Traditional indigenous values of ethno-botanical plants preserved in selected sacred groves of the Almora District (Western Himalayas), Uttarakhand, India

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Research

Abstract

Background: The current study primarily focused on documentation and identification of ethno-botanical plants utilized by local inhabitants in sacred groves of the Kumaon Himalayas. These plants are traditionally used by the indigenous communities of the region to treat various ailments.

Methods: The present study is based on extensive and frequent field surveys conducted in sacred groves of the Kumaon Himalayas. The respondents were interviewed using a semi-structured questionnaire and group discussions. Microsoft Excel was used for the analysis of the collected data.

Results: A total of 70 traditionally used ethno-botanical plant species belonging to 64 genera and 41 families were identified in the present study. Asteraceae was the most predominant family in the study area, followed by Fabaceae and Rosaceae. Sixty medicinal plant species are utilized to cure 19 major ailments. Different plant components, including leaves (53%), roots (27%), and bark (8%), are known to be utilized for treating various illnesses.

Conclusions: The impact of modernization and growing disbelief in traditional value systems among the young generation has impacted the preservation of sacred groves. Sacred groves are home to many wild but valuable plant species and play a significant role in restoring the original germplasm of the species. Understanding the traditional knowledge system of residents and communities in the Himalayan region could help and promote conservation practices for the sustainable use of medicinal species.

Keywords: Ailments, Conservation, Indigenous people, Sacred groves, Traditional knowledge

Background

Kumaon Himalaya has a long history of traditional medicinal practices, and the region is renowned for its extensive diversity of natural and cultural life forms. The inhabitants of the Himalayas are closely bonded to the natural world. People use plants for medicine, fruit, fuel, fodder, recreational and other purposes. Due to their spiritual significance, some plants are full-fledged in sacred groves and worshipped by local inhabitants. They are believed to have Gods in them and are therefore known for their synonyms. More than two-thirds of people living in villages and remote hilly areas rely on natural products to meet their needs for medicinal remedies, food, fodder, timber, and many more things. Multiple diseases are treated by communities utilizing various medicinal plants (Kala, 2000; Bisht *et al*., 2013). It has long been known that certain Himalayan plant species are used as medicines. Currently, more than 1748 ethno-medicinal plants from the Indian Himalaya region have been identified (Samant *et al*., 1998; Dimri and Kumar, 2024; Sharma *et al*., 2024). Currently, since ancient times, ethno-botany has become a significant field of study that emphasizes the benefits of various plant species and their qualities, such as medicine, food, and other purposes (Allen and Allen, 1990; Cotton 1997; Anand *et al*., 2023; Banerjee, 2024). In traditional societies, local cultures are sustained by their close linkages to the natural world, which serves as a driving force behind the sustainable management of natural resources (Rist *et al*., 2003). Worship and managing nature play important roles in influencing how people view sacred conservation and sustainable resource use. By maintaining sacred groves, local people protect specific plant species in a desired piece of land. According to their religious faiths, they preserve specific vegetation in their natural habitat. Vegetation patches known as sacred groves are well known for being preserved by local communities and serve as outstanding examples of in-situ biodiversity conservation.

The customary knowledge of medicinal plants has gained worldwide acceptance over the past few decades. According to the WHO, 80% of people in developing nations practice traditional medicines (Cotton, 1997; Adedeji *et al*., 2023; Birhan *et al*., 2023; Derso *et al*., 2024). Vedic literature, particularly the Susruta Samhita, Rigveda and Charak Samhita, provides vast knowledge of traditional herbal medicine. This practice represents India's rich cultural and medicinal legacy (Semwal *et al*., 2020). Remote hill communities have knowledge and expertise in folk treatments that should be documented and researched for use in contemporary drug therapy. Traditional medicine is the intelligent use of indigenous knowledge that has benefited the impoverished and saved of a region’s lives. Many plants are used in different ways depending on the type of ailment. Most plant species are mixed with other herbs in precise ratios rather than being utilized on their own. The majority of decoctions are created by simply crushing plant materials, whereas others are formed by boiling water from specific plant parts. These decoctions were decanted and cooled before oral intake. Some decoctions are applied directly to body parts or injuries afflicted with some ailments.

Currently the significance of indigenous knowledge for the locals and the role of sacred groves in sustainable forests conservation especially as modernization reshape the traditional society and landscape. Indigenous knowledge developed over centuries, is an invaluable resource for conserving biodiversity, providing insights into sustainable practices and species management that support ecological balance. Sacred groves protected by cultural or religious beliefs serve as vital conservation spaces, preserving unique biodiversity and offering refuge for rare plant species. As modernization accelerates, incorporating indigenous wisdom and respecting sacred groves can bridge traditional conservation with modern environmental needs, fostering sustainable solutions that support both ecological and community. Various sites selected for the present study was still not documented and are new to study. Also, the indigenous knowledge of various sites was still not documented. Keeping in mind the popularity of sacred groves and the significance of using local flora in traditional health care system, the present study was designed to document the plant species and traditional unknown wisdom of locals who consume these wild resources for various purposes in Kumaon region of Uttarakhand, India.

Materials and Methods

Study area

Almora is a hilly region located in the Kumaon Division of Uttarakhand. The Almora district is located between latitudes 29°30' and 30°20'N and longitudes 79°20' and 80°20'E. The district is bordered to the east by Pithoragarh, to the west by Garhwal Division, to the north by Bageshwar, and to the south by Nainital. The Almora district extends 46 km north to south and 86 km east to west. The study area of the Almora district as a whole is 3139 square km. It is situated at an elevation of 1,604 m (5,262 ft) amsl. Figure 1 is the map showing various locations of sacred groves in Almora, a district in the Indian state of Uttarakhand. These groves are distributed across the mountainous terrain of Almora at different elevations. District Almora is renowned for its deep cultural and spiritual history, as well as for its stunning scenery, handicrafts, and cuisine. It serves as a significant hub for the art and culture of the Kumaon region. The main occupations of people living in different villages of the district are agriculture, labour, dairy, horticulture, government services and others.

