Journal of Ethnobiology and Ethnomedicine

RESEARCH

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The shifting dynamics of plant and mushroom foraging in Kashmir

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Abstract

Background In the mountainous region of Kashmir, wild food plants (WFPs) are vital to traditional food systems and security. Ethnic communities possess rich foraging practices; however, current sociocultural and environmental impacts may affect the transmission of local plant knowledge among younger generations. This study explores traditional foraging practices and provides a cross-cultural analysis of five groups: Gujjar, Bakarwal, Lone, Syed, and Mughal. It investigates gender-based knowledge, intergenerational dynamics of local plant knowledge, and WFP knowledge among various age groups.

Methods Data were collected from 191 informants through semi-structured interviews and focus group discussions from March to September 2024. Factor analysis was conducted to analyse perceived threats to WFPs, and a Venn diagram illustrating WFP consumption patterns across groups was created using OriginPro and R software.

Results A total of 63 species were recorded, including 11 fungal species and 52 WFPs. The analysis revealed diverse consumption patterns, with the Gujjar group consuming the most at 59 species, while the Bakarwal group used only 20. Three distinct wild food plant-based ingredients not previously mentioned in the literature were identified: *Lagotis cashmeriana* (Bakarwal), *Fagopyrum cymosum*, and *Armillaria mellea* (Gujjar). The gender-based knowledge analysis shows that women possess more extensive knowledge about WFPs than men, as they frequently engage in harvesting, consuming, and preparing these plants. Participants aged 18–35 accounted for 21.99% of the knowledge and reported on 19 WFPs, primarily from the Gujjar and Bakarwal groups. Cultural transformation among communities has impacted the core body of knowledge, historically transmitted through storytelling during gatherings and events. However, sociocultural changes have affected social structures, impacting the sharing of traditional plant knowledge.

Conclusion The commodification and mobility of food ingredients have altered local practices, particularly in preparing *Dryopteris*, *Diplazium*, *Pteridium*, and *Morchella*. Preserving biocultural heritage and promoting sustainable foraging practices can enhance economic growth, food security, and rural development by safeguarding plant knowledge and encouraging commercial cultivation.

Keywords Cross-cultural ethnobotany, Food security, Traditional foraging practices, Fading heritage, Gender-based knowledge, Kashmir

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Background

Wild food plants (WFPs) are vital for global food security, nutrition, and climate change resilience [1, 2]. They offer significant dietary diversity, contribute significantly to micronutrient intake, and support the livelihoods of rural and indigenous communities [3, 4]. Wild edible plant species are consumed worldwide, particularly during times of food scarcity and famine [5]. Humans have gathered these plants since early civilization [1, 6]. As communities settled, they began domesticating plants and animals, a practice still observed in tribal communities today [7]. WFPs play a crucial role in socioecological systems, enhancing food diversification and agroforestry practices [8]. Consequently, WFPs are essential for maintaining food and nutrient security, particularly in the context of climate change, as highlighted by various studies [1, 9]. Globally, WFPs are vital for rural livelihoods in developing countries [10]. The gap between population and food supply presents a significant survival challenge. Researchers are concentrating on lesser-known edible plants to tackle food scarcity in these areas [11, 12]. However, threats such as land-use change, overharvesting, and climate change endanger these vital resources [1]. Interdisciplinary research is necessary to document, conserve, and integrate WFPs into sustainable food systems, enhancing dietary diversity, promoting biocultural resilience, and supporting adaptation to environmental changes [13].

The Kashmir Himalayas are a key region for plant diversity, offering a unique reservoir of flora that meets ecological and human needs [14–16]. The areas varied climatic zones, from subtropical to alpine, support a rich range of plant species, making it a biodiversity hotspot [17–20]. These plant help maintain ecological balance by providing essential ecosystem services and serve as valuable resources for residents [21, 22]. They include food plants crucial to indigenous communities' traditional cuisines and agricultural practices [1, 23]. This WFPs diversity is vital food security and nutrition, especially in the face of climatic and socioeconomic challenges [24–26]. The regions broad plant diversity has significant potential for sustainable use, particularly regarding climate change, where specific species may offer resilience to environmental conditions [27–29]. Additionally, the plant diversity is important for medical and cultural purposes, supporting local communities' well-being [30–33]. Therefore, the Kashmir Himalayas are vital for exploration and conservation, impacting local livelihoods and global biodiversity. WFPs are crucial for food security, cultural heritage, and biodiversity in Pakistan, especially in Kashmir. Cross-cultural studies on WFPs in Pakistan and Kashmir illustrate their diversity and the richness of traditional knowledge. Research has explored consumption trends and cultural practices related to WFPs in mountainous regions, highlighting their significance in local food systems and ethnobotany, as well as how ethnic groups adapt to their environments [1, 34–36].

Recent studies on WFPs primarily focus on consumption patterns while neglecting intergenerational knowledge dynamics among younger generations. The division of responsibilities within the traditional social structure, alongside urbanization and economic transitions, has led to significant disruptions in communal living arrangements and intergenerational bonds. The traditional joint family system, which was previously a vital component of social cohesiveness, is progressively breaking into nuclear families as younger generations move to cities for better education and job opportunities. This change threatens the social structure that upholds customs, including disseminating traditional knowledge essential for subsistence economies and adapting younger generations to urban life, resulting in either the fading or modifying of traditional knowledge to fit contemporary settings. The loss of this knowledge reduces community resilience, erodes cultural heritage, and impairs the ability to manage local ecosystems sustainably. This disorientation of the traditional social structure necessitates an urgent examination of how economic and social shifts affect cultural sustainability and the intergenerational dynamics of knowledge, emphasizing the importance of adaptive measures to bridge generational and geographical divisions [34]. This study is significant because it explores the intergenerational dynamics of knowledge about WFPs, addressing its decline among the younger generation. By focusing on five ethnic groups, it offers a cross-cultural analysis of gender-based knowledge, local food cuisines, and WFP consumption trends in both remote and urban regions. These findings are critical for understanding how traditional knowledge evolves in shifting sociocultural environments. The study's emphasis on food security and economic instability highlights its importance in policy, including methods for preserving local ecological knowledge (LEK) and promoting the sustainable use of WFPs. By addressing these gaps, this research helps preserve cultural heritage while offering strategies for regional food and economic sustainability. Our specific objectives are: (a) to document and categorize wild food plant species used by ethnic groups in the Kashmir Himalayas, focusing on consumption patterns between remote and urban areas; (b) to assess cross-cultural variations in WFP knowledge, particularly regarding gender roles and LEK among ethnic groups; (c) to evaluate the intergenerational dynamics of WFP knowledge among younger generations and its impact on cultural preservation; and (d) to assess the perceived threats to WFPs in the region.

Material and methods

Study area

The State of Azad Jammu and Kashmir (AJK) is in the western Himalayan region, with latitudes between 33° and 35° North and longitudes between 73° and 75° East [18, 37]. AJK is located in the north-eastern part of Pakistan. This region, positioned in the foothills of the Himalayan range, is recognized as a biodiversity hotspot, featuring a variety of species across mountains, rivers, and valleys. The area comprises various ecological zones: subtropical, temperate, and alpine zones [1]. Due to the diverse elevational range of 550–6223 m and its relative remoteness, local communities primarily rely on natural resources [38]. AJK consists of ten districts, but this study focuses on three: Neelum Valley, Hattian, and Muzaffarabad (Fig. 1). The study area exhibits a variety of vegetation due to its unique topography, diverse ethnic groups and their cultural heritage and foraging practices. The climate of the region varies between summer and winter. In winter, there is significant snowfall, with freezing temperatures reaching as low as − 10 °C from November to April. The average temperature during the summer months of July and August is around 10 °C. The study area receives an annual precipitation of 1000 mm, most of which falls as snow in the higher peaks covered by the glaciers throughout the year. These glaciers also serve as a source for the Neelum and Jhelum rivers in the region [39, 40].

Studied communities

The ethnic composition of the study region is very diverse, including the Bakarwal, Gujjar, Kashmiri, Mughal, Lone, Khawaja, Syed, Rajgan, and Awan (Supplementary table). The study focuses on the Gujjar, Bakarwal, Lone, Syed, and Mughal ethnic groups, each with unique sociocultural identities and livelihood strategies.

