

Conservation Assessment of Potential Aromatic and Medicinal Flora in the Khajjiar Valley, Chamba District, Himachal Pradesh, Northwestern Himalaya, India

Aromatic and Medicinal Flora in the Khajjiar Valley, Chamba District, Himachal Pradesh
Subtitle as needed

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Abstract—The Khajjiar Valley, located in the Chamba district of Himachal Pradesh within the Northwestern Himalayan region, represents a biologically rich landscape characterized by diverse ecological niches and a wide array of plant species with medicinal and aromatic significance. The present study aims to assess the conservation status, distribution patterns, and ecological importance of selected aromatic and medicinal plant species in this region. Field surveys were conducted across different habitats and altitudinal gradients to document species diversity, abundance, and ethnobotanical relevance. The study identified several high-value species, including both endemic and threatened taxa, which are increasingly subjected to anthropogenic pressures such as overharvesting, habitat degradation, and unregulated tourism. Conservation status was evaluated using standard criteria, highlighting species that require immediate conservation attention. The findings emphasize the need for sustainable utilization practices, habitat protection, and community-based conservation strategies to preserve these valuable bioresources. This assessment provides a scientific baseline for future conservation planning and policy formulation aimed at safeguarding the aromatic and medicinal plant diversity of the Khajjiar Valley and similar fragile Himalayan ecosystems.

Keywords—Aromatic plants; Conservation assessment; Ethnobotany; Medicinal flora; Northwestern Himalaya

I. INTRODUCTION (*Heading 1*)

The Himalayan region is globally recognized as one of the most significant biodiversity hotspots, harboring a remarkable diversity of flora with high ecological, medicinal, and economic value (Convention on Biological Diversity, 2020; World Wildlife Fund, 2019). Within this vast mountain system, the northwestern Himalaya, particularly Himachal Pradesh, supports a rich assemblage of aromatic and medicinal plant species that have been traditionally utilized in indigenous healthcare systems and local livelihoods (Singh and Rawat, 2011; Kala et al., 2006). The Khajjiar Valley in Chamba district represents a unique ecological niche characterized by moist temperate forests, grasslands, and wetland ecosystems, which together provide favorable conditions for the growth of diverse plant taxa with therapeutic and aromatic properties.

Medicinal and aromatic plants (MAPs) play a crucial role in primary healthcare, especially in rural and tribal communities, where traditional knowledge systems remain integral to disease management (World Health Organization, 2013; Sharma et al., 2017). Globally, approximately 80% of the population relies, at least partially, on plant-based medicines, underscoring the socio-economic importance of these biological resources (WHO, 2013). In India, the traditional systems such as Ayurveda, Unani, and Siddha extensively utilize plant-derived compounds, many of which originate from Himalayan biodiversity (Pandey and Tripathi, 2017). The Khajjiar Valley, often referred to as the “Mini Switzerland of India,” is not only a tourist destination but also an underexplored repository of medicinal and aromatic flora. Despite their ecological and economic significance, MAPs are increasingly threatened due to overexploitation, habitat fragmentation, climate change, and unregulated tourism activities (Kala, 2005; Negi et al., 2018). Unsustainable harvesting practices, particularly of roots, rhizomes, and whole plants, have led to the decline of several high-value species (Nautiyal et al., 2002). Additionally, land-use changes and developmental pressures in Himalayan regions further exacerbate the vulnerability of these plant populations (Xu et al., 2009). Conservation of MAPs is therefore essential not only for maintaining ecological balance but also for preserving traditional knowledge and ensuring sustainable livelihoods. The conservation assessment of medicinal and aromatic flora involves evaluating species diversity, distribution, abundance, and threat status using standardized frameworks such as those proposed by the International Union for Conservation of Nature (IUCN, 2022). Such assessments provide critical insights into species at risk and help prioritize conservation actions. In the Indian Himalayan context, several studies have emphasized the need for region-specific conservation

strategies, including in situ and ex situ conservation, cultivation practices, and community participation (Samant et al., 1998; Dhar et al., 2000).

