Exploring the traditional knowledge and medicinal flora of the communities residing along North Eastern India-Pakistan borders

Fahim Arshad, Waqas Ahmad, Muhammad Shoaib, Nidaa Harun, Kaneez Fatima, Zaheer Abbas, Sadia Jabeen and Muhammad Waheed

Correspondence

Fahim Arshad[1], Waqas Ahmad[1], Muhammad Shoaib[1], Nidaa Harun[1], Kaneez Fatima[1], Zaheer Abbas[2], Sadia Jabeen[1] and Muhammad Waheed[1]

[1]Department of Botany, Faculty of Life Sciences, University of Okara, Okara, Pakistan
[2]Department of Botany, Division of Science and Technology, University of Education, Lahore, Pakistan

*Corresponding Author: nidaadr@uo.edu.pk

Ethnobotany Research and Applications 26:10 (2023) - http://dx.doi.org/10.32859/era.26.10.1-41
Manuscript received: 19/12/2022 – Revised manuscript received: 11/07/2023 - Published: 21/07/2023

Research

Abstract

Background: Ethnobotanical studies underpin the understanding of plant-people interaction in any geographical area along with the conservation strategies and priorities. The current study was carried out in the marginalized communities residing along the North Eastern Indo-Pak border of Depalpur and its adjoining areas of the Punjab Province, Pakistan.

Methods: Snow-ball and random sampling techniques were employed for study participants. They were semi-structurally interviewed with open ended questions for the collection of desired data.

Results: Altogether, 75 plant taxa were recorded in 68 genera and 32 families. The majority of them were wild herbs (86%), and whole plants (82%) were utilized frequently for drug preparations. Studied plants were reported to treat 40 ailments, however significantly used for fever (43 spp.) and gastrointestinal disorders (40 spp.).

Conclusions: These findings endorsed the significant plant based knowledge of the border area populations. However, unprecedented rapid urbanization, economic development, and sociocultural dynamics challenged the retention of traditional knowledge. Profound decline was observed in the number of herbal practitioners, and their successors seem less interested in this field because of laborious jobs with low profit. Therefore, organic product development and the establishment of ethno species in home gardens and liaisoning with herbal industries may revitalize the existing traditional practices.

Keywords: folk knowledge, border area, bio-cultural diversity, ethnoflora

خلاصہ

پس منظر

ایتھنو بوٹینیکل اسٹڈیز کسی بھی جغرافیائی علاقے کے پودوں اور لوگوں کے باہمی تفہیم کے ساتھ ساتھ تحفظ کی حکمت عملیوں اور ترجیحات کی بنیاد ہے۔ موجودہ مطالعہ دیپالپور(صوبہ پنجاب، پاکستان) کی شمال مشرقی ہند-پاک سرحد اور اس سے ملحقہ علاقوں میں رہنے والی پسماندہ برادریوں میں کیا گیا۔

طریقہ کار

مطالعہ کے شرکاء کے لیے سنو بال اور بے ترتیب نمونے لینے کی تکنیکوں کا استعمال کیا گیا۔ مطلوبہ ڈیٹا اکٹھا کرنے کے لیے انٹرویو میں نیم ساختہ سوالنامے پہ مبنی جامع سوالات کے جواب طلب کیے گئے۔

نتائج

مجموعی طور پر 68 نسلوں اور 32 خاندانوں میں 75 پودوں کی فہرست ریکارڈ کی گئی۔ ان میں سے زیادہ تر جنگلی جڑی بوٹیاں تھیں (86%)، اور پورا پودا (82%) منشیات کی تیاری کے لیے کثرت سے استعمال ہوتا تھا۔

ان پودوں کو 40 بیماریوں کے علاج میں استعمال کرنے کی اطلاع ملی، تاہم یہ بخار (43 پودے) اور معدے کی خرابی (40 پودے) کے لیے نمایاں طور پر استعمال کیے جاتے ہیں۔

فیصلہ

ان نتائج نے سرحدی علاقے کی آبادی کے بارے میں پودوں پر مبنی اہم معلومات کی توثیق کی۔ تاہم، بے مثال تیزی سے شہر کاری، اقتصادی ترقی اور سماجی و ثقافتی حرکات روایتی علم کی برقراری کے لیے خطرے کا باعث ہیں۔ جڑی بوٹیوں کا علم رکھنے والے یعنی حکیموں کی تعداد میں نمایاں کمی دیکھی گئی ہے، اور ان کے پیروکار کم منافع کی وجہ سے اس شعبے میں کم دلچسپی لیتے ہیں۔ لہذا، نامیاتی مصنوعات کی نشوونما اور گھریلو باغات میں نسلی انواع کا قیام اور جڑی بوٹیوں کی صنعتوں کے ساتھ باہمی اشترک بنیادی طور پر ضروری ہے

کلیدی الفاظ: لوک علم، سرحدی علاقہ، جیو ثقافتی تنوع، ایتھنو فلورا

Background

The border human communities live a challenging social life particularly those where diplomatic relationships of bordering countries are hostile (Taran 2001; Naples 2009). According to an estimate, 91% of the world's border population has been experiencing different state restrictions worldwide. Due to persistent harsh diplomatic relations and geopolitical backgrounds of the countries, the human populations are always subjected to different restrictions, limited life facilities, poor infrastructure, and sometimes mobility. Moreover, they are offered limited opportunities for markets, resources, life necessities, and freedom (Fratianni and Kang 2006; Waheed *et al.* 2020; Haq *et al.* 2023). Therefore, these communities extract the limited biological resources at a high pace such as rangelands, fuel wood, medicinal plants, fodder etc. They hold ample local ecological knowledge (LEK) about their local environment including local flora and fauna. Traditional ethnoecological knowledge is geographically specific and often involves beliefs, myths, and, practical experience. Ethnoecological knowledge can significantly contribute to a better understanding of the current socio-economic and environmental fluctuations occurring across the globe (Mammun 2010; Naees, 2013; Khoja *et al.* 2022). In the current scenario, the increasing trend of modern life patterns, business ways, outmigration, and rampant urbanization have strikingly caused the fragmentation of sustaining folk knowledge (Sõukand and Pieroni, 2016; Mattalia *et al.* 2020). Additionally, the prevalent propensity of formal education also plays a significant role to downplay native resources and knowledge (Cruz, 2006; Haq *et al.* 2022).

The current global and regional changes demand the precise study and analysis of traditional knowledge of these transition communities of borders. It is a dire need for time to analyze the ecological knowledge along with the aspects of its production and sharing sources (Hopping *et al.* 2016). In the past decade, border ethnobotany has received increasing consideration from scholars, and ample cross-cultural border studies available on European borders (Akgul *et al.* 2018; Ozturk *et al.* 2018; Sõukand & Pieroni, 2016; Rexhepi *et al.* 2013; Berkes, 1999; Ceuterick *et al.* 2011; Pieroni *et al.* 2011). In Asia, such studies were carried out at Russian boundaries (Mamedov *et al.* 2005). Post-Soviet borders (Tajik) and Badakhshan region of Afghanistan (Kassam, 2009).

Pakistan shares a 3,323 km (2,065 mi) border area with India in the coastal areas, deserts, lower plains, hilly territories and, high-altitude mountains of the Karakorum and the Himalayas (Smith, 2013). Ethnobotanical studies have been growing fast in recent years and ample literature is now available from different parts of the country. However, specific areas have to be explored such as the communities of deep mountains, borders and deserts (Abbas *et al.* 2017a). India-Pakistan border was established in 1947 by the end of British colonial rule and always remained unwelcoming for researchers due to the geo-political hostility. Hence, the botany of border areas has been poorly studied in the post-subcontinent region (Garlick, 2018; Arshad *et al.* 2022). It is estimated that more than 5 million populations reside in the border areas. Similarly, the bordering territories of the Punjab province of Pakistan with India have been poorly investigated as compared to other areas for instance (Umair *et al.* 2017), (Gulshan *et al.* 2012), (Iqbal and Sher, 2011), (Ahmed *et al.* 2014), (Ahmed *et al.* 2015) etc. The

study area possesses intriguing flora and vegetation and host considerable human population (Waheed *et al.* 2021). We hypothesized that the socio-ecological conditions, priorities, and outmigration of the people in the study area are changing fast, particularly in the bordering territories. Consequently, traditional knowledge is in danger of loss and fragmentation. Therefore, the primary objectives of the study were to document the medicinally valued plant taxa of the study area and to record the associated traditional knowledge for assessing the conservation aspects of listed medicinal taxa.

Materials and Methods

Study area

The Indo-Pak border area is about 17 miles north of Depalpur, District Okara, the Punjab Province Pakistan (Table 1). Locally, the area is also called the Zero-line border area. Administratively, Depalpur is a Tehsil covering an area of 2502 km^2 at the elevation of 176 meters above sea level. Topographically, it's sandwiched between rivers Chenab and Sutlej comprising the alluvial fertile lands. The climate is dry in summer while humid in winter. The average temperature and rainfall of the area are recorded as 24.6^oC and 287mm, respectively. Population of Tehsil Depalpur is 1,375,785 RURAL 1,033,260 Urban 342,525 Population density per 2 km is 549.87 (Pakistan Bureau of Statistics 2017 a https://www.pbs.gov.pk/sites/default/files/population/2017/results/06201.pdf).

Table 1. Geographical (latitude, longitude, elevation) and demographic (population and ethnicity) attributes of targeted sites and communities of study area

Visited sites	Community	Latitude (N)	Longitude (E)	Elevation (m)	Population (household)	Ethnicity
Basirpur	Baqir-K-Mahar	30°29'25.30"N	73°53'58.97"E	177m	1,414	Arain, Mahar, Watto, Kamboh, Rajpoot
Mandi Ahmedabad	Attari	30°35'24.00"N	74° 1'48.00"E	181	5,086	Bodla, Jatt, Wattoo, Arain
Head Sulemanki	Kani Pur	30°30'0.00"N	73°49'48.00"E	177m	2,957	Gujjar, Arain
	Jamal Kot	30°27'13.57"N	73°50'26.73"E	176	5,298	Jatt, Joiya, Bodla Mahaar, Arain

Total population of tehsil Depalpur above the age ten is 984,002 out of which 474,264 are illiterate while 509,738 are illiterate. Moreover 503,996 people had a formal education while 5,742 had informal education. Overall literacy rate of area is 51.80 (Pakistan Bureau of Statistics 2017 https://www.pbs.gov.pk/sites/default/files/population/2017/results/06213.pdf). The area is famous for its Sulemanki Headworks, Head Sulemanki National Forest and Indo-Pak border. Maize, rice, and potato are the major food crops of the study area. The main ethnic groups of the area are Araain, Watoo, etc. The vegetation is scarce and sub-tropical humid type. Riverine forests, grasslands, and desert vegetation are the main representatives. The local people are mostly farmers and pheasants and have indispensable associations with the local flora (https://okara.dc.lhc.gov.pk).

Data Collection

A hybrid strategy was employed to find informants. For herbalists a snowball methodology and for non-herbalist informants a random strategy was employed**.** Field surveys were undertaken during spring 2020 to winter 2021 in the borderline areas of Depalpur and its adjoining parts (Figure 1). A total of 3 sites and 4 communities were visited situated along the bank of river Satluj (Table 1, Figure 2A.2B). The ethical guidelines for the survey of rural and indigenous communities provided by International Society of Ethnobiology (available online: www.ethnobiology.net/whatwe-do/coreprograms/ise-ethics-program/code-of-ethics) were carefully followed. Prior to interviews, formal verbal consent (regarding data collection and publication) of each participant was taken. The PRA (Participatory rural appraisal) approach mentioned in the Kyoto Protocol

(2017) was applied with the consent of the informant. In addition, formal consent from the University of Okara Ethical Review Committee was also taken (consent number UOERCC#124). The ethnomedicinal information related to folk medicinal plants was obtained from local inhabitants of various ages including local hakims, men, women, farmers and shepherds. During the interviews, data regarding the vernacular name, availability, used part(s), modes of preparation and administration, diseases treated, and cultural uses were asked in their native language (Punjabi).

Figure 1. Different sampling sites from study area

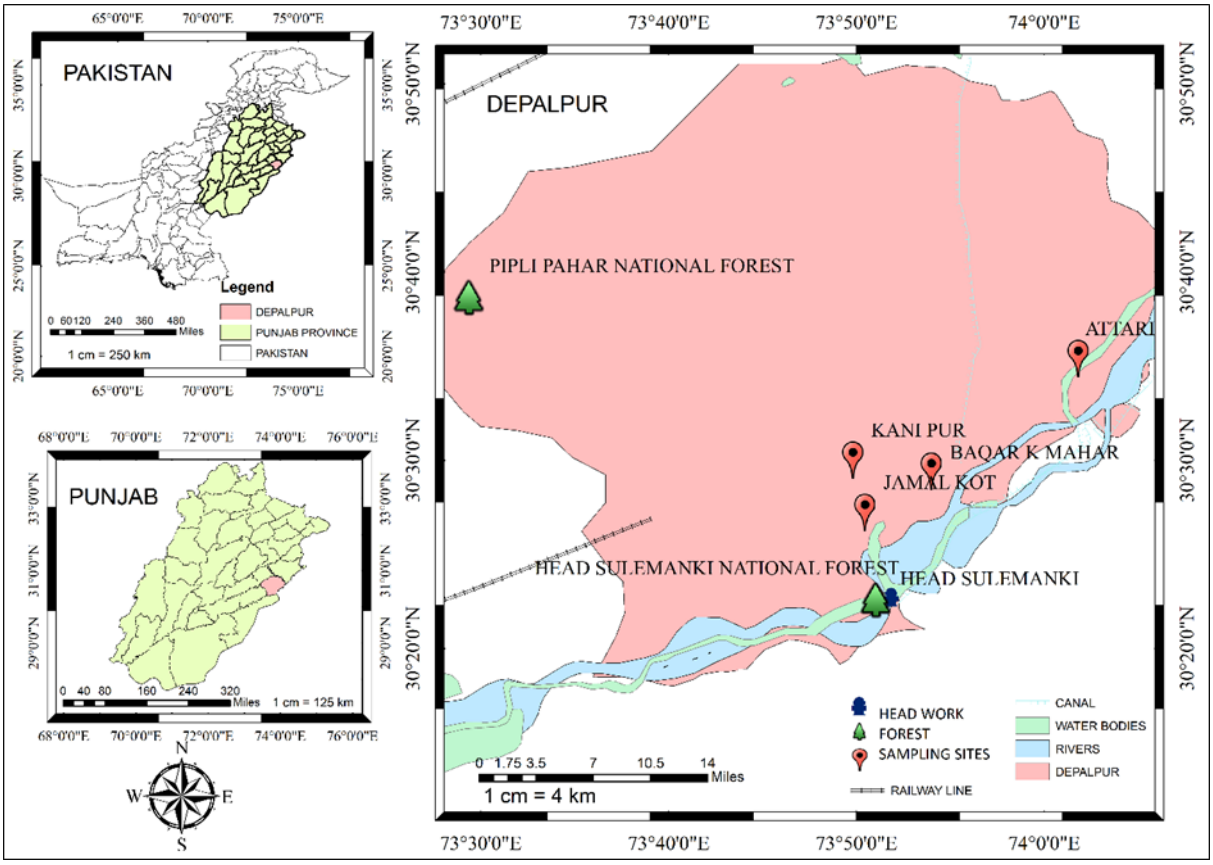

Figure 2A. Map of the study area showing the surveyed sites i.e. Basirpur, Mandi Ahmedabad and Head Sulemanki