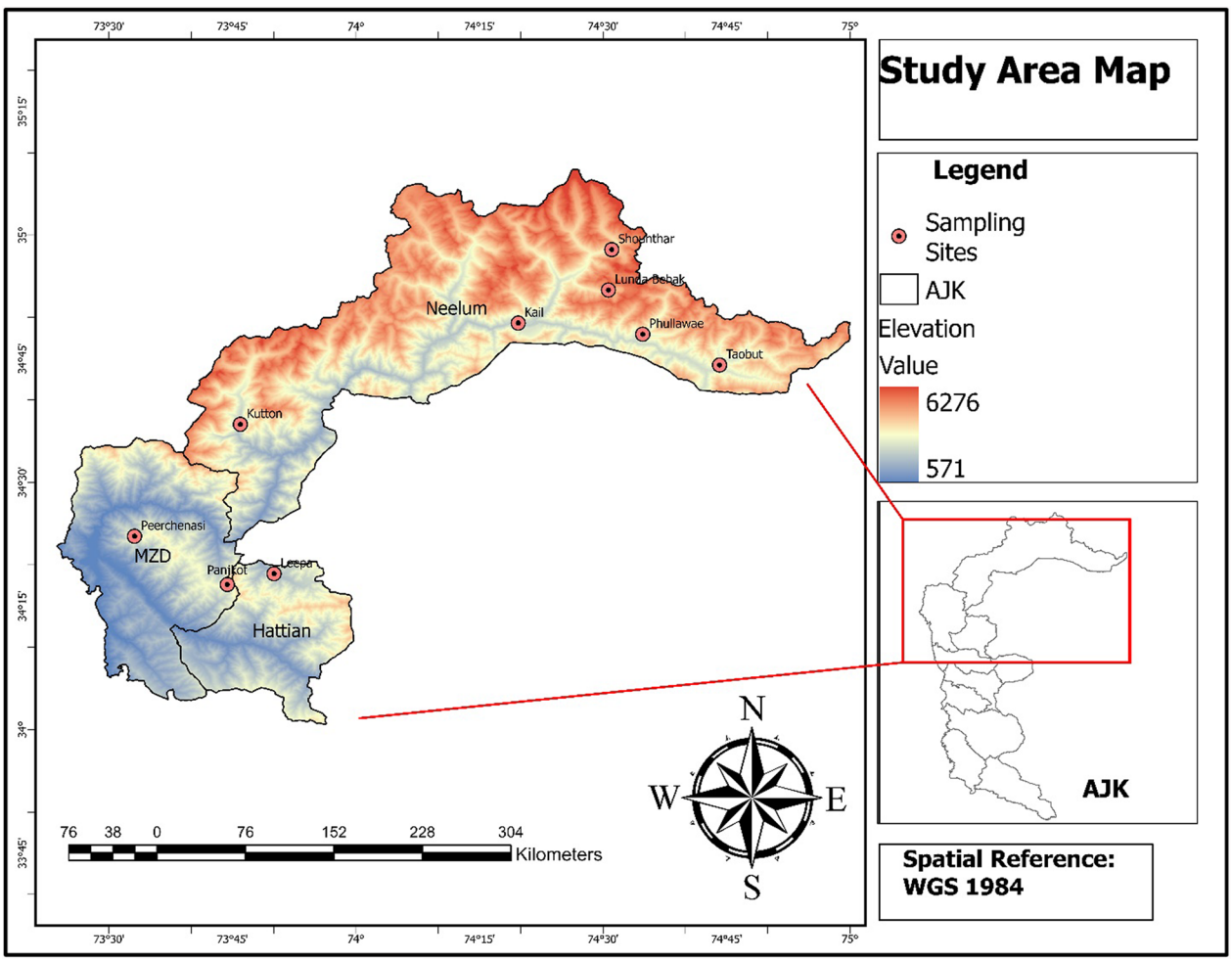

Fig. 1 Study area map representing the studied sites in the Kashmir region

The Gujjars and Bakarwals are nomadic pastoralists who migrate between lowland and high-altitude pastures and preserve knowledge about WFPs. The Lone group, with its distinct dialect, has substantial traditional ecological knowledge from long-term settlements in diverse environmental areas. The Syed and Mughal groups are farmers settled in lower areas, possessing ethnobotanical knowledge related to cultivated and wild plants. This selection of ethnic groups enables comparative WFP knowledge across livelihood types and cultural backgrounds. Including both endogamic and exogamic groups broadens the understanding of knowledge transmission patterns (Supplementary table). In a religious context, all respondents are Muslims, while the most popular local dialects are Hindko, Gojri, Kashmiri, and Shina (specific to the Lone ethnic group). The region is predominantly mountainous, lacking good infrastructure, and located at higher elevations with limited access to markets and healthcare centres. Most ethnic groups rely on natural resources in harsh conditions. With few job opportunities, many have moved to urban areas for work, while others run small businesses. Agriculture is the main subsistence occupation, with maize grown in summer, wheat in winter, and some vegetables alongside these crops. Key income sources include agriculture, cattle rearing, medicinal plant extraction, and small businesses. Ownership of domestic animals is seen as a marker of high socioeconomic status in these communities.

Ethnobotanical data collection

Field visits were conducted in the Muzaffarabad division between March and September of 2024, covering ten sites, including villages and summer alpine pastures: Shounter, Lunda Behak, Kel, Phullawai, Taobat, Kutton, Panjkot, Pir Chinasi, and Leepa. Data were collected through semi-structured interviews primarily focusing on older participants (above 50 years) and younger ones (18–30 years) to examine the intergenerational dynamics among the ethnic groups (Fig. 2) [41]. Participants were selected based on their long-standing relationships with the natural environment and local flora and their experiences regarding the harvesting and consumption of WFPs. The religious and social setup of the study area does not allow for interviews with females, which is why most respondents were male. During the field survey, we strictly followed the Code of Ethics (2006) of the International Society of Ethnobiology (https://www.ethnobiology.net). Prior oral consent was obtained from each participant before the interviews. One hundred ninety-one participants were selected, including 120 males and 71 females from different ethnic groups. We conducted interviews in Hindko, Pahari, and Gojri with all ethnic groups (Mughal, Gujjar, Syed, Lone, and Bakarwal). The Lone group speaks Shina but understands Hindko. We used a trained interpreter to interview Lone Group informants who shared information in Shina. We explained the study's objectives to each participant. The field survey used a mixed approach for selecting informants, starting with random sampling followed by the snowball method. Interview durations varied: 5–10 min for younger participants and 30–50 min for older respondents. Interviews took place in various locations, including shops, fields, alpine pastures, forests, and near mosques after prayers. The information collected focused on edible wild plant species, parts used, harvesting seasons, perceived threats, market availability, and medicinal and culinary uses. Informants were categorized into age groups to assess knowledge transmission from parents to younger generations, and male and female groups were separated to better represent traditional knowledge holders. We also classified intergenerational knowledge dynamics based on observations and information from informants among ethnic groups into five categories: traditional structures, cultural/communal activities, knowledge exchange platforms, modern structures, and social/religious gatherings.

Identification of WFPs

The authors collected herbarium specimens during field surveys, with informants' assistance, and dried them for scientific nomenclature. The scientific names of all recorded WFPs were verified using the online resource Plants of the World Online (https://powo.science.kew.org/). All specimens were mounted on herbarium sheets and submitted to the Herbarium of Pakistan (ISL), Department of Plant Sciences, Quaid-i-Azam University, Islamabad, Pakistan.

Data analysis

To examine the underlying structure of perceived threats to WFPs, we applied factor analysis to a binary species-by-threat matrix [42]. The data were standardized prior to analysis, and two latent factors were extracted to capture dominant patterns of threat co-occurrence. Loadings were visualized in a two-dimensional space to interpret the relative influence and grouping of threats. A Venn diagram analysis was also conducted to visualize the shared and unique WFPs consumed by the five ethnic groups, utilizing OriginPro software (2024). Data regarding WFP consumption trends among five groups were recorded during the field survey. This analysis quantified the distinct and overlapping species among the groups, allowing for visualization and understanding of traditional knowledge and cultural preferences.

Fig. 2 Interviews and group discussions with different ethnic groups: **a** interview with the Gujjar ethnic group, **b** & **d** interview with the Bakarwal ethnic group, **c** interview with the Mughal ethnic group, **e** preparing traditional drink Lassi (yoghurt milk) during the field survey, **f** interview with the Syed ethnic group

Results

WFPs and their uses

We recorded 52 WFPs and 11 fungal species across 45 genera and 27 botanical families. The Polygonaceae family ranked first with nine species, followed by Fabaceae (six species), Amaranthaceae (five species), Morchellaceae (five species), and Brassicaceae (four species) (Fig. 3). Asteraceae, Plantaginaceae, and Polypodiaceae each had three species. Six families contributed two species, while thirteen were represented by one species each. Herbs were identified as the leading category, accounting for 68.25%, followed by fungi, ferns, climbers, and shrubs. The collection season for WFPs varies between lower and upper elevations. Local perceptions indicate that 63.49% of WFPs are decreasing, while 36.51% are increasing due to various human-driven and natural causes. Our results showed that 63 plants were used as vegetables (62.38%), while 38 species (37.62%) were used as medicinal plants. Ethnic communities primarily utilized fresh vegetables (76.83%) and also used dry vegetables (23.17%), dried by sunlight or shade, for summer and winter consumption. Leaves were the most reported part used (42.42%),

