

A Field Survey to Investigate the Flora of Dharmashala Dhauladhar Range in North-Western Himalayan Region of India

¹Dr. Padala Thirupathi

Assistant Professor

Department of Botany, S.R.R. Government
Arts & Science College (A), Karimnagar, Telangana State

²Dr. Dushyant Kumar

Assistant Professor in Geography,

Govt. College Kheri Gujran Faridabad, Haryana (India)

³Dr. Tirukovela Srinivas

Associate Professor, Head,

Department of Botany, S.R.R. Government
Arts & Science College (A), Karimnagar, Telangana State

⁴Dr. Kunwar Singh.

Assistant Professor,

Department of Physics,
S.D.M. Government P.G. College Doiwala,
Dehradun Uttarakhand

⁵Dr. Tirunahari Ugandhar

Associate Professor,

Department of Botany, Kakatiya Government College (A),
Hanumakonda., Telangana State

Abstract:- The Flora of Dharmashala Dhauladhar Range in the North-Western Himalayan Region of India is an intricate tapestry of plant diversity shaped by the unique topography, climate, and altitudinal gradients of the region. Located in the Kangra district of Himachal Pradesh, this area is characterized by a wide range of habitats that span from subtropical zones in the lower reaches to alpine meadows in the higher altitudes. This diversity in habitat fosters a rich variety of plant species, many of which are endemic and have adapted specifically to the Himalayan environment. The Dhauladhar Range harbors an array of flora, including coniferous forests dominated by *Cedrus deodara* (Deodar), *Pinus wallichiana* (Blue Pine), and *Abies pindrow* (Himalayan Fir) in mid-altitude regions. The alpine meadows and subalpine zones support a range of herbaceous plants, such as *Primula*, *Rhododendron*, *Potentilla*, and *Anemone* species. Lower altitudes contain broad-leaved forests with species like *Quercus leucotrichophora* (Banj Oak), *Rhododendron arboreum* (Buras), and various shrubs and undergrowth species. **Endemic and Medicinal Species:** This region is notable for its medicinal plants like *Aconitum heterophyllum* (Atis), *Nardostachys jatamansi* (Spikenard), and *Valeriana jatamansi* (Indian Valerian), which have applications in traditional medicine and are sought after for their therapeutic properties. Endemic species are prevalent, with unique adaptations to the harsh climatic conditions, contributing to the ecological uniqueness of the Himalayan flora. **Ecological Significance:** The flora plays a crucial role in preventing soil erosion, especially on the steep slopes of the Himalayas. These plant communities form habitats for various faunal species,

including several endangered and endemic animal species, supporting biodiversity conservation. **Conservation Concerns:** Overharvesting of medicinal plants, deforestation, and land-use changes due to tourism and infrastructure development pose threats to this fragile ecosystem. Climate change impacts, such as rising temperatures and changing precipitation patterns, further challenge the survival of these species, necessitating conservation efforts.

Keywords:- Biodiversity, Endemic Species, Climate Change, Overharvesting, Deforestation, Precipitation patterns, Conservation, *Pinus Wallichiana*, *Abies Pindrow*, *Quercus Leucotrichophora*, *Aconitum Heterophyllum*.

I. INTRODUCTION

The Flora of Dharmashala Dhauladhar Range in the North-Western Himalayan Region of India represents a vibrant spectrum of biodiversity shaped by the varied topography, altitudinal gradients, and unique climatic conditions of this mountainous region. Nestled in the Kangra Valley of Himachal Pradesh, the Dhauladhar Range serves as a transitional zone, bridging the subtropical lowlands and the alpine highlands, which creates a mosaic of habitats ranging from dense forests to alpine meadows. This rich biodiversity is marked by a diverse assemblage of plant species that include towering conifers, unique shrubs, flowering herbs, and a variety of medicinal and endemic plants adapted to the Himalayan ecosystem. The region hosts several forest types, such as deodar, oak, and pine, and boasts a variety of alpine flora that thrive in higher altitudes, making it an essential part of the Himalayan biodiversity

hotspot. The ecological significance of this flora is multifold: it provides vital ecosystem services such as soil stability and watershed protection, supports a wide range of wildlife, and has great cultural and medicinal value. However, increasing human activity, climate change, and unsustainable resource extraction pose challenges to the conservation of this unique flora. This study of the flora of the Dharmashala Dhauladhar Range aims to catalog and understand this biodiversity, with a view to promoting conservation efforts and sustainable management practices

in one of the most ecologically and culturally significant regions of the Indian Himalayas. Dharamshala is a scenic hill town located at 23°13' North latitude and 76°19' East longitude in the northern Indian state of Himachal Pradesh. Nestled in the Dhauladhar mountain range of the Himalayas, it's known for its beautiful landscapes (fig. no. 1.2), Tibetan culture, and religious significance. It is a tehsil of Kangra district which has total geographical area is 352 43 sq. km with average elevation about 1457 m.