Ethnobotanical knowledge associated with MAPs constitutes an invaluable cultural heritage that has been transmitted across generations (Uniyal et al., 2006). However, this knowledge is rapidly eroding due to socio-economic transformations and changing lifestyles. Documenting and integrating traditional knowledge with scientific research is therefore essential for holistic conservation planning (Joshi and Edington, 1990). Furthermore, ethical considerations such as prior informed consent, benefit-sharing, and respect for indigenous intellectual property rights are critical in ethnobotanical research (CBD, 2020). Recent advancements in conservation biology emphasize participatory approaches that involve local communities in resource management and decision-making processes (Berkes, 2009). Community-based conservation models have shown promising outcomes in preserving biodiversity while supporting local economies (Pretty and Smith, 2004). In the context of Khajjiar Valley, integrating traditional ecological knowledge with modern conservation strategies can enhance the effectiveness of biodiversity management initiatives. Given the ecological fragility of Himalayan ecosystems and the increasing anthropogenic pressures, there is an urgent need to conduct systematic assessments of aromatic and medicinal plant diversity in lesser-explored regions such as Khajjiar Valley. Such studies not only contribute to biodiversity documentation but also provide a scientific basis for conservation prioritization and sustainable utilization. Therefore, the present study aims to assess the conservation status, ecological distribution, and ethnobotanical significance of selected medicinal and aromatic plant species in the Khajjiar Valley of Chamba district, Himachal Pradesh.

II. METHODOLOGY

A. Study Area Description

The present study was conducted in the Khajjiar Valley located in the Chamba district of Himachal Pradesh, India, within the northwestern Himalayan biogeographic zone. The area lies at an approximate altitude of 1,900–2,000 m above sea level and is characterized by moist temperate forests, grasslands, and wetland ecosystems. The climatic conditions include cold winters and mild summers, supporting a rich diversity of aromatic and medicinal plant species (Singh and Rawat, 2011; Kumar and Chopra, 2012).

B. Research Design and Ethical Considerations

A descriptive and exploratory research design was adopted to document, assess, and analyze the conservation status of aromatic and medicinal flora. Ethical guidelines were strictly followed during ethnobotanical data collection, including obtaining prior informed consent from local informants and ensuring confidentiality and fair representation of indigenous knowledge. The study adhered to principles outlined by the Convention on Biological Diversity (CBD, 2020), emphasizing access and benefit-sharing and respect for traditional knowledge systems (Berkes, 2009).

C. Field Survey and Sampling Strategy

Field surveys were conducted during different seasons (spring, summer, and autumn) to capture maximum floristic diversity. A stratified random sampling approach was employed across different habitats such as forest patches, grasslands, and wetland margins. Quadrat sampling methods were used for vegetation analysis, with quadrat sizes of 1×1 m for herbs, 5×5 m for shrubs, and 10×10 m for trees (Mueller-Dombois and Ellenberg, 1974). Transect walks and opportunistic sampling were also conducted to record rare and scattered species. The abundance and frequency of species were recorded to determine their ecological status (Curtis and McIntosh, 1950).

D. Plant Collection and Identification

Plant specimens were collected following standard herbarium techniques, including pressing, drying, and mounting (Jain and Rao, 1977). Identification was carried out using regional floras and taxonomic keys, and authenticated by consulting herbarium records and botanical experts. Nomenclature was standardized according to current taxonomic databases to ensure accuracy (The Plant List, 2013).

E. Ethnobotanical Data Collection

Ethnobotanical information regarding medicinal and aromatic uses of plants was collected through semi-structured interviews, questionnaires, and group discussions with local inhabitants, including traditional healers. Data included local names, plant parts used, preparation methods, and therapeutic applications. Standard ethnobotanical methods were followed to ensure reliability and validity (Martin, 2004; Uniyal et al., 2006).

F. Conservation Status Assessment

The conservation status of recorded species was evaluated using criteria provided by the International Union for Conservation of Nature Red List Categories and Criteria (IUCN, 2022). Species were categorized into Critically Endangered (CR), Endangered (EN), Vulnerable (VU), and Least Concern (LC) based on parameters such as population size, distribution range, and degree of threat. Additionally, local threat factors such as overharvesting, grazing pressure, habitat degradation, and tourism activities were documented through field observations and community interactions (Kala, 2005; Dhar et al., 2000). Quantitative analysis of

vegetation data was carried out using standard ecological indices, including frequency, density, and abundance (Curtis and McIntosh, 1950). Species diversity was assessed using indices such as Shannon–Wiener diversity index and Simpson’s dominance index to understand species distribution patterns (Magurran, 2004). Ethnobotanical data were analyzed qualitatively to identify commonly used species and their relative importance. The results were presented using tables, graphs, and charts to illustrate species diversity, family dominance, and conservation status distribution.

III. RESULTS AND DISCUSSION

Species Composition and Taxonomic Representation: The present study recorded 15 aromatic and medicinal plant species belonging to 13 genera and 11 families in the Khajjiar Valley. The taxonomic distribution indicates moderate diversity, with families such as Asteraceae, Lamiaceae, and Caprifoliaceae represented by multiple species, while others were represented by single taxa. The predominance of these families is consistent with Himalayan floristic patterns, where they exhibit high ecological amplitude and adaptability (Samant et al., 1998; Kala et al., 2006). The presence of economically important taxa such as *Nardostachys jatamansi*, *Saussurea costus*, and *Picrorhiza kurroa* highlights the phytotherapeutic significance of the region.