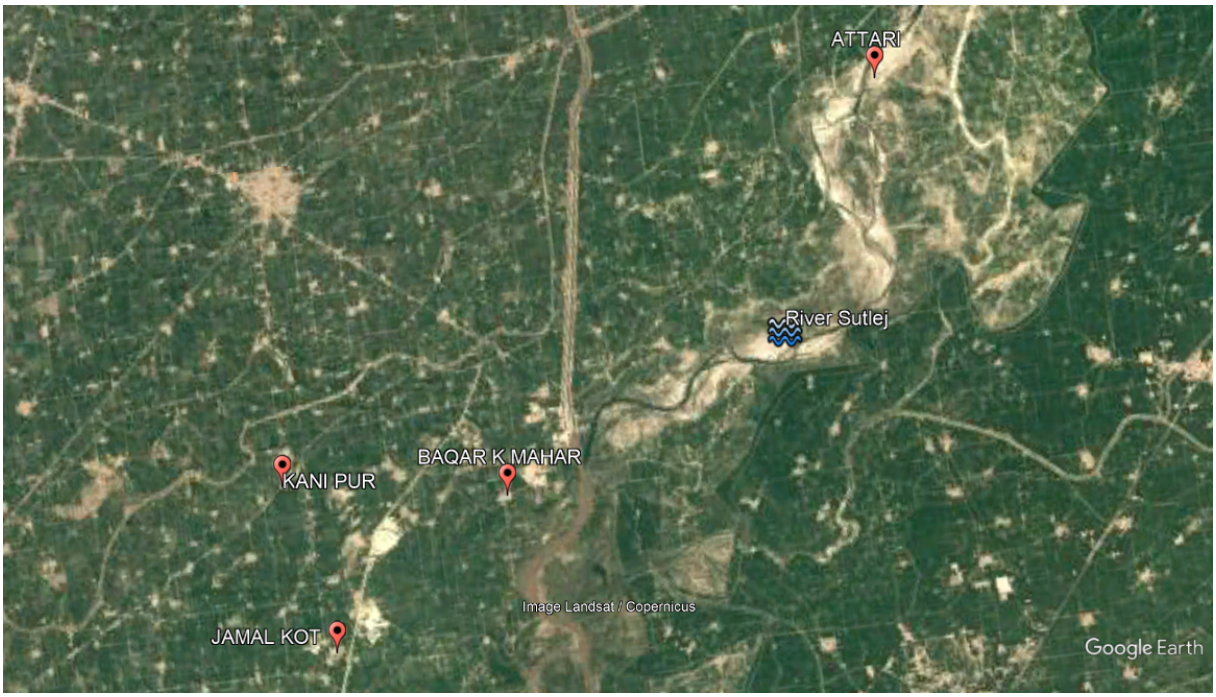

Figure 2B. Geo-reference of study sites on Google map

Collection and identification of plant specimens

At each study sites, guided walk by local inhabitants was made to collect the fresh plant specimens for herbarium protocols and identification. Most of the medicinal plants were identified in the field by local guides with vernacular nomenclature. The specimens were properly collected, pressed, and passed through herbarium techniques. Specimens were treated with 2g mercuric chloride and 10g Copper Sulphate dissolved in 1000 ml absolute alcohol (Jain & Rao 1977; Maden 2003). The collected specimens were initially identified by Dr. Fahim Arshad (plant taxonomist at the University of Okara), and later on confirmed by Flora of Pakistan (Ali and Nasir (1990-1991, 1993-2001, 2002 - 2019) (http://www.efloras.org/flora_page.aspx?flora_id=5) Flora of China (http://www.efloras.org/flora_page.aspx?flora_id=2) and Flora of India (http://www.flowersofindia.net/) were consulted for specimen authentication. The assigned botanical nomenclature of names and families were cross-checked by two online plant databases i.e., The Plant List (2010) (http://www.theplantlist.org.), and World Flora Online (http://www.worldfloraonline.org/). The identified plant specimens were properly labeled, stamped, and submitted to the Botanical Herbarium of the University of Okara, Pakistan

Relative Abundance

Relative abundance of enlisted herb species was estimated by using visual assessment method used by Kent (2011) (Kent, 2011). According to this, numbers of plots were selected randomly in every study area then the presence of each medicinal plant was counted. Later, following formula was used to calculate percentage relative abundance.

$$\frac{\text{Total Cover of a species}}{\text{Total Cover of all species}} \times 100$$

All medicinal plants were categorized into five groups like Abundant, Rare, Frequent, Common and Occasional by using scale of relevant abundance i.e. <5% (Rare) 5-20% (Occasional), 20 - 50% (Frequent), 50 - 90% (Common) and 90 - 100% (Abundant).

Data Analysis

The collected data were compiled and organized in MS Excel 2010 and various data analysis tools were applied for interpretations (Kushwaha *et al.* 2017; Zubair *et al.* 2017; Hachlafi *et al.* 2020).

Informant Consensus Factor (ICF)

The level of homogeneity between data provided by different informants was determined by the *Informant Consensus Factor (ICF)* (Heinrich *et al.* 1998; Logan, 1986). Its values ranged between 0 and 1, with FIC = 1 indicating the highest level of informant consensus. A value close to 1 reflects that relatively few taxa are used by a large proportion of informants; while

a value close to 0 indicates that opinion of informants varies about the taxa to be used in treatment within a category of illness. Therefore, usually if informants use few taxa, then a high degree of consensus is expected to be reached and medicinal tradition is thus viewed as well-defined (Heinrich, 2000).

$$\mathrm{FIC} = \frac{\mathrm{Nur} - \mathrm{Nt}}{\mathrm{Nur} - 1}$$

Where
Nur = number of use-reports in each category
Nt = number of taxa used

Relative Frequency Citations (RFCs)

The tool was used to set up the priority order among the listed plants. The RFCs was estimated by using the following equation (Vitalini *et al.* 2013) and (Phillips *et al.* 1994). This indicates a comparative importance of a particular species in a given community.

$$\mathrm{RFC} = \frac{\mathrm{FC}}{\mathrm{N}} \ (0 < \mathrm{RFC} < 1)$$

Where
FC is the number of respondents that stated that particular plant species
N is the total number of respondents in whole study

Use Value (UV)

UV measures the significance of every single plant species based upon the number of various recorded usages. The main purpose was to evaluate the significance of the plant taxa amongst the family (Vitalini *et al.* 2013; Thomas *et al.* 2009) measured as follow;

$$\mathrm{UV} = \frac{\sum \mathrm{Us}}{\mathrm{N}}$$

Where,
UVs = Use Value for the species
Σ Us = Total sum of the usages revealed for a particular plant species
N = Total No. of informants

Relative Importance (RI)

Relative importance (RI) is defined by the following formula (Albuquerque *et al.* 2006):

$$\mathrm{RI} = \frac{\mathrm{RBS} + \mathrm{RPH}}{2} \times 100$$

Where RPH= relevant value of PH that is Pharmacological uses of a plant
While RBS = relevant Value of BS that Body systems treated by a plant

Family Importance Value (FIV) and Family Use Values (FUV)

The FUVs and FIV ratios were applied to calculate the importance of a particular family uses (Kushwaha *et al.* 2017).

$$\mathrm{FUvs} = \frac{\sum \mathrm{UVs}}{\mathrm{Ns}}$$

$$\mathrm{FIV} = \frac{\sum \mathrm{FCs}}{\mathrm{N}} \times 100$$

Where
FUVs = Family Use Value
∑UVs = Total of the Use Values of all the plant species cited a specific family
NS = Total number of plant species cited from specific family
FIV = Family Importance Value
∑FCs = Total number of informants cited for all species of a specific family
N = Total No. of informants in study

Fidelity Level (FL)

It was used to quantify the percentage of informants who claimed the use of a certain plant for the same major purpose (Kushwaha *et al.* 2017).

$$\mathrm{FL} = \frac{\mathrm{Np}}{\mathrm{Nx}} \times 100$$

Where

Np = Number of informants who claimed a particular use of a plant species used for a typical disease.

N = number of informants/interviewees who used the plants as an ethnomedicine to treat given diseases (Khanum *et al.* 2022)

Relative Popularity Level (RPL) and Rank Order Priority (ROP)

RPL described the frequency of use of a particular species. In some analyses sporadically FL provided the same usage frequency of various species, further the relative popularity level index was used to reassure and confirm FL values of various trial species. It was calculated by using the formula adapted from Khanum *et al.* (2022)

$$\mathrm{RPL} = \frac{\text{Number of diseases treated}}{\text{Total number of informants reported these uses}}$$

To determine the correction between FL and RPL, rank order popularity was used. ROP designates the popularity rank to an individual as per FL and RPL values. The following formula was used for ROP (Khanum *et al.* 2022)

$$\mathrm{ROP} = \mathrm{FL} \times \mathrm{RPL}$$

Jaccard Index

Jaccard index (JI) helps in figuring out any novelty of the studies particularly newly reported medicinal plants from the region or area. For the contrast of recent data with prior published data collected from neighboring areas Jaccard similarity index was calculated (González-Tejero *et al.* 2008; Farooq *et al.* 2019), using the following formula:

$$\mathrm{JI} = \frac{\mathrm{c} \times 100}{(\mathrm{a} + \mathrm{b}) - \mathrm{c}}$$

Where

a = is the number of species in common

b =the number of species used only by one specific community and

c= is the number of species used only in the other community

Statistical Interpretations

IBM SPSS V: 25.0 version was employed for Descriptive statistical analysis of various qualitative parameters. In addition, Pearson correlation was also applied to identify the relationship between RFC, UV, and RI.

Results and Discussions

All the above-mentioned aims of the study were achieved systematically. Firstly we have enumerated the list of available medicinal plants in the study area and also recorded their associated traditional knowledge in terms of their medicinal uses. In addition, by estimating relative abundance, we have tried to find out conservation aspects of the listed medicinal taxa.

Participants' background

A total of 73 participants were interviewed during the present research work (Table 2). Majority of the respondents were men (70%) followed by women (30%). Men eagerly took part in the interview process but only women of old ages participated in the survey and shared ample folk wisdom as reported by Reyes-Garcia *et al.* (2013). The younger women remain reclusive and showed no interest in such surveys. Islamic limitations and rural lifestyle may be the reasons behind the women reclusiveness. Two ethnic groups were prominent in the study area i.e. Aarain and responded 32.88% and Mahaar (28.77%). Respondents of other groups such as Joiya, Rajpoot and Kamboh showed least presentation i.e., 1.4%. The ethnic groups prominent in area were local inhabitants while least representative ethnicities were recorded for immigrants during 1947 partition (Waheed *et al.* 2023)

Maximum number of informants were above 60 years of age (51%) and middle-aged i.e., between 40-60 years (26%). Young people (20-40 years) seemed less interested in herbal treatments and traditional knowledge of their elders as reported in various ethnobotanical studies (Abbas *et al.* 2017b; Bibi *et al.* 2022). Generally, they were illiterate and busy with farming,

pastoralism, wood cutting, gathering herbal medicine and government employment. The literate people possessed less knowledge as compared to those engaged with typical rural and traditional occupation such as farming, pastoralism etc. The most significant difference of knowledge was observed for the socioeconomic status of the informants such as herbal healers holding sufficient and diverse knowledge regarding medicinal plants. On the other hand, age and gender also influenced the quality of knowledge. People above 60 years old shared less information and observed with weak memory. The young people under 30 years had no contribution in the survey. Gender wise women were more knowledgeable as compared to men. Moreover, most of the herbal healers (Hakims) had achieved diploma and licence to practice their profession while few were practicing as their forefathers' legacy. Besides, housewives, farmers, and other layman have shared the knowledge that their forefathers have practiced. Ethnobotanical knowledge can be influenced by factors, such as age, gender ethnicity profession ethnicity. There is significant difference of knowledge between gender and ethnicity while age also effects the degree of knowledge (Ayantunde *et al.* 2008)

Table 2. Demographic attributes (locality, sex ratio, ethnic groups, age, education levels, and social livelihoods) of native communities showing their social and economic background

Social Variables	Description	Men	Women	People	%
Locality	Bakar k Mahar	11	4	15	21
	Kanipur	7	2	9	12
	Jamal Kot	7	9	16	22
	Atari	26	7	33	45
Sex Ratio	Men			51	70
	Women			22	30
Ethnic Groups	Arain	17	7	24	33
	Mahaar	15	6	21	29
	Wattoo	8	2	10	14
	Jutt	3	3	6	8
	Bodla	3	2	5	7
	Gujjar	3	1	4	5
	Joyia	1	0	1	1
	Rajpoot	0	1	1	1
	Kamboh	1	0	1	1
Age	Between 20 - 40 years	12	5	17	23
	Between 40 - 60 years	12	7	19	26
	Above 60	27	10	37	51
Education Level	Illiterate	20	12	33	45
	Primary	22	5	27	37
	Middle	7	5	12	16
	Graduate	1	0	1	1
	Post Graduate or above	0	0	0	0
Social Livelihood	Farmers	30	5	35	48
	Shepherds	13	3	16	22
	Wood cutters	3	0	3	4
	Herbalists	4	0	4	5
	Job holders	1	1	2	3
	Housewives	0	13	13	18

Medicinally valued flora of the study area

Current study reported 75 plant species belonging to 68 genera and 31 families used for the treatment of various ailments (like respiratory, gastrointestinal, nervous, dermatological disorders etc.) from the study area (Table 3) (Figure 3). All these species encountered from the study area were wild and endemic. Results reported that most of the species (n=13) belonged to family Asteraceae and Amaranthaceae (8 species). Fabaceae, Solanaceae and Poaceae were co-dominating families with 5 species each. Only Euphorbiaceae contributed 4 species while Chenopodiaceae, Malvaceae and Zygophyllaceae contributed 3 species each. Brassicaceae, Cucurbitaceae, Lamiaceae and Polygonaceae were having 2 species. The rest of the 18- families were monotypic (Figure 4A). Umair *et al*. (2019) and Ali *et al.* (2022) around Chenab river areas and Tareen et al. (2016) in Balochistan also documented Asteraceae and Poaceae among dominating families. Shah *et al.* (2020) documented Solanaeae with least number of species from the central Punjab Moreover, Shah *et al.* (2019) documented Poaceae and Solanaceae the dominant species while, Fabaceae as least dominant from District Sargodha. It shows the stereotype presence of different plants in different and same geographical areas. The possible reason of this dominance not only depends upon the geographical and climatic factors but now also on the anthropogenic factors; in many areas it might be possible that due to urbanization and construction of new housing societies many plants have been cut which may affect the number of plant families in different regions. Similar kinds of results reported by a quantitative tool i.e., Family importance value (FIV), which exhibited the popularity of the family in study area on the basis of the frequency citation. Highest FIV was accounted for Asteraceae (105.48%) followed by Amaranthaceae (49.32%) and Poaceae (39.73%) (Figure 4B) Maqsood *et al.* (2022) documented Amaranthaceae among moderate FIV in Bagh. While according to Tareen *et al.* (2016) Brassicaceae is with highest FIV in Balochistan. The highest FIV values indicates the greater number of informants cited for a particular family (Khan *et al.* 2015) which might depend upon cultural and traditional factors of areas where different people use various plant families according to their taste and practices. Medicinal significance of family Asteraceae is also well established through previous studies (Saini *et al.* 2020; Achika *et al.* 2014). It is one of the largest plant families with high ecological niche and distribution including mostly herbaceous species; inhabit varied geographical features and climatic conditions favorable for their growth. Due to which members can abundantly grow and are commonly available for the use by local communities and herbalists. On the contrary, FUV results reported Scrophulariaceae as the most utilized family (FUV=08) followed by Portulacaeae (FUV=07), Caryophyllaceae (FUV=6.3) and Cuscutaceae (FUV=5.60) (Figure 4C). Plant families with the higher FUV were highly used in the community while families with lower FUV were less utilized by the local people (Khushwaha *et al.* 2018). From these results, it is established that FIV represents the popularity of certain families based on their represented medicinal taxa. However, FUV represents the actual frequency of utilization for particular family in certain study areas.

