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ASSESSMENT OF CURRENT STATUS AND CONSERVATION STRATEGIES OF SOME HIGH VALUED MEDICINAL PLANTS FROM HIMALAYAN REGIONS

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Abstract – The Himalayan region is well known for its abundant biodiversity, especially for the wide variety of highly valued medicinal plants that are native to the region and have been utilized for generations in traditional healing practices. The current status and strategies for conservation of selected high-value medicinal plants from the Himalayan areas are evaluated in this review investigation, with an emphasis on the plant ecological significance, threats, conservation difficulties, and sustainable management techniques. It explores the risk factors that these plants encounter, which include habitat loss from deforestation, overharvesting, unethical collecting methods, the effects of climate change, and invasive species. The medicinal plants are threatened due to the overexploitation and being categorized into the various categories by IUCN. The management of medicinal plant resources is therefore so much crucial in the current time. There are a number of medicinal plants that grow in the Himalayan region that possess excellent medicinal properties. Medicinal plants like *Rhododendron* sp., *Aconitum* sp., *Bacopa monnieri, Glycyrrhiza glabra, Picrorhiza kurroa, Juglans regia* and other important medicinal plants mentioned in this review paper are of great importance. To conserve these medicinal flora and sustainable future availability, various *in situ* and *ex situ* approaches are considered, among them the most advanced are biotechnological approach like tissue culture is an advanced techniques that enables mass cultivation of medicinal plants. These techniques have the potential to meet the growing demand for plant derived medicines. The application of plant tissue culture approaches has resulted in substantial research into medicinal plant biodiversity conservation. *In vitro* regeneration is an extremely powerful biotechnological tool for propagating medicinal plants and increasing their bioactive compounds. The aim of this review is to provide an overview on the assessment of the current status and conservation challenges relating to high-valued botanical species in the Himalayan region. To ensure the sustainment of these species for future generations, conservation strategies must take into account their ecological, economic, and cultural dimensions.

Keywords: biodiversity, conservation, himalayas, medicinal plants, threats, secondary metabolites.

Introduction

Indian sub-continent and the Eurasian continent have collided constantly throughout history creating the Himalayan range. As a result of the varied habitats of the Himalayas, the region has a rich biodiversity spanning 3000 km from Northern Pakistan, Nepal, Bhutan, and the North-Western and North-Eastern parts of India. Lower Himalayas nurture luxuriant trees including *Pinus roxburghii* and *Alnus nitida* along the slopes, while moist terraces support *Alnus nepalensis*, *Quercus leucotrichophora*, *Rhododendron arboreum* etc. A higher altitude zone of the Lower Himalayas is characterized by forests of *Quercus semecarpifolia*, *Quercus floribunda*, and *Pinus wallichiana*. Several species of trees exist in the Great Himalayan range, including *Abies* sp., *Betula utilis*, *Rhododendron campanulatum*, and *Juniperus communis*. A unique assemblage of herbs can be found in the alpine meadows and grasslands at higher altitudes (above 3600

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meters). Some of the vital plants of these heights are the herbs of genera *Aconitum*, *Picrorhiza*, *Rheum*, *Meconopsis*, and the scrub species *Rhododendron anthopogon* and *Rhododendron lepidotum*. Some of the most endemism-rich Himalayan families are Rosaceae and Umbelliferae. A total of 3160 endemic plant species have been recorded. In all, over 10,000 plant species are used in medicine at some time or another with close to 18 % of the 70,000 known plant species having known therapeutic properties. It is mentioned in the ancient Indian texts that herbs have been growing in the Himalayan region for centuries. The ancient system of Ayurveda is a system of health and well-being. The repository still contains antiquated information (Kala, 2000; Patil et al., 2019; Sharma et al., 2022). According to Atharveda, countless herbs have medicinal properties for curing various maladies. The use of herbal plants as a remedy for a sick person is completely safe, as there are no side effects on the body. Due to their harmony with nature, herbal plants are preferred over synthetically treated items and manufactured drugs (Sharma et al., 2020; Thakur et al., 2020). Ayurvedic herbs possess a greater capacity to provide holistic healing to individuals in the long run compared to other drugs and medications (Khalsa, 2008). According to Rahman et al., (2011) the herbs can not only be used for producing medicines for humans but also be utilized as a source of bio-pesticides (Castor plant), dyes (Rattan jot), brews (*Rhododendron*) and perfumes (*Jatamansi*) (Sharma et al., 2024). A number of studies revealed there has been an increase in people turning to natural cures for a wide variety of ailments. Current healthcare systems around the world rely heavily on plant-based drugs. The majority of the world's population uses locally available herbs for medicinal purposes (Dubey et al., 2004; Sharma et al., 2023). Therefore, keeping in mind the severity of medicinal plants, this review paper aimed to review an important medicinal plant of the Indian Himalayas and discussed their IUCN status, description, distribution pattern, phytochemistry, medicinal properties, as well as the threats and conservation practices associated with them. This review paper attempt to assess the current status and conservation strategies of selected high-valued medicinal plants from the Himalayan regions.

Current status of medicinal plants

Only about 1% of the estimated 5,00,000 plant species have been investigated phytochemically, proving that these plants hold great potential for discovering new bioactive compounds. Traditional medicine provides primary healthcare to approximately 82% of the population in developing countries. In terms of area, India makes up 2.4% of the global biodiversity with 8% of the world's biotic resources, making it one of the 12 mega biodiversity hotspots of the world (Sharma et al., 2020; Thakur et al., 2020). Approximately 17500 species of high plants are found in India, including 64 gymnosperms, 1200 pteridophytes, 2850 bryophytes, 2021 lichens, 15500 fungi, and 6500 algae (Sanjappa, 2005). The Indian subcontinent has a lot of endemic flora or plants that are endemic to the region. Species diversity, genetic diversity, and habitat diversity are all found in India with abundant medicinal plant diversity. Mukherjee & Wahile (2006) concluded that the country has a wide variety of medicinal plants that are rich in all three aspects of biodiversity. It is estimated that 90 percent of India's medicinal plant diversity is found in forests, while only 10 percent of medical plants in India are found in non-forest habitats (Wakdikar, 2004). Out of 18,665 plant species in the world, only 3000 medicinal plants are used in the classic systems of medicine like Ayurveda, Siddha, and Unani (Schippmann et al., 2006; Sharma et al., 2021). Schippmann et al. (1990) estimate that one-fifth of all plants in India have medicinal properties. Approximately 12.5% of plant species in the world have medicinal value, while 20% of plant species in India are used for their medicinal properties. Hamilton (2003) estimates that India has approximately 44% of medicinal flora. In spite of the fact that it is difficult to estimate the number of medicinal plants present throughout the world, the fact remains that India, with its rich biodiversity, ranks first in terms of the percentage of its flora that contains active compounds (Mandal, 1999). According to Sarasan et al. (2006), over eight thousand plant species have been added to the ICUN (International Union for the Conservation of Nature Resources) and a RET endangered species list since 1996. There has been an increase of over 60% in the number of plants classified as critically endangered during the same period. For the higher plant species to become extinct or nearly extinct by 2050, up to 60,000 of them could become extinct or nearly extinct, according to the International Union for Conservation of Nature (ICUN) and the World Wildlife Fund (WWF) (Phani Kumar et al., 2011; Sharma et al., 2024). The IUCN status of the medicinal plants is given in Tab. 1. In order to preserve and manage these medicinal plant categories and to protect them from extinction, conservation and management plans would be necessary.

Threats to medicinal plants diversity

There are 560 plant species in India listed on the Red List of Threatened Species by the International Union for the Conservation of Nature and Natural Resources (IUCN). About 247 of these plant species are threatened. It has been estimated by the IUCN that about 12.5% of the world's vascular plants, around 34000 species, are under threat (Phartyal et al., 2002). Based on the severity of threats, IUCN

Table 1. Consolidated list of some high valued medicinal plant species of Himalayan Regions.

