a drug for gastric pains. They are stomachic, carminative, and stimulant, and are also useful in treatments for dyspepsia, anorexia, spasms, flatulent colic, and bronchitis. The leaves and stem of the plant are also used as stimulant and a cordial. Figure 8 shows different parts of *A. glauca*.

3.2.3 Seed and production

Angelica glauca seeds mature in September-October and are sown immediately after maturation. Good seed germination occurs in deep soil rich in organic matter and partial shade.

3.2.4 Agro-technology

Propagation

Angelica glauca multiplication is via seeds and occasionally through planting of root segments.

Soil requirements

Angelica glauca is a native of cool and temperate climate, and oil content development depends on the climate where it grows. Altitude between 2000-2500 meters is suitable for cultivation of this species. Deep soil rich in organic matter is suitable for growth of this species. Cultivation fields and nursery beds are prepared with heavy addition of vermin-compost 5000-6000 kg/ acre, or a similar quantity of sheep and goat manure may be applied in absence of vermin-compost.

Time of seed sowing

Angelica glauca seeds are sown immediately after harvesting during November and December. Viability of seed is very low, and immature seeds have better germination potential than mature seeds. Seeds germinate in 25-30 days. Germination is better in poly-house than open fields. Seedlings are transplanted from nursery after 6 months during rainy season to the plantation field at a distance of 60 cm. In irrigated fields, transplanting can also occur during month of May. Crop produced from seeds matures in three years. Photograph 3 shows cultivation of Angelica gluaca.

PHOTOGRAPH 3: ANGELICA GLAUCA

Root planting

Angelica glauca vegetative propagation through root cuttings is also very successful. Root apical portion is planted at 45-60 cm distances during the rainy season, as for *P. polyphylla* and *Aconitum heterophyllum*. Collection of apical root portions is also carried out after harvesting of the crop, and these are planted in poly-house or field immediately. In the following spring season, apical root cuttings sprout to grow as plants, and can be planted in the fields during April-May or during rainy season. Crop produced from root planting is ready for harvesting in 2 years.

Planting density

Angelica glauca is cultivated by broadcast sowing or planting of plants raised in nursery from seeds or root top segments. An estimated 2-3 kg of seed is required for sowing of 1 acre. Sowing of seeds occurs in raised beds. Nursery-raised plants are also planted in raised beds at a distance of 60 cm.

Nutrient requirement

Angelica glauca roots are large and require high concentration of nutrition. Therefore, around 5000-7000 kg vermin-compost or sheep and goat manure is added to the fields for cultivation of this species. Addition of manure occurs prior to planting and completion of annual growth phase in winter. Altitude of 2000-2500 meters is suitable for achieving quality production and successful growing.

Irrigation and weed control

Angelica glauca plantation is irrigated 2-3 times a week during the dry season. Cleaning weeds from the field occurs per requirement or once a month. Soil must be kept loose, and earthwork occurs once every month during the rainy season and every 2 to 3 months during the dry season.

Best period of harvesting

Angelica glauca harvesting in cultivated fields occurs within 2-3 years. Seed maturation is completed in October, and harvesting of roots can be carried out at this stage.

Crop production commercial viability

Angelica glauca collection is mainly from natural habitat except for few experiments in nurseries and cultivation trials. This is a popular condiment in tribal districts of HP for flavoring of food. Cultivation studies carried out in Uttarakhand estimated production of 500-600 kg/ha.

Post-harvest management

Angelica glauca roots are harvested as drug for trade and for use as condiment. Apical portion of the root should be removed at the time of harvesting for immediate planting to start next crop. Remaining roots are to be washed with clean running water to remove adhering soil. Spread washed roots on pucca clean floor or on cloth sheet. Cut roots into small pieces to dry, otherwise the roots will rot from the center with reduction in quality. Pieces of roots are dried in shade and stored in gunny bags or cloth bags for marketing.

3.3 PROFILE OF PARIS POLYPHYLLA SM.

Common Name: Naagchatri

3.3.1 Habit and habitat

Paris polyphylla is found throughout Asiatic countries, especially in the Southeastern hemisphere. Good population of the species is also reported in HP. It also occurs in Eurasian countries and can be grown in a variety of gardens throughout the world. It grows at an altitude of 2800 to 3300 meters, and blooms well in places with moist, humus-rich soil under partial or full forest canopy.

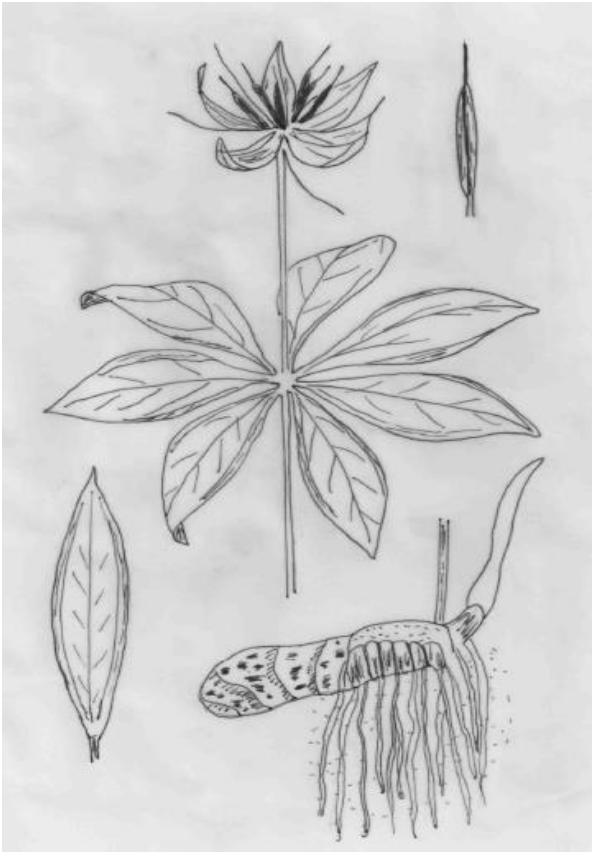
3.3.2 Active ingredients and uses

Paris polyphylla rhizome contains a glucoside, alpha-paristyphnin, which exerts depressant action on carotid pressure, myocardium, and respiratory movements. Figure 9 is a diagram of different parts of *Paris polyphylla.*

