A REPORT SUBMITTED TO
International Union for
Conservation of Nature - India

STATUS OF THREATENED MEDICINAL AND AROMATIC PLANTS AND THEIR USE BY THE BHOTIYA COMMUNITY IN NITI VALLEY, NANDA DEVI BIOSPHERE RESERVE, UTTARAKHAND


भारतीय वन्यजीव संस्थान
Wildlife Institute of India

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Principle Investigator(s)
Dr. Amit Kumar
Dr. B.S. Adhikari

Project Associate
Arun Pratap Mishra

Front cover:
A Bhotiya women crushing *Allium stracheyi* (Jambu pharan) in traditional pastel and mortar for drying

Back cover:
National Anthem written by a Bhotiya on the papery bark of *Betula utilis* (Bhojpatra)

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ABBREVIATIONS USED

APPEDA	:	Agriculture and Processed Food Products Export Development Authority
CAMP	:	Conservation Assessment and Management Prioritization
CAP	:	Centre for Aromatic Plants
CITES	:	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CSS	:	Centrally Sponsored Scheme
HRDI	:	Herbal Research and Development Institute
IUCN		International Union for Conservation of Nature
LCHP	:	Locally common heavy pressure
LCLP	:	Locally common low pressure
MAPs	:	Medicinal and aromatic plants
MPCA	:	Medicinal Plant Conservation Areas
MPCAs	:	Medicinal Plants Conservation Areas
NDBR	:	Nanda Devi Biosphere Reserve.
NGO	:	Non-governmental organization
NMPB	:	National Medicinal Plant Board
NMPB	:	National medicinal plant board
PKVY	:	Paramparagat Krishi Vikas Yojana
RDHP	:	Restricted distribution heavy pressure
RDLP	:	Restricted distribution low pressure
SMPB	:	State medicinal plant board
SSS	:	State Sector Scheme
UCLP	:	Under cultivation low pressure
UKFD	:	Uttarakhand forest department
WDHP	:	Wide distribution high pressure
WDLP	:	Wide distribution low pressure
WPA	:	Wildlife protection act

EXECUTIVE SUMMARY

Nested in the Western Himalaya, the state of Uttarakhand, also known as the 'herbal state of India,' harbors more than 5000 species of vascular plants, of which one-third species have medicinal uses. The state abounds in a rich and varied flora and fauna, constituting the most species-rich part of the whole of the Western Himalaya. The extreme north of the state contributes approximately 1% (*ca.* >1,000 km^2) of the total Trans-Himalayan region (*ca.* 98,660 km^2) of India. However, in spite of rich floral diversity, the cold-arid regions of Nilang, Niti, Mana, Johar, Darma and Byans valleys of Uttarakhand along the northern frontiers that falls under Trans-Himalayan Biogeographic Province (1C) are underexplored in terms of the current levels of pressure and patterns of biodiversity. These areas have also been facing tremendous pressure due to over-exploitation of forest resources including the unscientific and illegal harvesting of MAPs from the wild.

The current study was conducted to study selected threatened and high use value MAPs in Niti valley, a cold-arid region of Nanda Devi Biosphere Reserve with a focus to (i) assess the status, abundance, and use of MAPs, and (ii) suggest their sustainable harvesting and cultivation framework.

The information on the focal species was gathered through primary viz., semi-structured open-ended and closed-ended questions including individual interactions and group discussions in selected villages (7) and secondary information through offline and online sources. After reconnaissance and stratification of habitats, population status of focal species was assessed using stratified random sampling. Based on extensive interactions with younger generation, elder people including local healers, plant collectors and local traders, a total of five high value (with significant economic end usage) MAPs namely *Allium stracheyi, Carum carvi, Dactylorhiza hatagirea, Picrorhiza kurroa* and *Sinopodophyllum hexandrum* were selected in Niti valley, NDBR. The

selection of MAPs was based mainly on highest quantum of collection and high threat due to removal and usages.

The current study highlights that the population of the focal species (except *Carum carvi*) are sparse albeit rapidly declining due to excessive exploitation, unscientific, illegal and premature harvesting. Therefore, keeping their current population status in view, preparation of micro-plans, assessment of available growing stock and sustainable management and utilization of dwindling populations is recommended.

Besides over-exploitation of MAPs, knowledge on their available stock, lack of information on end users and middlemen and inadequate information on quantity of raw material traded due to secretive nature of the markets were reported. In Niti valley, the market trend, price *vis a vis* trade route is indiscernible for highly traded medicinal species such as *Gucchi, Morchella esculenta* and *Keedajadi, Ophiocordyceps sinensis* which sells in the market like a hot cake, and therefore has created hue and cry state among the locals. Hence, these issues need to be addressed to ensure long-term conservation of the MAPs in a way that livelihood needs of the locals depending on such resources are not compromised.

The focal species are one of the highly traded MAPs from the Western Himalaya, in general and Niti valley, particularly. Therefore, considering the existing threats, habitat specificity, population size and pressure level, the focus of conservation and regulated harvest is particularly needed for (i) restricted distribution heavy pressure (RDHP) species such as *Picrorhiza kurroa* and *Dactylorhiza hatagirea*, and (ii) locally common heavy pressure (LCHP) species such as *Allium stracheyi, Sinopodophyllum hexandrum* and *Carum carvi* in Niti valley, NDBR.

Bhotiyas, ethnic community of Indo-Mongoloid origin mailny depend on natural resources from the adjacent forests and alpine pastures or meadows (locally known as *payar*) for their livelihood. Therefore, considering the high use value, market opportunities, price of the produce, and ease of cultivation or harvesting processes, the current study proposes *Allium stracheyi, Carum carvi* and *Saussurea costus* as the

potential species that can be encouraged for their cultivation in Niti valley. It will not only provide livelihood opportunites to the local inhabitants but also check ruthless exploitation of the wild MAPs.

The local inhabitants are dependent on the wild MAPs for their traditional health care system. They are knowledgeable of about 72 MAPs that are locally utilized consumption and for curing at least 24 different human ailments. However, the practice of utilising MAPs in their local healthcare system is sharply declining due to lack of education facility and market, which has led to lack of knowledge as well as transfer of knowledge to younger generations.

The *payar* such as Bamplas, Lang, Goting, Rekhana (base of Mount Kamet) and Geldung in Ganesh Ganga; Timersain and Thali enroute Kalajowar, and Daman towards Sagar glacier in Amrit Ganga are rich in medicinal plant diversity. Thus, considering the unique medicinal diversity and traditional ways of their conservation in view, rotation grazing in the forested areas including heavily grazed *payars* such as Daman, Thali, Timsersain and Goting in a cycle of 2-3 years is proposed.

Owing to excessive human population, it is evident that the demand *vis-a-vis* harvesting pressure on wild populations of several MAPs is increasing every year. Thus, in order to meet the accelerating demand of high use value MAPs, there is an urgent need to develop farm scale agro-techniques for priority MAP species in the absence of such efforts on lab to land tested techniques. In the current study, sustainable harvesting and cultivation framework have been designed for the selected 05 MAPs, although appropriate demonstration sites showcasing such agro-techniques in the cold-arid landscapes such as Niti valley in Uttarakhand be set up to build confidence of the plant growers or locals in adoption of such medicinal crops in their agricultural practices.

Preparation of Jya (butter tea), a traditional tea by Bhotiyas

1. INTRODUCTION

The Indian Trans-Himalaya (ITH) usually described as High Altitude Cold Desert Zone (Zone 1) is broadly divisible into four biogeographic provinces, viz. 1A, Ladakh mountains: Kargil, Nubra and Zanskar in Jammu and Kashmir, and Lahaul and Spiti in Himachal Pradesh; 1B, Changthang Plateau in eastern Ladakh which is contiguous with the Tibetan Plateau; 1C, cold arid-regions of eastern Himachal Pradesh (Kinnaur) and Uttarakhand covering Nilang, Niti, Mana, Johar, Darma and Byans valleys and 1D, Sikkim Plateau (Rodgers et al. 2000; Kumar et al. 2017). These areas have a unique physical and biological setting that is markedly different from that of the adjoining alpine zones of the Greater Himalaya.

Alpine zone, locally termed as *bugyal* or *payar* in Uttarakhand represents one of the most fascinating biomes, among various climatic zone in the Indian Himalayan Region. It serves as special habitat for several native and high-value medicinal plants. The grassy-herbaceous meadows in the alpine landscape occur between the tree line (3300-3600m amsl) and perpetual snow cover (5300m) in the high altitudes of Western Himalaya. The alpine vegetation comprises of matted dwarf shrubs, herbaceous meadows, grassy slopes, bogs, snow swept grounds characterized by cushion shaped plants. From the ecological standpoint, the alpine scrubs, grassy slopes, herbaceous and sedge meadows represent different habitat types and a natural alpine ecosystem should have complete spectrum of all the habitats and greater representation of alpine biodiversity.

In the state of Uttarakhand, alpine zone spread over about 8524 km^2 area (24% of the geographical area) in more than 82 major *bugyals* (Rawat 2005). Some of the most extensive and prominent *bugyals* are located around basins of Nanda Devi, Kedarnath, Gangotri and Bandarpunch area ranging from a few to 400 km^2 in size. As evident from the large numbers of folklores, the life of the local inhabitants in higher altitudes of Uttarakhand is immensely associated with the *bugyals*. These *bugyals* or

payars are regarded as repositories of a large number of medicinal and aromatic plant species (MAPs), which are used in local medicine as well as for sale to the herbal industries (Nautiyal 2000).

In India, there are over 53 million tribal people belonging to 550 communities of 227 ethnic groups (Maikhuri and Gangwar 1993; Nautiyal et al. 2000). These tribal communities draw their sustenance largely from forests for food, medicine and other requirements. Forests represent a whole way of life for tribal peoples and as such their life and economy are, therefore, intimately interwoven with the forests and forest wealth (Gangwar and Ramakrishnan 1990). The mountainous region of the Himalaya is inhabited by diverse tribal communities, and among these the Bhotiyas mainly inhabit the cold-arid regions of Uttarakhand and practice transhumance pastoralism (Farooquee 1994; Maikhuri et al. 1998; Kala 2005; Mitra et al. 2013). The Bhotiya tribal communities have a wealth of knowledge on the use of medicinal plants in their locality. Collection of medicinal plants from the wild has long been conducted while grazing livestock in the forests and alpine pastures. Several medicinal plants have been listed as endangered, vulnerable and threatened due to over exploitation or unskillful harvesting in the forest and alpine meadows (Farooquee and Saxena 1996; Maikhuri et al. 1998; Nautiyal et al. 2000; Kala 2000 & 2002) and also due to commercial exploitation by a number of individuals and agencies.

The 'All India trade survey of prioritized medicinal plants (2019)' reported a 50% increase in the demand for high-value medicinal plants while the availability declined by 26%. While, through the years there has been an increase in the demand for natural resources, especially MAPs for healthcare and wellness. These MAPs apart from their role in the ecosystem are an important part of the support of national capital, natural resource economy for local communities, and in ensuring the health and wellness security of the Indian population and globally. The decline in availability of these MAPs is attributed to over-exploitation and subsequent degradation of the habitats. It is evident that the high-altitude areas are of critical importance for biodiversity as it harbors and form an important life-support

system for many remote and agro-pastoral communities. Despite the immense biological, socio-cultural, and hydrological values, this natural ecosystem is under severe threat from the high dependence of local communities on the natural resources, pressures from economic development, targeted removal of MAPs, and unforeseen changes due to climate.

To address issues with targeted extraction of MAPs, the project aims to-

i. To assess the status of selected high use value and threatened MAP species in Niti valley, Nanda Devi Biosphere Reserve with a focus on their sustainable harvesting and (ii) To suggest mechanisms for sustainable harvest practices that can provide livelihoods and community resilience and in turn ensure the persistence of the species within the habitat.

1.1 Project objectives

a. Assess the status, abundance, and use of selected threatened and high value MAPs.

b. Suggest sustainable harvesting framework of selected high use value and threatened MAPs.

2. STUDY AREA

The present study was conducted in the cold-arid and buffer zone of Nanda Devi Biosphere Reserve (NDBR) covering seven villages namely, Mahargaon, Kailashpur, Gurgutti, Pharkia, Bampa, Gamsali and Niti of Upper Dhauli Ganga catchment or Niti valley (**Figure 1**) in Chamoli District of Uttarakhand. The valley falls under 1C Trans-Himalayan Biogeographic Province with an average elevation ranging from 3500 to 5000m.

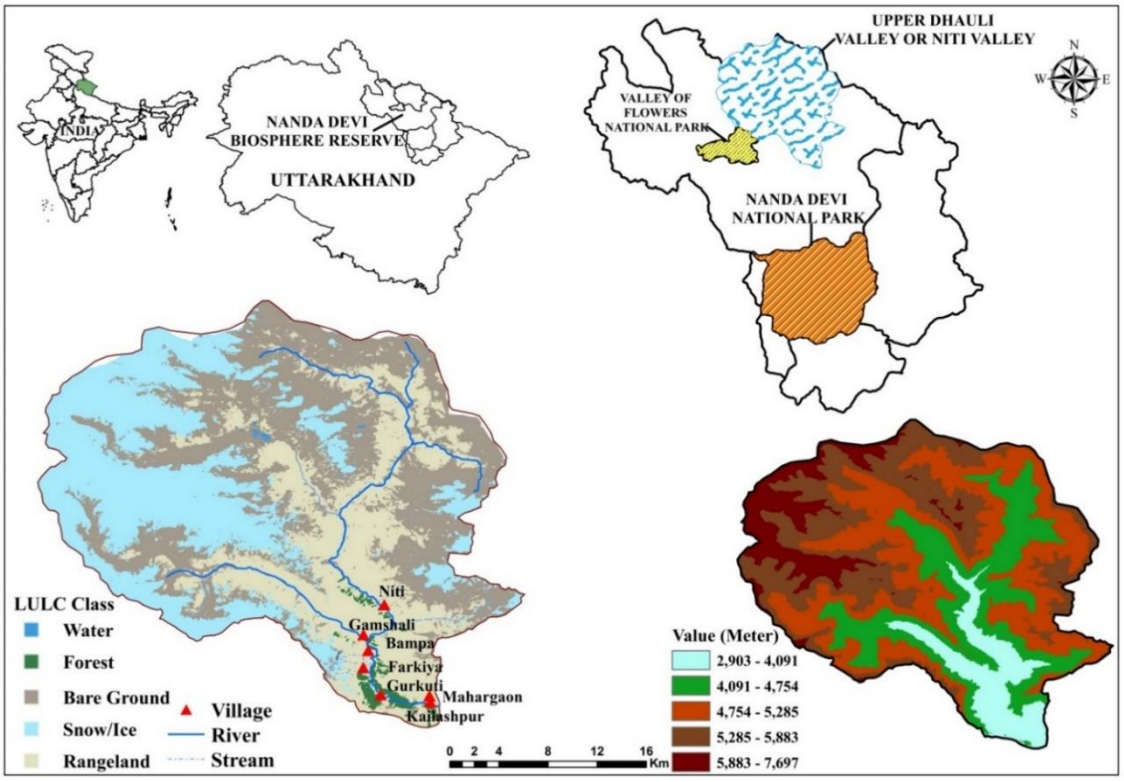


Figure 1. Map showing Niti valley in Nanda Devi Biosphere Reserve, Western Himalaya.

2.1 Physical features

Niti valley spreading over ca. 728 km^2 has three sub-watersheds namely, Amrit Ganga, Satyagad and Ganesh Ganga that comes under Trans-Himalayan region of Uttarakhand (Kumar, 2017; Kumar et al. 2017). The picturesque valley is situated in the rain-shadow zone and the dryness increases towards upper reaches of the Dhauli and adjacent Girthi valley,

which remain snowbound for more than six months in a year. In general, the vegetation in the valley comprises of dry temperate to dry alpine types, the flora is of steppe nature and rich at lower elevations (Kumar et al. 2016; Kumar 2017).

Image 1. Morainic deposits in Amrit Ganga catchment

Image 2. Scree slopes in Kalajowar catchment

Image 3. Geldung lake (5000m) in Ganesh Ganga catchment

2.2 Local inhabitants

Niti valley is inhabited by two clans of Bhotiya community, locally known as *Tolchhas* and *Marchhas*. Of the 47 villages present within the buffer zone of NDBR, seven migratory villages namely, Mahargaon, Kailashpur, Gurgutti, Pharkia, Bampa, Gamsali and Niti are located in the Niti valley. The Bhotiya ethnic community of Indo-Mongoloid origin has their own unique customs, folklore and religious beliefs. The inhabitants have two dwellings in cold-arid region of Niti valley between 3000 to 3600m, where they stay during the summer and the other in the lesser Himalaya, a permanent dwelling between 1000-1500m. The biotic pressure on the alpine rangelands is mainly due to heavy livestock grazing (Mitra et al. 2013). The locals depend on natural resources from the adjacent forests and alpine pastures for sustenance and livelihood, and the area continues to be used for transhumant pastoralism (Kumar and Mitra 2015).

Image 4. Glimpses of the Bhotiya community in the valley.

2.3 Floristic wealth of Niti valley

A number of studies on floral wealth have been conducted in Nanda Devi Biosphere Reserve (NDBR). A comprehensive account on vascular plants revealed a total of 801 species of vascular plants belonging to 406 genera under 120 families from the NDBR (Hajra and Balodi 1995). The region has been extensively surveyed in terms of floral diversity by various workers, albeit highly confined to the core zones i.e., Nanda Devi National Park and Valley of Flowers National Park (Kumar et al. 2016a; Kumar 2017; Kumar et al. 2019). Located in the buffer zone of NDBR in the Western Himalaya, Niti valley also known as upper Dhauli valley represents a cold arid region. Based on extensive surveys and systematic collections in the years 2011, 2012 and 2014, Kumar et al. (2013a),

Kumar et al. (2016a) and Kumar (2017) reported 495 species of vascular plants belonging to 267 genera and 73 families adding 189 species to the existing floral wealth of the NDBR. Further, Kumar et al. (2016b) and Rai et al. (2017) recorded four noteworthy additions viz., *Dontostemon glandulosus, Potentilla pamirica, Carex sagaensis* and *Anthoxanthum flexuosum* to the flora of the Western Himalaya. Recently, Pandey et al. (2021) discovered a new species viz., *Allium negianum* from the valley.

2.4 Ecology of cold-arid regions in Niti valley

In ecological systems, vegetation communities are shaped by various physiographic and edaphic factors which determine their structural and functional attributes. In Trans-Himalayan region of the state of Uttarakhand, limited studies on livestock, patterns of diversity in various vegetation communities and landforms are available. Mitra et al. (2013) reported migratory route and stopover sites that face maximum anthropogenic pressure during livestock migration in Niti valley. Kumar and Mitra (2015) reported higher percentage of livestock presence, however, the blue sheep (*Pseudois nayaur*) was absent from major pastures in the region. Kumar et al. (2016c) declared *Caragana versicolor* Benth. (Fabaceae), a keystone species of high conservation concerns in the Hindu Kush Himalayan region. Kumar (2017) reported major landforms (moraine, river bed and scree) in the same region, among three major landforms, the species richness was highest in moraine (99) followed by scree (88) and river bed (44). Considering the unique floristic diversity, fauna and geology of the cold–arid regions of Kinnaur, HP and Nilang, Niti, Mana, Johar, Darma and Byans valleys in Uttarakhand along the Northern frontiers, Kumar et al. (2017) proposed inclusion of these valleys as a new Trans-Himalayan Biogeographic Province (1C) of India.

2.5 Ethnobotanical wealth of Niti valley

According to floral statistics of India (2017) hosted by Botanical Survey of India, Kolkata, a total of 2,68,600 flowering plants worldwide among them 18,386 (6.84% of world) exited in India. In India, approximately 3000 plants species are known to have their medicinal properties. Prakasha et al. (2010) reports a total of 2500 plants that are used in traditional medicine, of which 100 plants are used regularly (Joshi and Pant 2012). In India, over 53 million tribal people belonging to 550 communities of 227 ethnic groups consume their food generally from forests for nourishment, pharmaceutical use and other prerequisites. Local communities in the Indian Himalaya fulfil their basic needs by utilizing many naturally occurring plant species including wild edibles. According to Phondani et al. (2010), 86 plant species were recognized as being utilized for the treatment of 37 common human ailments by *Tolchha* and *Marchha* sub-communities of the Bhotiya community in the Niti valley of Alaknanda catchment in the Western Himalaya. During a survey conducted in the upper catchment of Dhauli Ganga (also known as Niti valley), Kandari et al. (2012) documented 50 medicinal plants belonging to 31 families and 44 genera that are utilized by Bhotiyas. Of which, 70% were harvested from the wild, 22% were cultivated and 8% were cultivated as well as wild harvested. Kumar et al. (2013b) reported a unique archetype of conservation for safeguarding *Allium stracheyi* Baker (*Jambu-Pharan*) population in Niti valley. Kumar et al. (2015) raised a concern on depleting indigenous knowledge on medicinal plants of Bhotiya community and revealed that the locals are knowledgeable of about 38 medicinal plants used for curing 24 different human ailments. The local communities of the Himalaya have been utilizing fuelwood as one of the major sources of vitality for centuries. According to Mitra et al. (2017) Bhotiyas use 10 species for fuelwood (five species each of tree and shrub) in the same region. Singh et al. (2022) reported 27 potential wild edible fruits that are consumed by ethnic *Bhotia* community in the same region.