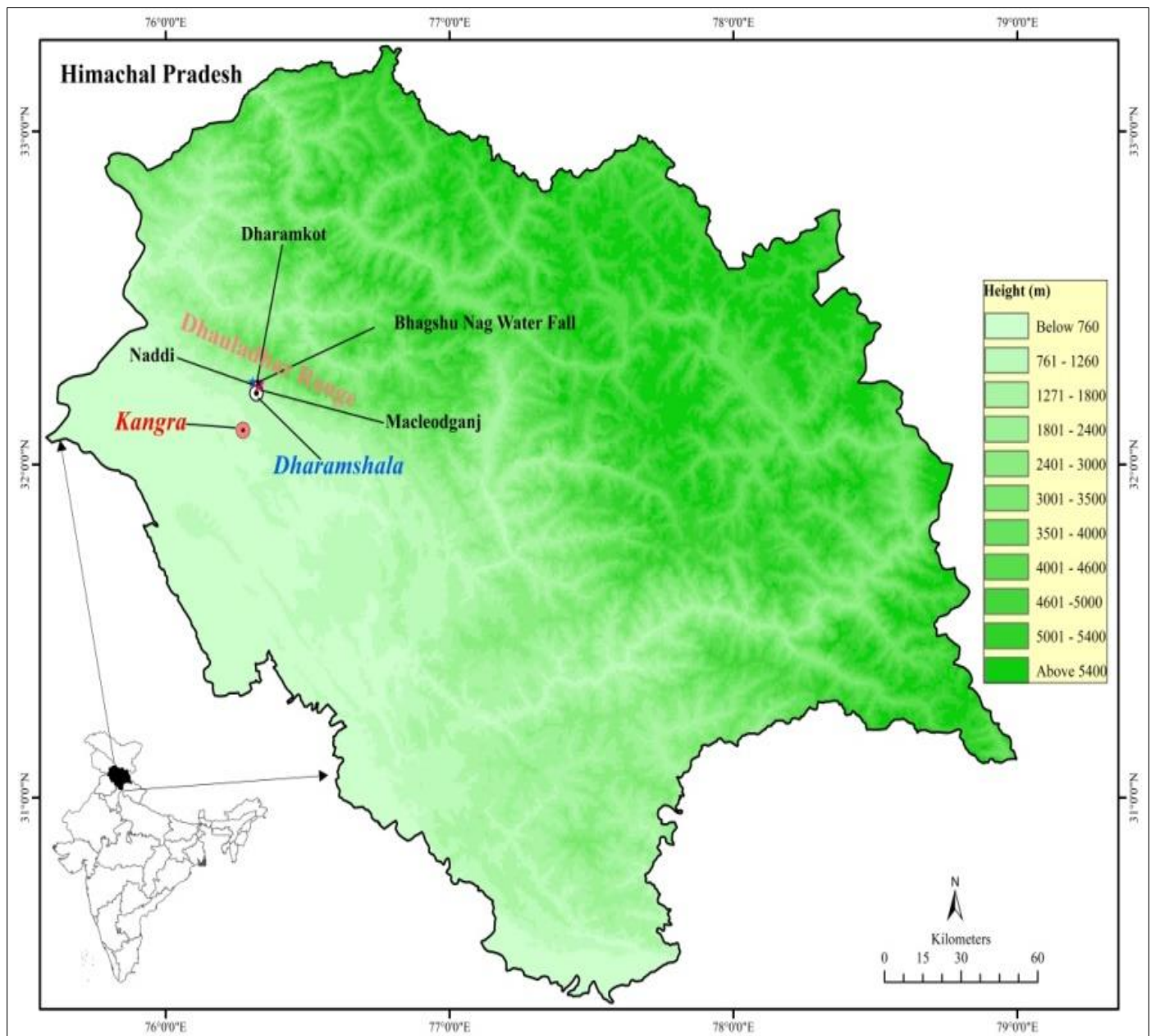


Fig 1 Location Map of Study Area – Dharmashala Dhauladhar Range, Himachal Pradesh

➤ Objectives:

The study of the **Flora of Dharmashala Dhauladhar Range in the North-Western Himalayan Region of India** is driven by several key objectives aimed at understanding, documenting, and conserving the rich plant biodiversity of this ecologically sensitive region. These objectives include:

• Documenting Plant Diversity:

- ✓ To catalog and identify the plant species found within the Dharmashala Dhauladhar Range, focusing on their taxonomic classification, distribution, and abundance across different altitudinal zones.

- *Assessing Endemic and Medicinal Species:*
 - ✓ To identify and study endemic, rare, and medicinally valuable plant species, particularly those that have traditional importance or potential therapeutic applications.
- *Understanding Human Impact:*
 - ✓ To analyze the impact of human activities, including tourism, resource extraction, and land-use changes, on the flora and overall ecosystem health of the Dhauladhar Range.
- *Promoting Sustainable Use and Conservation Strategies:*
 - ✓ To develop sustainable management strategies for conserving this floral diversity, including community-based initiatives, and promoting awareness about the ecological and cultural importance of the region's flora.

II. METHODOLOGY

Authors have identified different flora species were collected during 10 days National level adventure camp organized by Regional Mountaineering Centre Macleodganj, Dharamshala from 22 October 2024 to 31 October 2024. During the adventure camp real photograph of flora were taken from different parts of Dhauladhar Range.

- *Study Area Delimitation and Sampling Design*
 - **Site Selection:** Based on altitudinal gradients, forest types, and habitats, representative sampling sites across subtropical, temperate, and alpine zones are selected within the Dhauladhar Range.
- *Field Data Collection*
 - **Species Identification and Collection:** Botanists collect plant specimens for identification and documentation, noting distinguishing morphological characteristics and photographing plants in situ.
 - **Data Recording:** For each species, location, GPS coordinates, altitude, habitat type, and associated vegetation are recorded to understand the ecological distribution of flora.
 - **Phenological Observations:** Seasonal aspects, such as flowering and fruiting periods, are observed and noted to analyze the reproductive cycles and adaptations of various species.
- *Herbarium Preparation and Identification*
 - **Specimen Processing:** Collected specimens are preserved, labeled, and stored in herbariums, ensuring their availability for taxonomic verification.
 - **Taxonomic Identification:** Experts compare specimens against existing collections in regional herbaria, such as the Forest Research Institute (FRI) or the Botanical

Survey of India (BSI), and consult taxonomic keys and literature for accurate identification.

➤ *Data Analysis and Classification*

- **Vegetation Classification:** Based on data from different plots, plant communities are classified by habitat and elevation, allowing for a zonal vegetation profile of the Dhauladhar Range.
- **Biodiversity Indices:** Statistical analyses such as species richness, diversity indices (e.g., Shannon-Weaver Index), and similarity indices are calculated to understand the composition and diversity of plant communities.
- **Ecological Role Analysis:** Analysis is conducted to assess ecological roles, including interactions within plant communities, soil stabilization properties, and their importance as food or habitat for wildlife.

➤ *Conservation Assessment*

- **Threat Evaluation:** Plants are evaluated for conservation status based on IUCN Red List criteria, considering factors like rarity, overexploitation, and vulnerability to habitat loss.

