Ethnobotanical profile of plant resources utilized by local communities in the Trans-Himalayan Region

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Research

Abstract

Background: Plant resources are important sources of livelihood needs, especially for low-income populations living in remote isolated mountain areas, which rely on these plants for food, fuel wood, medicine and building materials. However, traditional knowledge about plant resources is site-specific and passed down orally through generations. Therefore, there is an urgent need to document the traditional ethnobotanical knowledge of these isolated indigenous groups living in remote regions of the Trans-Himalaya.

Methods: The study utilized a snowball sampling method to interview participants from diverse professions and age groups, representing local communities residing in the high-altitude mountains of the Trans-Himalaya. This paper presents an ethnobotanical profile of flora and examines how various demographic (gender, age), socioeconomic (education, occupation), ethnic, and cultural (language, livelihood) factors influence knowledge related to plant use.

Results: In this study, 49 plant taxa belonging to 41 genera and 29 different families were documented. Rosaceae, Lamiaceae, and Asteraceae were the dominant families used by local communities for multiple uses. The leaves were used most frequently plant part used followed by fruits. Most remedies were prepared as decoctions followed by raw application. The majority of the medicinal plant species were used to treat digestive issues, followed by respiratory issues and dermatological issues. The most important, well-liked, and valuable plant species were *Prunus armeniaca*, *Ficus carica*, *Rheum australe*, *Juglans regia*, *Malus domestica*, and *Artemisia annua.* This shows that plant resources are important across many dimensions of life for people living in distant places, notably for meeting their basic needs for food, housing, livelihoods, and healthcare.

Conclusion: By addressing these concerns, we intend to draw attention to the value of traditional plant knowledge in resolving contemporary environmental, social, and economic problems, as well as the necessity of sustainable development to avert catastrophes like the loss of biodiversity and climate change in the future.

Keywords: Ethnic groups; Ethnobotanical uses; Social; Economic; High-altitude Mountain; Trans Himalayas; Sustainable development

Background

Human communities living in remote and rugged ecosystems use different livelihood strategies, such as the use of different ethnoecological environments characterized by crop availability (Khan *et al.* 2014), altitudinal variation and accessibility (Kunwar *et al.* 2020), culture (Haq *et al.* 2023), and adaptation (Kunwar *et al.* 2018; Güler *et al.* 2021; Akbulut *et al.* 2022). When there is little arable land, indigenous livelihood strategies include livestock rearing, transhumance, seasonal agriculture, and the collection, use, and trade of medicinal plants (Ladon *et al.* 2023). Plant resources provide essential food, firewood, medicine, fodder, and building materials, especially for the poor in remote areas (Vinceti *et al.* 2012; Alrhmoun *et al.* 2024). However, as socio-economic development progresses, traditional knowledge of the plant world is gradually dwindling (Aswani *et al.* 2018). Moreover, traditional knowledge is site-specific and is passed down through generations (Karaköse *et al.,* 2022; Dasgupta *et al.* 2023). Therefore, there is an urgent need for documentation and assessment of traditional ethnobotanical knowledge.

Over the years, traditional knowledge has led to the development of livelihood systems for indigenous communities (Rukema and Umubyeyi, 2019). These sustainable livelihoods have evolved over the years through the interaction of indigenous knowledge, biodiversity, and the surrounding environment (Mukhopadhyay and Roy, 2015; Mekonnen *et al.* 2021). Traditional knowledge has also proven to be effective in the conservation of biological resources, as they are important actors in biodiversity conservation (Selemani 2020; Pieroni *et al.* 2024; Haq *et al.* 2025). It is a challenge for external professionals to manage this complicated relationship. To conserve the diversity of plants used by indigenous groups, it is therefore crucial to involve indigenous communities in the conservation process, as they know how the many elements of interaction work together (Congretel and Pinton, 2020). However, lifestyle changes brought about by globalization, population growth, changing land use, and global warming are impacting these livelihood strategies (Stavi *et al.* 2022). The sociocultural values of mountain people and plants jeopardize the link between people and biodiversity in the region. The collection and utilization of plants valued for their socio-economic benefits and cultural heritage have recently been threatened by the changing perspectives of local people and their context-specific socio-economic and cultural changes (Leakey *et al.* 2021; Haq *et al.* 2024).

In many remote high mountain regions, traditional medicine is the main method of treating diseases, relying on many plants as well as traditional treatment methods (Chauhan *et al.* 2020), and some of these medicinal plants are also collected for trade (Haq *et al.* 2021; Harun *et al.* 2025). Various edible wild plants have been collected for food (Haq *et al.* 2022). In addition, there is a wealth of knowledge about fodder, house building, tools, fuels, dyes, and spices (Aziz *et al.* 2022). However, to date, the traditional knowledge of plants used by the native ethnic groups in Gilgit has not been explored. Furthermore, accelerating socioeconomic development, environmental degradation, and the decline of indigenous knowledge systems all pose serious risks to the preservation of this tradition. We hypothesized that older people, native people, and traditional healers living in remote and rural areas would have a more diverse and detailed knowledge of plant use. Therefore, the purpose of this study was to document the ethnobotanical knowledge of Gilgit in the Gilgit-Baltistan region of Pakistan. In this study, we conducted an ethnobotanical profile of flora with the goal of 1) documenting traditional knowledge and practices related to the utilization of plant resources among local communities. 2), Identify and classify plant species used for various ethnobotanical purposes such as food, medicine, fuelwood, fodder, construction, and cultural ceremonies. 3), To investigate the sociocultural significance of ethnobotanical activities and their role in protecting local livelihoods and environmental resilience. By answering these questions, documenting and studying ethnobotanical activities is crucial not just for cultural preservation but also for guiding sustainable development, biodiversity conservation, and community-led conservation initiatives.

Materials and Methods

Study area

The study was conducted in Gilgit, a region in the Gilgit-Baltistan region in northern Pakistan. Located at a strategic crossroads of the Karakoram and Hindu Kush Mountain ranges, Gilgit is a region of great environmental, cultural, and economic

importance. The city of Gilgit is the administrative capital of the Gilgit-Baltistan region and is located at 35.9204° north latitude and 74.3088° east longitude at an altitude of about 1,500 meters above sea level. The present study was carried out in four villages (a) Jutial, (b) Nomal, (c) Danyore, (d) Naltarof the Gilgit area (Figure 1). Gilgit's unique geographical location contributes to its diverse climate, which ranges from dry and arid in the lower valleys to cold and temperate in the higher elevations. The region has four distinct seasons with cold winters and mild summers and is characterized by significant fluctuations in temperature and rainfall. The region is part of a critical biodiversity hotspot and is home to a wide variety of flora and fauna, some of which are unique to the area.

The study area includes the various valleys and tributary valleys of Gilgit, which are connected by the Gilgit River and its tributaries. The river system plays an important role in the ecology of the region as it supports both the natural vegetation and the agricultural practices of the local communities. Agriculture, together with livestock farming, forms the backbone of the local economy and provides a livelihood for a large proportion of the population. In addition, the rich natural resources of the region, including forests and medicinal plants, contribute to the livelihood and income-generating activities of the local communities. The population of Gilgit is ethnically diverse. The different communities include the Shina, Burusho, Wakhi, and Balti, all of whom have unique cultural traditions and practices, particularly regarding the use of local plant species.