Botanical name	Family	Plant Part Used	IUCN Status
***Aconitum chasmanthum* Stapf ex Holmes**	Ranunculaceae	Rhizome, fruits, leaves	CE
***Aconitum ferox* Wall. ex Ser.**	Ranunculaceae	Rhizome, fruits, leaves	CE
***Aconitum heterophyllum* Wall. ex Royle**	Ranunculaceae	Rhizome, fruits, leaves	EN
***Acorus calamus* L.**	Acoraceae	Leaves, stem and leaves	VU
***Swertia chirata* Buch.-Ham. ex Wall.**	Gentianaceae	Leaves, stem	CE
***Taxus wallichiana var. chinensis* (Pilg.) Florin**	Taxaceae	Bark, stem	CE
***Rauvolfia serpentina* (L.) Benth. ex Kurz**	Apocyanaceae	Flower	EN
***Berberis aristata* DC.**	Berberidaceae	Stem, roots and fruits	VU
***Asparagus racemosus* Willd.**	Asparagaceae	Dried roots	EN
***Nardostachys jatamansi* (D. Don) DC.**	Caprifoliaceae	Rhizomes	CE
***Picrorhiza kurroa* Royle ex Benth.**	Scrophulariaceae	Leaves, bark and roots.	EN
***Podophyllum hexandrum* Royle**	Podophyllaceae	Leaves, rhizomes, fruits	EN
***Aegle marmelos* (L.) Corrêa**	Rutaceae	Leaves, bark, roots, fruits, and seeds	VU
***Saussurea costus* (Falc.) Lipsch.**	Asteraceae	Roots	EN
***Rhododendron arboreum* Sm.**	Ericaceae	Flowers	EN
***Angelica glauca* Edgew.**	Apiaceae	Roots	EN
***Arnebia euchroma* (Royle) I.M.Johnst.**	Boraginaceae	Root, leaves	CE
***Carum carvi* L.**	Apiaceae	Dry seed	LC
***Capparis spinosa* L.**	Capparaceae	Green shoots, fruits	LR
***Clematis tibetana* Kuntze**	Ranunculaceae	Flower and soft stem	NT
***Dracocephallum heterophyllum* Benth**	Lamiaceae	Whole plant	R
***Dactylorhiza hatagirea* (D.Don) Soó**	Orchidaceae	Roots, tubers	CE
***Ephedra gerardiana* Wall. ex Stapf**	Ephedraceae	Node, red fruits, stem,root	EN
***Geranium wallichianum* D.Don ex Sweet**	Geraniaceae	Roots, leaf and flower	EN
***Hippophae rhamnoides* L.**	Elaeagnaceae	Fruits, seed, whole plant	VU
***Hyoscyamus niger* L.**	Solanaceae	Flower, fruits	EN
***Iris hookeriana* Foster**	Iridaceae	Flower and seeds	CE
***Juniperus communis* L.**	Cupressaceae	Leaves, fruits	VU
***Justicia adhatoda* L.**	Acanthaceae	Whole plant	VU
***Myricaria squamosa* Desv.**	Tamaricaceae	Flowering spikes	EN
***Oxytropis lapponica* (Wahlenb.) Gay**	Leguminosae	Flower and leaves	NT
***Pedicularis longiflora* Rudolph**	Orobanchaceae	Leaves and flowers	NT
***Rosa webbiana* Wall. ex Royle**	Rosaceae	Fruit, flower	NT
***Taraxacum officinale* F.H.Wigg**	Compositae	Stems and flowers	LC
***Tribulus terrestris* L.**	Zygophyllaceae	Fruits	LC
***Waldheimia tomentosa* (Decne.) Regel**	Asteraceae	Flower and fruits	R
***Juglans regia* L.**	Juglandaceae	Fruits, bark, leaves, roots	EN

CE: Critical Endangered, EN: Endangered, VU: Vulnerable, LC: Least Concern, LR: Lower Risk, NT: Nearly Threatened, R: Rare.

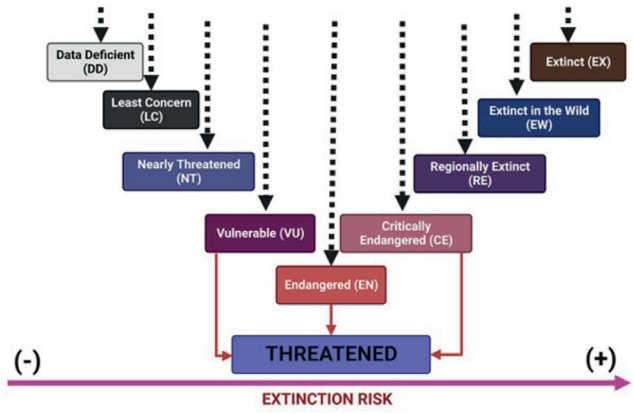

Figure 1. IUCN Red List categories

identifies and categorizes plant species according to Singh et al. (2006): extinct, extinct in the wild, critically endangered, endangered, vulnerable, near threatened, least concern, and data deficient. The term rare refers to a species that has a small population that is not endangered or vulnerable but is at risk. They are in danger of extinction in many cases (Fig. 1). Globally, herbal medicine has gained importance over the past few decades, while awareness of dwindling supplies of medicinal plants has been delayed (Bodeker, 2002). Plants used in phytopharmaceutical preparations are primarily obtained from naturally growing areas (Sharma et al., 2020; Thakur et al. 2020). Due to destructive harvesting practices and over-harvesting and exploitation of medicinal plants for the production of medicines without regard for the future, the genetic diversity of medicinal plants is being lost at an alarming rate. There are also numerous factors that threaten their existence, such as habitat destruction, forest degradation, agricultural encroachment, urbanization, pollution etc. (Gupta et al., 1998; Thakur et al., 2021) in Fig. 2.

In view of the vastly increasing world population, increasing anthropogenic activities, rapidly diminishing natural ecosystems, etc. In the midst of climate change, ocean acidification, and a range of other anthropogenic environmental impacts (Rands et al., 2010), native habitats of many herbs and trees are deteriorating, resulting in unsustainable exploitation of Earth's biological diversity. In order to restock the lost biodiversity, huge amounts of

Figure 2. Various threats to medicinal plants of Himalayan regions.

money are spent every year, and there are many conservation protocols available at the present time. There is no substantial improvement in the status of these medicinal plant species in nature, and the number of threatened plant species is gradually increasing (Tripathi, 2008; Mukherjee, 2009). The wide range of medicinal herbs found in the Himalayas are being endangered by several human-caused factors and land use patterns, which can harm the fragile natural equilibrium and threaten indigenous remedies (Sharma et al., 2020). Human activities that are affecting medicinal botanical species and their natural habitats either directly or indirectly constitute the source of these vulnerabilities (Sharma et al., 2021). Due to harvesting, building infrastructure, the agricultural sector, and human settlements, the Himalayan region is experiencing major degradation in land use cover. This is destroying natural habitats for medicinal plants, which is causing population reductions. Due to excessive harvesting and unethical practices for collecting medicinal plants for both traditional and commercial purposes, important medicinal species are being lost, imposing stress on nearby communities. The expansion of agriculture, including cash crops and monoculture farming, leads to the conversion of natural habitats into cultivated lands, soil degradation, biodiversity loss, and increased agrochemical use. In the Himalayan region, rapid infrastructure development and urbanization lead to habitat fragmentation, ecological disruption, plant isolation, and the spread of invasive species, all of which contribute to the decrease of medicinal plants. The Himalayan region's medicinal plant richness, phenology, and distribution are all being impacted by climate change, which puts them under stress and makes them more susceptible to other human-caused potential risks. Integrated conservation methods, including sustainable land use practices and responsible harvesting, involving local populations, policymakers, researchers, and conservation organizations are essential to maintain the rich medicinal plants found in the Himalayan areas (Tali et al., 2018; Ganie et al., 2019; Mishra et al., 2023).

Conservation of medicinal plants diversity

A major focus of the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro was the loss of biodiversity and preserving it (Fig. 3).

So, managing and conserving traditional medicinal plants has become a matter of necessity. Despite the fact that the most effective way to conserve threatened medicinal species is to manage wild populations and their native habitats, some of these plants do not produce seeds or their seeds are too small for soil germination. A plant may be discarded if the

Figure 3. Conservation strategies adopted to conserve medicinal flora

product is of poor quality for commercial distribution due to its heterozygous nature. It shows significant variations in growth, habit, and yield even when grown from seeds. Additionally, there are a number of cultivars that are unsuitable for vegetative propagation through cuttings or grafts, thereby limiting the potential for multiplication of the desired cultivars. As a result, many plants propagated by vegetative means contain systemic bacteria, fungi, and viruses that may adversely affect the appearance and quality of selected plants (Murch et al., 2000). Consequently, it becomes a general problem to multiply disease-free planting materials in large numbers. According to Sarasan et al. (2006) *ex situ* conservation techniques can overcome all these barriers (Negash et al., 2001). Through cultivation and maintenance of plant propagules in plant tissue culture repositories, threatened medicinal plants can be conserved ex-situ using methods outside their natural habitats (Rands et al., 2010). Mass propagation and germplasm conservation have become increasingly useful with *in vitro* techniques due to their superiority over conventional methods of propagation and some distinct advantages over alternative approaches. Among them is (1) collection can be made at any time during the flowering season, provided seed material is not required, (2) clonal material can be produced in situations where it is necessary to maintain elite genotypes by producing clonal material, (3) By using meristem culture, viruses can be eliminated from contaminated tissues, (4) It may be possible to facilitate the germination of seeds and embryos that are difficult to germinate or immature for breeding purposes, (5) In case there is a need for stocks, micropropagation procedures may be used for rapid multiplication at any time, (6) If it comes to germplasm distribution across borders, *invitro* cultures might be a more effective method, in terms of germplasm health status. Storage space requirements are greatly reduced using *in vitro* techniques compared with field storage, another positive aspect. Climate fluctuations,