➤ *Local Community Engagement and Ethnobotanical Survey*

- **Interviews with Local Inhabitants:** Surveys and interviews with local communities, including indigenous knowledge holders, are conducted to document traditional uses of medicinal and edible plants, which helps in identifying culturally significant species.
- **Participatory Conservation:** Local stakeholders are involved in discussions on sustainable practices and conservation needs, fostering community-based conservation efforts.

➤ *Documentation and Reporting*

- **Flora Inventory Compilation:** All collected data, including species lists, habitat descriptions, and conservation assessments, are compiled into a comprehensive inventory of the flora in the Dharmashala Dhauladhar Range.
- **Mapping:** Geographic Information System (GIS) mapping is used to visually represent species distribution, habitat types, and vegetation zones across the study area.

III. MATERIALS

➤ *Field Collection Materials*

- **Plant Press and Newspaper Sheets:** Essential for pressing and preserving plant specimens in the field, maintaining the structural and morphological integrity of samples for herbarium preparation.

- **Pruning Shears and Clippers:** Used for carefully collecting samples, especially for woody species, to obtain leaves, stems, flowers, and fruits without damaging the plant.
- **Sampling Bags and Labels:** For safely storing individual specimens with appropriate labeling for identification and tracking (e.g., location, altitude, date of collection).

➤ *Field Identification Tools*

- **Botanical Hand Lens:** A magnifying lens (10x or 20x) for examining small morphological details, such as leaf venation, trichomes, or floral parts, which aid in species identification.
- **Field Guide Books and Flora Manuals:** Comprehensive botanical guides and field manuals specific to Himalayan flora to facilitate on-site identification of plant species.
- **GPS Device:** For recording precise coordinates of each collection site, essential for mapping species distributions and understanding altitude-specific plant communities.

➤ *Data Recording Equipment*

- **Notebook and Waterproof Field Sheets:** To record essential details, including habitat type, phenological stage, associated vegetation, and any notable environmental conditions.
- **Digital Camera:** For capturing high-resolution images of plants in their natural habitat, including close-ups of distinguishing characteristics.
- **Tablet or Smartphone (optional):** With data entry applications or field-based software for direct data input, which can streamline data recording and organization.

➤ *Herbarium and Laboratory Materials*

- **Drying Oven or Desiccant Chamber:** For properly drying plant specimens post-collection, preventing fungal growth and ensuring long-term preservation.
- **Herbarium Mounting Paper and Glue:** To mount dried specimens on herbarium sheets, allowing for systematic and durable storage.
- **Identification Keys and Taxonomic Literature:** Comprehensive keys and reference literature to support taxonomic verification, particularly for species with complex morphology or closely related counterparts.

➤ *Analytical Tools and Conservation Assessment*

- **Biodiversity Analysis Software** (e.g., R, PAST): For calculating biodiversity indices and performing statistical analyses of species richness, diversity, and ecological data.
- **Geographic Information System (GIS) Software:** For mapping species distributions, vegetation zones, and generating spatial data analyses to understand plant distribution patterns and ecological influences.

➤ *Ethnobotanical and Conservation Materials*

- **Survey Questionnaires:** Designed for ethnobotanical interviews with local communities, particularly for documenting traditional uses, medicinal knowledge, and cultural significance of plants.
- **Voice Recorder:** For recording interviews and discussions with local inhabitants, ensuring accurate capture of traditional knowledge and community perspectives.

➤ *Personal Protective Gear and Field Essentials*

- **Weather-appropriate Clothing and Hiking Gear:** Essential for fieldwork in diverse and often challenging terrains, from subtropical zones to alpine meadows.
- **First Aid Kit:** For safety in remote field areas, where medical assistance may not be readily accessible.

IV. RESULT & DISCUSSION

➤ *Species Richness and Diversity*

- **Species Inventory:** The study identified a high diversity of plant species across different altitudinal zones, with notable representation from families like Asteraceae, Rosaceae, and Poaceae. Lower altitudes were dominated by subtropical species, while temperate and alpine zones had a unique assemblage of high-altitude flora.
- **Diversity Indices:** Biodiversity indices, such as the Shannon-Weaver Index, indicated that mid-altitude forests (1600–2400 meters) possessed the highest species richness, likely due to the favorable climatic conditions that support both temperate and alpine species.
- **Endemic Species:** Several endemic species were recorded, particularly in the higher altitudes, confirming the Dharmashala Dhauladhar Range as a biodiversity hotspot with unique species adapted to the region's microclimatic conditions.

➤ *Habitat Types and Vegetation Zones*

- **Vegetation Patterns:** Four major vegetation zones were documented: subtropical broad-leaved forests (up to 1600 meters), temperate coniferous forests (1600–2400 meters), subalpine shrublands (2400–3000 meters), and alpine meadows (above 3000 meters). Each zone exhibited distinct species compositions and structural characteristics.
- **Altitude-Specific Flora:** The study noted a clear stratification of flora with altitude, reflecting adaptations to temperature, humidity, and sunlight exposure variations. Alpine meadows hosted hardy species like *Rhododendron* and *Primula*, which are adapted to harsh, cold conditions.

➤ *Medicinal and Ethnobotanical Findings*

- **Medicinal Plants:** The study documented numerous medicinal plants, such as *Valeriana jatamansi*, *Nardostachys jatamansi*, and *Aconitum heterophyllum*.

These species are widely used in local traditional medicine, valued for their therapeutic properties in treating ailments like inflammation, fever, and digestive issues.

- **Ethnobotanical Knowledge:** Interviews with local communities revealed extensive ethnobotanical knowledge, particularly for species like *Rhododendron arboreum* (used in traditional beverages) and *Berberis aristata* (used for medicinal extracts). This underscores the cultural significance of the region's flora and the role of local knowledge in sustainable resource use.

