



Ethnobotanical Insights into Medicinal Plant Use Among Gujjar and Bakarwal Communities in Pahalgam, Jammu and Kashmir: Conservation, Traditional Knowledge, and Ecological Threats

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ABSTRACT

Keywords:

Ethnobotany, Gujjar and Bakarwal, Medicinal Plants, Pahalgam, Biodiversity, Traditional Knowledge, Conservation, Asteraceae, Oral Administration, Endangered Species, Sustainable Practices, SFRI Seer Hamdaan.

The present ethnobotanical study explores the traditional knowledge of medicinal plants among the Gujjar and Bakarwal communities in the Lidderwart, Aru, and Kothpatri regions of Pahalgam, Jammu and Kashmir. A total of 60 medicinal plant species belonging to 26 botanical families were documented, with a predominant use for treating respiratory ailments, digestive issues, skin conditions, and pain relief. The Asteraceae, Solanaceae, and Lamiaceae families were found to be the most frequently used. The study highlights the oral method as the primary mode of medicinal administration, accounting for 61.67% of practices. Notably, the transmission of ethnomedicinal knowledge shows a generational and gender-based pattern, with older males predominantly serving as knowledge custodians due to their close interaction with the natural environment. The research also reveals that over half of the documented species are classified as Critically Endangered or Endangered, emphasizing the urgent need for conservation efforts. Field data from three ecological zones—Lidderwart, Aru Valley, and Kothpatri demonstrate that local biodiversity significantly supports the healthcare needs of the region. Conservation efforts, both in-situ and ex-situ, led by institutions like SFRI Seer Hamdaan, along with community-based practices, are essential for sustaining these resources. Additionally, the rising threat from tourism, habitat destruction, and climate change calls for immediate attention. This study serves as a valuable reference for integrating traditional knowledge with scientific research to enhance sustainable healthcare practices and biodiversity preservation.



1. INTRODUCTION

According to the World Health Organization (WHO), medicinal plants are plants that have therapeutic properties or produce metabolites to be used in medicine. Historically, humans have depended on nature for basic needs, including food, shelter, and medicines, among other resources (Cragg and Newman, 2005). Medicinal plants can vary depending on the area of the world and are used in many cultures (Simpson, 1995). Plants have been used as medicines for thousands of years for various crude pharmaceuticals, including tinctures, teas, poultices, powders, and other preparations of herbal origin (Balick and Cox, 1997; Samuelsson, 2004).

There has been a global upsurge of interest in plant-based or herbal medications in recent decades. According to the World Health Organization, up to 80% of the world's population uses traditional medicine for basic health care. Traditional medicine is becoming more widely used in underdeveloped nations, with 3.5 billion people relying on plant-based medicine for their main health care. This is because modern allopathic drugs have shown to be not just out of reach for the average person, but many of them also have recognized negative effects.

As a result, herbal remedies are gaining in popularity even in developed countries healthcare practices of human societies have depended on medicinal plants for several centuries for their healing purposes. The World Health Organization [WHO] (2003) defines them as plant species that maintain bioactive compounds for medical therapy or medication synthesis. Ayurveda and Traditional Chinese Medicine (TCM) along with African traditional medicine depend on plant usage because of their cultural roots and historical heritage (Ekor, 2014). In contemporary pharmacology, medicinal plants retain their central functions since plant-based compounds form the origin of around 25% of all prescription drugs worldwide (Newman & Cragg, 2020).

The worldwide interest in medicinal plants stems from their power to handle healthcare challenges specifically within countries that have restricted access to conventional medical systems (WHO, 2019). The increasing demand for plant-derived medical therapies in industrially developed areas strengthens the healthcare systems' transition toward holistic treatments (Chen et al., 2016). The combined global interest confirms the necessity to study medicinal plants through their therapeutic worth together with their economic value assessment.

Bioactive compounds consisting of alkaloids along with flavonoids tannins and terpenoids contribute to the medicinal functions of plants according to Kumar and Pandey (2013). Gupta et al. (2017) demonstrated that these compounds show a range of pharmacological activities from anti-inflammatory to antimicrobial and antioxidant capabilities to cancer-fighting effects. Scientific testing of traditional knowledge combined with pharmacological analysis and clinical evaluation strongly establishes the therapeutic value of medicinal plants for contemporary medicine.

India maintains its reputation as "the land of medicinal plants" because of its extended tradition of using plants as therapeutic agents. Diverse climatic zones and ecological environments throughout India have transformed the nation into a major worldwide center for medicinal plant distribution. The ancient



medical traditions of Ayurveda alongside Siddha and Unani and Yoga steadily employ these plants as their primary foundation (Mukherjee & Wahile, 2006). Traditional Ayurvedic references from the Charaka Samhita and Sushruta Samhita along with the Atharva Veda describe medicinal plant treatments for various conditions (Patwardhan et al., 2005).

More than 8000 species comprising native medicinal plants identify India as their habitat (Kala, 2005). Traditional medicine depends on these plants while they support both rural population sustainability and pharmaceutical developments. The therapeutic properties of four prominent medicinal plants found in India including *Withania somnifera* (Ashwagandha) *Azadirachta indica* (Neem) *Curcuma longa* (Turmeric) and *Rauwolfia serpentina* (Sarpagandha) are extensively employed in traditional and contemporary medicines (Singh et al., 2010). The biological components of curcumin found in turmeric make this plant highly recognized throughout the world as an anti-inflammatory and antioxidant (Gupta et al., 2017).