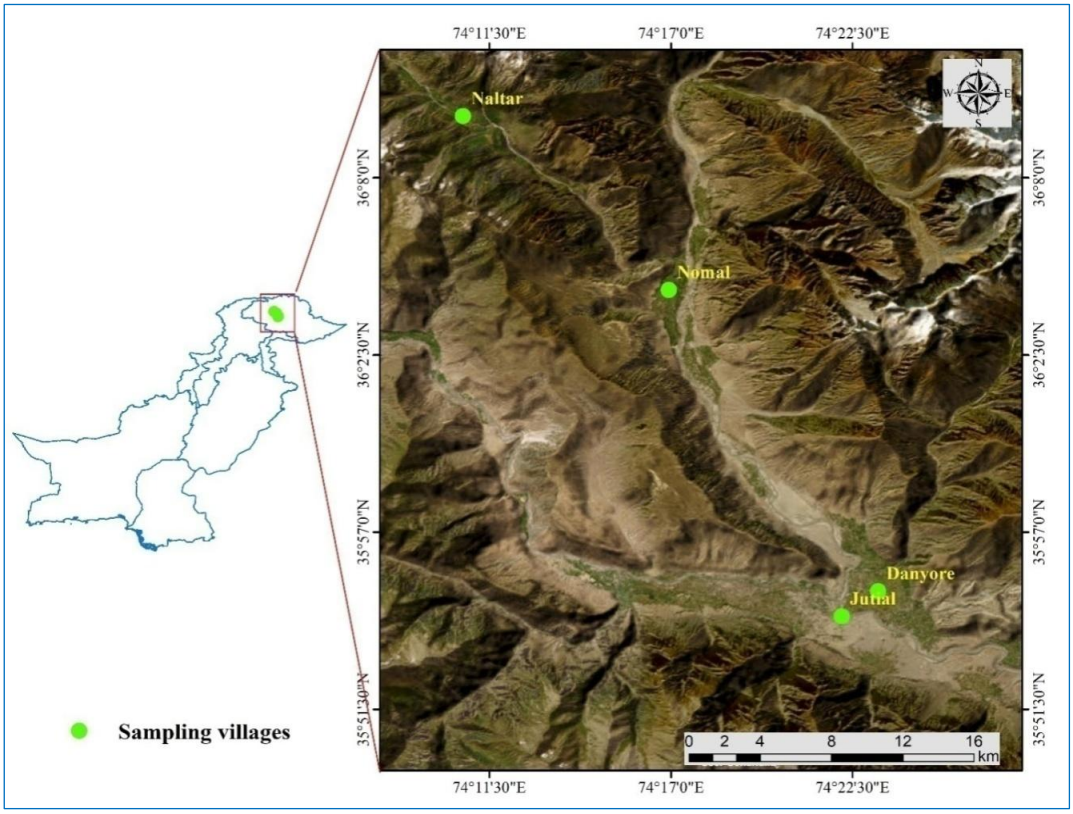

Figure 1. Map of the study area showing the sampling villages in the study area

Data Collection

The present study was conducted in the period 2022-2023. Informants from different occupations and age groups were selected for the study, including farmers, government employees, and housewives (Table 1). Information was collected through open-ended semi-structured interviews and focus group discussions following (Haq *et al.* 2024a). A total of 87 semi-structured interviews were conducted in the native languages of each ethnic group, with one of the authors being proficient in the languages (Table 1). The interviews were then translated into English. The informants were shown both photographs and real plants to identify them and learn the local names.

The survey focused on the use of plant parts for medicinal, religious, cultural, veterinary, and culinary purposes. The survey results were re-presented to informants after data collection to correct any inaccuracies or exclusions in the data. To validate the information collected, we cross-checked it with relevant literature sources (Bano *et al.* 2014; Stevens 2017; Hussain *et al.* 2021). Verbally informed consent was obtained from all informants before conducting the interviews. In addition, for each

indigenous community, we selected a person who was well respected and familiar with the traditions and norms of their respective community to accompany us in the field studies.

Throughout the study, we adhered to the Code of Ethics of the International Society of Ethnobiology, available at https://www.ethnobiology.net (accessed May 28, 2022). During our field studies, we collected detailed data on each plant specimen, including relevant taxonomic information. To identify the plants, we consulted the taxonomic literature (https://eforaindia.bsi.gov.in/eFlora/eFloraHomePage.action). To preserve the collected plant specimens, we followed conventional herbarium procedures, drying, preserving, labeling, and pasting them on herbarium sheets. We updated the nomenclature using the taxonomic database Plants of the World Online (POWO) (https://powo.science.kew.org).

Data analysis

The data were summarized in MS Excel, and the analysis was performed using PAST and Origin Pro software. To show the relation between medicinal preparation, plant part used, and traditional use categories of plant species, a chord diagram was prepared in Origin Pro software (version 9.95) (Haq *et al.* 2023b). The heat map was produced using the presence/absence data to show species distribution, and cluster analysis showed species that shared the same ethnobotanical uses. Sorensen's similarity coefficient, based on presence/absence data, was used to identify significant differences among diverse ethnobotanical uses and plant species. The chord diagram visualizes weighted relationships between species and ethnobotanical uses. A circular cluster heat map was created using Origin Pro software (version 9.95). The diseases were classified using the International Classification of Primary Care (ICPC) and International Classification of disorders (ICD), which are globally recognized standards for standardized symptom classification, clinical research, and public health systems.

Use value (UV)

The significance of the documented taxa was assessed by determining their use value (UV) (Tardio and Pardo de Santayana 2008). The UV was calculated using the following formula:

$$UV = \sum U/n$$

Where 'n' represents the total number of participants in the study, while 'U' represents the number of reports in which each participant mentioned a particular plant taxon. The UV value for a species that was not mentioned was between 0 and 1. Whereas, if a species was mentioned by every informant, its UV value was 1.

Results and Discussion

Respondents' demography

Our study comprised 87 respondents, including (N=42, 51.72%) men and (N=45, 42.28%) women (Table 1). The respondents represented a wide range of occupational groups, including farmers (N=25, 28.74%), housewives (N=20, 22.99%), Shopkeepers (N=15, 17.25%), daily wage laborers (N=9, 10.34%), government employees (N=10, 11.49%), and pastoralists (N=8, 9.20%). The greatest percentage of the informants (N=40, 45.98%) was over the age of 27-55 years, followed by those between the ages of 18-26 (N=30, 34.48%), and between the ages of 56-75+ (N=17, 19.54%). We found that the older participants had higher knowledge than the younger ones, which has also been found in other research (Abbas *et al.* 2021).