➤ Ecological Significance and Conservation Concerns

- **Ecosystem Roles:** The flora plays a critical role in maintaining ecological balance. Trees and shrubs in the temperate zone act as soil stabilizers on steep slopes, reducing erosion.
- risk, while the diverse plant cover in alpine meadows supports pollinators and other wildlife.
- **Threats to Biodiversity:** Conservation assessments revealed that habitat degradation, overharvesting of medicinal plants, and climate change are major threats to this region's flora. Alpine and subalpine species, in particular, are vulnerable due to their specialized habitat requirements and slow reproductive rates.

- **Impact of Tourism and Human Activities:** Increased tourism and expanding infrastructure have led to habitat encroachment, contributing to species stress and loss. This was especially evident in lower and mid-altitude zones where human settlement and agriculture have fragmented habitats.

➤ Conservation Implications and Recommendations

- **Community-Based Conservation:** Given the strong local knowledge of medicinal and ethnobotanical plants, involving communities in conservation initiatives is crucial. Community awareness programs could promote sustainable harvesting practices and reduce pressure on vulnerable species.
- **Policy Recommendations:** The findings emphasize the need for policies to protect endemic and threatened species. This includes regulating tourism, creating protected areas, and implementing sustainable management practices.
- **Climate Adaptation Measures:** Monitoring and studying climate-sensitive species in the alpine and subalpine zones could provide insights into climate resilience. Establishing ex-situ conservation programs, such as seed banks, could also safeguard species at risk from climate-related shifts.

Table 1 List of Lichen species found in the Dharmashala region, Himachal Pradesh

Common Name	Scientific Name	Usable Part	Medicinal Uses
Oakmoss	<i>Evernia prunastri</i>	Thallus	Has mild antimicrobial properties; used in traditional healing and perfumery for its aroma.
Beard Lichen	<i>Usnea longissima</i>	Whole lichen	Strong antibacterial properties; traditionally used to treat infections and respiratory ailments.
Reindeer Lichen	<i>Cladonia rangiferina</i>	Whole lichen	Used for treating coughs, colds, and inflammation; has anti-inflammatory and antimicrobial properties.
Rock Tripe	<i>Umbilicaria esculenta</i>	Thallus	Known for antifungal and antibacterial properties; traditionally used for wound healing.
Shield Lichen	<i>Parmelia sulcata</i>	Whole lichen	Applied for skin infections, sores, and has antibacterial properties.
Sunburst Lichen	<i>Xanthoria parietina</i>	Thallus	Anti-inflammatory; used for treating wounds and minor infections.
Blood Lichen	<i>Haematomma puniceum</i>	Thallus	Traditional applications for its antimicrobial properties; used to treat wounds and skin infections.
Speckled Shield Lichen	<i>Pseudevernia furfuracea</i>	Thallus	Has wound-healing and skin-soothing properties; also used in perfumes for its scent.
Hoary Fringe Lichen	<i>Ramalina farinacea</i>	Thallus	Contains antioxidants; traditionally used to alleviate respiratory ailments.
Common Greenshield	<i>Flavoparmelia caperata</i>	Whole lichen	Known for antifungal and anti-inflammatory properties; used to treat skin ailments.

These lichens are valued in traditional medicine for their antibacterial, antifungal, and anti-inflammatory properties and are known to thrive in the clean, unpolluted air and rocky habitats of the Dharmashala region in the Dhauladhar Range.