3.3.3 Seed production

*Paris polyphylla s*eed setting starts during rainy season in July-August and matures in

FIGURE 9: PARIS POLYPHYLLA



September. Clean the seed by removing the outer coat of the seed. Dry seed in defused sunlight for 2-3 days before storage. Immature seed will look wrinkled and separated them from viable seeds. Seeds must be stored in the air tight vials in dark away from sunlight. *Paris polyphylla* is slow germinating plant. Seeds take about 6-7 months to germinate. Seeds remain viable for a year, therefore, seeds collected the previous year are sown in the following season. Photograph 8 shows seed production stage of *Paris polyphylla.*

PHOTOGRAPH 4: SEED PRODUCTION FROM PARIS POLYPHYLLA

3.3.4 Agro-technology

Propagation

Paris polyphylla multiplication is by seeds and through planting of rhizome with growing bud.

Soil requirements

Studies of *Paris polyphylla* artificial regeneration and cultivation are limited. This grows well in soils with pH range of 5.6-7.5—slightly acidic to neutral soils. The plant prefers sandy and loamy soils. The plant requires moist, humus-rich soil and thus regular watering is essential to maintain soil moisture. Polyhouse and nursery-raised beds are prepared with a mixture of forest soil, sand, and vermicompost (1:1:1). Bulbs are fleshy and thick, and require rich nutrient soil for development and growth of the plant.

Time of seed sowing

Paris polyphylla seeds are sown in a small hole or harrow (deep line) not more than 1.25 cm deep on the raised nursery bed. Place overnight soaked seed in the hole or harrow gently. Keep seed-to-seed distance about 2-5 cm, and row-to-row distance about 10 cm. Seeds can be also be planted in nursery polybags, which are easy to transfer without damage and survive better after transplanting. Seed sowing occurs either in September immediately after seed collection or in January and February. The seedbed is mulched with a thin layer of about 5-cm-thick forest litter or dry grass. Irrigate bed 2-3 times a day to maintain the requisite moisture level in the bed for seed germination. Provide shade to the seed bed as soon as the seeds are sown and the seedbed is mulched. Plant is shade loving, and shading is required for growth and protection of the seedbed from heavy rain, direct sunlight, hailstorms, frost, etc. Provide shade using locally available wood, bamboo, straw, or plastic sheet or thin thatch roof of grass at 5-6 feet height to allow comfortable working in seedbeds. Seeds start germination in 6-7 months after sowing.

Rhizome planting

Paris polyphylla propagates efficiently with underground rhizomes, and this process is more prolific than propagation from seeds. Cut the rhizomes into small pieces, ensuring that growing buds are present in each piece. These rhizomes are then planted directly in the prepared field or grown in polybags during the dormant winter season. Keep rhizome to rhizome distance about 20 cm and row to row distance 30-60 cm. Leaves come out after 3 to 4 months when temperature starts rising in spring following snow melt.

Planting density

Paris polyphylla 1-year-old seedlings are ready for transplanting in the field. May-June is the best time for planting in the field. Plant the seedlings on the 5- to 10-cm raised beds in the field.

Plant to plant distance must be about 20-30 cm, while row-to-row distance must be 60 cm. Water the planted area immediately after planting. Planting in the afternoon leads to better survival of plants than planting in the morning.

Nutrient requirement

Paris polyphylla is a tuberous crop and needs high levels of nutrients for proper growth. Vermicompost or properly digested dung manure is applied in sufficient quantities to maintain soil fertility. Apply 4000-5000 kg vermin-compost or manure at the time of field preparation for planting, and annually apply 1000 kg during February-March around growing plants in a trench to maintain plant growth and vigor.

Irrigation and weed control

Paris polyphylla requires high moisture content, so water the plant two to three times after transplantation in summer season. Water logging for long duration yellows plants and can result in plant mortality; thus provide proper drainage. High moisture encourages growth of weeds in the fields, and during initial planting, weeding should occur every 15 days or as per requirement. After rainy season, conduct weeding once a month. Weeds deplete soil nutrition, resulting in failure of rhizomes to achieve desired weight.

Maturity and best harvesting

The seed of *Paris polyphylla* matures in September, marking the end of growing season. In most cases, aerial parts of the plant dry until this time, and in forests, it is difficult to locate the underground rhizome. But conditions in cultivated fields or nursery differ. Dig out the rhizomes after harvesting and collect the fruit and seed. Remove the apical part of the rhizome with growing buds, and plant in the nursery bed or polybags for further plantation. The remaining bulbs is kept for use as a drug component.

Best period of harvesting

For *Paris polyphylla*, the best harvesting period as per tradition is the twentieth day of the Bhadra month of the Hindu calendar, which falls in mid September. Supposedly, this is the time when maximum concentrations of the secondary metabolites are in the rhizomes. This plant has very limited use in human medicines, but was very popular for treating ailments in livestock. Households with large numbers of livestock previously marked plants in the forests to trace rhizomes on the day of collection, as no aerial parts exist on this day of collection.