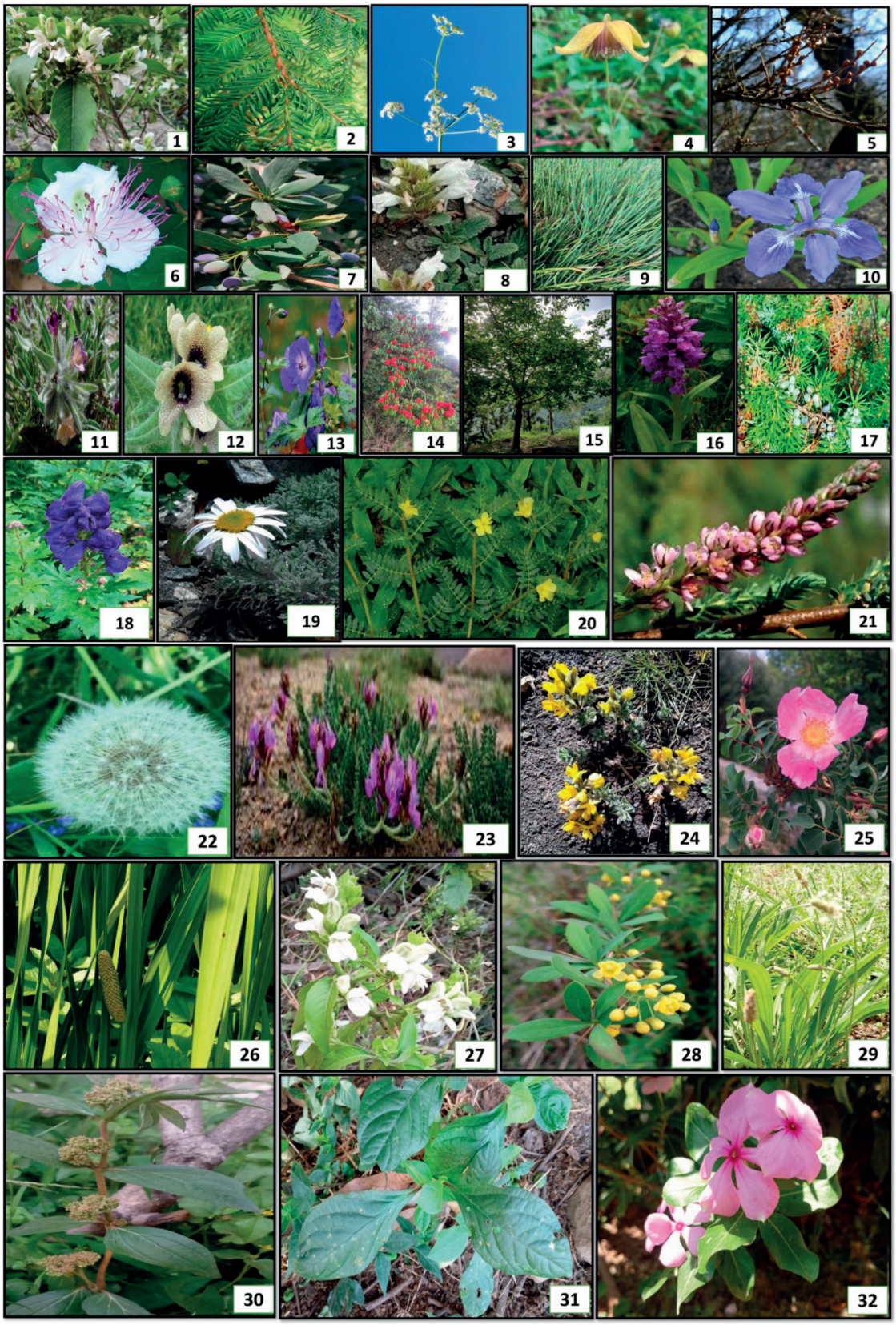

Figure 4. Medicinal flora of Himalayan regions (Adapted from authentic sources: https://identify.plantnet.org/; https://www.flowersofindia.net/

pests, cyclones, insects, and pathogens do not affect cultures in storage facilities (Bhojwani & Dennis, 1999; Shibli et al., 2006). In this regard, micro-propagation has significant potential as a means of achieving true-to-type, rapid and massive multiplication. Also, callus-derived plants exhibit a high genetic diversity that may be exploited to generate superior clones/varieties, particularly in vegetatively propagated species. Medicinally important species that are difficult to regenerate by conventional methods can be multiplied and preserved by tissue culture within short periods of time and within limited space. Cell and tissue culture *in vitro* has become increasingly popular in recent years as a means of conserving plant germplasm for long-term survival, propagating large-scale revegetation in mass quantities, and studying genetic manipulation under precisely controlled conditions. It may be possible to preserve biodiversity of native medicinal plants through a combination of *in vitro* propagation methods and cryopreservation (Singh et al., 2006).

Biotechnological approaches for conservation of medicinal plants

By utilizing scientific developments to address conservation problems and encourage responsible utilization, biotechnological techniques are essential to the conservation of medicinal plants. Micropropagation and tissue culture are both biotechnological methods used to mass-produce plants from small amounts of plant tissue, including embryos, meristems, or stem cells. This method prevents the decline of natural populations while facilitating the quick growth of threatened medicinal plant species (Sharma & Thakur, 2020). Herbal medicine uses cryopreservation methods, like liquid nitrogen cryogenic storage, to maintain the genetic variety of plants. With the use of this technique, plant germplasm such as seeds, embryos, branch tips, or pollen can be preserved for a long time in a dormant state for later use. The synthesis of secondary metabolites, including bioactive substances with therapeutic potential, is stimulated by biotechnological techniques like metabolic engineering, elicitation, as well as plant cell and tissue culture (Sharma et al., 2021). A sustained supply can be ensured by minimizing the demand for wild harvesting by optimizing the production of valuable components in controlled conditions found in bioreactors or culture systems. Pharmacological and functional investigations into medicinal plants are carried out using biotechnological technologies in order to gain insight into their therapeutic characteristics, mode of action, safety, and effectiveness. This information contributes in the creation of quality control guidelines, evidence-based herbal remedies, and legal frameworks for long-term use (Sharma & Thakur, 2020; Sharma et al., 2021; Sharma et al., 2024).

Medicinal flora of Himalayas

The threatened medicinal plants from Indian Himalayan Regions are shown in Fig. 4 (1-32).

***Adhatoda vasica* Nees**
***Taxus baccata* L.**
***Carum carvi* L.**
***Clematis tibetana* Kuntze**
***Hippophae rhamnoides* L.**
***Capparis spinosa* L.**
***Berberis aristata* DC**
***Dracocephalum heterophyllum* Benth.**
***Ephedra gerardiana* Wall. ex Stapf**
***Iris hookeriana* Foster**
***Arnebia euchroma* (Royle) I.M.Johnst.**
***Hyoscyamus niger* L.**
***Geranium wallichianum* D.Don ex Sweet**
***Rhododendron arboreum* Sm.**
***Juglans regia* L.**
***Dactylorhiza hatagirea* (D.Don) Soó**
***Juniperus communis* L.**
***Aconitum napellus* L.**
***Waldheimia tomentosa* (Decne.) Regel**
***Tribulus terrestris* L.**
***Myricaria squamosa* Desv.**
***Taraxacum officinale* Webb**
***Oxytropis acanthacea* Jurtzev**
***Pedicularis longiflora* Rudolph**
***Rosa webbiana* Wall. ex Royle**
***Acorus calamus* L.**
***Justicia adhatoda* L.**
***Berberis lycium* Royle**
***Plantago ovata* Forssk.**
***Euphorbia hirta* L.**
***Achyranthes aspera* L.**
***Catharanthus roseus* (L.) G. Don**

***RHODODENDRON*:** A species of Rhododendron commonly known as Buransh or Laligurans is classified in the Ericaceae family (Iqbal & Negi, 2017). According to Bhattacharyya (2011), India is home to only 12 species of Rhododendrons out of 80 species worldwide. The local population of the Indian Himalayan Region is reported to value most of these species highly. Incense and fuelwood are two of the most widely exploited species. Despite its

evergreen nature, it can reach heights of up to 20 meters. Leaf shape is narrow and lanceolate, crowded towards the base. Their length is 10-20 cm and their width is 3-4 cm. On the top of the leaves, the color is glossy green, while on the back, the color is rustic brown. There are several shades of pink to red in the flower (Sekar & Srivastava, 2010). The flowers of buransh trees grow in bright red colors at lower altitudes. Seeds are ellipsoid and the fruit is capsular. It is recommended to collect seeds in the last two to three weeks of October (Singh et al., 2003). For well-flourished growth of *Rhododendron* species, the moist slopes of the eastern Himalayas provide the ideal environment. In Uttarakhand, the *R. arboreum* species are found at altitudes between 1500 m and 3500 m. Among the few plants that can survive such acidic soil are the *R. arboreum* species (Tiwari & Chauhan, 2006). Different parts of the *Rhododendron* tree contain a variety of phytochemicals. Rhododendron leaves are rich in flavonoids, protecting the heart from oxidants. Leaf and flower extracts contain quercetin. The leaves are rich in rutin and sterol. Several compounds can be found in the bark, including betulin, lupeol, and ursolic acid. Compared with synthetic antioxidant drugs, *Rhododendron* extracts exhibit high antioxidant properties (Prakash et al., 2007). Plants native to hilly regions such as *R. arboreum* are used to make jam and jellies. Dysentery and dyspepsia can also be treated with fresh blossoms. Its bark contains bioactive substances that exhibit antifungal properties. An ethanolic extract of the leaves is shown to be antitumor in nature. Several *Rhododendron* species are used for fuel, including *R. barbatum*, *R. falconeri*, and *R. hodgsonii*. Incense sticks are made from leaves and twigs of *R. anthopogon*. A local brew is prepared with fresh corollas from *R. arboreum* and *R. cinnabarium*. Cups, spoons, boxes, and saddles are made from the tender leaves and woods. *R. lepidotum* bark is used for making drinks that have purgative properties. In addition to treating indigestion and lung infection, *R. anthopogon* leaves and flowers can also help with hay fever.