3. METHODOLOGY

The information on the high use value and threatened MAPs was collected through primary and secondary sources. The primary data was collected using semi-structured open-ended and closed-ended questions including individual interactions and group discussions. Surveys were carried out in selected seven villages and local/village markets in the study area. The secondary information was gathered from offline and online sources such as scientific research articles, reports, books, dissertations, PhD thesis and using numerous databases, such as Google scholar, Research-gate, Taylor and Francis online, Springer-link, Elsevier online (**Figure 2 and 3**) etc.

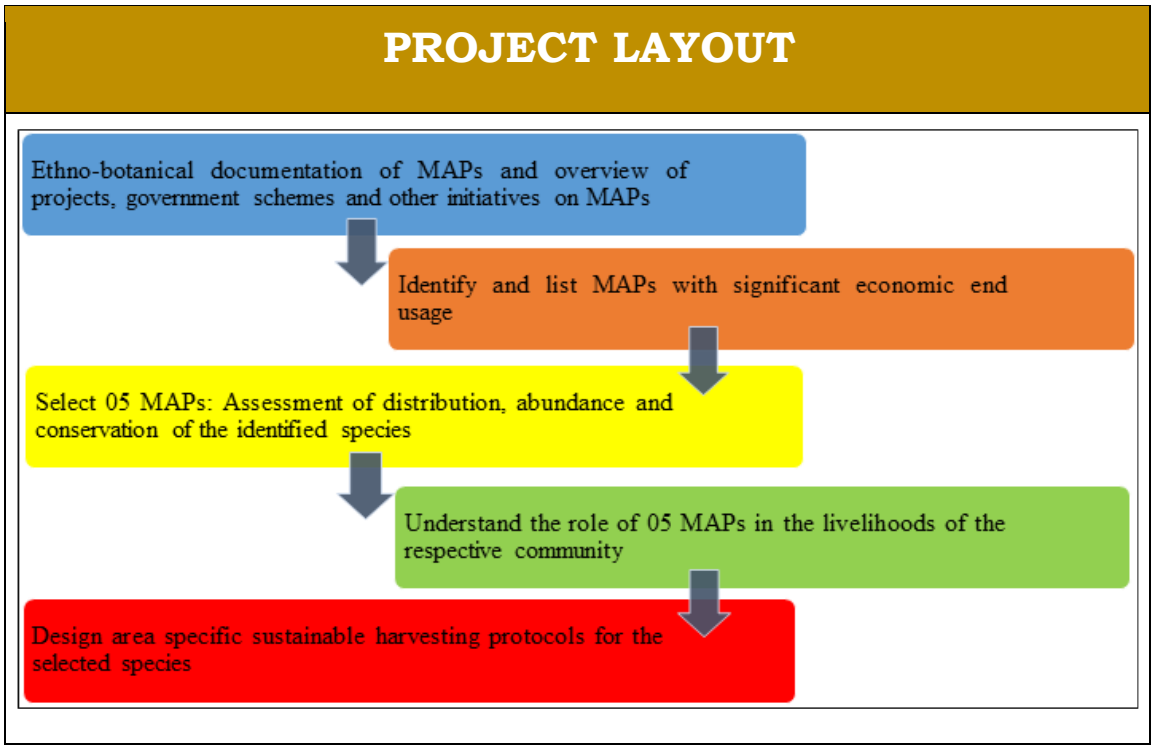


Figure 2. Methodology adopted in the project work.

The following were the basic steps for the preparation of an inventory of MAPs in the study area.

(i) Reconnaissance: During reconnaissance, the study area was delineated and a preliminary checklist of locally and commercially used plants available in the area, vegetation types, distribution pattern, trade route of the highly medicinal plants and size of the area were recorded with the help of local communities, shepherds and frontline staff of the forest department.

(ii) Stratification: Based on the initial reconnaissance and knowledge of the area, each survey locality was divided into smaller natural units or strata. The strata could be based on the landform, terrain, disturbance regime, altitude, and vegetation types.

(iii) Sample plot layout: Using stratified random sampling method, one 50m×50m plot was selected for sampling in the selected landforms/areas. In order to uniformly sample the selected area within each plot, 20, 1m×1m quadrats were laid for herbaceous species.

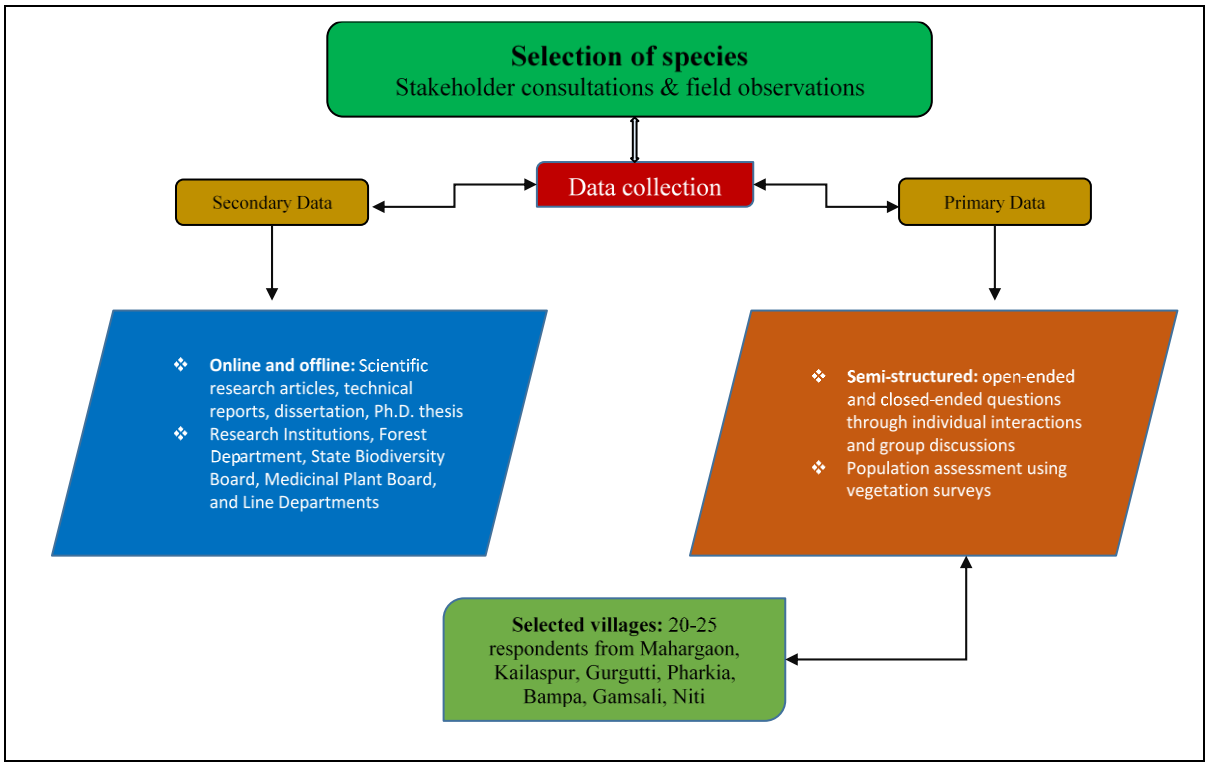


Figure 3. Data collection framework for the current study.

In each sampling site, the information on the habitat parameters, such as elevation, geographic coordinates (latitude and longitude), slope (degree), aspect (0-359°), habit, habitat characteristics, vegetation cover (%) and total number of species was recorded.

(iv) Data collection: The individual MAPs were counted within the sample plots. In addition to MAPs, environmental data such as altitude, aspect, closest associates of the survey species and topography was also recorded. The phyto-sociological data was collected and analyzed for the estimation of density, frequency and abundance following Curtis and McIntosh (1950); Phillips (1959); Curtis (1959); Misra (1968); Muller- Dombois and Ellenberg (1974).

3.1 Key tasks and approach

1. Ethno-botanical documentation of MAPs and overview of projects, government schemes and other initiatives on MAPs in the valley.

   Method*:* Reports on MAPs available with UKFDs, Govt. agencies, NGOs, and Institutions and consultations with different stakeholders.

2. Identify and list 05 MAPs (having global significance) with significant economic end usage in the valley.

   Method: Detailed field surveys to identify and list 05 MAPs of significant economic end usage. Analyses of data to develop an inventory of MAPs with significant economic end usage by different stakeholder groups. Primary data collection through a semi-structured questionnaire/ individual interviews/group discussion etc. to study the quantum of collection, and trade for high use value and threatened species by the local community. Consultations with stakeholders to study the prevailing dynamics of business (collection, value addition, enterprise, economic and legal framework) about the focal species.

3. Select significantly important, based on the global significance of MAPs in the study. Identify 05 MAPs with the highest volume of collection and highest threat perception due to removal and usage. Analyze secondary data from technical reports, CAMP exercises.

4. Assessment of distribution, abundance, and conservation of the prioritized 05 species identified in the valley. Create distribution and abundance of the focal species and the conservation status of the focal species. A literature review by consulting regional flora's, reports on vegetation studies, forest working plans, and research papers. Review distribution and abundance data of focal species. Primary data collection through field studies for selected MAP species.

5. Understand the role of selected 05 MAPs in the livelihoods of the respective community. Literature review for secondary information on baseline livelihood status with special focus on focal species' contribution; develop data collection formats; visit collection sites. Primary data collection through a semi-structured questionnaire to study the quantum of collection, local consumption, and trade of focal species by the local community.

6. Suggest area-specific sustainable harvesting protocols for the 05 selected MAP species. Collate information on prevailing harvesting techniques, from published literature and field surveys using a semi-structured questionnaire. Prepare the inventory and assess the harvesting mechanisms. Suggest mechanisms that may include tools and techniques for sustainable harvest for the selected MAP species in the existing conditions, including best practices that can be followed. Suggest a package of practices for the focal MAP species for adoption in the valley so that by adopting the suggested mechanism, the long-term persistence of the species is maintained.

Image 5: Interaction with Bhotiyas on ethno-medicinal knowledge in Niti valley.

4. RESULTS AND DISCUSSION

4.1 Medicinal plant diversity in Niti valley

In the Himalayan region, the local communities depend on collection and trade of medicinal plants, handicrafts, and agriculture for their livelihood due to inhospitable conditions. The current study recorded a total of 72 medicinal and aromatic plant species belonging to 58 genera under 31 families (**Table 1**). Of the recorded species, 74% were wild in nature whereas, 26% were wild as well as cultivated in the valley (**Figure 4**). Of the recorded medicinal plant species, 63% were in trade and locally consumed however, 37% species were only consumed by the Bhotiyas. In terms of medicinal usage, 51% of the species have high pressure due to overuse and unmanaged harvesting followed by 29% with moderate pressure and 20% have low pressure (**Figure 5**).

Image 6. Chippi, Dhoop, Keedajadi and Gucchi in high demand and trade in Niti valley.

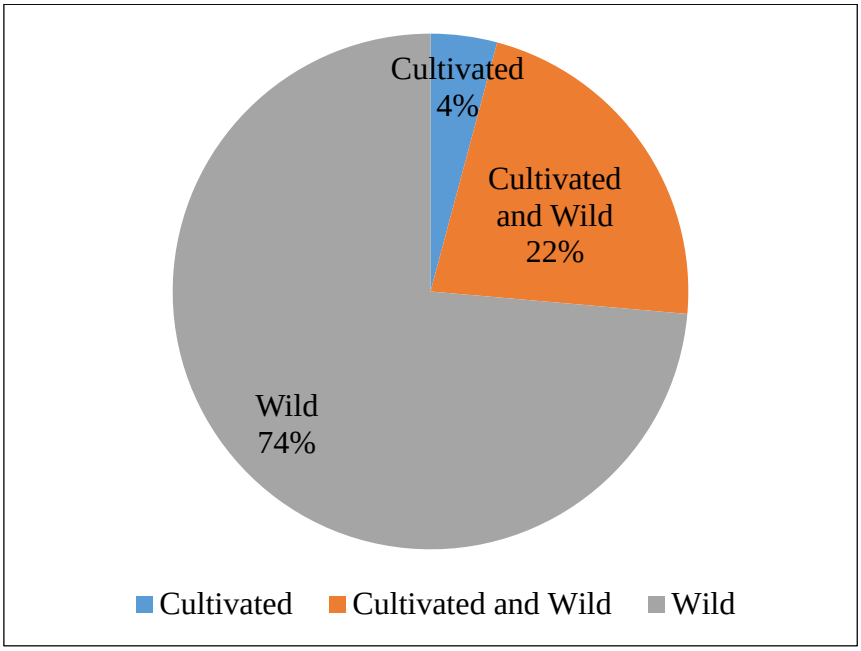


Figure 4. Distribution pattern of MAPs in Niti valley.

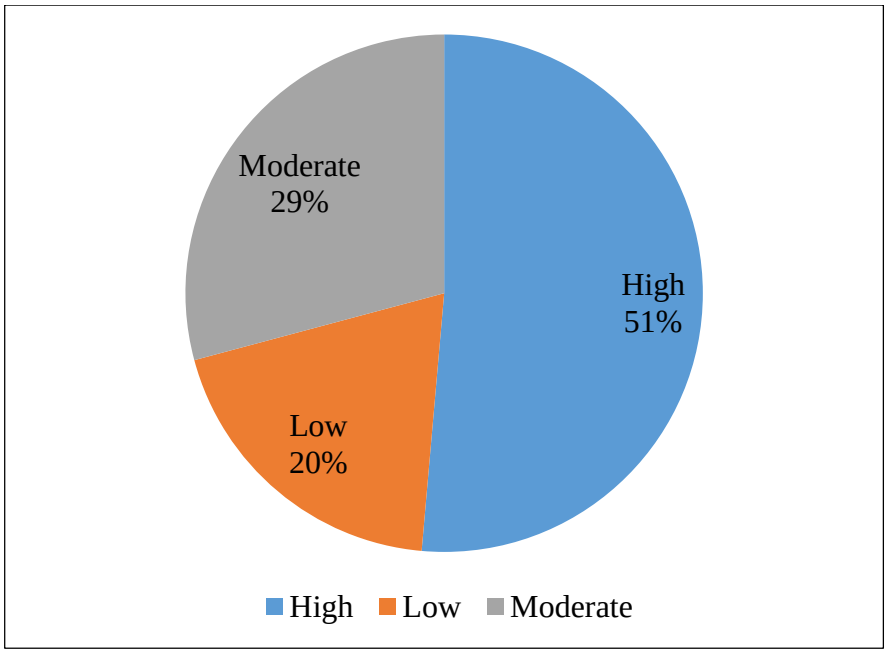


Figure 5. Extent of pressure or usage on MAPs in Niti valley.

Table 1: List of medicinal and aromatic plants reported in Niti valley.

S. No.	Botanical name	Family	Trade/ local consumption	Cultivated / wild	IUCN*/ CITES**/ WPA***	Price per kg	Pressure/ usage	Distribution (m)
1	*Aconitum lethale* Griff.	Ranunculaceae	Trade and Lc	Wild	--	2000-2500	High	3000-4000
2	*Aconitum violaceum* Jacquem. ex Stapf	Ranunculaceae	Trade and Lc	Wild	VU*	2000-2500	High	3500-4500
3	*Aconogonon tortuosum* (D.Don) H.Hara	Polygonaceae	Trade and Lc	Wild	--	400-500	Moderate	3500-4500
4	*Allium carolinianum* Redouté	Amaryllidaceae	Lc	Wild	--	NA	Moderate	3000-3500
5	*Allium stracheyi* Baker	Amaryllidaceae	Trade and Lc	Cultivated and Wild	--	1000-1500	High	2800-4000
6	*Allium wallichii* Kunth	Amaryllidaceae	Trade and Lc	Cultivated and Wild	--	800-1200	High	2800-3000
7	*Angelica archangelica* L.	Apiaceae	Trade and Lc	Wild	LC*	1800-2500	High	3000-3600
8	*Angelica glauca* Edgew.	Apiaceae	Trade and Lc	Wild	EN*	1800-2500	High	3000-3600
9	*Arctium lappa* L.	Asteraceae	Trade and Lc	Cultivated and Wild	LC*	2000-3000	High	3000-3800
10	*Arisaema tortuosum* (Wall.) Schott	Araceae	Trade and Lc	Wild	--	300-500	High	2800-4000
11	*Arnebia benthamii* (Wall. ex G.Don) I.M.Johnst.	Boraginaceae	Trade and Lc	Wild	--	1000-1500	High	3000-4800
12	*Artemisia gmelinii* Weber ex Stechm.	Asteraceae	Lc	Wild	--	NA	Low	3000-4800
13	*Artemisia maritima* L.	Asteraceae	Lc	Wild	--	NA	Low	2800-4000
14	*Astragalus candolleanus* Boiss.	Fabaceae	Trade and Lc	Wild	--	300-500	High	2800-4000
15	*Berberis pseudumbellata* R. Parker	Berberidaceae	Trade and Lc	Wild	--	1000-1500	High	2800-4000
16	*Bergenia ciliata* (Haw.) Sternb.	Saxifragaceae	Trade and Lc	Cultivated and Wild	--	2000-2500	High	3000-4700
17	*Betula utilis* D.Don	Betulaceae	Trade and Lc	Wild	LC*	800-1200	High	2800-4000
18	*Cannabis sativa* L.	Cannabaceae	Lc	Cultivated and Wild	--	NA	Low	2500-3500
19	*Carum carvi* L.	Apiaceae	Trade and Lc	Cultivated and Wild	LC*	3000-5000	High	2800-3600

S. No.	Botanical name	Family	Trade/ local consumption	Cultivated / wild	IUCN*/ CITES**/ WPA***	Price per kg	Pressure/ usage	Distribution (m)
20	*Cedrus deodara* (Roxb. ex D.Don) G.Don	Pinaceae	Trade and Lc	Wild	LC*	5000-7000	High	2800-3800
21	*Chenopodium foliosum* Asch.	Amaranthaceae	Trade and Lc	Wild	--	300-500	Moderate	3000-4800
22	*Cicerbita macrorhiza* (Royle) Beauverd	Asteraceae	Lc	Wild	--	NA	Low	3000-3500
23	*Corydalis cornuta* Royle	Papaveraceae	Lc	Wild	--	NA	Moderate	3400-3700
24	*Cotoneaster microphyllus* Wall. ex Lindl.	Rosaceae	Lc	Wild	--	NA	Low	3200-3800
25	*Dactylorhiza hatagirea* (D.Don) Soó	Orchidaceae	Trade and Lc	Wild	EN*, Appendix II** & Appendix II***	4000-8000	High	2800-4200
26	*Delphinium denudatum* Wall. ex Hook.f. & Thomson	Ranunculaceae	Trade and Lc	Wild	--	300-500	Moderate	3000-4200
27	*Ephedra gerardiana* Wall. ex Klotzsch & Garcke	Ephedraceae	Trade and Lc	Wild	VU*	400-600	Moderate	3000-5000
28	*Fagopyrum dibotrys* (D.Don) Hara	Polygonaceae	Trade and Lc	Cultivated	--	500-700	Moderate	2800-3500
29	*Fagopyrum esculentum* Moench	Polygonaceae	Trade and Lc	Cultivated	--	500-700	Moderate	2800-3500
30	*Fragaria nubicola* (Lindl. ex Hook.f.) Lacaita	Rosaceae	Trade and Lc	Wild	--	300-500	Moderate	3200-3800
31	*Gaultheria trichophylla* Royle	Ericaceae	Trade and Lc	Wild	--	200-400	High	3000-4000
32	*Geranium wallichianum* D.Don ex Sweet	Geraniaceae	Lc	Wild	LC*	NA	Low	3200-4500
33	*Gymnadenia orchidis* Lindl.	Orchidaceae	Trade and Lc	Wild	--	1000-1200	High	3400-4000
34	*Hippophae salicifolia* D.Don	Elaeagnaceae	Trade and Lc	Cultivated and wild	--	300-500	High	2800-3800
35	*Hyoscyamus niger* L.	Solanaceae	Lc	Wild	--	NA	Low	2500-3500
36	*Hyssopus officinalis* L.	Lamiaceae	Lc	Wild	DD*	NA	Low	2500-3500
37	*Juglans regia* L.	Juglandaceae	Lc	Cultivated and wild	LC*	NA	Low	2500-3500
38	*Juniperus communis* L.	Cupressaceae	Lc	Wild	LC*	NA	High	3000-4500
39	*Juniperus indica* Bertol	Cupressaceae	Trade and Lc	Wild	LC*	500-800	High	3000-4500