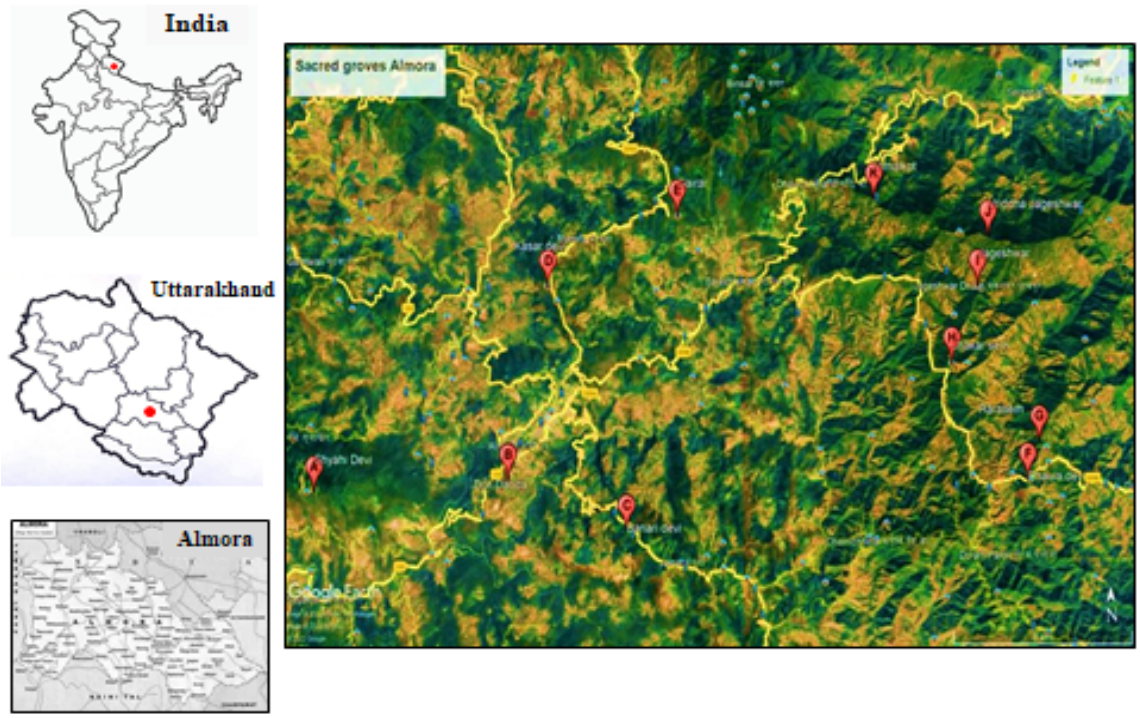

Figure 1. Map of the study area, red points marked showing the study sites in Almora district of Uttarakhand

Climate

The climate of this region ranges from subtropical to moderate. Almora receives heavy rainfall during the monsoon season, which lasts from July to September. The highest rainfall typically occurs in July, with an average of 797 mm (climate data; weather atlas). The temperature in Almora varies significantly throughout the year. May to June is the warmest period, with temperatures ranging from 22°C to 31°C (Weather Atlas). During the monsoon season (July to September), temperatures are milder, averaging between 21°C and 25°C (travel triangle. com). The weather remains pleasant from October to November (autumn), with temperatures ranging from 14°C to 24.5°C in October and from 14°C to 21.8°C in November (e Uttaranchal). Winters (December to February) are cold, with temperatures often dropping to 5°C or lower. Snowfall in Almora is primarily observed from December to February, with the heaviest snowfall typically occurring in January (e Uttaranchal; travel triangle. com).

Description of study sites

The geo-locations of all the research sites, i.e., sacred groves, are shown on the map of the Almora district. For the purpose of the present investigation, 11 sacred groves located in various blocks of the Almora district were selected on the basis of their altitudinal distribution, area and forest type for the study of ethno-botanical knowledge of the communities living in Kumaon Himalaya (Table 1).

Table 1. Geographical data of the research study sites

S. No.	Name of sacred grove	Latitude	Longitude	Altitude (m asl)	Area (hectares)
1	Banari Devi	29°33’39.3”N	79°41’41.4"E	2081	4 to 5
2	Dhaula Devi	29°34'27.57"N	79°52'24"E	1917	1 to 2
3	Doli Danda	29°34'40.3"N	79°38'29.2"E	1644	2 to 3
4	Gairar	29°39’51”N	79°43’10”E	1769	2 to 3
5	Jageshwar	29°38’15”N	79°51’6” E	1801	3 to 4
6	Jhakar Sem	29°36’47.2” N	79°50’23.4”E	2014	1 to 2
7	Kasar Devi	29°38’29”N	79°39’42”E	2116	1 to 1.5
8	Rarasem	29°35'12"N	79°52'41"E	2058	1 to 1.5
9	Shyahi Devi	29°34'34"N	79°33'27.4"E	2192	5 to 6
10	Vimalkot	29°40'03”N	79°48'24"E	2200	2 to 3
11	Vriddha Jageshwar	29°39'14.6"N	79°51'22.5"E	2178	1 to 2

Data collection and extensive surveys

The present study is based on extensive and frequent field surveys conducted in the sacred groves of the Almora district. This work was designed to collect, identify and record the ethno-botanical plant diversity of sacred groves located in the hilly regions of the district. Dehydration of the plants for the preparation of plant specimens was performed with the help of traditional techniques using blotting papers and herbarium presses. The collected herbarium specimens were identified with the help of various floras and the relevant literature (Duthie, 1960; Gaur, 1999). The voucher specimens with codes assigned to the herbarium were deposited at Gurukula Kangri (Deemed to be University), Haridwar, Uttarakhand, where suitable accession numbers were assigned.

Ethnobotanical survey

Several field visits and village surveys were done using semi-structured questionnaires, target interviews, and visual interpretation. Ethnobotanical surveys were conducted from December 2022 to January 2024. Total 55 respondents including *vaids*, local traditional healers and knowledgeable elderly persons were selected for the survey study with respect to the utilization of plant species for various ethno-botanical purposes of which 33 were males and 22 were females. Using the questionnaire, specific ethno-botanical information was gathered from the local people. The information collected were related to socio-demographic profile of informants (gender, age, education level, profession), medicinal plants with their part used and corresponding diseases treated, mode of preparation of the traditional herbal formulation, origin of knowledge (acquired, bequeathed, by experience), ethno-botanical plants and related information (parts used, ethno-botanical uses). The plants were collected and identified to study their ethno-botanical properties. The Informed consent has been obtained from the participant during this study.

Results

Socio-demography of the informants

The age group of the informants varied between 31 and 81 years, although most of them were between 60 and 80 years of age. The majority of the respondents were over 60 years old (49%), with the 40-60 years age group (45%) being the second most represented and the 20-40 years age group (5%) being the least represented (Table 2). Older people (35.2%) had more traditional ethno-botanical knowledge than younger people (30.7%). Senior citizens had better ethno-botanical knowledge and awareness of indigenous medicinal plants than young citizens. Highest number of informants that were 27 respondents belonging to age group of more than 60 years and informed about the plants having various ethno-botanical uses. There were more male respondents (60%) than female respondents (40%); however, females (51.06%) had more traditional knowledge of ethno-botanical species than males (48.93%).