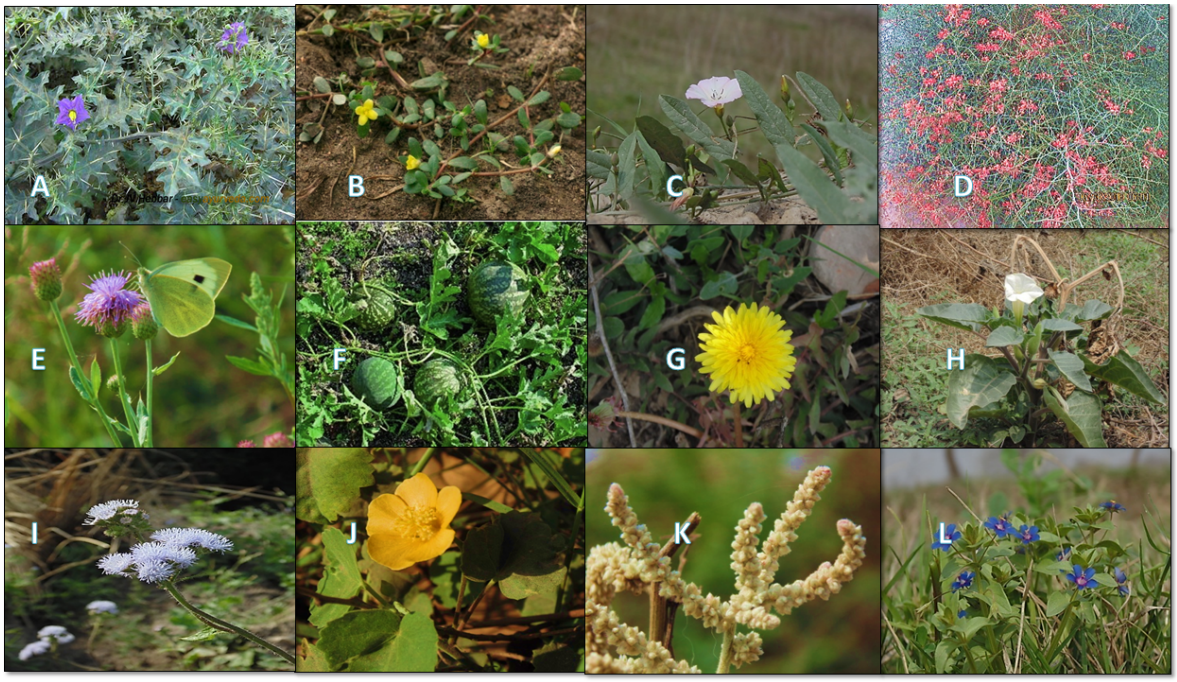

Figure 3. A Collage of selected plants reported from study area. (A) *Solanum surettense* Burm.f (B) *Portulaca oleracea* L. (C) *Convolvulus arvensis* L. (D) *Capparis decidua* (Forssk.) Edgew (E) *Cirsium arvense* (L.) Scop. (F) *Citrullus colocynthis* (L.) Schrad. (G) *Taraxacum officinale* F.H Wigg (H) *Datura innoxia* Mill (I) *Ageratum conyzoides* L. (J) *Abutilon indicum* (L.) Sweet (K) *Aerva javanica* (Burm.f.) Juss. Ex Schult (L) *Anagallis arvensis* L.

Table 3. Status of traditional knowledge associated with ethnobotanical plants and comparison with previous studies

Family	Voucher specimen no.	Botanical Name	Vernacular Name	Habit	Part(s) Used	Medicinal Uses	*Seasonal variability*	*Relative abundance*	RDS	RS	NR
Amaranthaceae	UO-001	*Achyranthus aspera* L.	**Puthkanda**	Hb	Rt, Lv, Sk	Toothache, cough, headache, abdominal pain, skin diseases, piles and spike for malarial fever. This plant also has a diuretic, purgative and emetic action.	Th Yr	Ocas	5, 8, 9, 10, 22, 24, 25, 26	2, 4, 6, 11, 12, 21	1,3, 7, 13-20,23, 27, 28
	UO-002	*Aerva javanica* (Burm.f.) Juss. Ex Schult.	**Boi**	Hb	Wp	Body swelling, Headache, skin dryness and diarrhea are usually treated. This plant exhibits diuretic, emollient properties and also cures urethral discharges.	Th Yr	Rare	2, 4, 26, 28	13	1, 3, 5-12, 14-25, 27
	UO-003	*Alternanthera philoxeroides* (Mart.) Griseb.	**Pipe Boti**	Hb	Lv	Mostly utilized as tonic.	Th Yr	Abnt	-	-	1-28
	UO-004	**A. pungans* Kunth.	**Kandiari**	Hb	Wp	Whole plant cures fever and jaundice	Spr, Aut	Rare	2	-	1, 3-28
	UO-005	**A. sessilis* (L.) DC	**Kandiari**	Hb	Wp	Local people use it to treat fever.	Spr, Smr, Aut	Rare	2, 10	-	1, 3-9, 11-28
	UO-006	*Amaranthus spinosus* L.	**Chulai**	Hb	Wp	Leaves are used as vegetable. It also cures stomach troubles.	Th Yr	Freq	10, 25	11	1-9, 12-24, 26-28
	UO-007	*A. viridis* L.	**Chulai**	Hb	Wp	Leaves are utilized for gastro-intestinal disorders, urinary disorders and joint pain. It also shows diuretic, laxative and purgative properties. Extract of whole plant is utilized to leucorrhea and piles.	Th Yr	Abnt	3, 8, 19, 21, 24-26	2, 10, 11, 13-16	1, 4-7, 9, 17, 18, 20, 22, 23, 27, 28

	UO-008	*Digera muricata* (L.) Mart**.**	**Tandala**	Hb	Wp	Whole plant is used as laxative. Leaves are used as vegetable and fodder.	Aut, Wnt	Comn	2, 6	-	1, 3-5, 7-28
Asclepiadaceae	UO-009	*Calatropis procera* R. Br.	**Akk**	Hb	Wp	Plant plays pivotal role for treating dysentery, improve digestion, catarrh and cough. Latex is externally applied to cure skin diseases. Leaves are given orally against dog and snake bite.	Th Yr	Freq	4,7-9, 15, 13, 22	5, 6, 10,11, 17, 18, 27, 28	1-3, 12, 14, 16, 19-21, 23-26
Asteraceae	UO-010	**Ageratum conyzoides* L.	**Neel Kanth**	Hb	Wp	Traditionally used to cure headache, rheumatism and sting bite. It also treats renal stone, ulcer and wounds.	Th Yr	Ocas	4, 10	-	1-3, 5-9, 11-28
	UO-011	*Carthamus oxycantha* M.Bieb.	**Pohli**	Hb	Sd	Seeds are beneficial for the treatment of intestinal worms in children.	Aut, Wnt	Ocas	6, 8, 10, 14	2	1, 3-5, 7, 9, 11-13, 15-28
	UO-012	*Cirsium arvense* (L.) Scop.	**Kandiari**	Hb	Wp	Utilized as tonic and enhance milk production in animals.	Th Yr	Abnt	2, 4, 10	8	1, 3, 5-7, 9, 11-28
	UO-015	*Cotula hemispherica* Roxb.	**Cotula/ Buttonweed**	Hb	Wp	Used as fodder for cattle.	Spr, Aut, Wnt	Abnt	2	-	1, 3-28
	UO-016	**Eclipta alba* (L.) Hassk.	**Bhngra**	Hb	Wp	Whole plant is utilized to stop bleeding and pain of different body parts.	Spr, Smr, Aut	Comn	2, 10, 28	-	1, 3-9, 11-27

		Erigeron canadensis L.	**Gider Boti**	Hb	Wp	Essential for the treatment of cough, cold, dysentery, diarrhea and sore throat. Stem is boiled in water and taken orally to open blockage of nose during cold.	Th Yr	Abnt	4	14, 15, 24, 25	1-3, 5-13, 16-23, 26-28
		Erogeron bonariensis L.	**Namkin Boti**	Hb	Wp	Plant is used to cure diabetes, diarrhea and dysentery. Herb is an effective remedyas diuretic,	Spr, Aut, Wnt	Freq	2, 4	10, 22	1, 3, 5-9, 11-21, 23-28
	UO-017	*Launaea procumbens* (Roxb.) Ramayya & Rajagopal	**Dhodal**	Hb	Wp	Whole plant is very useful for the cattle to enhance milk production.	Spr, Aut, Wnt	Ocas	2, 5, 7, 10, 14, 16, 25	11	1, 3, 4, 6, 8, 9, 12, 13, 15, 17-24, 26-28
	UO-018	*Parthenium hysterophorus* L.	**Gajar Boti**	Hb	St,Lv	Boiled stem is used to cure toothache and strengthens gums. It also shows antipyretic actions. A plant having toxic effects in over usage.	Th Yr	Abnt	2, 4, 10, 13, 22	3, 24	1, 5-9, 11, 12, 14-21, 23, 25-28
	UO-019	*Sonchus asper* (L.) Hill.	**Dhodh Booti**	Hb	Wp	Whole plant is applied for healing of wounds, scabies, diabetes, fever and other skin problems.	Spr, Smr, Aut	Ocas	3, 8, 10, 12	2, 11	1, 4-7, 9, 13-28
	UO-020	*Sonchus oleraceus* L.	**Dhodak**	Hb	Wp	This indigenous plant is used as blood purifier, anticancer, antimicrobial and treats stomach disorders.	Spr, Smr, Aut	Ocas	4, 24, 25	-	1-3, 5-23, 26-28
	UO-021	**Taraxacum officinale* Weber.	**Kanfhul**	Hb	Wp	The plant is given in treatment of cancer, kidney and liver disorders, constipation and jaundice.	Aut, Wnt	Ocas	4, 11, 22, 25	20, 23, 24	1-3, 5-10, 12-19, 21, 26-28

	UO-022	*Xanthium strumarium* L.	**Bandri**	Hb	Sd, Lv	Seeds & Leaves are given in urinary and renal complaints and also for fever. This plant also possesses diuretic actions.	Th Yr	Abnt	3, 10, 11, 15	2, 25	1, 4-9, 12-14, 16-24, 26-28
	UO-023	*Trianthema portulacastrum* L.	**It-Sit**	Hb	Wp	Leaves are utilized to treat cough, asthma, fever and mucus secretions and regulate menstrual disorders.	Spr, Aut, Wnt	Rare	2, 3, 10	8	1, 4-7, 9, 11-28
	UO-024	*Heliotropium europaeum* L.	**Hathy Sondi**	Hb	Wp	Have diuretic properties. Inflorescence of the plant is used to cures jaundice, teeth infection, gum infection. Leaf extract is implemented in healing of external wounds.	Spr, Smr, Aut	Ocas	2, 8	-	1, 3-7, 9-28
Brassicaceae	UO-025	*Cleome viscosa* L.	**Hulhul**	Hb	Wp	Leaves juice is used to cure ear problems like pain, infection and deafness. Whole plant is utilized for infertility, piles, dysentery and exhibits anthelmintic activities.	Spr, Smr, Aut	Comn	4	-	1-3, 5-28
Boraginaceae	UO-026	**Nasturtium officinale* W.T.Aiton	**Aabi Salad, Jarjeer**	Hb	Lv,Sd, St	Extract of leaves and seeds is administered to treat malaria, typhoid and chicken pox. Boiled shoot is used to treat constipation and other stomach troubles.	Aut, Wnt	Comn	12, 15	11	1-10, 13, 14, 16-28
Cannabaceae Caesalpiniaceae	UO-027	*Cannabis sativa* L.	**Bhang**	Hb	Lv, Fl,	Leaves are sedative, crushed leaves are used by the native people for treating piles and narcotic action.	Spr, Smr, Aut	Ocas	2, 4, 6, 10, 15, 20, 21, 24, 25, 27	3, 8, 11	1, 5, 7, 9, 12-14, 16-19, 22, 23, 26, 28

	UO-028	*_Cassia occidentalis_ L.	**Chasku**	Sb	Wp	Used to treat jaundice, constipation and other stomach disorders. Leaves show anti-microbial properties.	Th Yr	Ocas	2	-	1, 3-28
Capparaceae	UO-029	*_Capparis decidua_ (Forssk.) Edgew.	**Kari**	Hb	Wp	Fruit is utilized to relieve toothache and joint pain and has anti-diabetic properties. Stem is essential for cough, ulcer, cold and other respiratory problems.	Th Yr	Ocas	8, 10, 13, 18, 26	4, 27	1-3, 5-7, 9, 11, 12, 14-17, 19-25, 28
Chenopodiaceae	UO-030	*Chenopodium album* L.	**Batho**	Hb	Lv	This herb is vital for blood purification, improves appetite, diuretic, laxative and cure piles.	Th Yr	Abnt	4, 5, 7-10, 16, 20, 23, 25	1-3, 6, 11, 12, 14, 15, 28	17-19, 21, 22, 24, 26, 27
Capparaceae	UO-031	*Chenopodium murale* L.	**Karun**	Hb	Wp	This plant is a rich source of minerals and show anthelmintic and stomachic properties. Leaves are commonly used as a vegetable.	Th Yr	Abnt	2, 10, 13	11,14,	1, 3, 4-9, 12, 13, 15-28
Chenopodiaceae Convolvulaceae	UO-032	*Suaeda fruticose* Forssk. ex J. F. Gmel	**Kala Lana**	Sb	Wp	The fumigation of dried plant kills germs.	Th Yr	Freq	2, 4	26	1, 3, 5-25, 27, 28
	UO-033	*Convolvulus arvensis* L.	**Lehli**	Cb	Wp	Flowers regulates menstrual cycle in women, fever and blood purification.	Th Yr	Abnt	2, 3, 5-8, 13, 15, 21, 24	10,11, 14	1, 4, 9, 12, 16-20, 22, 23, 25-28
	UO-034	*Citrullus colocynthis* (L.) Schrad.	**Kor Tuma**	Hb	Fr, Lv, Rt	Fruits are commonly applied for constipation, fever, intestinal problems, asthma and rheumatism. It also reduces uric acid level in humans.	Spr, Smr, Au	Ocas	2, 5, 8, 10,20,26	6, 7, 9, 14, 15, 17, 18	1, 3, 4, 11-13, 16, 19, 21-25, 27, 28