India's medical plant industry maintains vital cultural worth simultaneously with massive economic value. The Indian market for herbal medicine continues to grow quickly because people seek natural medical treatments at home and worldwide. Organization data shows that India leads the world in herbal product production and export due to rising global interest in natural plant-based remedies (Ministry of AYUSH 2021).

The Indian sustainable management and protection of medicinal plants navigate through multiple obstacles today. Plants continue to decline because of human-caused activities including overharvesting along with deforestation and urbanization and changes caused by climate change (Kala, 2005). The uncontrolled medicinal plant market has triggered worries about product quality control alongside authenticity together with user safety (Ekor, 2014). Foundation programs including the National Medicinal Plants Board (NMPB) and the Medicinal Plants Conservation Areas (MPCAs) serve the Indian government to advance medicinal plant sustainable harvesting techniques and cultivation practices along with conservation efforts (Ministry of AYUSH, 2021). Jammu and Kashmir maintain worldwide recognition for their extensive biodiversity together with medicinal plant abundance in their northern Indian territory. Jammu and Kashmir benefit from broad climatic zones spanning from Jammu's subtropical climate to Kashmir and Ladakh's alpine zone which together make the perfect environment to grow multiple medicinal plant species (Kumar & Bhau, 2016). Independent healthcare systems such as Unani Ayurveda and Amchi medicine keep these traditional plants fundamental to heal the local population whose cultural roots incorporate them into socio-economic practices (Rather et al., 2016). Over 500 endemic medicinal plant species thrive in the Himalayan sections of Jammu and Kashmir according to Dar et al. (2017). Leading medical plants from this region include *Picrorhiza kurroa* (Kutki), *Saussurea costus* (Kuth), *Podophyllum hexandrum* (Indian Podophyllum), and *Artemisia absinthium* (Wormwood). The medicinal plants achieved widespread acceptance because their pharmacological properties demonstrate capabilities as anti-inflammatory drugs while also demonstrating antimicrobial functionality anticancer potency and hepatoprotective benefits (Shinwari et al., 2011). The plant substance *Podophyllum hexandrum* produces podophyllotoxin which later serves as a precursor for anticancer drugs and *Saussurea costus* assists in traditional medicine to treat both respiratory conditions and skin diseases (Dar et al., 2017).



In Jammu and Kashmir, medicinal plants perform a vital function to sustain the livelihoods of rural and tribal societies. Traditional knowledge enables community members to harvest and process plants into healthcare products and elements for economic profit (Kumar & Bhau, 2016). The cultural export of medicinal plants from the area makes a major financial contribution to the regional economy of the territory. Concerns about sustaining vital resources exist because unsustainable harvesting practices combine with habitat destruction alongside overexploitation of selected species (Sharma et al., 2021).

Numerous programs supporting the sustainable cultivation and conservation of medicinal plants throughout Jammu and Kashmir emerged when the National Medicinal Plants Board (NMPB) teamed up with the regional government. The establishment of Medicinal Plant Conservation Areas along with controlled cultivation projects represents two initiatives to confront biodiversity reduction and resource scarcity (Sharma et al., 2021).

The Kashmir region has relied on therapeutic plants as major cultural elements for medical care and economic foundation since the beginning of centuries. The Kashmir Valley shows remarkable biological diversity together with climate diversity while holding essential plant species for medical use. Scientists have strongly investigated the region's botanical assets to identify their medicinal characteristics while sustaining regional healing practices such as Ayurveda and Unani through their reliance on place-based medicinal plants. Pahalgam in the Anantnag district holds a unique position as the main center for pharmaceutical plant cultivation and native growth.

Pahalgam's weather conditions together with its deep soils and different elevations generate ideal circumstances that support diverse medicinal plant species. For medicinal purposes, the notable species of *Picrorhiza kurroa* (Kutki), *Rheum emodi* (Indian rhubarb), *Trillium govanianum* (Kashmir lily), and *Nardostachys jatamansi* (Spikenard) are found throughout Pahalgam's region. The pharmacological characteristics of these plants attract growing interest from national and international markets and local healing practitioners use them extensively.

Although valuably economic and employed in medicine and preserving culture these vital plants encounter numerous dangers that risk their survival as well as their sustainable development. Both natural and human-generated causes threaten medicinal plants in Kashmir's Pahalgam region while causing substantial depletions of their representation across the territory. Medicinal plants in the Pahalgam region face elevated threats because of climate change along with habitat destruction overharvesting and pollution and invasive species introduction. These numerous threats generate an accumulated impact toward endangering regional biodiversity as well as the basic sustenance of the resident population who depend on plant resources for medicines and financial security in addition to cultural practices.

1.1 Rationale of Undertaking the Present Research

The survival of medicinal plants in Kashmir suffers from increasing detrimental anthropogenic impacts including the combination of overgrazing pressure with deforestation rates and effects of climate change. The value of these important plants faces additional threats from growing urban settlements as



well as increasing commercial needs that use these plants for medical treatment and decoration. A specific research initiative examines the medicinal plant species' structure and environmental importance together with their conservation status throughout Kashmir to support ecological preservation approaches.