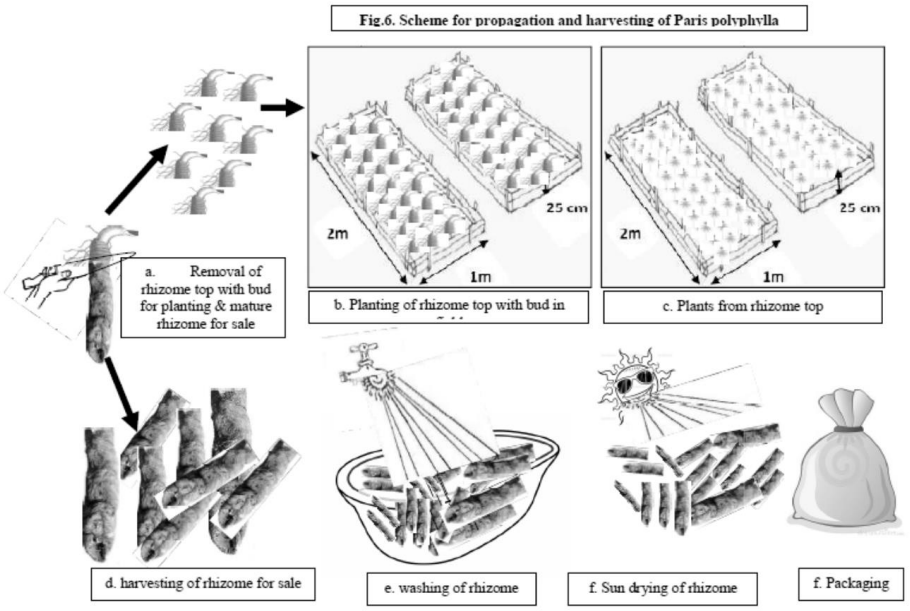
Crop production commercial viability

The only cultivation of *Paris polyphylla* in HP occurs in some experimental plots set up from time to time by specific workers. Reportedly, the plant is cultivated in Nepal and is consumed as vegetable. Market demand for the plant is limited, and sale is as mixture with rhizomes of Trillium govanianum.

Post-harvest management

Paris polyphylla rhizomes are washed with clean water to remove soil and debris. Rhizomes are dried in shade for 4-5 days and stored in gunny or cotton bags for household use or sale in the market, as shown in Figure 10.

FIGURE 10: HARVESTING AND SEMI PROCESSING OF *PARIS POLYPHYLLA* RHYZOMES



3.4 PROFILE OF PICRORHIZA KUROOA ROYAL EX BENTH

Common Name: Karu, Kutki, Picrorhiza

3.4.1 Habit and habitat

This is a perennial herb with creeping stolon (side branch with nodes having roots on lower side in contact with soil) found between 3000-5000 meters Plant has radical leaves with sharply serrate margins. Flower is light purple or pale white in dense terminal spicate raceme (cluster of flowers around the central stem) (see Figure 11). Fruit is avoid capsule. It is generally found near moist rocks or on sides of flowing springs, or below moist canopy of high-altitude broadleaf species such as *Quercus semecarpifolia* and *Rhododendron campanulatum* between 3000- 45000 meters.

FIGURE 11: DIFFERENT PARTS OF *PICRORHIZA KUROOA*

3.4.2 Active ingredients and uses

The roots yield a glycosidal bitter principle, kutkin, found to be a mixture of two iridoid glycosides, picrosideI and kutkoside. Also obtained were D-mannitol, kutkiol, kutkistero l and a ketone (identical with apocynin). Picroliv, a standardized fraction from the alcoholic extract of the root and rhizome, is a mixture of picroside I and kutkoside. Cucurbitacin glycosides, isolated from the

root, exhibit liver protective, tumor inhibitory, and anti-inflammatory activity. Photograph 5 shows different parts of *Picrorhiza kurooa*.

3.4.3 Seed production

Seeds of *Picrorhiza kurooa* are quite delicate without seed, coat and it is very difficult to collect and visualize seeds in the capsule. Special practice is required to harvest mature fruits and extract seeds from fruit capsules. Harvested fruits must be collected and stored in transparent polypropylene bags for drying in shade. Crush capsules gently in the bags to remove outer covering and remove outer broken capsule shells and spongy, minute, irregular seeds visible in the bags. Each plant contains an average 10-12 capsules with 200-300 seeds in each. Plants growing in dry areas with maximum exposure to sun will have capsules either without seeds or with less number of seeds. Seeds have limited viability of 1-2 months, but can be stored for longer time at low temperature (4-6 ^{o}C) under dry conditions that can be achieved by packing seeds in polypropylene bags stored in a refrigerator until sowing. Photograph 11 shows the seed production stage of *Picrorhiza kurroa.*

PHOTOGRAPH 5: SEED PRODUCTION STAGE IN PICRORHIZA KUROOA

3.4.4 Agro-technology

Propagation

Picrorhiza kurooa is mainly propagated through stolon cuttings to maintain quality and uniformity of the planting stock. Propagation from seeds is complicated and is practiced only for research and limited planting only.

Soil requirements

Sandy loam soil is best suited for cultivation. The plant grows best in soil with rich organic carbon and porous humus texture, with covering of litter to maintain desired moisture level. Canopy shade helps maintain moisture and encourages maximum growth, thickness of stolon, and productivity in natural habitats and cultivation. To meet all these requirements, field preparation begins 3-4 weeks prior to planting. *Picrorhiza kurooa* planting fields are normally at high altitude (above 2500 meters), and are selected 3-4 weeks prior to planting, considering availability of seedlings or rooted cuttings for plantation. Plough fields well to remove unwanted roots and debris. Spread layer of 300-400 kg vermicompost prepared from animal excreta per Bigha (12.5 Biga = 1 ha) in the field to increase organic carbon level and render soil porous. Mix the vermicompost thoroughly either by use of a plough or by digging manually with hand tools. Make raised beds 150 cm wide, with deep passage on both sides for drainage of excess water and for ease of weeding and compost addition in later stages. If possible, select fields with slopy surface to avoid water logging and achieve better growth of plants.