Convolvulaceae	UO-035	*Cucumismelo var. agrestis* Naudin.	**Chibber**	Cb	Fr	Fruit is utilized for treating kidney and urinary bladder troubles.	Spr, Smr, Aut	Freq	1	-	2-28
Cuscutaceae	UO-036	**Cuscuta reflexa*Roxb.	**Amar Bail**	Cb	Wp	Whole plant is used to cure jaundice, diarrhea, knee pain and diabetes. It also controls urine and purifies blood. Extract of plant is also essential in treating skin diseases.	Th Yr	Ocas	1, 6, 7, 9-11, 22, 25	2, 5, 27	3, 4, 8, 12-21, 23, 24, 26, 28
Cyperaceae	UO-037	*Cyperus rotundus* L.	**Murak**	Sg	Wp	Local inhabitants utilize the plant to cure fever, dysentery, diarrhea and cholera.	Spr, Smr, Aut	Abnt	1, 10	25, 26	2-9, 11-24, 27, 28
Caryophyllaceae	UO-038	**Stellaria media* (L.) Vill.	**Pan Booti**	Hb	Wp	Apply for body swelling, pain and broken bones. It also used to treat respiratory disorders like asthma, bronchitis and congestion. Local people also given in constipation, skin disorders, insects bite.	Spr, Aut, Wnt	Freq	4	10,11,	1-3, 5-9, 12-28
Euphorbiaceae	UO-039	**Chrozophora tinctoria* (L.) Raf.	**Hathi Sundi, Chutakki**	Hb	Sd, Rt	The plant has poisonous action. Its seeds cause vomiting. Root is used to treat children cough.	Th Yr	Comn	6, 10, 14	2	1, 3-5, 7-9, 11-13, 15-28
Caryophyllaceae	UO-040	*Croton bonplandianus* Baill.	**Jamal Ghoota**	Hb	Wp	For the treatment of fever and wounds.	Spr, Aut, Wnt	Ocas	10	2	1, 3-9, 11-28

Euphorbiaceae	UO-041	*Euphorbia helioscopia* L.	**Chadni**	Hb	St, Sd	Latex is applied tropically as ointment against ring worms. Seeds are utilized for treatment of cholera.	Th Yr	Freq	11,13,14	2, 4, 8, 10, 15, 25	1, 3, 5-7, 9, 12, 16-24, 26-28
	UO-042	*Ricinus communis* L.	**Arind**	Hb	Sd	Seed oil is used for constipation, jaundice and abdominal pain.	Th Yr	Ocas	3, 20, 23-25, 27	1, 6, 11, 12, 15	2, 4, 5, 7-10, 13, 14, 16-19, 21, 22, 26, 28
	UO-043	*Alhagi maurorum* Medik.	**Jawanh**	Hb	Wp	Used for blood purifier, expectorant, gastric disorder, kidney stone and pain relief.	Th Yr	Ocas	2, 6, 18, 20, 27	10, 26, 28	1, 3-5, 7-9, 11-17, 19, 21-25
Fabaceae	UO-044	**Lathyrus aphaca* L.	**Jangali Matar, Matri**	Hb	Wp	Seeds oil or paste is applied for healing of wounds and also grazed by cattle.	Spr, Aut, Wnt	Comn	2, 25	-	1, 3-24, 26-28
Fabaceae Fumariaceae	UO-045	*Melilotus indica* (L.) All.	**Sinji**	Hb	Wp	This plant is used to cure various body swellings and pain.	Th Yr	Freq	2	-	1, 3-28
	UO-046	*Trifolium alexandrinum* L.	**Barseen**	Hb	Lv	Local people applied this plant to increase milk production in animals and also used as fodder.	Spr, Aut, Wnt	Abnt	2	-	1, 3-28
	UO-047	**Vicia sativa* L.	**Jangli Mater**	Hb	Wp	Seeds are used to treat fever and this plant also grazed by animals.	Spr, Aut, Wnt	Comn	2, 25	-	1, 3-24, 26-28,

	UO-048	*Fumaria indica* (Hausskn) Pugsley	**Pitpapra**	Hb	Wp	Decoction of the plant is given in fever, malaria, typhoid, blood purification and allergic reactions.	Spr, Aut, Wnt	Comn	11, 14, 15, 20	2, 3, 12, 13, 16, 21, 22	1, 4, 5-10, 17-19, 23-28
	UO-049	**Mentha spicata* L.	**Podeena**	Hb	Wp	Leaves mainly cure vomiting, cholera and other stomach troubles.	Th Yr	Comn	4, 16	19, 25	1-3, 5-15, 17, 18, 20-24, 26-28
Fumariaceae	UO-050	*Salvia plebeia* R. Br.	**Samunder Sokh, Kunri**	Hb	Wp	The whole plant extract is the best remedial measure against leucorrhea, diarrhea, gonorrhea, & other sexual disorders.	Spr, Aut, Wnt	Rare	2	-	1, 3-28
Malvaceae	UO-051	*Abutilon indicum* (L.) Sweet.	**Pattaka**	Hb	Wp	This indigenous plant is utilized for the treatment of inflammation and toothache.	Th Yr	Freq	4, 8, 21, 25, 26	2, 28	1, 3, 5-7, 9-20, 22-24, 27
	UO-052	**Malva neglecta* Wallr	**Khobazi**	Hb	Lv	Leaves are used as anti-purgative.	Th Yr	Comn	11, 14, 20	18	1-10, 12, 13, 15-17, 19, 21-28
Malvaceae Oxalidaceae	UO-053	*Malvestrum coromendelianum* (L.) Garck.	**QatalBoti**	Hb	Lv,Fl	Leaves are utilized by local communities to treat cough and dysentery.	Th Yr	Freq	2, 3, 25	4	1, 5-24, 26-28
	UO-054	*Oxalis corniculata* L.	**Khati Meethi**	Hb	Wp	Herb relieves stomach problems, fever and acute headache. Sap of plant is vital for skin infection.	Th Yr	Abnt	3, 4, 11, 16, 21, 24, 25	12, 14, 15	1, 2, 5-10, 13, 17-20, 22, 23, 26-28

	UO-055	*Cymbopogon jawarancusa* (Jomes) Schul.	**Lemon Grass**	Gs	Wp	Plant is effective for flu, cough, fever&cold. Considered as diuretic and antiseptic. Leaves are important remedy for reducing cholesterol level, obesity and increases platelets.	Th Yr	Freq	6, 13	17	1-5, 7-12, 14-16, 18-28
Oxalidaceae	UO-056	*Cynodon dactylon* (L.) Pers.	**Ghaa**	Gs	Wp	Controls fever, pimples on face, bleeding from nose and purifies blood, also possessing antiseptic properties.	Th Yr	Abnt	1, 4, 6, 11, 13-15, 18, 21, 24, 25	-	2, 3, 5, 7-10, 12, 16, 17, 19, 20, 22, 23, 26-28
Poaceae Plantaginaceae	UO-057	*Dactyloctenium aegyptium* (L.) Wild.	**Madhana**	Gs	Wp	Seeds are used to treat typhoid fever. Commonly utilized as fodder plant.	Th Yr	Abnt	9	-	1-8, 10-28
	UO-058	*Desmostachya bipinnata* (L.) Stapf.	**Dhab**	Gs	Lv, Rt	Leaves are helpful to cure fever. Roots are used for treatment of cholera. Roots are ground with water and little amount of milk given during painful urination and piles.	Th Yr	Abnt	1, 4, 22	27	2, 3, 5-21, 23-26, 28
	UO-059	*Saccharum bengalense* Retz.	**Kana**	Gs	Rt,St	Roots are useful in diuretic and stem as refrigerant agent.	Th Yr	Abnt	11,18	-	1-10, 12-17, 19-28
	UO-060	**Veronica anagallis-aquatica* L.	**AabiBooti, Water Speedwell**	Hb	Wp	Whole plant is utilized for the treatment of scurvy, diuretic, ulcer and healing of wounds.	Spr, Aut, Wnt	Comn	2	-	1, 3-28
	UO-061	**Polygonum plebeium* R. Br.	**Warrank**	Hb	Wp	This plant plays an important role for treating pneumonia, cough and fever.	Spr, Smr, Aut	Ocas	9	2	1, 3-8, 10-28

Plantaginaceae	UO-062	**Rumex dentatus* L.	**Jangli Palk**	Hb	Lv	Extract of leaves is used for treating skin diseases, healing of wounds.	Th Yr	Freq	11	2, 4, 12, 22, 24	1, 3, 5-10, 13-21, 23, 25-28
Portulacaeae Primulaceae	UO-063	**Portulaca oleraceae* L.	**Lunak**	Hb	Wp	Hakims used the herb to cure constipation, kidney &urinary bladder problems, jaundice, typhoid, skin allergy and male sexual disorders. It also regulates menstrual cycle and have diuretic properties.	Th Yr	Ocas	2, 11, 19	16, 28	1, 3, 4-10, 12-15, 17, 18, 20-27
	UO-064	*Anagallis arvensis* L.	**Neeli Boti**	Hb	Wp	Whole plant cures inflammation, liver and kidney disorders and improves eyesight. Leaves are used tropically in healing of wounds.	Spr, Aut, Wnt	Ocas	4, 8, 14, 21, 25	2	1, 3, 5-7, 9-13, 15-20, 22-24, 26-28
Ranunculaceae	UO-065	*Ranunculus muricatus* L**.**	**Gul-a-Lala**	Hb	Wp	The whole plant is applied for the treatment of asthma.	Spr, Aut, Wn	Freq	2, 4, 14	,12, 22, 24, 25	1, 3, 5-11, 13, 15-21, 23, 26-28
Scrophulariaceae	UO-066	**Verbascum thapsus* L.	**Gider Tambacoo**	Hb	Wp	Plant is utilized tropically on piles, skin infection, allergies diarrhea, dysentery, lung congestion, urine tract infection. Leaves increase lactation in females, local inhabitants utilized the plant to give their domestic animals as fodder crop and the milk utilized contains properties of increasing milk production in females.	Spr, Aut, Wnt	Comn	2, 11, 22, 23, 25	21	1, 3, 4-10, 12-20, 24, 26-28

Solanaceae	UO-067	**Physalis minima* L.	**Mamulra**	Hb	Fr, St,Lv	Leaves extract is the best remedy for body inflammations and have anti- microbial activity. Extract of fruit is used for treating malarial fever.	Spr, Aut, Wnt	Comn	14	-	1-13, 15-28
Scrophulariaceae	UO-068	*Datura innoxia* Mill	**Datura**	Hb	Fr, Lv, St	Leaves decoction is utilized to cure flu, cold, cough and joint pain. Fruit extract is utilized to treat male sexual disorders.	Th Yr	Ocas	1, 5, 6, 8, 11, 15	-	2-4, 7, 9, 10, 12-14, 16-28
Solanaceae Verbenaceae	UO-069	*Solanum nigrum* L.	**Maku**	Hb	Wp	Traditional practioners utilized the plant for the treatment of Hepatitis B and C, also regulates menstrual cycle and in liver troubles. Also possesses diuretic property.	Th Yr	Freq	1-3, 9, 12, 14, 15, 18, 24	6, 11, 21, 28	4, 5, 7, 8, 10, 13, 16, 17, 19, 20, 22, 23, 25-27
	UO-070	**Solanum surettense* Burm.f.	**Kadiari**	Hb	Wp	Fruit of the plant is usedfor killing intestinal worms & also to treat cough, asthma, chest pain and toothache. It also lessens joint pain, headache and skin problems.	Th Yr	Comn	8, 11, 14, 18, 27	3, 5, 21, 28	1, 2, 4, 6-10, 12, 13, 15-17, 19, 20, 22-26
	UO-071	**Withania somnifera* (L.) Dunal	**Asghand**	Hb	Wp	Plant is used against rheumatic pain, body swellings and tumors.	Th Yr	Comn	11, 14, 26	1, 3, 6, 9, 28	2, 4, 5,7, 8, 10, 12, 13, 15-25, 27
	UO-072	*Phyla nodiflora* (L.) Greene.	**JalBooti**	Hb	Wp	Floral stalk is used to cure fever, cough and piles and improve digestion in children.	Spr, Aut, Wnt	Comn	2	-	1, 3-28

	UO-073	*Fagonia indica* Burm.f.	**Dhamasa**	Hb	Wp	The extract of plant is administrated to both man and women for sexual vitality and in children against anemia.	Th Yr	Comn	5, 14, 15, 18	2	1, 3, 4, 6-13, 16, 17, 19-28
Verbenaceae	UO-074	*Peganum harmala* L.	**Hermal**	Hb	Wp	Seeds had narcotic, antiseptic and stimulant actions. Extract of seeds is used to treat colic, fever, joint and backbone pain.	Spr, Aut, Wnt	Comn	5, 7, 9, 14, 15, 17, 20	18, 19	1-4, 6, 8, 10-13, 16, 21-28
Zygophyllaceae	UO-075	**Tribulus terrestris* L.	**Bhakra**	Hb	Wp	Local inhabitants utilized this plant for kidney and urinary bladder troubles. Seeds also cure cough and bleeding from nose.	pr, Aut, Wnt	Ocas	5, 6, 8, 14	2, 3, 9, 11, 15, 18, 20	1, 4, 7, 10-13, 16, 17, 19, 21-28

KEYS: Habit: Hb; herb, Sb; shrub,Cb; climber, Sg; Sedge, Gs; grass. **Part used:** Rt; roots, St; shoots, Sk; spike, Lv; leaves, Sd; seeds,Fl; flowers, Fr; fruits, Wp; whole plant. **Jaccard Comparison:** RDS; plant reported with dissimilar use, RS; plant reported with similar use, NR; non-reported plant species. 1 (Akram *et al.* 2011), 2 (Zareen *et al.* 2013), 3 (Qureshi *et al.* 2009), 4 (Ahmad *et al.* 2014), 5 (Yousaf *et al.* 2004), 6 (Qureshi *et al.* 2011), 7 (Qureshi *et al.* 2007), 8 (Ajaib *et al.* 2014), 9 (Yousaf 2014), 10 (Umair *et al.* 2019), 11 (Sher *et al.* 2011), 12 (Razzaq *et al.* 2010), 13 (Murad *et al.* 2013), 14 (Iqbal *et al.* 2014), 15 (Khan *et al.* 2018), 16 (Tareen *et al.* 2016), 17 (Noman *et al.* 2013), 18 (Tareen *et al.* 2010), 19 (Jan *et al.* 2016), 20 (Sarangzai *et al.* 2013), 21 (Raja *et al.* 2020), 22 (Shaheen *et al.* 2017), 23 (Ahmad *et al.* 2017), 24 (Furqan *et al.* 2019), 25 (Amjad *et al.* 2020), 26 (Hameed *et al.* 2017), 27 (Hussain *et al.* 2012), 28 (Memon *et al.* 2008)

All the plants reported in this study are wild and endemic to area to the area. *species are in IUCN red list.