- a) **Ecological Significance of Medicinal Plants in Kashmir** Due to its diverse geographical landscape which incorporates temperate and alpine zones Kashmir has numerous microhabitats that maintain a wide range of medicinal plant species. Darkharmanduk's ecological balance becomes maintained while its soil fertility increases and its plants support pollinators because these plants function as ecosystem essential components as described by Bisht et al. (2021). The unique climate structures along with the topographic features of Kashmir allow different medicinal species to thrive throughout separate wetland, forest, and alpine environmental zones (Iqbal & Sharma, 2014). Scanty studies have revealed multiple exclusive medicinal plants within the Kashmir area while demonstrating its critical role in world biodiversity preservation (Panday et al., 2013).
- b) The research field focused on medicinal plants of Kashmir lacks specific ecological studies, especially regarding their contributions to ecosystem services. The purpose of this research involves discovering and examining the geographical distribution patterns of these plants across Kashmir's different ecological environments alongside a study of their ecosystem functions and evaluation of their population and diversity patterns in response to environmental variations. Examining the natural habitat relationships between these species will produce essential insights into their ecological significance according to this study.
- c) **Importance of Medicinal Plants in Kashmir** the historical traditions of Kashmir hold its plants both culturally and medicinally significant. Traditional medical knowledge about medicinal plants used to treat digestive and skin conditions and respiratory problems has survived through family connections (Zargar et al., 2013). Ayurvedic and Unani practices as a whole incorporate Kashmiri herbal medicine which uses many plant species as main therapeutic agents (Rana et al., 2020). The native residents of the region heavily depend on these plants to maintain their survival because medicinal plants function as their primary defense system against illness.
- d) The pharmaceutical industry has identified medicinal plant species from Kashmir for broader applications in research. Research has proven that three important Kashmiri plants including *Arnebia benthamii* *Corydalis govaniana* and *Gentiana kurroo* demonstrate potential for creating new pharmaceutical materials (Dhar et al., 2016). The growing international interest in natural products calls for both local health system protection and bioactive compound research into the biotechnological applications of these plants. The excessive harvesting of these plants endangers them because there are insufficient regulations combined with insufficient sustainable management strategies (Koul et al., 2020).



- e) Conservation Challenges in Kashmir Medical plants in Kashmir experience numerous threats that endanger their preservation rates. Habitat fragmentation along with degradation mainly affects the lower elevation areas of the region because of agriculture expansion, illegal logging, and urbanization activities (Chaudhary et al., 2016). The high-altitude flora of the region experiences substantial damage from climate change because modified rainfall behavior combines with growing temperatures that disrupt medicinal plant growth patterns (Goswami et al., 2017). The continuing commercial and domestic demands on high-demand species have caused several plant populations to decrease thus raising doubts about their sustainable future (Mir et al., 2018).
- f) The Jammu & Kashmir Forest Department (2019) documented that ecological protection initiatives for medicinal plants were implemented insufficiently because policymakers have not developed proper coordination with communities nor established sufficient awareness programs. The exploitation of these plants for both domestic and international commercial purposes has grown stronger during recent years which compounds conservation difficulties for the practitioners.
- g) The research lacks sufficient ecological integration because researchers need to pursue scientific inquiry that bridges ecological conservation methods. The numerous medicinal plants of Kashmir exist without comprehensive research that combines ecology with cultural aspects and conservation methods. Some research exists to explore the pharmacological properties of particular species (Dhar et al., 2002), but detailed ecological studies about their roles in ecosystems their responses to environmental changes, and their exploitation reasons continue to be limited. The majority of Kashmir's medicinal plant research studies identify single plant species and their particular applications while neglecting the ecological systems and diversity of plants that require conservation of environmental changes (Panday et al., 2013).

The research intends to address this gap through a systemic ecological investigation of medicinal plants in Kashmir regarding their diversity and distribution with conservation assessments. Furthermore, this research investigates the complex relationship between environmental factors along economic aspects regarding medicinal plant conservation while providing sustainable solutions to protect plant species against mounting ecological and market demands. Throughout human history, medicinal plants have occupied an essential place in cultural practices since they serve essential functions in traditional and contemporary medical treatments. As per ethnobotany plants stand out as essential treatments because they constitute vital components of numerous pharmacopeias (Schippmann et al., 2006). Researchers conduct this investigation because it responds to the urgent requirement to examine medicinal plants both ecologically and for their ecosystem function and healthcare value while documenting their conservation concerns.

2. LITERATURE REVIEW

A literature review functions as a vital component for all scientific projects. The document contains theoretical elements as well as previously conducted work together with fundamental information about the study outcome. The research analyzed available literature which directly supported the investigative



studies. Ethnobotanical research serves as a critical method for tribal communities in India to document traditional healthcare knowledge which leads to business development and regulatory approval of indigenous remedies thus expanding medical services while creating sustainable income opportunities to assist local populations cope with financial obstacles (Khan et al.,2024).

Local populations in the Kashmir Himalayas including Pahalgam used 72 medicinal plants as per the documented records. The leaves of Asteraceae as well as Lamiaceae family members stood out as the most commonly used plant parts for treating gastrointestinal and dermatological and musculoskeletal ailments. (Khoja et al.,2024) The rising trend of health and wellness-related consumption of medicinal plants has triggered overharvesting activities which threatens the existence of *Trillium govianum* among other species (Tariq et al., 2024).

The research by Bano et al. (2024) demonstrates that deep knowledge about medicinal plants faces serious endangerment because of environmental deterioration and growing population and deforestation. Traditional knowledge documentation and conservation implementation have become necessary to secure valuable resources according to the authors. The deterioration of habitat and excessive harvest practices endanger the ecosystems because they target slow-growing essential plant species (Alum, 2024).

The comprehensive ethnobotanical surveys revealed more than 370 Maharashtra plant taxa according to Gupta & Wagh (2024) and Sharma et al. (2024) documented 201 medicinal species in Madhya Pradesh. The ethnobotanical documentation in Assam identified sixty plant species that highlight both the diverse biodiversity along with the traditional botanical knowledge practices of local ethnic groups according to Baruah et al. (2024). Scientists have determined *Hedychium coronarium* along with other plants possess exceptional medicinal values for treating eye disorders and hypertension symptoms according to Sharma et al., 2024.

