Ethnomedicinal utilization and conservation status of highland flora from Western Himalayas of Azad Jammu and Kashmir, Pakistan

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Research

Abstract

Background: Ethnobotany is an interdisciplinary field that investigates the intricate relationship between plants and humans. The study was aimed to investigate the ethnomedicinal utilization and assessment of the conservation status of highland flora in the western Himalayan region of Azad Jammu & Kashmir, Pakistan.

Methods: The study was conducted from May to September during the years 2018 to 2020 in the blooming season of subalpine and alpine lacustrine wetlands-associated flora. Information was collected from local farmers, herb vendor and herbalist/ hakims for various usage and remedies. During the fieldwork, 80 respondents (50 male and 30 female) of different age groups were selected and personal observations were also recorded. Plants that have been recorded are given together with their indication, portion used, preparation method, and use value (UV). The informant consensus factor (ICF) and fidelity level (FL) of the plants based on their utilization in relation to different disease categories were also determined through analysis of the results.

Results: The current study has documented 47 medicinal plant species from 25 families used for the treatment of 25 different major and minor illnesses and conditions. The rhizome (22%), roots (18%) followed by leaves and whole plants (17%) were the most favored plants parts amongst the species. The highest RFC was recorded for *Aconitum chasmanthum* (0.61%) while *Iris hookeriana* and *Persicaria alpina* has the lowest (0.03%). The maximum used value was reported for *Thymus linearis* (0.63) and minimum for *Iris hookeriana* that is (0.01). The highest FL value was found in *Thymus linearis* (73.75%) and lowest was observed for *Lindelofia longiflora* (1.25%). The highest IAR value (1.00) against gout, tuberculosis and tonic while lowest value is 0.20 for kidney diseases. The most frequently used plant component was rhizome, and powder was found to be the primary method of preparation. Preparations are often either ingested or used topically. The conservation status showed that 57% species are vulnerable, 19% endangered, 13% critically endangered and 11% are threatened.

Conclusion: This study contributes to the understanding of plant resource utilization patterns and the conservation status of high land flora in the western Himalaya region. The findings underscore the importance of implanting effective conservation measures to ensure the sustainable use of plant resources and the preservation of biodiversity in Azad Jammu & Kashmir, Pakistan.

Keywords: Medicinal plants, Highland flora, Western Himalayas, Conservation status

Background

Ethnobotanical studies involve the scientific exploration of the traditional knowledge, cultural practices, and uses of plants by indigenous communities for medicinal purposes (Jo *et al.* 2005; Kiringe 2006; Tefera & Kim 2019). The medicinal plants information is helpful to naturalists, chemists, and savage life managers to improving wealth in any area (Ibrar *et al*. 2007) and registered curative uses of species. In the past, people developed their specific knowledge in different localities by practicing traditional medicine through management and conservation technologies (Pankhurst *et al.* 2006). It plays a dynamic role between biological diversity, social and cultural systems to understand the relationship (Hussain *et al.* 2008). Every region of the globe has its specific remedial system related to their dependence and approaches regarding the usage of medicinal flora (Bartam 1995). Various herbal drugs in different geographical areas are used for the treatment of numerous human disorders (Qayum *et al.* 2016; Jain *et al.* 2007). The pastoral people typically depend on plants medication in folklore drug development (Ikram & Hussain 1978). From ancient time to present era, one can observe an international point of importance as people healed themselves through special constructions of prescriptions (Cragg & Newman 2003) and increased significant deliberation among the scientific societies (Heinrich 2000). Globally, about 85% (Farnsworth 1988) medicines developed from the plant species (Farnsworth 1988). (80%) population of under developing countries used native flora for fitness issues, livelihood improvement and income generation (WHO 2002). Ethno-medicinal records of indigenous knowledge highlighting locally important flora provides (Cox 2000) data about new drug development. Among different communities, qualitative data presented the values of plants use as medicine to cure different disorders (Norscia & Borgognini 2006). In ethnobotany, quantitative methods of data collection have developed recently. Quantitative data evaluate cultural features, such as plants flavor (Turner 1988; Pieroni 2001) and importance of families in communities (Benz *et al*. 2000; Phillips 1996).

Mostly valuation of plant resources depends on different factors such as social status, age, education, gender, profession, control of natural resources, roles in home and communities and economic status (Ayantunde *et al*. 2008).

Kashmir Himalaya provides good representation of medicinal plants (Dar *et al*. 2001). It remained a favorable place for local Hakims, exercise Unani system of herbal medicine that provided many opportunities to elevation this method. In Azad Kashmir, traditional health care activities are customarily based on traditional ethnobotanical knowledge. Different qualitative studies dealing with the medicinal flora of Azad Kashmir Himalaya have been carried out by (Ahmad *et al*. 2012; Habib *et al*. 2013). However, a very few reports were regarding the quantitative data collection and interpretation in different aspects of ethnobotany as Informant Consensus Factor (ICF), Fidelity level (FL), Relative Frequency Citation (RFC), Plant Part Values (PPVs) and Informant agreement ratio (IAR) (Ishtiaq *et al.* 2012; Amjad *et al*. 2017). Hence, the present study was designed to elaborate the link between quantitative ethnobotanical studies (which investigate the traditional knowledge and use of plants by local communities) and conservation status of highland flora. By examining the relationship between ethnobotanical data and conservation, this research could provide insight into the potential implications for biodiversity conservation, sustainable resource management, and local community livelihoods in the highland areas of Azad Jammu & Kashmir Pakistan.

Material and Methods

Study area

The Kashmir Himalayas includes parts of the Pir Panjal range of Lesser Himalaya in the south and southwest, with an area of about 15,948 km^2 within a large altitudinal range of 1,600 m to 5,420 m above mean sea level (MSL), situated between 33° – 36° N and 73° to 75° E. The valley of Kashmir is a lacustrine basin of the intra mountainous depression existing between the lesser and the Greater Himalayas and abounds with numerous freshwater ecosystems (Khuroo *et al.* 2007). The northern districts of the areas for example Sudhnoti, Poonch, Bagh, Hattian, Muzaffarabad and Neelum are generally mountainous while the southern districts include Bhimber, Mirpur and Kotli are relatively plain (Government of AJK 2019). The average rainfall ranges from 1000 mm to 2000 mm while the area has an average maximum temperature ranging from 20° C to 32° C and 04° C to 07° C minimum (Pak-met, 2018; Rehman *et al.* 2012). The mountainous avalanches, permafrost, glacial lakes and snowfall are the sources of water in the area (Cochard and Dar 2014; Pak-Met 2015).