Habit and Utilization Pattern: The life-form analysis revealed that herbaceous species dominate (80%), followed by shrubs and a single tree species (*Taxus wallichiana*). This dominance reflects the temperate climatic conditions and shorter growing cycles typical of Himalayan ecosystems (Singh and Rawat, 2011). In terms of utilization, roots and rhizomes were the most commonly used plant parts, followed by leaves and whole plants. Species such as *Aconitum heterophyllum*, *Dactylorhiza hatagirea*, and *Rheum emodi* are primarily harvested for underground parts, which poses a significant threat to their regeneration capacity. Similar extraction patterns have been reported across the Indian Himalaya (Nautiyal et al., 2002).

Conservation Status Analysis: The conservation assessment based on International Union for Conservation of Nature categories revealed a high proportion of threatened species Viz; Critically Endangered (CR): 3 species (20%); Endangered (EN): 6 species (40%); Vulnerable (VU): 2 species (13.3%) and Least Concern (LC): 4 species (26.7%). Thus, 60% of the recorded species fall under threatened categories (CR + EN), indicating significant conservation concern in the study area. Critically Endangered species such as *Nardostachys jatamansi*, *Saussurea costus*, and *Swertia chirayita* are under severe pressure due to commercial exploitation and illegal trade. Similarly, Endangered species like *Aconitum heterophyllum* and *Picrorhiza kurroa* are experiencing rapid population decline due to overharvesting and habitat degradation. These findings align with earlier reports highlighting the vulnerability of Himalayan medicinal plants (Kala, 2005; Dhar et al., 2000).

Threat Factors and Anthropogenic Pressures: Field observations and analysis indicate that overexploitation for medicinal and commercial purposes is the primary threat to most species. The extraction of roots and rhizomes, particularly in species such as *Podophyllum hexandrum* and *Angelica glauca*, leads to direct mortality and limits natural regeneration.

Additional threats include habitat degradation due to grazing and tourism activities, deforestation and land-use change and Climate variability, affecting species distribution and phenology. Such pressures are widely reported in Himalayan ecosystems and contribute significantly to biodiversity loss (Negi et al., 2018; Xu et al., 2009).

Ecological and Conservation Implications: The high proportion of threatened species suggests that the Khajjiar Valley is a sensitive ecological zone requiring urgent conservation attention. Species categorized under Least Concern, such as *Mentha longifolia* and *Origanum vulgare*, may serve as potential candidates for sustainable utilization and domestication, thereby reducing harvesting pressure on threatened taxa.

The presence of rare and high-value medicinal plants indicates the need for habitat-specific conservation strategies, including protection of natural habitats (in situ conservation), promotion of cultivation and agroforestry practices (ex situ conservation) and Regulation of harvesting and trade. Community involvement is crucial for the success of conservation programs, as local populations are primary stakeholders and knowledge holders (Berkes, 2009). Integrating traditional knowledge with scientific management can enhance conservation efficiency and sustainability.

Synthesis: Overall, the results demonstrate that while Khajjiar Valley supports valuable aromatic and medicinal plant diversity, it is simultaneously facing significant conservation challenges. The dominance of threatened species, coupled with unsustainable utilization patterns, underscores the need for immediate and integrated conservation measures. Before you begin to format your paper, first write and save the content as a separate text file. Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph. Do not add any kind of pagination anywhere in the paper. Do not number text heads-the template will do that for you (Table 1).

Table 1: IUCN Conservation Status of Selected Aromatic and Medicinal Plants of Khajjiar Valley
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Scientific Name	Family	Local Name	IUCN Category*	Threats
<i>Aconitum heterophyllum</i>	Ranunculaceae	Atis	Endangered (EN)	Overharvesting, habitat loss
<i>Picrorhiza kurroa</i>	Plantaginaceae	Kutki	Endangered (EN)	Unsustainable extraction

<i>Nardostachys jatamansi</i>	Caprifoliaceae	Jatamansi	Critically Endangered (CR)	Illegal trade, overexploitation
<i>Saussurea costus</i>	Asteraceae	Kuth	Critically Endangered (CR)	Commercial exploitation
<i>Dactylorhiza hatagirea</i>	Orchidaceae	Salam Panja	Endangered (EN)	Overcollection, grazing
<i>Valeriana jatamansi</i>	Caprifoliaceae	Mushkbala	Vulnerable (VU)	Habitat disturbance
<i>Bergenia ciliata</i>	Saxifragaceae	Pashanbhed	Least Concern (LC)	Localized overuse
<i>Rheum emodi</i>	Polygonaceae	Revand chini	Vulnerable (VU)	Overharvesting
<i>Taxus wallichiana</i>	Taxaceae	Himalayan Yew	Endangered (EN)	Logging, medicinal extraction
<i>Swertia chirayita</i>	Gentianaceae	Chirayata	Critically Endangered (CR)	Excessive harvesting
<i>Podophyllum hexandrum</i>	Berberidaceae	Bankakri	Endangered (EN)	Overexploitation
<i>Angelica glauca</i>	Apiaceae	Chora	Endangered (EN)	Habitat degradation
<i>Artemisia maritima</i>	Asteraceae	Tethwan	Least Concern (LC)	Moderate grazing pressure
<i>Origanum vulgare</i>	Lamiaceae	Ban Tulsi	Least Concern (LC)	Sustainable use
<i>Mentha longifolia</i>	Lamiaceae	Wild Mint	Least Concern (LC)	Minimal threat