Table1. Demographic status of the respondents

Variable	Categories	Number of people	Percentage
Gender	Male	42	48.28
	Female	45	51.72
Age group	Young (18-26 years)	30	34.48
	Middle (27-55 Years)	40	45.98
	Old (>56 Years)	17	19.54
Profession	Farmers	25	28.74
	Housewives	20	22.99
	Shopkeepers	15	17.24
	Daily wage laborers	9	10.34
	Pastoralist	8	9.2
	Govt. employees	10	11.49
Religion	Islam	87	100
Ethnic Groups	Bushro	25	28.74
	Shina	35	40.23
	Balti	15	17.24
	Wakhi	12	13.79

Ethnobotany resources

In this study, 49 plant taxa belonging to 41 genera and 29 families were documented (Table 2). In regions with a more diverse flora, there are usually more useful wild plant species. It is assumed that a greater supply of species leads to correspondingly more species being utilized (Emmanuel and Didier 2011; Abbas *et al.* 2017; Karaköse, 2022). The way in which a species is utilized depends strongly on the socio-economic conditions in an area, and distribution patterns can vary from place to place (Rana *et al.* 2019). The contributions of families to the different utilization categories vary greatly. The fact that several groups use plant resources shows how important these species are for the survival of the local community.

Table 2. List of plants with ethnoecological usage reports across ethnic groups

Family	Botanical name/ Code	Common & Local name	Parts used	Preparation	Administration	Disease treated	Ethnoecological usage	Use Report	UV
Asteraceae	*Artemisia annua* L. (Art. ann)	Tarkha, Zhond	Leaves, whole plant	The leaves and above-ground parts are dried and made into an infusion or tea. The dried plant material is boiled in water, and the resulting extract is taken orally. The leaves can also be crushed and applied externally	Oral, topical	Malaria, digestive disorders	Veterinary	49	0.56
Asteraceae	*Saussurea costus* (Falc.) Kasana & A.K.Pandey (Dol. cos)	Minaal, Minal	Roots	The roots are usually dried and then ground into a powder. This powder can be boiled in water to make a decoction. The extract obtained from this decoction is taken orally	Oral	Coughing, cold, indigestion, skin condition	Cultural and veterinary	45	0.52
Berberidaceae	*Berberis lycium* Royle (Ber. lyc)	Ishkeen, Chorko	Berries, roots	The roots are dried and then boiled in water to make a decoction. The resulting extract is taken orally. The berries are used to being fresh or dried. Dried berries can be ground into a powder and mixed with water or other liquids. The extract from the berries is taken orally	Oral	Digestive issues, liver problems	Cosmetic	34	0.39
Betulaceae	*Betula utilis* D.Don (Bet. uti)	Furay, Jonji	Bark	The bark is dried, ground into powder, mixed with water and applied externally. It is also boiled in water and taken orally as a decoction.	Topical, oral	Leprosy and earache	Timber	27	0.31

Boraginaceae	*Myosotis alpestris* F.W.Schmidt. (Myo. alp)	Shoumur	Leaves, flowers	Leaves and flowers are dried and ground into a powder, mixed with water to form a paste, and applied externally	Topical	Skin irritation and inflammation	Cultural	25	0.29
Cannabaceae	*Cannabis sativa* L. (Can. sat)	Chuup, Bhang	flower, leaves	The flowers can be dried and smoked, vaporized, or used to make edibles, including cannabis oil, which can be taken orally or applied topically. The leaves can be dried and used to make a tea or infusion. The extract obtained is taken orally.	Oral, topical	Inflammation, depression, seizures, cancer	Cosmetic, cultural and veterinary	19	0.22
Cannabaceae	*Celtis australis* L. (Cel. aus)	Tagran, Miyon	Fruit, bark	Bark is boiled in water and taken orally as a decoction. Fresh and dried fruits are used.	Oral	Digestive issues	Fodder and timber	31	0.36
Capparaceae	*Capparis spinosa* L. (Cap. spi)	Qaqashu, Loi malghari	Flower buds, fruits, roots	Flower buds and fruits are usually preserved in vinegar or brine and eaten orally as a spice or garnish. The roots are dried and used to make decoctions. The extract obtained by boiling the roots in water is taken orally.	Oral	Blood pressure, cough, cold	Food and veterinary	35	0.4
Cupressaceae	*Juniperus excelsa* M.Bieb. (Jun. exc)	Abhal, Chalgoza, Garoli	Berries, leaves	Dried berries are crushed and boiled in water for 15-20 minutes. The extract is taken orally twice a day. Crushed berries are mixed with water to form a paste and applied externally. Dried leaves are boiled in water for 20-25 minutes. The extract is taken orally twice a day. The infusion from the leaves is used externally.	Oral, topical	Respiratory issues, urinary tract infections	Cosmetics, food, timber, fuelwood and cultural	27	0.31
Cupressaceae	*Juniperus macropoda* Boiss. (Jun. mac)	Gashi, Chili	Berries, leaves	Berries are dried and ground into powder, which is used in cooking or as a flavoring. An infusion or decoction is made from the leaves.	Oral, topical	Wounds, joint pain, skin issues	Cosmetic, timber, cultural and veterinary	30	0.34

Ebenaceae	*Diospyros lotus* L. (Dio. lot)	Shoyo	Fruit, leaves, bark	Fresh and dried fruits are used. The bark is boiled in water and taken orally as a decoction.	Oral	Coughing, cold, digestive issue	Food and fuelwood	28	0.32
Ebenaceae	*Diospyros virginiana* L. (Dio. vir)	Harmit	Leaves, bark, fruit	The fresh fruit is used when it is fully ripened or can be dried and eaten as a snack. It is also used to make jams, jellies, puddings, and other desserts. The bark is dried and then boiled in water to make a decoction. The extract obtained is taken orally. The leaves can be dried and made into tea or infusion. The extract from the leaves is taken orally.	Oral	Abdominal pain, skin irritation, wounds	Cosmetics, food and timber	20	0.23
Elaeagnaceae	*Elaeagnus angustifolia* L. (Ela. ang)	Gindawar, gunair, Suzon	fruits, leaves, bark	The fruits are used fresh or dried and are eaten orally. The leaves can be dried and made into an infusion or tea. The bark is dried and boiled in water to make a decoction. The resulting extract is taken orally	Oral	Cough, colds, joint pain, wound healing, infections	Cosmetic, food, fodder, timber, cultural, fuelwood and Veterinary	34	0.39
Elaeagnaceae	*Hippophae rhamnoides* L. (Hip. rha)	Buru Sokh Phalo,	Leaves, berries	Fresh or dried berries are consumed orally. Dried leaves are used to make an infusion, which is taken orally twice a day. Fresh or dried berries are taken by mouth. An infusion is made from the dried leaves and taken orally twice a day.	Oral	Ulcer, skin condition, heart problems, cancer	Cosmetics, food, cultural and veterinary	36	0.41
Fagaceae	*Quercus baloot* Griff. (Que. bal)	Baloot, Bani	Corn, bark	Corn is dried and ground into a powder to make paste for topical or oral applications. Bark is used to make a decoction by boiling in water. The resulting liquid can be applied topically.	Oral, topical	Skin diseases, Digestive issues	Fodder, timber and fuelwood	35	0.4