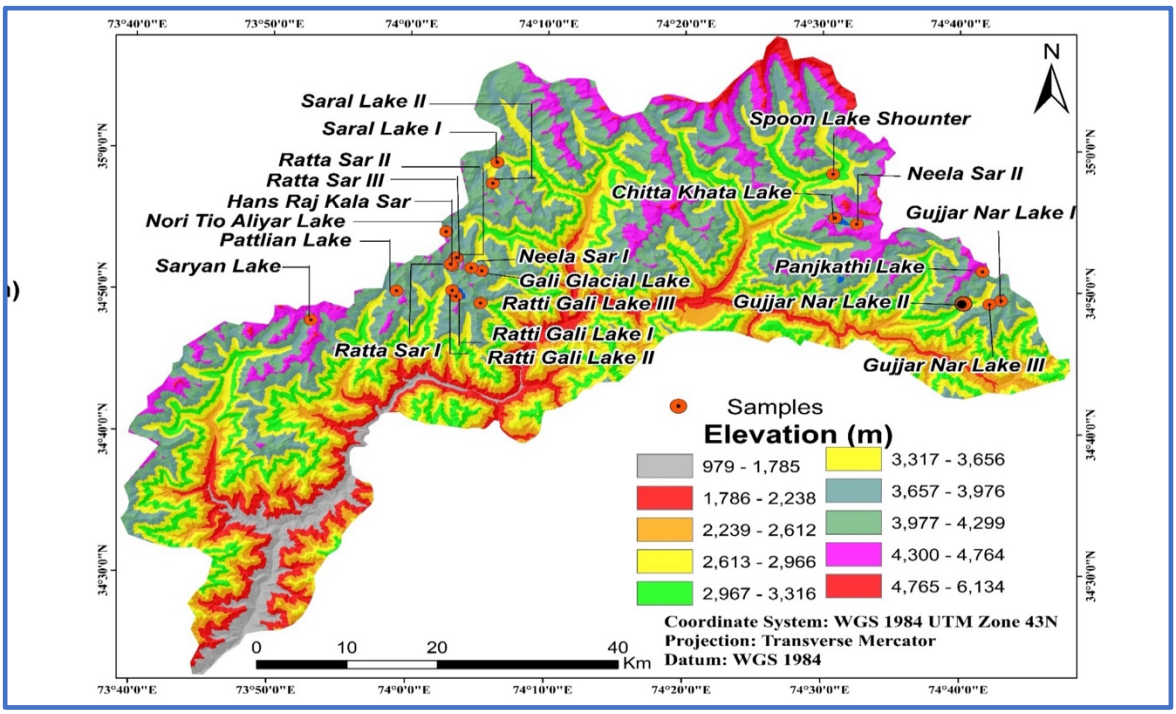

Figure 1. Map of the study sites from western Himalayan of Azad Jammu & Kashmir, Pakistan

Data collection

The study was conducted during May to September of the years 2018 to 2020 in the blooming season of subalpine and alpine lacustrine wetlands-associated flora, following the standard protocols (Presser 2004). Information was collected from local farmers, herb vendor and herbalist/hakeems for various usage and remedies. During the fieldwork 80, respondents (50 male and 30 female) of different age groups were selected and personal observations were also recorded.

Collection of ethnomedicinal data

The purpose of this research work was the documentation of associated lacustrine wetland flora and their medicinal usage. The study was conducted through interviews and questionnaires were also distributed among the informants (Martin 1995). The informants included teachers, farmers, hunters, wood sellers and forest and agriculture workers. All the respondents participated voluntarily and shared their knowledge freely as we kept a local guide with us who was well aware of the traditions and customs of the respondents.

Plant collection and identification

Comprehensive field surveys were conducted from May to September in 2018 and 2020, to ensure the detail exploration of the ethnomedicinal flora. Plant specimens were collected from all accessible parts along sampling sites and were pressed, dried (following herbarium specimen preservation protocols) and transferred to AKASH Herbarium of the University of Azad Jammu and Kashmir Muzaffarabad for identification with help of floras (Stewart 1961; Nasir & Ali 1970-1989; Ali & Nasir 1989-1992; Ali & Qaiser 1993-2011) under the supervision of expert taxonomist at the department of Botany, University of Azad Jammu and Kashmir Muzaffarabad.

Data analysis

The collected data were arranged in excel spread sheets in alphabetical order including botanical name of plant species with family, local names, habit, plant parts, use value, and mode of application.

Use value Index (UV)

The Use values index is calculated for individual plant species to give a quantitative measure of its relative importance to the respondents objectively (Jan *et al.* 2021). Use value index was calculated by the equation: UVs = ∑U/n where 'UVs' refers to the use value of a species, '∑U' refers to the sum of numbers of use reports cited by the respondents for that plant species and 'n' refers to the total number of respondents interviewed (Yabesh *et al*. 2014). Generally, UV is calculated to determine the extent of medicinal use for a given plant species. Plants with broad therapeutic uses or those that are widely accepted for the cure of a particular ailment will score a high UV.

Relative frequency citation (RFC)

The relative frequency citation index was used to calculate significance of each plant species reported/cited by local inhabitants (Birjees *et al*. 2022). It was calculated by following formula:

RFC = FC/N

Where "FC" stands for number of informants cited the usage a particular species while N represents the total number of informants.

Informant agreement ratio (IAR)

Informant Agreement Ratio (IAR) index was calculated to determine the homogeneity of the information for a particular plant to treat a particular ailment (Canales *et al*. 2005). Its values range from 0 to 1. IAR is calculated using the following formula:

IAR= Nur-Nt / Nur-1

where 'Nur' refers to the total number of uses reports for a particular illness category, and 'Nt' refers to the total number of species used for this illness category. In order to apply the above parameter, several diseases are placed into broad ailment category on the basis of similarity.