Table 2. Demographic profile of informants

Variable	Gender		Age (in years)		
Categories	Male	Female	20-40	40-60	above 60
No. of participants	33	22	3	25	27
Percentage (%)	60	40	5.45	45.45	49.09

Medicinal plants recorded in the study sites

Ethnobotanical knowledge was gathered from all age groups of informants inhabiting and around the sacred groves. The most information on approximately 50 plant species was gathered from Vimalkot, followed by Banari Devi and Shyahi Devi sacred groves, with 44 and 41 plant species, respectively (Figure 2). This was because these research sites were dominated by elderly people who had deep knowledge and vast experience coupled with good explanatory techniques. This visual representation helps in understanding the distribution of medicinal knowledge across these locations. Knowledge of the number of plant species varies significantly across the different study sites. Starting from Doli Danda, which has approximately 20 species, there was a gradual increase at the other sites. Notably, sites such as Shyahi Devi, Banari Devi, and Vimalkot show greater knowledge, peaking at approximately 40 species. This indicates that in these areas, more plant species were utilized by local communities than by other sites.

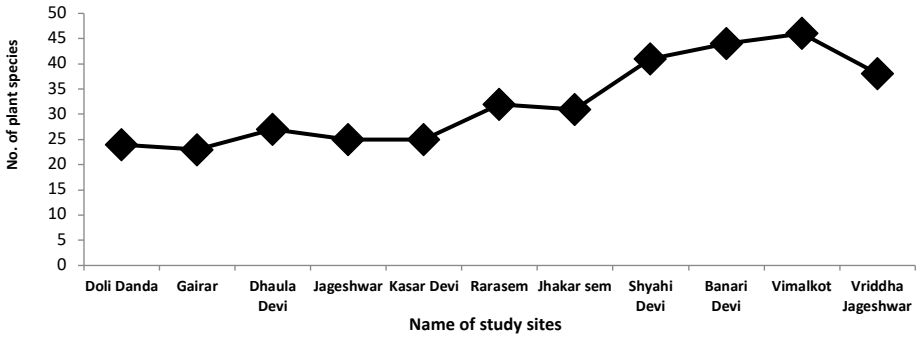

Figure 2. Knowledge richness on plant species across study sites in the study area

Ethnobotanical Plant Diversity and its Utilization Pattern

The present study revealed 70 plant species of ethno-botanical importance, representing 64 genera, 41 families and 30 orders (Table 1). There were 19 species of trees, 36 of herbs and 15 of shrubs. The Asteraceae, Fabaceae, Rosaceae, Fagaceae, Lamiaceae and Acanthaceae families dominate the sacred groves of Kumaon Himalaya, representing the greatest number of ethnobotanical plant species (Figure 3). This suggests significant diversity within these families, which is consistent with their well-documented adaptability and ecological niches. Families such as Cannabaceae and Betulaceae exhibit lower frequencies, indicating a narrower ecological range or fewer species within these families in the studied region. This disparity in family representation could be attributed to various ecological or anthropogenic factors, warranting further investigation into specific adaptive traits or conservation status.

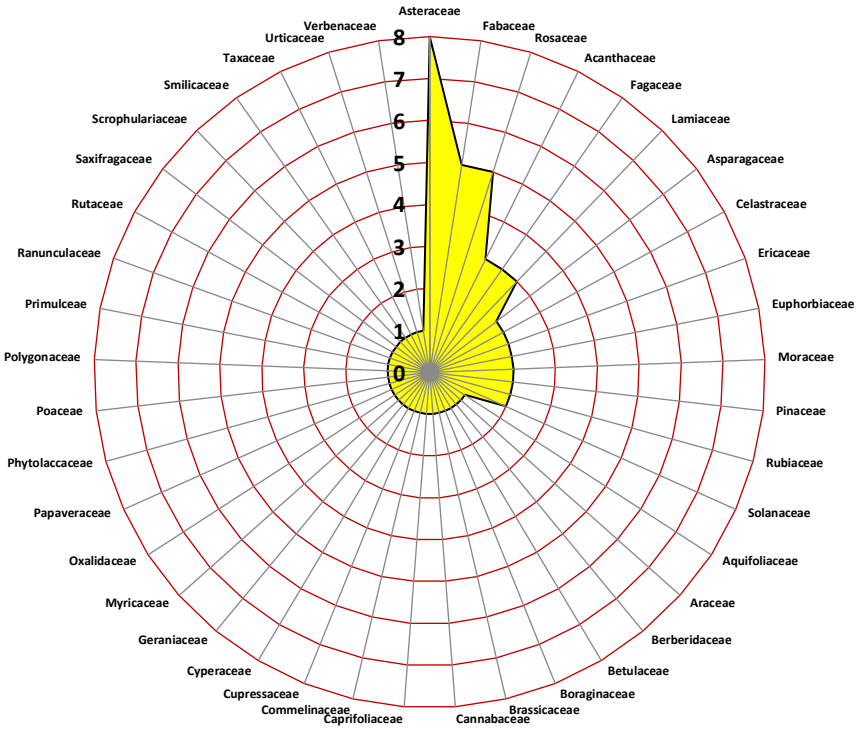

Figure 3. Distribution of plant taxa in each family utilized for various ethno-botanical purposes in the study area

The genus *Quercus* had the greatest number of ethno-botanical species (3 species), followed by *Desmodium*, *Erigeron*, *Ficus* and *Solanum* (2 species). The number and distribution of various genera and species of ethno-botanical plants differ among sacred groves located at different altitudes. The traditional ethno-botanical knowledge varied from one sacred grove to another. The traditional knowledge of 16 ethno-botanical species, i.e., *Ageratina adenophora, Artemisia vulgaris, Berberis asiatica, Cedrus deodara, Cynodon dactylon, Myrica esculenta, Pinus roxburghii, Pyracantha crenulata, Pyrus pashia, Quercus leucotrichophora, Rhododendron arboreum, Ricinus communis, Rubus ellipticus, Rumex hastatus, Urtica dioica* and *Zanthoxylum armatum,* was recorded from nearly all the sacred groves. This indicates their adaptability and possibly their dominant role in local ecosystems. The traditional ethno-botanical knowledge of eight ethno-botanical species was recorded

from different but single sacred groves, hinting at unique ecological requirements or possibly recent introductions in those areas (Table 3). Out of the 70 species present in the sacred groves, 4 species, i.e., *Ficus auriculata*, *Pyrus pashia*, *Taxus baccata*, and *Zanthoxylum armatum*, were cultivated by the local villagers of the area, whereas 63 species were grown as wild plants, and 3 species, i.e., *Acacia dealbata*, *Cannabis sativa*, and *Ricinus communis,* were found in both cultivated and wild forms.

