Ethnobotanical heritage of Kafir Kot, Dera Ismail Khan, Pakistan: Ethnobioinformatics and conservation

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Research

Abstract

Background: In remote and semi-arid regions, traditional phytotherapy remains a vital component of primary healthcare. However, indigenous botanical knowledge in geographically isolated areas like Kafir Kot (District Dera Ismail Khan, Pakistan) remains under-documented and vulnerable to socio-cultural erosion.

Methods: Semi-structured interviews were conducted with 78 key informants (50 males and 28 females) to document local medicinal plant utilization. Ethnobotanical data were quantitatively evaluated using use value (UV), family importance value (FIV), relative frequency of citation (RFC), informant consensus factor (ICF), and fidelity level (FL) metrics.

Results: A total of 50 therapeutic plant species spanning 24 botanical families were recorded, with Asteraceae and Poaceae demonstrating the highest family representation. Herbaceous species were the predominant growth form. High consensus among informants was observed for treatment of cancer (ICF = 0.966), followed by sexual performance (ICF = 0.957). *Centaurea cineraria*, *Parthenium hysterophorus,* and *Aerva javanica* exhibited the highest citation frequencies (RFC = 0.22). *Erigeron bonariensis* showed the highest FL (71.43%; Np=10/FC=14) for diarrhea, indicating high specificity for this ailment, whereas species with high UV such as *Boerhavia diffusa* (UV=0.88) showed low specificity but high versatility across multiple ailment categories.

Conclusions: The findings demonstrate a well-preserved ethnomedicinal heritage in Kafir Kot. High quantitative consensus values highlight candidate species for future pharmacological screening, while providing a foundational framework for biocultural preservation in Khyber Pakhtunkhwa.

Keywords: Kafir Kot, Medicinal plants, Traditional medicinal knowledge, Ethnobotanical heritage, Informant consensus factor, Fidelity level, Dera Ismail Khan, Pakistan

Ethnobotanical research examines the complex, dynamic relationships between human societies and their surrounding floristic environments, focusing on how indigenous beliefs, cultural practices, and resource management strategies are shaped by local vegetation (Amjad *et al.* 2020). Documenting plant species utilized by indigenous populations is particularly critical in the context of traditional medicine (Cox 2000). According to the World Health Organization, nearly 80% of the world's population depends on traditional medicine, largely through remedies derived from plants (World Health Organisation, 2013). Furthermore, approximately 25% of modern pharmaceutical drugs are derived directly or indirectly from plant secondary metabolites (Wakdikar 2004). The use of medicinal plants in human health care dates back centuries, serving as a rich source of biologically active compounds with therapeutic properties (Das *et al.* 2025, Biona *et al.* 2025). Plant-derived medicines are widely used therapeutically and are often perceived by local communities to have fewer adverse effects than synthetic pharmaceuticals, although this perception varies with the species, dosage, and mode of preparation and is not universally supported by clinical evidence (Biona *et al.* 2025, Khan *et al.* 2025). Documenting traditional ethnomedical knowledge is essential to explore its potential for discovering novel drugs. Moreover, this could help preserve local culture and sustainable use of natural resources (Ullah *et al*. 2025). Economic and medicinal plants face severe threats from climate change, genomic vulnerability, and the loss of traditional knowledge, demanding urgent documentation (Khan *et al*. 2024, Khan *et al*. 2025, Fan *et al.* 2026, Khan & Liu 2025).

In Pakistan, notable natural resources, ethnic communities, geographical landscapes, ecological zones and varied climatic conditions support a wide range of medicinal plant species. Pakistan has remarkable flowering plant diversity, with approximately 6000 species identified across the country. Of these, more than 10% (600-700 species) possess medicinal properties (Shinwari 2010). Rural communities often rely on a variety of traditional herbal medicines because of a lack of access to modern pharmaceuticals (Ali *et al.* 2023). Beyond medicinal applications, local plant biodiversity supports urban and rural livelihoods by providing food, timber, fuel, household implements, and shelter materials (Ibrar 2003). Modernization, urbanization and globalization contribute to changes in traditional practices and the transmission of knowledge across generations, with potential influence on the reliability and relevance of ethnobotanical information (Ishtiaq *et al.* 2024). In rural communities, traditional knowledge is more extensive among elders than among younger members, because younger generations have less confidence in traditional medicine than in modern medicines (Haq *et al.* 2024).

Recent ethnobotanical studies in Pakistan have documented medicinal plant knowledge across diverse ecological and cultural settings (Ishtiaq *et al.* 2024, Sameen *et al.* 2025, Sultana *et al.* 2025, Shariat *et al.* 2025, Shah *et al.* 2025, Hussain *et al.* 2026a). However, Kafir Kot, a semi-arid region situated in District Dera Ismail Khan, Khyber Pakhtunkhwa, remains poorly explored in terms of its medicinal plant diversity and associated indigenous knowledge. Contrasting with most previous ethnobotanical surveys from Khyber Pakhtunkhwa, which have generally focused on mountainous or agro-pastoral communities, Kafir Kot represents a semi-arid, archaeologically significant landscape in which plant-based traditional knowledge has developed alongside a long history of continuous human settlement; this ecological and cultural combination has not previously been documented for the surrounding region. Its semi-arid environment and local dependence on plant resources provide an important context for investigating traditional medicinal practices. Moreover, ongoing changes in traditional practices and intergenerational transfer of knowledge highlight the need for timely documentation of this knowledge. Therefore, the present study aims to: (1) formulate a comprehensive inventory of medicinal plant species in Kafir Kot; (2) quantify indigenous knowledge regarding plant utilization using quantitative ethnobotanical indices; and (3) provide an empirical baseline to support future ethnopharmacological research and biodiversity conservation efforts in the region.

Materials and Methods

Study area

The present study was conducted in Kafir Kot, District Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan. Kafir Kot is situated near Bilot Sharif in District Dera Ismail Khan, about 135 km from Dera Ismail Khan city (https://www.salampakistan.gov.pk/where-to-go/category/heritage-and-archaeology-sites/location/kafir-kot). It is located at 32**°**30'0" N and 71°20'0"E (Figure 1). The site lies on low hills overlooking the Indus River, at an elevation of approximately 170 m above sea level, broadly consistent with the surrounding Dera Ismail Khan plain. The district of Dera Ismail Khan experiences a continental climate marked by pronounced seasonal and daily temperature variations and a high degree of aridity. The area receives an average rainfall of 430-800 mm, while mean winter temperatures range from 4.2**°**C to 20.3°C and summer temperatures from 27°C to 42°C (Anees *et al.* 2022). The vegetation of Dera Ismail Khan is adapted to semi-arid conditions and includes thorn-bearing shrubs and sparse grasses, especially in relatively dry areas **(**Matiullah *et al.* 2025**).**

Kafir Kot is a historical archaeological site comprising a group of five temples, consisting of a massive wall surrounding it which is constructed of dressed stone. This site covers an area of 450 × 300 meters. The site is dated from the 7th to the early

11th century CE, and is protected under the Antiquities Act, 1975, as amended in 1999 (https://doam.gov.pk/public/sites/1013). The present structures were constructed during the rule of the Hindu Shahis, a dynasty that governed the Kabul Valley, Western Punjab and the Gandhara region (https://teahouse.buddhistdoor.net/processing-and-presenting-heritage-sites-digitally-reconstructing-the-temples-of-kafir-kot/). The historical and architectural importance of Kafir Kot, together with its semi-arid environment and locally availabl e plant resources, provides an important setting for documenting medicinal plants and associated indigenous knowledge.