S. No.	Botanical name	Family	Trade/ local consumption	Cultivated / wild	IUCN*/ CITES**/ WPA***	Price per kg	Pressure/ usage	Distribution (m)
40	*Malus domestica* Borkh.	Rosaceae	Trade and Lc	Cultivated		100-200	High	3000-3800
41	*Mentha longifolia* (L.) Huds.	Lamiaceae	Lc	Wild	LC*	NA	Moderate	2500-3500
42	*Morchella esculenta*	Morchellaceae	Trade and Lc	Wild	--	10000-20000	High	2800-4000
43	*Ophiocordyceps sinensis*	Ophiocordycipitaceae	Trade and Lc	Wild	VU*	10-15 lakh	High	3500-5500
44	*Origanum vulgare* L.	Lamiaceae	Trade and Lc	Wild	LC*	200-400	Moderate	2500-3500
45	*Phytolacca acinosa* Roxb.	Phytolaccaceae	Lc	Cultivated and Wild	--	NA	Moderate	2500-3500
46	*Picrorhiza kurroa* Royle ex Benth.	Plantaginaceae	Trade and Lc	Wild	EN*, Appendix II** & Appendix II***	800-1500	High	3500-4500
47	*Pinus wallichiana* A.B. Jacks.	Pinaceae	Lc	Wild	LC*	NA	Moderate	3000-3500
48	*Pleurospermum brunonis* (DC.) Benth. ex C.B.Clarke	Apiaceae	Trade and Lc	Wild	--	1200-1500	High	3000-4000
49	*Polygonatum verticillatum* (L.) All.	Asparagaceae	Trade and Lc	Wild	--	600-800	High	3200-3800
50	*Polygonum plebejum* R. Br.	Polygonaceae	Lc	Wild	--	NA	Moderate	2800-4000
51	*Potentilla fulgens* Wall. ex Sims	Rosaceae	Lc	Wild	--	NA	Moderate	2500-3500
52	*Prunus armeniaca* L.	Rosaceae	Lc	Cultivated and Wild	DD*	100-300	High	2500-3500
53	*Prunus cornuta* (Wall. ex Royle) Steud.	Rosaceae	Lc	Cultivated and Wild	--	NA	Low	2500-3500
54	*Prunus jacquemontii* Hook.f.	Rosaceae	Lc	Cultivated and Wild	--	NA	Moderate	2500-3500
55	*Prunus mira* Koehne	Rosaceae	Lc	Cultivated and Wild	--	NA	Moderate	2500-3500
56	*Rheum moorcroftianum* Royle	Polygonaceae	Trade and Lc	Wild	--	1000-1200	High	3000-4500
57	*Rheum webbianum* Royle	Polygonaceae	Trade and Lc	Wild	--	1000-1200	High	3000-4500
58	*Rhododendron anthopogon* D.Don	Ericaceae	Lc	Wild	--	NA	Low	3000-4800
59	*Ribes alpestre* Wall. ex Decne.	Grossulariaceae	Trade and Lc	Wild	--	1000-1500	High	3000-4000
60	*Ribes orientale* Desf.	Grossulariaceae	Lc	Wild	--	NA	Moderate	2500-3500

S. No.	Botanical name	Family	Trade/ local consumption	Cultivated / wild	IUCN*/ CITES**/ WPA***	Price per kg	Pressure/ usage	Distribution (m)
61	*Rosa macrophylla* Lindl.	Rosaceae	Lc	Wild	--	NA	Low	3000-3600
62	*Rosa sericea* Lindl.	Rosaceae	Trade and Lc	Wild	--	600-800	High	3000-3750
63	*Rosa webbiana* Wall. ex Royle	Rosaceae	Trade and Lc	Wild	--	200-400	Moderate	3000-4500
64	*Rumex nepalensis* Spreng.	Polygonaceae	Lc	Wild	--	NA	Low	900-4150
65	*Saussurea costus* (Falc.) Lipsch.	Asteraceae	Trade and Lc	Cultivated and Wild	CR*, Appendix I**, Appendix II***	300-500	High	3000-3200
66	*Saussurea obvallata* (DC.) Sch.Bip.	Asteraceae	Trade and Lc	Wild	--	500-1000	High	3800-4800
67	*Selinum wallichianum* (DC.) Raizada & H.O.Saxena	Apiaceae	Trade and Lc	Wild	--	1800-3000	High	3000-3500
68	*Sinopodophyllum hexandrum* (Royle) T.S.Ying	Berberidaceae	Trade and Lc	Cultivated and Wild	Appendix II** & Appendix II***	800-1000	High	3000-4000
69	*Taraxacum officinale* F.H.Wigg.	Asteraceae	Lc	Wild	--	NA	Low	3000-3800
70	*Thymus linearis* Benth.	Lamiaceae	Trade and Lc	Wild	--	300-500	Moderate	3000-5000
71	*Urtica dioica* L.	Urticaceae	Lc	Wild	LC*	NA	Moderate	2500-3800
72	*Valeriana hardwickii* Wall.	Caprifoliaceae	Trade and Lc	Wild	--	2000-3000	High	2500-3200

4.2 Ethno-botanical diversity in Niti valley

The Bhotiyas depend on the wild medicinal and aromatic plant species for their traditional health care system. Of total MAPs recorded in the valley, 72 species were locally utilized by the locals (**Table 2**). Of the recorded species, 47% of the medicinal plants are used in the common diseases. Bhotiyas use 21% medicinal species for fever followed by cold and cough (14%), nerve & joint pain and headache (7% each) and cuts and wounds (4%) (**Figure 6)**. In terms of plant part use, 27% species were used as a whole plant, 23% fruit, 20% leaf, 14% root, 7% bark, 5% seed and 4% tubers (**Figure 7**).

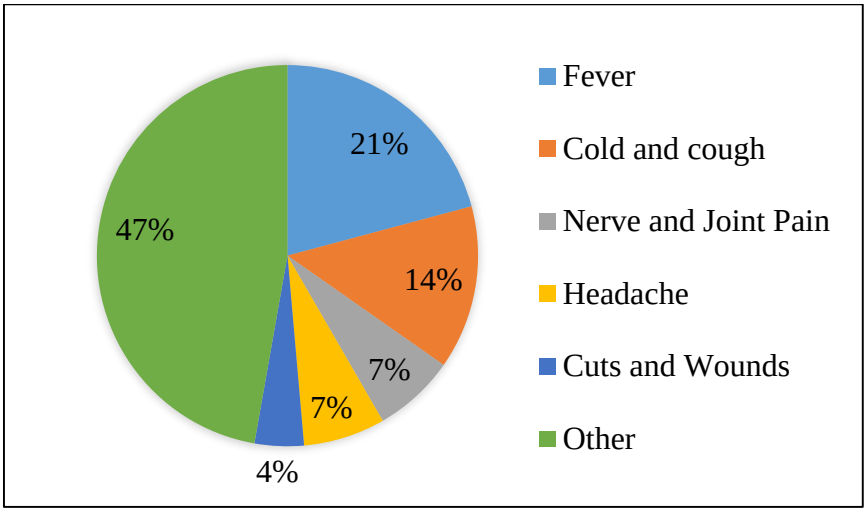


Figure 6. Use of medicinal plants in different ailments by locals

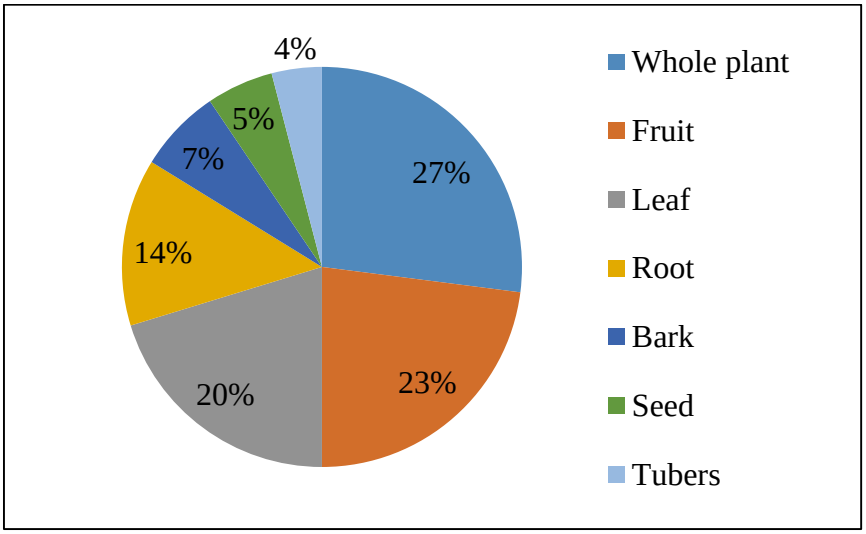


Figure 7. Plant parts used in different ailments by locals.

Table 2. List of ethno-medicinal plant species utilized by Bhotiyas in Niti valley.

S. No	Botanical name	Family	Vernacular name	Parts used	Medicinal uses
1	*Aconitum lethale* Griff.	Ranunculaceae	Meetha Jari	Root	Fever, rheumatism, nerve pain and sciatica
2	*Aconitum violaceum* Jacquem. ex Stapf	Ranunculaceae	Atish or Patish	Tuberous, Root	Nerve pain, stomachache, cough and heart disease

S. No	Botanical name	Family	Vernacular name	Parts used	Medicinal uses
3	*Aconogonon tortuosum* (D.Don) H.Hara	Polygonaceae	Naylo	Root and shoot	Leucorrhoea
4	*Allium carolinianum* Redouté	Amaryllidaceae	Doom	Whole plant	Constipation, digestion, loose motion, headache, joint pain, cold and cough, diarrhea
5	*Allium stracheyi* Baker	Amaryllidaceae	Jambu Faran	Whole plant	Headache, joint pain, cold, cough, diarrhea, and as condiments
6	*Allium wallichii* Kunth	Amaryllidaceae	Laynka	Whole plant	Jaundice, cold and cough
7	*Angelica glauca* Edgew.	Apiaceae	Choru	Root and Fruit	Acidity, vomiting, body ache, fever, headache
8	*Angelica archangelica* L.	Apiaceae	Choru	Root and Fruit	Acidity, vomiting, body ache, fever, headache
9	*Arctium lappa* L.	Asteraceae	Jangali Kunth	Root	Stomachache, rheumatism, fever
10	*Arisaema tortuosum* (Wal) Schott	Araceae	Kavakya, , Bal Mungari	Whole plant	Stomach infection
11	*Arnebia benthamii* (Wall. ex G.Don) I.M.Johnst.	Boraginaceae	Laljari, Balchadi	Root and leaves	Baldness, fever, cuts and wounds and blood pressure
12	*Artemisia gmelinii* Weber ex Stechm.	Asteraceae	Purchu	Leaf and Root	Cold and cough
13	*Artemisia maritima* L.	Asteraceae	Purchu	Leaf and Root	Stomachache, rheumatism, fever
14	*Astragalus candolleanus* Boiss.	Fabaceae	Rudravanti	Whole plant	Blood pressure, blood purifier, asthma and cough
15	*Berberis pseudumbellata* R. Parker	Berberidaceae	Kilmora	Fruit	Antioxidant
16	*Bergenia stracheyi* (Hook.f. & Thomson) Engl.	Saxifragaceae	Silfore	Whole plant	Kidney stone

S. No	Botanical name	Family	Vernacular name	Parts used	Medicinal uses
17	*Betula utilis* D.Don	Betulaceae	Bhuj, Bhoj	Bark	Rheumatism, asthma, cold, cough and fever
18	*Cannabis sativa* L.	Cannabaceae	Bhang	Whole plant	Urine infection, lack of concentration
19	*Carum carvi* L.	Apiaceae	Jangali Jira	Seed and leaf	Fever, diarrhea and stomachache
20	*Cedrus deodara* (Roxb. ex D.Don) G.Don	Pinaceae	Devdar	Inner wood	Inflammation, wrinkles, acne or any infection
21	*Chenopodium foliosum* Asch.	Amaranthaceae	Bethua	Leaf	Indigestion, cold, cough
22	*Cicerbita macrorhiza* (Roy le) Beauverd	Asteraceae	Karatu	Whole plant	Treating fever
23	*Corydalis cornuta* Royle	Papaveraceae	Chitra Jar	Tubers, bulbs and roots	Headache, insomnia, and dysmenorrhea
24	*Cotoneaster microphyllus* Wall. ex Lindl.	Rosaceae	Ruins	Fruit	Dermatitis
25	*Dactylorhiza hatagirea* (D.Don) Soó	Orchidaceae	Hatthajadi	Root	Dysentery, diarrhea, chronic fever, cough, stomachache, wounds, cuts and general weakness
26	*Delphinium denudatum* Wall. ex Hook.f. & Thomson	Ranunculaceae	Nirbishi	Root	Aconite poisoning, brain diseases, fungal infection, piles
27	*Ephedra gerardiana* Wall. ex Klotzsch & Garcke	Ephedraceae	Somlata	Root and shoot	Asthma, rheumatism, headache
28	*Fagopyrum esculentum* Moench	Polygonaceae	Phaphar	Root and leaves	Rheumatism, lung diseases and fever
29	*Fagopyrum dibotrys* (D.Don) Hara	Polygonaceae	Phaphar	Root and leaves	Toothache, lung diseases and fever
30	*Fragaria nubicola* (Lindl. ex Hook.f.) Lacaita	Rosaceae	Jangali Kafal	Fruit	Profuse menstruation

S. No	Botanical name	Family	Vernacular name	Parts used	Medicinal uses
31	*Gaultheria trichophylla* Royle	Ericaceae	Jheri	Fruit and leaves	Wounds, cold and cough
32	*Geranium wallichianum* D.Don ex Sweet	Geraniaceae	Neela Phool	Root	Toothache, skin disease
33	*Gymnadenia orchidis* Lindl.	Orchidaceae	Hathjod	Root	Acidity, lose motion, fever, diarrhea, cuts and wounds
34	*Hippophae salicifolia* D.Don	Elaeagnaceae	Ames, Chuk	Fruit and bark	Cold , cough, wounds, fever, chest pain
35	*Hyoscyamus niger* L.	Solanaceae	Phagun	Whole plant	Toothache, cold and cough
36	*Hyssopus officinalis* L.	Lamiaceae	Dhoop	Leaves and flowers	Colds, cough, congestion and lung complaints
37	*Juglans regia* L.	Juglandaceae	Jangali akhrot	Cotyledon	Helminthiasis, diarrhea, sinusitis, stomachache, arthritis, asthma, eczema, scrofula
38	*Juniperus indica* Bertol	Cupressaceae	Bitaru	Leaf and Fruit	Fever, cold and cough
39	*Juniperus communis* L.	Cupressaceae	Bitaru	Leaf and Fruit	Diuretic, antiseptic, gastrointestinal disorders
40	*Malus domestica* Borkh.	Rosaceae	Seb	Fruit	Digestion, cancer
41	*Mentha longifolia* (L.) Huds.	Lamiaceae	Jangali pudina	Whole plant	Stomach problems and allergy
42	*Morchella esculenta*	Morchellaceae	Gucchi	Whole plant	Cold, cough and immunity booster
43	*Ophiocordyceps sinensis*	Ophiocordycipitaceae	Keerajadi	Whole plant	Immunity booster
44	*Origanum vulgare* L.	Lamiaceae	Van tulsi	Leaf	Cold, fever and blood purification
45	*Phytolacca acinosa* Roxb.	Phytolaccaceae	Jagra	Whole plant	Asthma, cold and cough
46	*Picrorhiza kurroa* Royle ex Benth.	Plantaginaceae	Kutki	Whole plant	Cold, cough, fever, diabetes, jaundice,

S. No	Botanical name	Family	Vernacular name	Parts used	Medicinal uses
					typhoid and constipation
47	*Pinus wallichiana* A.B. Jacks.	Pinaceae	Kail	Seed	Skin complaints, wounds, sores, burns
48	*Pleurospermum brunonis* (DC.) Benth. ex C.B.Clarke	Apiaceae	Chippi	Whole plant	Stomachache, fever and condiments
49	*Sinopodophyllum hexandrum* (Royle) T.S.Ying	Berberidaceae	Ban Kakadi	Fruit and Root	Stomachache, skin disease, sugar, cancer, hair-fall, intestinal infection, old fever
50	*Polygonatum verticillatum* (L.) All.	Asparagaceae	Salam-misri	Root	Stamina booster, stomachache, tuberculosis (Kshay rog)
51	*Polygonum plebejum* R. Br.	Polygonaceae	Tanka Grass	Root	Skin disease, Boils
52	*Potentilla fulgens* Wall. ex Sims	Rosaceae	Vajradanti	Root	Toothache
53	*Prunus armeniaca* L.	Rosaceae	Chuli	Fruit	Body ache, diarrhea
54	*Prunus cornuta* (Wall. ex Royle) Steud.	Rosaceae	Jangali jamun	Fruit	Respiration and improve digestion
55	*Prunus jacquemontii* Hook.f.	Rosaceae	Khursang	Fruit	Improve digestion, hepatitis, hyperlipidemia, hypertension
56	*Prunus mira* Koehne	Rosaceae	Kirol	Fruit	Hair-loss
57	*Rheum moorcroftianum* Royle	Polygonaceae	Dholu	Root	Skin disease, pain, cold and cough, stamina
58	*Rheum webbianum* Royle	Polygonaceae	Tatari	Root and leaves	Ulcer, cuts and wounds, boils
59	*Rhododendron anthopogon* D.Don	Ericaceae	Awon	Stem, leaves, and buds	Headache, digestion
60	*Ribes alpestre* Wall. ex Decne.	Grossulariaceae	Lipchi	Fruit	Detoxification, glaucoma, cardiovascular disease, stomachache,

S. No	Botanical name	Family	Vernacular name	Parts used	Medicinal uses
61	*Ribes orientale* Desf.	Grossulariaceae	Darbag	Fruit	Treat rheumatism and joints pain
62	*Rosa macrophylla* Lindl.	Rosaceae	Kawa sidum	Fruit	Sexual and menstrual disorders, backache, and skin boils
63	*Rosa sericea* Lindl.	Rosaceae	Sidum	Fruit	Headaches
64	*Rosa webbiana* Wall. ex Royle	Rosaceae	Sidum	Fruit	Kidney stones, diabetes, eye strain, hemorrhoids, bronchitis, ulcers, gallstones
65	*Rumex nepalensis* Spreng.	Polygonaceae	Payoom	Root and aerial parts	Antioxidant and antibacterial
66	*Saussurea costus* (Falc.) Lipsch.	Asteraceae	Kuth	Whole plant	Asthma, inflammatory diseases, ulcer and stomach problems
67	*Saussurea obvallata* (DC.) Sch.Bip.	Asteraceae	Brahma Kamal	Whole plant	Rheumatism, cuts and wounds, boils
68	*Selinum wallichianum* (DC.) Raizada & H.O.Saxena	Apiaceae	Bhutkesh	Flower	Folk medicine and ritual
69	*Taraxacum officinale* F.H.Wigg.	Asteraceae	Karanphool	Root	Acidity, fever and headache
70	*Thymus linearis* Benth.	Lamiaceae	Marchaghas	Whole plant	Stomachache, cuts and wounds, acidity, skin disease, Nerve pain
71	*Urtica dioica* L.	Urticaceae	Kandali	Leaves and stems	Painful muscles and joints, eczema, arthritis, gout, and anemia
72	*Valeriana hardwickii* Wall.	Caprifoliaceae	Taggar	Whole plant	Urine infection, oil, dhoop, liver disease, stomachache and skin disease

4.3. Government schemes, initiatives and research projects on MAPs in Uttarakhand

4.3.1 Uttarakhand State Govt. Initiatives

The state of Uttarakhand is a repository of valuable wild medicinal and aromatic plant species. Therefore, in order to promote the cultivation of selected aromatic plant species, the following benefits are being provided to the farmers in the state.

- 50% subsidy on cultivation cost of 26 selected aromatic species.
- 20% matching grant against projects sanctioned by NMPB and NHB.
- 95% subsidy for establishing field distillation units to the farmer's group of the cluster.
- Free planting material to all farmers of border districts and BPL/ST/SC farmers of non-border districts for the cultivation of aromatic crops in 05 nalis.