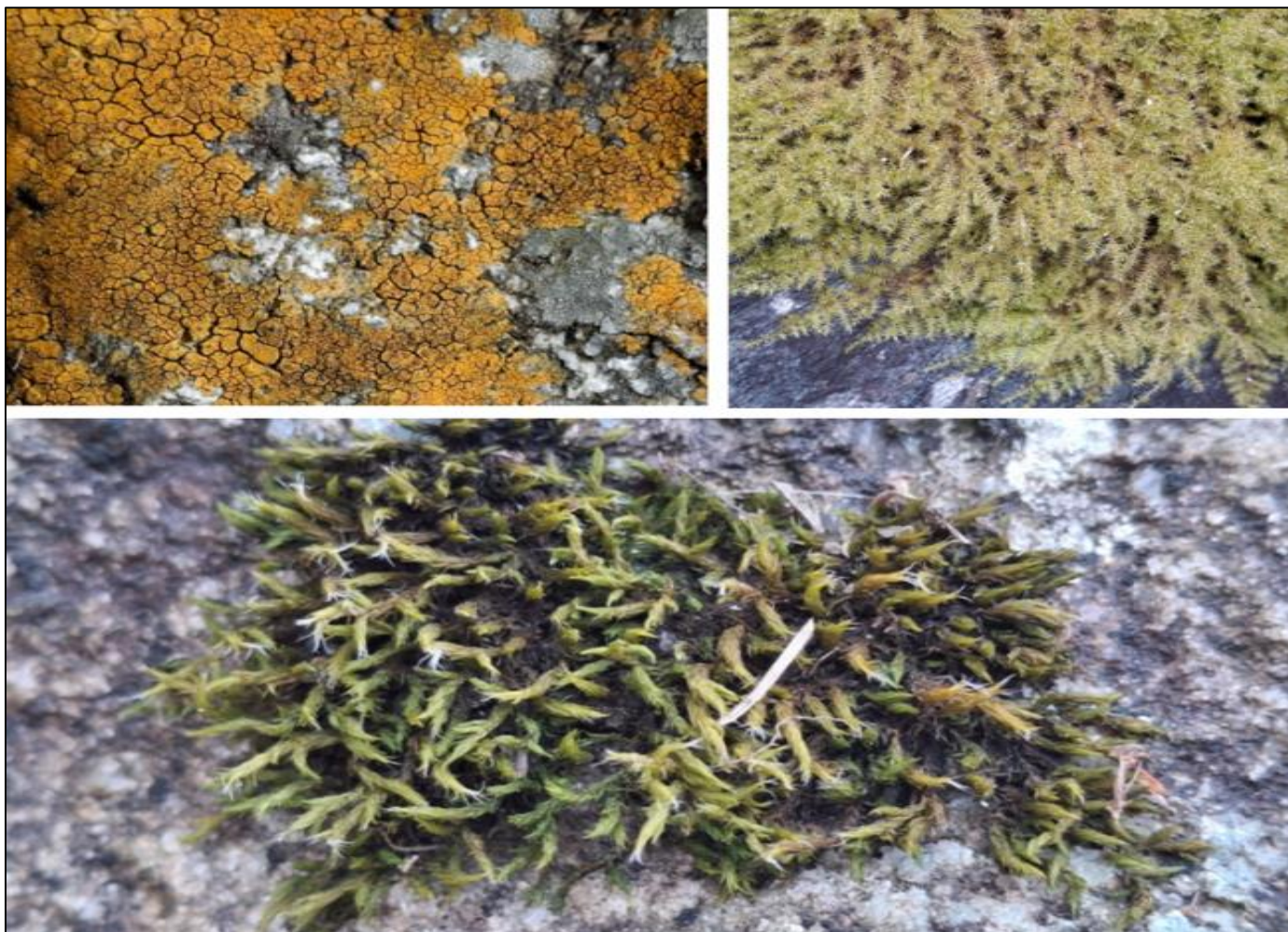


Fig 2 Photographs of Lichen Species are recorded in Dharamshala, Dhauladhar Range, Himachal Pradesh

Table 2 List of Bryophyte Species found in the Dharmashala Region, Himachal Pradesh.

Common Name	Scientific Name	Usable Part	Medicinal Uses	Number of Species
Marsh Bryum	<i>Bryum argenteum</i>	Whole Plant	Antimicrobial properties; applied to skin infections and wounds.	~10 species in <i>Bryum</i> genus
Feather Moss	<i>Hypnum cupressiforme</i>	Whole Plant	Used in poultices to reduce inflammation and soothe wounds.	~5 species in <i>Hypnum</i> genus
Haircap Moss	<i>Polytrichum commune</i>	Whole Plant	Diuretic; used for kidney and urinary health, and for inflammation.	~3 species in <i>Polytrichum</i> genus
Sphagnum Moss (Peat Moss)	<i>Sphagnum spp.</i>	Whole Plant	Antiseptic properties; historically used for dressing wounds and infections.	~12 species in <i>Sphagnum</i> genus
Pincushion Moss	<i>Leucobryum glaucum</i>	Whole Plant	Anti-inflammatory; applied as poultice for cuts and wounds.	~4 species in <i>Leucobryum</i> genus
Tree Moss	<i>Climacium dendroides</i>	Whole Plant	Used for skin rashes and irritations due to its soothing properties.	~2 species in <i>Climacium</i> genus
Greater Water Moss	<i>Fontinalis antipyretica</i>	Whole Plant	Traditionally used to reduce fever and inflammation.	~3 species in <i>Fontinalis</i> genus
Funaria (Cord Moss)	<i>Funaria hygrometrica</i>	Whole Plant	Antimicrobial; applied to minor skin infections and burns.	~8 species in <i>Funaria</i> genus
Rock Moss	<i>Grimmia pulvinata</i>	Whole Plant	Believed to have expectorant properties; used for respiratory relief.	~6 species in <i>Grimmia</i> genus
Thuidium Moss	<i>Thuidium delicatulum</i>	Whole Plant	Used in traditional poultices for muscle pain relief and soothing aches.	~7 species in <i>Thuidium</i> genus

Bryophytes play a vital role in traditional medicine for treating minor wounds, inflammations, and certain skin conditions due to their antibacterial and anti-inflammatory

properties. These mosses and liverworts thrive in the cool, moist, and shaded environments typical of the Dharmashala region.



Fig 3 Photographs of Bryophyte Species are recorded in Dharamshala, Dhauladhar Range, Himachal Pradesh

Table 3 List of Pteridophyte (fern and fern-allied) species found in the Dharmashala region, Himachal Pradesh.

Common Name	Scientific Name	Usable Part	Medicinal Uses	Number of Species
Maidenhair Fern	<i>Adiantum capillus-veneris</i>	Fronds	Used for respiratory issues like cough and bronchitis; also has anti-inflammatory properties.	~5 species in <i>Adiantum</i> genus
Rock Brake Fern	<i>Pteris vittata</i>	Whole Plant	Known for absorbing arsenic; traditionally used for skin issues and wound healing.	~4 species in <i>Pteris</i> genus
Male Fern	<i>Dryopteris filix-mas</i>	Rhizome	Used as an anthelmintic to expel worms and for respiratory infections.	~6 species in <i>Dryopteris</i> genus
Shield Fern	<i>Polystichum aculeatum</i>	Rhizome, Fronds	Used to relieve pain and inflammation; rhizomes also used for wound healing.	~3 species in <i>Polystichum</i> genus
Himalayan Bracken Fern	<i>Pteridium aquilinum</i>	Rhizome	Known for antimicrobial properties; used for treating skin infections.	~2 species in <i>Pteridium</i> genus
Bird's Nest Fern	<i>Asplenium nidus</i>	Fronds	Has anti-inflammatory properties; used for wound healing and ulcers.	~7 species in <i>Asplenium</i> genus
Common Horsetail	<i>Equisetum arvense</i>	Stems	Diuretic; used for kidney health, urinary infections, and wound healing.	~3 species in <i>Equisetum</i> genus
Royal Fern	<i>Osmunda regalis</i>	Rhizome, Young Leaves	Rhizome used for gastrointestinal issues; young leaves for skin soothing and wound healing.	~2 species in <i>Osmunda</i> genus
Wall Fern	<i>Asplenium trichomanes</i>	Fronds	Traditionally used for treating coughs and colds; has anti-inflammatory effects.	~7 species in <i>Asplenium</i> genus
Hart's Tongue Fern	<i>Asplenium scolopendrium</i>	Fronds	Used for throat and respiratory infections; also applied for minor skin irritations.	~7 species in <i>Asplenium</i> genus

These pteridophytes have been traditionally used in herbal medicine, often for respiratory, skin, and gastrointestinal treatments, showcasing their utility and abundance in the Dharmashala region's unique ecology.