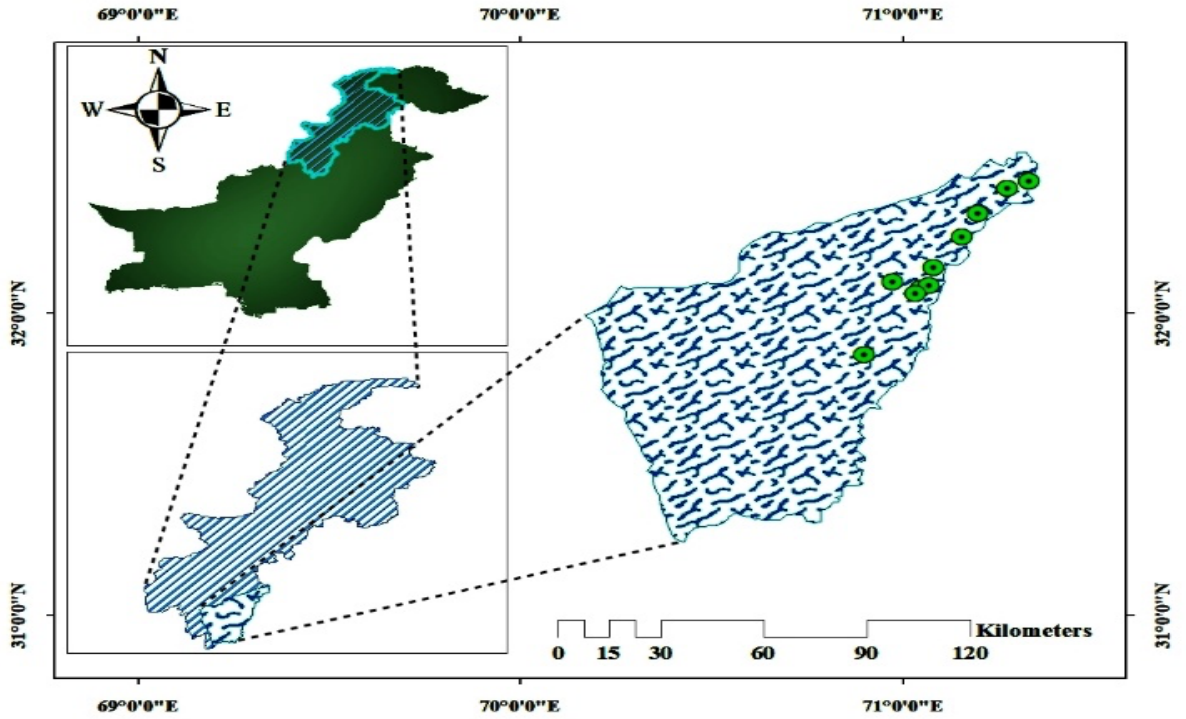


Figure 1. Map of the study area Kafir Kot, District Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan

Ethnobotanical Data Collection and Plant Identification

The informants were selected using snowball sampling (Goodman 1961, Bibi *et al.* 2026). Three villages surrounding Kafir Kot (Bilot Sharif, Mamua Wali, Dhaki Mor) were selected based on proximity to the archaeological site. Inclusion criteria: long-term residency (≥10 years) in study villages and self-reported or community-recognized knowledge of medicinal plant use. Exclusion criteria: temporary residents, individuals <20 years old, and those unwilling to share knowledge. Particular emphasis was placed on older community members and traditional herbal practitioners (Hakeems) who were identified through community referral. Prior informed consent was obtained verbally in the local language (Saraiki/Pashto), and the study objectives were explained. No monetary compensation was provided. Data were collected during 2023-2024 through four seasonal field visits to capture phenological availability. Semi-structured interviews, free-listing and focus group discussions were conducted following Ghorbani *et al*. (2011). Each interview lasted 30-45 minutes and was conducted in informants' mother tongue at their homes, fields/mosques/Baithaks and herbal stores. A standardized questionnaire documented local name, part used, mode of preparation, ailment treated and dosage. Plant specimens reported were photographed, collected, mounted on herbarium sheets with voucher numbers (MH-001 to MH-065) and identified by a taxonomist in the Department of Botany, Gomal University (Dr Sheikh Zain Ul Abidin) and verified using World Flora Online (WFO), Plants of the World Online (POWO), and International Plant Name Index (IPNI). Vouchers were deposited at the Herbarium, Department of Botany, Institute of Biological Sciences, Gomal University, Dera Ismail Khan. Data were cross-checked by showing specimens and repeating interviews with 15% of informants.

Data Analysis

All recorded ethnobotanical data were tabulated and organized using Microsoft Excel 2016. The quantitative ethnobotanical indices, including Fidelity Level (FL), Use Value (UV), Relative Frequency of Citation (RFC), Informant Consensus Factor (ICF), and Family Importance Value (FIV), were calculated using the formulas described below. Descriptive statistics were used to summarize the demographic characteristics of the informants. The results were presented using the appropriate tables and graphical illustrations.

Fidelity Level (FL)

For the most frequently reported illnesses and disorders, the fidelity level (FL), representing the proportion of informants reporting the use of a particular plant species for the same principal ailment, was calculated, following Friedman *et al.* (1986) and Devendar & Venkatesham (2023):

$$FL\ (\%) = (Np/FC) \times 100$$

Where Np is the number of informants who reported using a particular plant species to treat a specific ailment, and FC is the number of informants who reported using that species for any medicinal purpose (i.e., its total citation frequency for that species). FL therefore reflects the specificity of a species' use for a single ailment relative to its overall reported use. This species-specific FC should not be confused with the total sample size (N = 78 informants) used elsewhere in this study.