Further scientific studies of leucorrhoea therapy must focus on 55 medicinal plants from Odisha because research reports positive findings by Beura & Raul (2024).

A review of 116 Indian female contraceptive medicinal plants describes 130 formulations which outline their plant components, preparation processes, administration procedures and shows how they provide antifertility benefits without producing the side effects related to modern contraceptive methods. (Sharma et al.,2024).

The software application Agrosadhi works to improve access to ancient medicinal information while enabling better management along with commercialization of biomedical resources (Khan et al., 2024). This paper examines 32 medicinal plant species which tribal population such as Chenchu, Reddi, Valmiki, Gond, Saora, and Kondh utilize in India. The list provides information about scientific plant classifications and seed-bearing plant families along with the described community applications and reported sicknesses. (Banerjee and Pal,2024) Research identified 150 medicinal plants in Sudhnoti Azad Kashmir which included *Artemisia maritima*, *Berberis lycium*, *Morus nigra* alongside other plants useful for treating flu along with renal disorders malaria and joint pain in local indigenous communities. (Ishtiaq et al.,2024).



Most traditional medicine treatments utilize plants as therapeutic agents which represent 85% of its therapeutic practices. Their total global export value amounts to \$60 billion per year and projects a 6% annual growth rate despite delivering medications that are both less expensive and provide fewer unwanted medical reactions than contemporary pharmaceuticals. (Niazi and Monib,2024) Scientists have examined the petiole structure of eight medically essential Polygonaceae species found in Kashmir Himalayan Region with the goal of understanding their ethnobotanical applications as well as their taxonomic importance in species recognition and healthcare property research. (Gillani et al., 2024).

Plants that serve medical functions in treatments provide alternative remedies for multiple health problems. Medicinal plants preserve affordability while also providing minimal adverse reactions and presenting multiple therapeutic properties which cover antimicrobial defenses and anti-inflammatory functions and antioxidative capabilities. (Hossain,2024) The paper shows that India's different climatic conditions support the cultivation of medicinal and aromatic plants including species growing in Pahalgam (Chouhan,2024).

The current treatments involve gastrointestinal disorders together with dermatological and musculoskeletal problems while *Artemisia absinthium* and *Mentha longifolia* demonstrate high medical use values according to Khoja et al. (2024) and Gillani et al. (2024). The Kashmir Himalayas contain 72 plant species according to Khoja et al. (2024) and these species belong to the Lamiaceae and Apiaceae families among others (Gillani et al., 2024).

The paper evaluates several anticancer Indian medicinal plants while exploring their chemical properties and their effectiveness against breast, stomach, oral, colon, lung, hepatic, cervical, and blood cancers as affordable therapeutic possibilities (Lokuju et al.,2024). Local populations in Honduras along with Brazil use medicinal plants as treatments for diabetes and hypertension and obesity management. Lemon balm and moringa serve as popular species because of their health benefits and affordable cost in comparison with pharmaceutical medicines (Espinoza-Turcios et al., 2024).

3. STUDY AREA

Geographic Location

Jammu and Kashmir (J&K) occupies the northernmost position in India while maintaining its position as an area of important geographical character, ecological diversity, and cultural distinction. Jammu and Kashmir (J&K) occupies a total ground space of 55,673 square kilometers within the geographic area spanned by latitudes 32°17' to 37°05' N and longitudes 73°26' to 80°30' E. Jammu and Kashmir is surrounded by three national borders: Pakistan lies to the west and China occupies the northern and eastern sides while the southern reaches are defined by the Indian states Punjab and Himachal Pradesh.

Physiographic Divisions

J&K contains a wide range of geographical land features that transition through plains and mountains that reach great heights. The area has three separate geographic regions that can be identified separately.



1. **Jammu Region** The region forms the southern segment of Jammu and Kashmir (J&K) as a Union Territory, encompassing both the central Himalayas and the surrounding foothills, as well as the plains of the country. The territory experiences a subtropical climate in most areas, while the fertility of the land is significantly supported by the Tawi River basin.
2. **Kashmir Valley** Jammu and Kashmir exist between the Pir Panjal and the Greater Himalayas, forming a fertile, muscle-shaped depression. It is recognized for its spectacular natural scenery, warm seasons, and abundant wildlife.
3. **Ladakh** has functioned as its own Union Territory since 2019, after previously being part of the former Jammu and Kashmir state. The region features cold desert plains, rocky peaks, and sparse human settlements.

Climatic Divisions: The State of Jammu and Kashmir is in subtropical latitudes. However, due to its topographic features and snow-covered peaks, the climate in most parts of the state resembles that of mountainous and continental regions in temperate latitudes. The state can be divided into three climatic regions. i) Subtropical Jammu. ii) Temperate Kashmir iii) Sub Arctic Ladakh.

i) Jammu Region

The Jammu region features a monsoon climate with concentrated rainfall, hot summer months, a relatively dry yet distinct winter, and a predominance of alluvial soils. The heaviest rainfall occurs from July to September. The average elevation ranges from below 300 m to about 1350 m. The warmest months in this zone are May, June, and July, while the coldest are December, January, and February.

ii) Kashmir Region

The Kashmir region, or temperate zone, essentially encompasses the Kashmir valley. This zone faces wet and often harsh winters characterized by frost, snow, and rain and relatively dry and warm summers. Snowfall, a crucial form of precipitation, ensures an appropriate moisture supply during the summer months when rainfall is limited. The soils in the Kashmir valley are alluvial, with around 62 percent being irrigated. Key meteorological features of the temperate zone indicate that it receives approximately 680 mm of annual rainfall, with nearly 70 percent occurring during winter and spring (from December to May). The overall average temperature throughout different months ranges from 1.2°C to 24.5°C, exhibiting a cold thermal index.