Fig 4 Photographs of Pteridophyte Species are recorded in Dharamshala, Dhauladhar Range, Himachal Pradesh

Table 4 List of Gymnosperms Species found in the Dharmashala region, Himachal Pradesh

Common Name	Scientific Name	Useful Parts	Medicinal Importance
Himalayan Cedar	<i>Cedrus deodara</i>	Bark, Wood	Antiseptic, antifungal; used for skin ailments and respiratory issues.
Rhododendron	<i>Rhododendron arboreum</i>	Flowers, Leaves	Flowers used to treat diarrhea, leaves for inflammation.
Himalayan Blue Pine	<i>Pinus wallichiana</i>	Resin	Antiseptic; resin used for skin infections, joint pain relief.
Indian Horse Chestnut	<i>Aesculus indica</i>	Seeds, Bark	Seeds used for joint pain, bark for anti-inflammatory properties.
Himalayan Silver Oak	<i>Grevillea robusta</i>	Leaves	Leaves have antioxidant properties; traditional uses in wound healing.
Wild Himalayan Cherry	<i>Prunus cerasoides</i>	Bark	Bark used for cough and bronchitis.
Indian Barberry	<i>Berberis aristata</i>	Stem, Root	Antibacterial, digestive aid; used for skin diseases and eye infections.
Ban Oak	<i>Quercus leucotrichophora</i>	Bark, Leaves	Bark used to treat dysentery; leaves are anti-inflammatory.
Buransh	<i>Rhododendron campanulatum</i>	Flowers, Leaves	Flowers used in heart health; leaves for anti-inflammatory purposes.
Chir Pine	<i>Pinus roxburghii</i>	Resin	Resin used for respiratory issues and as a wound healer.
Indian Gooseberry (Amla)	<i>Phyllanthus emblica</i>	Fruit	Rich in vitamin C; boosts immunity, improves digestion, anti-aging.
Field Mint	<i>Mentha arvensis</i>	Leaves	Leaves aid in digestion, relieve cold symptoms, and have antimicrobial effects.
Himalayan Walnut	<i>Juglans regia</i>	Bark, Leaves, Nuts	Bark for dental care; leaves for skin ailments; nuts rich in nutrients.

Wild Marigold	<i>Tagetes minuta</i>	Flowers, Leaves	Anti-inflammatory; used for wound healing and respiratory relief.
Indian Bay Leaf (Tejpatta)	<i>Cinnamomum tamala</i>	Leaves	Used in digestive disorders, has antibacterial and antifungal properties.
Indian Snakeroot	<i>Rauvolfia serpentina</i>	Root	Known for antihypertensive properties; used in traditional medicine for anxiety.
King Fern	<i>Diplazium glaucum</i>	Leaves	Used traditionally as a diuretic and for skin problems.
Yellow Himalayan Raspberry	<i>Rubus ellipticus</i>	Fruit, Leaves	Fruits rich in antioxidants; leaves used for wound healing.
Indian Spikenard	<i>Nardostachys jatamansi</i>	Root, Rhizome	Calming effects; used in treating insomnia, mental disorders.
Sacred Fig	<i>Ficus religiosa</i>	Bark, Leaves, Latex	Bark for diabetes, leaves for wound healing; latex for digestive health.

Table 5 List of Gymnosperms No. of species within each genus found in the Dharmashala region, Himachal Pradesh

Common Name	Scientific Name	Number of Species
Himalayan Cedar	<i>Cedrus deodara</i>	Single species (<i>Cedrus</i> genus)
Blue Pine	<i>Pinus wallichiana</i>	~5 species in <i>Pinus</i> genus
Yew	<i>Taxus baccata</i>	~3 species in <i>Taxus</i> genus
Juniper	<i>Juniperus communis</i>	~4 species in <i>Juniperus</i> genus
Cypress	<i>Cupressus torulosa</i>	~2 species in <i>Cupressus</i> genus
Indian Fir	<i>Abies pindrow</i>	~4 species in <i>Abies</i> genus
Himalayan Hemlock	<i>Tsuga dumosa</i>	~3 species in <i>Tsuga</i> genus
Chilgoza Pine	<i>Pinus gerardiana</i>	~5 species in <i>Pinus</i> genus



Fig 5 Photographs of Gymnosperm Species are recorded in Dharmashala, Dhauladhar Range, Himachal Pradesh

Table 6 List of Angiosperms No. of species within each genus. found in the Dharmashala region, Himachal Pradesh

Common Name	Scientific Name	Usable Part	Medicinal Uses	Number of Species
Indian Gooseberry	<i>Phyllanthus emblica</i>	Fruit, Leaves	Used as a powerful antioxidant, for immune support, and for digestive health.	~2 species in <i>Phyllanthus</i> genus
Himalayan Maple	<i>Acer caesium</i>	Bark, Leaves	Traditionally used for wound healing and skin disorders.	~3 species in <i>Acer</i> genus
Himalayan Rhododendron	<i>Rhododendron arboreum</i>	Flowers, Leaves	Flowers used for digestive health; leaves used for respiratory issues and fever.	~4 species in <i>Rhododendron</i> genus
Ashwagandha	<i>Withania somnifera</i>	Root, Leaves	Roots used for stress relief and immunity; leaves used in wound healing.	~3 species in <i>Withania</i> genus
Indian Lilac (Neem)	<i>Azadirachta indica</i>	Leaves, Bark, Seeds	Antibacterial, antifungal, and used for skin diseases, dental health, and immunity.	~2 species in <i>Azadirachta</i> genus
Himalayan Blue Poppy	<i>Meconopsis aculeata</i>	Roots, Flowers	Used as an anti-inflammatory and analgesic for pain relief and to treat respiratory ailments.	Single species (<i>Meconopsis</i> genus)
Snake Root	<i>Rauvolfia serpentina</i>	Root	Known for treating hypertension and mental health conditions; used as a sedative.	~3 species in <i>Rauvolfia</i> genus
Brahmi	<i>Bacopa monnieri</i>	Whole Plant	Used as a brain tonic, for memory enhancement, and to reduce anxiety.	~5 species in <i>Bacopa</i> genus
Holy Basil (Tulsi)	<i>Ocimum sanctum</i>	Leaves, Seeds	Used for respiratory and immune health; anti-inflammatory and antioxidant properties.	~4 species in <i>Ocimum</i> genus
Indian Ginseng (Shatavari)	<i>Asparagus racemosus</i>	Root, Leaves	Known for reproductive health and as an adaptogen for stress relief.	~2 species in <i>Asparagus</i> genus

These angiosperms are traditionally used for a variety of medicinal purposes, from immune support and wound healing to stress relief and digestive health. These flowering

plants thrive in the diverse climate and altitude of the Dharmashala region in the Dhauladhar Range.