Fidelity level (FL)

The Fidelity level (FL) index represents the preference a species is given over others in the treatment of a particular disease (Friedman *et al*.1986). It was calculated by using the formula:

FL=Ip/Iu x100

where Ip is the number respondents using a species for a particular disease type while Iu is the number of respondents using of that plant for any kind of disease. The high FL value reflects high usage of a plant for a particular disease, while low FL value depicts extensive medicinal usage but with a low frequency for specific disease.

Plant Part Values (PPVs)

The plant part value index was calculated following (Chaachouay *et al.* 2019) to find out the relative use value of the several parts of a specific medicinal plant species. The plant part value was calculated by using the following formula:

PPVs = RU/Rupp

Where, "PPVs" stands for the Plant Part Values, "RU" is total number of medical plants uses (including all of its parts) cited by the informants, while "RUpp" stands for the total number of medicinal plants uses for each given part.

Conservation status

The conservation status of ethnobotanically important plant species was determined based on the conservation score. The conservation score for each species was calculated using the following formula: (Ilyas *et al.* 2015: Hussain *et al*. 2023).

$$\text{Conservation score} = \frac{(\text{Normalized IV} + \text{Used Value})}{2}$$

Where: Normalized IV = IV of single species/ largest value IV from all the species.

Table 1. Conservation scores and conservation status categories.

Conservation Score	Category
0-0.2	Critically Endangered
0.2-0.4	Endangered
0.4-0.6	Vulnerable
0.6-0.8	Near Threatened
0.8-1.0	Least Concern

Results and Discussion

In the current study, we interviewed 80 ethnic individuals, including farmers, nomads, housewives, students, laborers, teachers, hakims, and herbalists. There were 30female and 50 male informants. The informants ranged in age from 25 to above 65 years. These informants were then categorized into six literacy groups and four age groups. Mostly the informants belonged to the age group between 56 and 70 (39 with 48.25%), and it was shown that this age group had the knowledge regarding, followed by of 41 and 55 age group with 26.25%. There was a decrease in ethnic knowledge among informants aged 25 to 40 and above 70. It may be due to modern lifestyle, preferring allopathic treatments over natural therapies and a smaller number of informants above 70 years of age (Sargin 2015). Furthermore, a continuous decrease in informants 'traditional knowledge was seen with a higher literacy rate. This decline in trends in knowledge is because educated people prefer a more modern system of healthcare than a traditional system. Similar findings were also reported by (Bhatia *et al*. 2014; Jan *et al.* 2017). Based on the information provided, it appears that there is a trend in the use of plant-based therapies for treating different disorders. The use of such therapies was more common among elderly individuals and its popularity was decreasing in the young generation. The older respondents, who belong to the elderly age group, were found to possess more ancestral knowledge that is often transmitted to oral tradition (Yaseen *et al*. 2015; Bauzid *et al*. 2017)

Table 2. Demographic information of the informants participated in interviewed

indicator	**distribution of respondents**	
gender		
	Number	**Percentage**
Male	50	62.5
Female	30	37.5
age in years		
25-40	11	13.75
41-55	21	26.25
56-70	**39**	**48.75**
above 70	**9**	**11.25**
profession		
Farmer	12	15
Herb vendor	16	20
Herbalist/hakeems	9	11.25
Nomades	**37**	**46.25**
Educationist	**6**	**7.5**
Education		
Illiterate	**33**	**41.25**
Primary and Middle (1-8)	12	15
Matriculate (9-10)	15	18.75
Intermediate (11-12)	5	6.25
Bachelors (13-16)	10	12.5
Higher Education	**5**	**6.25**

Plant collection and identification

Through detailed survey, a total of 47 ethnomedicinally important plant species belonging to 25 families and 41 genera were recorded. The maximum number of plant species (06 species) belonging to Asteraceae and polygonaceae followed by Ranunculaceae and Rosaceae (3 species), Apiaceae, Boraginaceae, Dryopteridaceae, Gentianeceae, Lammiaceae, Saxifragaceae and Scrophulariaceae with 2 species each and remaining families were monospecific. Due to the remoteness of the area lacking alternative medicinal sources, there is a huge pressure on medicinal plants. The local population mainly depends upon natural remedies because they are affordable and easily accessible in the area (Tahir *et al*. 2023). In this study, the dominant plant families were Asteraceae, polygonaceae, Ranunculaceae and Rosaceae. These plant families were abundant and widely distributed in the region under investigation (Rahman *et al*. 2022). (Figure 2,Table 3)

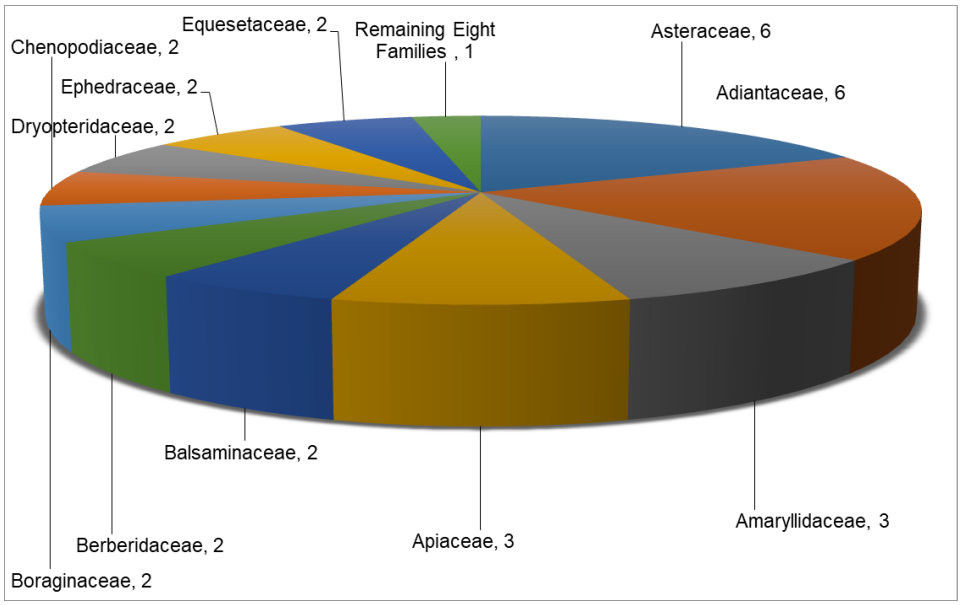

Figure 2. Asteraceae and Polygonaceae dominating the highland flora of studied area based on number of species.