Use Value (UV)

Use Value (UV) was used to indicate the relative importance of each medicinal plant species utilized by the local people. It was calculated using the formula originally proposed by Phillips & Gentry (1993):

$$UV = \Sigma Ui / N$$

Where Ui represents the number of uses reported by each informant for a given plant species, and N represents the total number of informants included in the study.

Relative Frequency of Citations (RFC)

The relative Frequency of Citation (RFC) was calculated to determine the relative importance of each medicinal plant species based on the frequency with which it was cited by the informants. RFC was calculated following Tardío & Pardo-de-Santayana (2008), using the following formula:

$$RFC = FC / N$$

Where FC is the number of informants who cited a particular plant species, and N is the total number of informants interviewed in the study.

Informant Consensus Factor (ICF)

The Informant Consensus Factor (ICF) was calculated to assess the level of agreement among informants regarding medicinal plant use for different ailment categories, following Trotter & Logan (1986). The reported ailments were grouped according to organ system and symptom similarity, following Cook (1995) and Heinrich et al. (1998), as presented in Figure 6. ICF was calculated using the following formula:

$$ICF = (Nur - Nt) / (Nur - 1)$$

Where Nur is the total number of use citations for a specific disease category from all informants, and Nt is the number of different plant taxa cited for that disease category. ICF ranges from 0 (indicating no consensus where informants cite different plant species), to 1 (indicating complete consensus where all informants cite the same plant species).

Family Importance Value (FIV)

The Family Importance Value (FIV) indicates the relative ethnomedicinal importance of plant families. FIV was used to determine the relative importance of plant families based on the percentage of informants who cited each family. FIV was calculated following the method described by Shariat *et al.* 2025.

$$FIV = (FC\text{-}family / N) \times 100$$

Where FC denotes the number of informants who cited a particular plant family, and N represents the total number of informants involved in the study.

Graphical Representation

Microsoft Excel 2016 was used to generate graphical representations of selected ethnobotanical data. The graphical outputs included the life form distribution of medicinal plant species, contribution of plant families, distribution of medicinal species

according to plant parts used, RFC values, ICF values for different ailment categories and FIV values of plant families (Figures 2-7).

Results

Ethnobotanical data were gathered from a total of 78 key informants in the Kafir Kot region. Demographically, the sample comprised 50 male informants (64.10%) and 28 female informants (35.90%; Table 1). Age stratification indicated that community members aged 50-65 years (20, 25.64%) and 75-85 years (20, 25.64%) represented the largest proportions of respondents, followed by those aged 40-50 years (18, 23.08%), 65-75 years (10, 12.82%) and 20-40 years (10, 12.82%). Also, 10 male respondents (12.82%) were recognized traditional herbal practitioners (Hakeems).

Table 1. Demographic information of the informants.

Category	Sub-category	Informants	Percentage %
Gender	Male	50	64.10
	Female	28	35.90
Age groups	20-40	10	12.82
	40-50	18	23.08
	50-65	20	25.64
	65-75	10	12.82
	75-85	20	25.64
Total		**78**	**100**

Note: Herbalists are included within age groups above; occupation is presented separately and not added to age totals.

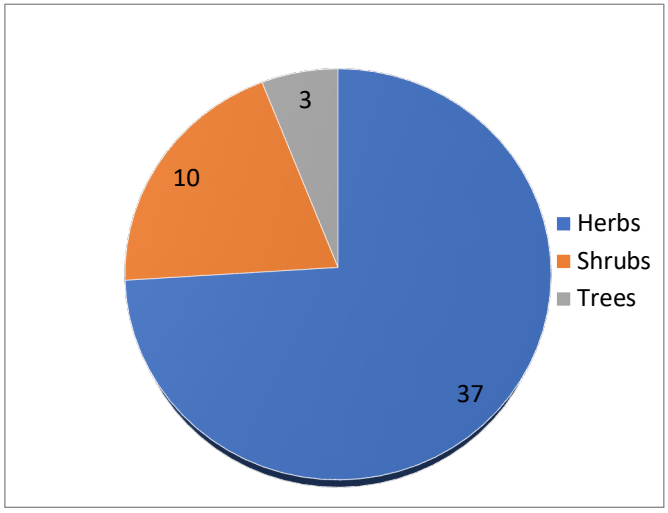


Figure 2. Life form distribution of the reported medicinal plant species in the study area

The floristic inventory documented 50 medicinal plant species belonging to 24 botanical families. Taxonomic analysis showed that Asteraceae (7 species) and Poaceae (6 species) were the most speciose families, followed by Amaranthaceae, Solanaceae, Euphorbiaceae, Fabaceae, and Apocynaceae (Figure 3). Growth form analysis demonstrated a marked dominance of herbaceous species, followed by shrubs and trees (Figure 2), reflecting the ecological conditions and semi-arid vegetation structure characteristic of the Kafir Kot landscape.

Table 2 compiles the recorded plant species, their scientific names, family affiliations, local nomenclature, voucher numbers, phenology, life forms, plant parts used, ethnomedicinal applications, and quantitative indices (FC, RFC, FL, UV).

Table 2. Ethnobotanical details of reported medicinal flora.

Families	Botanical name	Local name	Voucher Number	Flowering period	Life form	Parts used	Medicinal uses	FC	RFC	FL (%)	UV
Asteraceae	*Verbesina encelioides* (Cav.) A.Gray	Dhiota/Bhota	MH-001	April or May to September	Herb	Whole plant	Insect bites, Stings, Burns	12	0.154	66.67	0.31
	Sonchus asper (L.) Hill	Harali/kharal	MH-005	June to August	Herb	Whole plant	Skin problems, Malaria, Gastrointestinal problems	14	0.179	64.29	0.5
	Carthamus oxyacantha M.Bieb.	Khookhr/Gokhro	MH-012	March to June	Herb	Root	Wound healing, Skin infections, Blood purifier, dysmenorrhea	11	0.141	62.5	0.56
	Erigeron bonariensis L.	bathora /khammbhi	MH-034	April to November	Herb	Whole plant	Diarrhea, Blood purifier, antibacterial Wound healing, and Skin infections	14	0.179	71.43	0.6
	Centaurea cineraria L.	kala bhana/chitta gandhoda	MH-011	February to May	Herb	Aerial parts	Rheumatism, Skin infections, Dyspepsia, Diarrhea, Cough, Bronchitis	17	0.090	64.71	0.53
	Parthenium hysterophorus L.	gujjra/dhila	MH-043	June to September	Herb	Whole plant	Skin inflammation, Rheumatic pain, Diarrhea, Urinary tract infections, Dysentery, Malaria	17	0.077	64.71	0.5
	Glebionis coronaria (L.) Cass. ex Spach	chitta gul /zargul	MH-025	March to June	Herb	Whole plant	Digestive issues, Skin problems, Skin infections	12	0.154	66.67	0.31
Amaranthaceae	*Aerva javanica* (Burm.f.) Juss. ex Schult.	Bui booti	MH-026	December to February	Shrub	Roots and flowers	Rheumatism, Headache, Diarrhea, Chronic Chest pain, Diuretic, Kidney stones	17	0.218	64.71	0.5