***ACONITUM*:** In the genus Aconitum, there are 250 species of plants that are called aconite, wolfbane, queen's poison, or monkshood. It is a member of the Ranunculaceae family. Many traditional medicines incorporate it into their formulations (Jeelani et al., 2015). Despite the deadly nature of some Aconitum species, they have considerable therapeutic value. The plant's essential compounds must be extracted and formulated in a safe manner in order to overcome its toxic nature (Singhuber et al., 2009). The *Aconitum heterophyllum* is one of the most prevalent species of Aconitum and is often known as Atis, Ativisha, and Indian Atees. An important component of the Ayurvedic system of medicine, it is one of the most valued drugs. Various states of the Himalayan range are threatened by the genus due to the incredibly high demand for raw drugs on their local market (Jabbour & Renner, 2012). Tubers are economically important. These tubers are biennials and are paired. It has a simple stem with numerous branches that are erect and erect. It reaches a height of 15 to 20 centimeters. There are long petioles, glabrous leaves, and heteromorphic leaves. Black pyramidal seeds are embedded in violet-blue sepals. Ativisha grows in the alpine and sub-alpine areas of the Himalayas between 2000 and 5000 meters. It is indigenous to the Western Himalayas (Raina et al., 2011). It is found in abundance in Aconitum species to produce diterpene alkaloids and flavonoids. The plant's medicinal properties are attributed to the alkaloid aconitine in its tubers. As well as tannic acid, starch, fatty acids and their glycerides, carbohydrates, and others, the plant contains various other compounds (Bahuguna et al., 2000). In the case of communicable diseases, such as measles, aconite can prove useful. In addition, it successfully treats diseases such as asthma, diabetes, leukoderma, leprosy, and convulsions. Plant components such as flavonoids and phenols act as antioxidants and antibacterials. Coughs and congestion are effectively treated with it. In addition to being aphrodisiac, it also contains diuretic properties (Beigh et al., 2006). The hot potency of *Aconitum heterophyllum* makes it a popular ingredient in Ayurvedic medicine. Laxative properties are found in the seeds. Anorexia, arthritis, and ascaris are all treated effectively with the roots (Sekar & Srivastava, 2010). There are several names for Aconitum ferox, including Meetha Vish and Monkshood. The sedative nature of this agent also makes it effective in treating severe anxiety issues, fever, heart disease, asthma, and arthritis, as well as diuretic action. Nepal Monkshood, also known as safed bish or Nepal Monkshood, is a tall hairless herb with tuberous roots. It is used for treating acute headaches and rheumatism, as well as for treating boils. The roots of *Aconitum chasmanthum* are the most economically valuable part of the herb.

***BACOPA MONNIERI*:** Brahmi is the common name for *Bacopa monnieri*. It has been used extensively for more than 3000 years by Ayurveda and other ancient Indian medical systems. The plant belongs to the Scrophulariaceae family. There are over 4500 species in this family (Yadav et al., 2013). There is medicinal value to the entire plant. Both normal children and mentally retarded children have shown promising results with this method of improving memory and other psychological abilities. The Brahmi plant stalk grows from 10 to 30 cm in length and is 1-2mm thick (Yadav et al., 2013). Brahmi is an aromatic plant with a tender stem that can reach 10 to 30cm. There are 200 succulent leaves on the main stem and sessile leaves arranged oppositely. The flowering of the plant and the emergence of the fruit occur in the summer. A white to purple-blue flower can be found on it.

Despite the fruit's ovoid shape, its aroma is not discernible. Cooling properties are present in it. Based on Jana's (2006) comparison of the Indian pennywort with *B. monnieri*, the latter turned out to be superior to the former. It is native to the tropics and sub-tropics. The species can be found all over India and Nepal, especially in moist and wet conditions (Sharma et al., 2013). In addition to alkaloids, saponins, glycosides, flavonoids, and stigmasterols, this plant contains several compounds that have therapeutic benefits. Bacosides are the saponins of Brahmi. Flavonoids found in it include luteolin and apigenin. There are two alkaloids that have been isolated from Brahmi, herpes time and brahmine, which if taken at a high dosage may cause extreme headaches (Mitra et al., 2010). With Bacopa, it is possible to treat conditions like eczema, ulcerations, rashes, and rashes. A brain tonic, it is a popular medicine used to treat amnesia and Alzheimer's diseases. By detoxifying the blood, it removes toxins. In addition to preventing hair loss and premature graying, it is also an effective anti-hair loss and anti-hair loss herb. Hair follicles are rejuvenated and baldness is prevented (Bhandari et al., 2006). Anti-diabetic, anti-cancer, and anti-arthritic, it exhibits anti-diabetic and anti-cancer properties. A powerful antioxidant in Brahmi prevents free radical damage to the body (Rakhi & Vashistha, 2011). Aquatic *B. australis* plants are used in aquariums as decorative pieces. The perennial medicinal herb *B. crenata* is also known as moneywort. A creeping plant with an annual stem, *B. repens* can be found in the desert. A commercial use is not available for *B. rotundifolia* plant.

***GLYCYRRHIZA*:** Liquorice is the common name for *Glycyrrhiza glabra*. A variety of diseases can be cured using its ethnopharmacological value throughout the world. It is the roots and tubers of plants that have the greatest medicinal value (Thakur & Raj, 2017). Mulaithi and Yashtimadu are also named for this plant. It is used for flavoring because of its sweet taste. Ayurveda and Siddha use this plant extensively for medicinal purposes. This shrub is perennial in nature and grows to a height of 120 cm. This plant flowers after 2-3 years of planting and is generally pale blue in color. A pod consists of 2 to 5 seeds and measures about 2 cm x 2.5 cm. The roots are cylindrical, which have a diameter of 2 cm and are in a stolen form (Chhetri, 2007). In India, it is common to cultivate glycyrrhiza in areas of the Punjab and the sub-Himalayas. In between the Gangetic plains and the Himalayas, the Sub-Himalayan tract occupies an elevation range of 400 to 1200 meters and above sea level (Dhar et al., 2000). There are a number of compounds that contribute to licorice root's aroma, including anethole, which makes up 3% of the total volatile compounds. Glycyrrhizin gives the fruit its sweet taste, containing 30 to 50 times more sweetness than sugar (Gaur et al., 2010). These plants were used in traditional medicine by the Gujjar community in India. The sugary taste is less immediate than sugar, it lasts a lot longer, and it is tart at first but then it gradually becomes less tart. The root of liquorice contains two isoflavones, glabrene, and glabridin, both of which are phytoestrogens. Aside from saponin triterpenes (glycyrrhetinic acid, liquiric acid, and glycyrrhizin), the roots also contain flavonoids, coumarins, sugars, tannins, starch, choline, amino acids, and phytosterols, which are glycosides. There are many advantages to using Mulethi. It can reduce acid reflux and indigestion and can help to prevent ulcer formation by lowering stomach acid levels. It uses action on action to increase the flow of bile and lower the cholesterol level in the body. In terms of respiratory organ irritation and inflammation, this medicinal plant is useful for soothing and healing those symptoms. By enhancing levels of interferon in the body, Licorice improves the body's resistance power in the face of viruses by competing with them and defending the body from them. Moreover, it can also help with some symptoms of premenstrual syndrome (PMS), such as irritability, breast tenderness, and gassiness, which are commonly experienced during the premenstrual period. As a result of its anti-allergic properties, it has proven to be effective in treating allergic rhinitis, conjunctivitis and bronchial asthma. The ingredient can also be used to treat skin diseases such as eczema, psoriasis, and dermatitis (Thakur & Raj, 2017). In general, *G. asperrima* is commonly known as Chinese Liquorice and is useful for treating acid reflux and other reflux-related problems. The herb *G. glandulifera* contains a high concentration of betulic acid. Liquorice of American origin, *G. lepidota*, has a warm, aromatic quality. Prostate enlargement may be treated with *G. uralensis*, an herbal remedy.