Use value index and Relative Frequency Citation

In current study high used values were observed for *Thymus linearis* (0.63), *Aconitum chasmanthum* (0.51), *Viola pilosa* (0.49), *Bistorta amplexicaulis* (0.39), *Senecio graciliflorus* (0.39), *Saussurea costus* (0.38), *Rumex patientia* (0.36), *Caltha alba* (0.33) and *Aconitum hetrophyllum* (0.31) indicating massive ethnobotanical usage in the area. The lowest UVs were recorded for *Chenopodium album* (0.03), *Euphorbia wallichii* (0.03), *Lindelofia longiflora* (0.03), *Potentilla nepalensis* (0.03) and *Iris hookeriana* (0.01) (Table 3). Higher UVs for several plants' species might be due to their availability and wide range distribution across the proposed study area. The locals and nomads in the area commonly used these preferred species for many disease groups. Extract, decoction and paste of *Thymus linearis*, with highest UV is used to treat the suppression of urine, constipation, backache and reduce shivering. *Aconitum chasmanthum* flowers that are effective against asthma, roots paste used for foot and mouth diseases (Mukhar) of Animals. *Viola pilosa* fresh leaves are cooked and added to soups. They can also be dried for winter use. Root decoction is given to increase milk secretion and reduces prostate enlargement. The decoction is applied to reduce dandruff and baldness. While *Bistorta amplexicaulis* Roots are used for the general weakness of animal, and for the treatment of diarrhea and dysentery. Flower tea is used to treat stomach Problem (Ayyanar and Lgna cimuthu 2011). The values RFCs were in the range of 0.03% to 0.61%. *Aconitum chasmanthum* showed the highest RFC (0.61%). It indicates the popularity of a specific plant species in an area based on relative use. Asthma, foot and mouth diseases, diarrhea, urinary tract infections, fevers, gastrointestinal problems, diabetes, rheumatism, feminine problems, blood diseases, fractures and vomiting are some ailments, against that these species have been reported effective in curing, according to their significant values. *Arnebia* benthamii, *Gentiana kurroo, Iris hookeriana* and *Persicaria alpina* showed minimum RFC values of 0.03% (Table 3). Furthermore, it shows efficacy and wide range usage of plants with little or no side effects (Hussain *et al*. 2018). Our findings were also supported by the findings of a previous study (Munir *et al.* 2022). It is crucial to evaluate and demonstrate the pharmacological activity of ethnomedicinal species with high UVs and RFCs values (Yaseen, 2019). Although plants with low UVs are important (Amjad *et al*. 2017), their low values suggest that the locals are unaware of their benefits, which prevents the dissemination of information to recipient.

Table 3. Species names, family, local name, medicinal uses, Part used, Use value average IVI, conservation score and conservation category medicinal plants from western Himalaya AJK.

Species Name class	Family	Local Name	Medicinal uses	PU	UV	Avg. I.V.I.	C.S	C. C
Achillea millefolium L.	Asteraceae	Sultani Boti	Against stomach issues, urinary problems, toothache,	Rh	0.09	3.61	0.37	Endangered
Aconitum chasmanthum Stapf ex Holmes	Ranunculaceae	Mohri	Applied on chest to treat pneumonia, cold, fever, diarrhea, and dyspepsia,	Rh	0.31	12.69	0.57	Vulnerable
Aconitum heterophyllum Wall. ex-Royle	Ranunculaceae	Patrees	Flower effective against asthma, roots paste used for foot and mouth diseases (Mukhar) of Animals	Fl, Rh	0.51	3.05	0.29	Critically Endangered
Adiantum venustum D. Don	Adiantaceae	Kakwa	Decoction is taken orally for pulmonary disorders.	Wp	0.21	1.53	0.41	Vulnerable
Allium humile Kunth	Amaryllidaceae	Pyaz	Fresh plant is taken as salad for gastrointestinal disorders and UTI.	Wp	0.13	3.05	0.32	Endangered
Angelica glauca Edgew.	Apiaceae	Chora	Used in acute abdominal pain and kept in houses as emergency medicine for stomachache, rheumatism, hepatitis also used as condiment	R, L	0.09	3.43	0.14	Critically Endangered
Arnebia benthamii (Wall. ex G. Don) I.M.Johnst.	Boraginaceae	Gaw Zuban	Joint pain, stomachache, fever, and ulcer. Scurvy, Fever	Rh	0.04	2.09	0.4	Endangered
Berberis aitchisonii Ahrendt	Berberidaceae	Sumbalu	The plants have been used in eye disease, fever, jaundice, malaria; wound healing, rheumatism, vomiting during pregnancy, stones of bladder.	Bk, L, R & S	0.1	1.8	0.52	Vulnerable
Bergenia ciliate Sternb.	Saxifragaceae	Bat Bhewa	Latex is applied externally for gum diseases and decoction of rhizome is used in kidney stones.	Lx & Rh	0.16	3.93	0.3	Endangered

Species Name class	Family	Local Name	Medicinal uses	PU	UV	Avg. I.V.I.	C.S	C. C
Bergenia stracheyi (Hook.f. & Thomson) Engl	Saxifragaceae	Bat Bhewa	Root paste used on burns, in kidney stone, piles, diabetes, ulcer dysentery, and heart diseases. Crushed roots are mixed with milk and given in backache. Root powder with water or milk is used to reduce Obesity	Rh	0.18	5.92	0.66	Near Threatened
Bistorta affinis (D.Don) Greene	Polygonaceae	Masloonr	Powders prepared from rhizome taken with milk as anti-inflammatory &astringent.	Rh	0.24	6.91	0.56	Near Threatened
Bistorta amplexicaulis (D.Don) Greene	Polygonaceae	Masloonr	Roots are used for the general weakness of animals, and for the treatment of diarrhea, dysentery and Hoptysis. Flower tea is used to treat stomach Problem	Rh, F	0.39	2.43	0.56	Near Threatened
Bupleurum candollei Wall. ex DC	Apiaceae	Kali Boti	Roots put in the yogurt to increase the amount of Butter	R	0.08	2.51	0.46	Vulnerable
Caltha alba Jacq.ex Cart.	Ranunculaceae	Kakari Patra	Roots decoction is used as mouth wash; young shoots and leaves are cooked as vegetable for and considered as digestive.	R & Ap	0.33	3.24	0.52	Vulnerable
Chenopodium album L.	Chenopodiaceae	Bathwa	Vegetable for cough and constipation	L, S	0.03	3.19	0.45	Vulnerable
Dryopteris ramosa (C. Hope) C. Chr	Dryopteridaceae		Vegetable, rhizome is used for the treatment of cholera and dysentery.	WP	0.24	1.18	0.42	Vulnerable
Dryopteris wallichiana (Spreng.) Hylander,	Dryopteridaceae	Kunji	Young shoots are cooked as pot herbs and considered as digestive and purgative.	YS	0.08	1.82	0.43	Vulnerable