	Chenopodium album L.	Bathoo	MH-035	February to March	Herb	Leaves and seed	Digestive issues, Respiratory ailments, Skin infections	12	0.154	58.33	0.81
	Suaeda fruticosa (L.) Forssk. ex J.F.Gmel.	Lonii	MH-029	July to October	Shrub	Leaves and stem	Urinary disorder, Skin problems, and Skin infections	12	0.154	66.67	0.54
	Atriplex patula L.	lapa/chua	MH-044	July to September	Herb	Leaves, stem, flowers and seed	Joint/arthritis pain	9	0.115	66.67	0.67
	Achyranthes aspera L.	phattla/achita	MH-053	August to October	Herb	Leaves, root and seed	Diarrhea, Skin disorders, Respiratory issues, Skin infections	14	0.179	57.14	0.67
Apocynaceae	*Rhazya stricta* Decne.	paapi/papri	MH-017	May to August	shrub	Leaves, root	Fever, Skin conditions, Skin infections	12	0.154	50	0.56
	Calotropis procera (Aiton) Dryand.	Akk	MH-028	March to October	shrub	Latex, roots and leaves	Skin ailment, Rheumatism, and Digestive issues	12	0.154	58.33	0.6
	Pentatropis nivalis (J.F.Gmel.) D.V.Field & J.R.I.Wood	gajri/kajri	MH-063	May to June	Herb	Roots	Wounds, Cough, Cold, Respiratory and Skin diseases	14	0.179	57.14	0.31
Brassicaceae	*Isatis tinctoria* L.	wadari/witari	MH-059	May to July	Herb	Leaves	Skin issues, Fevers, and Respiratory ailments	12	0.154	66.67	0.56
	Sisymbrium irio L.	khaksa/khikhra	MH-041	June to August	Herb	Leaves and seed	Respiratory issues, Digestive problems	12	0.154	66.67	0.46
Caryophyllaceae	*Spergula arvensis* L.	Bhakhri	MH-036	August to January	Herb	Whole plant	Wounds, Tuberculosis	10	0.128	70	0.4
Cleomaceae	*Cleome brachycarpa* Vahl ex DC.	Dhila	MH-052	March to June	Herb	Leaves, seed and roots	Digestive issues, Fevers, and Poultice for skin conditions.	12	0.154	66.67	0.67
Convolvulaceae	*Convolvulus arvensis* L.	Likkri/Hikkri	MH-042	May to September	Herb	Root	Skin problems, Laxative	10	0.128	60	0.33

Cucurbitaceae	*Cucumis melo* L.	Khriyal	MH-030	Bloom in July	Herb	Fruit and seed	Digestive and Stomach problems	10	0.128	70	0.5
Cyperaceae	*Cyperus rotundus* L.	Nagrram	MH-040	May to July	Herb	Tubers or rhizomes	Gastrointestinal issues, Fever, Diuretic, Menstrual disorders, Body tonic	16	0.205	62.5	0.36
Euphorbiaceae	*Euphorbia hirta* L.	Dudhi	MH-051	March to August	Herb	Leaves and stem	Gastrointestinal issues, Skin diseases, Body tonic.	10	0.128	70	0.4
	Croton bonplandianus Baill.	tilia/banra	MH-049	June to August	shrub	Leaves and roots	Stomach ailments, Snakebites, and Skin issues.	14	0.179	57.14	0.47
	Euphorbia serpens Kunth	dudhi wai	MH-048	April to June	Herb	Leaves	Warts, Eczema, Asthma, Cough, Skin diseases	16	0.205	56.25	0.35
	Euphorbia prostrata Aiton	dudhi palati	MH-006	March to June	Herb	Leaves	Potential healing properties	9	0.115	66.67	0.44
Fabaceae	*Melilotus albus* Medik.	santri//sufaid moti	MH-045	June to August	Herb	Flowers and leaves	Digestive problems, Tonic	10	0.128	70	0.64
	Prosopis cineraria (L.) Druce	veen/jand	MH-037	March to June	Tree	Leaves, pods, gum, and bark	Diarrhea, Dysentery, Skin infection.	12	0.154	58.33	0.64
	Prosopis glandulosa Torr.	Jandi	MH-039	May to June	shrub	Bark, pods, leaves	Wound healing and Remedy for respiratory problems	10	0.128	70	0.56
Malvaceae	*Abutilon indicum* (L.) Sweet	Phulila	MH-065	Flower throughout the year	Shrub	Leaves and roots	Respiratory ailments, Digestive issues and Skin problems	12	0.154	66.67	0.31
Moraceae	*Fatoua villosa* (Thunb.) Nakai	mota bhaa	MH-062	Usually blooms in July	Herb	Whole plant	Kidney stone, Urinary tract infection, Fever, Diarrhea, Arthritis.	16	0.205	62.5	0.54
Nitrariaceae	*Peganum harmala* L.	Harmul/hamali	MH-055	May to June	Herb	Seed	Digestive issues, Asthma, Body tonic	16	0.205	62.5	0.54

Nyctaginaceae	*Boerhavia diffusa* L.	sagan bhida	MH-060	July to September	Herb	Root and leaves	Urinary disorders, Liver conditions, Inflammation, Remedy for certain respiratory issues	14	0.179	64.29	0.88
Plantaginaceae	*Kickxia spuria* (L.) Dumort.	chhati phuli	MH-058	November to April	Herb	Whole plant	Diabetes, Hemorrhoids, Wounds	12	0.154	58.33	0.5
Poaceae	*Eragrostis minor* Host	thali ghah/rani ghah	MH-021	June to September	Herb	Whole plant	Digestive, Urinary, Respiratory, Wounds, Fever	12	0.154	62.5	0.67
	Cynodon dactylon (L.) Pers.	Dub/haral	MH-007	March to September	Herb	Root and rhizomes	Urinary tract disorders, Skin ailments, and Digestive issues	12	0.154	66.67	0.54
	Tripidium ravennae (L.) H.Scholz	eelan/ghaneeri	MH-008	June to August	Herb	Whole plant	Dysentery, Skin problems, Bleeding, Cough, Anasarca	16	0.205	62.5	0.63
	Lolium perenne L.	baro/ghah kala	MH-009	May to July	Herb	Whole plant	Cancer, Diarrhea, Hemorrhages, and Malaria.	14	0.179	64.29	0.51
	Cenchrus ciliaris L.	dheena /bui	MH-032	September to November	Herb	Whole plant	Inflammation, Urinary tract infection, Tumors	12	0.154	66.67	0.5
	Polypogon monspeliensis (L.) Desf.	phatta ghah /khla ghah	MH-022	May to June	Herb	Whole plant	Heart problems	9	0.115	66.67	0.31
Portulacaceae	*Portulaca oleracea* L.	Loyii	MH-050	June to July	Herb	Leaves and stem	Gastrointestinal issues, Skin problems, Remedy for cough	12	0.154	66.67	0.35
Rhamnaceae	*Ziziphus mauritiana* Lam.	Beer	MH-061	April to June	Tree	Fruit, leaves, bark, and roots	Digestive issues, Skin conditions.	10	0.128	70	0.46
Salvadoraceae	*Salvadora persica* L.	Miswag/pilo	MH-056	April to June	Tree	Fruit	Cough, Asthma, Scurvy, Rheumatism, Piles	14	0.179	57.14	0.54