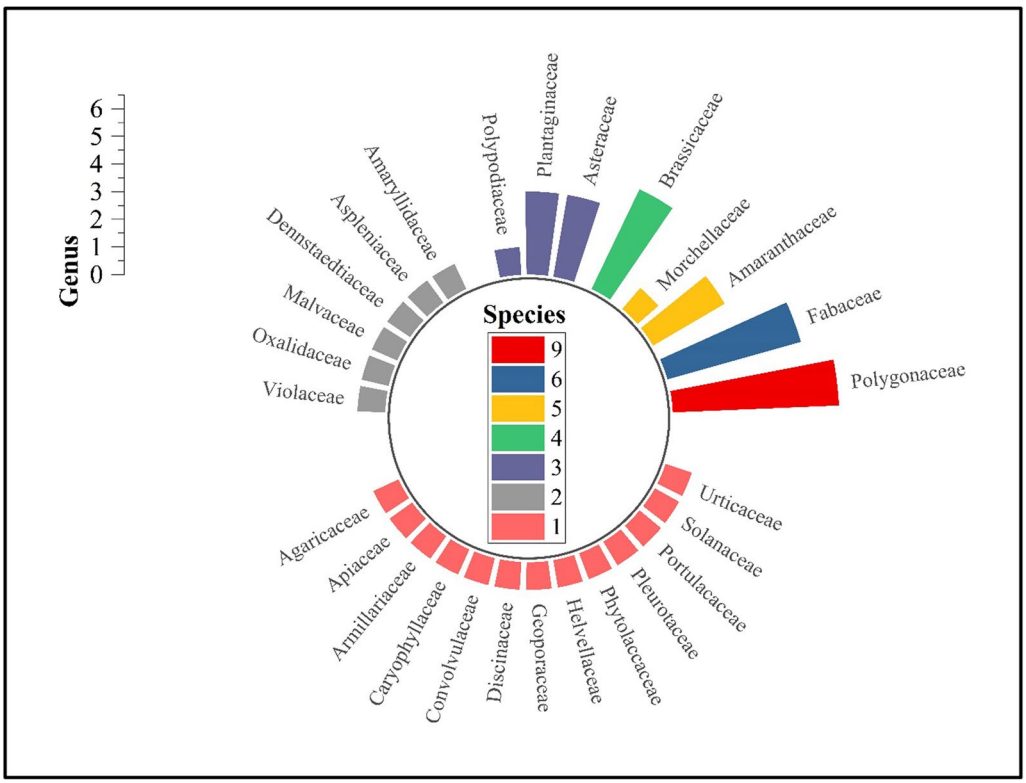

Fig. 3 Graph representing the proportions of WFP genera and species in the study area

followed by aerial parts (21.21%), fruiting bodies (16.97%), young fronds (10.61%), young leaves (3.03%), bulbs (3.03%), and young shoots and flowers (1.52% each) (Table 1). Six vegetables were the most collected (*Trifolium repens, Polygonum aviculare, Rumex acetosa, Morchella esculenta, Trifolium pratense, and Fagopyrum cymosum*), which were collected 27 to 40 times in a season. Thirty-six vegetables had a collection frequency of 10 to 24 times, while 21 were collected 1 and 10 times. Among fungal species, *M. esculenta* had the highest collection frequency, recorded 30 times due to its economic value. In contrast, the other four *Morchella* species had collection frequencies ranging from 10 to 18 times, while six other fungal species were collected 1 to 10 times, respectively.

WFP consumption patterns in the Kashmir region showed significant variations among groups. The study examined how WFPs are used in local cuisines, emphasizing their role in everyday diets and traditional recipes. Approximately 37 WFPs (58.73%) were used regularly, 12 species (19.05%) occasionally, and 14 species (22.22%) rarely, though they were used in the past. Key WFPs vital to local cuisine include *Diplazium* spp., *Pteridium* spp., *Dryopteris* spp., *Morchella esculenta*, *Chenopodium album*, *Amaranthus* spp., *Nasturtium officinale, Trifolium repens, Malva sylvestris, Polygonum aviculare, Portulaca oleracea*, and *Rumex nepalensis*. Several plants previously important in local culinary traditions, such as *Rheum australe, Rheum webbianum, Lagotis cashmeriana, Pimpinella diversifolia, Alliaria petiolata, Viola canescens, Koenigia alpina*, and *Silene conoidea*, are no longer used due to cultural changes, the availability of commercial substitutes, or the loss of traditional knowledge.

Cross-culture

Cross-cultural analysis results indicated heterogeneous consumption patterns of WFPs among five ethnic communities, influenced by the availability of WFPs and the unique cultures and traditions of these communities (Fig. 4) (Table 1). Five species identified as overlapping across all five groups were *Taraxacum officinale, Trifolium repens, Trifolium pratense, Plantago lanceolata*, and *Polygonum aviculare*. Of the 63 species analysed, 13 species overlapped among four ethnic groups, 21 species overlapped among three groups, and 21 species overlapped among two groups. The species *Lagotis cashmeriana* is confined to high-altitude alpine zones and is utilized exclusively by the Bakarwal ethnic group, which moves to high-altitude pastures with their herds.

Table 1 WFPs information, part used, recipes, source of knowledge, and availability in market

Species Name	Family	Ethnic Groups Using the Plant	Voucher Number	Frequency of Collection	Part Used	Mode of Use	Recipe	Use Type	Source of Knowledge	Plants availability in Market
Agaricus campestris L	Agaricaceae	G, L, M	MMSWG-3503	2	Fruiting body	Fresh	The fruiting body is fried in ghee with spices and then cooked	Food use	Parents, Education	N
Alliaria petiolata (M.Bieb.) Cavara & Grande	Brassicaceae	G, M	MMSWG-3509	8	Aerial parts	Fresh	Aerial parts with spices are cooked in ghee	Food use	Parents	N
Allium carolinianum Redouté	Amaryllidaceae	B, G	MMSWG-3464	5	Leaves, Bulb	Fresh/Dry	Fresh leaves are fried in ghee and used as a source of flavour in various dishes	Food use, Medicinal use	Parents	N
Allium humile Kunth	Amaryllidaceae	B, G	MMSWG-3499	7	Leaves, Bulb	Fresh/Dry	Fresh leaves are fried in ghee and used as a source of flavour in various dishes	Food use, Medicinal use	Parents	N
Amaranthus caudatus L	Amaranthaceae	G, L, M, S	MMSWG-3510	14	Leaves	Fresh/Dry	Fresh leaves are boiled, fried in ghee, seasoned with spices, and then cooked	Food use, Medicinal use	Parents	N
Amaranthus retroflexus L	Amaranthaceae	G, L, M	MMSWG-3481	14	Leaves	Fresh/Dry	Fresh leaves are boiled, fried in ghee, seasoned with spices, and then cooked	Food use, Medicinal use	Parents	N
Amaranthus viridis L	Amaranthaceae	G, L, M, S	MMSWG-3496	17	Leaves	Fresh/Dry	Fresh leaves are boiled, fried in ghee, seasoned with spices, and then cooked	Food use, Medicinal use	Parents	Y
Armillaria mellea (Vahl) P. Kumm	Armillariaceae	G	MMSWG-3500	1	Fruiting body	Fresh	The fruiting body is fried in ghee with spices and then cooked	Food use	Parents	N
Capsella bursa-pastoris (L.) Medik	Brassicaceae	G, L, S	MMSWG-3511	23	Aerial parts	Fresh	Aerial parts are boiled, fried with spices, and cooked	Food use, Medicinal use	Parents	N

Table 1 (continued)

Species Name	Family	Ethnic Groups Using the Plant	Voucher Number	Frequency of Collection	Part Used	Mode of Use	Recipe	Use Type	Source of Knowledge	Plants availability in Market
Chenopodiastrum murale (L.) S.Fuentes, Uotila & Borsch	Amaranthaceae	G, S	MMSWG-3466	4	Leaves	Fresh	Fresh leaves fried in ghee, seasoned with spices, and cooked	Food use, Medicinal use	Parents	N
Chenopodium album L	Amaranthaceae	G, L, S	MMSWG-3489	8	Leaves	Fresh	Fresh leaves fried in ghee, seasoned with spices, and cooked	Food use, Medicinal use	Parents	N
Cichorium intybus L	Asteraceae	G, L, M, S	MMSWG-3487	9	Leaves, Flowers	Fresh	Flowers and young leaves are fried in ghee with spices and then cooked	Food use, Medicinal use	Parents	N
Convolvulus arvensis L	Convolvulaceae	G, L, M, S	MMSWG-3506	8	Leaves	Fresh	Leaves are fried in ghee and then cooked	Food use	Parents	N
Diplazium esculentum (Retz.) Sw	Aspleniaceae	G, L, M, S	MMSWG-3465	14	Young fronds	Fresh/Dry	Young fronds are first boiled and flavoured with ghee and spices	Food use	Parents	Y
Diplazium maximum (D.Don) C.Chr	Aspleniaceae	G, L, M	MMSWG-3472	10	Young fronds	Fresh/Dry	Young fronds are first boiled and flavoured with ghee and spices	Food use	Parents	Y
Dryopteris filix-mas (L.) Schott	Polypodiaceae	G, L, M	MMSWG-3494	10	Young fronds	Fresh/Dry	Young fronds are first boiled and flavoured with ghee and spices	Food use	Parents	Y
Dryopteris ramosa (C.Hope) C.Chr	Polypodiaceae	B, G, L, S	MMSWG-3463	14	Young fronds	Fresh/Dry	Young fronds are first boiled and flavoured with ghee and spices	Food use	Parents	Y
Dryopteris stewartii Fraser-Jenk	Polypodiaceae	B, G, M	MMSWG-3460	19	Young fronds	Fresh/Dry	Young fronds are first boiled and flavoured with ghee and spices	Food use	Parents	Y