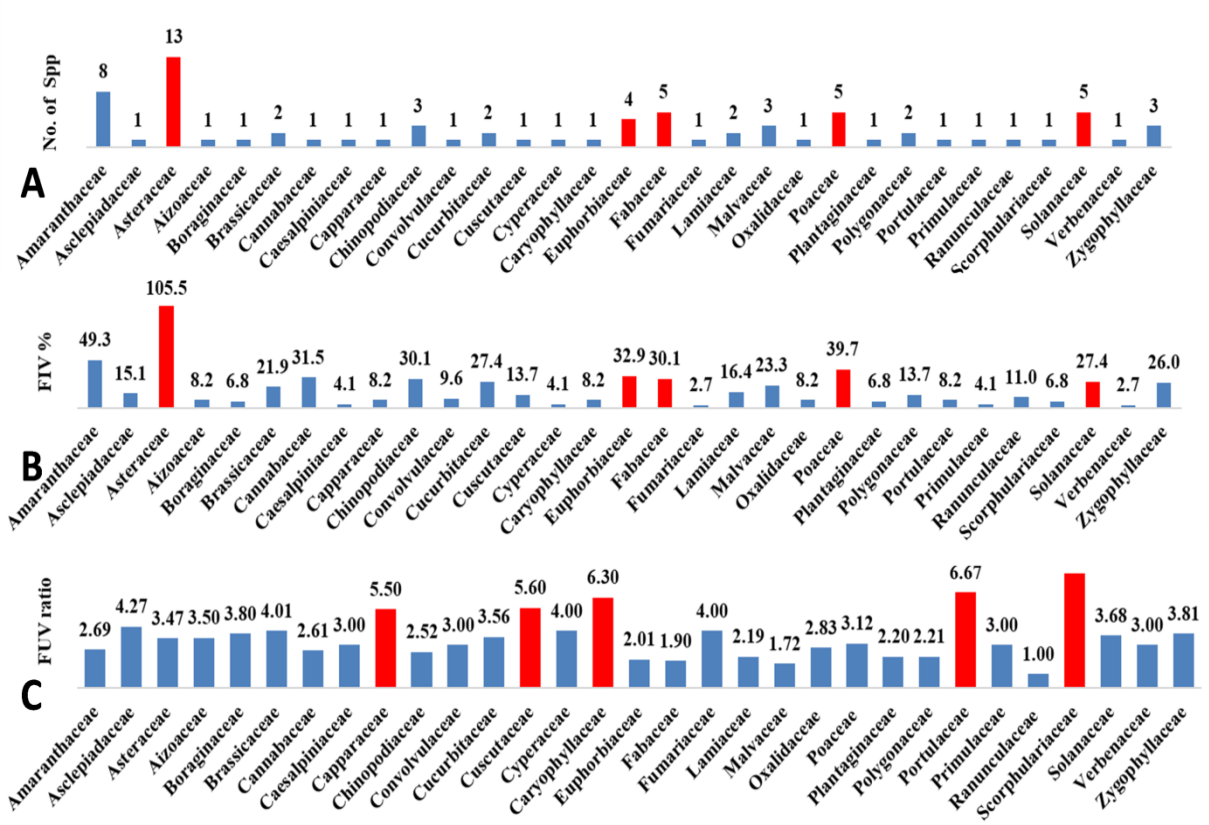

Figure 4. Red bars showing the families with peak values A. Comparative species frequency of reported families B. Family Importance value (FIV), C. Use value of plant families (FUV)

Status of traditional knowledge regarding medicinal plants

Local nomenclature

Local naming system is well recognized in the particular area for the native biota including flora fauna and fungi etc. It is the key for ethnobotanical interview process and data collection. The indigenous knowledge primarily based on vernacular nomenclature hence, regarded as the basic criteria of an ethnobiological research. Their name in local dialects reflects a large spectrum of information on their understanding of plants according to general appearance, habit, habitat, growth or any beneficial economic use of that plant (Singh 2008; Abbas *et al.* 2016). In the present survey, *Cestrum nocturnum* is known as *Raat ki Rani* means flowers bloom at night, and *Oxalis corniculata* is famous as *Khatti Meethi* due to its sour taste. Similarly, plant habit also effects its local nomenclature as due to aquatic habitat of *Veronica anagallis-aquatica* is familiar as *Aabi Booti* and due to thorny habit of *Solanum xanthocarpum* is known as Kandyara. Moreover, white fruit and flower colour of *Morus alba* and *Rosa alba* give them characteristic name of sufaid toot and sufaid gulab respectively.

Habit, part used, drug formulation and mode of administration

The predominant habit of cited flora was herbaceous (65 spp., 86%) followed by grasses (7 spp., 9.21%), climbers (3 spp., 4%) and sedges (1 sp., 1.3%) (Figure 5A). Previous ethnobotanical literature also reported the most of medicinally valuable species as herbs (Bibi *et al.* 2022; Birjees *et al.* 2022) They contribute a significant role in shaping the phyto-cultural diversity of rural traditional medicines (Ahmad *et al.* 2014; Bibi *et al.* 2022). Variety of plant parts was utilized to treat different ailments; however, whole plant (82%) was frequently used. Whereas the consumption of other plant materials was recorded as leaves (11%), roots (7%), inflorescence (3%), flowers (3%), latex (3%) and stem (1.31%) (Figure 5B). In drug recipes, decoction form (31%) was commonly consumed followed by powder (29%), extraction (21%) and paste (14%). Remaining species were used in the form of infusion (4%), oil extract (1 %) and as concoction (0.6%) (Fig 5C). Other ethnomedicinal studies of Pakistan supported decoction as most used preparation method (Wali *et al.* 2021; Rehman *et al.* 2023). These crude drugs were administered orally (63%), orally and topically (30%), and topically (5%), while as eye drop was only (2%) (Figure 5D).

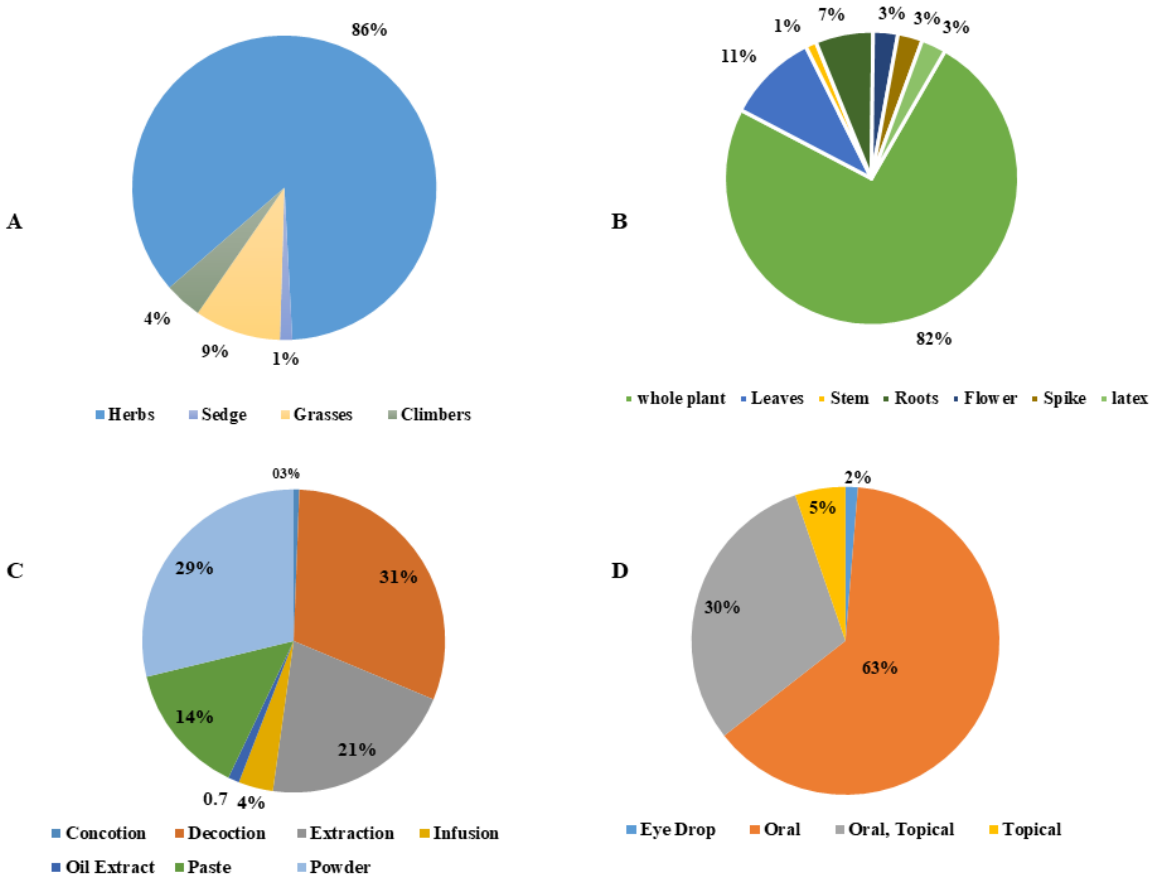

Figure 5. A. Depiction of plant habits from study area B. Percentage of medicinal uses of various plant parts, C. Drug recipes of D. Mode of administration

Ethnopharmacological Properties

The documented ethnomedicinal plants were used to treat 40 different ailments which were grouped in 10 categories following Farooq *et al.* (2019) and Umair *et al.* (2020). The highest numbers of ethnomedicinal species were used to treat fever (43 species), gastrointestinal (40 species), urinary (23 species), and dermal disorders (23 species). The results were in accordance to previously published ethnomedicinal literature of Punjab (Qureshi *et al.* 2011; Yousaf *et al.* 2014; Akram *et al.* 2009). Qureshi *et al.* (2011) and Umair *et al.* (2019) also documented gastrointestinal disorders among most treated diseases around Chenab river areas. Possible factors behind these diseases might be unhygienic conditions of the rural areas people heed no attention towards the cleanliness which leads to gastrointestinal disorders.

Present studies also accounted higher number of ethnomedicinal plants utilization against above stated disorders. However, least numbers of species were reported for nervous disorders and auditory problems (1 species each). ICF values were determined to ascertain the level of agreement among the informants of the study area communities regarding the plant use against particular disease categories. The highest ICF was reported for nervous disorders and hearing problem i.e. 1.00, whereas lowest for sexual disorders i.e. 0.83 (Figure 6). The overall reported ICF values were quite close to 1 which showed the homogeneity among the reported traditional knowledge of study area communities. As the value moves from 1 to 0, it reflects the least agreement between informants regarding therapeutic uses for reported plants (Ssenku *et al.* 2022).

Fidelity Level for fever disease category was recorded maximum (FL100) for *Alternanthera philoxeroides, A. sessilis, Eclipta alba, Launaea procumbens Parthenium hysterophorus, Melilotus indica, Trifolium alexandrinum, Vicia sativa* and *Dactyloctenium aegyptium*. Moreover, gastrointestinal disorders showed maximum (FL. 100) for *Amaranthus spinosus*, *Digera muricata*,*Carthamus oxycantha, Chenopodium murale*, *Mentha spicata* and *Malva neglecta.* In dermal and urinary tract infection highest FL values was scored by *Suaeda fruticosa , Lathyrus aphaca* and *Rumex dentatus* (Fl. 100 each) and for UTI *Cucumis melo* (FL. 100) for respiratory infections FL was highest for *Chrozophora tinctoria* and *Ranunculus muricatus* (100 each). Sexual Disorders had highest FL for *Fagonia indica* (FL.100) while in hepatic disorders *Sonchus oleraceus, A. punjans. Cassia occidentalis* (FL. 100 each). Many ethnomedicinal studies revealed that if a plant is possessing highest FL

values it means that it is the most useful species in an area for particular disorders (Bibi *et al.* 2022). For muscular, nervous and auditory disorders none of the plant showed FL 100 %. *Withania somnifera* showed maximum FL (64) for muscular disorders. Similar findings were reported by another ethnomedicinal study of Punjab (Umair *et al.* 2019). Whereas, for nervous and auditory disorders, *Cannabis sativa* and *Cleome viscosa* respectively showed highest fidelity values. This depicted that these medicinal categories had less popularity in the area for herbal treatments (Bibi *et al.* 2022).

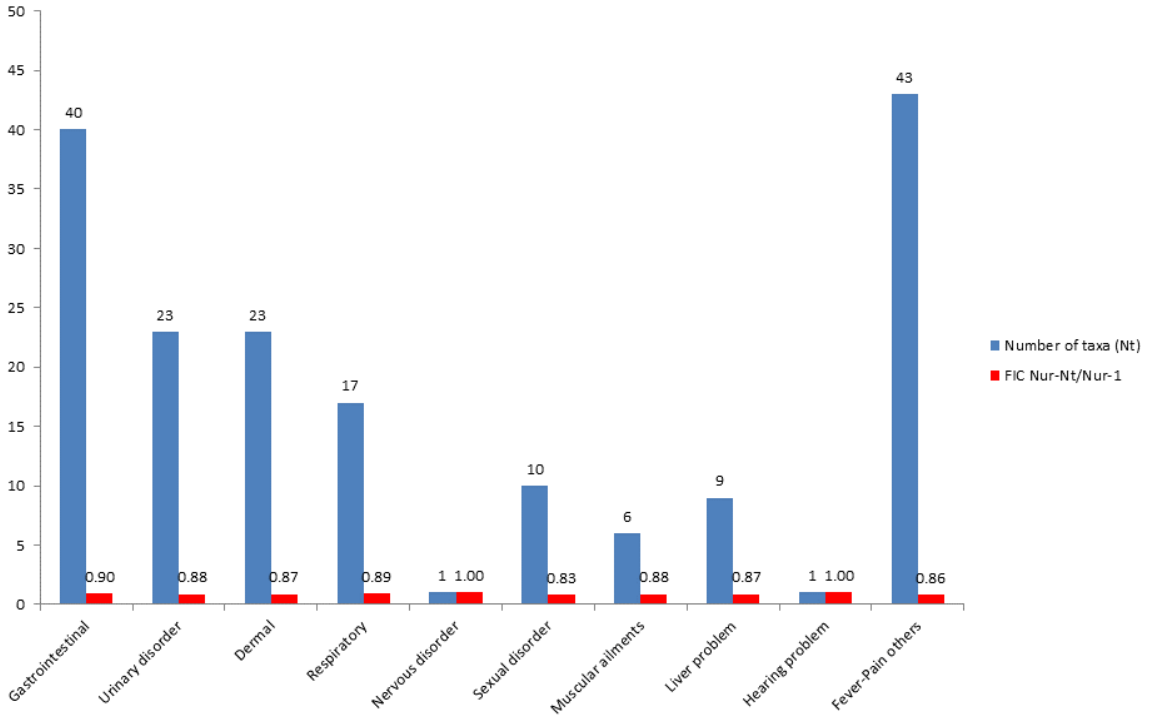

Figure 6. Number of taxa used for different health disorders along with ICF

The relative popularity level (RPL) and rank of popularity (ROP) indices were computed to ensure the data dependability and verified FL statistical values of the plants. When FL cannot explain related or identical data or values over 50%, RPL is employed as an input parameter. RPL runs from 0 to 1, with 0 being the lowest and 1 highest. If its value is one or close to it, it shows that plant species is often used to treat the ailment and vice versa (Umair *et al.* 2017). These two tools are used to determine local disease-curing effectiveness (Rehman *et al.* 2017). Relative Popularity Level was recorded lowest for *Suaeda fruticosa* (0.11), *Cannabis sativa* and *Ranunculus muricatus* (0.13 each) while *Fumaria indica* (5), *Solanum surettense* (2.5) and *Phyla nodiflora*, *Alhagi maurorum* and *Achyranthus aspera* (2 each). The prevalence of recurrent health problems especially gastric disorders recorded were due to poor hygiene and food selection and other climatic conditions (Bibi *et al.* 2022; Abbasi *et al.* 2010; Abbas *et al.* 2016; Waheed *et al.* 2023).