4.3.2 Herbal Research Development Institute

Herbal Research Development Institute (HRDI), Govt. of Uttarakhand has prioritized 28 medicinal and aromatic species for the cultivation in the state in different climatic and geographical regions. About 50 subsidies are given to the farmers on cultivation of the prioritized species. Besides receiving funds from the state government, HRDI is also implementing projects from different centrally sponsored funding agencies such as: -

- **National Mission on Medicinal Plants:** Sponsored by National Medicinal Plants Board (NMPB), Govt. of India, New Delhi for the sustainable development of medicinal and aromatic plants in the state of Uttarakhand. This project is aimed at establishment of nurseries to produce quality planting material, commercial cultivation of selected species, storing, value addition and to develop marketing infrastructure within the state.
- **Anwala Mission in Uttarakhand:** Sponsored by NMPB in 2010, anwala clusters has been established in each district of the state for the preparation of anwala products.

- **GEF-UNDP Project:** Global Environmental Facility-United Nations Development Programme, sponsored project entitled '*Mainstreaming Conservation and Sustainable Use of Medicinal Plant Diversity in Uttarakhand*' is being implemented with the help of State Forest Department, Uttarakhand to ensure *in-situ* conservation of medicinal plants by developing Medicinal Plants Conservation Areas (MPCAs). Now, this project has been transferred to SMPB, Dehradun for further implementation.
- **APPEDA Project:** With the help of Agriculture and Processed Food Products Export Development Authority (APPEDA), Govt. of India, a tissue culture laboratory is being developed at Mandal headquarter of HRDI, which will produce quality planting material of rare and endangered species for mass propagation and for ensuring *ex-situ* conservation of high-altitude valuable species.
- **National Agriculture Development Planning Projects (RKVY):** With the help of Agriculture Ministry, Govt. of India, two projects have been sanctioned by the Govt. of Uttarakhand for the sustainable development of medicinal plants in district Pithoragarh and Chamoli. The project is aimed at establishment of new nurseries and strengthening of new HRDI nurseries.
- **TSP Project:** A project under tribal sub-plan is being implemented in tribal areas of Uttarakhand. Main objective of the project is cultivation, training, value addition and marketing of herbs especially in the high altitude of the Himalaya.

4.3.3 Centre for Aromatic Plants

A new initiative has been taken under R&D efforts by Centre for Aromatic Plants (CAP), Govt. of Uttarakhand through distillation of Himalayan minor essential oils which are available in abundance in forest areas as well as in waste lands. CAP has adopted cluster approach for the cultivation of aromatic plant species in various agro-climatic zones. In 25

such clusters, natural essential oils of the major aromatic crops such as Lemongrass, Damask Rose, Japanese Mint, Palmarosa, *Tagetes patula*, Citronella, Basil, *Artemisia annua*, *Geranium*, *Carum carvi* (Caraway), Lemonbalm and Cinnamon are being produced by the farmers of Uttarakhand. Also, to promote farmers for distillation of these Himalayan minor essential oils, CAP has framed the promotional schemes and policies such training and awareness, distillation facility, marketing support and quality assessment.

- **Paramparagat Krishi Vikas Yojana (PKVY):** Under the 'Paramparagat Krishi Vikas Yojana (PKVY)' scheme, CAP is facilitating farmers for cultivation of aromatic organic crops in four districts Chamoli, Nainital, Haridwar and Pauri. Development of 45 aroma clusters in 900 hectares is being targeted under this scheme.

4.3.4 Uttarakhand Forest Department

Uttarakhand through Centrally Sponsored Schemes (CSS) and State Sector Schemes (SSS) is also responsible to conserve rare and endangered species for following activities: -

- Establishment of pilot plots for rare species of medicinal plants under CSS.
- Conservation and development of medicinal or herbal species for purpose of livelihood development under SSS.

4.3.5 Major research projects on MAPs in high altitude regions of Uttarakhand

Medicinal and aromatic plants are not only a major resource base for the traditional medicine and herbal industry but also provide livelihood and health security to a large segment of Uttarakhand people. Details of major research projects on MAPs in in high altitude regions Uttarakhand is provided in **(Table 3)**.

Table 3. Major research projects on wild MAPs in the state of Uttarakhand.

S.No	Name of the Project	Duration	Funding agency
1.	Status of threatened medicinal and aromatic plants and their use by the local community in Niti valley, NDBR, Uttarakhand	April - November 2022	IUCN-India
2.	Conservation of threatened plants in Indian Himalayan Region (IHR): Recovery and capacity building	2019-2022	National Mission on Himalayan Studies (NMHS)
3.	Adoption of medicinal and edible mushroom integrated with climate resilient interventions for up-scaling livelihoods in Garhwal Himalaya	2018-2022	National Mission on Himalayan Studies (NMHS)
4.	Survey and mapping of medicinal and aromatic plants and other RET/NTFPs on alpine regions of Uttarakhand and developing Uttarakhand-Alpine Information System (UK-AIS)	2016-2019	National Mission on Himalayan Studies (NMHS)
5.	Population dynamics and biogeography of Himalayan Mouse-Hare *Ochotona roylei* in relation to their impact on the medicinal flora of Western Himalaya	2016-2019	National Mission on Himalayan Studies (NMHS)
6.	Assessment of endemic, threatened and high value medicinal plants of cold desert areas in IHR	2012-2016	CSIR, New Delhi
7.	Ecological, taxonomical and ethnobotanical study of wild edible plants of Nainital district in Uttarakhand, India.	2015-2016	National Mission on Himalayan Studies (NMHS)
8.	Income generation programme (IGP) for rural women through high valued medicinal plants cultivation in higher altitude villages particularly in flood affected areas of Uttarakhand.	2015-2016	National Mission on Himalayan Studies (NMHS)

S.No	Name of the Project	Duration	Funding agency
9.	Assessment of existing stock and scaling up productivity of selected high value Himalayan medicinal plants through biological and biotech approaches	2002-2006	Ministry of Health and Welfare New Delhi
10.	Detailed assessment of medicinal and aromatic plant species including their collection, usage, demand, markets, price trends and life cycle, focusing on SECURE Himalaya Landscape	2020-2021	GEF-GoI-UNDP SECURE Himalaya Project
11.	Structural and functional attributes of plant communities in cold-arid region of Nanda Devi Biosphere Reserve, Uttarakhand in relation to resource use pattern	2011-2014	MoEFCC, New Delhi

4.4. Selection of focal MAP species

In Himalayan regions, the increased demand viz., commercial and local consumption has caused decline in wild population of several MAPs. Unfortunately, unorganized, over harvesting and premature harvesting are the major threats to the survival of threatened MAPs in the present scenario, that eventually has led to decline in their natural population, regeneration and survival.

Based on extensive interactions in the form of group discussions, individual communications with younger generartion, elder people (men and women) including local healers, plant collectors and local traders, a total of five high value (with significant economic end usage medicinal and aromatic plant species namely *Allium stracheyi, Carum carvi, Dactylorhiza hatagirea, Picrorhiza kurroa* and *Sinopodophyllum hexandrum* were selected in Niti valley, NDBR. The selection of MAPs was based mainly on two focal categories, (i) highest quantum of collection (HQC) and (ii) high threat (HT) due to removal and usages.

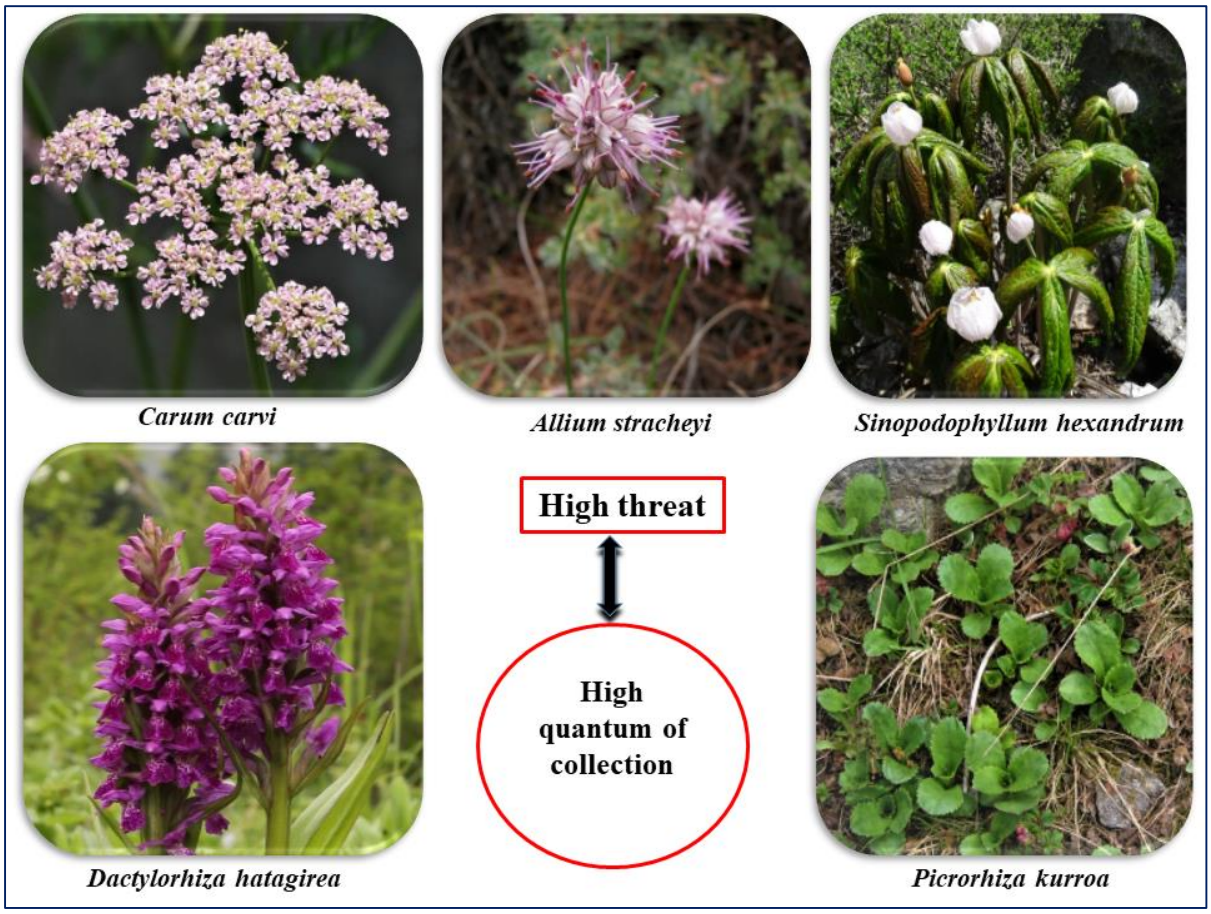


Image 7. High value medicinal and aromatic plant species in Niti valley.

4.4.1 Population status of the focal species

According to IUCN Red List guidelines, and Goraya and Ved (2017), population size, threats and geographic range are essential parameters to evaluate the threat or population status of a species. In the present study, based on the vegetation sampling, the population of MAPs was estimated to understand its habitat specificity, operative threats, exisiting pressure, potential source areas and impact on their survival (**Table 4, 5 and 6**). Of the selected focal species, *Allium stracheyi* and *Carum carvi* were cultivated by the villagers of Niti, Gamshali, Bampa, Pharkiya, Gurgutti, Kailashpur and Mahargaon, whereas *Sinopodophyllum hexandrum* was reported to cultivate at micro-scale in Gamshali and Niti. *A. stracheyi* has been brought under cultivation by the ethnic Bhotiyas of the Niti valley as a kitchen garden crop for a long time for their local consumption as well as trade.

Table 4. Population of focal species in Niti valley, NDBR.

Name of species	Density (ind. m^{-2} ± SE)	Individuals recorded	Associate species
Allium stracheyi Baker	1.8±0.855	186	*Juniperus* spp., *Rosa* spp., *Danthonia cachemyriana, Thymus linearis, Lotus corniculatus, Trigonella emodi* and *Origanum vulgare*
Dactylorhiza hatagirea (D.Don) Soó	**	05	*Sibbaldia parviflora, Euphrasia himalayica, Gaultheria trichophylla* and *Thymus linearis*
Picrorhiza kurroa Royle ex Benth.	0.75±1.03	148	*Bistorta affinis, Potentilla argyrophylla, Thymus linearis, Anaphalis* spp., and *Sibbaldia parviflora*
Sinopodophyllum hexandrum (Royle) T.S. Ying	0.91±0.827	65	*Berberis* spp., *Lonicera* spp., *Arisaema tortuosum, Potentilla* spp., *Geranium wallichianum* and *Juniperus* spp.

**Recorded in one locality

Table 5. Population size, habitat specificity, threat and level of pressure in Niti valley, NDBR.

Species	Local population size	Habitat specificity	Threat	Pressure level
Allium stracheyi	Small, sparse	Wide	Over exploitation for consumption and trade	High
Carum carvi	Large, dominant in and around villages and agricultural fields	Wide	High demand for consumption and trade	High
Dactylorhiza hatagirea	Small, non-dominant	Narrow	Over exploitation for medicine and trade	High
Picrorhiza kurroa	Small, non-dominant	Narrow	Over exploitation for medicine and trade	High
Sinopodophyllum hexandrum	Large, dominant at few locations	Wide	Over exploitation for medicine and trade	High

Table 6. Potential source areas, collection pressure and impact on survival of the focal species.

Species	Potential source areas	Distribution (m)	Collection pressure	Threat status		Impact on the survival
				IUCN	CAMP	
Allium stracheyi	Adjoining forested areas, bouldary slopes, grassy slopes	2800-3500	Highly destructive and selective	--	--	Threat to its wild population
Carum carvi	Domestic in villages and agricultural areas	2500-3500	High trade and local consumption	Least Concern	--	No reports from wild
Dactylorhiza hatagirea	Riverine areas and herbaceous meadows	3000-3800	Highly destructive, unselective and unmanaged	Endangered	Critically Endangered	Threat to its wild population, regeneration and survival
Picrorhiza kurroa	Moraine, rocky alpine slopes	3000-4000	Highly trade	Endangered	Critically Endangered	Threat to its wild population, regeneration and survival
Sinopodophyllum hexandrum	Adjoining forested areas, bouldary slopes, grassy slopes	2800-4000	Highly destructive, unselective and unmanaged	--	Endangered	Threat to its wild population

4.4.2 Species Prioritization Criteria

Owing to hidden markets along with market channel and route, the information on the trade of high use value and threatened medicinal plant species and income generated is lacking from the remote localities of the Himalaya. However, based on the distribution pattern and collection pressure, the selected high value MAPs can be categorized under high, medium and low pressure following Rawat (2007). This, coupled with availability in the wild provides a useful matrix of conservation that can be used for prioritization of these species. Using the aforesaid criteria, the

MAPs of Niti valley have been categorized under the following seven categories:

i. **Restricted distribution heavy pressure (RDHP):** Species with sparse population, high demand, threat to their wild population, regeneration and survival, for example *Dactylorhiza hatagirea, Picrorhiza kurroa, Saussurea obvallata, Arnebia benthamii, A. euchroma, Angelica archangelica, Dolomiaea macrocephala* and *Pleurospermum densiflorum.*

ii. **Restricted distribution low pressure (RDLP):** Species with sparse population and low demand, e.g., *Aconitum lethale, A. violaceum, Ephedra gerardiana, Saussurea nana, Cicer microphyllum, Rheum tibeticum* and *Thermopsis barbata.*

iii. **Locally common heavy pressure (LCHP):** Species with gregarious populations in several localities, high demand and threat to their wild population including regeneration, e.g., *Allium stracheyi, A. carolinianum, Sinopodophyllum hexandrum, Carum carvi, Rheum australe, R. moorcroftianum, R. webbianum, Arisaema tortuosum, Polygonatum verticillatum,* and *Betula utilis*

iv. **Locally common low pressure (LCLP):** Species that can withstand disturbances such as trampling and grazing and are in low demand, e.g., *Dioscorea deltoidea, Juniperus semiglobosa, Hyoscyamus niger, Mentha longifolia Oreganum vulgare* and *Thymus linearis.*

v. **Wide distribution high pressure (WDHP):** Species widely distributed and heavily exploited, e.g., *Hippophae salicifolia, Bergenia stracheyi, B. ciliata, Artemisia maritima, A. gmelinii* and *Juniperus indica.*

vi. **Wide distribution low pressure (WDLP):** Widely occurring species and at present low or no demand, e.g., *Taraxacum officinale, Geranium wallichianum, Astragalus candolleanus, Oxyria digyna, Gaultheria trichophylla* and *Berberis jaeschkeana.*

vii. **Under cultivation low pressure (UCLP):** Cultivated on a small scale, locally consumed and in trade, *Carum carvii, Sinopodophyllum hexandrum, Phytolacca acinosa, Saussurea costus* and *Arctium lappa.*

5. SUSTAINABLE HARVESTING AND CULTIVATION FRAMEWORK

Based on extensive interactions in the form of group discussions, individual communications with younger generartion, elder people (men and women) including local healers, plant collectors and local traders, direct field observations and secondary sources (published) viz., offline and online **(Table 7)**, sustainable harvesting and collection framework of focal MAPs were developed. A detailed information on the framework **(Figure 8)** including five core elements viz., what to collect, what stage, when, how and how much, species and location profile, habitat and distribution, morphology and phenology, population status, conservation status, potential threats, medicinal uses, market and trade, good harvesting and collection practices and last but not least cultivation and propagation techniques are as follows:

- *What to collect:* The plant part or material to be harvested.
- *What stage:* At the optimum stage of development with collection of mature and healthy material.
- *When:* Harvesting season, month and the time of the day.
- *How:* Different harvesting techniques for different parts, using the best practices by the assemblage of traditional and scientific knowledge.
- *How much:* Quantity depends upon species and population density. Sustainable harvesting practices should be species and location specific.

Image 8. Interaction with shepherds in Niti valley.

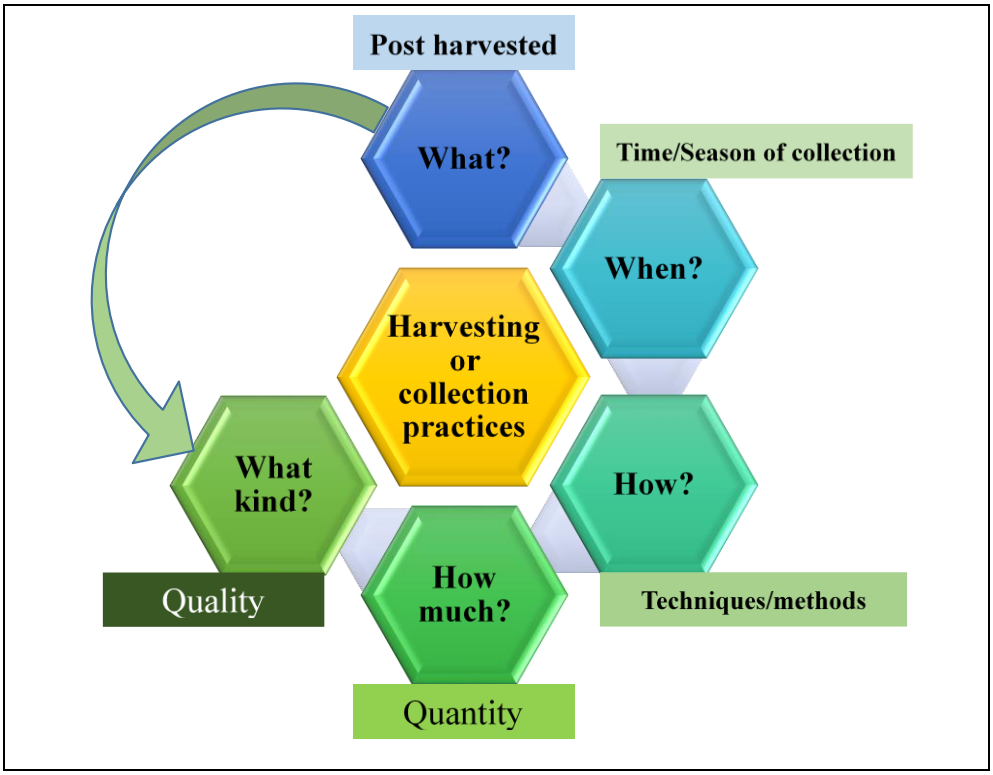


Figure 8. Sustainable harvesting and cultivation framework (adopted from Deepa et al. (2018).

Image 9. A mini-museum at Gamshali village portraying the ethno-medicinal wealth.

