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Research Article

Ethnomedicinal Plant Knowledge of Dheri Julagram, District Malakand, Pakistan: Diversity, Traditional Uses, and Conservation Implications

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Abstract | Medicinal plants represent an important component of traditional healthcare systems, particularly in remote mountainous regions where indigenous communities rely on local plant resources for treating various health conditions. However, traditional ethnobotanical knowledge is increasingly threatened by environmental changes and socioeconomic transformation, highlighting the need for documentation and conservation. This study aimed to document the ethnomedicinal plant diversity, traditional uses, and conservation significance of plant resources in a remote Hindu Kush community of Pakistan. Field surveys, semi-structured interviews, and ethnobotanical observations were conducted to record plant uses, while collected specimens were identified, preserved, mounted on herbarium sheets, and deposited in a recognized herbarium. A total of 60 ethnomedicinal plant species belonging to 34 families were documented. Herbs were the dominant life form, representing 42 species (70%), followed by trees (10 species, 16.66%) and shrubs (8 species, 13.33%). The family Asteraceae showed the highest species representation with 8 taxa, followed by Lamiaceae and Poaceae with 6 taxa each. Rosaceae and Solanaceae contributed 4 taxa each, while Fabaceae, Apiaceae, and Polygonaceae were represented by 3 taxa each. The documented plants were traditionally used for various ailments, including respiratory disorders, digestive problems, fever, diabetes, skin diseases, urinary disorders, and circulatory problems. Several species were also reported as food supplements and general tonics. This study highlights the importance of indigenous ethnobotanical knowledge in supporting local healthcare practices. It provides baseline information for biodiversity conservation, sustainable utilization, and future pharmacological investigations in the Hindu Kush region.

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Introduction

Ethnobotany is an interdisciplinary field that explores the complex relationships between humans and plants, including traditional knowledge, utilization patterns, and cultural significance of plant resources within different communities (Martin, 1995; Ullah, 2024). It provides valuable insights into how indigenous societies identify, manage, and utilize local plant diversity for medicinal, nutritional, agricultural, and cultural purposes (Abel and Busia, 2005; Gilani *et al*., 2013). Traditional plant knowledge represents an important component of rural healthcare systems, particularly in remote regions where access to modern medical facilities is limited (Francis, 2009; Bekele and Reddy, 2015). Therefore, ethnobotanical studies contribute not only to the documentation of indigenous knowledge but also to biodiversity conservation and the sustainable utilization of plant resources (Garcia *et al*., 2007; Ahmad *et al*., 2011). Medicinal plants have played a fundamental role in human healthcare throughout history and continue to provide primary healthcare support for many rural communities worldwide (Gilani *et al*., 2007; Khan *et al*., 2012). According to the World Health Organization (WHO), a large proportion of the population in developing countries relies on traditional medicine to manage various health conditions (Goodman and Ghafoor, 1995; Abel and Busia, 2005). Indigenous knowledge related to medicinal plants has contributed significantly to the discovery of bioactive compounds and the development of modern therapeutic agents (Ahmad *et al*., 2011). In addition, ethnobotanical investigations provide important information for identifying valuable plant species, conserving threatened flora, and understanding the ecological and cultural importance of plant resources (Albuquerque, 2010; Ajaib *et al*., 2014; Hassan *et al*., 2015).

Pakistan is recognized for its diverse flora due to its wide range of ecological zones, including mountainous, arid, and subtropical regions (Hazrat *et al*., 2007; Ajaib *et al*., 2013). The northern mountainous areas, particularly the Hindu Kush region, harbor rich plant diversity and support communities that have maintained traditional knowledge of plant utilization for generations (Betti, 2004; Henry *et al*., 2013; Bekele and Reddy, 2015). Local populations in these remote areas often rely on wild and cultivated plants for healthcare, food, fodder, fuel, and other livelihood purposes (Choudhary *et al*., 2008; Chhetri, 2009; Hazrat *et al*., 2015). However, rapid socioeconomic changes, habitat degradation, climate change, and the decline of traditional knowledge transmission are increasingly threatening these valuable ethnobotanical resources (Cotton, 1996; Hilary *et al*., 2005; Hazrat *et al*., 2011). Several ethnobotanical studies have been conducted in different regions of Pakistan, documenting medicinal plant diversity and traditional uses among local communities (Cox and Balick, 1994). However, many remote villages of the Hindu Kush region remain poorly investigated, and quantitative information regarding plant diversity, traditional uses, and conservation significance is still limited (Farnsworth, 1988; Devi and Muniyandi, 2015). The loss of indigenous knowledge from these understudied areas may result in the disappearance of valuable information related to plant-based healthcare practices and sustainable resource management (Farnsworth, 1993; Dolatkhahi *et al*., 2014; Foo *et al*., 2016).

The present study focuses on Dheri Julagram, District Malakand, Pakistan, a remote Hindu Kush community where traditional knowledge of medicinal plants remains an important component of local healthcare practices (Hussain *et al*., 2008; Homervergel and Kim, 2014). Despite the continued use of medicinal plants by local inhabitants, comprehensive ethnobotanical documentation from this area is lacking (Iain *et al*., 2005; Ibrar *et al*., 2007). Therefore, this study provides the first systematic assessment of ethnomedicinal plant diversity and traditional plant utilization in Dheri Julagram by integrating floristic documentation, indigenous knowledge, and ethnobotanical analysis. The findings provide baseline information for biodiversity conservation, sustainable utilization of plant resources, and future research on medicinal potential. Therefore, the objectives of this study were to: (1) document the diversity of ethnomedicinal plant species used by the local community of Dheri Julagram; (2) record traditional uses and plant utilization patterns; (3) analyze the importance of documented species using ethnobotanical approaches; and (4) highlight conservation implications of indigenous plant knowledge in the Hindu Kush region of Pakistan.

Materials and Methods

Study area

The present ethnobotanical study was conducted from

January 2021 to December 2021 in Dheri Julagram, District Malakand, Khyber Pakhtunkhwa Province, Pakistan (Figure 1) (Iiengme, 1983; Islam *et al*., 2013). The study area is located approximately 180 km north of Peshawar at 34.610669° N latitude and 71.911306° E longitude (Jain, 1965; Jamila and Rahman, 2016). The region is characterized by mountainous terrain, rain-fed agricultural systems, and diverse vegetation communities (Jeruto *et al*., 2008; Jan *et al*., 2011). The total cultivated area of Dheri Julagram is approximately 15,664 hectares, while 2,522 hectares are covered by forest vegetation (Jem *et al*., 2014). Rangelands constitute approximately 18,434 hectares, shrubs and bushes occupy 3,037 hectares, and riverbeds cover approximately 109 hectares (Kaigongi and Musila, 2015). The natural vegetation of the area includes important tree species belonging to *Pinus*, *Taxus*, *Abies*, *Quercus*, *Acacia*, and *Olea*. Agriculture is an important livelihood activity for local communities (Kamau *et al*., 2016). Major cultivated crops include *Triticum aestivum* L., *Zea mays* L., *Oryza sativa* L., *Hordeum vulgare* L., *Solanum tuberosum* L., *Lycopersicon esculentum* Mill., *Brassica campestris* L., and *Cucurbita maxima* Duchesne. Common fruit crops cultivated in the region include *Malus pumila* Mill., *Prunus persica* (L.) Batsch, *Psidium guajava* L., *Citrus medica* L., *Juglans regia* L., and *Diospyros lotus* L. (Kalle and Sõukand, 2012; Kaingua *et al*., 2014).