Juglandaceae	*Juglans regia* L. (Jug. reg)	Akhrot, Khakia, Talay	Nuts, leaves, bark	The nuts are consumed orally, either raw or roasted. Walnut oil, extracted from the nuts can be used both orally and topically. Dried leaves are boiled in water for 15-20 minutes, and the extract is taken orally twice a day. Infusion from dried leaves is used topically. Dried bark is boiled in water for 20-25 minutes, and the extract is taken orally	Oral, topical	Digestive disorders, heart disease, skin diseases	Cosmetics, food, fodder, timber, fuelwood and veterinary	55	0.63
Lamiaceae	*Mentha longifolia* (L.) Huds. (Men. lon)	Podeena, Phileel	Leaves, whole plant	Dried leaves are brewed in boiling water for 5-10 minutes to make tea and then drunk. Fresh leaves are boiled in water and the steam is inhaled. Whole plants can be dried or fresh.	Oral	Headache, Digestive issues, respiratory problems	Cosmetics, food, cultural and veterinary	36	0.41
Lamiaceae	*Thymus linearis* Benth. (Thy. lin)	Jangli Ajwain	Leaves, flowers	The leaves and flowers are dried and made into a decoction, which is boiled in water for 5-10 minutes. The resulting tea is drunk orally.	Oral	Respiratory issues, digestive problems	Food	39	0.45
Lamiaceae	*Thymus serpyllum* L. (Thy. ser)	Tumur, Tumoro	leaves, flowers	Leaves and flowers are dried and used to make a decoction by boiling them in water for 10 minutes. The resulting decoction is taken orally. The oil is extracted from the fresh or dried leaves and flowers by steam distillation, whereby the steam permeates the plant material and carries the essential oil with it, which is then condensed and collected.	Oral, topical	Pneumonia, coughing, fever	Cosmetics, food, cultural, timber, veterinary and fuel wood	46	0.53
Linaceae	*Linum usitatissimum* L. (Lin. usi)	Humaan, Phono	Seed	The seeds are ground into a powder and mixed with water to form paste, which is then applied externally or eaten orally.	Oral, topical	Eye syndrome, cancer, skin, sugar control, cholesterol	Cosmetics, food, fodder, veterinary, fuelwood and cultural	42	0.48

Lythraceae	*Punica granatum* L. (Pun. gra)	Anar, Danio	Fruit, peels	The fruits are eaten raw, often fresh or as juice.	Oral	Heart problems, Digestive issues	Food and culture	47	0.54
Moraceae	*Ficus carica* L. (Fic. car)	Injeer, Fang	Fruit, leaves	Used fresh or dried, used in cooking or made into jams. Leaves are used to make an infusion or decoction	Oral, topical	Skin diseases	Food, Cultural and Veterinary	63	0.72
Moraceae	*Morus alba* L. (Mor. alb)	Tut, Sho maroch	Leaves, fruit, bark	The bark is boiled in water and taken orally as a decoction. The fruits are used fresh or dried and can be used to make jams or juices. Fresh leaves are used to make an infusion or decoction.	Oral, topical	Anemia, diabetes	Cosmetic, food and fodder	44	0.51
Myrtaceae	*Eucalyptus camaldulensis* Dehnh. (Euc. Cam)	Sufaida, Phanch	Leaves, bark	The leaves are often dried and made into an infusion or tea. *Eucalyptus* leaf oil can also be extracted and used externally. The bark can be boiled in water to make a decoction. The extract obtained from this is taken orally.	Oral, topical	Wounds and infections	Cosmetic and fuelwood	29	0.33
Nitrariaceae	*Peganum harmala* L. (Peg. har)	Ispandur, spandur	Seeds, roots	The seeds are ground into a powder and taken orally or infused in water to make a decoction. The roots are used externally as a paste or poultice.	Oral, topical	Mental health, asthma, indigestion	Cultural	38	0.44
Oleaceae	*Fraxinus xanthoxyloides* (G.Don) Wall. Ex (Fra. xan)	Sumur	Bark, leaves	Dried bark is boiled in water for 20-25 minutes, and the extract is taken orally twice a day. An infusion is made from the dried leaves and taken orally twice a day.	Oral	Joint pain, fever	Fodder and timber	34	0.39
Pinaceae	*Cedrus deodara* (Roxb. ex D.Don) G.Don (Ced. deo)	Deyar, floojo	Wood, bark	Wood is often distilled to obtain essential oil, which can be used externally or aromatically. The bark is dried and then boiled in water to make a decoction. The extract obtained is taken orally.	Topical, oral	Skin diseases, Respiratory issues	Cosmetic, timber and cultural	43	0.49

Pinaceae	*Pinus wallichiana* A.B.Jacks. (Pin. wal)	Kail, Choi	Needles, bark	The needles are used to make herbal tea for oral consumption. The bark is dried, and the crushed bark is mixed with a small amount of water to make a paste. This paste is then applied directly. It can also be boiled in water to make a decoction that can be used as a wash.	Oral, topical	Respiratory issues	Timber and Firewood	48	0.55
Plantaginaceae	*Picrorhiza kurroa* Royle ex Benth. (Pic. kur)	Karuu	Rhizomes	The rhizomes are dried, pulverized, and taken orally or infused in hot water to make a decoction.	Oral	Hepatitis	cultural	33	0.38
Poaceae	*Saccharum bengalense* Retz. (Sac. ben)	Phuru, Phro	Roots, leaves	The leaves are dried and ground into a powder. The powder is mixed with water to make a paste, which is applied. The roots are dried and ground into a powder and then boiled in water to make a decoction. The decoction is taken orally.	Oral, topical	Demulcent, urinary tract health	Fodder and cultural	29	0.33
Polygonaceae	*Rheum australe* D.Don (Rhe. aus)	Chuplak, Pambashuk, Chontal	Roots	The roots are dried and ground into a powder, which is used orally.	Oral	Digestive issues, liver problems	Food	60	0.69
Polygonaceae	*Rumex hastatus* D.Don (Rum. has)	Churkee, Chotal	Roots, leaves	A decoction is made from the leaves by boiling them in water for 5-10 minutes. The resulting tea is drunk orally. The roots are dried and ground into a powder, which is boiled with water. The decoction is taken orally.	Oral	Skin conditions, gastrointestinal issue	Fodder	18	0.21
Rhamnaceae	*Ziziphus jujuba* Mill. (Ziz. juj)	Ber	Fruit, leaves	The fruit is eaten fresh, or dried or fresh leaves are ground into a paste.	Oral, topical	Digestive issues, respiratory problems	Food, fodder and cultural	33	0.38