Table 7: Existing knowledge on harvesting and cultivation techniques of selected MAPs.

S. no.	Author(s)	*Allium stracheyi*	*Carum carvi*	*Dactylorhiza hatagirea*	*Picrorhiza kurroa*	*Sinopodophyllum hexandrum*
1	Semwal et al. (1983)	-	-	-	✓	-
2	Furmanowa (1984)	-	✓	-	-	-
3	Nautiyal et al. (1987)	-	-	-	-	✓
4	Bhadula et al. (1996)	-	-	-	-	✓
5	Silori and Badola (2000)	✓	-	-	-	-
6	Nadeem et al. (2000)	-	-	✓	✓	-
7	Chauhan (2001)	-	-	-	✓	✓
8	Nautiyal (2001)	✓	-	-	✓	✓
9	Nautiyal and Nautiyal (2004)	✓	-	✓	✓	✓
10	Chandra (2004)	-	-	-	✓	-
11	Rawat (2005)	✓	✓	-	-	-
12	Chandra et al. (2006)	-	-	-	✓	-
13	Chauhan and Nautiyal (2007)	-	-	-	✓	-
14	Chauhan and Chauhan (2008)	✓	-	✓	✓	✓
15	NMPB (2008)	-	-	✓	✓	-
16	Ved and Goraya (2008)	-	✓	✓	✓	✓
17	Samant et al. (2008)	-	✓	-	✓	✓
18	Bist et al. (2008)	-	-	-	✓	-

S. no.	Author(s)	*Allium stracheyi*	*Carum carvi*	*Dactylorhiza hatagirea*	*Picrorhiza kurroa*	*Sinopodophyllum hexandrum*
19	Kharkwal (2008)	-	-	-	-	✓
20	Sreenivasulu et al. (2009)	-	-	-	-	✓
21	Uniyal et al. (2011)	-	-	-	✓	-
22	Qazi et al. (2011)	-	-	-	-	✓
23	Chaurasia et al. (2012)	-	-	-	-	✓
24	Pandit et al. (2013)	-	-	-	✓	-
25	Sharma (2013)	-	-	-	-	✓
26	Kumar et al. (2013b)	✓	-	-	-	-
27	NMPB (2016)	-	-	✓	✓	✓
28	Kalsang (2016)	-	-	-	✓	✓
29	Rasolli et al. (2016)	-	✓	-	-	-
30	Kuniyal and Negi (2018)	✓	-	-	-	-
31	Sharma and Sharma (2018)	-	-	-	-	✓
32	Pandey et al. (2019)	-	-	✓	-	-
33	Kumar et al. (2021)	-	-	✓	✓	✓
34	HRDI, Gopeshwar	✓	-	✓	✓	✓
35	HFRI, Shimla	-	-	-	-	✓

Allium stracheyi Baker

Image 10. Faran in cultivation; harvested leaves and flowers.

Species and location profile

Allium L. is one of the largest genera under Amaryllidaceae that occur in temperate climates of the Northern Hemisphere, except for a few species distributed in Chile (such as *A. juncifolium* D.Don ex Steud.), Brazil (*A. sellowianum* (Kunth) Regel), and tropical Africa (*A. spathaceum* Steud. ex A.Rich.) (Costa et al. 2020; Namgung et al. 2021). *Allium* has about 1,100 species distributed world-wide (Li et al. 2010; Govaerts et al. 2021), over 30 species are known from India and four species from Nanda Devi Biosphere Reserve with *Allium negianum* A.Pandey, K.M.Rai, Malav & S.Rajkumar being a newly reported species from the cold-arid regions of Uttarakhand (Pandey et al. 2021). *Allium* species vary in height ranging between 5 to 150 cm. Mostly, the plants are bulbous perennials and culinary herbs. The flowers form an umbel at the top of a leafless stalk. The bulbs vary in size between species, from small (around 2-3 mm in diameter) to rather large (8-10 cm). Most species of *Allium* are edible and some of them have long been cultivated in the Himalayan region and elsewhere, such as *A. cepa* L., *A. sativum* L., *A. stracheyi* Baker and *A. humile* Kunth, to name a few.

Etymology

Allium refers to AL-le-um, the Latin term for garlic; now the name for all the onion family, or from the Celtic *all*, meaning pungent or burning. And, *stracheyi* to honor General Richard Stracheyi (1808-1908), who along with R. Winterbottom, extensively surveyed the Almora to Pindari glacier belt in the Kumaon Himalaya in 1846 (Pusalkar and Singh 2012).

Common and vernacular name: *Allium stracheyi* is a high-altitude growing plant, commonly known as Jamboo and Jambu pharan in Garhwal and Dhungar, Faran, Jawaridhun and Sekua in Kumaon regions of Uttarakhand.

Trade name: Faran

Folk name: Faran, Jambu, Kaunch and Tibeti pharan

Family: Amaryllidaceae

Elevation (m): 2800-4000

Part Used: Whole plant

Description: A slender herb up to 30 cm high. Bulbs small, leaves cylindrical, hollow. Flowers purple, in dense heads (Rawat 2005). Scapigerous, bulbiferous and perennial herb, 8-35 cm high with rosy flowers. Leaves are 3-5, narrowly linear, 15-30 mm long, to 5mm broad, flattened and blunt-tipped. Flowering scapes slender, compressed above, to 35 cm high, erect, glabrous. Flower head at the top is spherical or hemispherical, densely flowered, 2.5 cm in diameter. Flowers pink or pinkish-white, pedicels slender, stalks are shorter than the flowers. Tepals oblong to oblong ovate, stamen filaments are thread like, much protruding out, capsules globose, 3-6 mm long, seeds 3, black, acutely 3-angled (Pusalkar and Singh 2012; Rai et al. 2017).

Habit: Perennial herb and bulbous geophyte.

Habitat and Ecology: Common on moist herbaceous meadows and rocky slopes, frequently growing in association with *Danthonia cachemyriana, Rheum australe* and *Allium victorialis* (Rawat 2005; Rawat et al. 2016). In dry alpine pastures, it generally grows in open, sunny and dry hill slopes amidst rocks, boulders and shrubs such as *Juniperus communis, J. indica, Rosa sericea, R. webbiana* and *Cotoneaster microphyllus* and herbs such as *Thymus serphyllum, Lotus corniculatus, Trigonella emodi, Origanum vulgare* and *Turritis glabra* (Kumar et al. 2013a,b). It is recorded on rocky slopes and moist herbaceous meadows (Singh et al. 2021) and open rocky-grassy slopes in alpine meadows (Pusalkar and Singh (2012).

Flowering and fruiting: June-September

Conservation status: Native to Himalayan region, it is regarded as an important medicinal and aromatic plant placed under 'Vulnerable'

category of Red Data Book plants of India (Nayar and Sastry 1987-90) and IUCN (Walter and Gillett 1998). According to Ved et al. (2003), *A. stracheyi* is also assessed as 'Vulnerable' in the Western Himalayan states of Jammu & Kashmir, Himachal Pradesh, and Uttarakhand. Considering the high value and demand due to trade and local consumption of *A. stracheyi*, Bhotiyas have been practicing a unique archetype of conservation for safeguarding Jambu pharan population in Niti valley, NDBR (Kumar et al. 2013b).

Medicinal properties: Leaves used for indigestion (Bisht and Badoni 2009). The whole plant used to repel insects and also used as spice (Rawat 2005; Pondani et al. 2010; Kandari et al. 2012; Singh et al. 2022). *A. stracheyi* also contains sulphur rich compounds with antioxidant, anti-inflammatory and antimicrobial properties. The sulphur rich compounds are reported in reducing blood cholesterol (Abuajah 2015).

Ethnobotany: In cold-arid regions of Uttarakhand, it is used commonly as a spice to garnish soups and dals. The species is used by the indigenous Bhotiya people as a flavoring, spice/condiment and a remedy for cold and cough, jaundice, stomach-ache, and various other ailments such as joint pain, swelling, analgesic and anti-inflammatory (Ranjan et al. 2010; Pondani et al. 2010; Kandari et al. 2012; Kumar et al. 2013b; Kumar et al. 2015; Maikhuri et al. 2017; Payal et al. 2020).

Trade: Jambu pharan is consumed locally as well as traded at the regional level in its distributional range. According to Kuniyal and Negi (2018), it is traded at a market price of Rs. 250-600 Kg^{-1} in regional markets, although price has been observed three times higher in national/city markets. Based on an ethno-botanical survey conducted during May-October 2022, market price of Rs. 1000-1500 Kg^{-1} was reported in Niti valley, NDBR. A small packet of about 40-50 gm is usually sold at Rs. 30-50 by Bhotiyas in Niti and Mana valleys, NDBR, whereas it fetches a price of Rs. 140-150 per 50 gm at Pahadi store and various trade fairs in Dehradun.

Jambu pharan in full bloom and dried leaves.

Nativity: It is a bulbous geophyte and grows primarily in the cold-arid regions of the Himalaya. The native range of *A. stracheyi* is Nepal, Pakistan and West Himalaya **(Figure 9)** (www.powo.science.kew.org).

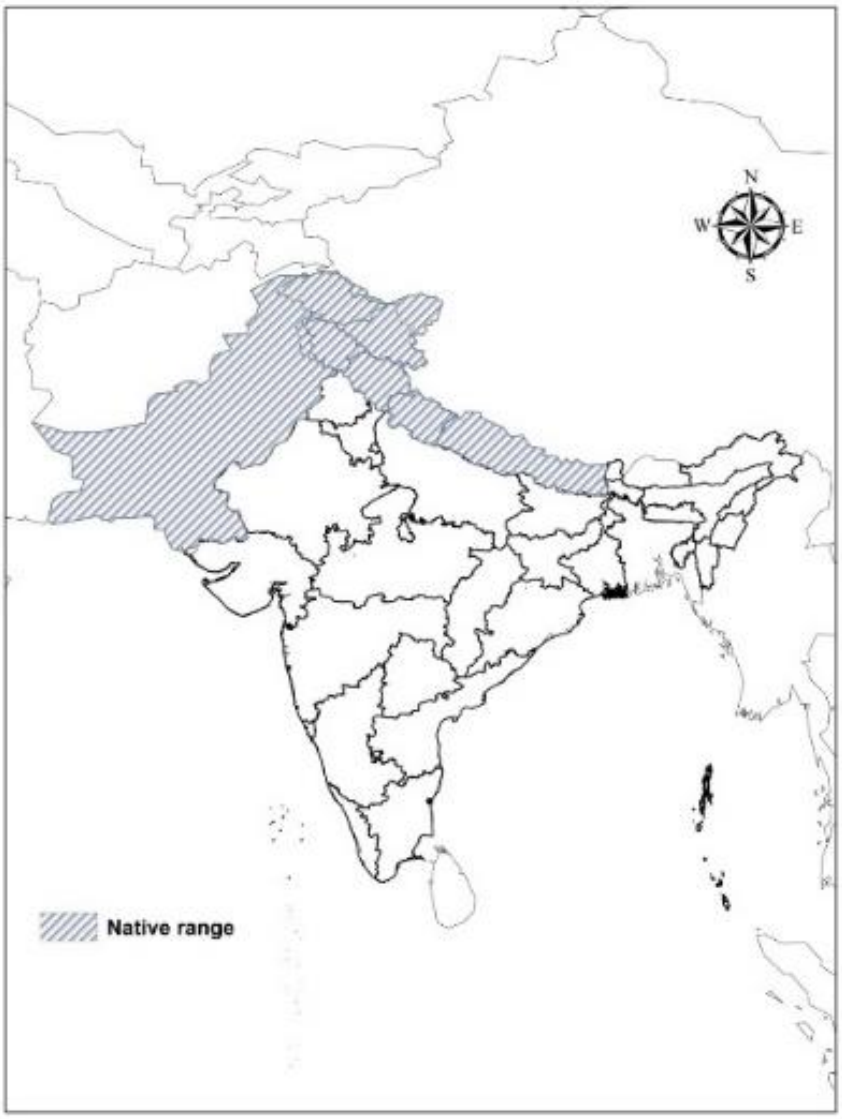


Figure 9. Map showing the native range of *Allium stracheyi.*

Global distribution: India, Afghanistan, China, Nepal and Pakistan (Pusalkar and Singh 2012).

Distribution in the Indian Himalaya: Western Himalaya: Jammu and Kashmir to Uttarakhand (Pusalkar and Singh 2012).

Distribution in the Uttarakhand Himalaya: *Allium stracheyi* is a sparsely distributed with high frequency in the region of its occurrence. It is chiefly found in rain shadow zones or the cold-arid regions of Uttarakhand. Some of the representative populations were recorded at

Lata Kharak in Nanda Devi Forest Division, Mana in Badrinath Forest Division, Sundardhunga in Bageshwar Forest Division (Rawat 2005; Rawat et al. 2016). Other alpine meadows of its occurrence recorded were Jeolinkong, Lessar valley, Ralam, Milam, Rambara, Madhmaheshwar, Mandani, Rudranath, Niti, Mana, Dronagiri, Hemkund, Pindari, Devikund, Hark Ki Doon, and Valley of Flowers National Park (Singh et al. 2021), Gangotri-Rudragaira, Kedar Ganga valley, Chirwasa-Gangotri, Nelang-Shanker glacier, Chirwasa-Bhojwasa and Gangotri-Bhaironghati (Pusalkar and Singh 2012). It is extensively cultivated by villagers in the Johar valley, particularly in Milam village (Singh et al. 2021) and in Upper Dhauli or Niti valley (Kumar et al. 2013b; Kumar et al. 2015; Kumar 2017).

Sustainable harvesting and cultivation framework

Within its distribution range in the Indian Himalayan region, *A. stracheyi* has been locally consumed by the indigenous communities for a long time. Owing to high demand and multiple ethno-botanical and ethno-medicinal uses, the species face tremendous pressure on its wild population base, however no systematic protocols for cold-arid region such as Niti valley are in place. Based on detailed discussion with local inhabitants, field observations and secondary sources (published) viz., offline and online (Silori and Badola 2000; Nautiyal and Nautiyal 2004; Rawat 2005; Chauhan and Chauhan 2008; Kuniyal and Negi 2018) (**Table 7**), the sustainable harvesting and cultivation framework for *A. stracheyi* have been developed.

Climate: In wild, *A. stracheyi* grows in open, sunny and dry hill slopes amidst rocks, boulders in alpine regions. Hence, dry and cold-arid regions are best suitable for the proper growth and development of Jambu pharan.

Propagation: *A. stracheyi* being a bulbous geophyte can be easily propagated either through seeds or thinning of bulbs. On an average, a

single mature individual can produce 50-70 viable seeds and 10-20 small clustered bulbs. Well dried seeds should be stored at cooler places.

Soil: Porous sandy soil rich in nitrogen and potassium is suitable for *Allium* cultivation. Tilth beds increase plant growth at higher altitudes. At lower elevation (2200-2800m) plain beds with sandy loam textured soil and rich organic carbon content is suitable for *Allium* cultivation.

Seed sowing, transplanting and growth: The agro-techniques of all *Allium* species are similar. It is perennial crop, but in some places, farmers cultivate these annually to obtain a good yield. It requires a cold, dry climate with sandy loam and sunny places. Before planting the bulbs, the field is well ploughed during the monsoon period, followed by manuring according to soil conditions and plants requirement. The areas where snow falls during October-November, transplanting of thinned bulbs should be done in June-July, so that the mature individuals are harvested before snowfall. During seed sowing, about 20-25 seeds are sown 8x8 inches apart at a depth of ½ inch in the soil. *A. stracheyi* has been brought under cultivation by the ethnic Bhotiyas of the Niti valley as a kitchen garden crop for a long time for their local consumption.

Density and intercropping:

In one hectare, approximately 1, 80,000 to 2, 70,000 bulbous plants can be grown. The root stocks are usually kept around three or four inches apart at the time or transplant. Seedlings are generally transplanted five to six inches apart.

Nutrient requirement: A huge quantity of organic manure consisting mainly of humus and leaf litter is required for its cultivation. About 4-5 sacks of cow dung/manure is required for one *nali* (land). Beds are ploughed or dug out and manuring is done before planting.

Water management and weed control: At an early stage of seedlings growth and at the time of tuber transplant, watering is needed

every 24 hours during the pre-monsoon season. At the time of maturity, irrigation after four to five days is sufficient. Similarly, frequent weeding with the help of a shallow scraper every 15 to 20 days is required during the early development stages and in the rainy season.

Maturity and harvesting period: The crop is often harvested three times a year viz., once or twice at lower altitudes and three times at higher elevations, beginning in April, June, and September or October. Using a sickle, the above-ground biomass is gathered.

Post harvesting techniques: The harvested aboveground biomass is initially segregated to obtain mature and healthy individuals and dried in a moderate sunlight. In order to preserve the flavour for a longer time, the dried pharan is placed in cotton bags to avoid moisture.

Image 11. *Allium stracheyi,* a kitchen garden crop in Niti valley.

Carum carvi L.

Image 12. *Carum carvi* in full bloom.

Species and location profile

Commonly known as Caraway, *Carum carvi* L. is widely cultivated all over the world. It is a biennial herb grown for its high essential oil content which is mainly found in seeds (Sedlakova 2001). Due to high oil content, this aromatic species has attracted enormous researchers worldwide to experimentally validate the therapeutic uses of caraway seeds, which are documented in several indigenous healing systems. The plant is of 40-60 cm long with small white or pink flowers in umbles. Fruits are (also called seeds) crescent shaped achenes, around 2 mm long with 5 pale ridges. Its root is considered as tap root that grows in a slender form of about 8-9 inches long. It is widely cultivated spice which is native to Europe, Asia, and Northern Africa. It is also found in wild throughout Russia, Siberia, Persia, Caucasus and Himalaya (Hornok 1985; Halva 1986; Toxopeus and Bouwmeester 1992).

Etymology: *Carum,* KA-rum; Latinised form of the Greek word *karon*, and *carvi*, KAR-vi, from Caria, in Asia Minor where it was widely grown.

Common and vernacular name: *Carum carvi* is commonly known as *Jangli Jira, Jeera* and *Kala Jeera.* In Niti valley of NDBR, *C. carvi* is popularly called as *Kala Jeera* and *Bhotiya Jeera.*

Trade Name: *Kala Jira, Jangli Jeera*

Folk Name: *Kala Jira, Bhotiya Jeera*

Family: Apiaceae

Elevation (m): 2800-3600

Part Used: Seed

Description: Biennial herb, 10-60 cm high, aromatic; stem erect, branched from base, slender glabrous; branches erect or ascending, glabrous. Basal leaves clustered, rosulate; petioles 2-15 cm long with scarious-margined sheathing base. Flowers white or pinkish, in

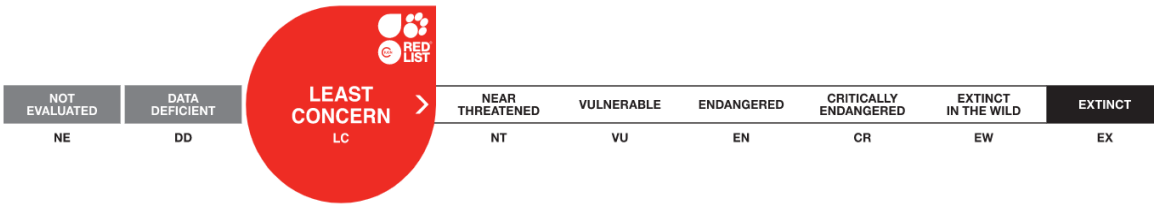
compound, penduncled umbel; peduncle 2-15 cm long; involucre and involucel absent or of few filiform bracts or bracteoles. Calyx teeth minute or obsolete; petals obvovate or obcordate, 0.5-1.3 mm long, 0.5-1.5 mm broad; stylopodium conical. Fruits rounded to oblong, pale yellow to dark brown with filiform, prominent ribs (Pusalkar and Singh 2012; Rai et al. 2017).

Habit: Biennial herb

Habitat and ecology: It is found common in forest fringes, alongside roads and agricultural areas which is weedy in crop fields; grows in the high altitude areas up to 4,000m. The plant also grows in meadows and a wide range of anthropogenic habitats. It is locally common in its distributional range, colonizing on moist grassy ground (Pusalkar and Singh 2012). As per Rawat et al. (2016), it is common in moist areas along water courses mostly associated with *Chaerophyllum villosum*, *Potentilla atrosanguinea* and *Danthonia cachemyriana* between 3000-4000m.

Flowering and fruiting: July-September

Conservation status: Regardless of of high quantum of collection due to huge market price and demand, *Carum carvi* is locally common with low pressure. It is mainly cultivated in agricultural fields and no individuals were recorded in wild in the current study. *Carum carvi* has most recently been assessed for The IUCN Red List of Threatened Species in 2014. It is listed as 'Least Concern' (Schweizer and Hasinger 2014).