Climate of the study area

The climate of Dheri Julagram is influenced by monsoon rainfall and mountainous conditions. Summers are relatively warm with seasonal precipitation, whereas winters are cold and may reach freezing temperatures (Khan *et al*., 2012; 2015). During June and July, temperatures range from approximately 16°C to 44°C, while December to February represent the coldest months, with temperatures ranging from approximately 8.8°C to -5°C. The agricultural irrigation system mainly depends on the Swat River and monsoon rainfall (Khan *et al*., 2013).

Ethnobotanical data collection

Field surveys were conducted throughout 2021 to document ethnomedicinal plants and associated indigenous knowledge of the local community of Dheri Julagram (Mahmood *et al*., 2011). Several field expeditions were organized for plant collection, direct observation, and documentation of traditional plant utilization practices (Martin, 2007). Ethnobotanical information was collected through semi-structured interviews, informal discussions, and field observations (Martin, 1995). Information regarding local plant names, medicinal applications, plant parts used, preparation methods, harvesting periods, storage practices, availability, and other traditional uses was recorded (Marwat *et al*., 2012). The documented plant species were categorized according to their traditional utilization, including medicinal, food, fodder, fuel, timber, and other ethnobotanical uses (Matthews and Medhi, 2014). Medicinal applications were recorded based on information provided by local informants

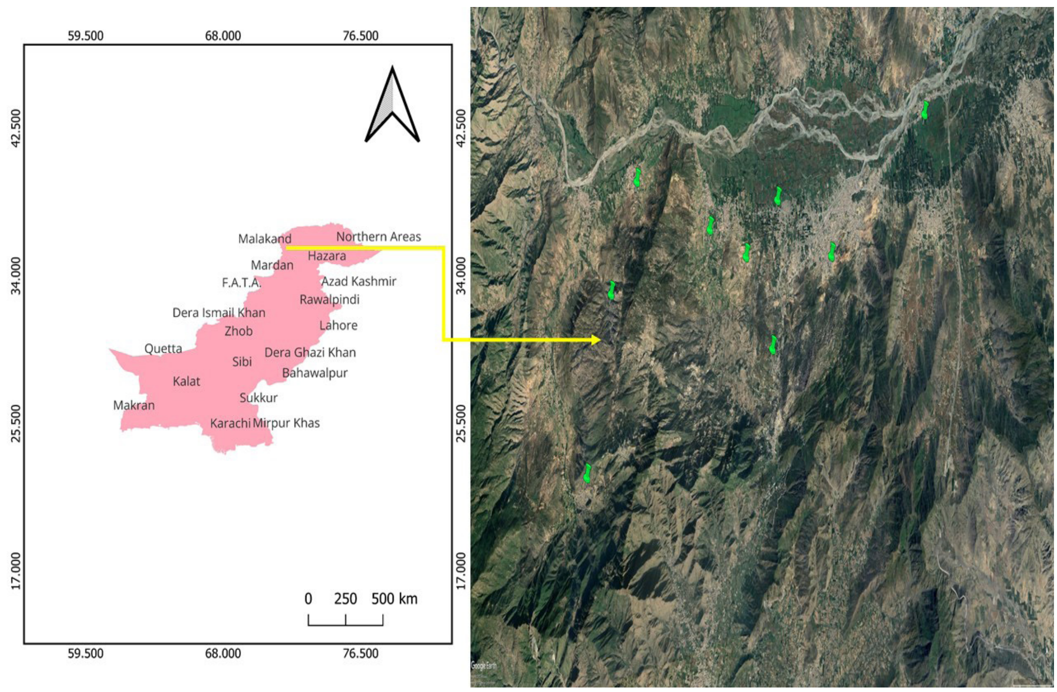

Figure 1: *Location map of the study area showing Dheri Julagram, District Malakand, Khyber Pakhtunkhwa, Pakistan.*

and represent traditional knowledge reports rather than experimentally confirmed therapeutic effects (Mesfin *et al*., 2014).

Informant selection and interviews

A total of 50 informants were selected from the local community based on their knowledge and experience regarding plant utilization practices (Mohamadi *et al*., 2015). The participants included traditional healers (Hakims), local healers, farmers, and elderly community members possessing traditional knowledge of medicinal plants (Mesfin *et al*., 2013). Semi-structured interviews and discussions were conducted to collect information related to plant identity, local names, medicinal uses, preparation techniques, plant parts utilized, harvesting methods, and conservation perceptions (Mohammadi *et al*., 2016). Information obtained from different informants was repeatedly checked during subsequent field visits to improve accuracy and reliability (Mosaddegh *et al*., 2016). The collected ethnobotanical information was organized according to species, traditional uses, and utilization categories (Murray, 2013).

Field observation

Field observations were conducted during plant collection trips and community visits to understand the relationship between local inhabitants and surrounding vegetation (Naz *et al*., 2014). Observations focused on plant availability, habitat conditions, collection methods, harvesting seasons, processing techniques, storage practices, and modes of utilization (Negbenebor *et al*., 2017). Traditional practices related to medicinal plant preparation, preservation, and consumption were documented through direct observation and discussions with local knowledge holders (Oliveira *et al*., 2009).

Plant collection, identification, and taxonomic verification

Plant specimens were collected during field surveys and labelled with detailed information, including collection date, locality, habitat, and collector information (Khan *et al*., 2025; Ullah, 2025). The collected specimens were pressed, dried, and mounted on herbarium sheets following standard herbarium procedures (Manan *et al*., 2025). The voucher specimens were deposited in the Herbarium of the Department of Botany, University of Malakand, Lower Dir, Khyber Pakhtunkhwa, Pakistan (Ullah *et al*., 2025). A total of 60 voucher specimens were assigned numbers ranging from UOMBOT_210 to UOMBOT_269 for future reference and taxonomic verification. Plant identification was carried out using the Flora of Pakistan (Ali and Qaiser, 1993; http://www.efloras.org) and other relevant taxonomic literature. Taxonomic identities were verified using available floras, protologues, and herbarium references (Khan *et al*., 2024). Herbarium acronyms followed (Ali and Qaisar, 1995–2009). The accepted scientific names, author citations, families, and taxonomic classifications were verified and standardized primarily according to Plants of the World Online (POWO, 2025). The Plant List was consulted where necessary for additional taxonomic comparison (Ullah, 2024). All scientific names were italicized throughout the manuscript according to botanical nomenclature standards (Subhan *et al*., 2024; Ullah *et al*., 2024).