Rosaceae	*Eriobotrya japonica* (Thunb.) Lindl. (Eri. jap)	Lokaat	Fruit	The fruits are used fresh or for making jams and preserves. The seeds can be ground into powder and used in various preparations. Sometimes they are boiled in water to make a decoction that is taken orally.	Oral	Stress, cough, skin problems	Food	29	0.33
Rosaceae	*Malus domestica* (Suckow) Borkh. (Mal. dom)	Saib, bahlt, fala, Palio	Fruit, seeds	The fruits are eaten fresh or as juice. The seeds are ground and used in small quantities as a traditional remedy.	Oral	Sugar, headache, heart issues	Cosmetics, food and cultural	55	0.63
Rosaceae	*Prunus amygdalus* Batsch (Pru. amy)	Badaam, Badam	Seed(nuts)	The seeds are eaten raw or roasted as a snack or used in cooking. The almond oil extracted from the kernels can be taken orally or applied externally.	Oral, topical	Memory, skin health, heart problems	Cosmetics, food, cultural and veterinary	44	0.51
Rosaceae	*Prunus armeniaca* L. (Pru. arm)	Khubani, Joroti, joo	Fruit, kernels, flowers	The fruit is eaten fresh or dried. The seeds are extracted from the kernels, dried and sometimes ground into powder. The flowers are dried and then brewed into an herbal tea.	Oral, topical	Respiratory issues, digestive problems	Cosmetics, food, cultural, timber and fuelwood	65	0.75
Rosaceae	*Prunus avium* (L.) L. (Pru. avi)	glass, cherry, Cheri	Fruit	In summer, the fruit is eaten raw, often fresh or as a juice.	Oral	Blood pressure, fat, heart issues	Fodder, cultural and timber	43	0.49
Rosaceae	*Prunus cerasifera* Ehrh. (Pru. cer)	Alabalu, alucha, Alo Bukhara	leaves, fruit, roots	The fresh leaves are ground into a paste, which is applied externally. The fruits are eaten fresh or dried, the roots are dried and ground, then boiled in water to make a decoction.	Oral, topical	Digestive issues	Food	47	0.54
Rosaceae	*Prunus persica* (L.) Batsch (Pru. per)	Aru, Aaro	Fruit, leaves	The leaves are ground into pasties applied externally. The fruits are eaten fresh, dried for later use or cooked into dishes.	Oral, topical	Digestive issues, skin diseases	Food and culture	54	0.62

Rosaceae	*Pyrus communis* L. (Pyr. com)	Nashpati, tong, Tango	Seeds, fruit	The fruits are eaten fresh or dried. The seeds are crushed and mixed with honey. The mixture is applied externally.	Oral, topical	Joint pain, wounds healing	Food and culture	40	0.46
Rosaceae	*Pyrus pashia* Buch.-Ham. ex D.Don (Pyr. pas)	Tangor, Dandru,	Fruit, leaves	Fruits are used raw or cooked and are often used in traditional dishes. The dried leaves are used to make a decoction by boiling them in water for 5-10 minutes. The resulting extract is strained and consumed orally.	Oral	Digestive issues	Food and fodder	46	0.53
Rosaceae	*Rosa webbiana* Wall. ex Royle (Ros. web)	Sia Kura, Shigio	Leaves, flowers	To prepare decoction, the dried leaves are boiled in water for about 5-10 minutes. The mixture is then strained, and the resulting liquid is drunk as an herbal tea. The flowers are dried and made into an infusion which is taken orally.	Oral	Vitamin C deficiency, digestive issues	Timber	41	0.47
Salicaceae	*Salix alba* L. (Sal. alb)	Bedi, Baihek, Beayo	Bark	Bark is dried and ground into a powder or made into a decoction by boiling in water. The resulting liquid is taken orally or applied externally.	Oral, topical	Pain and inflammation	Fodder, timber, fuelwood and cultural	25	0.29
Sapindaceae	*Acer cappadocicum* Gled. (Ace. cap)	Chinar, Bouch	Leaves, bark	The bark is dried and then boiled in water. The extract obtained is taken orally. Fresh leaves can be crushed and applied externally for their calming effect or made into infusion to be drunk.	Oral, topical	Cough, colds	Fodder, fuelwood, and cultural	25	0.29
Sapindaceae	*Aesculus indica* (Wall. ex Cambess.) Hook. (Aes .ind)	Bankhor	Seeds, bark	The seeds are dried, ground to a powder, and then boiled in water. The extract thus obtained is taken orally, often early in the morning. The bark is dried, boiled in water, and the extract obtained is taken orally.	Oral	Joint pain, varicose veins	Fodder and timber	27	0.31

Tamaricaceae	*Tamarix aphylla* (L.) H.Karst. (Tam. aph)	Khuzar, Ghaz, Hooker	Leaves, bark	To prepare a decoction, the fresh leaves are boiled in water and taken orally. The outer bark is used externally as a poultice.	Oral, topical	Infections, wound healing	Fodder, timber and fuelwood	35	0.4
Ulmaceae	*Ulmus wallichiana* Planch. (Ulm. wal)	Maina	Bark	Bark is dried, pulverized and then boiled in water to make a decoction. The resulting liquid is taken orally.	Oral	Cough, colds	Cosmetics, fodder, timber, cultural and fuelwood	29	0.33
Urticaceae	*Urtica dioica* L. (Urt. dio)	Bichu Buti, Jomi	Leaves, roots	Fresh or dried leaves and roots are used to make a decoction which is boiled in water for 5-10 minutes. The resulting liquid is taken orally. Fresh leaves are also applied externally as a paste.	Oral, topical	Joint, muscles, connective tissues	Cosmetics	37	0.43

Plant distribution across families

Among the 29 botanical families, the plant species collected were unevenly distributed and only nine families: Rosaceae (N=10), Lamiaceae (N=3), Asteraceae, Cannabaceae, Cupressaceae, Ebenaceae, Elaeagnaceae, Moraceae, Pinaceae, Sapindaceae and Polygonaceae (N=2 each), accounted for half of the plant species reported, whereas the other families consist of only one species (Figure 2). In the documented flora, the species and family relationship ($y=0.0038x^2 - 0.0598x + 1.1724$; $R^2 = 0.8302$) was observed (Figure 2). The circle-shaped dots in green in the diagram show the species distribution pattern in the families. The black dotted line in the diagram represents the degree of a polynomial function observed in the recorded flora. The value of the coefficient of determination (R^2) shows the correlation of the association between the study variables (species vs. families) (Figure 2). These families are also reported to be dominant in other Himalayan regions (Bano *et al.* 2014). This result is supported by (Sher *et al.* 2020) from Lalku Valley, District Swat, Pakistan, (Khoja *et al.* 2023) from the northwestern Himalayas, who reported Rosaceae as the dominant family. According to Khoja *et al.* (2022), Lamiaceae is the predominant family in the western Himalaya, which is consistent with our findings.