The highest ROP against fever and gastrointestinal disorders was recorded for *Achyranthus aspera* (ROP.167). For urinary tract infection highest ROP values were shown by *Achyranthus aspera* (ROP 83) for dermal disorders, it was maximum in *Fumaria indica* (ROP. 100), for respiratory infections ROP was highest for *Alhagi maurorum* (ROP 83) in sexual disorders for *Fagonia indica* (ROP 100), for hepatic disorders *Cassia occidentalis* (ROP. 56), for muscular disorders *Solanum surettense* (ROP. 94), nervous and auditory disorders showed highest values for *Cannabis sativa* (ROP. 5) and *Cleome viscosa* (ROP. 16) respectively. Most of the plants showing high fidelity also exhibited high ROP values indicated a strong positive correlation.

Impact of geographical and cultural factors on medicinal plants utilization

RFC is the quantitative indicator of a plant's popularity among the informants. Results reported that *Cannabis sativa* (0.315) *Taraxacum officinale* (0.260), *Citrullus colocynthus* (0.15) were the most familiar plants to the communities of study area (Table 4). Higher RFCs values indicated about its widespread knowledge among the local communities. A plant could be popular in the area due to its easy availability and abundance (Bibi *et al.* 2022). The utilization significance of species in the community was calculated by use value (UV) (Kushwaha *et al.* 2018). The maximum use value was observed for 3 plant species out of 75. i.e., *Launaea procumbens* (11), *Verbascum thapsus,* (8) and *Aerva javanica* (7). It endorses the frequently utilization from the study area for a particular purpose (Bibi *et al.* 2022). While 12 plant species were observed least use value (0.013), this might be due to their fewer benefits or rare abundance (Table 4). Relative Importance (RI) indicated the use of plant species for the treatment of various body systems (Yaseen *et al.* 2015). Three plants, i.e. *Achyranthus aspera* (91.7)*, Cuscuta reflexa* (76.7) and *Stellaria media* (73.3) possessed maximum RI values (treated the 5 body systems out of 6) (Table 4). However, 13 plant species exhibited least RI values (13.3) i.e. *Alternanthera philoxeroides, A. sessalis, Amaranthus spinosus, Digera muricata, Carthamus oxycantha, Launaea procumbens, Suaeda fruticosa, Lathyrus aphaca, Trifolium alexandrinum, Vicia sativa, Malva neglecta, Dactyloctenium aegyptium* and *Ranunculus muricatus* were used to treat only 1 body system (Table 4). The Pearson correlation between UV and RFCs showed insignificant positive correlation ($R^2 = 0.0008$). These indices are independent of each other concerning ethnomedicinal knowledge of the communities residing along the River Sutlej (Figure 7 A). It can be concluded that availability of a plant species could be the reason of its popularity among people, but RFCs did not show the medicinal values of that species, it could only be analyzed by Use Value (Bibi *et al.* 2022). However, a significant positive relationship was observed between UV and RI i.e., $R^2 = 0.503$. Both of these indices reported value of a particular plant on the basis of the number of uses attributed to it. Therefore, results positive correlation among them suggested that they could be used interchangeably to evaluate local knowledge of a given resource (Albuquerque *et al.* 2006) (Figure 7 B).

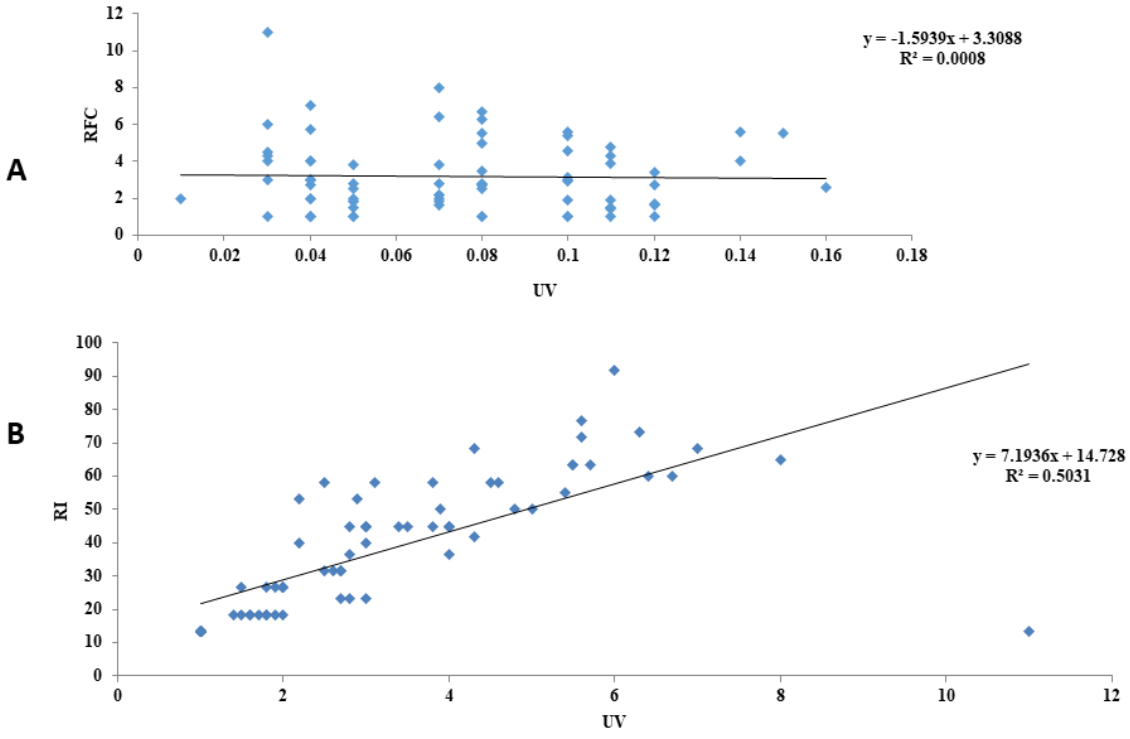

Figure 7. A Pearson correlation between UV and RFCs showing insignificant relationship B. Pearson correlation between UV and RI showing significant positive relationship

Table 4. Quantitative indices calculated for the documented taxa of Indo-Pak border of Deplapur, Pakistan.

Botanical Name	FC	RFC	UV	RI	FL										ROP										
					Gastrointestinal	urinary disorder	Dermal	Respiratory	Nervous Disorders	Sexual Disorders	Muscular ailments	Liver problem	Hearing problems	Fever-Pain other	RPL	Gastrointestinal	urinary disorder	Dermal	Respiratory	Nervous Disorders	Sexual Disorders	Muscular ailments	Liver problem	Hearing problems	Fever-Pain other
Achyranthus aspera L.	2	0.03	6	91.7	33	17	17	0	0	0	0	0	0	33	5.00	167	83	83	0	0	0	0	0	0	167
Aerva javanica (Burm.f.) Juss. Ex Schult.	3	0.04	7	68.3	38	24	14	0	0	14	0	0	0	10	1.40	53	33	20	0	0	20	0	0	0	13
Alternanthera philoxeroides (Mart.) Griseb.	6	0.08	1	13.3	0	0	0	0	0	0	0	0	0	100	0.17	0	0	0	0	0	0	0	0	0	17
A. punjans Kunth.	5	0.07	2	18.3	0	0	0	0	0	0	0	50	0	50	0.40	0	0	0	0	0	0	0	20	0	20
A. sessilis (L.) DC	7	0.10	1	13.3	0	0	0	0	0	0	0	0	0	100	0.14	0	0	0	0	0	0	0	0	0	14
Amaranthus spinosus L.	3	0.04	1	13.3	100	0	0	0	0	0	0	0	0	0	0.33	33	0	0	0	0	0	0	0	0	0
A. viridis L.	6	0.08	2.5	58.3	47	20	0	0	0	20	13	0	0	0	0.83	39	17	0	0	0	17	11	0	0	0
Digera muricata (L.) Mart.	4	0.05	1	13.3	100	0	0	0	0	0	0	0	0	0	0.25	25	0	0	0	0	0	0	0	0	0

Calatropis procera R. Br.	2	0.03	4.3	68.3	45	0	26	30	0	0	0	0	0	0	0.64	28	0	16	19	0	0	0	0	0	0
Ageratum conyzoides L.	7	0.10	5.6	71.7	28	21	23	0	0	0	23	0	0	5	0.86	24	18	20	0	0	0	20	0	0	4
Carthamus oxycantha M.Bieb.	2	0.03	1	13.3	100	0	0	0	0	0	0	0	0	0	0.50	50	0	0	0	0	0	0	0	0	0
Cirsium arvense (L.) Scop.	5	0.07	1.6	18.3	0	0	0	0	0	38	63	0	0	0	0.40	0	0	0	0	0	15	25	0	0	0
Conyza canadensis L.	8	0.11	4.3	41.7	56	0	0	44	0	0	0	0	0	0	0.63	35	0	0	28	0	0	0	0	0	0
Conyza bonariensis L.	3	0.04	3	45	44	56	0	0	0	0	0	0	0	0	1.33	59	74	0	0	0	0	0	0	0	0
Cotula hemispherica Roxb.	8	0.11	1.4	18.3	45	0	0	0	0	0	0	0	0	55	0.25	11	0	0	0	0	0	0	0	0	14
Eclipta alba (L.) Hassk.	3	0.04	2	26.7	0	0	0	0	0	0	0	0	0	100	0.67	0	0	0	0	0	0	0	0	0	67
Launaea procumbens (Roxb.) Ramayya & Rajagopal	2	0.03	11	13.3	0	0	0	0	0	0	0	0	0	100	0.00	0	0	0	0	0	0	0	0	0	0
Parthenium hysterophorus L.	4	0.05	1.8	26.7	0	0	0	0	0	0	0	0	0	100	0.50	0	0	0	0	0	0	0	0	0	50
Sonchus asper (L.) Hill.	6	0.08	5	50	0	0	53	0	0	0	0	0	0	47	0.83	0	0	44	0	0	0	0	0	0	39
Sonchus oleraceus L.	7	0.10	2.9	53.3	40	25	0	0	0	0	0	35	0	0	0.57	23	14	0	0	0	0	0	20	0	0
Taraxacum officinale Weber.	7	0.10	3.1	58.3	0	51	0	0	0	0	0	0	0	49	0.26	0	13	0	0	0	0	0	0	0	13

Xanthium strumarium L.	3	0.04	2.7	31.7	0	63	0	0	0	0	0	0	0	38	1.00	0	63	0	0	0	0	0	0	38
Trianthema portulacastrum L.	6	0.08	3.5	45	0	0	0	33	0	33	0	0	0	33	0.67	0	0	0	22	0	22	0	0	0	22
Heliotropium europaeum L.	5	0.07	3.8	58.3	0	32	32	0	0	0	0	21	0	16	1.00	0	32	32	0	0	0	0	21	0	16
Cleome viscosa L.	7	0.10	4.6	58.3	38	0	0	0	0	28	0	0	22	13	0.71	27	0	0	0	0	20	0	0	16	9
Nansturtium officinale W.T.Aiton	9	0.12	3.4	45	52	0	0	0	0	0	0	0	0	48	0.44	23	0	0	0	0	0	0	0	0	22
Cannabis sativa L.	12	0.16	2.6	31.7	50	0	0	0	42	0	0	0	0	8	0.13	7	0	0	0	5	0	0	0	0	1
Cassia occidentalis L.	3	0.04	3	23.3	44	0	0	0	0	0	0	56	0	0	1.00	44	0	0	0	0	0	0	56	0	0
Capparis decidua (Forssk.) Edgew.	6	0.08	5.5	63.3	27	0	0	24	0	0	30	0	0	18	1.00	27	0	0	24	0	0	30	0	0	18
Chenopodium album L.	8	0.11	4.8	50	47	53	0	0	0	0	0	0	0	0	0.63	30	33	0	0	0	0	0	0	0	0
Chenopodium murale L.	5	0.07	1.8	18.3	100	0	0	0	0	0	0	0	0	0	0.40	40	0	0	0	0	0	0	0	0	0

Suaeda fruticose Forssk. ex J. F. Gmel	9	0.12	1	13.3	0	0	100	0	0	0	0	0	0	0	0.11	0	0	11	0	0	0	0	0	0
Convolvulus arvensis L.	7	0.10	3	40	0	0	0	0	0	52	0	0	0	48	0.43	0	0	0	0	0	22	0	0	0	20
Citrullus colocynthis (L.) Schrad.	11	0.15	5.5	63.3	42	0	0	33	0	0	0	0	0	25	0.55	23	0	0	18	0	0	0	0	0	14
Cucumismelo var. agrestis Naudin.	9	0.12	1.7	18.3	0	100	0	0	0	0	0	0	0	0	0.22	0	22	0	0	0	0	0	0	0	0
*Cuscuta reflexa*Roxb.	10	0.14	5.6	76.7	21	30	20	0	0	0	0	29	0	0	0.70	15	21	14	0	0	0	0	20	0	0
Cyperus rotundus L.	3	0.04	4	36.7	50	0	0	0	0	0	0	0	0	50	1.33	67	0	0	0	0	0	0	0	0	67
Stellaria media (L.) Vill.	6	0.08	6.3	73.3	39	0	24	18	0	0	0	0	0	18	1.33	53	0	32	25	0	0	0	0	0	25
Chrozophora tinctoria (L.) Raf.	4	0.05	1.5	18.3	0	0	0	100	0	0	0	0	0	0	0.50	0	0	0	50	0	0	0	0	0	0
Croton bonplandianus Baill.	4	0.05	2	26.7	0	0	50	0	0	0	0	0	0	50	0.50	0	0	25	0	0	0	0	0	0	25
Euphorbia helioscopia L.	7	0.10	1.9	26.7	46	0	54	0	0	0	0	0	0	0	0.29	13	0	15	0	0	0	0	0	0	0
Ricinus communis L.	9	0.12	2.7	23.3	38	0	0	0	0	0	0	33	0	29	0.33	13	0	0	0	0	0	0	11	0	10