Table 3. List of ethno-botanical plant species recorded from the study area along with their family, voucher number and their presence in various sacred groves of Kumaon Himalaya

Botanical Name (Family)	**Voucher No.**	**Banari Devi**	**Dhaula Devi**	**Doli Danda**	**Gairar**	**Jageshwar**	**Jhakar Sem**	**Kasar Devi**	**Rarasem**	**Shyahi Devi**	**Vimalkot**	**Vriddha Jageshwar**
Acacia dealbata Link. (Fabaceae)	GKV/BOT.MIC/115	-	-	-	+	-	-	-	-	-	-	-
Agave cantala (Haw.) Roxb. ex Salm-Dyck (Asparagaceae)	GKV/BOT.MIC/68	-	-	+	-	-	-	-	-	+	-	+
Ageratina adenophora (Spreng.) R.M. King & H. Rob. (Asteraceae)	GKV/BOT.MIC/87	+	+	+	+	+	+	+	+	+	+	+
Ageratum houstonianum Mill. (Asteraceae)	GKV/BOT.MIC/52	+	+	-	-	+	+	-	+	+	-	+
Ajuga bracteosa Wall. Ex Benth. (Lamiaceae)	GKV/BOT.MIC/116	-	-	-	-	+	-	-	-	-	-	-
Alnus nepalensis D. Don (Betulaceae)	GKV/BOT.MIC/75	-	-	-	-	-	+	-	-	-	-	+
Anaphalis contorta (D. Don) Hook.f. (Asteraceae)	GKV/BOT.MIC/61	-	-	-	-	-	-	-	-	-	+	+
Argemone mexicana L. (Papaveraceae)	GKV/BOT.MIC/88	-	-	+	-	-	-	-	-	-	+	+
Arisaema jacquemontii Blume (Araceae)	GKV/BOT.MIC/03	-	-	+	+	-	-	-	-	-	+	-
Artemisia vulgaris L. (Asteraceae)	GKV/BOT.MIC/28	+	+	+	+	+	+	+	+	+	+	+
Asparagus adscendens Willd. (Asparagaceae)	GKV/BOT.MIC/71	+	-	-	+	-	+	-	-	+	+	-
Berberis asiatica Roxb. ex DC. (Berberidaceae)	GKV/BOT.MIC/79	+	+	+	+	+	+	+	+	+	+	+
Bergenia ciliata (Haw.) Sternb. (Saxifragaceae,)	GKV/BOT.MIC/25	+	-	+	+	+	+	+	-	-	+	-
Bidens pilosa L. (Asteraceae)	GKV/BOT.MIC/21	+	+	-	-	+	+	-	-	-	-	-
Boenninghausenia albiflora (Hook.) Rchb. ex Meisn. (Rutaceae)	GKV/BOT.MIC/150	-	-	-	-	-	-	-	-	-	-	+
Cannabis sativa L. (Cannabaceae)	GKV/BOT.MIC/104	+	-	+	-	+	-	+	+	+	-	-
Cedrus deodara (Roxb. ex D. Don) G. Don (Pinaceae)	GKV/BOT.MIC/80	+	+	+	+	+	+	+	+	+	+	+
Cirsium verutum (D. Don) Spreng. (Asteraceae)	GKV/BOT.MIC/113	+	+	-	-	-	-	-	+	-	-	-

Oplismenus compositus (L.) P. Beauv. (Poaceae)	GKV/BOT.MIC/98	+	+	-	-	+	-	-	-	+	+	+
Platycladus orientalis L. (Cupressaceae)	GKV/BOT.MIC/85	-	-	-	-	+	+	+	+	-	-	-
Cynodon dactylon (L.) Pers. (Poaceae)	GKV/BOT.MIC/05	+	+	+	+	+	+	+	+	+	+	+
Cynoglossum lanceolatum Forssk. (Boraginaceae)	GKV/BOT.MIC/04	+	+	-	-	-	-	-	+	-	+	-
Cyperus niveus Retz. (Fabaceae)	GKV/BOT.MIC/112	-	-	-	-	-	-	-	-	-	+	+
Desmodium heterocarpon (L.) DC. (Fabaceae)	GKV/BOT.MIC/08	+	-	-	-	-	-	-	-	+	+	-
Desmodium microphyllum (Thunb.) DC. (Acanthaceae)	GKV/BOT.MIC/02	+	-	+	+	-	+	-	-	-	+	+
Dicliptera bupleuroides Nees (Acanthaceae)	GKV/BOT.MIC/24	+	-	-	-	-	-	-	-	-	-	-
Erigeron bonariensis L. (Asteraceae)	GKV/BOT.MIC/92	-	-	-	-	-	-	-	-	+	+	-
Erigeron karvinskianus DC. (Celastraceae)	GKV/BOT.MIC/42	-	-	-	-	-	+	-	+	-	+	-
Euonymus lucidus D. Don (Celastraceae)	GKV/BOT.MIC/140	+	-	-	-	-	-	-	+	+	+	+
Euphorbia pilosa L. (Euphorbiaceae)	GKV/BOT.MIC/07	+	-	+	+	+	+	+	-	+	+	-
Ficus auriculata Lour. (Moraceae)	GKV/BOT.MIC/152	-	-	+	-	-	-	-	-	+	-	-
Ficus palmata Forssk. (Moraceae)	GKV/BOT.MIC/125	+	-	-	-	-	-	-	-	+	-	+
Flemingia strobilifera (L.) W.T. Aiton (Fabaceae)	GKV/BOT.MIC/30	-	-	-	-	-	-	-	+	+	-	-
Fragaria vesca L. (Rosaceae)	GKV/BOT.MIC/14	+	-	-	-	-	+	+	+	-	+	-
Galium aparine L. (Rubiaceae)	GKV/BOT.MIC/11	+	+	-	-	-	-	-	-	+	+	-
Geranium nepalense Sweet (Geraniaceae)	GKV/BOT.MIC/111	-	-	-	+	-	-	+	-	-	-	-
Ilex dipyrena Wall. (Aquifoliaceae)	GKV/BOT.MIC/147	-	-	-	-	-	-	-	-	-	-	+
Indigofera heterantha Wall. ex Brandis (Fabaceae)	GKV/BOT.MIC/107	-	-	-	-	-	-	-	-	+	-	+
Lantana camara L. (Verbenaceae)	GKV/BOT.MIC/105	+	-	-	-	+	-	-	-	+	+	+
Lepidium virginicum L. (Brassicaceae)	GKV/BOT.MIC/151	-	-	-	-	-	-	-	-	-	+	-
Lonicera quinquelocularis Hardw. (Caprifoliaceae)	GKV/BOT.MIC/137	-	-	-	-	-	-	-	-	+	-	-
Lyonia ovalifolia (Wall.) Drude (Ericaceae)	GKV/BOT.MIC/69	+	-	-	-	-	-	-	-	+	+	+
Micromeria biflora (Buch.-Ham. ex D.Don) Benth. (Lamiaceae)	GKV/BOT.MIC/23	+	-	-	-	-	-	-	-	-	+	-
Myrica esculenta Buch.-Ham. ex D.Don (Myricaceae)	GKV/BOT.MIC/81	+	+	+	+	+	+	+	+	+	+	+