Solanaceae	*Solanum melongena* L.	Watow	MH-019	June to September	Herb	Whole plant	Skin infections, Cardiac debility, Neuralgia, Ulcer in nose, Cholera	16	0.205	62.5	0.71
	Withania frutescens (L.) Pauquy	kandri/rat kandri	MH-016	June to September	Shrub	Roots and leaves	Anxiety, Sleep disorders, Respiratory issues, Neurological conditions	14	0.179	64.29	0.54
	Withania somnifera (L.) Dunal	Asghandha	MH-024	Flowers primarily in December	Shrub	Whole plant	Insomnia, Anxiety, Support to reproductive health	12	0.154	66.67	0.5
	Solanum virginianum L.	Ghul khar	MH-023	Bloom in July	Herb	Leaves and root	Fever, Cough, Asthma, Skin problems, Headache	16	0.205	62.5	0.63
Urticaceae	*Forsskaolea tenacissima* L.	Bhilla	MH-064	April to June	Herb	Whole plant	Urinary tract disorder, Gastrointestinal issues	10	0.128	70	0.54
Verbenaceae	*Verbena bipinnatifida* (Nutt.) Schauer	Phattila	MH-020	May to July	Herb	Leaves and flowers	Coughs, Colds, Respiratory problems	12	0.154	66.67	0.46
Zygophyllaceae	*Zygophyllum indicum* (Burm.f.) Christenh. & Byng	Dhamari	MH-047	March to May	shrub	Aerial parts	Fever, Asthma, Diabetes, and Urinary tract disorders	14	0.179	57.14	0.46

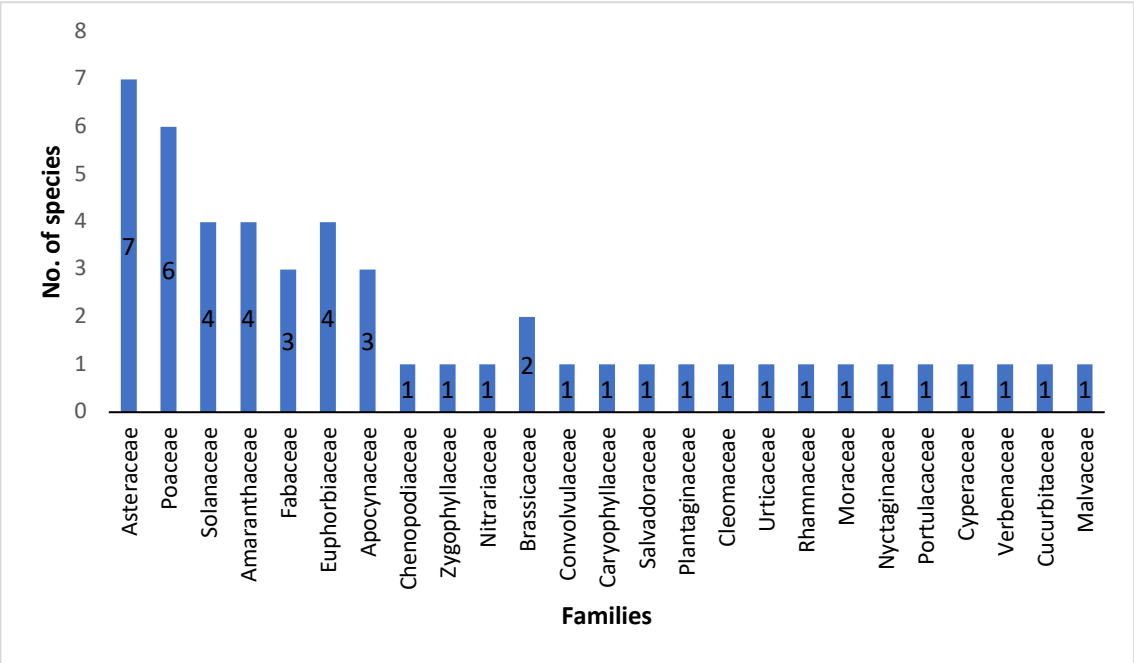


Figure 3. Medicinal plant families' contribution in the Kafir Kot region

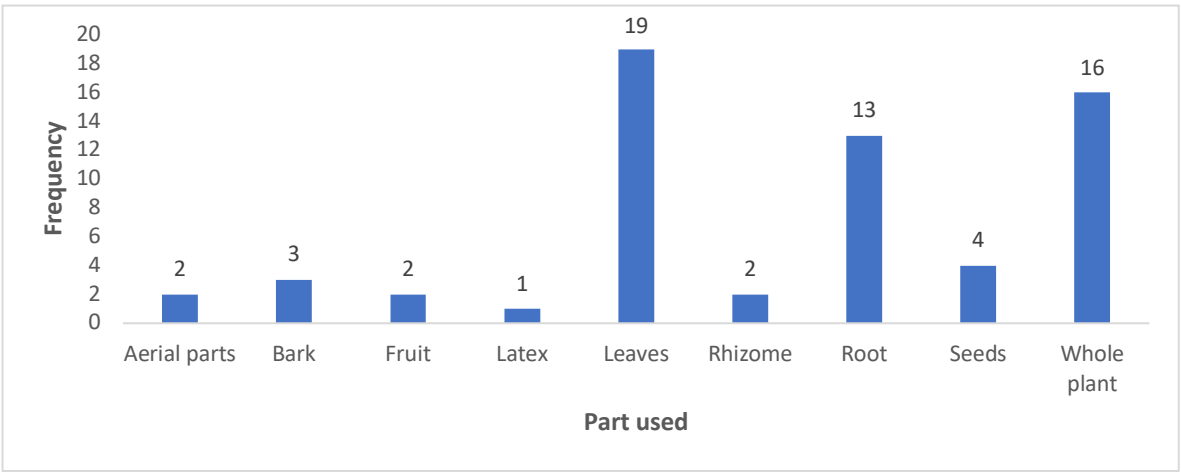


Figure 4. Distribution of medicinal species by part used in ethnomedicine

Relative Frequency of Citation (RFC)