Table 1 (continued)

Species Name	Family	Ethnic Groups Using the Plant	Voucher Number	Frequency of Collection	Part Used	Mode of Use	Recipe	Use Type	Source of Knowledge	Plants availability in Market
Fagopyrum cymosum (Trevir.) Meisn	Fabaceae	B	MMSWG-3517	27	Aerial parts	Fresh	Aerial parts with spices are cooked in ghee	Food use, Medicinal use	Parents	N
Fagopyrum esculentum Moench	Polygonaceae	G, L	MMSWG-3493	21	Aerial parts	Fresh	Leaves are fried in ghee and then cooked	Food use, Medicinal use	Parents	N
Geopora arenicola (Lév.) Kers	Geoporaceae	B, G	MMSWG-3469	1	Fruiting body	Fresh	The fruiting body is fried in ghee with spices and then cooked	Food use	Parents	N
Gyromitra esculenta Pers. ex Fr	Discinaceae	L, M	MMSWG-3457	2	Fruiting body	Fresh	The fruiting body is fried in ghee with spices and then cooked	Food use	Parents	N
Helvella crispa Bull	Helvellaceae	B, G, L, M	MMSWG-3456	1	Fruiting body	Fresh	The fruiting body is fried in ghee with spices and then cooked	Food use	Parents	N
Koenigia alpina (All.) T.M.Schust. & Reveal	Polygonaceae	B, G	MMSWG-3497	12	Leaves	Fresh	Leaves are fried in ghee and then cooked	Food use	Parents	N
Lactuca dissecta D.Don	Asteraceae	B, G	MMSWG-3461	4	Leaves	Fresh	Fresh leaves with spices are cooked in ghee	Food use	Parents	N
Lagotis cashmeriana (Royle ex Benth.) Rupr	Plantaginaceae	B	MMSWG-3470	7	Leaves	Fresh	Leaves are fried with spices, and then cooked	Food use, Medicinal use	Parents	N
Lathyrus aphaca L	Fabaceae	G, L, M, S	MMSWG-3468	5	Aerial parts	Fresh	Aerial parts with spices are cooked in ghee	Food use	Parents	N
Malva parviflora L	Malvaceae	G, L, M	MMSWG-3512	16	Aerial parts	Fresh	The aerial parts are fried with spices and added to a traditional dish called Kalari for flavour	Food use	Parents	N

Table 1 (continued)

Species Name	Family	Ethnic Groups Using the Plant	Voucher Number	Frequency of Collection	Part Used	Mode of Use	Recipe	Use Type	Source of Knowledge	Plants availability in Market
Malva sylvestris L	Malvaceae	B, G, L, M	MMSWG-3476	12	Aerial parts	Fresh	The aerial parts are fried with spices and added to a traditional dish called Kalari for flavour	Food use	Parents	N
Medicago polymorpha L	Fabaceae	B, G, M	MMSWG-3508	8	Leaves	Fresh	Leaves are fried in ghee and then cooked	Food use, Medicinal use	Parents	N
Morchella costata Pers	Morchellaceae	G, L, M	MMSWG-3513	10	Fruiting body	Fresh/Dry	The fruiting body is fried in ghee with spices and then cooked	Food use, Medicinal use	Parents, Education	y
Morchella deliciosa Fr	Morchellaceae	G, M	MMSWG-3484	13	Fruiting body	Fresh/Dry	The fruiting body is fried in ghee with spices and then cooked	Food use, Medicinal use	Parents, Education	y
Morchella elata Fr	Morchellaceae	G, L, M	MMSWG-3498	18	Fruiting body	Fresh/Dry	The fruiting body is fried in ghee with spices and then cooked	Food use, Medicinal use	Parents, Education	y
Morchella esculenta (L.) Pers	Morchellaceae	G, L, M, S	MMSWG-3467	30	Fruiting body	Fresh/Dry	The fruiting body is fried in ghee with spices and then cooked	Food use, Medicinal use	Parents, Education	y
Morchella tridentina Bres	Morchellaceae	G, L, M	MMSWG-3458	14	Fruiting body	Fresh/Dry	The fruiting body is fried in ghee with spices and then cooked	Food use, Medicinal use	Parents, Education	y
Nasturtium officinale W.T.Aiton	Brassicaceae	G, M, S	MMSWG-3477	14	Aerial parts	Fresh	The aerial parts are fried in ghee and then cooked	Food use, Medicinal use	Parents	N
Oxalis acetosella L	Oxalidaceae	G, M	MMSWG-3475	23	Leaves	Fresh	Leaves are fried in ghee and then cooked	Food use, Medicinal use	Parents	N
Oxalis corniculata L	Oxalidaceae	G, L, S	MMSWG-3490	17	Leaves	Fresh	Leaves are fried in ghee and then cooked	Food use, Medicinal use	Parents	N
Oxyria digyna (L.) Hill	Polygonaceae	G, L	MMSWG-3462	23	Leaves	Fresh	Leaves are fried in ghee and then cooked	Food use, Medicinal use	Parents	N

Table 1 (continued)

Species Name	Family	Ethnic Groups Using the Plant	Voucher Number	Frequency of Collection	Part Used	Mode of Use	Recipe	Use Type	Source of Knowledge	Plants availability in Market
Phytolacca latbenia (Moq.) Maxim	Phytolaccaceae	G, M	MMSWG-3495	14	Leaves	Fresh	Leaves are boiled, fried with spices, and cooked	Food use, Medicinal use	Parents	N
Pimpinella diversifolia DC	Apiaceae	L, M	MMSWG-3479	8	Aerial parts	Fresh	Fresh leaves are fried in ghee and then cooked	Food use	Parents	N
Plantago lanceolata L	Plantaginaceae	B, G, L, M, S	MMSWG-3473	17	Leaves	Fresh	Leaves are fried in ghee and then cooked	Food use, Medicinal use	Parents	N
Pleurotus ostreatus (Jacq.) P. Kumm	Pleurotaceae	G, L, M, S	MMSWG-3486	3	Fruiting body	Fresh	The fruiting body is fried in ghee, spiced with lassi, and then cooked	Food use	Parents	N
Polygonum aviculare L	Polygonaceae	B, G, L, M, S	MMSWG-3492	34	Aerial parts	Fresh	Aerial parts with spices are cooked in ghee	Food use, Medicinal use	Parents	N
Portulaca oleracea L	Portulacaceae	G, S	MMSWG-3459	13	Aerial parts	Fresh	Aerial parts with spices are cooked in ghee	Food use	Parents	N
Pteridium aquilinum (L.) Kuhn	Dennstaedtiaceae	B, G, L, S	MMSWG-3483	15	Young fronds	Fresh/Dry	Young fronds are first boiled and flavoured with ghee and spices	Food use	Parents	N
Pteridium revolutum (Blume) Nakai	Dennstaedtiaceae	G, L, M	MMSWG-3515	13	Young fronds	Fresh/Dry	Young fronds are first boiled and flavoured with ghee and spices	Food use	Parents	N
Rheum australe D. Don	Polygonaceae	B, G, M	MMSWG-3478	13	Leaves	Fresh	Fresh leaves with spices are cooked in ghee	Food use, Medicinal use	Parents	Y
Rheum webbianum Royle	Polygonaceae	B, G	MMSWG-3504	24	Leaves	Fresh	Fresh leaves with spices are cooked in ghee	Food use, Medicinal use	Parents	Y
Rumex acetosa L	Polygonaceae	B, G	MMSWG-3505	31	Leaves	Fresh	Leaves are fried in ghee and then cooked	Food use, Medicinal use	Parents	N
Rumex dentatus L	Polygonaceae	G, L	MMSWG-3488	16	Leaves	Fresh/Dry	Leaves are boiled, fried with spices, and cooked	Food use, Medicinal use	Parents	N

Table 1 (continued)