Ethical considerations

Prior informed consent was obtained from all participants before conducting interviews and documenting traditional knowledge. The information provided by local communities was recorded respectfully, and the contribution of knowledge holders was acknowledged (Ullah *et al*., 2024). The collected ethnobotanical information was used exclusively for scientific documentation, biodiversity conservation, and academic research purposes (Ullah *et al*., 2023).

Ethnobotanical data analysis

The recorded ethnobotanical information was organized according to plant species, family, life form, plant parts used, preparation methods, and traditional utilization categories (Ullah *et al*., 2023). The documented species were evaluated based on their ethnobotanical importance and utilization patterns (Sajid *et al*., 2023). Medicinal uses were grouped into different disease categories according to the reported traditional applications, including respiratory disorders, digestive problems, fever, diabetes, skin diseases, urinary disorders, and other health-related conditions (Ullah *et al*., 2021). All abbreviations and quantitative parameters used in tables and figures were clearly defined in their respective captions and legends.

Statistical analysis

All statistical analyses and graphical representations were performed using R software version 4.5.1 (R Core Team, 2025). The dataset was analyzed using appropriate R packages to evaluate patterns of plant utilization and relationships among ethnobotanical variables. Principal Component Analysis (PCA) was performed to visualize variation patterns among documented plant species based on recorded ethnobotanical characteristics. Correlation analysis was conducted to evaluate relationships among quantitative variables and identify significant associations within the dataset. All figures and graphical outputs were generated using R to ensure consistent formatting, clear labels, readable legends, and publication-quality resolution.

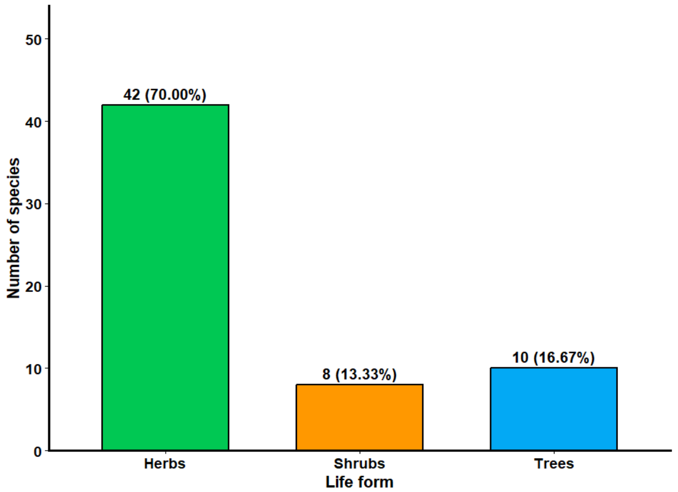

Figure 2: *Life-form composition of ethnomedicinal plant species recorded from Dheri Julagram, District Malakand, Pakistan.*

Results

A total of 60 ethnomedicinal plant species belonging to 34 families were documented from Dheri Julagram, District Malakand. The recorded information, including scientific names, families, local names, plant parts used, traditional applications, and other ethnobotanical attributes, is presented in Table 1 (Ullah *et al*., 2021).

Life-form composition of documented ethnomedicinal plants

A total of 60 ethnomedicinal plant species were documented from Dheri Julagram, District Malakand, Pakistan. The recorded species showed three major life forms: herbs, shrubs, and trees. Herbs were the dominant life form, comprising 42 species (70.00%) of the total recorded medicinal flora (Ullah, 2017). Trees represented the second most abundant life form with 10 species (16.67%), while shrubs contributed 8 species (13.33%) (Figure 2). The predominance of herbaceous species indicates that herbaceous plants represent the major component of traditional medicinal resources utilized by the local community. Their abundance may be associated with their wider distribution, easy accessibility, and frequent availability around agricultural fields, forests, and surrounding habitats (Ullah *et al*., 2019).

Genus-wise Distribution of Ethnomedicinal Plants

The documented ethnomedicinal flora of Dheri Julagram comprised diverse genera, with most genera represented by a single species. Among the recorded genera, six genera showed the highest species representation, each contributing 2 species (3.33%) of the total documented flora. These included *Mentha, Medicago, Papaver, Iris, Morus,* and *Euphorbia*. Other genera, including *Eulaliopsis, Salvia, Brassica,* and *Amaranthus*, were represented by a single species each, accounting for 1.67% of the total recorded species (Figure 3). The predominance of single-species genera indicates considerable taxonomic diversity among the ethnomedicinal plants of the study area (Ullah *et al*., 2019).

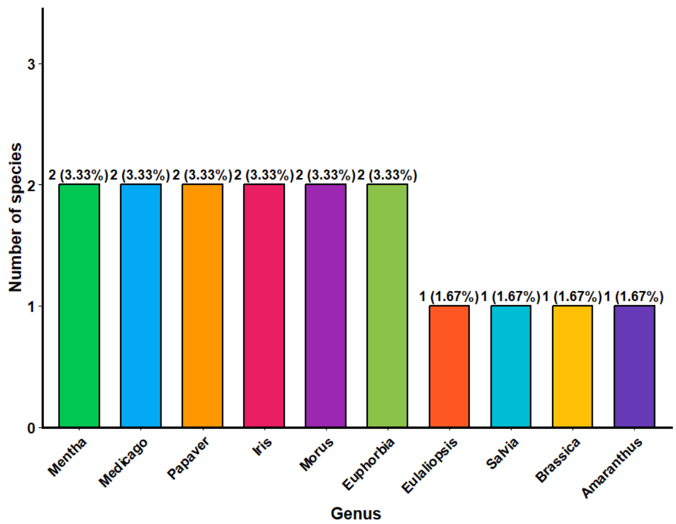

Figure 3: *Genus-wise distribution of ethnomedicinal plant species recorded from Dheri Julagram, District Malakand, Pakistan.*

Family-wise distribution of ethnomedicinal plants

The documented ethnomedicinal flora comprised 60 plant species belonging to 34 families. The distribution of species among families showed considerable variation. The most dominant families were Lamiaceae and Poaceae, each contributing 6 species (10.0%) of the total recorded flora (Ullah *et al*., 2019. Asteraceae was the third most represented family with 5 species (8.3%). The families Brassicaceae, Apiaceae, and Fabaceae were represented by 4 species

Table 1: *Ethnomedicinal information of plant species documented from Dheri Julagram, District Malakand, Pakistan*