The relative frequency of citation metric was evaluated to determine the cultural prominence of each documented taxon (Figure 5). Relative frequency of citation (RFC) was used as a measure of informant citation frequency. The highest values (RFC=0.179, FC=14) were recorded for *Erigeron bonariensis* L. and *Sonchus asper* (L.) Hill, reflecting a higher proportion of informants citing these taxa. RFC quantifies reporting frequency and familiarity, which may be influenced by local availability, accessibility and cultural transmission, and should not be interpreted as direct evidence of therapeutic efficacy, safety or conservation need. Because the present study did not assess ecological abundance, harvesting pressure, or clinical effectiveness, high RFC alone is insufficient to prioritise species for drug development or conservation. Similarly, low RFC values (0.077, FC=6) for *Parthenium hysterophorus* L. indicate fewer citations, not an absence of medicinal value. Low RFC values may indicate limited awareness of these species among local people, particularly younger community members who are unfamiliar with their use.

Informant Consensus Factor (ICF)

The ICF measures the informants' agreement concerning the utilization of plant species. The value for ICF ranges from 0 to 1, whereas a value closer to 1 indicates a high degree of agreement among informants, whereas values near 0 indicate less consensus, greater diversity in plant selection or limited sharing of knowledge among respondents. Analysis of the informant consensus factor revealed high levels of agreement across disease categories (Table 3, Figure 6). The highest ICF was recorded for cancer (0.966), followed by sexual performance (0.957), antidote (0.949), nervous system disorders (0.945) and rheumatic

diseases (0.944). The lowest values were observed for dermatological concerns (0.925) and digestive disorders (0.929). ICF values ranged from 0.925 to 0.966, indicating high consensus and strong agreement but not unanimous agreement (ICF <1.00); no category showed complete consensus (ICF=1.0).

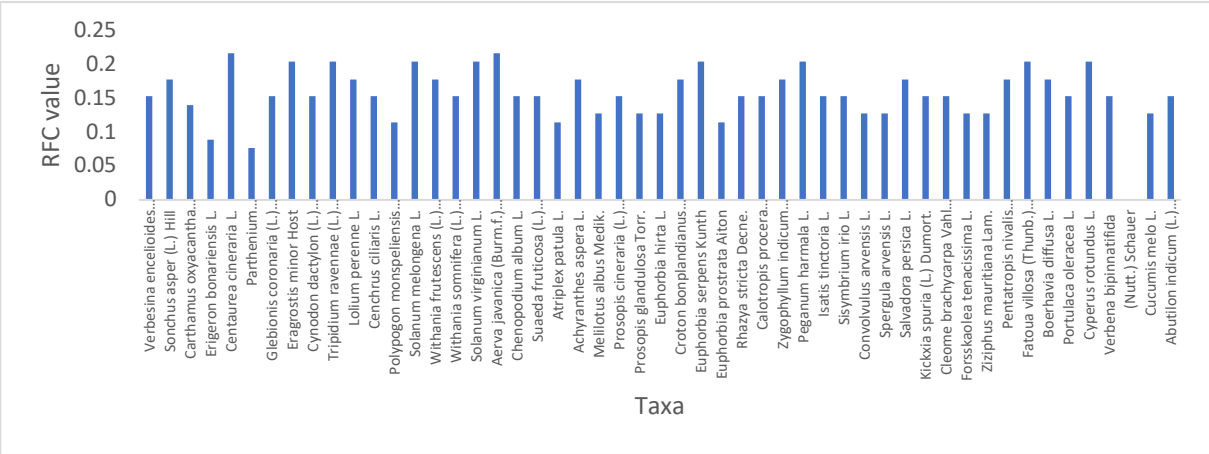


Figure 5. RFC of medicinal flora of the study area

Table 3. Informant Consensus Factor (ICF) of medicinal plants across different ailment categories.

Rank	Ailment Category	Nt	Nur	ICF
1	Cancer	2	30	0.966
2	Sexual Performance	2	24	0.957
3	Antidote	3	40	0.949
4	Nervous system disorders	4	56	0.945
5	Rheumatic Diseases	5	72	0.944
6	Circulatory disorders	3	36	0.943
7	Urinary tract disorders	9	123	0.934
8	Respiratory Diseases	20	279	0.932
9	Fever	11	147	0.932
10	Digestive System Disorders	26	351	0.929
11	Dermatological Concerns	26	333	0.925

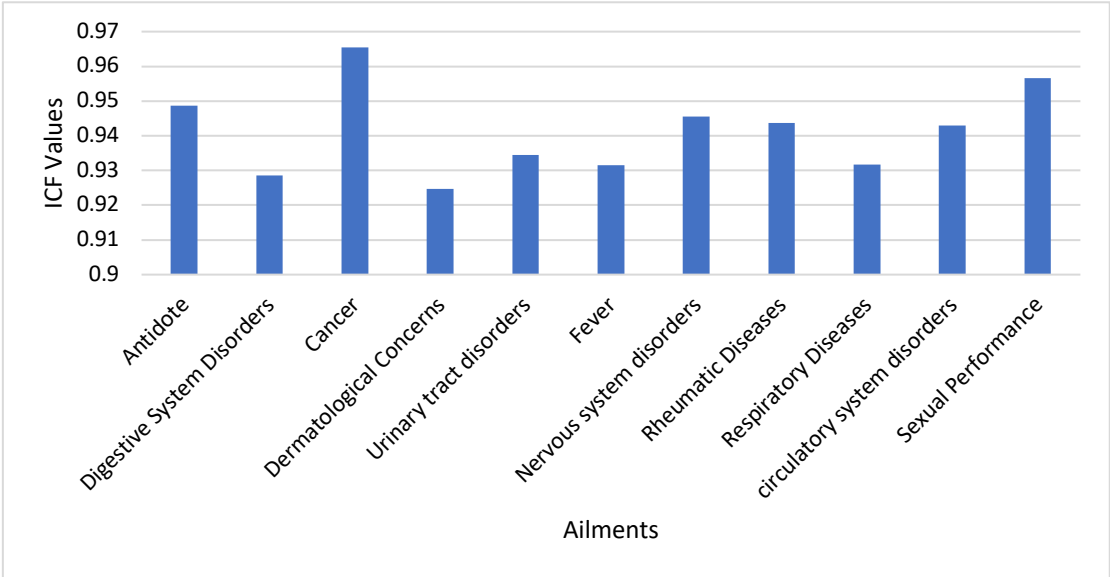


Figure 6. ICF values in treating different ailments with medicinal plants

Fidelity Level (FL)