Time of seed sowing

Collecting, handling, and germinating seeds of this species is difficult, as stated above. Therefore, propagation normally occurs with rooting of stolon cuttings. Expertise in collection and handling of seeds will increase production of more planting material in short duration even on small nursery beds. Germination of seeds occurs either in poly-house or in open nursery

beds. Sowing in poly-house occurs early during December-January, and seed sowing in open nursery is carried out during March. Raised beds in poly-house or nursery are prepared in the same way as explained in soil requirements, with mixing of forest soil/field soil and vermin-compost. Seeds are soaked in glass container overnight prior to sowing, and are mixed with sieved vermin-compost on the following day to facilitate better spread. One gram (g) of soaked seeds is mixed gently by hand in 1-2 kg sieved and fine vermin-compost in the tub. This mixture of soaked seeds and vermin-compost is sprinkled on pre-prepared and moist poly-house or nursery bed of 1 x 5 meters. Watering after sowing is avoided for 10-12 hours, which helps anchor seed to soil and prevents clustering of seed at one place. Cover beds with dry oak leaves or moss to maintain moisture. Mulch will also help control damage and avoid displacement of seeds. Seeds can also be germinated in Styrofoam seedling trays, but these may not be easily available to farmers. Sowing in poly-house in December-January can occur at high altitude after snow melt in April-May, which reduces harvesting period.

Stolon rooting

Picrorhiza kurooa propagation and cultivation with rooting of stolon cutting is most successful and suitable for good production within a short time than is production via seeds. Vegetative multiplication is successful by application of a commonly available rooting hormone (Rootex-1) or without hormone application by dipping in water for 24-48 hours. Best way is to collect cuttings in dormant season during November-December before snowfall, and to bury in a trench with apical bud facing the surface. Cover the trench with moss or litter layer and soil at the top to retain moisture and provide aeration. Trench should be on the slope to minimize entry of water into the trench and provide drainage on sides to avoid water logging in the trench. All cuttings produce roots when temperature starts increasing in the spring. Remove the soil and litter layer from the top. Green leaves will appear from the apical buds. Remove cuttings with growing leaves and plant in nursery beds or poly-bags for further development during rainy season. A small trench 60 x 30 x 30 cm will accommodate around 1000 cuttings—preferable to a big trench suitable for bulk storage/rooting of cuttings.

Planting density for Picrorhiza kurooa seedlings

Picrorhiza kurooa seedlings or rooted cuttings are planted 30 cm apart from plant to plant for better development of plant and harvestable stolon. Plant is perennial, and side stolon is harvested as a drug for consumption and marketing. The plant needs space to grow on all sides, which will also facilitate weeding and hoeing at different stages. Best success is achieved on leveled and slopy field at more than above 2000 meters altitude. Plant will grow and survive at lower elevations and on flat fields but harvestable stolon either will not form or fail to acquire desired thickness. Photograph 6 shows ready seedlings of *Picrorhiza kurooa*.

PHOTOGRAPH 6: *PICRORHIZA KUROOA* SEEDLINGS READY FOR PLANTATION

Nutrient requirement

Fertility requirement for *Picrorhiza kurooa* depends on type of soil at the selected site. Normally, soil with high organic matter and addition of vermin-compost, as stated earlier, is good for growing. Because the plant is perennial, development of stolon requires high nitrogen. Therefore, regular addition of vermin-compost or decomposed litter with humus is needed at different intervals—400-500 kg vermin-compost/Bigha (12.5 Bigha = 1 ha) will be required to achieve good production. This compost addition occurs before planting or during winter months. Add manure followed by thorough mixing with soil prior to planting or in trench 4-6 inches deep around the plant in winter. Avoid broadcast of compost on the plantation, which will damage leaves and plants. Farmyard manure or semi-digested animal excreta applications will lead to insect pest problem and should be avoided. If vermin-compost litter is unavailable, use broad leaves (e.g., from oaks) as substitute to increase fertility of *Picrorhiza kurooa* plantation. Planting methodology appears on Photograph 15 below.

PHOTOGRAPH 7: PLANTING OF *PICRORHIZA* KUROOA SEEDLINGS

Irrigation and weed control at Picrorhiza kurooa plantation site

High moisture achieved through regular irrigation is required for better survival of seedlings and cuttings in field plantation. Watering occurs once daily to reduce mortality, and can further be assessed as per demand on the specific site and under specific climate conditions. Excessive moisture will encourage growth of weeds, and hence proper weeding is required for normal growth and optimum production of *Picrorhiza kurooa* plants. Weeding should occur weekly during early stages when plants are small, and monthly during later stages. This may vary from site to site and can be planned as per site conditions.

Maturity and best harvesting Picrorhiza kurooa

Picrorhiza kurooa plants mature at different stages at different altitudes. Completion of reproductive phase of the plant marks its maturation. This terminates with fruit setting and seed formation in September at lower altitude and in October within alpine zone. Harvesting of stolon, normally in third year after planting, occurs by use of a knife or pruning scissors. Mother plant is kept intact for regular growing, and harvested stolon with roots is removed from the mother plant. Apical part of the harvested stolon with two to three roots is removed from the remaining stolon and planted or buried in the soil to provide new plant for planting during the following rainy season. Harvesting of every stolon will provide twin benefits of raw drug and new plant for next-year planting.

Best period of harvesting Picrorhiza kurooa

Harvesting occurs mainly during September-October. As per the indigenous knowledge system and literature on Ayurveda, harvesting of high-altitude medicinal plants should occur during 20 days of *Bhadra* month of the Hindu calendar (*Bees Bhado*), which normally mark the end of the growing season for temperate and alpine plants. This was further verified in scientific studies which showed that harvesting of plants at the end of growing season accumulates maximum concentrations of secondary metabolites that form bases of drugs used for cure of different ailments. Harvested parts of *Picrorhiza kurooa* are shown in Photograph 8.