Botanical Name	Local name	Family	Part used	Habit	Used against diseases
Mentha longifolia (L.) L.	Enally	Lamiaceae	W P	H	+, +, -, +, +, +
Mentha arvensis L.	Podeena	Lamiaceae	W P	H	+, -, -, +, +, +
Coriandrum sativum L.	Dhaniya	Apiaceae	W P	H	+, -, -, +, -,+
Rumex dentatus L.	Shalkhy	Polygonaceae	W P	H	-, +, +, -, +, -
Medicago sativa L.	Lusan	Fabaceae	W P	H	+, +, -,-,-, +
Trifolium repens L.	Shaftal	Fabaceae	W P	H	+, +, -, -, +, -
Peganum harmala L	Spylani	Zygophyllaceae	W P	H	-, +, +, -, +, -
Veronica persica Poir.	Birdeye speedwell	Plantaginaceae	W P	H	+,+,-, -,+,+
Medicago truncatula Gaertn.	Peshtary	Fabaceae	W P	H	+,+,-,+,+,-
Coronopus didymus (L.) Sm.	Swine wartcress	Brassicaceae	W P	H	+,+,-,+,+,+
Brassica campestris L	Sharsham	Brassicaceae	W P	H	-,-, -, - ,- , +
Capsella bursa-pastoris (L.) Medik.	Sheperds purse	Brassicaceae	W P	H	-,- +,+,-,-
Micromeria biflora L.	White-leaved savory	Lamiaceae	W P	H	-, -, +,-,+, -
Spinacia oleracea L.	Palak	Amaranthaceae	W P	H	-, -, +, -, -, +
Amaranthus viridis L	Chulwaii	Amaranthaceae	W P	H	-, -, -, +, -, +
Chenopodium ambrosioides L	Skha boty	Amaranthaceae	W P	H	-, -, +, -, +, -
Trichodesma indicum L	Khwaga abai	Boraginaceae	W P	H	-, -, +, -, +, +
Ajuga bracteosa Wall. ex Benth.	Goti boti	Boraginaceae	W P	H	+, +, +, +, +, +
Scandix pecten-veneris L.	Kangahy	Apiaceae	W P	H	-, -, -, -, +, -
Nasturtium officinale L	Tarmera	Brassicaceae	L	H	+, +, -, -, -, -
Verbascum thapsus L.	Khwar dag	Scrophulariaceae	W P	H	-, +, +, -, +, +
Salvia moorcroftiana Wall. ex Benth.	Khwarghwag	Lamiaceae	W P	H	+, +, +, -, +, +
Avena sativa L	Jowdar	Fabaceae	W P	H	+, -, -, -,- , +
Eulaliopsis binata (Retz.) C.E. Hubb.	Sharghashi	Poaceae	W P	H	-, -, +, -, -, +
Saccharum spontaneum L	Boogara	Poaceae	W P	H	+, -, +, -, -, +
Hordeum murinum L.	Wakha	Poaceae	W P	H	-, -, -, -, -, +
Triticum aestivum L	Ghanam	Poaceae	W P	H	-, -, -, -, -, +
Zea mays L	Jawar	Poaceae	W P	H	-, +, +, +, -, -
Cynodon dactylon L	Kabal	Poaceae	W P	H	+, +, -, -, +, +
Oxalis corniculata L	Taroky	Oxalidaceae	W P	H	+, +, +, -, -, +
Papaver rhoeas L	Sor goly	Papaveraceae	W P	H	+, +, -, -, +, -
Silybum marianum L	Kareza	Asteraceae	W P	H	+, +, +, -, +, +
Artemisia vulgaris L.	Raidy	Asteraceae	W P	H	+, - , -, +, -, +,
Eryngium planum L	Sea holly	Poaceae	W P	H	-, -, +, +, +, -
Xanthium strumarium L	Geshey	Asteraceae	W P	H	+, +, -, - , -, +
Iris germanica L	Golingus	Iridaceae	W P	H	+, +, -, -, -, +
Urtica dioica L	Sizunkay	Urticaceae	W P	H	+, +, -, -, -, +
Erigeron canadensis L.	Horseweed	Asteraceae	W P	H	+, +, +, -, -, -
Fumaria indica L.	Kagenaly	Fumariaceae	F	H	+, +, +, +, +, +
Anagallis arvensis L	Tamatar boty	Primulaceae	F	H	+, -, -, +, +, +
Cichorium intybus L	Chicory	Asteraceae	W P	H	+, +, -, -, +, +
Iris hookeriana L	Qabar boty	Iridaceae	L	H	+, +, -, -, -, +
Ranunculus muricatus. L	Chapatra	Ranunculaceae	W P	H	-, -, +, +, +, -
Moraea sisyrinchium L	Gandychar	Iridaceae	W P	H	-, -, +, +, +, -

Polygonum hydropiper L	Palpolak	Polygonaceae	L	H	+, +, -, -, +, +
Marrubium vulgare L.	White horehound	Lamiaceae	L	H	+, +, -, +, -, +
Ocimum basilicum L	Kashmaly	Lamiaceae	F L	H	+, +, -, +, -, +
Foeniculum vulgare L	Kaga	Apiaceae	F	H	+, +, -, +, -, +
Eruca sativa Mill.	Jomama	Brassicaceae	W P	H	+, +, -, +, -, +
Kickxia ramosissima (Benth.) D.A. Sutton	Tarukey	Plantaginaceae	W P	H	+, +, -, +, +, -
Papaver somniferum L	Khash khash	Fabaceae	F	H	+, +, +, +, +, +
Euphorbia helioscopia L	Mandano	Euphorbiaceae	F	H	-, +, +, +, +, -
Euphorbia hirta L.	Asthma plant	Euphorbiaceae	F	H	+,+, +, +, +, +
Citrus limon L	Nimboo	Rutaceae	F L	Sh	+, +, -, +, -, -
Sageretia theezans L	Mamana	Rhamnaceae	R S	Sh	-, -, -, -, +, +
Morus alba L	Baidana	Moraceae	F	T	+, +, +, -, - , +
Morus nigra L	Tor toot	Moraceae	F	T	+, +, +, -, - , -
Ziziphus jujuba Mill.	Bera	Rhamnaceae	F	T	+,-, -, -, +, +
Populus nigra L.	Gentus	Salicaceae	F Lx	T	+, +, -, -, +, +
Ficus carica L	Inzar	Moraceae	F L	T	+, +, -, +, +, +

Note: WP = Whole plant; L = Leaf; F = Fruit; FL = Flower; S = Stem; B = Bark; SD = Seed; R = Root; RS = Root stock/Rhizome; SH = Shoot; LX = Latex; H = Herb; Sh = Shrub; T = Tree. Disease categories: + = Plant reported as traditionally used for the respective disease category; – = No traditional use reported for the respective disease category.