Species Name	Family	Ethnic Groups Using the Plant	Voucher Number	Frequency of Collection	Part Used	Mode of Use	Recipe	Use Type	Source of Knowledge	Plants availability in Market
Rumex nepalensis Spreng	Polygonaceae	G, M, S	MMSWG-3485	14	Leaves	Fresh/Dry	Leaves are fried in ghee and then cooked	Food use, Medicinal use	Parents	N
Silene conoidea L	Caryophyllaceae	G, M, S	MMSWG-3502	12	young leaves	Fresh	Young leaves are fried in ghee and then cooked	Food use	Parents	N
Sisymbrium irio L	Brassicaceae	M, S	MMSWG-3507	5	Young shoot	Fresh	Young shoots are fried in ghee and then cooked	Food use	Parents	N
Solanum nigrum L	Solanaceae	G, M, S	MMSWG-3501	9	Leaves	Fresh	Leaves are fried in ghee and then cooked	Food use, Medicinal use	Parents	N
Taraxacum officinale F.H.Wigg	Asteraceae	B, G, L, M, S	MMSWG-3491	13	Leaves	Fresh	Fresh leaves with spices are cooked in ghee	Food use, Medicinal use	Parents, Education	N
Trifolium pratense L	Fabaceae	B, G, L, M, S	MMSWG-3480	30	Aerial parts	Fresh	Aerial parts are boiled, fried with spices, and cooked	Food use, Medicinal use	Parents	N
Trifolium repens L	Fabaceae	B, G, L, M, S	MMSWG-3482	40	Aerial parts	Fresh	Aerial parts are boiled, fried with spices, and cooked	Food use, Medicinal use	Parents	N
Urtica dioica L	Urticaceae	G, L, M, S	MMSWG-3471	17	Young Leaves	Fresh	Fresh leaves with spices are cooked in ghee	Food use, Medicinal use	Parents	N
Veronica arvensis L	Plantaginaceae	G, L, S	MMSWG-3516	20	Leaves	Fresh	Leaves are fried in ghee and then cooked	Food use	Parents	N
Vicia sativa L	Fabaceae	G, L, M	MMSWG-3514	14	Aerial parts	Fresh	Aerial parts with spices are cooked in ghee	Food use, Medicinal use	Parents	N
Viola canescens Wall	Violaceae	G, L	MMSWG-3518	12	Leaves	Fresh	Leaves are fried in ghee and then cooked	Food use, Medicinal use	Parents	N
Viola odorata L	Violaceae	G, M	MMSWG-3474	9	Leaves	Fresh	Leaves are fried in ghee and then cooked	Food use, Medicinal use	Parents	N

Ethnic groups (*B* Bakarwal, *G* Gujjar, *L* Lone, *M* Mughal, *S* Syed), Plants availability in Market (*Y* Yes, *N* No),

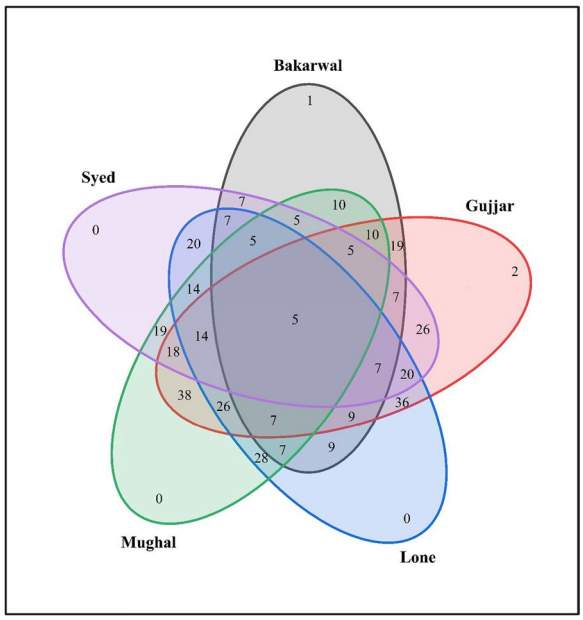

Fig. 4 Venn diagram depicting the species overlapping patterns among the five ethnic groups of the study area

In contrast, two species, *Fagopyrum cymosum* and *Armillaria mellea*, were solely observed within the Gujjar ethnic group, highlighting their unique status. The Gujjar ethnic group resides at higher elevations and is intricately connected to natural resources. They were identified as the leading group in terms of consuming and reporting a greater number of plants (59 species). The Gujjars, along with their families and herds, migrate to various locations during the summer (locally known as Behak and Maali) to harvest WFPs, sustaining their lives due to limited access to the market. As a result, the Gujjar ethnic group is entirely reliant on WFPs. Compared to the Bakarwals, the Gujjars spend more time in high-altitude areas with their herds, as they are mostly migratory and only move to these regions during the summer. Additionally, the Gujjar ethnic group, which speaks the Gojri language, is localized in Kashmir and possesses unique local plant knowledge (LPK). This group has developed remarkable knowledge of WFPs and foraging practices integral to their daily life. The Gujjar ethnic group is strictly endogamous, prohibiting marriages with other groups. This practice contributes to their rich LPK, and their foraging methods remain distinct compared to those of other studied groups.

Gender-based knowledge

Gender-based knowledge is crucial in TEK, as both men and women possess valuable insights regarding the uses of WFPs. A total of 191 informants were surveyed through group discussions and interviews, with men contributing 120 (62.83%) and women 71 (37.17%). Despite women contributing less due to the social structure of the Kashmir region, they reported 37 species (58.74%), while men reported 26 species (41.26%). Our results indicate that women have a better understanding than men of WFP harvesting, consumption, trends, and recipes. Men are more aware of WFPs for secondary uses like trade or medicine, primarily regarding economically important plants sold in local markets, such as *Morchella* spp., *Rheum webbianum*, *Rheum australe*, *Diplazium* spp., *Allium carolinianum*, and *Dryopteris* spp. Women play a greater role in foraging and cultural practices, as they are more frequently engaged with their natural surroundings to harvest WFPs. Knowledge transmission follows gendered lines, with women being the primary custodians of traditional knowledge. In contrast, men are often away from their communities for work, leaving only a few old individuals behind. Additionally, the social structure in the Kashmir region restricts discussion about these topics with women, except for a few older women over 50.

Intergenerational dynamics of LPK

The study examines the intergenerational dynamics of WFPs across different ethnic groups, emphasizing the preservation of cultural identity and foraging practices. It found that WFP knowledge is passed from older to younger generations, but not extensively. The Gujjar and Bakarwal communities exhibited greater knowledge of WFPs due to their cultural beliefs, foraging practices, and nomadic lifestyles. Residing mainly in pastures and upper temperate forest areas, these groups show a stronger dependence on natural resources and increased awareness of WFPs. Traditional practices such as Jirga, storytelling, household gatherings, cultural festivals, and religious congregations facilitated knowledge transfer, though many have become limited in scope. The study classified intergenerational knowledge dynamics among five ethnic groups into five categories: traditional structures (Jirga), cultural/communal activities (storytelling, festivals, and rituals), knowledge exchange platforms (foraging groups and workshops), modern structures (social media and NGOs), and social/religious gatherings (household gatherings and religious congregations like Friday prayers). Jirga, storytelling, household gatherings, and religious congregations are the most common methods of knowledge transfer. Festivals, rituals, and social media are less common for knowledge transmission, with younger generations primarily using them for entertainment. Knowledge exchange platforms are rare or used selectively, ranking as the third least common source of knowledge transmission in the study area.

Diversity of preparation of food ingredients

We observed various traditional cuisines among the studied ethnic communities, with different preparation methods across all groups. Most communities refer to wild recipes as saag, commonly used daily. The typical method for preparing saag involves boiling plant parts in water, frying them in oil with onion and tomato, and adding spices. The dish is then cooked for some time, with lassi (yoghurt milk), and plain milk added for flavour and to prepare specific recipes. There are a few traditional cuisines unique to the study area (Fig. 5). One important dish is pickle, locally known as Anchar. It is very spicy and bitter, often served with meals, particularly lunch and dinner. This pickle is made mostly from August to November by soaking carrots, radishes, turnips, beans, and broadleaf vegetables in mustard oil (*Brassica campestris*) for one month in an airtight container with various spices. After a month, the pickle is transferred to another container for use with different dishes or on special occasions. The second traditional cuisine is Sheldiyan, made from fungal species harvested from the nearby forest. It is used fresh; otherwise, it alters the taste and quality of the dish. After harvesting, it is cut into small pieces by hand without a knife, as ethnic communities prefer to peel and break it into longer, smaller pieces. These pieces are then washed and fried with oil, onion, garlic paste, and various spices. After frying for 5–10 min on low heat, boiled milk is added to the mixture, which is then heated again for 3–5 min. Sheldiyan is now ready to serve. If served with wheat bread or cornbread, it becomes thick; when paired with rice, more water is added to dilute it. The third traditional cuisine is Kaarhi, prepared by frying one vegetable or a mixture of vegetables with oil and some spices. When nearly ready, a large amount of lassi (yoghurt milk) is added for flavour and boiled for 5 min on low heat. This dish is served with pickle (Anchar), sauce (chutney), and especially with cornbread. People often mash the bread into the Kaarhi and eat it, drizzling sauce (chutney) over the dish. The fourth traditional cuisine is Guuchiyan di Sbzi, prepared using *Morchella* species. Five species of *Morchella* are used, either fresh or dried. First, wash the mushrooms to remove debris, then cut them into smaller pieces. If using dried mushrooms, boil them briefly. Next, fry the mushrooms in oil with onion, garlic, and traditional spices for 5–8 min, and then add boiled milk and continue boiling for another 5 min. If served with rice, dilute the dish; if served with bread, thicken it by heating it longer. The fifth traditional dish, known as Booli, is made from the early yellow milk of cows, goats, and buffalo. Women collect the early yellow milk and store it in large utensils, locally known as Mitti da Dola. After three days, they begin boiling it and add sugar to taste, continuing to boil over moderate heat. When prepared, an older person (male or female) begins the prayer, and after the prayer, an older female serves the Booli, mostly after the meal.