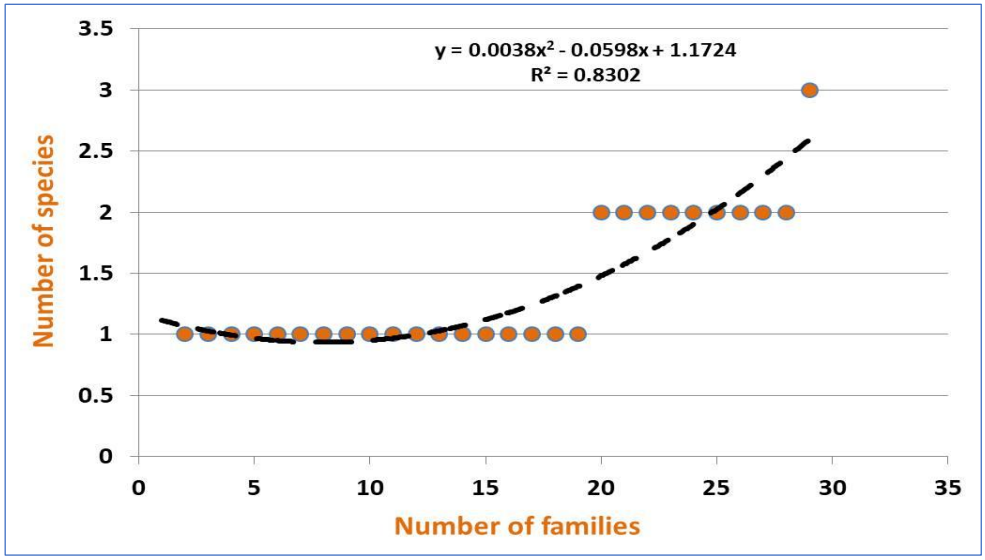

Figure 2. Species-family relationship of the flora in the study area; Green circle-shaped dots: distribution pattern of species within their respective families. Black dotted line: degree of polynomial function observed in the recorded flora. The value of the coefficient of determination (R^2) reflects a significant strength of association between the study variables, especially the species and families, and shows a clear relationship between them.

Plant part used

The preference analysis showed that leaves were used most frequently, followed by fruits, bark, flowers, roots, seeds, whole plants, wood, and rhizomes (Figure 3). Dry powders were prepared by most of the plant constituents by crushing well-dried plant materials and storing them in glass bottles for further use. The leaves and whole plants of the herbaceous species were used regularly. The leaves are commonly used in herbal preparations due to their active secondary constituents. Compared to previously published reports, these results show a similar pattern in that leaves were the most used (Akbulut et al., 2019; Khoja *et al.* 2024; Waheed *et al.* 2023; Alrhmoun et al. 2024; Pieroni et al. 2024). Leaves are thought to contain more easily extractable phytochemicals, crude drugs, and many other mixtures that could prove valuable in phytotherapies (Ahmad *et al.* 2014; Savikin *et al.* 2013; Niaz *et al.,* 2026). This could be the reason why several studies, including the present one, cite leaves as the most utilized plant part for medicinal purposes (Khan *et al.* 2015; Haq and Singh 2020; Zaman *et al.* 2024).

Preparation

Most remedies were prepared as decoctions (26 %), followed by raw application (15 %), infusion and powder (14 % each), paste (10 %), herbal tea (8 %), oil (4 %), jam (3 %), juice and poultice (2 % each), spice and incense (1 % each) (Figure 4). Decoctions are often one of the main forms of preparation in ethnobotanical practice, as they can be easily prepared by mixing with water, tea, or soup (El Amri *et al.* 2015; Martins *et al.* 2015). Similar results have also been reported in other studies. For example, the main forms of preparation in the forest area of Madhupur, Bangladesh, include (Islam et al. 2014). Nondo *et al.* (2015) reported on medicinal plants for the treatment of malaria in the Kagera and Lindi regions of Tanzania, where 108 plants were mainly taken orally or in the form of a decoction. Similarly, Siew *et al.* (2014) reported decoctions as the main preparation method, while they documented the traditional use of 104 plants from Singapore.

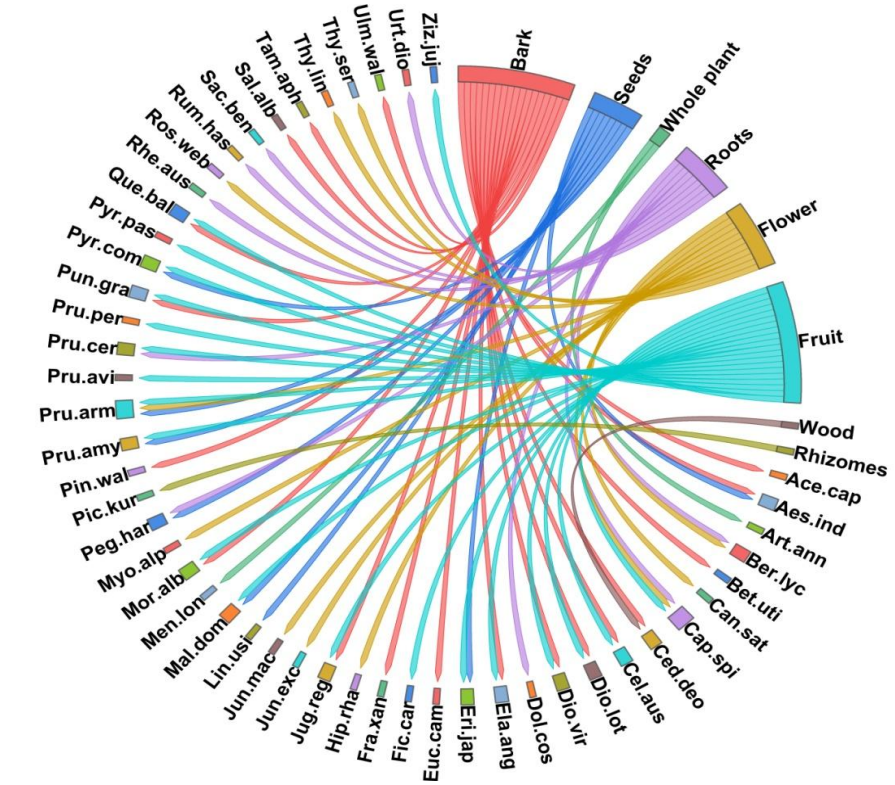

Figure 3. Plant resources and plant parts used for the different ethnobotanical uses.