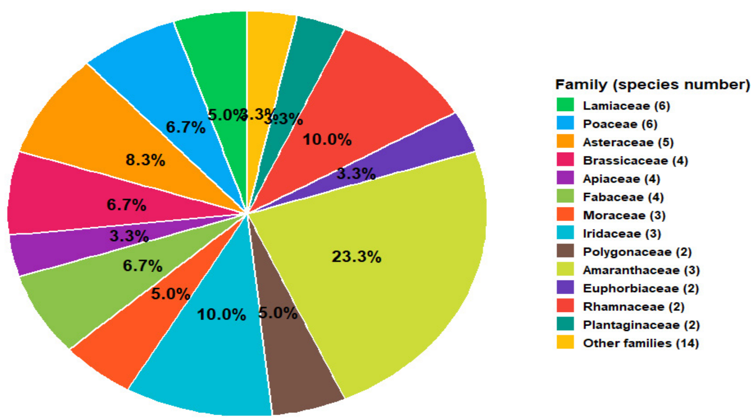

Figure 4: *Family-wise distribution of ethnomedicinal plant species recorded from Dheri Julagram, District Malakand, Pakistan.*

each (6.7%). Several families showed moderate representation, including Moraceae, Iridaceae, and Amaranthaceae, each contributing 3 species (5.0%), while Polygonaceae, Euphorbiaceae, Rhamnaceae, and Plantaginaceae contributed 2 species each (3.3%). The remaining 14 families were represented by a single species each, collectively accounting for 23.3% of the recorded ethnomedicinal flora (Figure 4). The dominance of Lamiaceae, Poaceae, and Asteraceae indicates their important contribution to the medicinal plant diversity of the study area. These families are widely distributed and contain numerous species commonly utilized by local communities due to their availability and traditional importance.

Plant parts used for traditional medicinal preparations

Different plant parts were utilized by the local community for the preparation of traditional remedies. Among the recorded ethnomedicinal species, leaves were the most frequently used plant part, representing 30 species, followed by stems (12 species) and fruits (11 species). Whole plants were utilized in 9 species, while seeds accounted for 6 species. Flowers and bark were used in 5 species each, whereas latex and shoots were the least frequently utilized plant parts, recorded in 3 species each (Figure 5). The dominance of leaves as the primary medicinal plant part indicates their accessibility and ease of collection, as well as the presence of bioactive compounds commonly associated with vegetative tissues. The frequent use of whole plants also reflects the traditional harvesting practices of local communities in the study area (Abel and Busia, 2005).

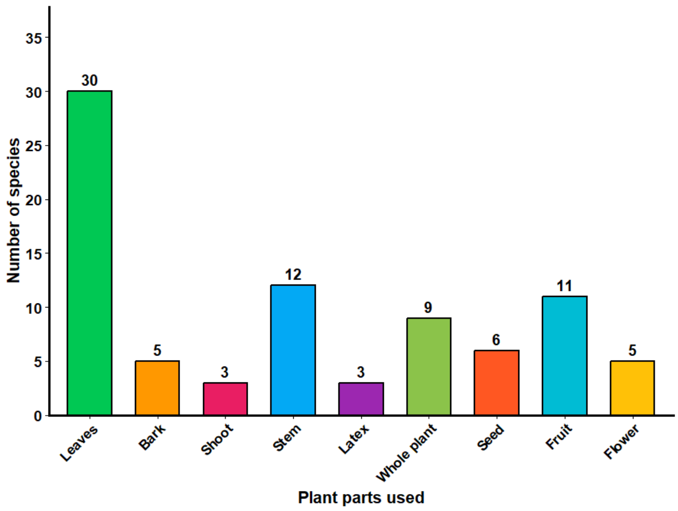

Figure 5: *Distribution of plant parts used for traditional medicinal preparations among ethnomedicinal plants recorded from Dheri Julagram, District Malakand, Pakistan.*

Traditional uses of ethnomedicinal plants against different ailments

The documented ethnomedicinal plants were reported to be used for the management of various human ailments. The highest number of plant species was associated with diarrhea, for which 11 species were traditionally utilized. Pain relief and wound healing were each represented by 6 species, while antioxidant activity, blood coagulation, diabetes-related disorders, and headache were each associated with 5 species. Respiratory disorders were reported for 4 species, whereas analgesic, chilblain, miscarriage-related uses, and throat pain were associated with 3 species each. Antibacterial applications represented the least frequently reported category, involving 1 species (Figure 6). The results indicate that digestive disorders, particularly diarrhea, represented one of the most important traditional healthcare categories in the study area. The wide range of reported applications demonstrates the multifunctional role of medicinal plants in supporting local healthcare practices (Ahmad *et al*., 2011).

Saliency index of important ethnomedicinal plant species

The saliency index analysis identified the most culturally important medicinal plant species recognized by the local community of Dheri Julagram. Among the documented species, *Ajuga bracteosa* showed the highest saliency value (3.00), indicating its high recognition and importance among informants. It was followed by *Fumaria indica* with a saliency value of 2.80 and *Papaver somniferum* and *Mentha arvensis*, both with values of 2.60. Other highly recognized species

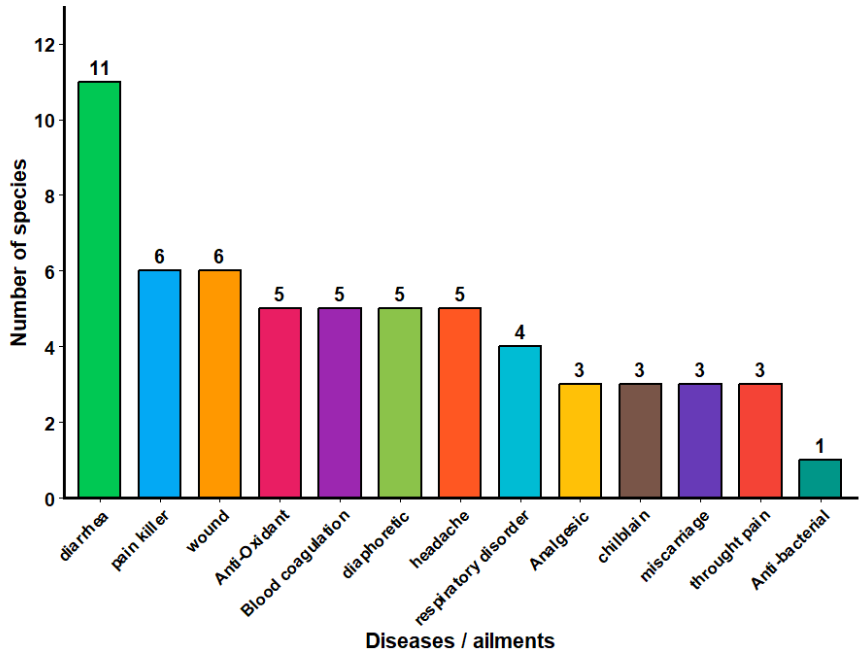

Figure 6: *Frequency of ethnomedicinal plant species associated with different disease and ailment categories in Dheri Julagram, District Malakand, Pakistan.*

included *Euphorbia hirta* and *Ficus carica* (2.50 each), *Silybum marianum* (2.40), and *Salvia moorcroftiana* (2.30). *Mentha longifolia* showed a saliency value of 2.20, while *Veronica persica* and *Coronopus didymus* exhibited the lowest values among the top-ranked species (2.00 each) (Figure 7). The high saliency values of these species indicate their strong cultural importance, frequent recognition, and widespread traditional use within the local community. Species with higher saliency values may represent priority candidates for further pharmacological investigation and conservation planning Table 2.