PHOTOGRAPH 8: STOLON OF PICRORHIZA KUROOA

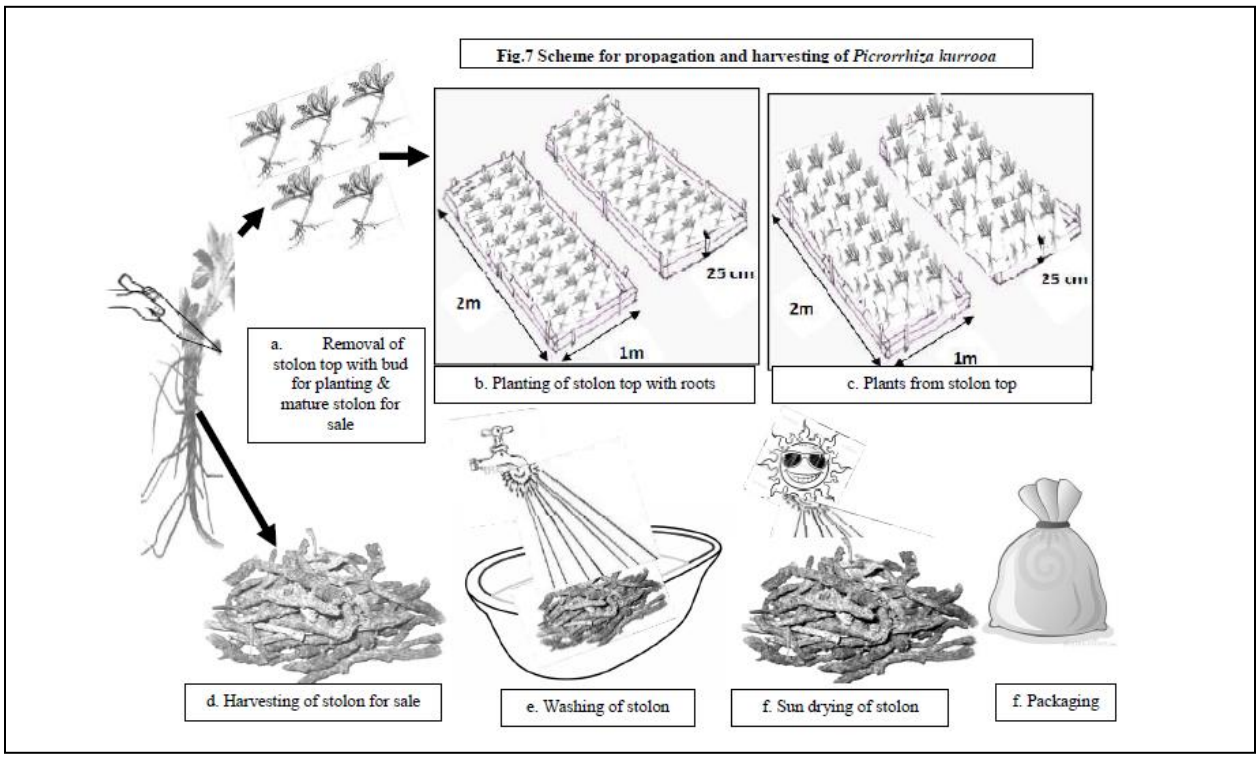
Crop production and commercial viability of Picrorhiza kurooa

It is not yet possible to grow *Picrorhiza kurooa* like other agriculture crops, and cultivation is limited to a countable number of farmers in the Indian Himalayan mountains on a limited scale. Crop production and yield have been found to vary from site to site: at lower altitude of about 2000 meters, production is approximately 400-500 kg/ha; above 2500 meter altitude, yield is around 600 kg/ha. Yield varies among individual sites, and depends heavily on cultivation practices. Market value of *Picrorhiza kurooa* also varies from year to year—it was quite high during year 2014 in HP at 1000-1200 rupees/kg. Generally, average sale price of *Picrorhiza kurooa* ranges between 400-500 rupees/kg. Dried stolon was shown on Photograph 8.

Post-harvest management

Normal harvesting of *Picrorhiza kurooa* from natural settings occurs by uprooting plants along with stolon, leaves, and roots. There are myths that roots of *Picrorhiza kurooa* are salable as drug, and that uprooting damages the population of this plant in nature. Roots of the plant are in fact fibrous, and only side branches (stolons) are useful as components of drugs. If uprooted plants with leaves and stolon are collected in plastic bags within areas of humid climate, the material spoils fast because heat in bags begins degradation of material immediately after harvesting. Therefore, harvesting of only side branches should occur, with removal of apical portion with leaves for enrichment of plantation. Stolon without root and leaves should be stored in gunny bags or bamboo basket with proper aeration. Collected stolons free of leaves and roots should be washed to remove adhering soil. Spread on the pucca floor or on tarpaulin or cloth sheet for drying in diffused sunlight. Slow drying will maintain quality of the drug and color of the stolon, which is necessary for good price in the market. Until sale, store dried stolon in cloth bags in a room free of moisture, as shown on Photograph 8.

FIGURE 12: STEPS INVOLVED IN PROPAGATION AND HARVESTING OF *PICRORHIZA KUROOA*



3.5 PROFILE OF TRILLIUM GOVANIANUM WALL.EX D. DON

Common Name: Naagchatri

3.5.1 Habit and habitat

Trillium govanianum is a perennial herb found growing in patches in forests under shade in humus-rich soils at altitudes ranging from 2500-3500 meters in the Himalayas. Plant is up to 25-30 cm tall having three leaves at the tip of stem and tuberous roots. A solitary purple flower is at the center of the three leaves. Flower is brown with narrow spreading petals. Fruit is red berry around 2 cm in diameter.