Alhagi maurorum Medik.	2	0.03	4.5	58.3	33	22	0	33	0	0	0	0	0	11	2.50	83	56	0	83	0	0	0	0	0	28
Lathyrus aphaca L.	4	0.05	1	13.3	0	0	100	0	0	0	0	0	0	0	0.25	0	0	25	0	0	0	0	0	0	0
Melilotus indica (L.) All.	3	0.04	2	26.7	0	0	0	0	0	0	0	0	0	100	0.67	0	0	0	0	0	0	0	0	0	67
Trifolium alexandrinum L.	7	0.10	1	13.3	0	0	0	0	0	0	0	0	0	100	0.14	0	0	0	0	0	0	0	0	0	14
Vicia sativa L.	6	0.08	1	13.3	0	0	0	0	0	0	0	0	0	100	0.17	0	0	0	0	0	0	0	0	0	17
Fumaria indica (Hausskn) Pugsley	2	0.03	4	45	0	0	50	0	0	0	0	0	0	50	2.00	0	0	100	0	0	0	0	0	0	100
Mentha spicata L.	8	0.11	1.9	18.3	100	0	0	0	0	0	0	0	0	0	0.25	25	0	0	0	0	0	0	0	0	0
Salvia plebeia R. Br.	4	0.05	2.5	31.7	40	20	0	0	0	40	0	0	0	0	0.75	30	15	0	0	0	30	0	0	0	0
Abutilon indicum (L.) Sweet.	6	0.08	2.7	31.7	56	0	0	0	0	0	0	0	0	44	0.50	28	0	0	0	0	0	0	0	0	22
Malva neglecta Wallr	3	0.04	1	13.3	100	0	0	0	0	0	0	0	0	0	0.33	33	0	0	0	0	0	0	0	0	0
Malvestrum coromendelianum (L.) Garck.	8	0.11	1.5	26.7	50	0	0	50	0	0	0	0	0	0	0.25	13	0	0	13	0	0	0	0	0	0
Oxalis corniculata L.	6	0.08	2.8	36.7	35	0	29	0	0	0	0	0	0	35	0.67	24	0	20	0	0	0	0	0	0	24

Cymbopogon jawarancusa (Jomes) Schul.	5	0.07	6.4	60	0	25	25	25	0	0	0	0	0	25	1.40	0	35	35	35	0	0	0	0	0	35
Cynodon dactylon (L.) Pers.	8	0.11	3.9	50	0	0	48	0	0	0	0	0	0	52	0.63	0	0	30	0	0	0	0	0	0	32
Dactyloctenium aegyptium (L.) Wild.	3	0.04	1	13.3	0	0	0	0	0	0	0	0	0	100	0.33	0	0	0	0	0	0	0	0	0	33
Desmostachya bipinnata (L.) Stapf.	4	0.05	2.8	45	55	27	0	0	0	0	0	0	0	18	1.00	55	27	0	0	0	0	0	0	0	18
Saccharum bengalense Retz.	9	0.12	1.6	18.3	50	50	0	0	0	0	0	0	0	0	0.22	11	11	0	0	0	0	0	0	0	0
Veronica anagallis-aquatica L.	5	0.07	2.2	53.3	36	36	27	0	0	0	0	0	0	0	0.80	29	29	22	0	0	0	0	0	0	0
Polygonum plebeium R. Br.	6	0.08	2.7	31.7	0	0	0	56	0	0	0	0	0	44	0.50	0	0	0	28	0	0	0	0	0	22
Rumex dentatus L.	4	0.05	1.8	18.3	0	0	100	0	0	0	0	0	0	0	0.50	0	0	50	0	0	0	0	0	0	0
Portulaca oleraceae L.	6	0.08	6.7	60	30	23	23	0	0	0	0	25	0	0	1.17	35	26	26	0	0	0	0	29	0	0
Anagallis arvensis L.	3	0.04	3	45	0	33	33	0	0	0	0	33	0	0	1.33	0	44	44	0	0	0	0	44	0	0
Ranunculus muricatus L.	8	0.11	1	13.3	0	0	0	100	0	0	0	0	0	0	0.13	0	0	0	13	0	0	0	0	0	0

Verba scumthapsus L.	5	0.07	8	65	28	25	23	25	0	0	0	0	0	0	1.60	44	40	36	40	0	0	0	0	0	0
Physalis minima L.	5	0.07	2.8	23.3	0	0	50	0	0	0	0	0	0	50	0.60	0	0	30	0	0	0	0	0	0	30
Datura innoxia Mill	4	0.05	3.8	45	0	0	0	40	0	40	0	0	0	20	1.00	0	0	0	40	0	40	0	0	0	20
Solanum nigrum L.	3	0.04	4	45	0	25	0	0	0	42	0	33	0	0	1.33	0	33	0	0	0	56	0	44	0	0
Solanum surettense Burm.f.	3	0.04	5.7	63.3	18	0	0	18	0	0	47	0	0	18	2.00	35	0	0	35	0	0	94	0	0	35
Withania somnifera (L.) Dunal	5	0.07	2.2	40	0	0	0	0	0	0	64	0	0	36	0.60	0	0	0	0	0	0	38	0	0	22
Phyla nodiflora (L.) Greene.	2	0.03	3	45	33	0	0	33	0	0	0	0	0	33	2.00	67	0	0	67	0	0	0	0	0	67
Fagonia indica Burm.f.	2	0.01	2	26.7	0	0	0	0	0	100	0	0	0	0	1.00	0	0	0	0	0	100	0	0	0	0
Peganum harmala L.	7	0.10	5.4	55	39	0	32	0	0	0	0	0	0	29	0.86	34	0	27	0	0	0	0	0	0	25
Tribulus terrestris L.	10	0.14	4	45	0	50	0	50	0	0	0	0	0	0	0.40	0	20	0	20	0	0	0	0	0	0

Quantitative Analysis: FC; frequency citation, RFCs; relative frequency citations, UV; use value, RI; relative importance, FL; fidelity level, RPL; Relative Popularity Level. ROP; rank order priority.

Novelty index (Jaccard Index (JI)

The present study has been evaluated with the already published ethnomedicinal literature. Recognized list of 75 ethnomedicinal plants of this study has been cross checked in the 28 published articles (Table 3). This evaluation supported to find out the exploitation variations of native plants existed across the diversity of areas and communities. This kind of differences and similarity is usually numerically calculated in terms of Jaccard Index (JI) by the ethnobotanists (Yaseen *et al.* 2015). In the contemporary study, the JI values ranged from 3.306 to 37.209 (Table 5). The highest values have been reported from the eight districts of Central Punjab (Zareen *et al.* 2013) followed by the Changa Manga Forest Punjab (Ahmad *et al.* 2014), District Karak KPK (Iqbal *et al.* 2014), Chenab Reverine area Punjab (Umair *et al.* 2019) and Buner District KPK (Sher *et al.* 2011) i.e.≥ 11.The higher JI value reflects the similarity in vegetation types of both areas due to similar geographic or climatic conditions (Farooq, 2019). The minimum JI has been calculated in the ethnomedicinal study of Azad Jamu and Kashmir i.e. 3.306 (Ahmed *et al.* 2017). In the terms of percentage similarity in plant usage, current documentation has shown the greater resemblances with ethnomedicinal data of eight district of Central Punjab i.e., Lahore, Faisalabad, Pakpattan, Narrowal, Sahiwal, Sialkot, Nankana Sahib and Vehari (Zareen *et al.* 2013) i.e. 37.209%.

Significant plants of the study with their novel uses

On comparison with previously published literature (Table 5) it was observed that twenty three (23) medicinal plants already have been reported in available literature but the current study accounts for their different medicinal uses i.e. *Alternanthera pungans, Digera muricata., Ageratum conyzoides*, *Cotula hemispherica, Eclipta alba, Sonchus oleraceus, Heliotropium europaeum, Cleome viscosa, Cassia occidentalis, Cucumis melo var. agrestis , Lathyrus aphaca, Melilotus indica, Trifolium alexandrinum, Vicia sativa, Salvia plebeia, Cynodon dactylon, Dactyloctenium aegyptium, Saccharum bengalense, Veronica anagallis-aquatica, Physalis minima, Datura innoxia,* and *Phyla nodiflora.* For example *Alternenthra pungens* was mostly used as fodder for cattles in previous ethnobotanical study of Punjab (Zareen *et al.* 2013) however, current study reported this plant as a cure of fever and jaundice (Table 3). Similarly, in previous literature i.e., Amjad *et al.* (2020); Zareen *et al.* (2013). *Lathyrus aphaca* valued as fodder with narcotic effects while local people of under study area utilized this plant for wound healing purpose (Table 3). This study accounts leaves to cure body inflammation and malarial fever whereas in other areas of Punjab it is also utilized to treat bleeding gums (Iqbal *et al.* 2014) (Table 3).

The current study also reports one (01) medicinal plant which has been rarely documented for its medicinal importance from the studied ethnomedicinal literature. i.e. *Alternanthera philoxeroides*. Overall this study reported *Phyla nodiflora*, *Datura innoxia*, *Solanum nigrum*, *Fumaria indica*, *Fagonia indica*, *Anagallis arvensis*, *Alhagi maurorum*, *Cymbopogon jawarancusa*, *Aerva javanica* and *Launaea procumbens*, as most potential medicinal plants in the view of local people of study area. Plants with medicinal uses and with higher UV could be recommended for further screening of bioactive compounds and their pharmacological activities. This could lead to the introduction of novel drugs.

Table 5. Novelty index of reported ethnomedicinal plants

Authors	Reported	Study area	Province	Total rep plant species=b	Total p with si uses	Total p with disi uses	Total sp common both are	c*100	a+b	(a+b)-c	JI
Akram *et al.*	2011	Sarghoda	Punjab	36	3	7	10	1000	111	101	10
Zareen *et al.*	2013	Central Punjab	Punjab	102	17	31	48	4800	177	129	37
Qureshi *et al.*	2009	Chakwal	Punjab	29	7	10	17	1700	104	87	20
Ahamd *et al.*	2014	Changa manga fore	Punjab	37	5	21	26	2600	112	86	30
Yousaf *et al.*	2004	Mianwali	Punjab	38	3	9	12	1200	113	101	12
Qureshi *et al.*	2011	Khushab	Punjab	48	6	10	16	1600	123	107	15
Qureshi *et al.*	2007	Mianwali	Punjab	21	1	6	7	700	96	89	8
Ajaib et al	2014	District Gujrat	Punjab	50	4	12	16	1600	125	109	15
Yousaf	2014	Khushab	Punjab	24	3	8	11	1100	99	88	13
Umair *et al.*	2019	Chenab Riverine are	Punjab	129	7	21	28	2800	204	176	16
Sher *et al.*	2011	Buner district	KPK	138	15	14	29	2900	213	184	16
Razzaq *et al.*	2010	District Shangla	KPK	50	7	3	10	1000	125	115	9
Murad *et al.*	2013	District Karak	KPK	58	3	8	11	1100	133	122	9

Iqbal *et al.*	2014	District Karak	KPK	38	7	16	23	2300	113	90	26
Khan *et al.*	2018	District Banu	KPK	47	8	9	17	1700	122	105	16
Tareen *et al.*	2016	Harnai	Balochistar	59	3	4	7	700	134	127	6
Noman *et al.*	2013	Ormara, Gawadar	Balochistar	31	3	1	4	400	106	102	4
Tareen *et al.*	2010	Kalat & Khuzdar	Balochistar	61	4	7	11	1100	136	125	9
Jan *et al.*	2016	Qila Abdullah	Balochistar	35	2	2	4	400	110	106	4
Sarangzai *et a*	2013	Ziarat district	Balochistar	90	2	8	10	1000	165	155	6
Raja *et al.*	2020	Muzaffarabad	AJK	50	3	7	10	1000	125	115	9
Shaheen *et al.*	2017	District Poonch	AJK	136	4	7	11	1100	211	200	6
Ahamd *et al.*	2017	Neelum Valley	AJK	50	1	3	4	400	125	121	3
Furqan *et al.*	2019	Dhirkot	AJK	140	5	9	14	1400	215	201	7
Amjad *et al.*	2020	Harighal	AJK	150	6	18	24	2400	225	201	12
Hameed *et al.*	2011	Cholistan desert	Sindh	58	3	7	10	1000	133	123	8
Hussain *et al.*	2012	Mirpurkhas	Sindh	53	4	4	8	800	128	120	7
Memon *et al.*	2008	Dadu & Jamshoro	Sindh	30	8	2	10	1000	105	95	11

Conservation aspects

Availability of these species was varying in different seasons however, most of the species (30%) were available throughout the year, whereas about 25% spp. were available in autumn and about 21% spp. were available in the spring, 15% spp. in winter while only 9% spp. were available in the summer season due to harsh and hot climate (Figure 8 A). Estimation for the relative abundance of plant species showed that most of the species were growing occasionally about 28% followed by commonly growing spp. 24%, abundantly growing spp. 22%, frequently growing spp. 21% and rarely growing spp. 5% only (Fig 8 B). Comparison among the percentage of the relative abundance of wild species showed very less difference among occasional, common, abundant and frequent presence of plants. In addition, 24 listed medicinal plants species (Table 3) have reported as threatened species worldwide by IUCN red list (https://www.iucnredlist.org). This exhibited the negative impact of community behavior towards plant resources. Other ethnobotanical studies from all over Pakistan also showed that medicinal plants are under continuous threat of being loss (Majid *et al.* 2020; Shah *et al.* 2020; Shinwari *et al.* 2010; Ali *et al.* 2012; Qureshi *et al.* 2009). Extending urbanization, unsustainable use, agricultural encroachments and mismanaged grazing may be the potential factors behind the low vegetation cover (Tahir *et al.* 2023). This also urges to devise long term conservation strategies for the local vegetation of the river ecosystem along with the associated information. The effective approaches could be control of human interventions for deforestation. Development of home gardens and protected areas, plantation in mosques and churches areas, reforestation or afforestation and conduction awareness raising seminars or walks could bring a magnificent change. It is a need of time to employ community-based governmental biodiversity conservation practices for maintenance of the sustainable use of medicinal plants and their products.

Conclusions

The human communities of North Eastern Indo-Pak border of Depalpur (Pakistan) possessed a significant traditional Knowledge about ethnomedicinal plants. Results reported, 75 medicinal plant taxa (belonged to 68 genera and 32 families). It was observed that most of them were wild herbs (86%), as used as whole plants (82%) for drug preparations by local inhabitants. These studied plants were reported to treat 40 ailments, however significantly used for fever (43 spp.) and gastrointestinal disorders (40 spp.). Such medicinal plants played their role in shaping the phytocultural diversity and augment traditional healthcare systems. It urges the extensive studies regarding the TEK potential and reconnaissance of medicinal flora. Collected taxonomic and ecological data about medicinal plants can be used to manage such initiatives aimed at fostering sustainable rural development in the study area. The outcomes of this paper argued to conserve invaluable local knowledge systems, as well as plant diversity of North Eastern Indo-Pak Border of Depalpur (Pakistan). Moreover, the crops of other reported medicinally valued taxa may be established considering their highly unsustainable use, eroding ethnoecological knowledge, limited business circles and low life standard. Results of this study will legally utilize to provide preparatory measures against the Nagoya Protocol (2010) about benefit-sharing for traditional knowledge of genetic resources.