Table 2: *Top ten ethnomedicinal plant species ranked according to the number of ailments treated and saliency index in Dheri Julagram, District Malakand, Khyber Pakhtunkhwa, Pakistan.*

Botanical name	Number of ailments treated	Saliency
Ajuga bracteosa	6	3.03
Fumaria indica	6	3.03
Papaver somniferum	6	3.03
Euphorbia hirta	6	3.03
Mentha longioflia	5	2.53
Veronica persica is	5	2.53
Coronopus didymus	5	2.53
Salvia moorcroftiana	5	2.53
Silybum marianum	5	2.53
Ficus carica	5	2.53

Principal component analysis of ethnobotanical traits and disease-use categories

Principal Component Analysis (PCA) was performed to evaluate the relationships among ethnobotanical characteristics, plant parts used, and disease-use categories of the documented medicinal plants. Disease-use categories were converted into binary variables, where the presence of a reported traditional use was coded as 1 and absence as 0. Six major disease categories were considered: digestive disorders (D1), respiratory disorders (D2), skin diseases (D3), fever and general health disorders (D4), diabetes/metabolic disorders (D5), and urinary/kidney disorders (D6). The first two principal components explained 55.1% of the total variation, with PC1 accounting for 32.8% and PC2 accounting for 22.3% of the variation (Figure 8). The PCA biplot demonstrated clear associations between plant-use traits and disease categories. PC1 showed strong positive contributions from fruit use, leaf use, flower use, and plant habit, indicating their importance in differentiating species based on utilization patterns. In contrast, whole plant use (WP) showed a negative association with PC1. The disease-use variables showed different contributions to the PCA structure. Digestive disorders (D1) and urinary/kidney disorders (D6) showed strong positive associations with PC2, whereas respiratory disorders (D2) and skin diseases (D3) contributed negatively to this axis. Fever/general health disorders (D4) also showed a positive contribution, while diabetes/

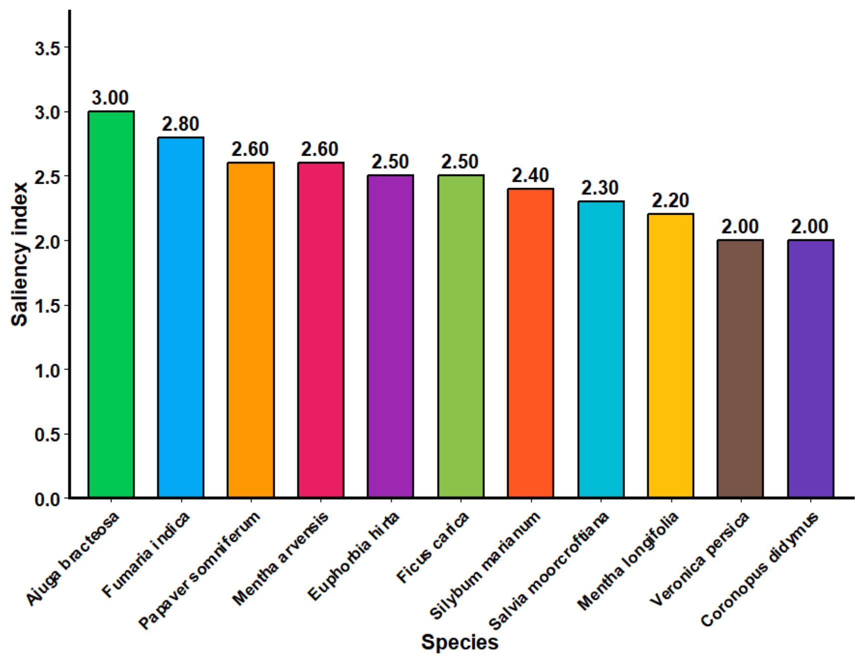

Figure 7: *Top ten ethnomedicinal plant species ranked according to saliency index values in Dheri Julagram, District Malakand, Pakistan.*

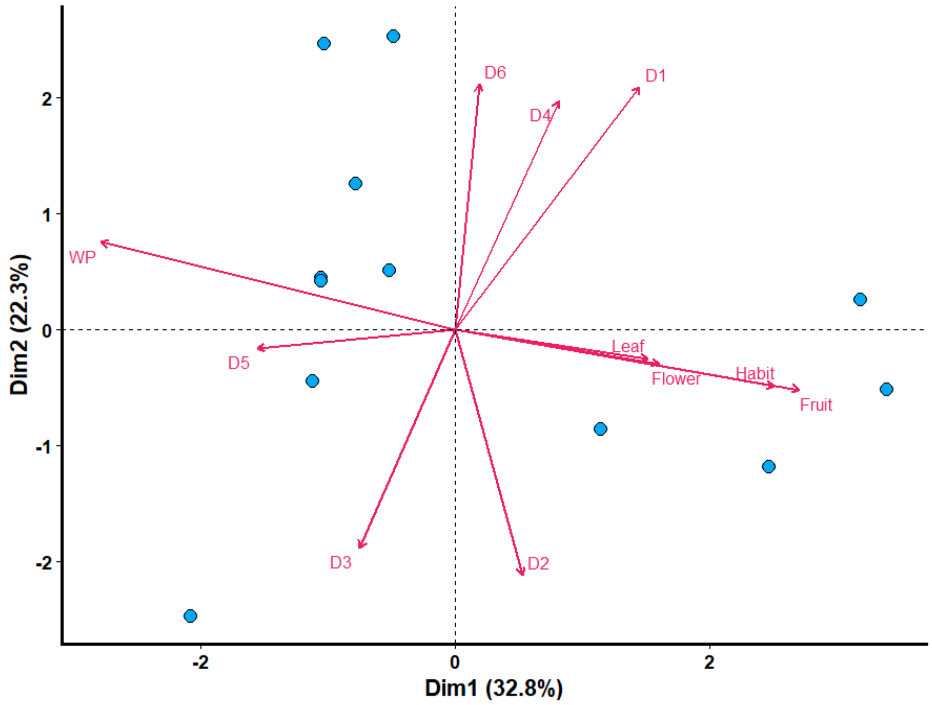

Figure 8: *Principal component analysis (PCA) biplot showing relationships among ethnobotanical traits, plant-use characteristics, and disease-use categories of medicinal plants recorded from Dheri Julagram, District Malakand, Pakistan.*

metabolic disorders (D5) displayed a negative association with PC1. The PCA analysis indicates that ethnomedicinal plant species are differentiated according to their traditional utilization patterns, plant parts used, and associated therapeutic applications. Species positioned near specific trait vectors showed stronger relationships with corresponding ethnobotanical characteristics.