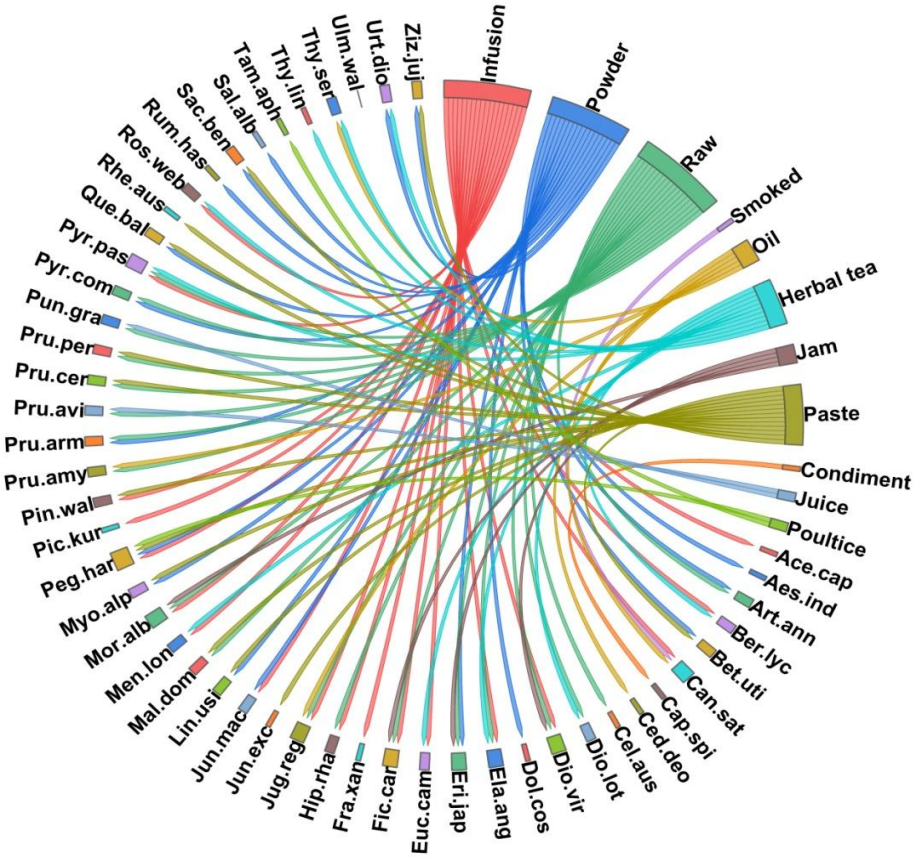

Figure 4. Plant resources and different preparations are used in the study area.

Disease treated

The majority of the medicinal plant species were used to treat digestive issues (N=22, 24%), followed by respiratory issues and dermatological issues (N=17, 19% each), joint and muscle problems (N=10, 11%), cardiovascular issues (N=9, 10%), neurological issues (N=4, 5%), fever and headache (N=4, 4% each), psychological and hepatic (N=3, 3% each) and full name here (ENT) (N=2, 2%) (Figure 5). The study revealed a notable reliance on a range of plant resources for medicinal applications. Abbas *et al.* (2021) reported 47 medicinal plant species from Deosai National Park in Pakistan, Bano *et al.* (2014) reported 50 medicinal plants from Deosai Plateau, Western Himalayas, and Gilgit Baltistan Pakistan. Sher et al. (2020) reported 53 plants from District Swat Pakistan, Hussain *et al.* (2021) reported 60 medicinal plants from Kharmang district, Trans-Himalayas. Asif *et al.* (2021) reported 29 species of different ethnic groups from a remote tehsil (Karnah); Haq *et al.* (2023) reported 46 species from high altitude areas of Kashmir Himalaya. The results could be explained by the fact that gastrointestinal and hepatobiliary diseases are prevalent in these regions due to poor sanitation, malnutrition, and lack of clean water. Similar findings have been reported by researchers from Pakistan (Tariq *et al*. 2015) and northern Nigeria (Abdul Rahman 2021), Pakistan (Waheed *et al.* 2022), and the northern Himalayas (Farooq et al. 2019; Amjad et al. 2017) among different ethnic groups. The treatment of digestive disorders is one of the most widespread uses of plants in medicine (Khoja *et al.* 2022; Mazher *et al.* 2023).

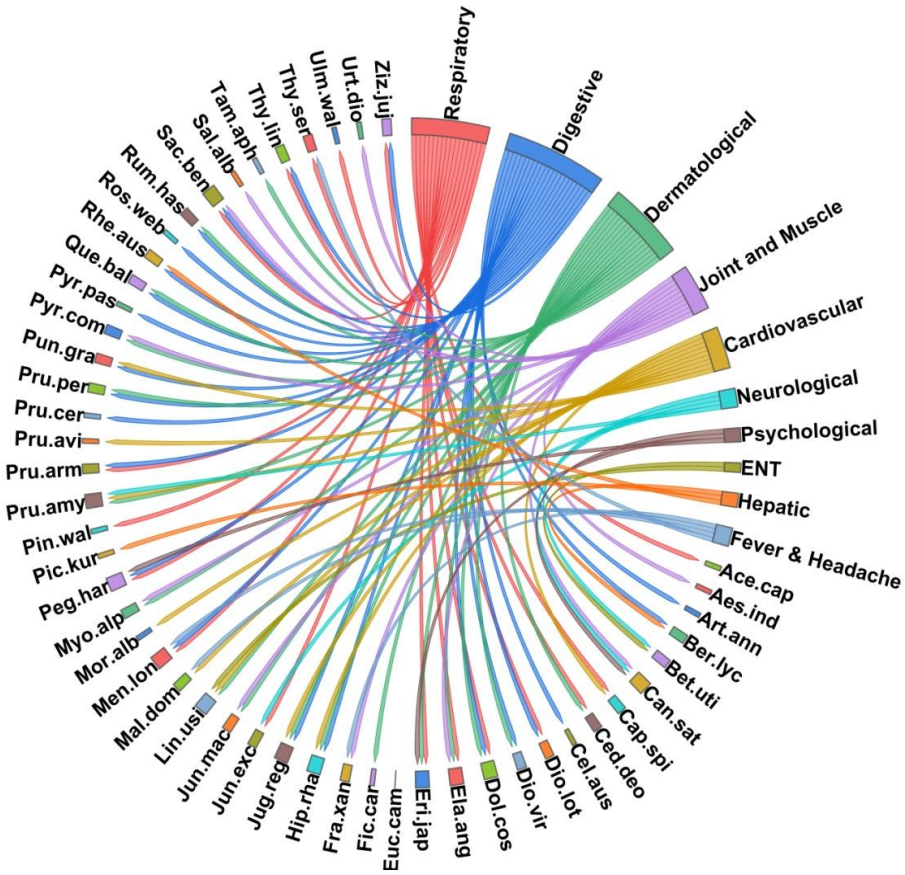

Figure 5. Distribution of plant resources used for the treatment of different diseases in the study area.

Other ethnobotanical use

More than half of the forest resources collected in the study area were used as food (19% each), followed by wood (16%), cosmetics (14%), fodder (12%), firewood (11%), and veterinary medicines (9%) (Table 2). The dendrogram showed two distinctly separated clusters based on the degree of intensity of plant species and ethnobotanical use (Figure 6). Forage collection in the Trans-Himalayan region takes place mainly between summer and fall, with the collected forage being dried and stored for use during the harsh winter months. This seasonal pattern of resource management is consistent with the findings of Haq *et al.* (2023b), who report similar practices in other high-altitude and remote regions of the Himalaya. This practice highlights an important adaptation strategy for communities living in geographically isolated and climatically challenging areas where the ability to store and preserve essential resources for winter is critical for survival. Our findings underscore the far-reaching importance of plant resources, especially medicinal plants, in the daily lives of these communities. Plants are deeply intertwined with the socio-economic and cultural fabric of the people (Belayneh *et al.* 2012;

Jabeen *et al.* 2024). For communities living in remote high mountain regions such as the Trans-Himalayas, where access to modern health care, markets, and infrastructure is limited, the availability and sustainable use of medicinal plants is particularly important (Chaudhary *et al.* 2023).