FIGURE 13: TRILLIUM GAVANIANUM

3.5.2 Active ingredients and uses

Trillium govanianum roots contain Trillarin, which on hydrolysis yields 2.5% diosgenin—a cortico-steroid hormone. The cortico-steroid hormone isolated from the plant is used in various preparations like sex hormones, cortisone, and allied preparations used to treat rheumatism, regulation of menstrual flow, and the like. It is also used to address stomach- related problems. Because of its effective medicinal properties, demand for

this drug is high in international markets. Photograph 16 shows different parts of *Trillium govanianum*.

3.5.3 Seed production

Trillium govanianum fruit is a red, globular berry 1-2 cm in diameter. Seeds are not collected and used for raising plants. Plants are generally raised via separation and planting of rhizomes. Photograph 9 shows the flowering stage of *Trillium govanianum*.

PHOTOGRAPH 9: FLOWERING IN *TRILLIUM GOVANIANUM*

3.5.4 Agro-technology

Propagation

Trillium govanianum propagation proceeds mainly by division and planting of rhizomes with growing bud, as for *Paris polyphylla (*depicted on Photograph 9). Multiplication by seed is reported in many research publications, but details regarding seed collection, dormancy, and viability are not described. Propagation occurs only through planting of rhizomes with growing tip.

Soil requirements

Trillium govanianum requires similar soil conditions for growth in nursery and plantation, as described previously for *Paris polyphylla* and other Himalayan species.

Rhizome planting

Trillium govanianum is propagated by planting rhizomes with growing apical bud; growing from seed has not yet been practiced. Rhizomes of this species are smaller than those of *Paris polyphylla.* Rhizomes are planted in nursery polybags or directly in the field (prepared prior to planting) in rows, as explained for *Paris polyphylla* on Photograph 9. Smaller sizes of plants and rhizomes allow greater density of planting than for *Paris polyphylla*—plants are placed 10 cm apart and 15-20 cm row to row. Planting of rhizomes occurs during dormant period in winter months November-December, and sprouting begins in February-March.

Planting density

Smaller sizes of *Trillium govanianum* plants and rhizomes allow greater density of planting than for *Paris polyphylla*, as stated earlier, with spacing of 10 cm plant to plant and 15-20 cm row to row.

Nutrient requirement

Trillium govanianum is a tuberous crop, requiring high soil nutrients and organic matter, achieved by addition of 4000-5000 kg vermin-compost/ha. Application of the vermin-compost and manure is more or less the same as for *Paris polyphylla*. Importantly, these are preliminary specifications for this species, resulting from initial studies and subject to change per future investigations/experiences.

Irrigation and weed control

Trillium govanianum also requires a high soil moisture (60-70%) level for desired growth. Water two to three times during summer months to help ensure survival of the plants in nursery and

plantations. Initially, weeding is required once a week, and later once a month to maintain vigorous growth.

Maturity and best harvesting

Trillium govanianum flowers during May-June, and seeds mature in early September. Best period for harvesting of rhizomes is during mid September. Rhizomes are harvested by digging the rhizome and cutting the apical portion with bud of the rhizomes for planting in nursery polybags or in bed for growing fresh plants for future production, as for *Paris polyphylla* (Photograph 9).

Crop production commercial viability.

Trillium govanianum is currently harvested from nature during growing season for desired authenticity from natural habitat for commercial use. No cultivation currently occurs, although efforts are under way to bring species into nursery and cultivation by application of techniques closely associated with those utilized for *Paris polyphylla* (Photograph 9.) It is premature to comment on production and commercial viability of this plant.

Post-harvest management

Trillium govanianum rhizome is washed and dried after collection from forests to remove soil and adhering debris. Washed rhizomes are spread on tarpaulin for drying in shade for 4-5 days. Dried material is packed in gunny bags or cotton bags for sale. Steps involved are similar to those applied for *Paris polyphylla* (Photograph 9).

4.0 SUSTAINABLE HARVESTING TECHNIQUES FOR SELECTED NTFPS

Use of medicinal plants is a long tradition in India. Various parts of plants, such as roots, bark, leaf, flower, fruit, and seed material, are collected, dried, stored, and used in different parts of the country. Use of medicinal plants in traditional healing systems of Ayurveda, Sidha, Homeopathy, Unani, and Tibetan cater to demands of the health sector. Large numbers of practitioners selling herbal remedies and medicinal plants formulations indicate the acceptance and popularity of herbal medicine not only in India but globally. Because of lack of traditional knowledge and growing demand for these herbal remedies from both domestic and foreign markets, many medicinal plants in the open woodlands of Indian Himalayas are over-harvested. Unsustainable harvesting of plants in use as herbal drugs is threatening and endangering many species. Furthermore, most medicinal plant species of high quality found in Indian Himalayas that address a wide range of human diseases and ailments do not grow anywhere else in the world. Long-term availability of medicinal plants is of vital importance, not only for practitioners, but for preservation of local medicinal practices.

Thus, conservation and sustainable use of medicinal plants are of a high importance. Although cultivation may be a solution to decrease the threat of extinction of some plant species, this either has not been tried seriously or is difficult, and may be impossible for some plants without loss of quality. Therefore, collection of medicinal plants from the wild will always occur. Traditional healers previously harvested and processed plants according to their need, often after performing the due rituals. These practices usually restrained amounts harvested to low levels, and always after seed shedding. All such practices are almost out of practice, and herbal medicines are available in pharmaceutical stores prepared and marketed by modern manufacturing and marketing chains. Harvesting and selling of medicinal plants have become highly commercialized, with small regard for conservation and sustainability of these plants.

Sustainability of production and trade will continue only if needs of the present are satisfied without impacting needs of future generations. The most critical factor for developing sustainable harvesting techniques for these plants is complete knowledge of three plant growth stages—flowering period, setting of seeds, and seed maturation (followed by seed harvesting). Care should be taken in harvesting to maintain enough seeds for regeneration in the ensuing season.