***BERBERIS*:** This plant belongs to the family Berberidaceae and is also known as Indian barberry in English or Daru Haldi in Hindi. Around 500 species of Berberis can be found worldwide. There are a number of Berberis species that have gained significant prominence in traditional medicine. It is a perennial shrub that grows well in temperate climates (Komal et al., 2011). Depending on the variety, it can reach a height of up to 3 meters. Yellow flowers are present in the plant. A variety of yellow to pink seeds are contained in the fruit, which is shaped as an ovoid berry. It has a sweet to acidic taste (Singh & Kakkar, 2009). Among Indian Himalayan plants, Berberis is well known for its herbal properties. It grows in small patches on slopes of hills. It is found in Uttarakhand and Himachal Pradesh at altitudes between 1800 and 3000 meters (middle altitude areas). Wild areas are generally the source of this plant material. A status of endangered has been assigned to this plant by the IUCN. The plant is usually grown for the fruits it

produces (Samant et al., 2007). Berberine, a quaternary iso-quinoline alkaloid found mostly in the stems and roots of this herbal plant, is its most important constituent. Roots and stems usually contain it. Quaternary ammonium salts of iso-quinoline alkaloids make up the bark. The leaves and stems of plants can also be used to extract lignans. *Berberis* species in the western Himalayas are rich in fibre, protein, fats and some minerals (Srivastava et al., 2001). Melasma is cured by Berberis extremely effectively. Counteracting stomach disorders is one of its benefits. Liver disorders can be prevented with its use. Due to its ability to prevent water loss, it is used as an occasional mild laxative (Joshi et al., 2011). Jaundice, diabetes, inflammations, and wounds have been treated traditionally with the roots, stems, leaves, and fruits of the plant. (Ray et al., 2011) have confirmed that this plant extracts contain antibacterial, antiviral, antifungal, anticancer, anti-inflammatory, and antidiabetic properties. Inflammatory properties are present in *B. vulgaris*. There are antimicrobial properties in *B. heterophylla*. As a remedy for cholera and serious diarrhea, *B. lyceum* is highly effective (Das et al., 2009). Antimicrobial activity and chronic inflammation are effective characteristics of *B. aetnensis*. Eyes, liver, and heart disease can be alleviated with *B. lyceum*. The antibacterial properties of *B. repens* are well known.

***AEGLE MARMELOS*:** As a member of the Rutaceae family, *Aegle marmelos* is widely recognized as the Bael Tree in tropical and subtropical regions, and is a popular vulnerable medicinal plant. Kala et al. (2006) reported that this plant contains a variety of alkaloids, including aegline, marmesin, marmin, and marmelosin. In addition to diarrhea, dysentery, dyspepsia, malaria, fever, jaundice, and skin diseases like ulcers, urticaria, and eczema, nearly all parts of the tree are used to prepare herbal medicines (Sharma & Thokchom, 2014).

***7. HEDYCHIUM*:** This plant belongs to the family Zingiberaceae, also known as Kapoor in Hindi, spiked ginger lily in English, and Shati in Ayurveda. Despite its small size, it is a hardy rhizomatous herb (Jugran et al., 2011). There are orange yellow flowers on this perennial herb which grows to 1-2 meters high. Seeding occurs between September and October, with flowering between July and August. There are fragrant leaves on this 1.5-metre-tall plant with a robust stem. The leaves of this plant are lanceolate and 30cm long. Despite its strong odour, the rhizome tastes bitter. The aril has a black color with red markings (Rawat et al., 2011). An endemic herb species of the South-East Asian region is *H. spicatum* and it is found in a variety of countries throughout the region. In addition to being native to the Himalayan region, this species also occupies a wide range of habitats set within subtropical and temperate climate zones in the region. In the Central Himalayan Region of India, the species can be commonly found at altitudes varying between 1200m and 2400 m in moist and rocky habitat near a water body or mixed forest, surrounded by oak trees or oak and pine trees (Rawat et al., 2011). A subtropical zone with sunny weather is the best place for this species. However, a shady area is not a good place for it. A temperature as low as -2°C can be tolerated by this species (Rasool & Maqbool, 2019). It has been reported that *H. spicatum* has antidiabetic properties, tranquillizing actions, pediculicidal effects, antimicrobial properties, antioxidant properties, antimalarial hepatoprotective actions, cytotoxic effects, anti-helminthic effects, stomachic effects, and tonic activities. Its anti-diabetic properties are attributed to 1, 8 cineole, a compound obtained from the rhizome. A study conducted by Chaudhary et al. (2012) demonstrated the anti-microbial properties of the essential oil. *H. acuminatum* is used most commonly for liver problems. Cataracts can be cured with *H. coronarium*. Indigestion is the best application of *H. marginatum* (Devi et al., 2014).

***PICRORHIZA KURROA*:** A herb used for medicinal purposes, Kutki or *Picrorhiza Kurroa* grows in the Himalayan region of India and belongs to the Scrophulariaceae family. Katuko, Kuru, Katukarogani, Katuko, Kurri and Katuka are some other names for this plant. Liver disorders have been successfully treated with this herbal medicine. Plant extracts show decent results against liver damage caused by carbon tetrachloride, paracetamol, and alcohol. This plant has been found to have beneficial effects as a laxative, liver stimulant, appetite and stimulant, and febrifuge in Ayurveda. Besides alleviating stomach aches, it is believed to stimulate appetite as well. Asthma and epidemic jaundice are also treated with the plant. In addition to treating disorders related to the chakra system, the herb is also useful for treating billow fever, urinary discharge, hiccups, blood troubles, burning sensations, and leukoderma (Sharma & Thokchom, 2014).

TAXUS WALLICHIANA: Native to the Himalayan region and the surrounding areas, it is also commonly known as the Himalayan yew or the Himalayan Taxus. It is a species of coniferous trees. As a member of the Taxus genus, which contains multiple yew species, *Taxus wallichiana* is a member of the Taxaceae family. This tree is evergreen and can grow up to 25 meters (82 ft) in height, with a conical or columnar crown. The leaves are lanceolate, dark green, and distributed spirally along the branches, with scaly, reddish-brown bark. The Himalayan region, which includes portions of Afghanistan, Pakistan, India, Nepal, Bhutan, and Tibet, is home to this species. At elevations between 1,500 and 4,000 meters (4,900 and 13,100 feet) above sea level, it grows well in mountainous regions. In mixed

forests, *Taxus wallichiana* grows best in well-drained soils, frequently in close proximity to other coniferous and broad-leaved trees. Taxol, a substance having anticancer qualities, is produced by *Taxus wallichiana*, which is well known for its therapeutic qualities. The tree's bark, needles, and seeds are the source of taxol, which is used to treat a variety of cancers, such as lung, breast, and ovarian cancers. It is economically significant in the pharmaceutical industries because of its medicinal properties (Sharma & Garg, 2015; Bhuju & Gauchan, 2018).

JUGLANS REGIA: *Juglans regia* is a species of deciduous tree in the Juglandaceae family. It is often referred to as the Persian walnut, English walnut, or common walnut. Native to areas of Central Asia, the Middle East, and the Himalayan region, it is found throughout the region that stretches from the Balkans to China. The enormous *Juglans regia* tree can grow to a height of 25–30 meters (82–98 feet). With 5–9 leaflets per leaflet, its pinnately complex leaves have a broad, spreading crown. In the autumn, the dark green leaves turn yellow. The walnut tree yields round or oval-shaped nuts with a tough, wrinkled shell that is widely recognized as walnuts. For ages, people have been cultivating and appreciating walnuts for their nutritional worth and culinary applications. The nuts are a healthy complement to a variety of foods, salads, baked products, and desserts since they are high in omega-3 fatty acids, antioxidants, vitamins, and minerals. Walnut consumption is linked to a number of health advantages, such as enhanced heart health because of the omega-3 fatty acids it contains, decreased inflammation, lowered cholesterol, and support for cognitive and mental health. They are also a good source of nutritional fiber and protein. *Juglans regia* is a valuable and adaptable species with both economic and ecological significance. It is important for agriculture, forestry, culinary traditions, and human health (Sharma et al., 2022; Sharma et al., 2024).

ANGELICA GLAUCA: It is a perennial herbaceous plant in the Apiaceae family, sometimes referred to as Himalayan angelica or Chuan Xiong in traditional Chinese medicine. It grows naturally in alpine meadows, along forest borders, and on rocky slopes throughout the Himalayan area, which includes portions of India, Nepal, Bhutan, and Tibet. The genus Angelica, which contains a number of flowering plant species prized for their fragrant leaf and therapeutic qualities, is where *Angelica glauca* is categorized. Tall, hollow stems, divided compound leaves with serrated edges, and umbel-shaped clusters of tiny white or greenish-yellow flowers are some of its distinguishing features. It is prized for its medicinal qualities in traditional medical systems like Ayurveda and traditional Tibetan medicine. The plant's most pharmacologically active portions, the roots and rhizomes, are utilized in a variety of herbal treatments. Because of its well-known analgesic and anti-inflammatory qualities, it is helpful in the management of inflammatory diseases, arthritis, and pain. It is frequently used as a natural substitute for non-steroidal anti-inflammatory medicines (NSAIDs). The aromatic leaves and stems are occasionally used as a culinary herb or flavouring in dishes, drinks, and soups. The plant is also a common ingredient in herbal remedies and fragrances due to its aromatic properties (Bisht et al., 2006; Pandey et al., 2011).