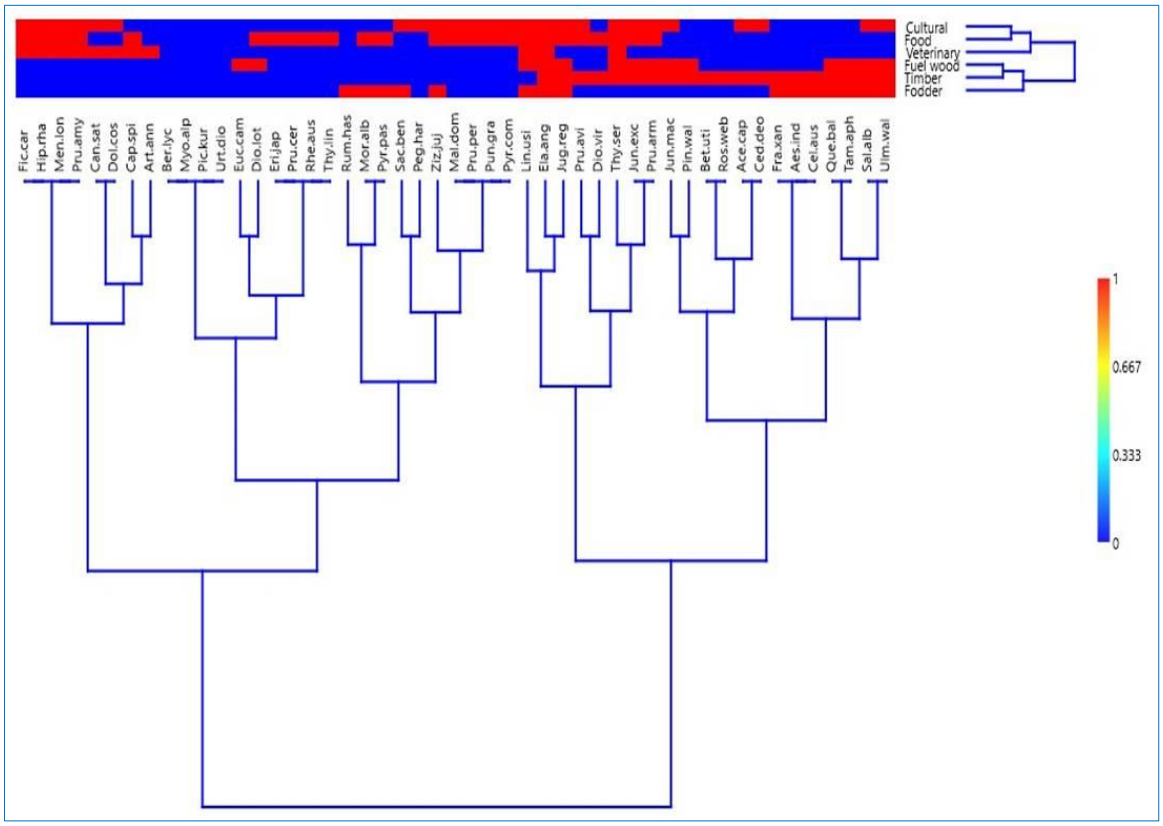

Figure 6. Heat map with cluster dendrogram based on ethnobiological use of plant resources in the study area.

Use value (UV)

The relative importance of species used for treating types of ailments can be calculated using the UV. The most important, well-liked, and valuable plant species are typically those with the highest UV. *Prunus armeniaca* (0.75), *Ficus carica* (0.72), *Rheum australe* (0.63), *Juglans regia* and *Malus domestica* (0.63 each), and *Artemisia annua* (0.56) were the most popular plant taxa (Table 2). The taxa with the lowest UV values were *Diospyros virginiana* (0.21), *Cannabis sativa* (0.22) and *Myosotis alpestris* (0.29). Although these species were not very popular locally, it was observed that local healers regularly combined them with other plants in their regional herbal mixtures. According to the highest use report, there is a greater need for these medicinal plants to treat a variety of diseases, which increases their excess demand and is the main reason for their extinction in their natural habitat. The reason for the high UV of *Prunus armeniaca* is its diverse use as food, fodder, firewood, timber and other economic purposes. *P. armeniaca* is rich in phenols, especially chlorogenic acid, gallic acid, ferulic acid, caffeic acid, 4-aminobenzoic acid, salicylic acid and p-coumaric acid, and the most important flavonols are quercetin, the glycoside rutin, resveratrol and vanillin (Sochar *et al.* 2010). The fruits are rich in carotenoids, including β-carotene, γ-carotene, lycopene, β-cryptoxanthin, phytoene, phytofluene and lutein (Ayour *et al.* 2016). One way to measure the relative benefits of plants is the utilization value (UV), which considers both the frequency of use and the presence of these plants in different ethnic groups. The high UV of *Rheum australe* can be traced back to its long history of cultivation, which originated in the mountainous regions of northwest China and Tibet. There is evidence that the Chinese recognized the healing properties of Rhubarb as early as 2700 BC, and it was first mentioned in the " The ShenNong Ben Cao Jing"," the oldest medical text on Materia Medicine the world (Fang *et al.*2011).

Conclusion

This study revealed that the ethnic groups in the Himalayan highlands have a wide knowledge of wild plants. The study showed that each community was able to preserve its own unique traditional ethnobotanical knowledge. A total of 49 plant species belonging to 41 genera and 29 families were documented. The results show that the most important family is the Rosaceae. The most used plant part was the leaves. *Prunus armeniaca*, *Ficus carica*, *Juglans regia* and *Malus domestica* were

the most popular plant taxa. Most of the plant species collected are used for medicinal purposes, followed by food, cultural purposes, timber, cosmetics, fodder, firewood and veterinary medicine. The majority of the medicinal plant species were used to treat digestive issues, followed by respiratory issues. The current study fills the knowledge gap by documenting the local knowledge and cultural practices of plant species used by local communities for various purposes, thus demonstrating the range of traditional knowledge and the connection of indigenous peoples with their environment.

Declarations

Ethics approval and consent to participate: All the participants provided prior informed consent before the interviews. The ISE code of ethics was followed.

Consent for publication: Not applicable

Availability of data and materials: All data have been included in the manuscript.

Competing interests All the authors declare no conflict of interest.

Authors' contributions Conceptualization- Rainer W. Bussman, Shiekh Marifatul Haq; **Study Design**; Muhammad Azhar Jameel; Shiekh Marifatul Haq; **Data collection**- Nausheen Niaz; **Data analysis-** Shiekh Marifatul Haq; Muhammad Waheed; **Original draft writing** Shiekh Marifatul Haq; Aadil Abdullah Khoja; Nausheen Niaz; **Review and editing**- Rainer W. Bussmann, Aadil Abdullah Khoja, Muhammad Azhar Jameel, Muhammad Waheed, Shiekh Marifatul Haq. All authors read and approved of the final manuscript.

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