Fig 6 Photographs of Angiosperm Plant Species are recorded in Dharmashala, Dhauladhar Range, Himachal Pradesh

V. CONCLUSION

The Flora of the Dharamshala Dhauladhar Range in the North-Western Himalayan Region of India reflects a rich mosaic of biodiversity shaped by varied altitudinal gradients, diverse habitats, and unique climatic conditions of the region. This study cataloged the significant floral diversity across subtropical, temperate, and alpine zones, identifying numerous endemic and medicinally valuable plant species. Each vegetation zone—from subtropical forests to alpine meadows—supports a unique assemblage of plant life, contributing to the overall ecological resilience of the Dhauladhar Range.

The research underscores the ecological importance of this flora in soil stabilization, watershed protection, and as a critical habitat for wildlife. Additionally, the deep ethnobotanical knowledge within local communities highlights the cultural and medicinal significance of many plant species, emphasizing the need for sustainable resource management.

However, human-induced pressures, including tourism, deforestation, and the impacts of climate change, pose significant threats to this fragile ecosystem. Conservation efforts are essential to preserve the region's biodiversity and protect vulnerable species, especially in the high-altitude alpine zones where plants are particularly susceptible to environmental changes. Engaging local communities, regulating resource use, and implementing climate adaptation measures will be key to safeguarding the Dharamshala Dhauladhar Range's unique flora.

VI. SUGGESTIONS & FUTURE RESEARCH

➤ Conservation Strategies and Sustainable Management

- **Community Involvement:** Foster partnerships with local communities to promote sustainable harvesting practices, particularly for medicinal plants. Community-led conservation initiatives can ensure that local knowledge and cultural practices are respected while supporting biodiversity.
- **Protected Areas:** Designate more protected zones within the Dhauladhar Range, especially in regions of high endemism and vulnerability, such as alpine meadows. Implementing legal protections can prevent habitat loss and curb human encroachment.
- **Tourism Regulation:** Develop guidelines to manage eco-tourism sustainably, including designated trails, waste management, and controlled access to sensitive areas. This can reduce the ecological footprint of tourism in the region.

➤ Climate Change Adaptation and Monitoring

- **Climate-Sensitive Species Study:** Initiate long-term monitoring of climate-sensitive species, particularly in subalpine and alpine zones, to track their response to temperature and precipitation changes. Understanding species adaptation can guide climate resilience efforts.

- **Seed Banks and Ex-situ Conservation:** Establish regional seed banks for endangered and climate-sensitive species, preserving genetic diversity and providing options for reintroduction if populations decline. Ex-situ conservation facilities can also serve as educational resources for local communities and tourists.

➤ Research on Ecological Interactions and Ecosystem Services

- **Pollinator Studies:** Investigate plant-pollinator interactions within different vegetation zones to understand the ecological services provided by native plants, which can guide conservation efforts for both plants and pollinators.
- **Soil and Water Studies:** Conduct research on the role of vegetation in soil stabilization, erosion prevention, and water retention. This information can be valuable in developing land management strategies to preserve watershed health.

➤ Detailed Ethnobotanical Studies

- **Documentation of Traditional Knowledge:** Conduct more extensive ethnobotanical surveys to capture traditional uses of local flora, documenting medicinal, edible, and cultural applications. This can help preserve local knowledge and inform sustainable management practices.
- **Economic Potential of Medicinal Plants:** Research the economic viability of cultivating medicinal plants in controlled environments. Controlled cultivation could reduce pressure on wild populations and provide income opportunities for local communities.

➤ Biodiversity and Genetic Studies

- **Genetic Diversity Assessments:** Perform genetic diversity studies of key endemic and threatened species to understand their adaptability and resilience, providing a basis for targeted conservation measures.
- **Invasive Species Monitoring:** Identify and monitor the spread of invasive plant species, which can threaten native biodiversity. Early detection and control measures can prevent invasive species from destabilizing local ecosystems.

➤ Future Research Directions:

Future research in the Dharamshala Dhauladhar Range should focus on understanding the impacts of climate change on altitudinal vegetation shifts, species migration, and ecosystem stability. Studies investigating adaptive mechanisms of alpine flora under changing climatic conditions, coupled with remote sensing and GIS-based monitoring of vegetation dynamics, can offer insights into long-term conservation needs. Additionally, exploring the socio-economic aspects of biodiversity conservation, including community-based ecotourism and sustainable harvesting practices, will be essential to achieve a harmonious balance between conservation and livelihood needs. In summary, sustained research efforts, policy

support, and community engagement are essential for the preservation of the Dhauladhar Range's unique flora. These measures will not only enhance scientific understanding but also contribute to the ecological integrity and cultural heritage of this vital Himalayan region.

ACKNOWLEDGEMENT

The Authors are highly thankful to Sri. Jitender, Officiating Mountaineering incharge of Regional Mountaineering Centre, Dharmashala. A unit of Atal Bimanshu Vajpayee Institute of Mountaineering & allied sports, Manali, Himachal Pradesh for Providing accommodation, Valuable Suggestions for this research study & required tools, along with NSS Volunteers and instructors within the part of National Adventure Training Camp, at Dharmashala, Dhauladhar Range, Himachal Pradesh.