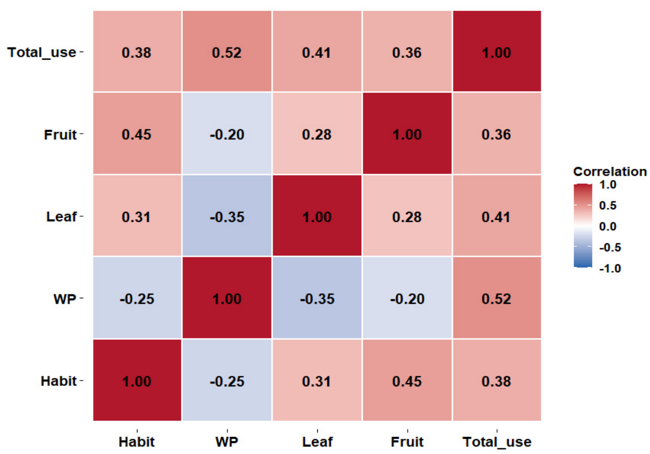

Figure 9: *Correlation heatmap showing relationships among ethnobotanical traits and utilization characteristics of medicinal plant species recorded from Dheri Julagram, District Malakand, Pakistan.*

Correlation analysis of ethnobotanical characteristics

Correlation analysis was performed to evaluate the relationships among plant growth form, plant parts used, and overall ethnobotanical importance (total use) of the documented medicinal plants. The correlation matrix revealed different levels of association among the analyzed variables (Figure 9). The total use showed positive correlations with all evaluated traits. The strongest positive relationship was observed between total use and whole plant utilization (WP) (r = 0.52), followed by leaf utilization (r = 0.41), habit (r = 0.38), and fruit utilization (r = 0.36). This indicates that species with greater utilization of specific plant parts, particularly whole plants and leaves, tended to have higher numbers of reported traditional uses. Among plant-use characteristics, fruit utilization showed a positive correlation with habit (r = 0.45), suggesting that woody plants, particularly shrubs and trees, were more frequently associated with fruit use. Leaf utilization showed a moderate positive association with habit (r = 0.31). In contrast, whole plant use showed negative relationships with habit (r = −0.25) and leaf use (r = −0.35), indicating that whole-plant harvesting was more common among herbaceous species. Overall, the correlation analysis demonstrated that plant growth form and utilized plant parts influence the ethnobotanical importance of medicinal species. Species with multiple reported uses and greater utilization diversity showed higher ethnobotanical significance within the local community.

Overlap of plant parts used in traditional medicine

The utilization pattern of different plant parts showed considerable overlap among the documented ethnomedicinal species. Leaves, fruits, and whole plants represented the major categories of plant materials used by the local community. Among these categories, 18 species were exclusively used for leaves, while 17 species were exclusively used as whole plants. Fruit-only utilization was recorded for 5 species. Several species involved multiple plant parts in traditional preparations. The overlap between leaves and fruits comprised 6 species, whereas 12 species showed combined use of leaves and whole plants. Only 1 species showed overlap between fruits and whole plants, while no species was recorded with simultaneous use of all three categories (leaves, fruits, and whole plants) (Figure 10). These findings indicate that local medicinal practices rely mainly on easily accessible vegetative parts, particularly leaves and whole plants, while multiple-part utilization contributes to the versatility of traditional remedies.

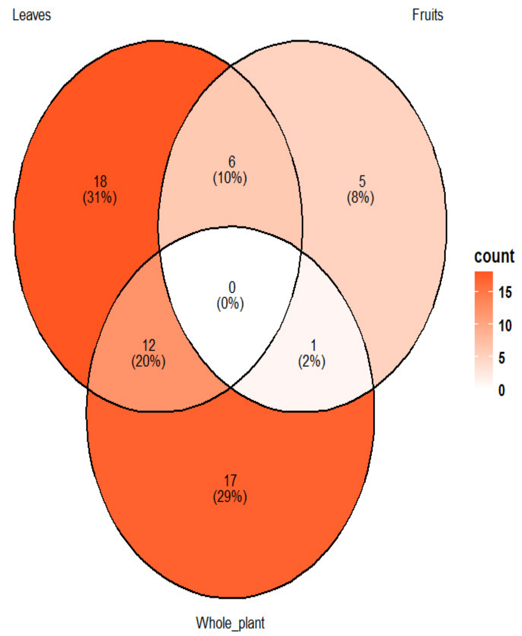

Figure 10: *Venn diagram showing overlap among major plant parts (leaves, fruits, and whole plants) used in traditional medicine in Dheri Julagram, District Malakand, Pakistan.*

Discussion

Ethnomedicinal diversity and indigenous knowledge

Ethnobotanical studies provide important insights into the relationship between local communities and plant resources, particularly in remote regions where traditional knowledge remains an essential component of primary healthcare (Ahmad *et al*., 2011; Ajaib *et al*., 2014; Ajaib *et al*., 2013; Azhar *et al*., 2015). The present study documented 60 ethnomedicinal plant species belonging to 34 families from Dheri Julagram, District Malakand, Pakistan, highlighting the rich traditional knowledge of the local community (Ali and Qaisar, 1995–2009). Similar ethnobotanical investigations from different regions of Pakistan have demonstrated that rural populations continue to rely on medicinal plants due to limited access to modern healthcare facilities, economic constraints, and the cultural importance of traditional remedies (Suhail et al., 2026; Ali *et al*., 2018). The dependence on medicinal plants in rural communities is closely associated with the availability of local flora and the transmission of indigenous knowledge between generations (Betti, 2004; Becker, 2014; Bekele and Reddy, 2015). In the Hindu Kush region, mountainous landscapes and diverse vegetation provide a valuable source of medicinal resources, food, fodder, and other ecosystem services (Choudhary *et al*., 2008; Devi and Muniyandi, 2015; Foo *et al*., 2016). However, increasing anthropogenic pressure, habitat alteration, and changing lifestyles may threaten both plant diversity and traditional knowledge systems (Garcia *et al*., 2007).