Medicinal properties: The fruits usually used whole, have a pungent, anise-like flavor and aroma that comes from essential oils, mostly carvone,

limonene, and anethole (Johri 2011). Seeds contain a volatile oil rich in ketones and carovene (Rawat et al. 2005).

Ethnobotany: *C. carvi* is traditionally used for treatment of indigestion, pneumonia and as appetizer, galactagogue, and carminative (Rasooli et al. 2016). Decoction of seeds is given for gastric ailments (Kala 2000; Payal et al. 2020). It is mainly used in stomach ache, fever, headache and diarrhoea (Kumar et al. 2015). In Niti valley, a cold arid region of Uttarakhand, Bhotiyas use it as green leafy vegetable and dry seeds as condiment. The powdered seeds are also used to cure gastric ailments.

Trade: *C. carvi* is mainly cultivated by locals due to its high value and demand. Owing to locally common and abundant populations, the species is under low pressure. In its distribution range, *C. carvi* is heavily traded at the regional level and also consumed locally. Based on the current study on ethno-botanical survey, market price of Rs. 3000-5000 Kg^{-1} was reported in the Niti valley, NDBR.

Nativity: The native range is Afghanistan, Albania, Altay, Amur, Austria, Baltic States, Bangladesh, Belarus, Belgium, Bulgaria, Buryatiya, Central European Rus, China North-Central, China South-Central, Chita, Czechoslovakia, Denmark, East European Russia, East Himalaya, Finland, France, Germany, Hungary, India, Inner Mongolia, Iran, Iraq, Irkutsk, Italy, Kamchatka, Kazakhstan, Khabarovsk, Kirgizstan, Krasnoyarsk, Krym, Kuril Is., Manchuria, Mongolia, Nepal, Netherlands, North Caucasus, North European Russi, Northwest European R, Norway, Pakistan, Poland, Primorye, Qinghai, Romania, Sakhalin, South European Russi, Spain, Sweden, Switzerland, Tadzhikistan, Tibet, Transcaucasus, Turkey, Turkmenistan, Tuva, Ukraine, Uzbekistan, West Himalaya, West Siberia, Xinjiang, Yakutskiya, Yugoslavia **(Figure 10)** (www.powo.science.kew.org).

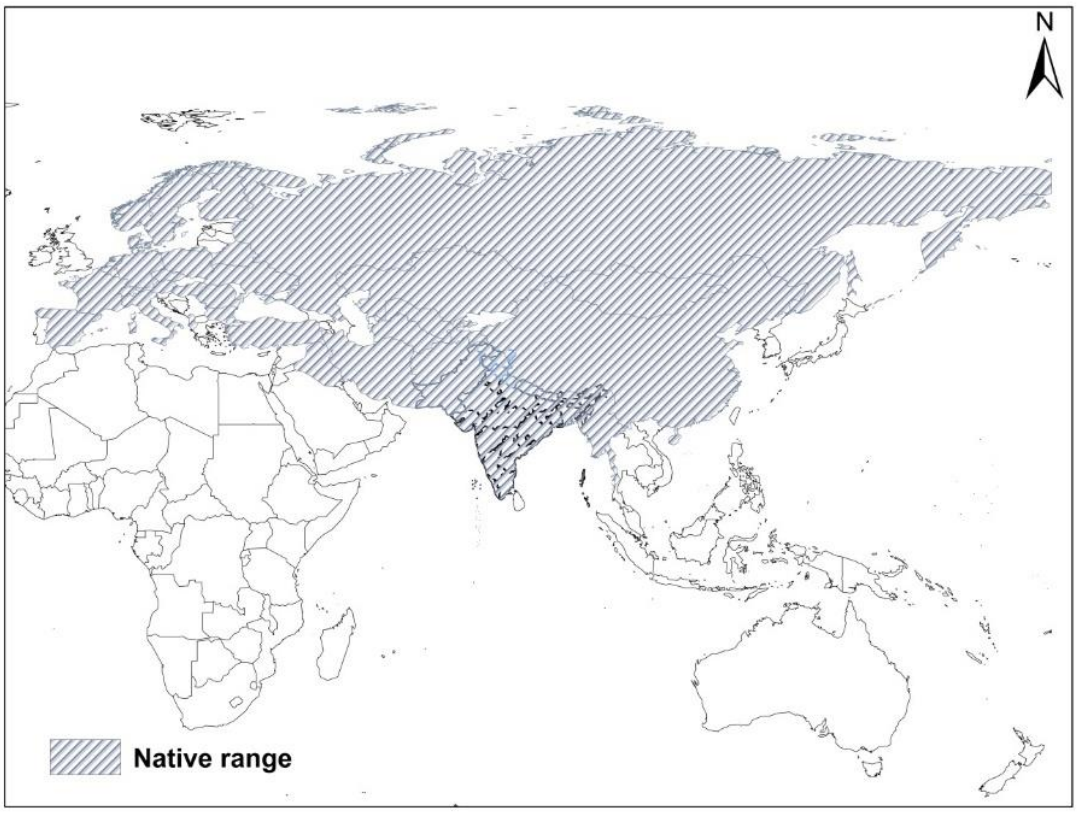


Figure 10. Map showing the native range of *Carum carvi.*

Global distribution: India, Afghanistan, Bhutan, China, Nepal, Pakistan (Pusalkar and Singh 2012).

Distribution in the Indian Himalaya: Himalaya: Jammu and Kashmir to Uttarakhand (Pusalkar and Singh 2012).

Distribution in the Uttarakhand Himalaya: *Carum carvi* is sparsely distributed with high frequency in the regions of its occurrence. It is found in slightly lesser rainfall areas. Some of the representative populations were recorded at Lata Kharak in Nanda Devi Forest Division, Mana in Badrinath Forest Division, Sundardhunga in Bageshwar Forest Division (Rawat et al. 2016). It is extensively cultivated by villagers in the Johar valley, particularly by Milam villagers and in Upper Dhauli or Niti valley (Rawat 2005; Kandari et al. 2012; Kumar et al. 2015; Singh et al. 2021).

Sustainable harvesting and cultivation framework

It is a commonly distributed species alongside forested areas, roadside and villages, hence it can be easily cultivated in agricultural fields in its distributional range. Generally, *C. carvi* can easily colonize on moist grassy meadows amidst other herbaceous species. The plant is widely used as a condiment and therefore is also cultivated on large scale. The species doesn't need special care and nursery requirements. Nevertheless, based on detailed discussion with local inhabitants, field observations and secondary sources (published) viz., offline and online (Furmanowa 1984; Nautiyal and Nautiyal 2004; Chauhan and Chauhan 2008; Rasolli et al. 2016) (**Table 7**), the harvesting and cultivation protocol of *C. carvi* has been developed.

Climate: The cold-arid or rain shadow areas up to 4,000m, with warm summers followed by cold winters and snowfall is found to be the best climate for its optimum growth.

Propagation: It is a commonly grown species that can be easily cultivated in agricultural fields. It is mainly propagated through seeds or sometimes through bulbous roots. Notably, the species doesn't need special care and nursery requirements.

Soil: Loam and sandy loam is found to be best for its cultivation, especially for the better production of bulbous root, but any soil is adequate, although waterlogging increases the mortality rate.

Seed sowing and growth behaviour: The suitable seed sowing as well as multiplication through rootstock should be carried out during October and November in its distributional range. Seeds sowing in lines 20-30cm apart has shown best results in terms of seed production. Germination takes place during February-March as soon as the snow starts melting. After germination, plants form small rootstock during the first year and remain dormant until the next year. Thinning to 20cm apart in the line is recommended as soon as plants attain height of 5-7 cm. The

cycle is repeated for four growing seasons to ensure better production of the crop. It has been observed that the propagation through bulbous rootstock is also found successful.

Planting density and intercropping: About 38,000 plants or 6-8 kg seeds are required for one acre of land, if plants are placed 40 cm apart. In Himachal Pradesh, it is also recommended as an intercrop in orchards.

Nutrient requirement: The land is dug up or ploughed twice or thrice until a fine tilth is obtained. This crop requires a large quantity of organic manure, especially in sandy soil. Normally 25 qt. manure is required for one hectare of land. In the areas where manure or litter are not available, an application of nitrogen (25-30 kg) and phosphorous at 10-12 kg per hectare is also found beneficial.

Water management and weed control: The crop is irrigated once a fortnight during the dry months, however during the dormancy period, irrigation once a week is sufficient. Thinning once during the growing season increases growth. The fields are weeded with a shallow scraper every 15 days during the growing season.

Maturity and best harvesting period: Flowering occurs during the end of May to June, and seeds are formed in mid-June i.e. 30-35 days after its flowering. Harvesting is mainly carried out once the seeds turn brown. Seeds for sowing are harvested upon its maturity. The best harvesting time is during morning hours, which prevents the loss of seed due to shattering of fruits.

Commercial viability: The yield of seeds is estimated at nearly 600-750 kg ha^{-1}. The total crop including bulbs and aerial parts is estimated about 2000 kg ha^{-1}. However, yield of 200 kg seed ha^{-1} is possible after first harvesting.

Post-harvesting techniques: After harvesting, the plant should be properly dried for best yield of the crop. The fruits can be threshed with wooden sticks in large scale cultivation whereas it can also be handpicked

directly in the field in small scale farming. Seeds are marketed either whole or ground. Notably, the whole seeds are in high demand than ground as sometimes the seeds are adulterated with cheaper seeds of a similar flavour. Complete drying is recommended before storage as moist conditions can cause fungal infections and further can hamper the quality of the produce.

Image 13. *Carum carvi* in flowering and fruiting.

Dactylorhiza hatagirea (D.Don) Soó

Image 14. Hathajadi in full bloom (inset showing palmately shaped tubers).

Species and location profile

Dactylorhiza hatagirea is a perennial herb inhabiting sub-alpine to alpine regions ranging between 2800-4000m elevation. With palmately lobed rhizome and lanceolate leaves having a sheathing leaf base, it bears pink flowers with purple-colored notches and a curved spur. It grows well in moist places, open areas, shrub land and open meadows. It is found from west to east at temperate to sub-alpine bioclimates. Regarded as an Asian species of the genus *Dactylorhiza,* it is distributed across India, China, Pakistan, Iran, Afghanistan, Tibet, Bhutan, Europe, North Africa, Temperate Asia, Mongolia, and Nepal (Bhatt et al. 2005; Samant et al. 1998). In the Western Himalaya, it has been reported from various locations of Jammu & Kashmir (Dhar and Kachroo 1983), Himachal Pradesh (Aswal and Mehrotra 1994) and Uttarakhand (Hajra and Balodi 1995). It is, perhaps one of the orchids recorded from the highest altitude in the Western Himalaya (Rau 1975).

Etymology: The generic name of *Dactylorhiza* is derived from the Greek word *'daktylos'* means finger and '*rhiza*' means root, referring to the palmately 2-5 lobed tubers. The term *'hatagirea'* is derived from vernacular name '*hata jadi*' which means root (*jad*) looking like hand (*hath*) with finger.

Common and vernacular name: *Dactylorhiza hatagirea* commonly known as *Hatpanja, Salampanja* and *Hatha jadi* in Garhwal and Hatha jadi, Panja and Hathpanja in Kumaon regions of Uttarakhand.

Trade name: Salampanja

Folk name: Salampanja, Hatha jadi, Panja, Hathpanja, Salep

Family: Orchidaceae

Elevation (m): 2800-4200

Part Used: Tubers

Description: Perianal terrestrial herb, up to 80 cm height; roots tuberous; tubers white palmately 2-5 lobe, often with elongated tips; stem stout more or less fistular leafy glabrous. Leaves 3-6 erect appressed or spreading arranged more or less along the whole length of stem, broadly lanceolate oblong-ligulate or elliptic, base conspicuously narrowed, with broadest part in the middle or slightly above the middle, margins entire apex acute surfaces glabrous; lowest leaf often ovate (Rai et al. 2017). Influences cylindric, densely many-flowered; bracts lanceolate; lower exceeding the flower. Flower purplish-lilac or spotted rosy purple rarely whit to 18 mm long (including stout curved spur), variable in size. Petals obliquely ovate or broadly lanceolate, slightly shorter than sepals; lip nearly flat, mostly border than long oval or sub-orbicular entire or slightly 3 lobed in front, mid lob triangular, minutely papillose above, often tinged or dotted with dark purple spot and lines; spur hanging down, cylindric more or less straights obtuse. Ovary slightly twisted, acute (Pusalkar and Singh 2012).

Habit: Tuberous geophyte

Habitat and ecology: The distribution of *D. hatagirea* is both wide and restricted at elevations between 2800-4000m. The plant prefers moist, temperate environments with wide, grassy slopes, water courses and marsh meadows (Bhatt et al. 2005; Rawat et al. 2005). This species is also found on rocky grassy slopes and rarely in shrubberies (Pusalkar and Singh 2012). *Rhododendron anthopogon, Nardostachys jatamansi,* and *Aconitum* spp. are the main associate species (Rawat 2005; Rawat 2016; Prasad 2016; Singh et al. 2021).

Flowering and fruiting: June-October

Nativity: It is a perennial herb inhabiting sub-alpine to alpine regions. The native range of *D. hatagirea* is China North-Central, China South-Central, East Himalaya, Inner Mongolia, Manchuria, Mongolia, Nepal, Pakistan, Qinghai, Tibet, West Himalaya, Xinjiang (www.powo.science.kew.org; **Figure 11**).

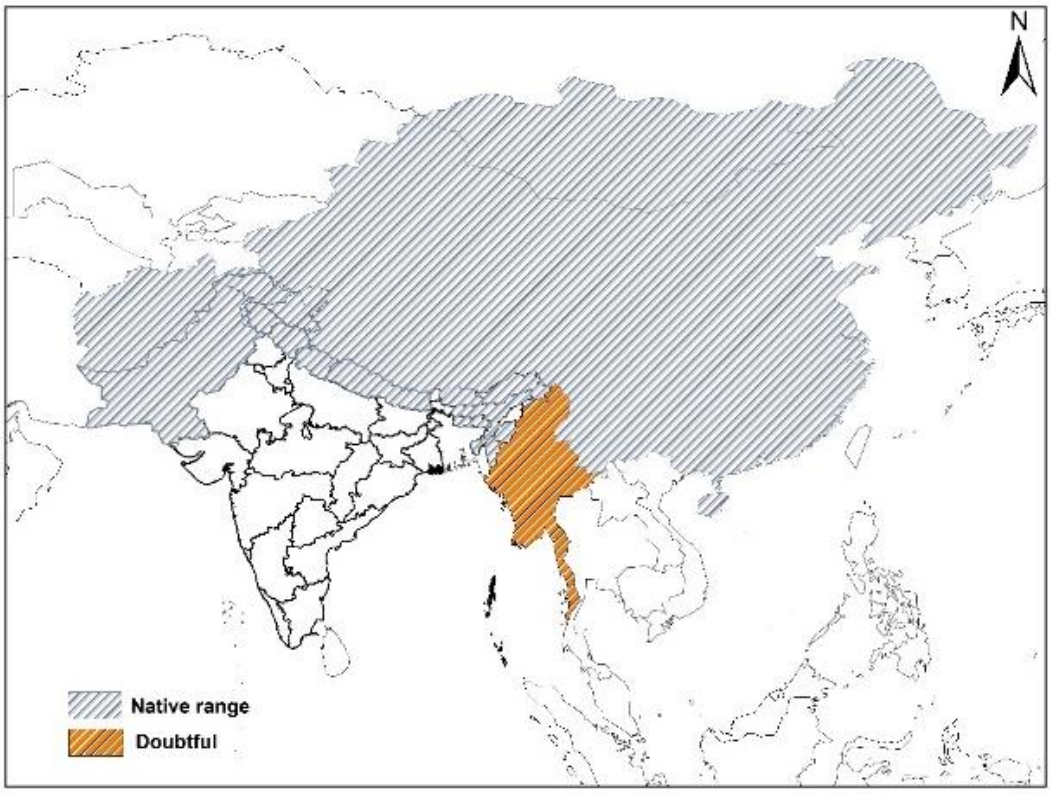


Figure 11. Map showing the native range of *Dactylorhiza hatagirea.*

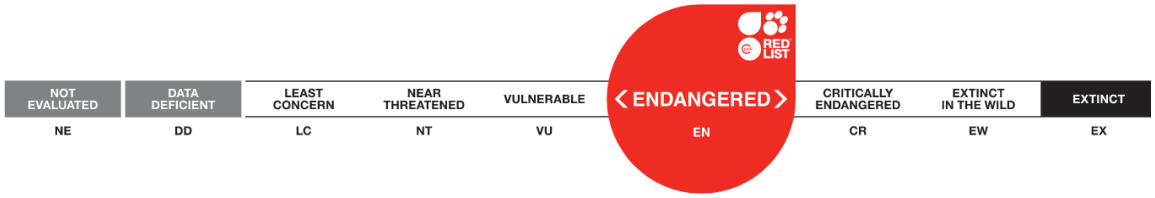
Global distribution: India, Bhutan, China, Nepal and Pakistan (Pusalkar and Singh 2012).

Distribution in the Indian Himalaya: Western Himalaya: Jammu and Kashmir to Uttarakhand (Pusalkar and Singh 2012).

Distribution in the Uttarakhand Himalaya: It is widely distributed in moist meadows with low population density. Some of the representative populations were recorded at Nagtal in Nanda Devi Forest Division, Valley of Flowers National Park, Kandara in Gangotri Forest Division (Singh et al. 2021). Other occurrence sites were recorded at Panchachuli, Garbyang, Poting, Ralam, Milam, Martoli, Laspa, Baling, Napalchunala (Pithoragarh Forest Division), Dayara, Gidara, Kyarki (Gangotri Forest Division), Kedarnath, Rudranath, Tungnath, Madani, Kham, Maggu, Bansinarayan, Madhmaheshwar, Patyuri, Khating, Har ki Doon, Dwali, Sundardhunga, Phurkia, Devikund, Kafani, Nila, Kedar valley, Devwasa-Bhojwasa zone, Duthie, Ardha Mardini and Upper

Dhauli or Niti valley (Rawat 2005; Pusalkar and Singh 2012; Kandari et al. 2012; Rawat et al. 2016; Singh et al. 2021).

Conservation status: In the Western Himalayan meadows, exploitation pressure is particularly high on species such as *D. hatazirea* (Rawat 2007). *D. hatagirea* has been categorized as rare (Samant et al. 2001), Critically Endangered (Kala, 2000; Ved et al. 2003; Goraya et al. 2013; Goraya and Ved, 2017), Endangered (Choi et al. 2020) and listed under appendix II of CITES (Uniyal et al. 2002). The large-scale indiscriminate exploitation of the species from the wild due to high value of medicinal tubers has seriously threatened the wild population of the species, and brought in the red data list of Indian plant as 'Endangered' taxon. Further, this species is listed as prime target species for conservation (Pusalkar and Singh 2012).



Medicinal properties: The extract from *D. hatagiera* shows considerable effects to the body abnormalities such as diarrhoea, dysentery, cough, wounds, cuts, burns, diabetes, chronic fever, stomach-ache, fractures, sexual problems, including the dreadful disease like cancer (Thakur and Dixit 2007). It has been observed that extract from *D. hatagirea* shows considerable effect on cancerous cell lines (Sood 2021).

Ethnobotany: Roots are used in variety of local and ayurvedic medicine including treatment of general weakness (Rawat 2005). Tubers are used in wounds, bone fracture, general debility (Pande et al. 2006). It is widely used to cure various diseases like dysentery, diarrhoea, chronic fever, cough, stomach-ache, wounds, cuts, burns, fractures, weakness, and widely used in modern medicine (Pondani et al. 2010; Kandari et al. 2012; Kumar et. 2015; Rawat et al. 2016; Singh et al. 2021). A decoction of the tubers is helpful to relieve colic pain and fever besides for speckling over cuts, burns, and wounds to stop bleeding (Khare 2007; Chauhan and

Chauhan 2008). In Niti valley, a cold-arid region of Uttarakhand, it was observed that a number of plants, growing in wild are used for medicinal purposes such as tuber paste is applied on joints in arthritis, fever and in labor pain by the Bhotiya community.