Commodification's practices

We observed significant commodification in the foraging practices, consumption trends, and harvesting of WFPs. The main changes are attributed to shifts in traditional practices, lack of interest, and modern education. Key alterations involve changes in preparation methods and spices that contribute to the flavour of traditional recipes. In the past, recipes for vegetables like *Dryopteris* and *Diplazium* involved frying in local oil (desi ghee) with various spices and green chilies, followed by the addition of traditional drink (lassi). These dishes were typically served with maize bread and a sauce made from mint, onion leaves, garlic, spices, walnuts, and Crataegus fruits. Contemporary practices have shifted significantly, with frying now done in market-based oil and fewer spices added for flavour. Wheat bread has become the primary choice instead of maize bread, although maize bread is still occasionally served. These changes are due to socioeconomic, cultural, and accessibility factors. Increased market integration and economic mobility have led to packaged goods and market-based oils replacing traditional fats. Wheat bread is preferred for its ease of processing, while maize flour processing is labour-intensive. The use of spices has declined because of their cost, the availability of market alternatives, and the time-consuming harvesting process. Time constraints and changing gender roles have also contributed to these shifts.

Traditional foraging recipes are being commodified, with older generations enjoying them regularly, while younger generations show little interest. Younger informants prefer modern dishes, influenced by the belief that market products are easier to access, more hygienic, and promote better health. The availability of WFPs in the market contributes to this commodification, with only 13 WFPs available, while 50 species are unavailable. The presence of cultivated vegetables and export spices has altered local cuisine, and the fusion of this external knowledge with traditional foraging practices threatens local traditions. The declining interest in traditional foraging, decreasing consumption of WFPs, and the influence of modern education pose significant threats to this cultural heritage and foraging knowledge, potentially leading to its erosion in the coming decades.

WFP knowledge among diverse age groups

We categorized the informant's age data into seven groups, with age group VI (56–70 years) as the largest, accounting for 25.65% of the data. The study assessed the flow of LEK among younger generations in three

Fig. 5 Famous traditional dishes consumed among the studied ethnic communities: **a** Langroo traditional dish, **b** mixed vegetables, **c** sauce preparation (locally known as Chutney) with the addition of Citrus species to enhance bitterness, **d** fresh harvest of various Morchella species for vegetables, **e** traditional pickle (locally known as Anchar) used primarily with various foods for its great flavour, **f** traditional dish of corn bread, vegetables, sauce (Chutney), and traditional drink lassi (yoghurt milk), **g** traditional dish of mixed Dryopteris species, **h** freshly harvested WFP Dryopteris species, **i** famous traditional dish locally known as Sheldiyan, **j** traditional Sbzi Kaarhi, **k** traditional spices (Zeera, Mint, Babrri, and green chilies), **l** traditional dish Booli

categories: knowledge acquisition, ethnobotanical practices (culinary/medicinal), and cultural engagement. Results indicated a decline in LEK among younger generations across the studied ethnic groups. Younger informants showed less interest in learning about WFPs and preferred market products over cultural and foraging

practices due to lack of interest and difficulties in identifying and harvesting from natural environments. Knowledge acquisition depended on traditional knowledge from older generations, while ethnobotanical practices were less common. Cultural engagement was limited, with age groups I and II showing minimal participation, while age groups III, IV, and V were more actively engaged (Table 2).

Descriptive statistics revealed gender-based variation in TK across all age groups, with women demonstrating greater resilience and a higher mean number of citations in food plants, medicinal plants, and fungi compared to men. Women reported an average of 5.57 food plants in the 20–35 age group, 6.20 in the 36–55 age group, and 8.25 in the 56–70 age group (Fig. 6A–C). These differences suggest that women retain and potentially transmit TK, particularly regarding food and fungal resources. Independent samples t tests indicated higher mean use values among women, but none reached statistical significance at the 0.05 threshold: food plants ($t = -1.733$, $p = 0.137$), medicinal plants ($t = -1.280$, $p = 0.267$), and fungi ($t = -1.609$, $p = 0.163$). The lack of significance is likely due to limited sample size, reducing statistical power. Nonetheless, the consistently higher scores for women across all categories and age groups highlight gender as a critical variable in ethnobotanical knowledge systems.

WFPS consumption trends

WFP's consumption trends analysis revealed a decline from remote to urban zones. We classified the sampling sites into four categories: remote zone (higher elevations with no market access), middle zone (upper temperate zone with limited market access), transition zone (junction between upper temperate and urban areas with mostly market access), and urban zone (near the city with full market access). The remote zone consists of three sites, with the Shounter area identified as the leading site, accounting for 46 WFP reports (73.02%). This is followed by the Lunda Behak site, which contributed 43 reports (68.25%), and Panjkot, which contributed 39 reports (61.90%) (Fig. 7). These sites are located at higher elevations ranging from 3140 to 3521 m due to the lack of direct market and road access. This explains the higher WFP consumption rate recorded in the remote zone. The middle zone comprises two sites, Phullawai and Pir Chinasi, each contributing 53.97% (34 reports). The transition zone includes two sites: Kel, which contributed 39.38% (25 reports), and Taobat, which contributed 38.10% (24 reports). The urban zone is further divided into two sites: Kutton, which contributed 30.16% (19 reports), and Leepa, which contributed 25.40% (16 reports).

Perceived threats to WFPs

To explore the underlying structure of perceived threats to WFPs, we employed factor analysis (FA) on a binary matrix representing the presence or absence of nine major threats across species. The two extracted latent factors revealed meaningful dimensions that describe the co-occurrence and influence of these threats. Factor 1 was primarily associated with overexploitation (loading = 0.76), habitat degradation (0.42), and climate change (0.32), indicating a dimension reflecting direct ecological and anthropogenic pressure. Factor 2 was most strongly influenced by diseases (0.42) and fire (0.22), suggesting a dimension linked to biological and disturbance-related stressors. Notably, urbanization (−0.54) and invasive species (−0.51) loaded negatively on both factors, suggesting these threats act in distinctive, perhaps more

Table 2 Age-based categorization and ethnobotanical knowledge among informant groups, including age classifications, number and percentage of informants, modes of knowledge acquisition, types of practices, and levels of cultural engagement

Groups	Age (Years)	No. of Informants	Percentage (%)	Knowledge Acquisition	Ethnobotanical Practices (Culinary/Medicinal)	Cultural Engagement
Group I	20–25	9	4.71	Reliance on TK	Less Common or Incidental Uses	Limited (Mostly Observational)
Group II	26–30	14	7.33	Reliance on TK	Less Common or Incidental Uses	Limited (Mostly Observational)
Group III	31–35	19	9.95	Reliance on TK	Growing Interest, Trend driven practices	Minimal Participation
Group IV	36–45	31	16.23	Older Peoples, Personal Experimentation	Predominant Practices	Balanced
Group V	46–55	38	19.90	Older Peoples, Personal Experimentation	Predominant Practices	Active Participation
Group VI	56–70	49	25.65	Personal Experimentation	Strong Practices	Strong Participation
Group VII	Above 70	31	16.23	Personal Experimentation	Deep Rooted	Custodians