Species Name class	Family	Local Name	Medicinal uses	PU	UV	Avg. I.V.I.	C.S	C. C
Ephedra gerardiana Wall.exStapf.	Ephedraceae	Bata	Powder of the crushed plant and sometime its tea is used for TB, asthma, astringent, relaxation of bronchial muscles.	Wp	0.13	0.97	0.09	Critically Endangered
Equisetum arvense L.	Equesetaceae	Deela	Powder prepares from aerial parts are used for bone strengthening, hairs and nail development and weakness caused by TB.	Ar	0.05	1.16	0.35	Endangered
Euphorbia wallichii Hook.f.	Euphorbiaceae	Hervi	Latex is extracted and mixed with milk in small amounts and used against worms, as cathartic, purgative and diaphoretic.	Lx	0.03	0.83	0.49	Vulnerable
Euphrasia adenonota I.M. Johnst.	Scrophularaceae		Local people cook and use it against cold, cough, sore throat	Wp	0.04	3.07	0.59	Vulnerable
Fragaria nubicola (Hook. f.) Lindl. ex Lacaita	Rosaceae	Budi mewa	Fruit eaten, decoction of roots used in Jaundice and typhoid.	F, R	0.15	3.86	0.6	Near Threatened
Galium boreale L.	Rubiaceae	Nekiboti	Its decoction is used in urinary tract infection.	Wp	0.15	1.41	0.52	Vulnerable
Gentiana kurroo Royle	Gentianaceae	Bhangri	Tonsillitis and toothache. Oil is astringent and applied as massage around throat. Decoction is used for joint pain, gyne problems, constipation, and digestion	R	0.05	2.21	0.09	Critically Endangered
Geranium pratense L.	Geraniaceae	Ratan Jot	Paste of leaves is used in rheumatism. Extract of the plant is regarded as cooling agent and cathartic.	Wp	0.1	1.24	0.4	Vulnerable

Species Name class	Family	Local Name	Medicinal uses	PU	UV	Avg. I.V.I.	C.S	C. C
Impatiens thomsonii Hook.f. H	Balsaminaceae	Buntil	Minute amount of powder of dried rhizome is used as diuretic, cathartic and in gall bladder diseases.	Wp	0.26	0.47	0.43	Vulnerable
Iris hookariana Foster	Iridaceae	Ghory Gha	Used in digestion, backache, diarrhea, and joint pains. Root paste is eaten after cooking in rice or flour	Rh	0.01	2.88	0.6	Near Threatened
Jurinea ceratocarpa (Decne.) Benth. ex C.B.Clarke	Asteraceae	Gugal Dhoop	Used to cure female diseases	Rh	0.26	1.22	0.13	Critically Endangered
Lindelofia longiflora var. falconeri Brand	Boraginaceae	Neeli boti	Young leaves and aerial parts are used as source of vitamin C.	Fl, R	0.03	1.18	0.49	Vulnerable
Oxyria digyna (L.) Hill	Polygonaceae	Khatkurla	Paste prepared from fresh leaves is used in skin problems especially soured feet.	Ar.	0.16	1.95	0.54	Vulnerable
Plantago alpine L.	Plantaginaceae		Vegetable, flower as alternate of ispaghol in dysentery	L	0.1	0.41	0.46	Vulnerable
Plantago major L.	Plantaginaceae	Chamchi Patra	Roots are used as astringent. Stalk is used for washing of ulcers, constipation	Fl, L	0.13	0.3	0.47	Vulnerable
Persicaria alpina (All.) H.Gross	Polygonaceae	Khatibooti	Root tea is taken for stomach problems	Ar, R, S	0.04	1.49	0.52	Vulnerable
Potentilla nepalensis Hook.	Rosaceae	Mali Di Cha	Powdered rhizome mixed with honey is used to cure Ophthalmia and Leukoderma.	R	0.03	1.47	0.55	Vulnerable

Species Name class	Family	Local Name	Medicinal uses	PU	UV	Avg. I.V.I.	C.S	C. C
Primula denticulata Sm.	Primulaceae	Mameera	Vegetable, stem is edible, root paste is applied externally in muscular injury, cuts, wounds, mumps, headache, stomachache constipation, dysentery, swelling of throat, earache and blood purification	Rh	0.25	1.95	0.48	Vulnerable
Rheum webbianum Royle	Polygonaceae	Chootial	Processed flowers (Arq) are used in asthma While bark is considered as mild astringent.	L. Rh,	0.2	4.33	0.36	Endangered
Rosa macrophylla Lindl.	Rosaceae	Jangli Gulab	Vegetable. Root paste is anti-lice. Constipation of Animals	Fl, Bk	0.13	0.46	0.46	Vulnerable
Rumex acetosa L.	Polygonaceae	Hola	Constipation, worm killing, joint pain, antiseptic, toothache, and backache, weakness, sugar	L, Rh	0.36	3.74	0.49	Vulnerable
Saussurea costus (Falc.) Lipsch.	Asteraceae	Kuth	Gas trouble in humans and for the release of after birth in animals	Rh	0.38	1.98	0.05	Critically Endangered
Senecio graciliflorus (Wall.) DC.	Asteraceae	Bagoo	Powders are used in constipation & dyspepsia.	R	0.39	0.84	0.46	Vulnerable
Swertia speciosa D.Don	Gentianaceae	Rech Endeh	Vegetable. Also used in cold, cough and diabetes and kidney pain	Wp	0.15	2.09	0.56	Vulnerable
Taraxecum officinale Webb	Asteraceae	Hand	Extract is used to treat Cough, cold	L, R	0.14	0.43	0.48	Vulnerable
Taraxacum tibetanum Hand.-Mazz.	Asteraceae	Mali Ki Hand	Suppression of urine, constipation and shivering	L, R	0.13	2.78	0.33	Endangered
Thymus linearis Benth ex Benth	Lammiaceae	Chikal	Fresh plant is used as anti-anthelmintic (Cattles poison)	L, Fl	0.63	4.3	0.31	Endangered