Taxonomic diversity and life-form composition

The recorded medicinal flora represented considerable taxonomic diversity, with 34 families and approximately 54 genera. The dominance of Lamiaceae and Poaceae (6 species each), followed by Asteraceae (5 species), reflects the ecological abundance and medicinal importance of these families in the study area Gilani *et al*. (2013), Hassan *et al*. (2015), and Hassan *et al*. (2015). These families are widely distributed in Pakistan and are frequently reported as dominant groups in ethnobotanical surveys because they contain numerous aromatics, bioactive, and easily accessible species (Hazrat *et al*., 2011; Ullah *et al*., 2026). The predominance of herbs (70% of recorded species) indicates that herbaceous plants constitute the major medicinal resources used by the local community (Homervergel and Kim, 2014). Similar patterns have been reported in other ethnobotanical studies from mountainous regions of Pakistan, where herbs dominate due to their abundance, accessibility, and diverse therapeutic applications (Hussain *et al*., 2008). Herbaceous species are often preferred because they regenerate quickly and are easier to collect compared with woody plants (Iain *et al.*, 2005; Ullah *et al.*, 2026). In the present study, leaves represented the most frequently utilized plant part, followed by stems, fruits, and whole plants (Ibrar *et al.*, 2007). The frequent use of leaves has also been reported in several ethnobotanical studies because leaves are easily collected, renewable, and contain important secondary metabolites responsible for biological activities (Islam *et al.*, 2013; Kaigongi and Musila, 2015; Kamau *et al.*, 2016; Jamila and Rahman, 2016). The use of whole plants was also considerable, particularly among herbaceous species (Khan *et al.*, 2012; Jamila and Rahman, 2016). Although whole-plant harvesting provides access to multiple bioactive tissues, excessive collection may negatively affect natural populations (Mahmood *et al.*, 2011). Therefore, sustainable harvesting strategies should be promoted, especially for highly utilized medicinal species (Marwat *et al.*, 2012).

Traditional applications and disease categories and multivariate analysis of ethnobotanical patterns

The documented plants were traditionally used for treating diverse ailments, including digestive disorders, respiratory problems, skin diseases, fever, diabetes-related conditions, and urinary problems (Matthews and Medhi, 2014). Digestive disorders represented one of the most frequently reported medicinal categories, which agrees with previous ethnobotanical studies from Pakistan where gastrointestinal problems are among the major health concerns treated with plant-based remedies (Mohamadi *et al.*, 2015; Mohammadi *et al.*, 2016). Species with high cultural importance, including *Ajuga bracteosa*, *Fumaria indica*, *Papaver somniferum*, and *Euphorbia hirta*, showed high saliency values, indicating their frequent recognition and importance among local informants (Negbenebor *et al.*, 2017; Ullah *et al.*, 2025). Overall. These species may represent priority candidates for future phytochemical and pharmacological investigations; however, the reported traditional uses should be interpreted as ethnobotanical knowledge rather than confirmed therapeutic efficacy (Manan *et al.*, 2025). The PCA and correlation analyses revealed relationships between plant characteristics, utilized plant parts, and medicinal applications (Khan *et al.*, 2024). Species associated with multiple plant parts and broader disease categories showed higher ethnobotanical importance (Ullah *et al.*, 2019). This indicates that traditional preference is influenced not only by plant availability but also by perceived effectiveness, accessibility, and cultural familiarity (Aziz *et al.*, 2026). The positive association between total medicinal uses and plant-part diversity suggests that species with multiple usable parts tend to have greater cultural significance (Asif *et al.*, 2025; Naz et al., 2026). Such quantitative approaches provide a better understanding of how indigenous communities select and utilize medicinal plants (Sohail *et al.*, 2026; Haq *et al.*, 2026).

Conservation implications and limitations

The documentation of medicinal plant knowledge from Dheri Julagram contributes valuable information for conserving both biological resources and traditional knowledge. Several medicinal plants are collected from natural habitats, and increasing harvesting pressure may threaten vulnerable species. Conservation programs should therefore combine habitat protection with community-based sustainable harvesting practices. This study has some limitations. Ethnobotanical information was obtained from local informants and may be influenced by recall bias and individual experience. The study was conducted within a geographically restricted area and involved a limited number of informants. Furthermore, the reported medicinal applications require pharmacological validation before confirming therapeutic effects.

Conclusions

The present study documented the ethnomedicinal knowledge and traditional utilization of plant resources in Dheri Julagram, District Malakand, Khyber Pakhtunkhwa, Pakistan. A total of 60 ethnomedicinal plant species belonging to 34 families and approximately 54 genera were recorded, demonstrating the rich botanical diversity and cultural importance of medicinal plants in the Hindu Kush region. Herbs represented the dominant life form, followed by trees and shrubs, indicating the major contribution of herbaceous species to local healthcare practices. The local community utilizes different plant parts, particularly leaves and whole plants, for the preparation of traditional remedies against a wide range of ailments, including digestive disorders, respiratory problems, skin diseases, fever, diabetes-related conditions, and urinary disorders. Species with higher saliency values, such as *Ajuga bracteosa*, *Fumaria indica*, *Papaver somniferum*, and *Euphorbia hirta*, represent culturally important medicinal resources and reflect the strong traditional knowledge maintained by local inhabitants. The integration of quantitative approaches, including PCA and correlation analysis, revealed relationships among plant characteristics, utilization patterns, and medicinal applications, providing a better understanding of the factors influencing traditional plant selection. These findings highlight the importance of documenting indigenous knowledge before it declines due to social and environmental changes. Although the study provides valuable ethnobotanical information, further phytochemical, pharmacological, and conservation studies are required to validate traditional claims and ensure sustainable utilization of medicinal plant resources. The findings provide a scientific baseline for future research, biodiversity conservation, and community-based management of medicinal plants in the Hindu Kush region.

Recommendations

- Promote sustainable harvesting and conservation of medicinal plant resources.
- Preserve indigenous ethnomedicinal knowledge through proper documentation.
- Encourage cultivation of important medicinal species to reduce pressure on wild populations.
- Conduct phytochemical and pharmacological studies to validate traditional uses.
- Increase community awareness and training for medicinal plant conservation.
- Perform further ethnobotanical surveys in the Hindu Kush region to document additional plant diversity and traditional knowledge.

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Novelty statement

The novelty of this study lies in providing the first comprehensive ethnobotanical documentation of medicinal plant diversity and indigenous knowledge from Dheri Julagram, a remote Hindu Kush village of District Malakand, Pakistan. Unlike previous studies conducted in broader regions, this research focuses on a localized community and integrates taxonomic documentation with quantitative ethnobotanical approaches, including saliency analysis, PCA, and correlation analysis, to evaluate patterns of plant utilization. The study highlights culturally important medicinal species, traditional therapeutic applications, and conservation concerns, providing valuable baseline information for sustainable management and future pharmacological investigations of medicinal plant resources.

Author Contributions

Nizakat Bibi, Mohsin Khan, Murad Ali, Ghani Subhan, and Gul Rahim: Contributed to field surveys, plant collection, ethnobotanical data collection, and documentation of indigenous knowledge.
Nizakat Bibi and Shakir Ullah: Performed data analysis, statistical analysis, interpretation of results, and preparation of figures and tables.
Murad Ali and Ghani Subhan: Supported plant identification, taxonomic verification, and herbarium specimen preparation.
Shakir Ullah: Conceived and designed the study, supervised the research, critically revised the manuscript, and finalized the manuscript. All authors read and approved the final manuscript.

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Generative AI or AI-assisted Technology Statement
The authors declare that no generative AI tools or AI-assisted technologies were used in the preparation, analysis, or writing of this manuscript.

Conflict of interest
The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

Data availability
All data generated or analyzed during this study are included in this article and its supplementary materials. Additional information or datasets are available from the corresponding author upon reasonable request.

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