iii) Ladakh Region

In India, the arid zone covers an area of 387,390 km², with 107,545 km² situated within the cold arid region of the Western Himalayas. The remaining area constitutes the hot, arid regions of the Indo-Gangetic plains and peninsular India (Dulay, 1987; Directorate of Economics and Statistics, J & K, 2010-11). The cold, arid region of the Western Himalayas primarily includes the Ladakh area of the Jammu and Kashmir State, along with certain parts of the Lahul-Spiti sub-division in Himachal Pradesh. This region in Jammu and Kashmir is located at the northernmost tip of the Asian subcontinent, nestled between the Karakoram and greater Himalayan ranges. It is characterized by its bare and rugged landscape.



Biodiversity and Ecological Significance

Jammu and Kashmir exist inside the Himalayan biodiversity hotspot which supports many types of flora and fauna. The ecological range of the region develops because of its variable elevation differences, distinct geological formations, and climatic conditions. The region contains three major ecological systems which are alpine meadows together with temperate forests and wetlands.

- 1. Flora** These regions consist of three important medicinal plants, namely *Podophyllum hexandrum*, *Aconitum heterophyllum*, and *Artemisia absinthium*. The diverse forest habitats consist predominantly of *Pinus*, *Cedrus* as well as *Abies* trees.
- 2. Fauna** within this area consists of distinctive wildlife creatures including the Kashmir stag (*Cervus hangul*) together with the Himalayan black bear (*Ursus thibetanus*) and the snow leopard (*Panthera uncia*).
- 3. Wetlands** The Wular Lake with Hokersar Wetlands provide ecological buffering areas that serve as critical habitats for migratory birds.

Socio-Cultural Context

Multiple cultures together with numerous linguistic traditions and distinctive regional traditions make Jammu and Kashmir an intermix of traditions. The residents of this area practice Islam together with Hinduism Buddhism and Sikhism among other faiths. The region includes several spoken languages which consist of Kashmiri, Dogri, Urdu, Ladakhi, and Pahari. The local economy hinges on three main economic sectors which are agriculture combined with horticulture and handicrafts.

Significance of the Study Area

For Medicinal Plant Research, J&K's particular geographical landscape, alongside its atmospheric circumstances, provides perfect conditions for medicinal plant cultivation. Traditional knowledge about therapeutic plant practices exists principally in the Kashmir Valley. The research setting enables scholars to investigate the natural habitats and folk applications as well as the protection methods for medicinal plants, which benefits environmental sustainability and biodiversity protection.



Figure 1: Map of India



Figure 2: Map of Jammu & Kashmir

Study Area /Site: Pahalgam

1. Physical Parameters

Pahalgam serves as a renowned town in India's Anantnag district of Jammu and Kashmir where visitors find it famous for its beautiful forests alongside calm surroundings. The location rests at 2,130 meters (6,990 feet) above sea level by the Lidder River banks. The geomorphology of Pahalgam combines sloping pastures with thick woodlands alongside Rocky Mountains which establishes this place as an exceptional geomorphological body in the Kashmir Valley.

The geographical area mainly has a moderating climate which shows notable differences between seasons. Pahalgam experiences milder summer conditions when temperatures fluctuate between 11°C to 25°C yet winter brings cold temperatures alongside heavy snowfalls. Pahalgam faces an average yearly precipitation of 1,200 mm that turns into significant snow accumulation during the winter season. The climate of Pahalgam strongly affects the hydrology of the area by supplying continuous water flow to the Lidder River while maintaining ecological stability in the region.

Alluvial soil deposits covering Pahalgam show features that promote rich organic content suitable for different plant life to thrive. Glacial activity together with steep slopes throughout the region creates rocky areas maintaining particular plant species adapted to live in these environments.

2. Biological Parameters

The vegetation in the area exists mainly as alpine vegetation with subalpine vegetation on top of temperate forest zones. The primary forest members at this location are the conifer trees comprising *Pinus wallichiana* (Blue Pine), *Cedrus deodara* (Deodar), *Abies pindrow* (Himalayan Fir), and *Picea smithiana* (Spruce). *Betula utilis* Himalayan Birch together with various *Acer* species thrive among the deciduous plant populations found at great altitudes.



Shrubs including Rose species, Berberis species, and Viburnum species dominate parts beneath the trees alongside many herbs and grass species. Indian Podophyllum (*Podophyllum hexandrum*) Atis (*Aconitum heterophyllum*) and Kuth (*Saussurea costus*) serve as important medicinal plants in the region that provide substantial research opportunities in ethnobotany and pharmacology. The local people make traditional use of these medicinal plants for healing digestive problems respiratory conditions and inflammation. Indian Podophyllum (*Podophyllum hexandrum*) exhibits proven capabilities against cancer whereas the fever and gastrointestinal treatments benefit from the presence of *Aconitum heterophyllum*. Medical plants of this region function both as traditional healing resources and scientific opportunities for pharmaceutical research as well as therapeutic applications.

Several native mammals alongside numerous bird and insect species comprise the animal diversity of Pahalgam. People can find three important mammalian species in Pahalgam consisting of *Ursus arctos isabellinus* (Himalayan Brown Bear), *Capra ibex* (Ibex), and *Moschus chrysogaster* (Himalayan Musk Deer) which are facing a high risk of endangerment. The mountainous region supports two important bird species which include Himalayan Monal (*Lophophorus impejanus*) and Koklass Pheasant (*Pucrasia macrolopha*). Additionally, its habitat hosts numerous migrating waterfowl species. Endemic fish species *Schizothorax* spp exists with the Lidder River biodiversity while sustaining aquatic life.