Species Name class	Family	Local Name	Medicinal uses	PU	UV	Avg. I.V.I.	C.S	C. C
Trifolium repens L.	Fabaceae	Shatal	Root 's powder is considered as aphrodisiac; leaves, paste is used in skin problems; leaves are also smoked as narcotic and sedative.	Wp	0.04	0.84	0.46	Vulnerable
Verbascum Thapsus L.	Scrophulariaceae	Gady Kan	Fresh leaves are cooked and added to soups. They can also be dried for winter use. Root decoction is given to increase milk secretion and reduces prostate enlargement. The decoction is applied to reduce dandruff and baldness.	Wp	0.04	1.04	0.39	Endangered
Viola pilosa Blume	Violaceae	Banafsha	Used in stomach-ache and in urinary infections, the root with ginger root powder is also used for curing high fevers. The roots were also used as bitter tonic, and as an antiperiodic, expectorant, astringent, stomachic, anti-inflammatory, antipsychotic, sedative, anthelmintic and antibacterial	L, F	0.49	0.46	0.41	Vulnerable

P. U.: Part Used**; R:** Roots**; L:** Leaves**; Wp:** Whole Plant**; Fl:** Flower**; Rh:** Rhizome**; Lx:** Latex**; Bk:** Bark**; S:** Stem**; YS:** Young Stem**; Ap:** Aerial Part; **U. V**; Used Vales, **C. S**; Conservation Score, **C. C**; Conservation Category

Table 4. Use Value Index (UV) and Relative Frequency of Citation (RFC) of medicinal plants from studied area

Plant species	∑U	N	UV=∑U/n	FC	N	RFC=FC/N
Achilia milliefolium	7	80	0.09	9	80	0.11
Aconitum hetrophyllum	25	80	0.31	22	80	0.28
Aconitum chasmanthum	41	80	0.51	49	80	0.61
Adiantum venustum	17	80	0.21	22	80	0.28
Allium humile	10	80	0.13	12	80	0.15
Angelica glauca	7	80	0.09	4	80	0.05
Arnebia benthamii	3	80	0.04	2	80	0.03
Berberis aitchisonii	8	80	0.10	11	80	0.14
Bergenia ciliata	13	80	0.16	26	80	0.33
Bergenia stracheyi	14	80	0.18	17	80	0.21
Bistorta affinis	19	80	0.24	45	80	0.56
Bistorta amplexicaulis	31	80	0.39	34	80	0.43
Bupleurum candollei	6	80	0.08	4	80	0.05
Caltha alba	26	80	0.33	21	80	0.26
Chenopodium album	2	80	0.03	3	80	0.04
Dryopteris wallichiana	19	80	0.24	14	80	0.18
Dryopteris ramose	6	80	0.08	12	80	0.15
Ephedra gerardiana	10	80	0.13	8	80	0.10
Equisetum arvense	4	80	0.05	6	80	0.08
Euphorbia wallichii	2	80	0.03	5	80	0.06
Euphrasia himalayica	3	80	0.04	4	80	0.05
Fragaria nubicola	12	80	0.15	14	80	0.18
Galium boreale	12	80	0.15	10	80	0.13
Gentiana kurroo	4	80	0.05	2	80	0.03
Geranium pratense	8	80	0.10	10	80	0.13
Impatiens thomsonii	21	80	0.26	17	80	0.21
Iris hookeriana	1	80	0.01	2	80	0.03
Juraniam acrocephala	21	80	0.26	18	80	0.23
Lindelofia longiflora	2	80	0.03	7	80	0.09
Oxyria digyna	13	80	0.16	11	80	0.14
Plantago alpine	8	80	0.10	12	80	0.15
Plantago major	10	80	0.13	15	80	0.19
Persicaria alpine	3	80	0.04	2	80	0.03
Potentilla nepalensis	2	80	0.03	4	80	0.05
Primula denticulate	20	80	0.25	16	80	0.20
Rheum webbianum	16	80	0.20	12	80	0.15
Rosa macrophylla	10	80	0.13	16	80	0.20
Rumex patientia	29	80	0.36	19	80	0.24
Saussurea costus	30	80	0.38	20	80	0.25
Senecio graciliflorus	31	80	0.39	21	80	0.26
Swertia speciosa	12	80	0.15	21	80	0.26
Taraxacum officinale	11	80	0.14	22	80	0.28
Taraxacum tibetanum	10	80	0.13	20	80	0.25
Thymus linearis	50	80	0.63	43	80	0.54
Trifolium repens	3	80	0.04	6	80	0.08
Verbascum thapsus	3	80	0.04	5	80	0.06
Viola pilosa	39	80	0.49	44	80	0.55

Fidelity levels (FL) data was analyzed of the reported plant species, it varied widely for a specific ailment. It ranged from 1.25% to 73.75% for plants species in the area. The highest fidelity level of *Thymus linearis* is (73.75%) was reported followed by *Aconitum chasmanthum*, *Bergenia ciliate*, *Bergenia stracheyi*, *Aconitum hetrophyllum* and *Ephedra gerardiana* which are used

against Gastric/dysentery/Diarrhea disorders backache and analgesic while minimal fidelity level was recorded 1.25 % shown by *Lindelofia longiflora* which is used against female diseases (Table 6). This may be due to the fact that these ailments are more common in these areas and locally these species are specifically used for the treatment of such ailments. These plants are extensively used in many ethnobotanical practices around the world with sufficient scientific proofs of their therapeutic use (Pengelly 2021; Daniel 2006). The higher FL indicates that their frequent mention among local communities, are considered more reliable and preferred choices for the treatment of a specific disease. This knowledge can be valuable in guiding conservation efforts and the development of effective herbal remedies for the identified health condition (Hussain et al. 2019).