Myrsine africana L. (Primulceae)	GKV/BOT.MIC/74	-	-	-	-	-	-	-	-	+	-	-
Oxalis latifolia Kunth (Oxalidaceae)	GKV/BOT.MIC/114	+	-	-	-	-	+	-	-	-	+	+
Phytolacca acinosa Roxb. (Phytolaccaceae)	GKV/BOT.MIC/13	-	-	-	-	-	+	-	-	+	-	-
Pinus roxburghii Sarg. (Pinaceae)	GKV/BOT.MIC/83	+	+	+	+	+	+	+	+	+	+	+
Pyracantha crenulata (D. Don) M. Roem. (Rosaceae)	GKV/BOT.MIC/86	+	+	+	+	+	+	+	+	+	+	+
Pyrus pashia Buch.-Ham. ex D. Don (Rosaceae)	GKV/BOT.MIC/82	+	+	+	+	+	+	+	+	+	+	+
Quercus floribunda Lindl. ex A. Camus (Fagaceae)	GKV/BOT.MIC/22	+	-	-	-	-	-	-	-	+	+	+
Quercus leucotrichophora A. Camus (Fagaceae)	GKV/BOT.MIC/84	+	+	+	+	+	+	+	+	+	+	+
Quercus semecarpifolia Sm. (Fagaceae)	GKV/BOT.MIC/31	+	-	-	-	-	-	+	+	+	+	-
Rhododendron arboreum Sm. (Ericaceae)	GKV/BOT.MIC/77	+	+	+	+	+	+	+	+	+	+	+
Ricinus communis L. (Euphorbiaceae)	GKV/BOT.MIC/153	+	+	+	+	+	+	+	+	+	+	+
Rosa moschata Herrm. (Rosaceae)	GKV/BOT.MIC/130	+	-	-	-	-	+	+	-	-	-	-
Rubia cordifolia L. (Rubiaceae)	GKV/BOT.MIC/118	+	-	-	-	-	-	-	-	+	-	-
Rubus ellipticus Sm. (Rosaceae)	GKV/BOT.MIC/78	+	+	+	+	+	+	+	+	+	+	+
Rumex hastatus D. Don (Polygonaceae)	GKV/BOT.MIC/40	+	+	+	+	+	+	+	+	+	+	+
Smilax aspera L. (Smilicaceae)	GKV/BOT.MIC/72	-	+	-	-	-	-	-	-	-	+	+
Solanum nigrum L. (Solanaceae)	GKV/BOT.MIC/120	+	-	-	-	-	-	-	+	-	+	-
Solanum viarum Dunal (Solanaceae)	GKV/BOT.MIC/109	+	+	-	-	-	+	+	+	+	-	+
Strobilanthes angustifrons C.B. Clarke (Acanthaceae)	GKV/BOT.MIC/35	-	-	-	-	-	-	-	+	+	+	+
Taraxacum officinale Weber ex F.H. Wigg. (Asteraceae)	GKV/BOT.MIC/18	-	-	-	-	-	-	-	+	-	+	-
Taxus baccata L. (Taxaceae)	GKV/BOT.MIC/123	-	+	-	-	-	-	-	+	-	-	-
Thalictrum foliolosum DC. (Ranunculaceae)	GKV/BOT.MIC/129	+	+	-	-	-	-	-	-	+	+	+
Thymus mongolicus (Ronniger) Ronniger (Lamiaceae)	GKV/BOT.MIC/66	-	+	-	-	-	+	-	-	-	+	+
Urtica dioica L. (Urticaceae)	GKV/BOT.MIC/63	+	+	+	+	+	+	+	+	+	+	+
Verbascum thapsus L. (Scrophulariaceae)	GKV/BOT.MIC/12	+	-	-	-	-	-	-	+	-	+	-
Zanthoxylum armatum DC. (Cyperaceae)	GKV/BOT.MIC/122	+	+	+	+	+	+	+	+	+	+	+

Table 4 provides a list of plants recorded from the research sites utilized by the local inhabitants along with their scientific names, local names, habit, plant parts used and their ethno-botanical importance. The majority of plants are herbs, followed by shrubs and trees, indicating a preference for smaller plants in traditional medicine, possibly due to easier accessibility and faster growth. Some plants serve additional purposes such as dyeing, fodder, fuel-wood and ornamental uses, showcasing their multifaceted roles in local economies and lifestyles. Plants like *Berberis asiatica* (Kilmora), *Bergenia ciliata* (Silphora), *Cannabis sativa* (Bhang), *Myrica esculenta* (Kaphal), *Pyracantha crenulata* (Ghingharu), *Rubus ellipticus* (Hisalu) are noted for both medicinal and edible uses, underscoring their dual cultural significance in religious rituals and traditional medicine. Plants such as *Cedrus deodara* (Devdar) and *Cynodon dactylon* (Dooba) are used ritually, highlighting the cultural and spiritual dimensions of certain species in local traditions.

Table 4. Ethno-botanical plants with scientific and local name, habit, part used and their importance