Trade: The annual demand for *D. hatagirea* was reported approximately 5000 tons due its use in traditional as well as modern medicine (Kala 2004). Around ~7.38 tons of salep (processed tubers) obtained from *D. hatageria* are consumed annually to cure different ailments and over the years, the market value of crude drugs obtained from the plant has shown an increasing trend which has led to the expansion of its market across different Indian states (Nautiyal et al. 2005; Tripathi 2010; People et al. 2016). The huge demand in the pharmaceutical sector has driven a flourishing trade of around USD 71,583 (Dhiman et al. 2019). In its geographic range of distribution, *Hatha jadi* is consumed locally and traded at the regional level. According to Dhiman et al. (2019), its tubers fetch a price of Rs 1,000 kg^{-1} due to high demand in pharmaceutical industries. In current study, market price of Rs. 4000-8000 Kg^{-1} was reported in Niti valley, NDBR.

Major threats: Overharvesting and unsustainable extraction practices such as removal of whole underground parts (root/rhizome) of *D. hatagirea* due to high pressure for its local use and trade has resulted in decline of wild populations. Based on an ethnobotanical survey conducted in May-October 2022, a total of five individuals of *D. hatagirea* were reported in Niti valley. Unfortunately, the species is said to have declined drastically during last 8-10 years from many valleys especially Darma and Byans (Rawat 2005).

Sustainable harvesting and cultivation framework

Within its distribution range in the Himalayan region, *D. hatagirea* has been locally consumed by the indigenous communities for a long time. Owing to high demand and multiple ethno-botanical and ethno-medicinal uses, the species face tremendous pressure on its wild population base, however no systematic protocols are in place for its cultivation and

harvesting. Based on detailed discussion with local inhabitants, field observations and secondary sources (published) viz., offline and online (Nautiyal and Nautiyal 2004; Chauhan and Chauhan 2008; Pandey et al. 2019) **(Table 7)**, the sustainable harvesting and cultivation framework for *D. hatagirea* have been developed.

Climate: *D. hatagirea* grows in moist grassy slope in the sub-alpine and alpine zone. Hence, moist, cool and snow fall areas are best suitable for its proper growth and development.

Propagation: The flowering season starts in early June and spreads up to July end. Subsequently, the fruiting season starts in August-September. It is generally propagated vegetative using tubers, which is generally collected after fruiting, while it may also be propagated through seeds.

Soil: *Dactylorhiza* favors acidic and sandy loamy soil with rich organic manure and sufficient moisture. The healthy plant development and rooting requires 80-90% humidity in controlled conditions.

Seed sowing, transplanting and growth:

Hatha jadi is mainly multiplied through tubers due to poor viability of seeds. Vegetative propagation through division of tubers has been reported successful in its natural habitats. It has been reported that small slices of tuber, even of 4 mm size, with meristematic tissues are best to develop plantlets when transplanted at 5-7 cm depth and 15 cm apart. Plants raised from tuber cuttings produce about 4-8 cm tall healthy plants with well-established tubers and roots after one year.

Density and intercropping: Approximately 45,000 tubers or tuber cuttings are required in one acre of land and are transplanted 30 cm apart. Intercropping with *Aconitum heterophyllum* (Atish) is found suitable as it requires more or less similar edaphic and climatic conditions for its good growth and yield. Planting should be done during August-September at a distance of 15x15cm.

Water management and weed control: At the early stage of plant development (for rooting and leaf initiation from cuttings), 80-90% humidity is required in controlled conditions. Irrigation every 12 hours is needed, especially at lower altitude during this stage. Frequent weeding every seven to ten days especially during the rainy season is required.

Maturity and best harvesting period: Tubers are usually harvested after five years to fetch a good yield. Sometimes, it is harvested after two or three years of transplanting. Tubers should be collected after seed maturity in late September.

Commercial viability: Its approximate yield is 1764 kg ha^{-1} in natural conditions. Under greenhouse and cultivated conditions productivity may increase up to 1800-2000 kg ha^{-1} if appropriate techniques are used.

Post harvesting techniques: The collected tubers undergo processing for sorting and grading so as to remove and separate unwanted and damaged or immature plant material. The cleaning of crop is mainly carried out before drying and also before packaging to ensure that the tubers are of the best quality. Drying of the tubers directly in moderate sunlight or shade is recommended to ensure protection from deterioration of the tubers.

Image 15. Salampanja flowers and leaves.

Picrorhiza kurroa Royle ex Benth

Image 16. Wild population of Kutki in Niti valley.

Species and location profile

Picrorhiza kurroa Royle ex Benth is a perennial medicinal herb found between 3000-5000m elevation in the Himalayan region (Debnath et al. 2020; Sharma et al. 2021; Singh et al. 2021). It is also widely distributed in the mountainous regions of Pakistan, Nepal, Bhutan and Southern China (Sultan et al. 2016). Locally known as '*Kutki, Kaur* and *Kadvi*' *Picrorhiza* is predominantly distributed in the north-western Himalaya. In India, this rhizomatous herb is found in Chota Bhagal, Miar valley, Hadsar, Kadu Nala and Kurched in Himachal Pradesh (Uniyal et al. 2006; Uniyal et al. 2011; Kumar et al. 2021), Chauras valley in Uttarakhand (Joshi et al. 2010; Arya et al. 2021), Ladakh (Bhardwaj et al. 2021), Jammu and Kashmir (Dawa et al. 2018; Bhardwaj et al. 2021), Zumu in Sikkim (Bhattacharjee et al. 2013; Bhardwaj et al. 2021) and Arunachal Pradesh (Bhardwaj et al. 2021). According to Rakesh et al. (2012), it is also found in the higher reaches of Chamba, Kangra, Mandi, Shimla, Kinnaur and Lahaul & Spiti districts in Himachal Pradesh.

Etymology: The generic name *Picrorhiza* is derived from the Greek word '*picros*' means bitter, while '*rhiza*' refers to root, whereas the species name '*karu*' means bitter is taken from the Punjabi dialect.

Common and vernacular name: Commonly known as kutki, kaur, kadu, kedar kadvi and kadvi, it is a high-altitude perennial herb.

Trade name: Kutki and Kadu

Folk name: Kadvi, Kadu

Family: Plantaginaceae

Elevation (m): 3500-4500

Part Used: Root and rhizome

Description: Perennial herb, 10-25 cm hight; rhizome thick stout creeping stem erect and sub erect or ascending pubescent or glabrate below. Leaves almost all basal, rosulate narrowed to a winged to a petioled

based, elliptic to oblanceolate or spathulate. Margins coarsely serrate, apex acute to obtuse, surface glabrate to sparsely pubescent, dark above, pale beneath blackening or drying. Flowering stems 5-20 cm long, erect to ascending naked or with 1-4, bracts like leaves below inflorescences, glaucous pubescent; scape elongated in frutescence. Flowers pale or purplish blue to violet, in terminal 2-6 cm long, sub cylindrical densely many flowered, pubescent spikes; bracteoles oblong-lanceolate 7-13 mm long. Obtuse to sub-acute, pubescent, concealing flowers; pedicels 1.5-5 mm long, pubescent. Calyx 6-10 mm long; lobe lanceolate, acute, ciliate or pilose; fruiting calyx elongated. Corolla sub-actinomorphic or weakly zygomorphic, 4-5 mm long, with lobes united slightly farther on posterior side, hidden under calyx/bracts, finely lobed; lobes ovate or ovate-lanceolate, acuminate, equalling to slightly longer than tube, conspicuously ciliate. Stamens 4, long exerted, twice the calyx or longer; filament blue or violet. Capsules ovoid, 9-12 mm long, slightly exceeding the calyx; seed many, 1-2 mm long, brown, with faint reticulations (Pusalkar and Singh 2012; Rai et al. 2017).

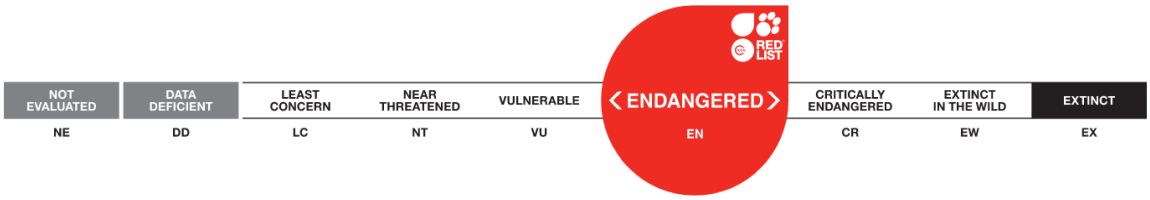
Habit: Perennial herb

Habitat and Ecology: Kutki is a perennial creeping herb distributed in wild form in the north-western Himalayan regions from Kashmir to Sikkim. Naturally, kutki grows at an elevation of 3000-5000m (Samant et al. 2007). It prefers moist, relatively less exposed, north-west facing slopes and found near springs on moist rocks from timberline to alpines. Kutki grows in wild form near springs on moist rocks from timberline to alpines, cliffs, and the turf of glacial flats and in organic soils (Masood et al. 2015). It prefers moist rocks and steep slopes for its growth (Uniyal et al. 2011) but also found in open pastures, near springs and under the shrub/scrub canopy (Nautiyal et al. 2001) and grassland, rocky areas (e.g. inland cliffs, mountain peaks (Chauhan 2021). According to Rawat (2005), it mostly grows along shady moist and well-drained soil in association with *Salix lindleyana, Gaultheria trichophylla* and *Polygonum affine* between 3200-4500m. As per Arya et al. (2013), it is reported from diverse habitats ranging from alpine slopes to temperate forests (*Rhododendron* forest

margin, *Betula-Taxus* forest, *Juniperus* mixed forest, *Quercus-Abies* forest and *Quercus* forest in the Kumaun Himalaya.

Flowering and fruiting: June-September

Conservation status: In the Western Himalayan meadows, exploitation pressure is particularly high on species such as *Picrorhiza kurroa* (Rawat 2007). Owing to unorganized cultivation and indiscriminate collection from the wild, kutki is an 'Endangered' species (Rawat et al. 2013). According to Arya et al. (2013), the taxon is considered rare and threatened in the Himalayan region due to the destruction of its natural habitats and over-exploitation. Notably, owing to rapid decline in wild populations, *P. kurroa* has most recently been assessed for The IUCN Red List of Threatened Species in 2021 and is listed as Endangered under criteria A2cd (Chauhan 2021). Further, to control the illegal trade of the species, *P. kurroa* was listed in Appendix II of the Convention on International Trade in Endangered Species (Mehta et al. 2021; Gowthami et al. 2021).



Medicinal properties: Used in the treatment of cough, dandruff, ulcer and stem bark is used in cuts and wounds for rapid healing (Rawat 2005; Kala 2005). The plant extract also contains some important chemical constituents such as carbohydrate, aromatic acids, vanillic acid and ferulic acid (Masood et al. 2021). The rhizomes of kutki are valued for their effectiveness as anantibiotic, hepatoprotective, anticholestatic, antioxidant and immunomodulatory properties (Kant et al. 2013; Rawat et al. 2016).

Ethnobotany: In India, kutki is widely used in traditional medicine systems such as Bhotiya use it to cure cough, cold, stomach ache, fever, malnutrition, jaundice, diarrhoea, dysentery and for veterinary purposes in the cold arid regions of Uttarakhand (Ranjan et al. 2010; Kandari et al.

2012; Kumar et al. 2013b; Kumar et al. 2015; Rawat et al. 2016; Maikhuri et al. 2017). The rhizome is used to treat skin disease, liver disease, indigestion problems and metabolic disorders (Khare 2004; Rawat 2005; Singh et al. 2021; Singh et al. 2022).

Trade: Rapid use in traditional medicines has put an additional strain on naturally occurring populations of *P. kurroa* (Shitiz et al. 2013). According to Kuniyal et al. (2013), approximately 1.43 MT of *P. kurroa* rhizomes were sold each year during 2007-2010. Based on an ethno-botanical survey conducted during May-October 2022, market price Rs. 800-1500 Kg^{-1} of dry roots and stolon cuttings/underground parts was reported in Niti valley, NDBR. Unfortunately, lack of knowledge on harvesting leads to the uprooting of the whole plant, which leads to damage to the young buds, resulting in difficulty in its propagation in the wild.

Nativity: The native range of this species is Pakistan to West Himalaya. It is a perennial and grows primarily in the sub-alpine to alpine areas **(Figure 12)** (www.powo.science.kew.org).

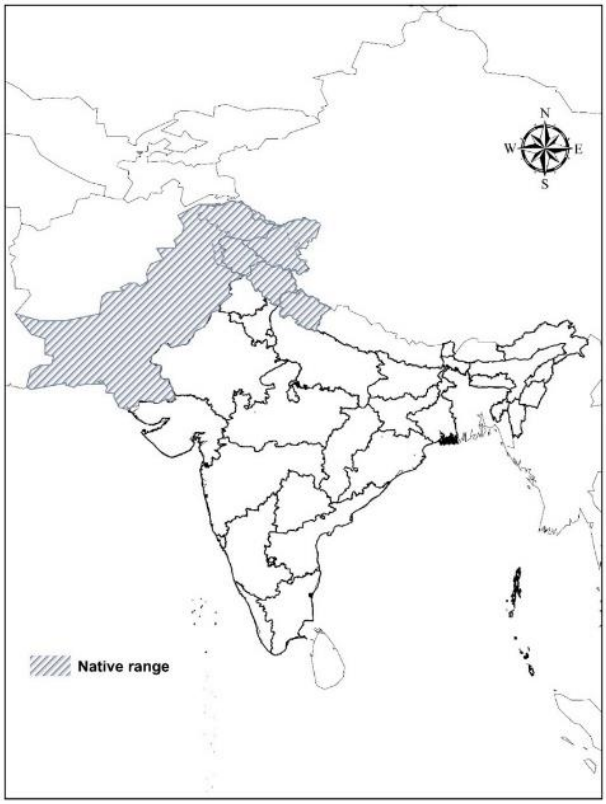


Figure 12. Map showing the native range of *Picrorhiza kurroa.*

Global distribution: India, China, Nepal, Myanmar (mainland) and Pakistan (Pusalkar and Singh 2012; Chauhan 2021).

Distribution in the Indian Himalaya: Western Himalaya: Jammu and Kashmir to Uttarakhand (Pusalkar and Singh 2012).

Distribution in the Uttarakhand Himalaya: *P. kurroa* is widely distributed across various habitats and also cultivated in high altitude villages. Important areas of its occurrence are Bansinarayan in Kedarnath WS, Laspa, Panchachuli in Pithoragarh Forest Division. Other areas of its occurrence were recorded at Burfu, Paoting, Martoli, Napalchunala, Milam, Shumdum, Chiplakedar, Martoli, Chiyalekh, Garbyang (Pithoragarh Forest Division), Tungnath, Madhmaheshwar, Kham, Kedarnath (Kedarnath WLS), Gidara, Bhojwasa-Chirwasa, Nalacamp, Kush Kalyan, Dayara (Gangotri Forest Division), Khatling (Tehri Forest Division), Hemkund (Nanda Devi Forest Division), Upper Dhauli or Niti valley, Dwali, Phurkia, Sundardhunga, Pindar (Bageshwar Forest Division) (Rawat 2005; Kandari 2012; Pusalkar and Singh 20012; Kumar et al. 2013b; Rawat et al. 2016; Kumar 2017; Singh et al. 2021).

Sustainable harvesting and cultivation framework

Narrow distribution range, small population size, high use value, unscientific harvesting and lack of organized cultivation have threatened the species. Unfortunately, lack of knowledge to plant collectors on harvesting leads to the uprooting of the whole plant, which further leads to damage to the young buds, resulting in difficulty in its propagation in the wild. Based on detailed discussion with local inhabitants, field observations and secondary sources (published) viz., offline and online (HRDI; Nautiyal et al. 2001; Nautiyal and Nautiyal 2004; Chandra 2004; Chandra et al. 2006; Chauhan and Nautiyal 2007; Bist et al. 2008; Chauhan and Chauhan 2008; Uniyal et al. 2011; Pandit et al. 2013). **(Table 7)**, the sustainable harvesting and cultivation framework for *P. kurroa* have been developed.

Climate: The plant grows well in cool and moist climate naturally above 3000m, delayed and intense rainfall are detrimental to its survival.

Propagation: *P. kurroa* is mainly propagated using seeds, underground stem/stolon cutting and rhizomes. Interestingly, vegetative propagation through stolon cuttings/underground stems are found to be more successful for multiplication as well as for higher production within a short period than cultivation through seeds. Monsoon season is found best for propagation through stolon cuttings/underground stems (HRDI). Spacing of 30x30cm is observed best for propagation of stolon cuttings/underground stems. As per HRDI, a total of 2200 cuttings per *nali* or 1,10,000 cuttings per *nali* would be required at 30x30cm spacing. It has been reported that regeneration through seed is hampered due to low germination rates. Seed sowing is observed best during March and April in nursery beds in areas above 2500m and during May in alpine areas or above 3000m elevation. The harvesting period can be reduced to at list six months, by raising seedlings at lower elevations in winter and transplanting them to higher elevations during the spring season. In order to promote rooting in stolon cuttings, trenches of approximately 2x1x1 ft. size for 1000 cuttings to retain high moisture in soil is recommend. Top segments of stolons are found more suitable for multiplication.

Soil: Sandy textured loamy soil is found best for cultivation of *P. kurroa*. High moisture content is needed for its cultivation. Furthermore, partially shaded areas such as canopy of small shrubs encourage maximum growth and productivity.

Density and intercropping: One acre of land requires about 44,000 plants if the seedlings or stolon cuttings are planted 30cm apart. However, a planting interval of 5-10 cm is known to be beneficial for plant survival if the planting is carried out during the rainy season. It has been observed that providing moisture under its canopy for a long time, intercropping with *Foeniculum vulgare* (saunf) improves yield and creates an ideal

microclimate for *P. kurrooa* plant growth. However, areas between 1800-2800m are best suitable for intercropping with *Digitalis purpurea.*

Nutrient requirement: A higher concentration of livestock manure however causes powdery mildew and needs excessive irrigation during the initial phase of manuring. Forest litter is found more suitable for good growth and yield. Lacking forest litter, well decomposed farmyard manure may apply with the soil at the rate of 6 tonnes per hectare at least 15 days before transplanting.

Water management and weed control: Field should be irrigated immediately after planting the cuttings. Subsequently, watering within 15 days during summer and as and when required during winter is suggested, however the field should be kept sufficiently moist at all times. Manual weeding should take place frequently at an interval of 15 to 20 days during the first growing season.

Maturity and best harvesting period: This crop have a life cycle of three years, however a crop of 2 years and 3 months is found best for maximum production (HRDI). After the completion of flowering, the fruiting starts in August and continues up to September. The plant needs one year to complete the seed maturity. The rhizomes are manually harvested in October-November when the shoots or the aerial parts begin to wither and dry. Plants raised through stem cuttings mature almost a year earlier than those raised from the seedlings. However, to get higher active contents, plants must be collected before flowering.

Commercial viability: On an average, 20-25 kg per *nali* dry roots can be obtained in an ideal condition (HRDI). In areas above 2200m, production is six to seven times higher than the first year, when a maximum 612 kg ha^{-1} production is estimated from high dose of forest litter treated beds. Benefits are meagre through cultivation by seedlings in comparison to cultivation by vegetative propagation.

Post harvesting techniques: After harvesting, the stolon cuttings and roots are washed to remove soil particles, mud and other unwanted materials. Stolons and roots are dried in shade to yield higher content of picrotin and picrotoxin. Proper drying is a critical process, because traders offer better prices for clean and dried material, therefore kutki is dried at optimal temperature (15-25°C). On completion of drying, the weight of fresh material is reduced by half. Drying in direct sunlight or in oven is avoided as this process decreases the active contents rapidly. Once the material is completely dried, it is packed in gunny sacks, airtight polythene lined jute bags to ensure protection from moisture.

Image 17. Rhizomes of Kutki in high demand and trade.

Sinopodophyllum hexandrum (Royle) T.S.Ying

Image 18. Different plant parts of Bankakdi.

Species and location profile

Sinopodophyllum hexandrum is a high value medicinal herb popularly known as the Himalayan May Apple that grows in the Himalayan alpine and sub-alpine zones, predominantly occurring in the Northern temperate zone and discontinuously distributed in the Eastern North America and East Asia. It comprises of about 22 species mainly distributed in different areas of China, Yunnan, USA, Bhutan and India. Four species i.e., *Sinopodophyllum hexandrum*, *Podophyllum versipelle*, *Podophyllum aurantiocaule* and *Podophyllum sikkimensis* are reported in the Indian Himalaya (Airi et al. 1997). *S. hexandrum* grows across the Himalayan regions from east to Afghanistan, and north to south-west China (Kala 2005). It is an erect, glabrous, succulent, 15-60 cm tall herb with creeping rootstock. It bears 1-3 leaves (usually 2) which are alternate, long stalked, often purple spotted, round, 6-10 inch in diameter, deeply divided to the middle or base into 3-5 lobes, which are sharply toothed and often with deep incision.