3. Geographical Parameters

The location of Pahalgam exists at the junction where Lidder Valley meets Sheshnag Valley near the Pir Panjal Mountain range. The Lidder River functions as Pahalgam's critical maintenance source because it originates from the Kolahoi Glacier and then shapes both the landscape and the adjacent ecosystem of the valley.

The location of Pahalgam exists between 34.01°N latitude and 75.19°E longitude. The town stands as a main access point for various trekking paths that lead to the Amarnath Cave and the Kolahoi Glacier. The region shows glaciological importance through its landscape features which contain moraines together with cirques and hanging valleys among glaciated terrain. Natural hazards such as landslides and avalanches threaten Pahalgam because of its strategic positioning in the terrain which becomes exposed to such threats as snowmelt occurs and precipitation intensifies. Sustainable development faces obstacles because of these events so proper planning and mitigation strategies become essential for dealing with them.



Figure 3: Satellite Imagery of Pahalgam Valley

**Primary Study Sites: Kothpatri, Aru Valley, Lidderwat**

Located inside the Himalayas, the Kashmir Valley represents an ecologically rich treasure area. The medicinal plant research opportunities in Aru Valley, Kothpatri, and Lidderwat remain distinctive because of their special ecosystems alongside their great medicinal plant potential. The locations establish excellent research environments for ethnomedicine studies because they span different heights and possess diverse climates alongside traditional indigenous knowledge practices.

a) Kothpatri**Location and Geography:**

This region lies around 12 kilometers beyond Pahalgam with its altitude resting at 2,400 meters above sea level. The valley functions as a vital access point to trekking routes that ascend to the Kolahoi Glacier through its mountain peaks which are topped with snow while creating an environment of coniferous woods and meadows covering most of the territory.

Flora and Medicinal Significance:

Rheum emodi (Indian rhubarb) Aconitum heterophyllum (Atis) and Podophyllum hexandrum (Himalayan Mayapple) grow within the valley because of its cool temperate climate and diverse ecosystems. Rheum emodi, Aconitum heterophyllum, and Podophyllum hexandrum serve multiple purposes in medicine because they possess anti-inflammatory characteristics analgesic properties, and anti-cancer compounds. Research opportunities for studying wild flora interactions with pastoral and forested areas exist because Aru maintains a strategic position between forested and grazing land areas.

Ethnobotanical Context:

The people of Gujjar and Bakarwal who live in Aru have inherited skills concerning medicinal plant treatments which provide solutions for numerous health problems including digestive conditions and skin issues. Recorded monitoring of local practices will increase natural resource conservation programs and help sustain resource use effectively.

b) Lidderwat**Location and Geography:**

From Aru Valley, the remote destination of Lidderwat exists at a height of 3400 meters which is located 11 kilometers away. The faraway location is set amidst an alpine meadow that borders dense forests and snow-fed streams as it belongs to the Kolahoi Basin.

Flora and Medicinal Significance:

Lidderwat features unspoiled alpine plants with the rare medicinal species Saussurea costus (Kuth), Angelica glauca (Choru), and Arnebia benthamii (Ratanjot) present in this area. The plant species are actively desired by traditional medicine practitioners and Ayurvedic professionals because they demonstrate anti-microbial and tonic effects. High-altitude medicinal plant investigation is possible within an undisturbed habitat at this location.



Challenges and Conservation:

The natural order of this habitat is jeopardized due to overharvesting along with excessive grazing activities. Daliland Association Scientific Investigations conducted at Lidderwat will generate important findings about practical resource management methods and both habitat recovery operations and people-driven ecological preservation plans.

c) Aru Valley

Location and Geography:

Located at 2,408 meters elevation Aru Valley exists as an untouched natural destination that lies in Jammu and Kashmir between 12 kilometers and Pahalgam. The valley rests at 2408 meters above sea level getting its natural beauty from Himalayan mountains and luxuriant grassy highlands with clustering forests and glistening river currents. The Kolahoi Glacier and Tarsar-Marsar Lakes serve as access points from Aru Valley so the destination provides a quiet refuge for users who love nature and outdoor exploration. The untouched natural surroundings along with the varied landscape feature the valley perfectly for scientific studies of ecology and the environment.

Flora and Fauna:

The biodiversity hotspot called the valley presents many types of fauna and flora for exploration. The alpine and sub-alpine surroundings of Aru enable the successful plant growth of important medicinal species including Ativisha (*Aconitum heterophyllum*), Kuth (*Saussurea costus*), and Indian Mayapple (*Podophyllum hexandrum*). Different communities in India have used these plants in traditional medical practices because they contain valuable therapeutic values. The valley contains vital biodiversity habitats where Himalayan brown bears and snow leopards along with several bird species live in the region alongside other animals.

Tourism and Environmental Impact:

Aru Valley attracts diverse types of visitors who prefer the peaceful surroundings for vision-based holiday experiences including outdoor activities and leisure activities that combine nature's beauty. The rapidly increasing number of visitors to the area has triggered environmental problems consisting of damaged habitats together with waste accumulation and increased demand for local natural resources. Medical plant species face survival risks because of the uncontrolled tourist activities in this region.