Scientific name	Local Name	Habit*	Plant part used	Ethno-botanical Importance
Acacia dealbata Link.	Khair	T	Bark	Medicinal importance
Agave cantala (Haw.) Roxb. ex Salm-Dyck	Rambans	S	Leaves	Medicinal importance
Ageratina adenophora (Spreng.) R.M. King & H.Rob.	Kala basa	S	Leaves	Medicinal importance
Ageratum houstonianum Mill.	Visadodi	H	Leaves	Medicinal importance
Ajuga bracteosa Wall. ex Benth.	Nilkanthi	H	Leaves	Medicinal importance
Alnus nepalensis D. Don	Utis	T	Bark, Wood	Medicinal importance, Miscellaneous (For packing boxes)
Anaphilis contorta (D. Don) Hook. f.	Bhukiphul	H	Leaves	Medicinal importance
Argemone mexicana L.	Satyanashi	H	Leaves	Medicinal importance
Arisaema jacquemontii Blume	Sarpko	H	Roots	Medicinal importance
Artemisia vulgaris L.	Pati	S	Leaves	Medicinal importance
Asparagus adscendens Willd.	Kairua	S	Leaves, Roots, Spines	Medicinal importance
Berberis asiatica Roxb. ex DC.	Kilmora	S	Fruits, Roots	Edible, Medicinal importance, Miscellaneous (For dyeing clothes)
Bergenia ciliata (Haw.) Sternb.	Silphora	H	Leaves, Roots	Edible, Medicinal importance
Bidens pilosa L.	Kumr ghas	H	Flowers, Leaves	Medicinal importance
Boenninghausenia albiflora (Hook.) Rchb. ex Meisn.	Pissumar	H	Roots	Medicinal importance
Cannabis sativa L.	Bhang	H	Leaves, Seeds	Medicinal importance, Edible
Cedrus deodara (Roxb. ex D. Don) G. Don	Devdar	T	Wood	Rituals and religious purposes
Cirsium verutum (D. Don) Spreng.	Katili	H	Roots	Medicinal importance
Commelina bengalensis L.	Kankwa	H	Leaves	Medicinal importance
Cupressus torulosa D. Don	Surai	T	Leaves	Ornamental
Cynodon dactylon (L.) Pers.	Doob	H	Leaves	Medicinal importance, Rituals and religious purposes
Cynoglossum lanceolatum Forssk.	Chitkura	H	Roots	Medicinal importance
Cyperus niveus Retz.	Seto motha	H	Leaves, Roots	Medicinal importance
Desmodium heterocarpon (L.) DC.	Kundliya	H	Leaves	Medicinal importance
Desmodium microphyllum (Thunb.) DC.	Choti dudhi	H	Leaves	Medicinal importance
Dicliptera bupleuroides Nees	Morh	H	Leaves	Medicinal importance
Erigeron bonariensis L.	Guju gha	H	Leaves	Medicinal importance
Erigeron karvinskianus DC.	Fulyudi	H	Leaves	Medicinal importance
Euonymus lucidus D. Don	Bhambeli	T	Leaves	Fodder, Medicinal importance

Euphorbia pilosa L.	Dudhiya	H	Fruits, Leaves	Medicinal importance
Ficus auriculata Lour.	Timila	T	Fruits, Leaves	Edible, Fodder
Ficus palmata Forssk.	Bedu	T	Leaves, Roots	Edible, Fodder
Flemingia strobilifera (L.) W.T. Aiton	Kamalu	S	Fruits, Leaves, Roots	Medicinal importance
Fragaria vesca L.	Kophou jhad	H	Leaves	Edible, Medicinal importance
Galium aparine L.	Malankuri	H	Roots	Medicinal importance
Geranium nepalense Sweet	Syuli	H	Leaves	Medicinal importance
Ilex dipyrena Wall.	Kanderu	T	Flowers, Roots	Medicinal importance
Indigofera heterantha Wall. ex Brandis	Nilini	S	Flowers, Leaves	Ornamental, Medicinal importance
Lantana camara L.	Panchphuli	S	Seeds	Medicinal importance
Lepidium virginicum L.	Halang	H	Bark	Medicinal importance
Lonicera quinquelocularis Hardw.	Bhatkukra	T	Flowers, Leaves, Wood	Medicinal importance
Lyonia ovalifolia (Wall.) Drude	Anyar	T	Leaves	Medicinal importance, Fodder, Fuel-wood
Micromeria biflora (Buch.-Ham. ex D. Don) Benth.	Van ajwain	H	Bark, Fruits	Medicinal importance
Myrica esculenta Buch.-Ham. ex D. Don	Kaphal/ Kafal	T	Leaves	Medicinal importance, Edible
Myrsine africana L.	Banva	S	Leaves, Roots	Medicinal importance
Oxalis latifolia Kunth	Teenpati	H	Leaves	Medicinal importance
Phytolacca acinosa Roxb.	Jarak	H	Gum and latex, Leaves, Wood	Edible
Pinus roxburghii Sarg.	Chir	T	Fruits, Roots, Wood	Medicinal importance, Miscellaneous (As bedding for animals), Fuel-wood
Pyracantha crenulata (D. Don) M. Roem.	Ghingharu	S	Bark, Fruits	Edible, Medicinal importance, Ornamental
Pyrus pashia Buch.-Ham. ex D. Don	Mehal	T	Leaves, Wood	Medicinal importance, Edible
Quercus floribunda Lindl. ex A. Camus	Moru	T	Leaves	Fodder, Fuel-wood
Quercus leucotrichophora A.Camus	Banj	T	Leaves	Fodder
Quercus semecarpifolia Sm.	Kharsu	T	Flowers, Leaves	Fodder
Rhododendron arboreum Sm.	Burash	T	Leaves, Seeds	Edible, Medicinal importance
Ricinus communis L.	Arandi	S	Flowers	Medicinal importance
Rosa moschata Herrm.	Jangli gulab	S	Roots	Ornamental
Rubia cordifolia L.	Mangishta	C	Fruits, Roots	Medicinal importance
Rubus ellipticus Sm.	Hisalu	S	Flowers, Leaves	Edible, Medicinal importance
Rumex hastatus D. Don	Chilmora	S	Leaves, Roots	Medicinal importance, Edible
Smilax aspera L.	Kalisar	C	Fruits, Leaves, Roots	Medicinal importance
Solanum nigrum L.	Macheti	H	Leaves, Seeds	Medicinal importance
Solanum viarum Dunal	Kanderi	S	Leaves, Roots	Medicinal importance
Strobilanthes angustifrons C.B. Clarke	Karvi	S	Roots	Medicinal importance
Taraxacum officinale Weber ex F.H. Wigg.	Kanfulya	H	Bark	Medicinal importance
Taxus baccata L.	Thuner	T	Leaves, Roots	Medicinal importance
Thalictrum foliolosum DC.	Pili jari	H	Leaves	Medicinal importance

Thymus mongolicus (Ronniger) Ronniger	Bhainsi jeera	S	Leaves, Stems	Edible
Urtica dioica L.	Sisoor/ Bicchu	H	Leaves	Edible, Medicinal importance
Verbascum thapsus L.	Ekanbeer	H	Leaves	Medicinal importance
Zanthoxylum armatum DC.	Timoor/ Timur	T	Fruits, Stems, Wood	Medicinal importance

The most common species were of medical relevance (60%), followed by fodder or fuel-wood (11%), wild edible species (10%), ornamental species (7%), religious plant species and invasive species (6% each). Based on the observations drawn from the response questionnaires, various plant parts of specific species were utilized against different ailments and diseases. The inhabitants used 31 species of leaves, 16 of roots, 5 of bark, 3 of fruits, 2 of flowers and only 1 each of seeds/gum/latex for curing different types of ailments (Figure 4). There is a significant reliance on leaves (approximately 53%) for medicinal preparations, followed by roots (approximately 27%) and bark (approximately 8%). The lesser use of other parts, such as fruits, flowers, seeds, gum and latex, suggests a specific selection of plant parts, possibly due to their greater efficacy or availability. This pattern aligns with traditional knowledge where leaves and roots are commonly used due to their rich phytochemical content.