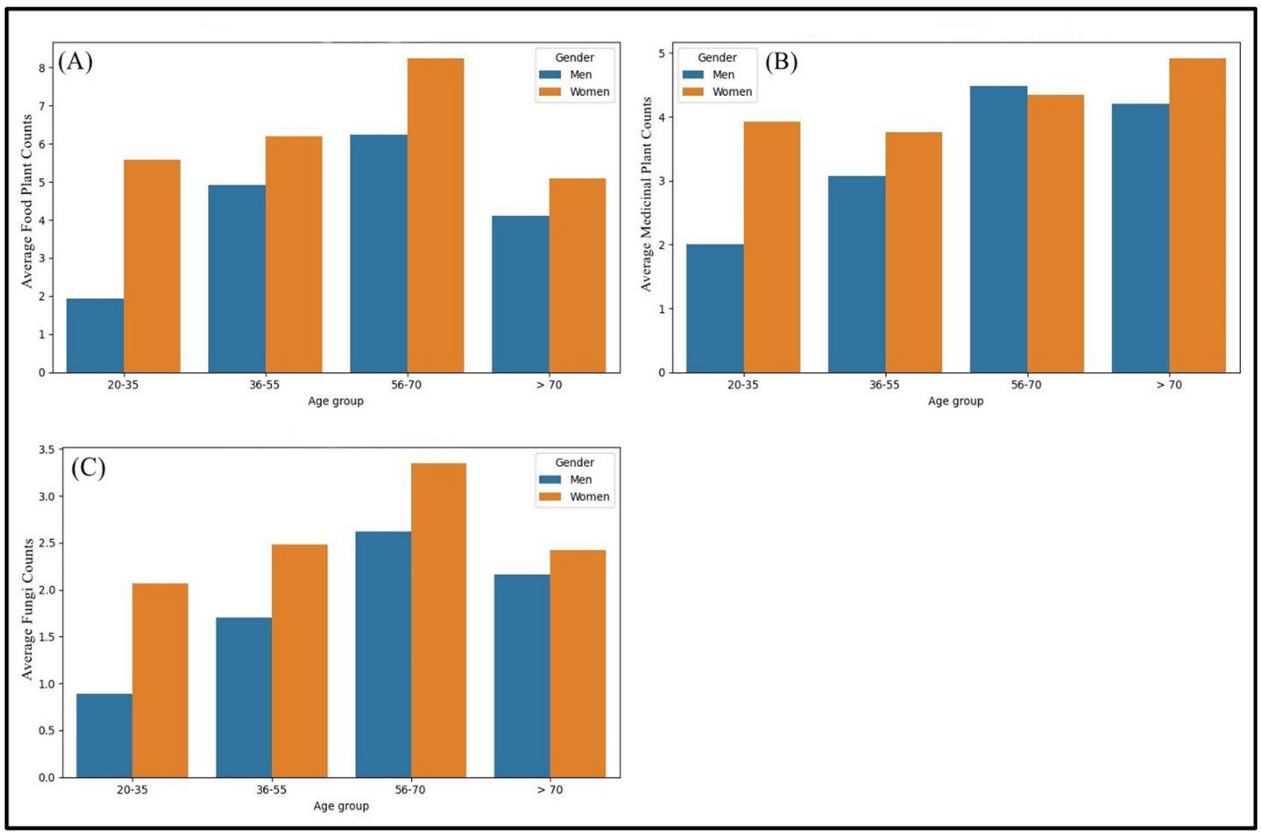

Fig. 6 **A** Bar plot comparing the mean number of food plants by gender across various age groups, **B** Bar plot comparing the mean number of medicinal plants by gender across various age groups, and **C** Bar plot comparing the mean number of fungi by gender across various age groups

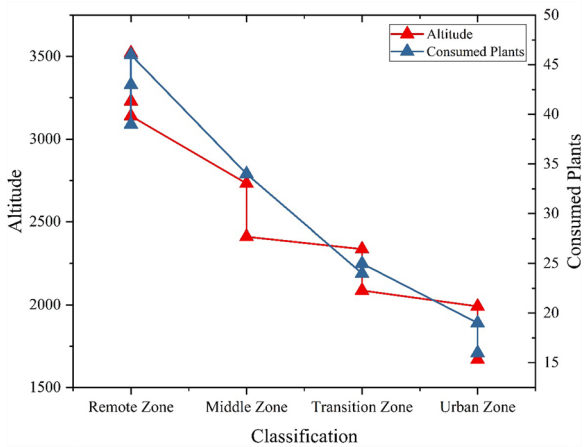

Fig. 7 Graph depicting the consumption trends of WFPs along elevational gradients and their consumption value across different zones of the study area

isolated ways across the studied species. A two-dimensional scatterplot of the threat loadings (Fig. 8) illustrated the relative influence and directionality of each threat in the latent space. The analysis demonstrates that local perceptions of threat are structured by a combination of direct resource extraction pressures and emergent ecological risks, with species variably exposed depending on their ecological and cultural contexts. The species reported by informants as rare in the region include *Lagotis cashmeriana, Morchella esculenta, Rheum australe, Rheum webbianum*, and *Allium carolinianum*. Their rarity is largely attributed to wild harvesting for medicinal purposes, as well as climate change and habitat degradation, which have potentially reduced the abundance of these species.

Discussion

Transformation and loss of traditional knowledge (TK)

The Kashmir region has a unique social structure shaped by its cultural heritage, mountainous geography, and community interactions. TK is transmitted through oral traditions, foraging practices, and communal gatherings, with elders playing a key role in passing it to younger generations. However, these pathways have been disrupted by the division of responsibilities and modern education. The traditional joint family setup, which allowed elders and younger to live together, has been disrupted, leading

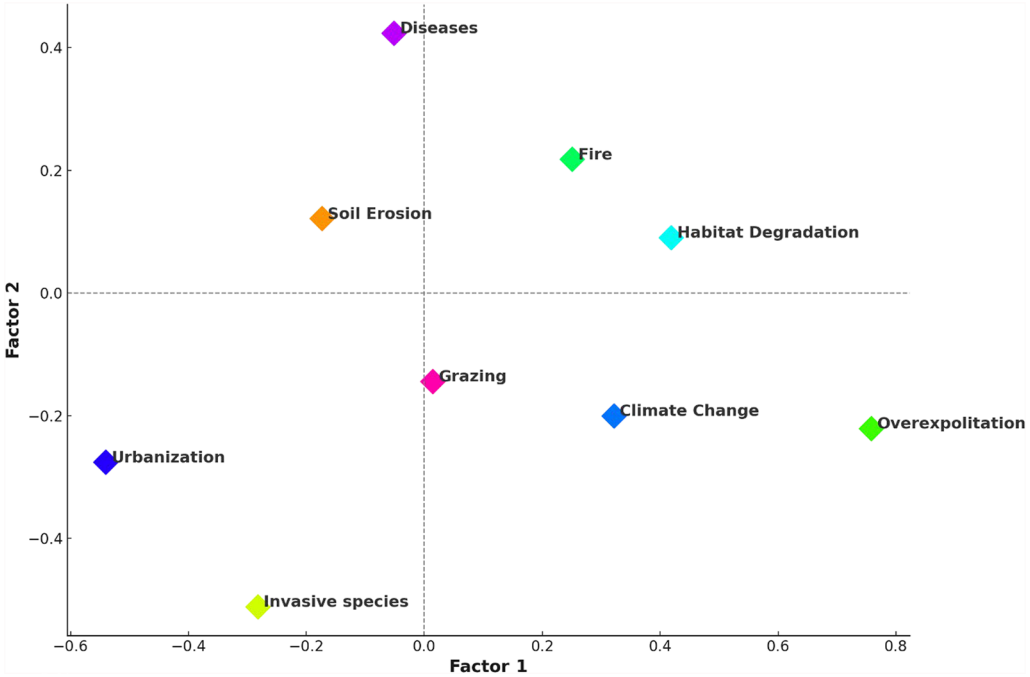

Fig. 8 Factor loadings of perceived threats to wild food plants (WFPs) based on factor analysis. The plot displays the contribution of each threat across two extracted latent factors. Marker positions represent the strength and direction of each threat's influence

to a disconnection from their cultural roots. Past conflicts and political instability have displaced communities and fragmented families, breaking intergenerational bonds essential for preserving traditional knowledge. Advancements in technology have further contributed to this decline, as younger generations increasingly rely on digital platforms, often overlooking traditional knowledge. Climate change has altered ecosystems and affected the availability of WFPs, particularly impacting resource-dependent communities. These changes have diminished traditional practices and weakened the incentive to transmit knowledge, collectively contributing to the erosion of knowledge among younger generations. These findings are supported by [23, 34, 41], who report similar trends in the decline of traditional knowledge. Approximately 37 WFPs (58.73%) were used regularly, 12 species (19.05%) were used occasionally, and 14 species (22.22%) were rarely used, although they were utilized in the past. Key WFPs in the region include *Diplazium* spp., *Pteridium* spp., *Dryopteris* spp., *Morchella esculenta*, *Chenopodium album*, *Amaranthus* spp., *Nasturtium officinale*, *Trifolium repens*, *Malva sylvestris*, *Polygonum aviculare*, *Portulaca oleracea*, and *Rumex nepalensis*. These plants have also been reported by various researchers in the area [1, 23, 25, 26].

The Kashmir region is experiencing socioeconomic changes that disrupt local subsistence economies. Communities that traditionally relied on small-scale trade, pastoralism, and agriculture now face challenges due to climate change, which negatively impacts farming and livestock practices. Market-driven cash crops and tourism divert attention from self-sustaining activities, marginalizing those dependent on traditional practices. Additionally, the migration of younger generations to urban areas threatens local plant knowledge and practices. WFPs hold cultural and ecological significance in Kashmir. Current practices reflect TK and modern preferences, particularly for species like *Rheum australe, Rheum webbianum, Lagotis cashmeriana, Pimpinella diversifolia, Alliaria petiolata,* and *Oxalis acetosella*, which are now primarily valued for health benefits rather than as food. These medicinal plants treat various diseases, such as diabetes, muscular pain, swelling, bone fractures, and stomach issues [28, 43–45], indicating a loss of knowledge and diminished cultural preferences regarding their use as medicines instead of wild vegetables. The use of WFPs for medical purposes highlights their cultural and therapeutic value. Various plants, including *Rheum australe, Rheum webbianum, Lagotis cashmeriana, Pimpinella diversifolia, Alliaria petiolata, Viola canescens, Koenigia alpina*, and *Silene conoidea*, have been abandoned due to lifestyle shifts, urbanization, and a decline in knowledge transfer across generations. This highlights the decline of TK among younger generations and the urgent need to preserve it. Recent studies indicate that climate change impacts in the western

Himalayan region, alongside the rise of cultivated products and commercialized food, have decreased ethnic groups' dependence on natural food resources [1, 23, 26, 34].