4. RESEARCH METHODOLOGY

Pahalgam village is prominent in the Anantnag district of Jammu and Kashmir due to its stunning landscapes that draw many tourists. According to the 2011 Census Pahalgam had a total population of 9,264 inhabitants including 5,541 males and 3,723 females (Census 2011 India). The Pahalgam literacy rate reached 64.87% and fell beneath the state average of 67.16%. The literacy rate for males in Pahalgam was higher at 80.57% while females achieved a rate of 40.01%. Among Pahalgam residents, the child population aged 0-6 reached 1,245 which constituted 13.44% of the total resident count. The community exhibits 989 females for every 1,000 males according to child sex ratio statistics which surpasses the state norm of 862.



Pahalgam is home to various tribal communities. These communities enhance the regional culture together with local traditional practices while shaping the distinct local way of living. The community of the area consists of main tribal groups such as:

Gujjars: The Gujjars maintain their position as one of the notable indigenous groups both within Pahalgam and throughout the entire Jammu and Kashmir territory. Through generations, people have recognized this community as livestock keepers who specialize in milk production. The activity of Gujjars has evolved toward both agricultural farming and small-scale trading as well as working for government positions in recent times. These nomadic people belong to the Muslim faith yet they spend most months of summer tending livestock on alpine grazing fields. Throughout the Jammu and Kashmir area, the Gujjars maintain a distinct dialect along with traditional crafts and folk music practices.

Bakarwals: Bakarwals make up another big tribal community within Pahalgam together with the rest of Anantnag district. Their way of life matches that of Gujjar tribes since they follow a pattern of seasonal migration by herding sheep and goats. When summer arrives the Bakarwals move their herds to mountain peaks through the transhumance practice. The Bakarwals practice the Muslim religion and use Gojri as their main language. The tribal community embraces a rich cultural legacy that includes exceptional handicrafts as well as traditional musical traditions which form the backbone of their communal identity.

Additional tribal communities such as Gaddi and Sippi also inhabit Pahalgam although they have ancestral ties to the region which mirrors the pastoral methods of Gujjars and Bakarwals.

The study took place in Pahalgam because this location displays both extensive biodiversity and remarkable historical usage patterns of medicinal plants according to Dar et al. (2021). Pahalgam's temperature conditions together with its varied landscape and forest density create perfect conditions for investigating medicinal plant species and native ecological expertise.

Three different study sites named Kothpatri, Aru Valley, and Lidderwart have been chosen for medicinal plant collection because they represent specific vegetation areas and ecological habitats.

Au contrary to the primary sites research information was gathered from the State Forest Research Institute (SFRI), Seer which acted as a supporting study location. The State Forest Research Institute (SFRI) delivered essential information regarding medicinal plant species occurrence ranges together with both their conservation standing and their management procedures in the geographic area (Sharma & Kour, 2019).

The research lasted from 2021 to 2023 to properly observe seasonal shifts and changes in plant variety as well as accessibility.

5. COLLECTION OF PLANT SPECIMEN

The field research executed systematic methodology during visits to the study sites for plant specimen collection. The methodology of botanical specimen collection and identification aligned with Jain and Rao's (1977) standard procedures was used for all samples. Documentation of plant specimens was done using their latest scientific name together with vernacular names, morphological traits, medicinal applications, utilization parts, and natural habitats of each plant.



Collected plant materials were preserved by pressing them before they dried them for herbarium mounting. The herbarium sheets received complete written identification including the exact collection location and its account of events and the specific natural environment. IUCN Red List of Threatened Plants (IUCN, 2023) was used to determine the conservation statuses of the collected specimens for accuracy verification purposes. The Department of Forestry Jammu and Kashmir supplied supplementary information about species included in the red list.

6. FIELD INTERVIEW

The ethnobotanical survey began with field interviews with 78 informants from the study area whose ages ranged between 18 and 78 years to acquire traditional plant healthcare knowledge. Male informants displayed superior levels of expertise and knowledge-sharing activities compared to females in the entire informant group. Most of the participants lacked reading skills while the more educated individuals among them had reached the highest level of secondary education. The entire pool of interviewees belonged to the Muslim religious community throughout the surveyed area where Muslims represent the main faith. The field interview was mainly conducted in the Urdu language. The details about participant demographics appear in Table 1 below.

Table 1: Demographic Details of The Participants

Demographic Variable	Category	Number of Participants	Percentage (%)
Gender	Male	48	61.50%
	Female	30	38.50%
Age Group	18–30 years	18	23.10%
	31–50 years	20	25.60%
	51+ years	40	51.30 %
Education Level	No Formal Education	50	64.10%
	Primary Education	15	19.20%
	Secondary Education	10	12.80%
	Higher Education	3	3.90%
Occupation	Pastoralism	55	70.50%
	Agriculture	15	19.20%
	Other	8	10.30%
Region	Kothpatri	30	38.50%
	Lidderwart	25	32.10%
	Aru valley	23	29.40%

The participants were chosen based on the in-depth traditional knowledge they possessed about plant treatments of various categories of diseases. Participants provided verbal consent before discussions or interviews took place according to the International Society of Ethnobiology (2006) ethical principles. Proper ethical guidelines were followed to maintain respect for local customs together with traditions and confidentiality standards. The following is the format of the questionnaire used during the interview:



7. RESULTS

The ethnobotanical survey conducted in the Kothpatri, Lidderwart, and Aru Valley regions of Pahalgam, Anantnag, between 2021 and 2023 included participants from various segments of the population. The sample consisted of mostly males (61.5%) and females (38.5%), representing different age groups, educational backgrounds, occupational profiles, and geographical areas. The gender distribution indicates a higher participation rate among males, which may be influenced by the traditional norms prevalent in the study area.