Etymology: *Sinopodophyllum*, si-no-pod-o-FIL-lum; from prefix *sino*, China and *Anapodophyllum*; duck's-foot-leaved. *Podophyllum*, pod-o-FIL-lum; a contraction of *Anapodophyllum*; duck's-foot-leaved. The species epithet *'hexandrum'* is derived from the Greek word *'hexa'* means six, and '*andro*' refers to anthers or stamens of the flowers.

Common and vernacular name: *S. hexandrum* is commonly known as Bankakdi. In Uttarakhand, it is locally called as Bankakdi, Bankakri, Ghenu, Pakghenu and Lalghenu.

Trade name: Bankakri, Ghenu

Folk name: Ghenu, Pakghenu and Lalghenu

Family: Berberidaceae

Elevation (m): 3000-4000

Part Used: Fruit and rhizome

Description: Apex acute or acuminate, surface pubescent beneath; lobes 2-3 lobuled to the middle, not divided in young leaves. Flowers white or pinkish-tinged white, solitary, terminal (apparently supra-axillary), erect, cup-shaped, 2.5-5.5 cm across; peduncle erect in flower, curved, nodding in fruiting, thickened, elongated, glamorous. Sepals 3, broadly oblong, petaloid, white or pinkish-tinged white caducous. Petals 4-6, white or pinkish white, obovate to obovate-oblong, 1-3.5 × 1-2.8 cm, obtuse or rounded. Stamens 4-6; filaments slightly flattened at base; anthers yellow, linear-oblong, 5-6.5 mm long. Berries oblong or ovoid, 2.5-6 × 2-5 cm, reddish to scarlet on ripening, pulpy, smooth, and angled or not; seed many, enveloped in pulp, obovoid or sub-orbicular, 2-5 mm (Pusalkar and Singh 2012; Rai et al.2017).

Habit: Perennial or rhizomatous geophyte

Habitat and ecology: *S. hexandrum* are distributed in the sub-alpine to alpine regions of the Himalaya from 2400-4200 m (Rajesh et al. 2014). The species thrives best as undergrowth as well as in forests in well drained humus rich, glacial riverine, rocky moist areas, alpine dry scrub, open grassy slopes, alpine slopes, shady moist alpine slopes and forest edges (Pandey et al. 2007; Sharma and Sharma 2018). Occasional in moist, boulder places and shrubberies between 2500-4000m. Several intermediate growth forms can be seen in Uttarakhand for example one in the sub-alpine forests among the boulders and other at high alpine scrub usually around 4000m along with *Berberis jaeschkeana* and *Juniperus indica* (Rawat et al. 2016).

Flowering and fruiting: May-September

Conservation status: Due to declining populations, it has been categorized as 'Endangered' (Kala 2000; Chaurasia et al. 2012; Goraya et al. 2013) and 'Critically Endangered' (Goraya and Ved 2017; ENVIS Centre

for Medicinal Plants, FRLHT). In the fringes of the Valley of Flowers National Park, the plant density is about one individual per square meter (Kala 2005) and is abundant in the Great Himalayan National Park, Himachal Pradesh (Chaurasia 2012).

Medicinal properties: Purgative, cytotoxic, anti-neoplastic, strongly irritant to skins and mucous membranes (Pande et al. 2006; Khare 2008; Sarin 2008).

Ethnobotany: Among the treasures of medicinal plant wealth, a perennial plant *S. hexandrum* has been reported to be used as an intestinal purgative and emetic, a cure for contaminated and necrotic wounds and a tumor growth inhibitor over the ages and in modern times (Khare 2008; Sarin 2008). Plant is also used for gonorrhoea, and syphilis (Pande et al. 2006; Lohiya et al. 2016; Maikhuri et al. 2017). In Niti valley, a cold arid region of NDBR, Bhotiyas use it to cure typhoid fever, jaundice, dysentery, chronic hepatitis, rheumatism, stomachache, skin diseases, tumorous growth, kidney and bladder problems (present study).

Trade: In India, *S. hexandrum* species are prohibited for export if the plants are collected from the wild. According to Kaul (1997) about 37.3 tonnes of rhizomes of *S. hexandrum* were uprooted during 1995-2000 in Himachal Pradesh. Raw drug obtained from cultivated material can however, be exported (Sharma 2013). The reported total annual trade of raw *S. hexandrum* by domestic herbal industry and rural households was 0.10 MT respectively, whereas, the annual trade of raw drug was 10-50 MT (Goraya and Ved, 2017). Bankakdi is consumed locally and highly traded at the regional level throughout the region of its distribution. Based on the current study on ethno-botanical survey, market price of Rs. 800-1000 Kg^{-1} was reported in the Niti valley, NDBR.

Nativity: The native range is Afghanistan, Pakistan, China, Nepal and West Himalaya **(Figure 13)** (www.powo.science.kew.org).

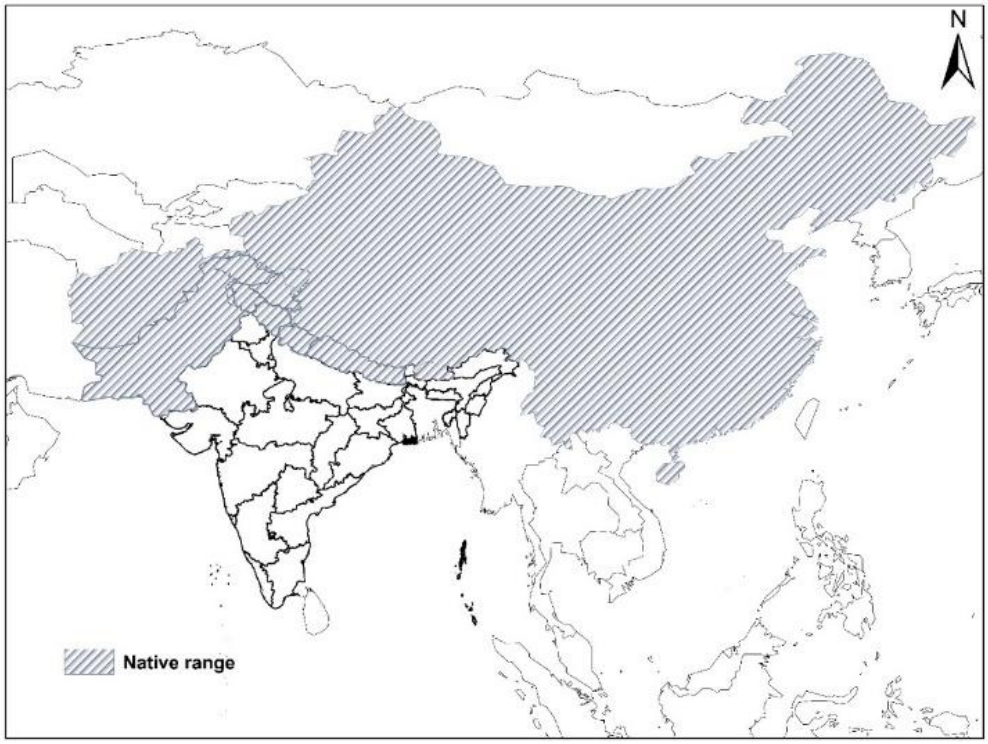


Figure 13. Map showing the native range of *Sinopodophyllum hexandrum.*

Global distribution: India, Bhutan, China, Nepal and Pakistan (Pusalkar and Singh 2012).

Distribution in the Indian Himalaya: Himalaya: Jammu and Kashmir, Uttarakhand to Arunachal Pradesh (Pusalkar and Singh 2012).

Distribution in the Uttarakhand Himalaya: *S. hexandrum* is patchily but widely distributed species across various habitats. Important localities having good populations include Bansinarayan, Kham in Kedarnath WS, Phukia in Bageshwar Forest Division. Other than these it was also recorded at Byundar valley (Nanda Devi Forest Division), Keddarakantha (Tons Forest Division), Bhojbasa, Jagdhar, Kush Kalyan, Gidara, Dayara, Bhojawas-Gomukh, Dodital (Gangotri Forest Division), Har Ki Doon (Govind National Park), Bedang, Namphanala, Panchachuli, Sipu, Milam, Kuti, Ralam (Pithoragarh Forest Division), Uppar Dhauli valley (Niti), Baloni top, Dwali, Phukia, Pindari, Devikund (Bageshwar

Forest Division), Valley of National Park, Tungnath, Chopta (Kedaranth Forest Division) (Rawat 2005; Pusalkar and Singh 2012; Kumar et al. 2015; Rawat et al. 2016; Singh et al. 2021).

Sustainable harvesting and cultivation framework

The massive extraction of its rootstock over the last decades has resulted in decline of wild population. The species, which grow very slowly, are becoming increasingly scarce due to intensive collection, lack of cultivation and to their own biological characteristic (Guerram et al. (2012). This has led to severe reduction in its population density and the species is now listed in endangered plant species category (Ved et al. 2003). Based on detailed discussion with local inhabitants, field observations and secondary sources (published) viz., offline and online (HFRI; Nautiyal et al. 1987; Bhadula et al. 1996; Nautiyal and Nautiyal 2004; Kharkwal 2008; Sreenivasulu et al. 2009; Qazi et al. 2011; Chaurasia et al. 2012; Sharma 2013; Sharma and Sharma 2018) (**Table 7**), the sustainable harvesting and cultivation framework for *S. hexandrum* has been developed.

Climate: Grows favorably in the temperate and sub-alpine regions. Partly shaded places are favorable for its survival and growth.

Propagation: A slow growing plant, it can be propagated by seeds as well as from sections of rhizomes but propagation through rhizomes show good results. The rhizomes should be ideally collected in March-April. For planting, fresh rhizomes that usually weigh around 500-900 gm should be cut in to small pieces of 1-2cm having at least 2 buds (HFRI). The rhizomes ready for planting need to be kept 6cm deep in the soil with a spacing of 30x30cm apart (HFRI). Under natural conditions, seeds show erratic and poor germination. The seeds germinate after remaining dormant for one or two years. The main reason for poor seed germination is due to difficult postharvest care of seeds. Seeds washed with water showed better germination than unwashed seeds. During pre-land

preparation, 10 t ha^{-1} manure is required and the land needs to be ploughed or dug after 4-week interval. Seed showing should be done during March-May.

Soil: For cultivation of *S. hexandrum,* rich organic black soil with sufficient moisture is required (Chauhan and Chauhan 2008; Sharma 2013). Cow dung is found useful, though the soil needs to be ploughed well before planting the rhizomes (HFRI).

Seed sowing and growth behavior: Seed sowing is mainly done during November in natural conditions, whereas during October in the greenhouse at 1800-2500m altitudes and seedlings are ready for transplanting during May and June. In addition, pre-sowing treatments of seeds by adding cow dung and special sowing techniques showed best and early germination. Due to the delay in seed germination, multiplication of *S. hexandrum* is done by rhizome transplantation or through rhizome cuttings of 1.0-1.5. cm length. The youngest top portion of the rhizome bearing leafy buds gives the best results. Treatments of IBA or NAA to apical segment result in multiple root formation (Lata 1997; Nadeem et al. 2000). Generally, one shoot develops from each cutting. Basal rhizome segment also produces roots and shoots successfully when treated with 10ppm IBA or kinetin. Transplantation of rhizomes and cuttings during March and April at lower altitudes and May and June at higher altitudes gives the best survival and growth.

Planting density: Nearly 4200 seedlings or rhizome cuttings are needed for the cultivation of one acre of land. Planting 30x30 cm apart is found suitable for its best growth and yield.

Nutrient requirement: Farmyard manure and forest litter treatments increase growth and yield. At 1800-2000 m sites, 60 qt of manure is generally required for every hectare of land. Nearly 20 tons of manure is needed at 2200-2800m, where the soil is rich in organic humus, and no further manuring is necessary for the following years. Furthermore,

decomposed broadleaf forest litter increases plant growth and yield more than farmyard manure.

Water management and weed control: Seedlings and rhizomes cuttings at the time of transplant i.e. March to June need watering every 24 hours. Watering needs to be done in a week after the establishment of the plants (HFRI). During winter, beds with underground rhizomes need watering every four to five days. Frequent weeding during the rainy season is required, and once a month during winter.

Maturity and best harvesting period: Growth is very slow and it take three to five years to produce a rhizome suitable for exploitation whereas, seed sown plants takes 5 to 6 years to attain full maturity (HFRI). Rhizome collected in May have a higher Podophyllotoxin content than those collected in November. For maximum production, however, rhizomes should be harvested during July and August after the formation of berry and seed setting. Among the four morphological variants found in Garhwal, the maximum resin and toxin content is found in the one-leaved and the least in four-leaved variant. During April-May, harvesting of rhizomes in natural conditions showed best outcomes in terms of its quantity which can be up to 39 qtl per hectare (HFRI).

Commercial viability: In nature the estimated production is approximately 39.38 qtls per hectare after the plant matures. The existing rate per hectare return from this species is Rs 1,41,120.00 at the rate of Rs 60/kg. Under cultivation, production is estimated to be far greater than in nature.

Post-harvesting techniques: After harvesting, rhizomes are washed thoroughly with water to remove soil. The cut (2x4 cm long) rhizomes helps in easy drying (HFRI). Drying the rhizome in the sun does not appear to affect the resin; however, drying in shade has proven best for its storage. The dried roots should be stored in cool places (HFRI).

Image 19. A mature individual of Ghenu in fruiting.

6. KEY FINDINGS AND RECOMMENDATIONS

The cold-arid regions of Uttarakhand along northern fronteirs have been facing additional stress due to over-exploitation on forest as well as medicinal plant resources, which functions parallel to the illegal and hidden markets. Thus, it has put tremendous pressure on the wild resource base, resulting in the dwindling populations and precarious livelihoods of local communities. The current study highlights that the population of the focal species (except *Carum carvi*) are sparse albeit rapidly declining due to excessive exploitation, unscientific, illegal and premature harvesting. Therefore, keeping their current population status in view, preparation of micro-plans, assessment of available growing stock and sustainable management and utilization of dwindling populations along with *Aconitum lethale, A. violaceum, Allium* spp., *Angelica archangelica, Arnebia* spp., *Betula utilis, Dioscorea deltoidea, Ephedra gerardiana, Juniperus semiglobosa, J. indica, Polygonatum verticillatum, Pleurospermum densiflorum, Saussurea obvallata, S. nana, Rheum* spp. and *Thermopsis barbata* is recommended.

Besides over-exploitation of MAPs, knowledge on their available stock, lack of information on end users and middlemen and inadequate information on quantity of raw material traded due to secretive nature of the markets have been reported. In Niti valley, the market trend, price *vis a vis* trade route is indiscernible for highly traded medicinal species such as *Gucchi* or Bhotiya mushroom, *Morchella esculenta* and *Keedajadi* or caterpillar fungus, *Ophiocordyceps sinensis* which sells in the market like a hot cake, and therefore has created hue and cry state among the locals. Hence, these issues need to be addressed to ensure long-term conservation of the MAPs in a way that livelihood needs of the locals depending on such resources are not compromised.

The focal species are one of the highly traded MAPs from the Western Himalaya, in general and Niti valley, particularly. Therefore, considering the existing threats, habitat specificity, population size and pressure level,

the focus of conservation and regulated harvest is particularly needed for (i) restricted distribution heavy pressure (RDHP) species such as *Picrorhiza kurroa* and *Dactylorhiza hatagirea*, and (ii) locally common heavy pressure (LCHP) species such as *Allium stracheyi, Sinopodophyllum hexandrum* and *Carum carvi* in Niti valley, NDBR.

As the rare and threatened species are mostly encountered amidst peculiar microhabitats or special habitats such as *Caragana* steppe, Juniper scrub, cushioned habitat, tussock formation and alpine arid pastures, prioritization and mapping of such habitats and their communities in the course of qualitative and quantitative assessment is also suggested.

Bhotiyas mainly depend on natural resources from the adjacent forests and alpine pastures or meadows (locally known as *payar*) for their livelihood. Therefore, considering the high use value, market opportunities, price of the produce, and ease of cultivation or harvesting processes, the current study proposes *Allium stracheyi, Carum carvi* and *Saussurea costus* as the potential species that can be encouraged for their cultivation in Niti valley. It will not only provide livelihood opportunites to the local inhabitants but also check over-exploitation of the wild MAPs.

The local inhabitants are dependent on the wild MAPs for their traditional health care system. They are knowledgeable of about 72 MAPs that are locally utilized for consumption and curing atleast 24 different human ailments. However, the practice of utilising MAPs in their local healthcare system is sharply declining due to lack of education facility and market, which has led to lack of knowledge as well as transfer of knowledge to youger generations.

The *payar* such as Bamplas, Lang, Goting, Rekhana (base of Mount Kamet) and Geldung in Ganesh Ganga; Timersain and Thali enroute Kalajowar, and Daman towards Sagar glacier in Amrit Ganga are rich in medicinal plant diversity. Notably, villagers of Niti valley have banned livestock grazing and entry of trespassers to the sacred Lang payar, to

protect high value medicinal plant species such as *Rheum* spp., *Picrorhiza kurooa, Pleurospermum densiflorum, Aconitum violaceum* and *Betula utilis*, to name a few. Similarly, a unique archetype of conservation is also practiced by the Bhotiyas in Gamshali village to conserve wild population of the vulnerable *Allium stracheyi*. Thus, considering the unique medicinal diversity and traditional ways of their conservation in view, rotation grazing in the forested areas including heavily grazed *payars* such as Daman, Thali, Timsersain and Goting in a cycle of 2-3 years is suggested.

Owing to excessive human population, it is evident that the demand *vis-a-vis* harvesting pressure on wild populations of several MAPs is increasing every year. Thus, in order to meet the accelerating demand of high use value MAPs, there is an urgent need to develop farm scale agro-techniques for priority MAP species in the absence of such efforts on lab to land tested techniques especially for cold-arid regions such as Niti valley. In the current study, sustainable harvesting and cultivation framework have been designed for the focal MAPs (05), although appropriate demonstration sites showcasing such agro-techniques in the cold-arid landscapes such as Niti valley in Uttarakhand will be set up to gain the confidence of local cultivators in adoption of such medicinal plants in their agricultural practices.

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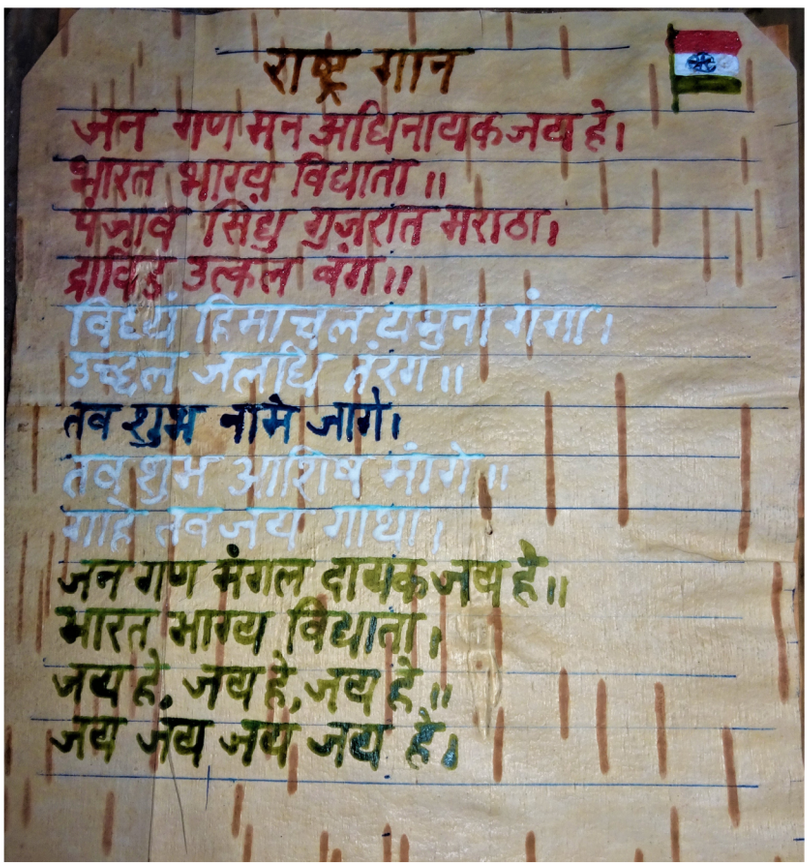

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भारतीय वन्यजीव संस्थान
Wildlife Institute of India

CONTACT

Dr. Amit Kumar
Scientist-D, Dept. of Habitat Ecology,
Wildlife Institute of India, Dehradun
248002 Uttarakhand, India
Email: amit@wii.gov.in