This module focuses on provision of information to harvesters, foresters, herbal traders, and industries with intent to convince them to popularize and adopt simple practices of harvesting selected plants of Himalayan origin in order to sustain availability of these plants for future generations.

4.1 COMMON HARVESTING GUIDELINES

4.1.1 Time to harvest

- Appropriate harvesting time varies from one species to another. Collect at a time when the plant is not threatened and is at optimum condition for required medicinal quality and efficacy.
- Identify the best time for collection in terms of season, date, or time of day to achieve quality and quantity of active ingredients rather than total amount of material collected. This ensures best possible quality of raw material and products.
- Time of harvest determines concentration of biologically and medically active ingredients. These vary with stage of plant growth and development.
- Select best possible climate conditions for harvesting to avoid spoilage and deterioration of material.

4.1.2 Material to harvest

- Properly identify the species to harvest.
- Avoid unwanted mixture of wild relatives of the desired plants by distinguishing other wild relatives that appear similar.
- Harvest material of healthy and fully developed mature plants only.
- Avoid harvest from plants and material infested with fungi or insects. Such associations alter secondary metabolites and the ingredient profile, and could also be poisonous.
- Plants and materials selected for harvesting should not have been sprayed with pesticides, herbicides, or fertilizers. Avoid collection around edges of farm fields, roadsides, or near industrial premises.

4.1.3 Method of harvesting

- Harvest and collect only plants abundant in that area. Collect conscientiously and leave a healthy population after collection.
- Take special care during collection of leaves and flowers, which are much more vulnerable to deterioration than roots due fragility of their tissue.
- Prevent any unnecessary damage to the plant, and exercise caution to enable the plant to regenerate.
- Avoid damage to harvested material that results in undesirable opening for infections.
- Separate damaged and severed bulbs to avoid spread of organisms facilitating spoilage.
- Discard unwanted plant materials during harvesting to ensure that no foreign matter, weeds, or toxic plants are mixed with the harvested materials.
- Place different plant materials in different containers.

4.1.4 Tools required for harvesting

- Keep harvesting tools clean and free of remnants of earlier harvested plants.
- All collecting containers should be clean, washed with water, and dried to keep them free of contamination by previously harvested plants and other foreign matter.
- Watch plastic containers for possible retention of moisture that would lead to rotting and growth of molds.

- Store containers before and after collection under dry conditions and within an area protected from insects, birds, and other pests, and from moisture and direct sunlight.

4.1.5 Observe over harvesting

- Observe signs of over-harvest, especially when the plants you want to collect are at lower quantity or in worse condition.
- Observe other signs of over-harvesting if the distance you must travel to collect your desired plants increases.
- Observe smaller population of desired plants within areas where growth was abundant in the recent past.
- Note extreme shortage of some desired plants that cannot be found locally anymore.
- Declines in populations of associated plants also indicate overharvesting

4.2 SELECTED SPECIES AND GUIDELINES FOR SUSTAINABLE HARVESTING

Among five species of Himalayan medicinal plants (*Paris polyphylla/Trillium govanianum* (Naagchhatri), *Picrorhiza kurooa (Karoo)*, *Angelica glauca* (Chora), and *Aconitum heterophyllum* (Patish/Ativisha) selected for developing sustainable harvesting techniques, four are harvested for their roots and rhizomes, and one (*Picrorhiza kurooa)* is harvested for its creeping side branches (stolons) for marketing. All these plants except for *Paris polyphylla* and *Trillium govanianum* have been present in herbal trading for ages, and survived because of strong traditional knowledge. Demand for sustainable harvesting has arisen because of commercial exploitation, lack of traditional knowledge about harvesting, and overutilization of these species in recent times. Harvesting of roots in routine practice is through destructive harvesting, and hampers subsequent regeneration and survival of a population. Ignorance about *Picrorhiza kurooa* (from which only side branches are used as raw herbal drug) has resulted in uproot of whole plants by communities. This kind of practice persists because of lack of communication between researchers and primary collectors. Efforts have been exerted to shortlist and communicate simple and effective, sustainable harvesting techniques regarding these important species in order to address collectors' needs and sustain populations of these plants in the fields. This section provides details about plants and specific guidelines for harvesting and utilizing them.

4.2.1 Aconitum heterophyllum Wall

After attaining maturity, the plant starts flowering in July and completes this in August. Seed setting occurs during September and October. A usual sign of seed maturation is yellowing of the plant in November. Seed harvesting should occur over a period of 3 months from September to November, so extraction of a marketable drug part must occur thereafter only. Collectors are also required to leave the top segment of root with gemma (bud) in the soil for regeneration of a single-stem plant in the next year. Current collection of drug material, spread over 5 months beginning in August and ending in December, is thus detrimental to sustainable harvest of the species.

4.2.2 Angelica glauca Edgew.

After the plants have attained full growth, they begin flowering in July, continuing up to September. Seed setting occurs in October. The seeds mature by November, and hence

harvesting of seeds should begin in November and carry forward through December. Collection of marketable root part must occur after December. For perennation of the plant, apical stem collar portion must be retained in the soil at time of harvesting of drug part (i.e., the fleshy root). The prevailing practice of harvesting of drug material, spread over 5 months from August to December, is detrimental to sustainability of the plant.

4.2.3 Picrorhiza kurooa Royal ex Benth.

The plants of Karroo begin to flower in May and continue until the end of August. Seed setting occurs during September at high altitudes and in June at lower elevations. The seeds mature and are ready for harvesting in October. Harvesting of seeds should occur in November. Collection of only side branches (stolons) for marketing must occur after the seeds have fallen on the ground, without uprooting the complete plant. Moreover, one or two suckers of each plant must be left in the soil at time of collection of suckers for drug use. Present practice involves collection of drug material beginning early in the season from July, continuing until the end of November, a 5-month period that thus threatens sustainability of this species.