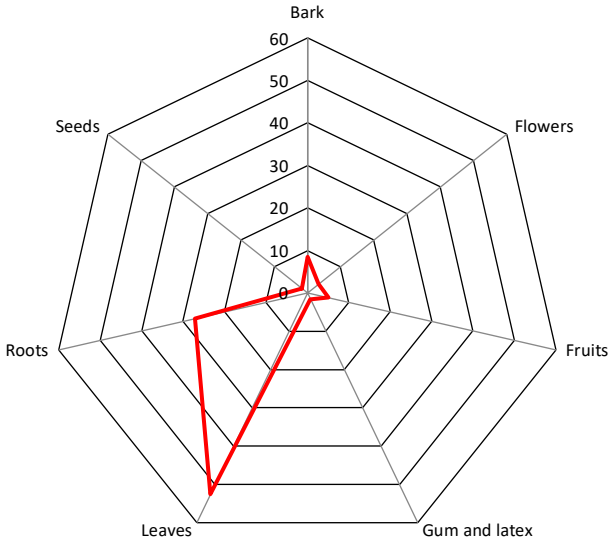

Figure 4. Utilization pattern of plant part/product of ethno-medicinal plants in study area

The ethno-medicinal plants were used to cure 19 major ailments. Most species are used to cure skin-related diseases or problems, followed by the treatment of cuts, wounds, burns, headache and fever (Figure 5). The most frequently treated conditions are skin-related problems, each with a frequency of 14. This indicates a high reliance on traditional remedies for skin issues and external skin problems, reflecting their common occurrence and the effectiveness of plant-based treatments. Traditional plant-based treatments for skin conditions are widely recognized for their soothing and healing properties. Cuts, wounds, burns, and fever are also commonly treated with medicinal plants. These external injuries are prevalent in many regions, and the use of ethnobotanical remedies underscores the importance of accessible and effective treatments. The results also highlight the use of medicinal plants for a variety of other conditions, including eye problems, liver disorders, tooth problems, diabetes, and epilepsy. Each of these conditions demonstrates the breadth of ethnobotanical applications in traditional medicine.

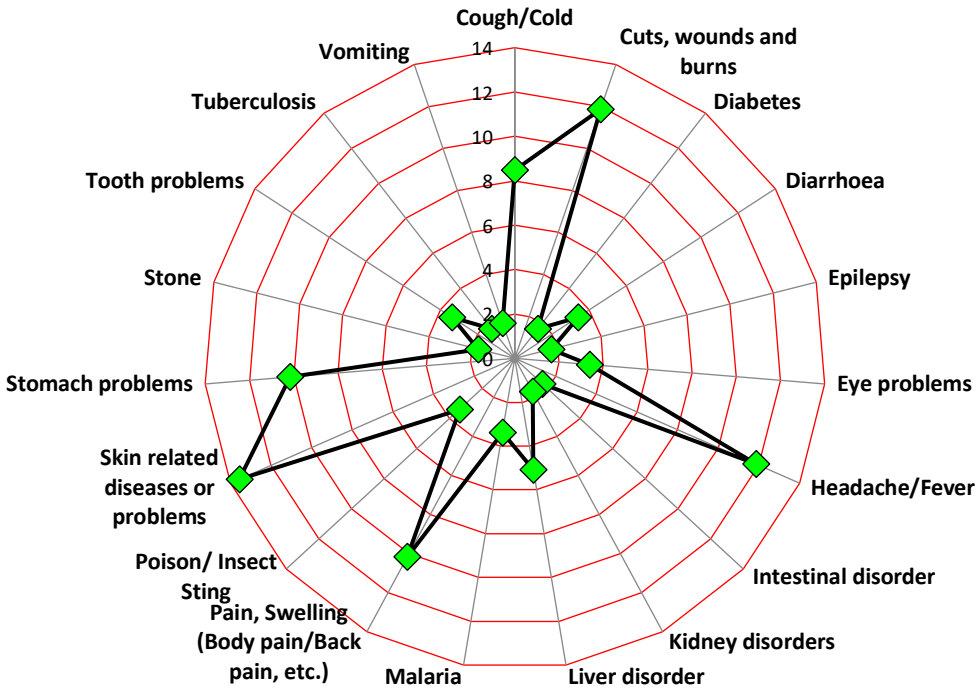

Figure 5. Number of medicinal plant species used to treat various ailments in the study area

Sixty medicinal species have been found to cure nineteen major ailments/diseases. Decoction preparation was the most common mode of plant part use (36%). Another common mode of plant part application includes the formation of paste (31%), plant juice (17%), powder (10%) and direct application (7%) of the plant itself (Figure 6).

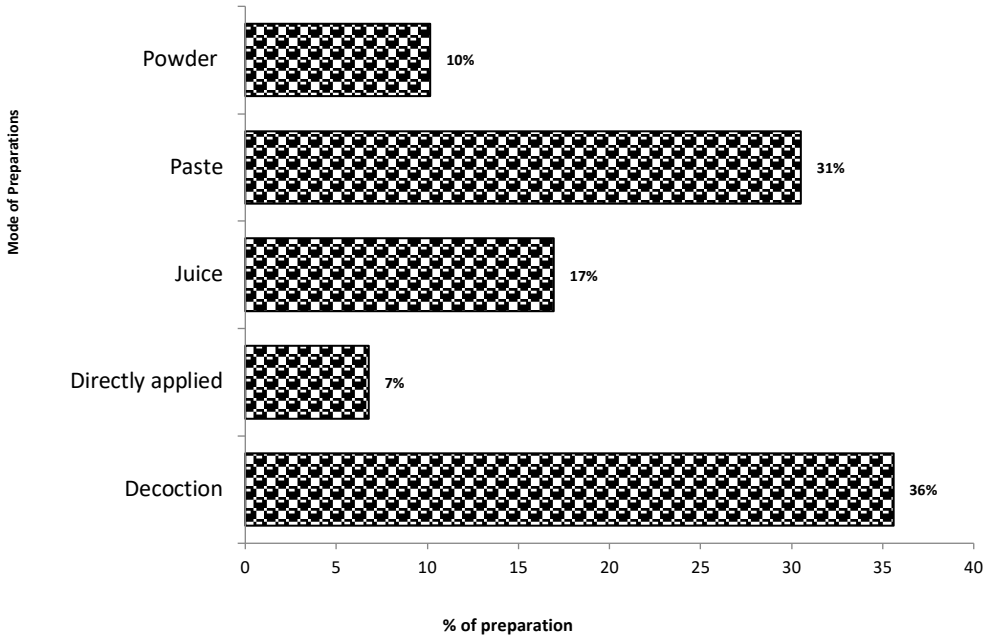

Figure 6. Per-cent distribution of preparation modes of medicinal plant species in the study area