Fidelity level (FL) analysis identified several taxa with relatively specific ethnomedicinal applications. *Erigeron bonariensis* showed the highest FL (71.43%), particularly for the treatment of diarrhea, indicating a relatively consistent use of this species for this ailment among the informants. *Melilotus albus, Prosopis glandulosa, Euphorbia hirta, Spergula arvensis, Forsskaolea tenacissima, Ziziphus mauritiana* and *Cucumis melo* each showed an FL of 70%. These species were associated with specific therapeutic domains, including digestive disorders (*Melilotus albus, Forsskaolea tenacissima, Ziziphus mauritiana* and *Cucumis melo*), wound healing and respiratory problems (*Prosopis glandulosa*), gastrointestinal and dermatological conditions (*Euphorbia hirta*), and wounds and tuberculosis (*Spergula arvensis*). The relatively high FL values suggest that these species had comparatively consistent medicinal use within the corresponding therapeutic categories among the informants. In contrast, species with lower FL values were associated with a greater range of reported medicinal applications, indicating comparatively less specificity of use. Regarding overall versatility, *Boerhavia diffusa* yielded the highest Use Value (UV = 0.88), indicating the highest versatility with 69 use-reports across informants, followed by *Chenopodium album* (UV = 0.80) and *Solanum melongena* (UV = 0.70), indicating broader medicinal use across multiple therapeutic categories in the study area.

Table 4. Quantitative assessment of FIV of plant families.

Family	Family size	FC-family	N	FIV
Asteraceae	7	76	78	97.44
Poaceae	6	75	78	96.15
Amaranthaceae	5	64	78	82.05
Solanaceae	4	58	78	74.36
Euphorbiaceae	4	49	78	62.82
Apocynaceae	3	38	78	48.72
Fabaceae	3	32	78	41.03
Brassicaceae	2	24	78	30.77
Cyperaceae	1	16	78	20.51
Moraceae	1	16	78	20.51
Nitrariaceae	1	16	78	20.51
Nyctaginaceae	1	14	78	17.95
Salvadoraceae	1	14	78	17.95
Zygophyllaceae	1	14	78	17.95
Cleomaceae	1	12	78	15.38
Malvaceae	1	12	78	15.38
Plantaginaceae	1	12	78	15.38
Portulacaceae	1	12	78	15.38
Verbenaceae	1	12	78	15.38
Caryophyllaceae	1	10	78	12.82
Convolvulaceae	1	10	78	12.82
Cucurbitaceae	1	10	78	12.82
Rhamnaceae	1	10	78	12.82
Urticaceae	1	10	78	12.82

Footnote**:** FC-family = number of distinct informants citing at least one species in the family; N = total number of informants (78); FIV = (FC-family / N) × 100. Informants citing multiple species within the same family were counted once. All FIV values therefore range from 0 to 100.

Family Importance Value (FIV) analysis (Table 4) indicated that Asteraceae exhibited the greatest ethnomedicinal importance (FIV = 97.44), followed by Poaceae (FIV = 96.15) and Amaranthaceae (FIV = 82.05), reflecting the high species diversity and citation frequency of these families in the study area. Solanaceae (FIV = 74.36) and Euphorbiaceae (FIV = 62.82) also contributed substantially to the local ethnomedicinal flora, whereas single-species families such as Cucurbitaceae, Caryophyllaceae, Convolvulaceae, Rhamnaceae and Urticaceae recorded the lowest FIV values (12.82 each). These family-level patterns are consistent with the species-richness and RFC results reported above and further support the ethnomedicinal prominence of Asteraceae and Poaceae in the Kafir Kot flora.

Discussion

This study provides the first systematic inventory of medicinal plants in the Kafir Kot landscape, where a semi-arid ecology converges with a historically significant archaeological settlement. Beyond documenting floristic richness, the results establish a critical local baseline for comparing indigenous knowledge and use patterns with other ethnobotanical regions in Pakistan and beyond. The discussion below therefore focuses on convergences with wider regional trends and divergences in quantitative ethnobotanical indices (Hussain *et al.* 2026b). Asteraceae and Poaceae were the most species-rich families in Kafir Kot, consistent with surveys from other parts of Pakistan (Shah *et al.* 2025, Dastagir *et al.* 2022, Jan *et al.* 2022) and reports from wider geographic settings (Abbasi *et al.* 2013, Ahmad *et al.* 2014, Kadir *et al.* 2014, Umair *et al.* 2017). This agreement suggests that the prominence of these families is not unique to Kafir Kot. However, family-level representation can reflect both local floristic availability and the range of plants recognized and reported by informants; the present survey did not test these influences separately. Thus, the pattern should be interpreted as a combination of botanical representation and reported ethnomedicinal knowledge rather than direct evidence of greater therapeutic efficacy. The predominance of herbs in Kafir Kot aligns with previous ethnobotanical inventories from Pakistan, including Shawal Valley and Daulat Nagar, as well as with reports from the Tropical Rift Valley, Gurafera, and Western Mizoram (Ullah *et al.* 2023, Hussain *et al.* 2026a, Wendimu *et al.* 2024, Awoke *et al.* 2024, Ralte *et al.* 2024). This recurrent pattern has been attributed in regional literature to the wide availability of herbaceous flora in semi-arid and disturbed habitats, ease of collection, and relatively high concentration of bioactive compounds compared to woody forms. In Kafir Kot, the higher representation of herbs may further reflect the prevailing semi-arid vegetation and seasonal availability during the survey period. However, these ecological and cultural drivers were not empirically tested in the present study. Unlike inventories from forested regions where trees contribute a larger share, the present findings may suggest a greater reliance on readily accessible herbaceous resources in this landscape, though this requires validation through comparative vegetation and use-availability assessments.