REFERENCES

- [1]. Bhatt, D., & Joshi, S. (2020). Floral Diversity in the Western Himalayas: A Comprehensive Study on Vegetation Zones and Ecological Variations. *Journal of Himalayan Ecology*, 12(4), 215–232.
- [2]. Chauhan, N. S. (1999). *Medicinal and Aromatic Plants of Himachal Pradesh*. Indus Publishing, New Delhi, India.
- [3]. Singh, G., & Rawat, G. S. (2012). Patterns of Plant Diversity and Conservation Status in the
- [4]. Kala, C. P. (2005). Ethnobotany and Conservation of Plant Diversity in the Himalayas: The Case of Himachal Pradesh. *Environmental and Sociological Perspectives*, 3(2), 101–112.
- [5]. Samant, S. S., & Dhar, U. (1997). Diversity, Endemism, and Economic Potential of Wild Edible Plants in Indian Himalaya. *International Journal of Sustainable Development & World Ecology*, 4(3), 179–191.
- [6]. Sharma, P., & Rai, S. C. (2014). Impacts of Tourism on Flora and Fauna in the Kangra Valley, Himachal Pradesh. *Mountain Research and Development*, 34(2), 139–147.
- [7]. Botanical Survey of India (BSI). (2021). *Flora of Himachal Pradesh*. BSI Reports, Vol. 8.
- [8]. Rawat, Y. S., & Uniyal, S. K. (1993). Impact of Climate and Altitudinal Gradients on Plant Distribution in the Northwestern Himalayas. *Biodiversity and Conservation*, 2(2), 145–158.
- [9]. Forest Research Institute (FRI). (2020). *Himalayan Flora Database*. FRI Publications, Dehradun, India.
- [10]. IUCN Red List of Threatened Species (2023). *Flora of the Indian Himalayas*. Retrieved from IUCN.org
- [11]. Kumar, P., & Sharma, R. (2015). Biodiversity and Conservation in the Indian Himalaya: A Focus on Medicinal Plants. *Himalayan Ecology and Development*, 15(2), 87–102.
- [12]. Bhandari, M. M. (1986). *Flora of the Indian Himalayas: A Comprehensive Guide to the Vascular Plants of the Region*. Vol. 1. Botanical Survey of India, Calcutta.
- [13]. Bhatt, A., & Kumar, S. (2017). Impact of Climate Change on Himalayan Biodiversity: A Review. *Environmental Science and Policy*, 75, 96–106.
- [14]. Gaur, R. D., & Sharma, R. C. (2002). Ethnobotanical Studies of the Dhauladhar Range in Himachal Pradesh. *Ethnobotany Journal*, 14(1), 59–66.
- [15]. Pal, A., & Singh, K. (2016). Flora and Ethnobotanical Uses of Plants in the Dhauladhar Region of Himachal Pradesh. *Journal of Ethnobiology and Ethnomedicine*, 12, Article 9.
- [16]. Ministry of Environment, Forest and Climate Change, Government of India. (2019). *State of Forest Report 2019*. Forest Survey of India.
- [17]. Biodiversity Conservation and Research Institute. (2018). *Biodiversity of the Western Himalayas: Conservation Needs and Strategies*. BCRI Publications.
- [18]. Kumar, A., & Bhattacharyya, A. (2011). Impact of Land Use Change on Flora and Fauna in the Western Himalayas. *Journal of Environmental Management*, 92(6), 1676–1684.
- [19]. Singh, J., & Bansal, A. (2013). Assessment of Floral Diversity in Himachal Pradesh: A Case Study of Dhauladhar Range. *Journal of Himalayan Studies*, 5(1), 29–37..
- [20]. Plant Resources of the Himalayas (PROH) Database. (2020). Retrieved from Himalayan Biodiversity
- [21]. Bhagwan, R., & Sharma, R. K. (2018). Flora of Himachal Pradesh: A Comprehensive Study of the Vascular Plants of the Region. *Himalayan Ecology and Development*, 18(1), 1–20.
- [22]. Chandra, K., & Bansal, R. (2021). Diversity and Conservation Status of Medicinal Plants in the Dhauladhar Range. *Journal of Medicinal Plants Studies*, 9(3), 77–83.
- [23]. Sharma, C. M., & Sharma, S. K. (2014). Conservation of Endangered Plant Species in the Indian Himalayas. *Biodiversity and Conservation*, 23(12), 3033–3048.
- [24]. Mishra, A., & Dhanai, A. (2017). Floral Diversity and Conservation Strategies in the Indian Himalayas: A Review. *Journal of Biodiversity and Conservation*, 6(2), 45–56.
- [25]. Kumar, A., & Singh, S. (2019). Impact of Climate Change on Biodiversity in the Himalayan Region: A Case Study of the Dhauladhar Range. *Environmental Science and Policy*, 102, 55–63.
- [26]. Nandi, D., & Chaudhary, P. (2016). Floral and Faunal Diversity in the Dhauladhar Biosphere Reserve: A Study of Its Ecological Importance. *International Journal of Ecology and Environmental Sciences*, 42(1), 35–48.
- [27]. Kaur, R., & Singh, J. (2020). Ethnobotanical Importance of Flora in the Western Himalayas: A Study of Local Practices. *Journal of Ethnobiology and Ethnomedicine*, 16, Article 12.
- [28]. Jha, A. K., & Bhatt, S. (2015). Assessment of Plant Diversity and Conservation Needs in the Himalayan Region: A Case Study of Himachal Pradesh. *Asian Journal of Plant Sciences*, 14(1), 35–42.

- [29]. Prakash, A., & Rawat, G. S. (2013). Floral Composition and Diversity in the Dhauladhar Range, Himachal Pradesh. *Indian Journal of Forestry*, 36(2), 233-240.
- [30]. Zuhair, M., & Sharma, N. (2022). Conservation of Medicinal Plants in the Dhauladhar Range: Challenges and Opportunities. *Journal of Biodiversity and Environmental Sciences*, 11(3), 1-10.