Decoction involves boiling plant materials to extract medicinal compounds. This method is often used for tougher plant parts such as the bark and roots, which require prolonged heating to release their active ingredients. The high prevalence of this preparation mode highlights its effectiveness and traditional acceptance. The preparation of medicinal plants in paste form is common, particularly for topical applications. This method allows for the direct application of active ingredients to the skin, facilitating localized treatment of ailments. The significant use of paste indicates its importance in treating external conditions. Juice extraction involves squeezing or pressing the plant material to obtain liquid extracts, which are typically used for their potent medicinal properties. The moderate use of juice preparations reflects their efficacy for internal treatments. Powdered preparations involve drying and grinding plant materials to a fine consistency. This mode is particularly useful for easy storage and dosage control. The relatively lower prevalence suggests that it may be used for specific conditions or combined with other preparation methods. Direct application involves using plant parts without any processing. This method is often used for its simplicity and immediate application benefits. The lower percentage indicates that while useful, it is less versatile than other preparation methods. Most medicinal plants are common among different sacred groves, and their use of medicinal plants is quite similar among different local communities of sacred groves.

Discussion

The study conducted in the sacred groves of the Kumaon Himalayas offers valuable insights into the traditional use of ethno-botanical plants by local communities. The documentation of seventy plant species, belonging to 64 genera, underscores the region's rich biodiversity and the extensive traditional knowledge embedded within the indigenous cultures. Singh *et al*., 2014 reported 89 medicinal plant species from seven sacred groves of Kumaun Himalaya. The predominance of families such as Asteraceae, Fabaceae, and Rosaceae reflects their ecological adaptability and cultural importance in traditional medicine similar with the previous studies done by Pala *et al*., 2012, Rawat *et al*., 2013; Balkrishna *et al*., 2024. Older respondents possessed greater traditional knowledge, with males having more respondents, but females demonstrating more knowledge similar with the reports of Bisht and Adhikari, 2018, Kumar *et al*., 2015. The high reliance on leaves (53%), roots (27%), and bark (8%) for medicinal preparations highlights the practical and efficacious use of these plant parts. Previous studies reported that leaves are the most utilized plant part in herbal preparations (Ali *et al*., 2023; Rehman, 2023; Balkrishna *et al*., 2024). This preference is likely due to the rich phytochemical content of these parts, making them effective in treating a wide range of ailments, from skin conditions to fever and cuts (Semwal *et al*., 2010; Gairola *et al*., 2013; Ali *et al*., 2023; Balkrishna *et al*., 2024). The use of decoctions, pastes, and plant juices as common preparation methods further illustrates the sophisticated understanding of plant properties and their therapeutic applications also reported by Ali *et al*., 2023, Rehman, 2023; Nair and Mathew, 2024.

The study also sheds light on the impact of modernization and the erosion of traditional knowledge among younger generations. This shift poses a significant threat to the preservation of sacred groves and the invaluable plant species they harbour. Sacred groves are not only cultural and spiritual landmarks but also vital conservation areas that maintain the original germplasm of many species. The traditional knowledge associated with these plants is crucial for biodiversity conservation and sustainable resource use. Promoting the integration of traditional practices with modern conservation strategies is essential to safeguarding this heritage. Raising awareness about the importance of traditional knowledge and its role in conservation can help bridge the gap between generations. This study emphasizes the urgent need to document and preserve the ethno-botanical knowledge of indigenous communities to ensure the continued availability and sustainable use of medicinal plant resources in the Kumaon Himalayas.

Conclusion

The current study highlights the rich ethno-botanical heritage of the Kumaon Himalayas, documenting the plant species used by local communities for medicinal purposes. The predominant families underscore the ecological and cultural significance of these plants. The findings reveal a strong reliance on leaves, roots, and bark for treating a variety of ailments, indicating the depth of traditional knowledge in the region. Sacred groves, which serve as reservoirs of biodiversity and traditional knowledge, are crucial for conserving medicinal plant species. However, modernization and diminishing belief in traditional practices among the younger generation pose a threat to this invaluable heritage. Promoting awareness and integrating traditional practices with modern conservation efforts can ensure the sustainable use of these resources. Therefore, traditional wisdom needs to be passed on from one generation to the next, or it may disappear forever. The next generation needs to be made aware of the value of sacred groves and the necessity to protect them. For the purpose of creating innovative tactics for the preservation and appropriate management of deteriorated sacred groves, knowledge and awareness of sacred groves are crucial. Much community participation, celebration of festivals and rituals within the sacred grove premise, and educational awareness meets should be initiated for the sustainable conservation of sacred groves and

their indigenous diversity. This study emphasizes the need to preserve and document traditional knowledge to support biodiversity conservation and the sustainable use of ethno-botanical resources in the Kumaon Himalayas.

Suggestions

Cultural indigenous knowledge preserved among the local inhabitants in sacred groves of Kumaon Himalaya can play a crucial role in shaping the conservation policies and community-based initiatives by emphasizing sustainable and culturally aligned practices. Medicinal plant diversity conserved in sacred groves too holds spiritual and ecological significance. By integrating this knowledge, policies can promote the protection of rare and endemic species, fostering biodiversity conservation efforts aligned with local beliefs and traditions. Inhabitants view sacred groves as integral to their heritage, which strengthens local stewardship. By involving the local communities in decision-making, policies can leverage this cultural significance to improve compliance and effectiveness making them more sustainable in the long term conservation initiatives. The ethno-botanical practices of indigenous communities often include sustainable harvesting, land-use patterns and soil management techniques. Policymakers can incorporate these practices into broader conservation strategies thus integrating scientific approaches with traditional wisdom for better environmental outcomes.

Declarations

List of abbreviations: amsl- Above mean sea level; E- East; ft- Feet; km- Kilometer; m- Meter; mm- Millilitre; N- North; WHO- World Health Organization; °C- Degree Celcius

Ethics approval and consent to participate: The data collection process ensured confidentiality and anonymity; with all participants being informed about the study's objectives and providing their informed consent prior to participation.

Consent for publication: Not applicable

Availability of data and materials: All the data generated or analysed during this study are included in this published article.

Competing interests: The authors declare that they have no competing interests.

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