Knowledge sharing and transmission

Women in the region possess extensive knowledge about harvesting seasons, distribution ranges, and traditional cuisine recipes, with older individuals having more experience due to their roles in cooking. Socioeconomic factors influence this knowledge, as women in resource-constrained households rely on WFPs for cost-effective nutrition. Women's knowledge is gender-specific, primarily shared among them through foraging and cooking practices. However, the decline of social structures and younger generations' preference for market-based products has diminished traditional knowledge. The spread of non-native information about WFPs via digital platforms has homogenized local cuisines, and mass media often promotes commercial food products. A similar case was also reported by [46] regarding gender-specific knowledge. Additionally, religious and social structures restrict interviews with women and the sharing of traditional cuisines, complicating the accurate representation of traditional foraging practices and recipes [1, 23, 28, 41, 47]. The study emphasizes the challenge of authentically representing TK in communities where older women have significant expertise in WFPs and medicinal plants. The findings contradict previous research suggesting that women have less knowledge about WFPs, possibly due to urban settings where they work domestically and lack access to natural environments [48]. Informants struggled to recall the names of WFPs and their recipes, indicating a decline in significant TK. This cultural heritage must be preserved. Future strategies should promote knowledge and resource sharing among older women.

Intergenerational knowledge is vital for preserving cultural heritage and plant knowledge, which are essential for subsistence in harsh environments. However, the transfer of foraging practices is limited across all ethnic groups; older individuals possess extensive knowledge of various WFPs, while younger generations are familiar with only a few commonly used plants. This gap threatens biodiversity conservation, cultural heritage preservation, and the connection between ethnic groups and their natural environments [49]. Contributing factors include changes in social structure, access to market products, modern lifestyles, and cultural shifts [23, 50]. In contrast, the Gujjar and Bakarwal ethnic groups have retained more knowledge due to their strong connection to their cultural heritage. TK transfer methods, such as storytelling, household gatherings, cultural festivals, and religious congregations, are essential for understanding WFPs among younger generations. These practices, which occur monthly or as needed, are particularly relevant for community issues. To preserve this knowledge, it is crucial to highlight these practices and raise awareness.

Commodification practices threaten traditional foraging methods among certain ethnic groups and in specific areas [51]. These practices affect communities' ecological knowledge and their interactions with the environment. The study found significant changes in foraging practices, including altered harvesting frequency, variations in spices, and modifications in food preparation methods. Market-based alternatives are eroding original knowledge, especially among younger generations, leading to a decline in foraging practices and traditional recipes [52–54]. Sociocultural and political factors influence these changes, impacting the social lives of ethnic communities and altering foraging behaviours. As a result, many cultures are reorienting their ecological relationships within the evolving sociopolitical landscape [50, 55, 56]. WFPs are vital for the survival and resilience of ethnic communities, especially in remote areas facing climate change and food security issues [1]. However, their consumption is declining in urban areas due to limited knowledge, easy access to cultivated foods, and modern lifestyles. Greater knowledge of traditional foraging practices leads to increased reliance on WFPs, which provide essential nutrients, enhance diets, and reduce malnutrition risk [9, 57, 58]. Despite their benefits, WFP consumption is decreasing due to socioeconomic changes, shifts in agriculture and markets, urban unavailability, and time constraints. In urban areas, many consume highly processed foods that lack health benefits, influenced by global markets that promote poor nutritional choices among indigenous communities [59].

Food security

This study reports various WFPs that can enhance local food security in the Kashmir region. Due to economic instability, communities rely heavily on these natural resources for nutrition. The region's ecological diversity offers a variety of WFPs as alternatives in times of crisis. Remoteness limits access to food during severe conditions, leading to food insecurity. Economically marginalized communities face increasing challenges, exacerbated by global food scarcity, particularly in developing nations. WFPs provide a pathway to sustainable food systems while mitigating agricultural impacts amidst climate change [60]. Preserving wild food ecosystems and utilizing their variety is essential to combat hunger [61, 62]. WFPs offer a sustainable option for vulnerable communities amid rising economic instability and food insecurity. Geopolitical concerns, natural disasters, and climate change further threaten local food systems. WFPs deliver

essential nutrients and economic support [63, 64], and are sold in local markets, thus supporting household economies [9, 65]. Species such as *Diplazium* spp., *Dryopteris* spp., *Morchella* spp., *Amaranthus viridis*, and *Rheum* spp. are significant to local cuisines, and their market availability bolsters household economies. Traditional foraging practices, often led by women, help fill food supply gaps, highlighting community resilience. WFPs also facilitate local trade and reduce reliance on unstable markets, supporting informal economies. However, perceived threats like overharvesting, habitat degradation, and the loss of traditional knowledge challenge their conservation and sustainable use. Research in Europe values non-wood forest products (mostly food plants) at €19.5 billion, with a per hectare value of €77.8, significantly higher than official estimates [66]. Policymakers should integrate WFPs into regional food security initiatives, focusing on community-based natural resource management and value chain development. Utilizing WFPs through agroforestry and ecotourism can create sustainable livelihoods and empower communities. Establishing market connections and value-added processing can transform WFPs from subsistence to economic assets, enhancing food security and supporting livelihoods. Prioritizing WFPs addresses food security issues in Kashmir, considering ecological fragility and sociopolitical instability.

Women empowerment and future prospect

In the Kashmir region, women play a crucial role in preserving, utilizing, and transmitting ethnobotanical knowledge, particularly regarding WFPs. Their deep-rooted association with local biodiversity and TEK systems positions them as key custodians of cultural and biological heritage. Women are responsible for foraging, identifying, processing, and incorporating WFPs into daily diets, reflecting an intimate understanding of plant seasonality, habitat specificity, and nutritional value. This close interaction sustains local food security and enriches the region's culinary heritage through unique preparation methods and recipes. Women's contributions to household nutrition, healthcare through medicinal plants, and adaptive responses to environmental changes are significant yet often underrecognized in scientific and policy discussions [67]. Integrating women's knowledge systems into formal ethnobotanical research enhances biodiversity conservation and provides a platform for promoting gender equity [68, 69]. Empowering women through participatory research, community-based conservation programmes, and inclusive value chain development can foster ecological resilience and socioeconomic well-being [70, 71]. Future ethnobotanical research should prioritize gender-sensitive approaches that document, validate, and support women's knowledge and practices. Recognizing women as equal stakeholders in the management and sustainable use of plant resources will not only bridge the gap in TK systems, but also pave the way for inclusive and culturally grounded conservation strategies in the region.

Conclusions

The study explores the foraging landscape in Kashmir, highlighting the dynamic nature of TEK in response to changing livelihoods, climate variability, and modernization. It examines the resilience and negotiation between tradition and change. We analysed 63 species of WFPs across five groups, revealing diverse consumption patterns. The Gujjar group consumed the most, with 59 species. Gender analysis indicated that women generally possess more TK, but younger females are experiencing a decline in this knowledge. Traditional foraging practices have evolved due to market products. There is a growing divide between generational knowledge holders and younger community members, influenced by education, migration, and shifting priorities. Despite this divide, localized expertise persists, often preserved through community memory and the active participation of women. The study emphasizes the importance of culturally responsive conservation strategies in mountainous regions, highlighting the necessity for inclusive policy frameworks that acknowledge the rights and roles of indigenous and local communities. It advocates for interdisciplinary approaches, ethnobotany, and participatory research to effectively address these dynamics and preserve biodiversity and cultural heritage.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13002-025-00805-0.

Additional file1

Acknowledgements
The authors would like to extend their sincere appreciation to Ongoing Research Funding program (ORF-2025-134), King Saud University, Riyadh, Saudi Arabia.

Author contributions
Conceptualization, MM, SWG and MA; Field investigation, MM, SWG and AS; Methodology, MM, MAA and SWG; Software, MM, SWG; validation, AP, MA, MAA; writing—original draft preparation, MM, SWG, and MAA; writing—review and editing, MM, SWG, MAA, AS, MW, AH, KFA, EFA and AP; visualization, AP and MA; supervision, MA. All authors having substantial contributions in research, read and agreed to the published version of the manuscript.

Funding
The authors would like to extend their sincere appreciation to Ongoing Research Funding program (ORF-2025-134), King Saud University, Riyadh, Saudi Arabia.

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent of participants
This study is part of the research conducted by PhD scholar Mr. Muhammad Manzoor (first author), which was approved by the Advanced Studies & Research Board (ASRB) at Quaid-i-Azam University, Islamabad, Pakistan. The present study is based on a field survey rather than human or animal trials, and we obtained verbal consent from participants for data collection and publication. All informants permitted us to share their opinions and photographs for publication. Additionally, we strictly adhered to ethical guidelines and rules of the International Society of Ethnobiology (ISE) (http://www.ethnobiology.net/).

Consent of publication
All informants permitted us to share their opinions and photographs for publication. Additionally, we strictly adhered to the ethical guidelines and rules set forth by the International Society of Ethnobiology (ISE) (http://www.ethnobiology.net/).

Competing interest
The authors declare no competing interests.

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Received: 12 May 2025 Accepted: 8 July 2025
Published online: 25 August 2025

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