SAUSSUREA COSTUS: a perennial herbaceous plant in the Asteraceae family, is also referred to as Costus or Kuth. It is indigenous to the Himalayan region, growing between 2,000 and 4,000 meters (6,500 and 13,100 feet) in height. It is especially prevalent in India, Nepal, Bhutan, and Tibet. The genus *Saussurea*, which includes over 300 species of flowering plants, includes *Saussurea costus*. Strong, meaty rhizomes, long, lanceolate leaves with serrated edges, and tall blooming stems with clusters of tubulars, purple or yellow flowers are some of its distinguishing features. The growth stage and environmental factors affect the plant's appearance. Traditional medical systems, such as Ayurveda, Tibetan medicine, and Unani, have long used *saussurea costus*. The plant's rhizomes are its most pharmacologically active component and are prized for their wide range of therapeutic benefits. The anti-inflammatory, analgesic, digestive, and expectorant properties of costus are well-known. Costus is a widely used element in fragrance and incense manufacture due to its fragrant properties. The rhizomes are useful for creating exotic perfumes because of their characteristic musky odour, which lends depth and richness to fragrances (Nadda et al., 2020; Ali & Venkatesalu, 2022).

RAUVOLFIA SERPENTINA: Native to Southeast Asia and the Indian subcontinent, *Rauvolfia serpentina* is also known as Indian snakeroot or sarpagandha. It is a member of the Apocynaceae family and is well known for its pharmacological qualities and historical application in conventional medicine. The perennial, evergreen shrub or small tree *Rauvolfia serpentina* has a maximum height of 1-2 meters (3-6 feet). Its tall, thin branches are topped with whorls of oval leaves that surround the stem. The shrub bears juicy, red berries with seeds within as well as tiny, white or pink flowers. The most pharmacologically active portion of *Rauvolfia serpentina* is its roots, which have long been utilized in traditional medicine. Bioactive alkaloids such as reserpine, ajmaline, ajmalicine, and serpentine are abundant in it. Due to the diverse medicinal effects of these alkaloids, *Rauvolfia serpentina* is useful in the management of a number of illnesses. The ability of *Rauvolfia serpentina* to reduce blood pressure is one of its most well-known

therapeutic qualities. In contemporary medicine, serpine which is derived from the roots is used to treat hypertension, or high blood pressure, by decreasing sympathetic nervous system activity and vasodilation. According to studies, *Rauvolfia serpentina* extracts contain antibacterial qualities that make them effective against fungus and bacteria. Furthermore, the plant's alkaloids have shown antimalarial action, suggesting that it may be used to treat or prevent malaria. Historically, *rauvolfia serpentina* has been used as a sedative and anxiolytic a substance that lessens anxiety. Anxiety, tension, and sleeplessness can be lessened by the plant's alkaloids, which have a relaxing impact on the central nervous system. Because of its medicinal qualities and prospective applications in contemporary healthcare, it is still being studied scientifically and has tremendous pharmaceutical potential (Negi et al., 2014; Roy et al., 2023).

Conclusions

The Himalayas are the highest mountain peak on earth and the largest mountain range in the world. The assessment of the current status and conservation strategies of high-valued medicinal plants from the Himalayan regions underscores the critical importance of preserving these invaluable botanical resources. Several medicinal and aromatic species grow in this area, which plays a major role in herbal pharmaceuticals. As medicinal plants continue to deliver a variety of alternative treatment approaches. Many popular high valued medicinal plants are found in the Himalayas like *Bacopa monnieri, Glycyrrhiza glabra, Picrorhiza kurroa, Aconitum heterophyllum, Swertia chirata, Berberis aristata, Valeriana jatamansi, Juglans regia*. The Himalayan range has a high chance of generating social and economic benefits through the industrial utilization and commercial cultivation of these natural products. In the face of various degrees of threats, these medicinal plant species have been threatened with extinction, so every possible step has been taken to develop biotechnological tools and techniques that can be used to domesticate wild species under threat. It has become imperative that we find out other methods of conserving them. The study attempted to concluded that a number of conservation programmes and strategies that are intended to preserve and manage highly valued medicinal plants in the Himalayan areas in a sustainable manner. These approaches cover a wide range of techniques, such as the creation of protected areas, community-based conservation, sustainable harvesting techniques, habitat restoration, agricultural initiatives, conservation of genetic resources, and biotechnological interventions. The evaluation of highly valuable medicinal plants from the Himalayan areas concludes by emphasizing the necessity of multidisciplinary and integrative approaches to conservation. Prioritizing fair benefit-sharing, sustainable management, and biodiversity conservation can help protect these priceless botanical resources, maintain traditional knowledge, boost local economies, and foster a more resilient and healthy future for people and the environment.

List of Abbreviations

IUCN- International Union for Conservation of Nature
UNCED- United Nations Conference on Environment and Development
WWF- World Wildlife Fund
RET- Rare and Endangered Species

Declarations

Ethics approval and consent to participate

Ethics approval is not required for this study.

Consent for publication

Not required for this study.

Availability of data and materials

Not applicable.

Competing interests

Not applicable.

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Author contribution

Munish Sharma collected the data and involved in draft preparation for the review. Munit Sharma suggested the idea and designed the study. The final editing was done by Munit Sharma and Munish Sharma and approved the final version.

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References

Ali S.I., Venkatesalu, V., 2022. Botany, traditional uses, phytochemistry and pharmacological properties of Saussurea costus–An endangered plant from Himalaya-A review. Phytochemistry Letters 47(16), 140-155.

Bahuguna R., Purohit M.C., Rawat M.S.M., Purohit A.N., 2000. Qualitative and quantitative variations in alkaloids of Aconitum species from Garhwal Himalaya. Journal of Plant Biology 27(2), 179-183.

Beigh S.Y., Nawchoo I.A., Iqbal M., 2006. Cultivation and conservation of Aconitum heterophyllum: A critically endangered medicinal herb of the northwest Himalayas. Journal of herbs, spices & medicinal plants 11(4), 47-56.

Bhandari P., Kumar N., Gupta A.P., Singh B., Kaul V.K., 2006. Micro-LC determination of swertiamarin in Swertia species and bacoside-A in Bacopa monnieri. Chromatogra 64(9-10), 599-602.

Bhattacharyya D. 2011. Rhododendron species and their uses with special reference to Himalayas–a review. Assam University Journal of Science and Technology 7(1), 161-167.

Bhojwani S.S., Dennis T., 1999. *In vitro* conservation of plant genetic resources. Botanica 49, 47-52.

Bhuju S., Gauchan D.P., 2018. Taxus wallichiana (Zucc.), an endangered anti-cancerous plant: a review. International Journal of Research 5(21), 10-21.

Bisht A.K., Bhatt A., Rawal R., Dhar U., 2006. Assessment, extraction pattern and restoration through propagation of Angelica glauca, a critically endangered Himalayan medicinal herb. The International Journal of Biodiversity Science and Management 2(2), 105-113.

Bodeker G., 2002. Medicinal plants: towards sustainability and security. IDRC Medicinal Plants Global Network Sponsored Discussion Paper for WOCMAP III, Chiang Mai, Thailand.

Chaudhary A.A., Dhar U., Ahmad A., Bhatt I.D., Jugran A., Kaur G., 2012. Analysis of genetic diversity in *Hedychium spicatum* Buch. Ham. ex. D. Don in West Himalaya, India. Journal of Medicinal Plants Research 6(23), 3984-3991.

Chhetri D.R., 2007. Medicinal plants scenario in Darjeeling Himalayas: Conservation and cultivation as alternative crop.

Das S., Das M.K., Mazumder P.M., Das S., Basu S.P., 2009. Cytotoxic activity of methanolic extract of *Berberis aristata* DC on colon cancer. Global Journal of Pharmacology 3(3), 137-140.

Devi N.B., Singh P.K., Das A.K., 2014. Ethnomedicinal utilization of Zingiberaceae in the valley districts of Manipur. Journal of Environmental Science, Toxicology and Food Technology 8(2), 21-23.

Dhar U., Rawal R.S., Upreti J., 2000. Setting priorities for conservation of medicinal plants—a case study in the Indian Himalaya. Biological Conservation 95(1), 57-65.

Dubey N.K., Kumar R., Tripathi P., 2004. Global promotion of herbal medicine: India's opportunity. Current Science 86(1), 37-41.