Most survey participants (51.3%) were aged 51 years or older, while those in the 31–50 age range represented 25.6%, and participants aged 18–30 comprised 23.1% of the total. The results suggest that older generations had a more significant presence in the survey, as they possess a deeper understanding of traditional ethnobotanical practices.

The study demonstrated high rates of educational limitations as 64.1% of them lacked formal education due to inadequate access to educational facilities and widespread illiteracy within the region. A total of 19.2% of the respondents reached the primary education level and secondary education holders comprised 12.8% while those who obtained higher education amounted to 3.9%. The educational challenges experienced by local people are shown in these statistics and might drive them to continue relying on traditional knowledge and life practices for sustenance.

The census of participants confirmed that pastoralist practices were the primary occupation for 70.5% of participants because pastoralism remains the prevalent economic sector in the area. Agriculture was the second largest occupation after pastoralism, with 19.2% of respondents involved, while other types of employment made up 10.3% of participants. The occupational makeup of the participants matches the rural and mountainous character of the study areas since livestock rearing and farming are traditional activities there.

The participants primarily lived in Kothpatri, comprising 38.5% of the population, followed by Lidderwart at 32.1% and Aru Valley with 29.4%. The participant numbers demonstrate equitable sampling from the key study sites, which enabled the survey to obtain knowledge from various regions across the area.

Table 2: Demographic Details of The Participants

Demographic Variable	Category	Number of Participants	Percentage (%)
Gender	Male	48	61.50%
	Female	30	38.50%
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	51+ years	40	51.30 %
Education Level	No Formal Education	50	64.10%
	Primary Education	15	19.20%
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Occupation	Pastoralism	55	70.50%
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	Other	8	10.30%
Region	Kothpatri	30	38.50%
	Lidderwart	25	32.10%
	Aru valley	23	29.40%

Analysis of Current Threats and Their Impact on the Distribution of Medicinal Plants in Pahalgam valley.

The medicinal plants in Pahalgam are under threat from various environmental and human-related factors, as detailed in the table below. Each category of threat is assessed individually, taking into account its underlying causes and ecological impacts on species distribution, along with specific examples of affected plants.

Climate change poses risks to medicinal plant species such as *Picrorhiza kurroa*, *Rheum emodi*, and *Trillium govanianum* due to shifts in growth patterns and changes in habitat viability. Herbal species like *Berberis aristata*, *Aconitum heterophyllum*, and *Podophyllum hexandrum* are endangered as their vital habitats are lost with the destruction of forests. The situation worsens as pollutants travel through air and soil networks, leading to a decline in the health and vitality of *Artemisia absinthium*, *Valeriana jatamansi*, and *Dioscorea deltoidea*.

Increasing human activities, including unsustainable harvesting and illegal collection, have significantly diminished the populations of *Saussurea costus*, *Nardostachys jatamansi*, and *Inula racemosa*. The species *Gentiana kurroo*, *Angelica glauca*, and *Dactylorhiza hatagirea* suffer negative impacts from habitat loss due to tourism and soil compression. Additionally, native medicinal plants are threatened by invasive species like *Parthenium hysterophorus*, *Eupatorium adenophorum*, and *Lantana camara*, as these species compete for resources in the region.

8. CONCLUSION AND FUTURE WORK

The ethnobotanical survey conducted in the Lidderwart, Aru, and Kothpatri regions of Pahalgam presents a comprehensive documentation of 60 medicinal plant species used by the Gujjar and Bakarwal communities. These findings contribute significantly to the preservation of indigenous knowledge systems and highlight the crucial role of local biodiversity in sustaining traditional healthcare practices. The survey illustrates that a substantial number of species belong to families such as Asteraceae, Solanaceae, and Lamiaceae, indicating their pharmacological relevance due to the presence of bioactive compounds. Notably, oral administration remains the dominant method of treatment, while topical and dual applications also reflect the flexibility and depth of traditional practices.

The study also underscores the gendered and generational patterns in knowledge transmission. A majority of the knowledge bearers are older males, indicating an urgent need to involve younger generations and women through community-based educational programs. The fact that most



respondents lacked formal education yet possessed profound botanical knowledge reveals the strength of oral traditions and indigenous expertise. With 57.1% of the species documented being globally Critically Endangered, urgent conservation efforts are needed, including habitat restoration, sustainable harvesting, and the strengthening of ex-situ conservation programs such as those at SFRI Seer Hamdaan. Looking ahead, future work should focus on a multi-dimensional approach to ensure the preservation and integration of traditional knowledge with modern science. First, ethnopharmacological validation of frequently used plants such as *Aconitum heterophyllum*, *Rubia cordifolia*, and *Acorus calamus* should be prioritized to explore their potential for drug development. Second, intergenerational knowledge transmission can be strengthened by introducing school-based herbal gardens and storytelling initiatives that connect youth with their natural heritage. Third, community-based conservation strategies, including the establishment of medicinal plant cooperatives and nurseries, will not only preserve biodiversity but also provide alternative livelihoods. Additionally, digital documentation and GIS mapping of medicinal plant locations and ecological zones will enhance monitoring and conservation planning.

The increasing pressures from tourism, climate change, and habitat destruction call for policy-level interventions. Implementing eco-tourism guidelines, enforcing anti-poaching laws, and incentivizing conservation through local benefit-sharing mechanisms can reduce the anthropogenic stress on fragile alpine ecosystems. By combining scientific research, traditional knowledge, and community involvement, the region can evolve into a model for sustainable ethnobotanical conservation and development. Continued interdisciplinary research will ensure that this invaluable traditional wisdom is preserved, protected, and utilized for future generations.

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