4.2.4 Paris polyphylla Sm.

Flowering of plants of Himalayan *Paris* usually begins in April and continues until the end of June. Seed setting occurs during July-August. The seeds are mature and are ready for harvesting during September. Harvesting is advised from September onward, with prior marking of plants in the field during flowering; otherwise, aerial parts of the plants are not available after wards and it is difficult to spot the plants in nature. Harvesting of root material must occur after September following seed shedding, which not only helps in regeneration but provides more quantity per plant harvest to collectors. Furthermore, collectors should leave the crown portion of the root in the ground for further regeneration. In current practice, however, harvesting of drug plant part is occurring prior to flowering over a period of 4 months beginning from April and ending in July, thus disallowing production and shedding of seeds for further propagation.

4.2.5 *Trillium govanianum Wall.ex* D. Don

Plants of the species grow until April and then produce flowers during May-June. Seed setting is not continuous, and after a gap of about 1 month (July), begins in August and ends in September. Seeds attain maturity in October and are ready for harvesting. Prior marking of the area and plants aids extraction of material because aerial parts are not available at this stage. Similar to *Paris*, delayed harvesting of rhizomes after rainy season provides more quantity per plant, and harvesting after rainy season does not result in spoilage of material. However, current practice is to harvest the drug material from April to the end of August for proper identification, and in later stages, aerial parts degenerate due to high moisture. Hence, this does not allow seed dispersal and endangers further propagation of the species.

4.3 CONCLUSION

This NTFP resource book explains tools, techniques, and methodologies for assessment of NTFP resources, habit, habitat, and seasonality of high-value NTFPs that grow at higher altitude; their roles in ecology; parts that are useful; and how to harvest them sustainably. It also explains in detail about nursery development, cultivation, and post-harvest management of selected NTFPs. To explain various processes and stages of NTFPs to community members (especially women) and front-line staff members, a number of photographs and drawings have

accompanied the text, which conveys information in straightforward wording. This resource book also can serve front-line staff and nursery managers as a reference.

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ANNEX I: RED-LIST STATUS OF CANDIDATE SPECIES AS PER SHIMLA CAMP 2010 AND 2003

S. No.	Botanical Name	Habit	Status assessed for Himachal Pradesh (Shimla CAMP 2010)	Previous Status (Shimla CAMP 2003)
1.	Aconitum heterophyllum	H	CR	CR
2.	Aconitum deinorrhizum	H	CR	EN
3.	Atropa acuminata (=Atropa belladona)	H	CR	CR
4.	Dactylorhiza hatagirea (=Orchis latifolia)	H	CR	CR
5.	Gentiana kurroo	H	CR	CR
6.	Habenaria edgeworthii	H	CR	-
7.	Jurinea dolomiaea (=J. macrocephala)	H	CR	EN
8.	Lilium polyphyllum	H	CR	CR
9.	Malaxis muscifera	H	CR	CR
10.	Picrorhiza kurroa	H	CR	EN
11.	Swertia chirayita (= S. chirata)	H	CR	CR
12.	Angelica glauca	H	EN	EN
13.	Arnebia benthamii	H	EN	CR
14.	Arnebia euchroma	H	EN	CR
15.	Berberis aristata	S	EN	-
16.	Betula utilis	T	EN	EN
17.	Colchicum luteum	H	EN	VU
18.	Dioscorea deltoidea	C	EN	EN
19.	Fritillaria roylei	H	EN	EN
20.	Habenaria intermedia	H	EN	EN
21.	Nardostachys grandiflora (=N. jatamansi)	H	EN	EN
22.	Paris polyphylla	H	EN	EN
23.	Podophyllum hexandrum (= P. emodi)	H	EN	EN
24.	Polygonatum cirrhifolium	H	EN	EN
25.	Polygonatum multiflorum	H	EN	VU
26.	Polygonatum verticillatum	H	EN	VU
27.	Rheum moorcroftianum	H	EN	EN
28.	Saussurea obvallata	H	EN	CR
29.	Taxus wallichiana (= T. baccata)	T	EN	EN
30.	Zanthoxylum armatum (= Z. alatum)	S	EN	EN
31.	Aconitum violaceum	H	VU	VU

32.	Allium stracheyi	H	VU	VU
33.	Bunium persicum	H	VU	VU
34.	Cinnamomum tamala	T	VU	VU
35.	Ephedra gerardiana	S	VU	EN
36.	Hypericum peforatum	H	VU	VU
37.	Juniperus communis	S	VU	-
38.	Litsea glutinosa (= L. chinensis)	T	VU	VU
39.	Malaxis acuminate	H	VU	-
40.	Rheum australe (= R. emodi)	H	VU	EN
41.	Rheum webbianum	H	VU	VU
42.	Roscoea alpina	H	VU	-
43.	Roscoea procera	H	VU	-
44.	Selinum vaginatum	H	VU	-
45.	Selinum connifolium (S. tenuifolium)	H	VU	-
46.	Skimmia laureola	S	VU	-
47.	Symplocos paniculata	T	VU	-
48.	Didymocarpus pedicillata	H	NT	VU
49.	Hyoscyamus niger	H	NT	EN
50.	Hyssopus officinalis	H	NT	VU
51.	Onosma hispidum	H	NT	-
52.	Rheum speciforme	H	NT	VU
53.	Paeonia emodi	H	DD	-
54.	Aconitum laeve	H	NE	-
55.	Desmodium gangeticum	H	NE	-
56.	Oroxylum indicum	T	NE	-
57.	Uraria picta	S	NE	-

Notes:

H Herb
S Shrub
T Tree)
C Climber
CR Critically endangered)
EN Endangered
VU Vulnerable
NT Near threatened
DD Data deficient
NE Not evaluated)

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