Flowers of India. Retrieved May 16, 2024, from http://www.flowersofindia.net

Gaira K.S., Rawal R.S., Rawat B., Bhatt I.D., 2014. Impact of climate change on the flowering of *Rhododendron arboreum* in central Himalaya, India. Current Science 1735-1738.

Ganie A.H., Tali B.A., Khuroo A.A., Reshi Z.A., Nawchoo I.A., 2019. Impact assessment of anthropogenic threats to high-valued medicinal plants of Kashmir Himalaya, India. Journal for Nature Conservation 50, 125715. https://doi.org/10.1016/j.jnc.2019.125715.

Gaur R.D., Sharma J., Painuli R.M., 2010. Plants used in traditional healthcare of livestock by Gujjar community of Sub-Himalayan tracts, Uttarakhand, India.

Gupta A., Vats S.K., Lal B., 1998. How cheap can a medicinal plant species be? Current Science 74(7), 565-566.

Gupta M., Srivastava S., Mehrotra S., Sharma V., Rawat A.K.S., Srivastava M., (2007). Pharmacognostic evaluation of Pipper longum Linn. fruit. Natural Product Sciences, 13(2), 97-100.

Hamilton A. 2003. Medicinal plants and conservation: issues and approaches [online].

Iqbal K., Negi A.K., 2017. Rhododendrons in Uttarakhand: Diversity and conservation. International Journal of Environment 6(1), 31- 45.

Jabbour F., Renner S.S., 2012. A phylogeny of Delphinieae (Ranunculaceae) shows that Aconitum is nested within Delphinium and that Late Miocene transitions to long life cycles in the Himalayas and Southwest China coincide with bursts in diversification. Molecular phylogenetics and evolution 62(3), 928-942.

Jana J.C., 2006. Use of traditional and underutilized leafy vegetables of Sub-Himalayan Terai region of West Bengal. In I International Conference on Indigenous Vegetables and Legumes. Prospectus for Fighting Poverty, Hunger and Malnutrition 752, 571-575.

Jeelani S.M., Siddique M.A.A., Rani S., 2015. Variations of morphology, ecology and chromosomes of *Aconitum heterophyllum* Wall., an endangered Alpine medicinal plant in Himalayas. Caryologia 68(4), 294-305.

Joshi P.V., Shirkhedkar A.A., Prakash K., Maheshwari V.L., 2011. Antidiarrheal activity, chemical and toxicity profile of *Berberis aristata*. Pharmaceutical biology 49(1), 94-100.

Jugran A., Bhatt I.D., Rawat S., Giri L, Rawal R.S., Dhar U., 2011. Genetic diversity and differentiation in *Hedychium spicatum*, a valuable medicinal plant of Indian Himalaya. Biochemical genetics 49(11-12), 806-818.

Kala C.P., 2000. Status and conservation of rare and endangered medicinal plants in the Indian trans-Himalaya. Biological conservation 93(3), 371-379.

Kala C.P., Dhayani P.P., Sajwan B.S., 2006. Developing the medicinal plants sector in northern India: challenges and opportunities. Journal of Ethnobiology and Ethnomedicine 2,1-15.

Khalsa K.P.S., 2008. The practitioner's perspective: introduction to Ayurvedic herbalism. Journal of Herbal Pharmacotherapy 7(3-4), 129-142.

Komal S., Ranjan B., Neelam C., Birendra S., Kumar S.N., 2011. *Berberis aristata*: A review. International Journal of Research in Ayurveda and Pharmacy 2(2), 383-388.

Mandal B.B., 1999. Conservation Biotechnology of endemic and other economically important plant species of India. Plant Conservation Biotechnology, CRC Press, pp. 237-252.

Mishra A.P., Kumar A., Yadav S., 2023. Ecology and conservation of threatened medicinal plants in the Trans-Himalayan region of Nanda Devi Biosphere Reserve, Western Himalaya. Trees, Forests and People 14, 100451. https://doi.org/10.1016/j.tfp.2023.100451.

Mitra P.K., Mitra P., Das A.P., Ghosh C., Sarkar A., Chowdhury D., 2010. Screening the efficacy of some East Himalayan medicinal plants on ethanol induced gastric ulcer in Albino rats. Pleione 4(1), 69-75.

Mukherjee D., 2009. Current status, distribution and ethno-medicinal values of medicinal plant in hilly regions of Darjeeling district of West Bengal. Journal of Crop and Weed 5(1), 316-320.

Mukherjee P.K., Wahile A., 2006. Integrated approaches towards drug development from Ayurveda and other Indian system of medicines. Journal of ethnopharmacology 103(1), 25-35.

Mukherjee S., Dugad S., Bhandare R., Pawar N., Jagtap S., Pawar P.K., Kulkarni O., 2011. Evaluation of comparative free-radical quenching potential of Brahmi (*Bacopa monnieri*) and Mandookparni (*Centella asiatica*). Ayu (An international quarterly journal of research in Ayurveda) 32(2), 258-264.

Murch S.J., Krishnaraj S., Saxena P.K., 2000. Phyto-Pharmaceuticals: Massproduction, Standardization, and Conservation. Herbal Medicine 4(2), 39-43.

Nadda R.K., Ali A., Goyal R.C., Khosla P.K., Goyal R., 2020. Aucklandia costus (syn. Saussurea costus): Ethnopharmacology of an endangered medicinal plant of the Himalayan region. Journal of Ethnopharmacology 263, 113199.

Negash A, Krens F., Schaart J., Visser B., 2001. *In vitro* conservation of enset under slow-growth conditions. Plant Cell, Tissue And Organ Culture 66, 107-111.

Negi J.S., Bisht V.K., Bhandari A.K., Bisht D.S., Singh P., Singh N., 2014. Quantification of reserpine content and antibacterial activity of Rauvolfia serpentina (L.) Benth. ex Kurz. African Journal of Microbiology Research 8(2), 162-166.

Pandey H., Nandi S.K., Nadeem M, Palni L.S.M., 2000. Chemical stimulation of seed germination in Aconitum heterophyllum Wall. and A. Balfourii Stapf.: important Himalayan species of medicinal value. Seed Science and

Technology (Switzerland) 28(1), 39-48.

Pandey M., Dhar U., Sher Singh S., Mrudul Vijay S., Shubhada Ratnakar T., 2011. Recurrent somatic embryogenesis and plant regeneration in Angelica glauca Edgew., a critically endangered medicinal plant of the Western Himalaya. The Journal of Horticultural Science and Biotechnology 86(5), 493-498.

Patil D.P., Urunkar N., Patil S.S., 2019. Tomorrow - Ayurveda in a Daily Routine. Paripex-Indian Journal of Research 8(11), 111.

Phani Kumar G., Kumar R., Chaurasia O.P., Singh S.B., 2011. Current status and potential prospects of medicinal plant sector in trans-Himalayan Ladakh. Journal of Medicinal Plants Research 5(14), 2929-2940.

Phartyal S.S., Thapliyal R.C., Koedam N., Godefroid S., 2002. *Ex situ* conservation of rare and valuable forest tree species through seed- gene bank. Current Science 1351-1357.

Pl@ntNet regional floras are based on WCVP. Govaerts R (ed.). 2022. The World Checklist of Vascular Plants (WCVP). Royal Botanic Gardens, Kew. [Accessed May 16, 2024].

Prakash D., Upadhyay G., Singh B.N., Dhakarey R., Kumar S, Singh K.K. 2007. Free-radical scavenging activities of Himalayan rhododendrons. Current Science 526-532.

Rahman H., Shaik H.A., Madhavi P., Eswaraiah M.C., 2011. A review: pharmacognostics and pharmacological profiles of *Nardastachys jatamansi* DC. Elixir pharmacy 39, 5017-5020.

Raina R., Chauhan R., Naithani R., 2011. A Note on the Floral Morphology of *Aconitum heterophyllum* Wall. (Ranunculaceae)-An Important Temperate Medicinal Plant. Open Access Journal of Medicinal and Aromatic Plants 2(2), 1-4.

Rakhi R., Vashistha D.P., 2011. Shortlisting of cultivable herbal plants in the Bhabhar region of the Garhwal Himalaya, Uttarakhand, India. International Journal of Medicinal and Aromatic Plants 1(1), 23-27.

Rands M.R.W., Adams W.M., Bennun L., Butchart S.H., Clements A., Coomes D., et al. 2010. Biodiversity conservation: challenges beyond 2010. Science 329(5997),1298-1303.

Rasool S., Maqbool M., 2019. An overview about *Hedychium spicatum*: a review. Journal of Drug Delivery and Therapeutics 9(1-s), 476-480.

Rawat S., Bhatt I.D., Rawal R.S., 2011. Total phenolic compounds and antioxidant potential of *Hedychium spicatum* Buch. Ham. ex D. Don in west Himalaya, India. Journal of Food Composition and Analysis 24(4-5), 574-579.

Ray R., Gururaja K.V., Ramchandra T.V., 2011. Predictive distribution modeling for rare Himalayan medicinal plant *Berberis aristata* DC. Journal of Environmental Biology 32(6), 725.