Table 2: Category-wise Distribution

IUCN Category	Number of Species	Percentage (%)
Critically Endangered (CR)	3	20%
Endangered (EN)	6	40%
Vulnerable (VU)	2	13.3%
Least Concern (LC)	4	26.7%

The table 2 indicates a high proportion of threatened species (CR + EN = 60%), highlighting significant conservation concerns in the Khajjiar Valley. Species such as *Nardostachys jatamansi*, *Saussurea costus*, and *Swertia chirayita* require urgent conservation interventions, including habitat protection, cultivation initiatives, and regulation of trade. The presence of Vulnerable and Least Concern species suggests opportunities for sustainable utilization and domestication strategies to reduce pressure on wild populations.

CONCLUSION

The present study provides a focused conservation assessment of aromatic and medicinal flora in the Khajjiar Valley of Chamba district, Himachal Pradesh, revealing both ecological richness and pronounced vulnerability. The documentation of 15 species

across 11 families, with a strong dominance of herbaceous taxa, underscores the valley's suitability for high-value medicinal plant diversity within temperate Himalayan ecosystems. However, the conservation analysis highlights a critical concern as 60% of the recorded species fall within threatened categories (Critically Endangered and Endangered) under the criteria of the International Union for Conservation of Nature. Species such as *Nardostachys jatamansi*, *Saussurea costus*, and *Swertia chirayita* are under acute pressure due to unsustainable extraction and commercial demand, while other taxa like *Aconitum heterophyllum* and *Picrorhiza kurroa* show declining population trends linked to habitat disturbance and overharvesting. The predominance of root- and rhizome-based utilization further intensifies the risk, as such practices directly affect plant survival and regeneration.

The findings clearly indicate that Khajjiar Valley represents a fragile yet valuable phyto-diversity hotspot, where ecological stability is increasingly challenged by anthropogenic pressures, including tourism, grazing, and land-use changes. At the same time, the continued dependence of local communities on these plant resources highlights their socio-economic and cultural importance. Therefore, balancing conservation with sustainable utilization emerges as a central priority.

Therefore, the study establishes a scientific baseline for conservation planning and emphasizes the urgent need for integrated, evidence-based strategies to safeguard medicinal and aromatic plant diversity in this Himalayan landscape. Priority should be given to the protection of natural habitats supporting threatened species through the establishment of micro-reserves and conservation zones within the Khajjiar landscape. Regulation of grazing, tourism, and land-use changes is essential to maintain ecological integrity (Dhar et al., 2000). Unsustainable extraction of underground plant parts must be minimized through the development and dissemination of non-destructive harvesting techniques. Training programs for local collectors can significantly reduce pressure on wild populations (Schippmann et al., 2002). High-value and threatened species such as *Nardostachys jatamansi* and *Picrorhiza kurroa* should be prioritized for cultivation, nursery development, and germplasm conservation. Integration of these species into agroforestry systems can provide alternative income sources while conserving wild populations. Active involvement of local communities is crucial for long-term conservation success. Participatory models that integrate traditional knowledge with scientific practices should be promoted to ensure sustainable resource management (Berkes, 2009). Strict implementation of conservation policies and monitoring of medicinal plant trade are necessary to prevent illegal exploitation. Collaboration with forest departments and conservation agencies should be strengthened to enforce regulations effectively. Long-term ecological monitoring programs should be established to track population trends and assess the impacts of environmental change. Further research on species ecology, propagation techniques, and climate resilience is recommended (Negi et al., 2018). Educational and awareness campaigns should be conducted to sensitize local communities, tourists, and stakeholders about the importance of conserving medicinal plant diversity. Capacity-building initiatives can empower communities to adopt sustainable practices. A holistic conservation framework combining ecological research, community participation, sustainable utilization, and policy intervention is essential to ensure the long-term survival of aromatic and medicinal flora in Khajjiar Valley. Such an approach can serve as a model for conservation efforts across the Northwestern Himalayan regions.

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