Leaves were the most frequently reported plant part (Figure 4), followed by whole plants and roots. The prominence of leaves aligns with findings from Haripur (47.9%; Siddique *et al.* 2021) and with other inventories from Pakistan and Ethiopia (Ullah *et al.* 2025, Liaqat *et al.* 2023, Tahir *et al.* 2023, Ahmad *et al.* 2017), where leaves are commonly favored due to ease of collection, high photosynthetic activity and associated metabolite accumulation. The substantial reporting of whole plants and roots in Kafir Kot, alongside leaves, suggests variation in harvesting practices linked to species identity, remedy type and local tradition. While leaf harvesting is generally considered less destructive than uprooting whole individuals, this advantage is not universal and depends on species and harvesting method. Given that whole-plant and root collection removes individuals, our findings support a practical conservation priority: future studies should determine which heavily used species are subject to destructive harvesting and evaluate their local abundance before making species-specific sustainability claims. The high consensus for *Aerva javanica, Parthenium hysterophorus* and *Centaurea cineraria* in Kafir Kot aligns with their frequent citation in other regional inventories, although absolute values vary; for example, lower RFCs have been reported for *A. javanica* in Shawal Valley (0.15) (Ullah et al 2023) and for *P. hysterophorus* in Head Maralla, Punjab (0.18) (Iqbal *et al.* 2021). Such inter-site differences have been attributed in the literature to variation in local abundance (particularly for ruderal and invasive taxa such as *P. hysterophorus)*, familiarity, cultural transmission and the breadth of uses retained in local knowledge, as well as to methodological differences in informant number and sampling effort. In this context, RFC reflects reported consensus within a sample rather than direct evidence of clinical efficacy, and the relative contribution of these drivers was not disentangled in the present study. Likewise, taxa with low consensus in Kafir Kot, such as *Polypogon monspeliensis, Atriplex patula* and *Euphorbia prostrata*, have been cited more prominently elsewhere, suggesting that low local RFC indicates limited recognition in this sample rather than absence of medicinal value.

Informant consensus was strongest for cancer and sexual performance, followed by antidote, nervous-system and rheumatic uses, placing Kafir Kot toward the upper end of the range reported in previous studies. For cancer, ICFs of up to 0.85 in Taiwan, 0.85-0.95 in Uganda and 0.90 in Bhimber, Azad Kashmir have been reported (Ko *et al.* 2025, Kudamba *et al.* 2023, Ishtiaq *et al.* 2022), compared with the high value observed here. In the literature, such elevated consensus has been interpreted as reflecting concentrated knowledge around a limited set of taxa for serious or culturally salient conditions and shared cultural transmission, rather than evidence of efficacy or safety. Direct comparability is limited, however, because disease-category circumscription, number of use-reports and taxa richness differ across studies. The pronounced consensus for sexual-performance, antidotal and rheumatic categories in Kafir Kot is also consistent with reports from diverse regional and global settings where these concerns are commonly managed with plant-based remedies (Edo *et al.* 2024, Aziz *et al.* 2018, Tariq *et al.* 2018, Adhikari *et al.* 2018, Butt *et al.* 2015, Bamogo *et al.* 2023, Shah *et al.* 2025, Malik *et al.* 2018, Sulaiman *et al.* 2020, Amin *et al.* 2024). The present data do not establish why agreement was higher for some categories than others. Given the health risks associated with high-consensus categories such as cancer and poisoning, future work should document the specific taxa, preparations and reported outcomes underpinning this consensus with appropriate caution.

Reported uses for several taxa show parallels in phytochemical and experimental literature that may help prioritize future research, but do not independently validate the remedies documented here. The high consensus observed for *Aerva javanica* in Kafir Kot is notable in light of reports of phenolic compounds and flavonoids with antioxidant and anti-inflammatory activity in experimental assays (Saleem *et al*. 2021). Similar compositional and radical-scavenging properties have been reported for *Centaurea cineraria* (Hashim 2023), while experimental work on *Euphorbia hirta* has reported antidiarrheal activity (Ali *et al*. 2020), which provides context for the high fidelity for diarrheal disorders observed for *Erigeron bonariensis* in the present survey and its recent phytochemical profiling (Sharma & Alam 2025). These lines of evidence differ in method and scope, and chemical composition or in-vitro activity alone cannot establish therapeutic effectiveness or safety in humans. Follow-up studies should therefore focus on authenticated local specimens, detailed documentation of traditional preparation and dosage, and evaluation of relevant biological activity and safety using appropriate methods.

Conclusion

The present study documented the rich indigenous knowledge of medicinal plants among the local communities of Kafir Kot, District Dera Ismail Khan. A total of 50 medicinal plant species belonging to 45 genera and 24 families were recorded, demonstrating the considerable diversity of plants used in traditional healthcare. The predominance of herbaceous species and the use of different plant parts for treating a wide range of ailments reflect the extensive reliance of local communities on available plant resources. Quantitative ethnobotanical indices, including RFC, UV, FL, ICF and FIV, provided further insight into the cultural importance, use patterns and informant consensus associated with the documented medicinal plants. Species with high citation frequencies and high-fidelity levels (e.g., *Aerva javanica, Parthenium hysterophorus* and *Centaurea cineraria* for citation frequency; *Erigeron bonariensis* for fidelity to antidiarrheal use) represent important components of the local ethnomedicinal system and merit further investigation. The study provides baseline ethnobotanical documentation from Kafir Kot, where systematic information on locally utilized medicinal plants and associated traditional knowledge remains limited. This documentation contributes to the understanding of the ethnobotanical importance of local flora and provides a basis for preserving knowledge that may be vulnerable to gradual loss. However, the study was limited to selected communities within Kafir Kot, and the findings therefore may not represent the ethnomedicinal practices of other communities across District Dera Ismail Khan. Further studies should include broader geographical coverage and investigate temporal changes in plant availability and traditional knowledge. Further phytochemical, pharmacological and toxicological investigations are recommended for highly cited and high-fidelity species to evaluate their therapeutic potential and safety. Conservation efforts should prioritize frequently utilized species and those harvested through potentially destructive practices, particularly roots and whole plants, while sustainable harvesting and documentation of indigenous knowledge should be encouraged. Such measures can help safeguard both the medicinal plant resources of Kafir Kot and the traditional knowledge associated with their use.

Declarations

List of abbreviations: RFC: Relative Frequency of Citation; FC: Citation Frequency; N: Total number of informants; FL: Fidelity Level; UV: Use Value; ICF: Informant Consensus Factor; FIV: Family Importance Value

Ethics approval and consent to participate: The study was approved by the Department of Botany, Gomal University. Oral consent was obtained from all participants after explaining the survey's objectives.

Consent for publication: The manuscript contains no photographs of identifiable people.

Availability of data and materials: The datasets generated and/or analyzed during the current study, including the informant interview records and voucher specimen data, are available from the corresponding author upon reasonable request.

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

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Author contributions: Muhammad Mehran: Performed data collection, original draft and study design; Sheikh Zain Ul Abidin: Supervisor, Conceptualization of research, Plant identification, Formal analysis and data review; Muhammad Abubakar: Data curation and methodology; Raees Khan: Plant identification, revised draft manuscript; Asma Saeed: Data review; Muhammad Imran: Manuscript writing, formatting and final revision; Tehreem Fatima: Methodology analysis; Shehla Nawaz**:** Editing and revision, and Nishwa Noreen: Statistical analysis.

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