Table 5. Fidelity levels (FL) of different species used for different ailments/diseases in western Himalayan of AJK, Pakistan

Plant species	Lp	Lu	F.L %=(Lp/Lu) *100
Achilia milliefolium	9	80	11.25
Aconitum hetrophyllum	24	80	30.00
Aconitum chasmanthum	51	80	63.75
Adiantum venustum	11	80	13.75
Allium humile	12	80	15.00
Angelica glauca	17	80	21.25
Arnebia benthamii	7	80	8.75
Berberis aitchisonii	19	80	23.75
Bergenia ciliate	44	80	55.00
Bergenia stracheyi	39	80	48.75
Bistorta affinis	19	80	23.75
Bistorta amplexicaulis	12	80	15.00
Bupleurum candollei	7	80	8.75
Caltha alba	16	80	20.00
Chenopodium album	10	80	12.50
Dryopteris wallichiana	13	80	16.25
Dryopteris ramose	11	80	13.75
Ephedra gerardiana	20	80	25.00
Equisetum arvense	6	80	7.50
Euphorbia wallichii	2	80	2.50
Euphrasia himalayica	3	80	3.75
Fragaria nubicola	3	80	3.75
Galium boreale	5	80	6.25
Gentiana kurroo	3	80	3.75
Geranium pratense	4	80	5.00
Impatiens thomsonii	5	80	6.25
Iris hookeriana	2	80	2.50
Juraniam acrocephala	2	80	2.50
Lindelofia longiflora	1	80	1.25
Oxyria digyna	3	80	3.75
Plantago alpine	7	80	8.75
Plantago major	8	80	10.00
Persicaria alpine	2	80	2.50
Potentilla nepalensis	2	80	2.50
Primula denticulate	3	80	3.75
Rheum webbianum	5	80	6.25
Rosa macrophylla	4	80	5.00
Rumex patientia	3	80	3.75
Saussurea costus	9	80	11.25
Senecio graciliflorus	2	80	2.50
Swertia speciosa	3	80	3.75
Taraxecum officinale	4	80	5.00
Taraxacum tibetanum	5	80	6.25
Thymus linearis.	59	80	73.75

Plant species	Lp	Lu	F.L %=(Lp/Lu) *100
Trifolium repens	3	80	3.75
Verbascum thapsus	3	80	3.75
Viola Pilosa	2	80	2.50

Informant Agreement Ratio (IAR)

The IAR is an index used for evaluating how a specific plants species is well-suited for mitigating a given ailment. Its values for studied ethno medicinal plants showed that the highest value is 1.00 against gout, tuberculosis and tonic for various conditions. Followed by blood disorders and burning with IAR score (0.92), followed by Joint pain (0.88) and Dermatological problems (0.86) respectively. The studied plant species also showed strong potential as antibacterial, anti-inflammatory, Anti-lice and Constipation in Animals and anti-Dandruff and anti-hair fall, according to IAR value (Table 6).

Table 6. Informant Agreement Ratio (IAR)

Disease Type	Nt	Nur	Nur-Nt	Nur-1	IAR = (Nur - Nt) / (Nur – 1
Gout	1	5	4	4	1.00
Tonic	1	6	5	5	1.00
Tuberculosis	1	6	5	5	1.00
Blood diseases and burning	3	27	24	26	0.92
Joint pain	2	9	7	8	0.88
Dermatological problems	3	15	12	14	0.86
Antibacterial	3	13	10	12	0.83
Urinary Tract Infections	2	7	5	6	0.83
anti-inflammatory	10	49	39	48	0.81
Fractures	4	17	13	16	0.81
Analgesiac	5	22	17	21	0.81
Diabetes	5	21	16	20	0.80
Fever	10	44	34	43	0.79
Coughing and Constipation	4	15	11	14	0.79
Gastric/dysentry/Diarrhea	6	23	17	22	0.77
Anti-lice and Constipation in Animals	3	7	4	6	0.67
Liver Diseases	2	4	2	3	0.67
Jaundice and Typhoid	4	9	5	8	0.63
Asthma	7	14	7	13	0.54
Dandruff and baldness	6	10	4	9	0.44
Energizer	3	4	1	3	0.33
Cathartic	4	5	1	4	0.25

Plant Part Value (PPV) and mode of administration

The results of the Plant Part Value (PPV) index showed that most of the people used main plant parts used rhizome, roots and whole parts for the treatment of the ailments in the study area. The maximum PPV was 22% showed by rhizome followed by roots and leaves with 18% and 17% respectively. While minimum PPVs were shown by latex and bark with 3% each (Figure 2). While the analysis of the ethno botanical investigations showed that the usage of medicinally important plant for the treatment of diseases was taken as powder with milk or water, used as a cooked vegetables, decoction/tea and paste is applied especially in skin diseases. When producing herbal medication fresh plant material was typically used rather than dried plant material fresh rhizome, leaves and stem having higher nutrient content, active enzyme, volatile compound, moisture content, reducing oxidation and aromatic properties (Ullah et al. 2021) (Figure 3).

Conservation status assessment

The current study revealed that based on conservation scores out of the 47 medicinal plants 6 (13%) species are critically endangered, 9 (19%) endangered, 27 (57%) vulnerable, and 5 (11%) near threatened. Critically endangered species of the study area included *Aconitum hetrophyllum*, *Angelica glauca*, *Ephedra gerardiana*, *Jurania macrocephala*, *Saussurea costus*, and *Gentiana kurroo* similar species were reported by (Ahmed *et al*. 2012) from Sharda neelum valley of AJ&K. The importance of value allows to identify the most significant and abundant species within a plant community. Phytosociological and importance value index helpful in understanding distribution as well as conservation status assessment, its response to environmental gradients (e.g., climate, soil condition, elevation), and ecological roles of different species within the ecosystem (Hussain et al., 2023). Other ethnobotanical studies in Pakistan also revealed that medicinal plants are facing serious threats leading to their loss and engagement (Majid et al. 2020; Shah et al). The sustainable use of medicinal plants and their products is important for biodiversity conservation and well-being of both human communities and the environment. Community based governmental biodiversity conservation practices play a vital role in achieving this goal (Figure 4).