Roy, A.C., Prasad, A., Priya, K., Das, P., Singh, S., Ghosh, C., & Ghosh, I. (2023). Anticancer effect of antioxidant-rich methanolic extract of Rauvolfia serpentina (L.) Benth. ex Kurz leaves in HepG2 and HeLa cells: A mechanistic insight. Biocatalysis and Agricultural Biotechnology, 50, 102674.

Samant Pant S., Singh M., Lal M., Singh A., Sharma A., Bhandari S., 2007. Medicinal plants in Himachal Pradesh, north western Himalaya, India. The International Journal of Biodiversity Science and Management 3(4), 234-251.

Sanjappa M., 2005. Plant diversity in India-status, conservation and challenges (P. Maheshwari Medal Award Lecture). In XXVIII Conference of Indian Botanical Society, BSI 24(26), 5-6.

Sarasan V., Cripps R., Ramsay M.M., 2006. Conservation *in vitro* of threatened plants-Progress in the past decade. In Vitro Cellular & Developmental Biology - Plant 42(3), 206-214.

Schippmann U., Leaman D.J., Cunningham A.B.A., 2002. Impact of Cultivation and Gathering of medicinal plants on Biodiversity: Global Trends and Issues. *In:* Biodiversity and the Ecosystem Approach in Agriculture, Forestry and Fisheries, FAO pp. 1-21.

Schippmann U., Leaman D.J., Cunningham A.B.A., 2006. A comparison of cultivation and wild collection of medicinal and aromatic plants under sustainability aspects. In: Bogers R.J., Craker L.E., Lange D. editors. Medicinal and Aromatic Plants pp. 75-95.

Sekar K.C., Srivastava S.K., 2010. Rhododendrons in Indian Himalayan region: diversity and conservation. American Journal of Plant Sciences 1(02), 131.

Shahid M., Rahim T., Shahzad A., Latif T.A., Fatma T., Rashid M. et al., 2009. Ethnobotanical studies on *Berberis aristata* DC. root extracts. African Journal of Biotechnology 8(4).

Sharma A.K., Sharma A.K., Sharma M., Sharma M., 2022. Assessment of Land Use Change and Climate Change Impact on Biodiversity and Environment. In: Bahukhandi K.D., Kamboj N., Kamboj V. (eds) Environmental Pollution and Natural Resource Management, pp. 73-89. Cham: Springer

International Publishing. https://doi.org/10.1007/978-3-031-05335-1_5.

Sharma A.K., Sharma M., Sharma A.K., Sharma M., Sharma M., 2023. Mapping the impact of environmental pollutants on human health and environment: A systematic review and meta-analysis. Journal of Geochemical Exploration 255, 107325. https://doi.org/10.1016/j.gexplo.2023.107325.

Sharma H., Garg M., 2015. A review of traditional use, phytoconstituents and biological activities of Himalayan yew, Taxus wallichiana. Journal of integrative medicine 13(2), 80-90.

Sharma J., Gairola S., Gaur R.D., Painuli R.M., Siddiqi T.O., 2013. Ethnomedicinal plants used for treating epilepsyby indigenous communities of sub-Himalayan region of Uttarakhand, India Journal of Ethnopharmacology 150(1), 353-370.

Sharma M., Sharma A.K., Thakur R., Sharma M., 2020. Dynamics of traditional information of medicinal plants from hilly terrains of Ramban (J&K) India. Indian Journal of Ecology 47(4), 1009-1013.

Sharma M., Sharma A.K., Sharma M., 2021. Ethno-Botanical Study of Medicinal Plants from Unexplored Area of District Ramban (J&K) India. Indian Journal of Agricultural Research 55(6), 702. doi:10.18805/IJARe.A-5561.

Sharma M., Sharma M., Sharma M., 2022. A comprehensive review on ethnobotanical, medicinal and nutritional potential of walnut (Juglans regia L.). Proceedings of the Indian National Science Academy. Part a, Physical Sciences, 88(4), 601–616. https://doi.org/10.1007/s43538-022-00119-9.

Sharma M., Sharma M., Sharma M., 2024. Assessment of Variability and Genetic Factors among High Heritable Traits of Juglans regia (Walnut) from North Western Himalayan Regions. Agricultural Research. https://doi.org/10.1007/s40003-024-00697-8

Sharma M., Thakur R. 2020. ADVANCED BIOTECHNOLOGY TECHNIQUES USED IN CONSERVATION OF THREATENED MEDICINAL AND AROMATIC PLANTS. Plant Science 2(296), 737-740.

Sharma M., Thakur R., Sharma, M., 2020. Ethnomedicinal, phytochemical and pharmacological properties of Crocus sativus (saffron). The Journal of Indian Botanical Society, 99(3-4), 115-125. https://doi.org/10.5958/2455-7218.2020.00017.0.

Sharma M., Thakur R., Sharma M., (2020). Ethno-botanical survey of medicinal plants of unexplored hilly areas of district Ramban (J&K). International Journal of Botany Studies 5(3), 55-63. https://www.botanyjournals.com/archives/2020/vol5/issue3/5-2-45.

Sharma M., Thakur R., Sharma M., Sharma A.K., Sharma A.K., 2020. Changing scenario of medicinal plants diversity in relation to climate change: a review. Plant Archives 20(2), 4389-4400.

Sharma S., Thokchom R., 2014. A review on endangered medicinal plants of India and their conservation. Journal of Crop and Weed 10(2), 205-218.

Sharma M., Yangzom S., Sharma M., Sharma M., 2024. Ethnobotanical Studies of High Valued Medicinal Plants Reported from Spiti Valley in Himachal Pradesh. Biology Bulletin, 1-11. https://doi.org/10.1134/s1062359023601568.

Shibli R.A., Shatnawi M.A., Subaih W.S., Ajlouni M.M., 2006. *In vitro* conservation and cryopreservation of plant genetic resources: a review. World Journal of Agricultural Sciences 2(4), 372-382.

Singh J., Kakkar P., 2009. Antihyperglycemic and antioxidant effect of Berberis aristata root extract and its role in regulating carbohydrate metabolism in diabetic rats. Journal of ethnopharmacology, 123(1), 22-26.

Singh J.S., Singh S.P., Gupta S.R., 2006. Ecology, Environment and Resource Conservation. Anamaya Publishers, New Delhi, India.

Singh K.K., Kumar S., Rai L.K., Krishna A.P., 2003. Rhododendrons conservation in the Sikkim Himalaya. Current Science 85(5), 602-606.

Singhuber J., Zhu M., Prinz S., Kopp B., (2009) Aconitum in traditional Chinese medicine-a valuable drug or an unpredictable risk? Journal of ethnopharmacology 126(1), 18-30.

Srivastava S.K., Khatoon S., Rawat A.K.S., Mehrotra S., Pushpangadan P., 2001. Pharmacognostic Evaluation of the Root of *Berberis aristata* DC. Natural Product Sciences 7(4), 102-106.

Tali B.A., Khuroo A.A., Nawchoo I.A., Ganie A.H., 2018. Prioritizing conservation of medicinal flora in the Himalayan Biodiversity Hotspot: an Integrated ecological and socioeconomic approach. Environmental Conservation, 46(2), 147–154. https://doi.org/10.1017/s0376892918000425.

Tandon P., Kumaria S., Nongrum I., 2009. Conservation and management of plant genetic resources of Northeast India. Indian Journal of Traditional Knowledge 8(1), 29-34.

Thakur A.K., Raj P., 2017. Pharmacological perspective of *Glycyrrhiza glabra* Linn: A mini-review. J Analytical Pharmaceutical Res 5(5), 00156.

Thakur N., Sharma M., Sharma M., 2021. Phytoremediation-a green technology adapted to eradication of harmful heavy toxic metals from contaminated soil. Journal of Innovative Agriculture 8(1), 26-31. https://doi.org/10.37446/jinagri/ra/8.1.2021.26-31.

Thakur R., Sharma M., Sharma M., Sharma A.K., 2020. Biodiversity Status of Major Medicinal and Aromatic Plants (MAPs) in J&K, India. In: Traditional Medicinal Plants, AkiNik Publications 81-112. https://doi.org/10.22271/ed.book.911.

Tiwari O.N., Chauhan U.K., 2006. Rhododendron conservation in Sikkim Himalaya. Current Science, 90(4), 532-541.

Tripathi M., 2008. Tissue culture technology and transgenic biology-A boon or bane? Current Science (00113891) 94(1), 7-8.

Wakdikar S., 2004. Global health care challenge: Indian experiences and new prescriptions. Electronic Journal of Biotechnology 7(3), 02-03.

Yadav K.D., Reddy K.R., Agarwal A., 2013. Preliminary physico-chemical profile of *Brahmi Ghrita*. AYU (An international quarterly journal of research in Ayurveda) 34(3), 294-296.

Yadav K.D., Reddy K.R.C., Kumar V., 2013. Encouraging effect of *Brahmi Ghrita* in amnesia. International Journal of Green Pharmacy (IJGP) 7(2).