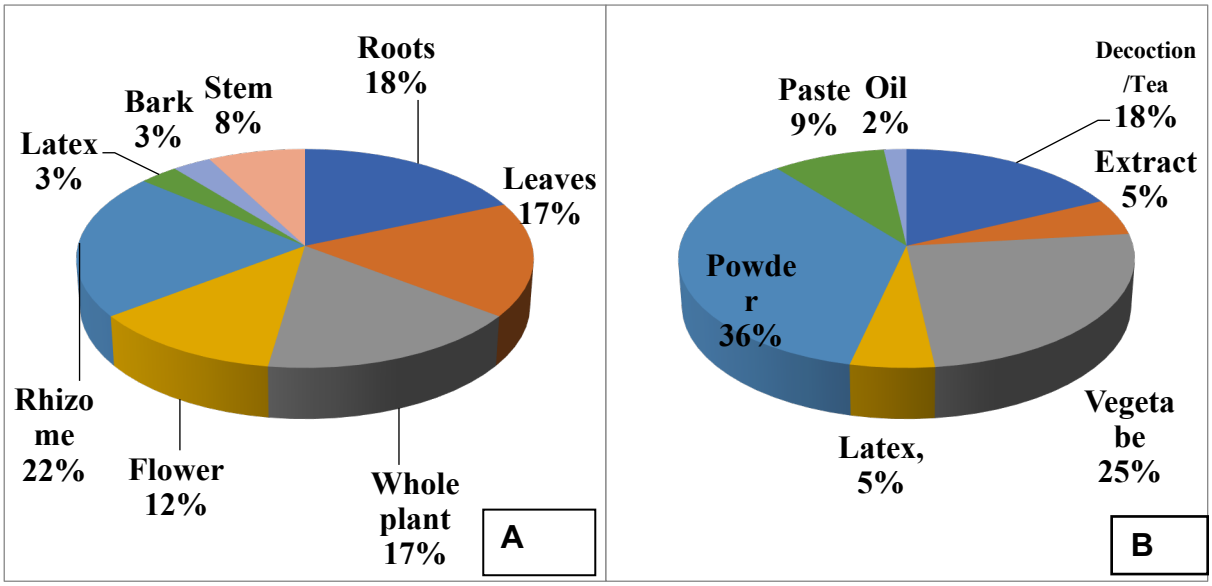

Figure 3. (A) Plant part value (PPVs) and (B) Mode of administration of the studied plants species

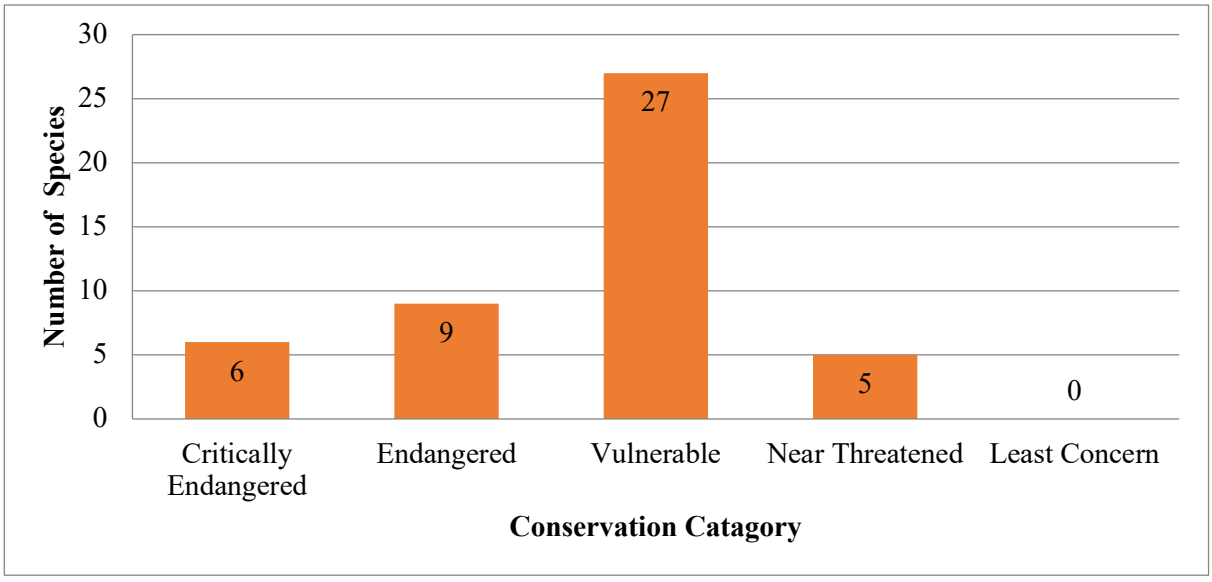

Figure 4. Conservation status assessment of plant resources of Western Himalayas of Azad Jammu and Kashmir

Conclusion

The study conducted a comprehensive survey and analysis of the plant resources, highlighting the patterns of utilization by local communities and assessing the conservation status of the highland flora. The findings revealed a rich diversity of plant species in the region, with numerous species being utilized for medicinal purposes. However, the research also identified several challenges to the conservation of the highland flora. These challenges include overexploitation, non-scientific collection, overgrazing, trampling and tourism. The study emphasizes the need for effective conservation strategies and sustainable management practices to ensure the long-term survival of the diverse plant species in the region.

Declarations

List of abbreviations: RFC= relative frequency of citation, UV= use value, FL= Fidelity Level, IAR= Informant Agreement Ratio, PPV= Plant Part Value

Ethics approval and consent to participate: This study did not involve the export of any animal or plant material. Information was obtained from the participants. All informants were orally consented.

Consent for publication: Oral permission was taken from all the authors.

Availability of data and materials: The manuscript contains all the data.

Competing interests: We declare that there is no conflict of interest.

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Authors' contributions: MSA and IUID designed the study; MSA, SS and KH conducted the fieldwork, AM and TI conducted the main statistical analysis; MSA wrote the manuscript, SS, TH and TI revised the data analysis and the manuscript; all authors read, corrected, and approved the manuscript.

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