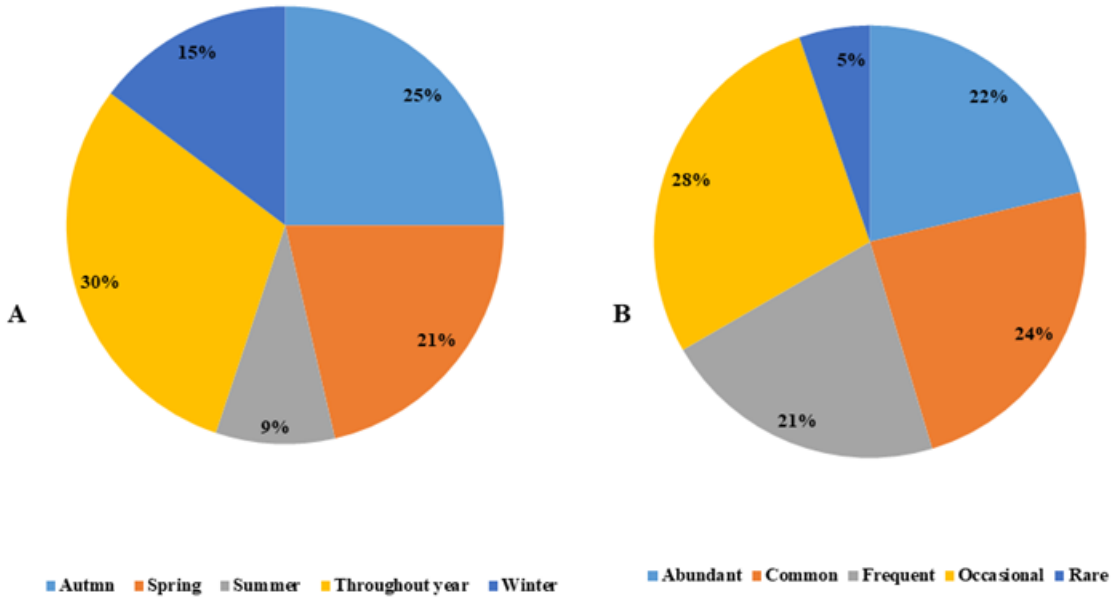

Figure 8. A. Seasonal availability B. Relative abundance of the reported medicinal plants

Declarations

List of abbreviations: Relative Frequency Citation (RFC), Use Value (UV), Relative Importance (RI), Family importance value (FIV) and Family Use Values (FUV), Jaccard Index (JI), Relative Popularity Level (RPL) and Rank Order Priority (ROP)

Ethics approval and consent to participate: The ethical guidelines for the survey of rural and indigenous communities provided by International Society of Ethnobiology (available online: www.ethnobiology.net/whatwe-do/coreprograms/ise-ethics-program/code-of-ethics) were carefully followed. Prior to interviews, formal verbal consent (regarding data collection and publication) of each participant was taken. The PRA (Participatory rural appraisal) approach mentioned in the Kyoto Protocol (2017) was applied with the consent of the informant. In addition formal consent from the University of Okara Ethical Review Committee was also taken (consent number UOERCC#124).

Consent for publication: "Not applicable" in this section.

Availability of data and materials: All data generated or analyzed during this study are included in this published article

Competing interests: The authors have no relevant financial or non-financial interests to disclose.

Funding: It is the part of MS thesis of Mr. Waqas Ahmed and no funding was received from any organization for its accomplishment. Authors utilized their own resources for completion of the study.

Authors' contributions: **F.A** designed and supervised the entire study, **W.A, M.S.** and **M.W.** conducted field surveys and collected data. **K.F., M.S. M.W.** and **S.J** contributed in data arrangement, presentation and analysis. **N.H** played role in statistical interpretation of data and also wrote the first draft of the manuscript along with **W.A.** and **K.F**. Later **F.A. and Z.A** incorporated the scientific input and improvised the language by several rounds of peer review.

Acknowledgements

We acknowledge the cooperation of local councils for their immense support in data collection. In addition, we are thankful to all informants who contributed and shared their valuable traditional knowledge.

Literature Cited

Abbas Z, Khan SM, Abbasi AM, Pieroni A, Ullah Z, Iqbal M, Ahmad Z. 2016. Ethnobotany of the Balti community, Tormik valley, Karakorum range, Baltistan, Pakistan. Journal of Ethnobiology and Ethnomedicine 12(1):1-6.doi: 10.1186/s13002-016-0114-y

Abbas Z, Khan SM, Abbasi AM, Pieroni A, Ullah Z, Iqbal M, Ahmad Z. 2016. Ethnobotany of the Balti community, Tormik valley, Karakorum range, Baltistan, Pakistan. Journal of Ethnobiology and Ethnomedicine 12:38.

Abbas Z, Khan SM, Alam J, Khan SW, Abbasi AM. 2017. Medicinal plants used by inhabitants of the Shigar Valley, Baltistan region of Karakorum range-Pakistan. Journal of Ethnobiology and Ethnomedicine 13(1):1-5. doi: 10.1186/s13002-017-0172-9

Abbas Z, Khan SM, Alam J, Khan SW, Abbasi AM. 2017a. Medicinal plants used by inhabitants of the Shigar Valley, Baltistan region of Karakorum range-Pakistan. Journal of Ethnobiology and Ethnomedicine 13:1-15.

Abbas Z, Khan SM, Alam J, Khan SW, Abbasi AM. 2017b. Medicinal plants used by inhabitants of the Shigar Valley, Baltistan region of Karakorum range-Pakistan. Journal of Ethnobiology and Ethnomedicine 13:53.

Achika JI, Arthur DE, Gerald I, Adedayo A. 2014. A review on the phytoconstituents and related medicinal properties of plants in the Asteraceae family. IOSR Journal of Applied Chemistry 7(8):1-8..doi: 10.9790/5736-07810108

Ahmad KS, Hamid A, Nawaz F, Hameed M, Ahmad F, Deng J, Akhtar N, Wazarat A, Mahroof S. 2017. Ethnopharmacological studies of indigenous plants in Kel village, Neelum valley, Azad Kashmir, Pakistan. Journal of Ethnobiology and Ethnomedicine 13(1):1-6.doi: 10.1186/s13002-017-0196-1

Ahmad SS, Erum S, Khan SM, Nawaz M, Wahid A. 2014. Exploring the medicinal plants wealth: A traditional medico-botanical knowledge of local communities in Changa Manga Forest, Pakistan. Middle East Journal of Scientific Research 20:1772-9. http://dx.doi.org/10.5829/idosi.mejsr.2014.20.12.21090

Ahmed N, Mahmood A, Ashraf A, Bano A, Tahir S, Mahmood A. 2015. Ethnopharmacological relevance of indigenous medicinal plants from district Bahawalnagar, Punjab, Pakistan. Journal of Ethnopharmacology 175:109-123.

Ahmed N, Mahmood A, Mahmood A, Tahir S, Bano A, Malik RN, Hassan S, Ishtiaq M. 2014. Relative importance of indigenous medicinal plants from Layyah district, Punjab Province, Pakistan. Journal of Ethnopharmacology 155: 509-523.

Ajaib M, Ashraf Z, Riaz F. 2014. Ethnobotanical studies of some plants of Tehsil Kharian, District Gujrat. FUUAST Journal of Biology 4(1):65-71.

Akgul A, Akgul A, Senol SG, Yildirim H, Secmen O, Dogan Y. 2018. An ethnobotanical study in Midyat (Turkey), a city on the silk road where cultures meet. Journal of Ethnobiology and Ethnomedicine 14(1):1-8. doi: 10.1186/s13002-017-0201-8

Akram M, Siddiqui MI, Akhter N, Waqas MK, Iqbal Z, Akram M, Khan AA, Madni A, Asif HM. 2011. Ethnobotanical survey of common medicinal plants used by people of district Sargodha, Punjab, Pakistan. Journal of Medicinal Plants Research 30(5):7073-5. doi: 10.5897/JMPR.9000594

Albuquerque UP, Lucena RF, Monteiro JM, Florentino AT, Cecília de Fátima CB. 2006. Evaluating two quantitative ethnobotanical techniques. Ethnobotany Research and Applications 31(4):051-60. doi: 10.1186/s13002-022-00520-0

Ali HA, Ahmad H, Marwat KB, Yousaf M, Gul B, Khan I. 2012. Trade potential and conservation issues of medicinal plants in District Swat, Pakistan. Pakistan Journal of Botany 44(6):1905-12. https://www.pakbs.org/pjbot/PDFs/44(6)/12.pdf

Ali SI, Qaiser M. (Eds.) (1993-2001) Flora of Pakistan, Islamabad, Karachi

Ali SI, Qaiser M. 1986. A phytogeographical analysis of the phanerogams of Pakistan and Kashmir. Proceedings of the Royal Society of Edinburgh, Section B: Biological Sciences 89:89-101.

Ali SI. 2008. Significance of flora with special reference to Pakistan. Pakistan Journal of Botany 40(3):967-71

Ali, SI, Nasir YJ. (Eds.) (1990-1991) Flora of Pakistan, Islamabad, Karachi

Amjad MS, Arshad M, Saboor A, Page S, Chaudhari SK. 2017. Ethnobotanical profiling of the medicinal flora of Kotli, Azad Jammu and Kashmir, Pakistan: Empirical reflections on multinomial logit specifications. Asian Pacific Journal of Tropical Medicine 10(5):503-514. doi: 10.1016/j.apjtm.2017.05.008

Amjad MS, Zahoor U, Bussmann RW, Altaf M, Gardazi SM, Abbasi AM. 2020. Ethnobotanical survey of the medicinal flora of Harighal, Azad Jammu & Kashmir, Pakistan. Journal of Ethnobiology and Ethnomedicine 16(1):1-28. doi: 10.1186/s13002-020-00417-w

APG. 2009. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. Botanical Journal of Linnaeus Society 161:105–121. doi: 10.1111/j.1095-8339.2009.00996.x

Arshad F, Waheed M, Harun N, Fatima K, Khan BA, Fatima K, Abbas Z, Jabeen S, Majeed M. 2022. Indigenous farmer's perception about fodder and foraging species of Semi-arid lowlands of Pakistan: A case study of District Kasur, Pakistan. Taiwania 67(4):510-523.

Ayantunde, A.A., Briejer, M., Hiernaux, P. *et al.* 2008. Botanical Knowledge and its Differentiation by Age, Gender and Ethnicity in Southwestern Niger. Human Ecology 36:881–889. doi: 10.1007/s10745-008-9200-7

Bibi F, Abbas Z, Harun N, Perveen B, Bussmann RW. 2022. Indigenous knowledge and quantitative ethnobotany of the Tanawal area, Lesser Western Himalayas, Pakistan. PloS one 22;17(2):e0263604. doi: 10.1371/journal.pone.0263604

Bibi F, Abbas Z, Harun N, Perveen B, Bussmann RW. 2022. Indigenous knowledge and quantitative ethnobotany of the Tanawal area, Lesser Western Himalayas, Pakistan. PloS One 17:e0263604.

Birjees M, Ahmad M, Zafar M, Nawaz S, Jehanzeb S, Ullah F, Zaman W. 2022. Traditional knowledge of wild medicinal plants used by the inhabitants of Garam Chashma valley, district Chitral, Pakistan. Acta Ecologica Sinica; 42(2):19-33. doi: 10.1016/j.chnaes.2020.12.006

Ceuterick M, Vandebroek I, Pieroni A. 2011. Resilience of Andean urban ethnobotanies: a comparison of medicinal plant use among Bolivian and Peruvian migrants in the United Kingdom and in their countries of origin. Journal of Ethnopharmacology 14;136(1):27-54.doi: 10.1016/j.jep.2011.03.038

Cruz García GS. 2006. The mother–child nexus. Knowledge and valuation of wild food plants in Wayanad, Western Ghats, India. Journal of Ethnobiology and Ethnomedicine 2(1):1-6. .doi: 10.1186/1746-4269-2-39

Diallo D, Hveem B, Mahmoud MA, Berge G, Paulsen BS, Maiga A.1999. An ethnobotanical survey of herbal drugs of Gourma district, Mali. Pharmaceutical Biology 37(1):80-91. doi: 10.1076/phbi.37.1.80.6313

District Courts Okara. Brief History of Okara https://okara.dc.lhc.gov.pk. Accessed 02 Sept 2021.

Farooq A, Amjad MS, Ahmad K, Altaf M, Umair M, Abbasi AM. 2019. Ethnomedicinal knowledge of the rural communities of Dhirkot, Azad Jammu and Kashmir, Pakistan. Journal of Ethnobiology and Ethnomedicine 15(1):1-30.doi: 10.1186/s13002-019-0323-2

Fratianni M, Kang H. 2006. International terrorism, international trade, and borders. In; Regional Economic Integration (Vol. 12, pp. 203-223). Emerald Group Publishing Limited.

Fratianni M, Kang H. 2006. *International terrorism, international trade, and borders. Regional Economic Integration*. Emerald Group Publishing Limited, pp. 203-223.

Garlick J. 2018. Deconstructing the China–Pakistan economic corridor: Pipe dreams versus geopolitical realities. Journal of Contemporary China 27(112):519-33. doi: 10.1080/10670564.2018.1433483

Gulshan AB, Dasti AA, Sabir H, Atta MI. 2012. Indigenous uses of medicinal plants in rural areas of Dera Ghazi Khan, Punjab, Pakistan. Journal of Agricultural and Biological Science 7:750-762.

Hameed M, Ashraf M, Al-Quriany F, Nawaz T, Ahmad MS, Younis A, Naz N. 2011. Medicinal flora of the Cholistan desert: a review. Pakistan Journal of Botany 43(2):39-50.

Haq SM, Waheed M, Khoja AA, Amjad MS, Bussmann RW, Ali, K. 2023. A cross-cultural study of high-altitude botanical resources among diverse ethnic groups in Kashmir Himalaya, India. Journal of Ethnobiology and Ethnomedicine, 19(1):12.

Haq SM, Yaqoob U, Majeed M, Amjad MS, Hassan M, Ahmad R, Waheed M, Bussmann RW, Soares Calixto E, Proćków J, de la Lastra JMP. 2022. Quantitative ethnoveterinary study on plant resource utilization by indigenous communities in high-altitude regions. Frontiers in Veterinary Science 9.

Hasrat MH. 2007. *Baltistan Tehzeeb-o-Saqafat*. Baltistan Book Point and Publications Naya Bazar Skardu.doi: 10.1186/s13002-016-0114-y

Hill AF. 1952. Economic Botany McGraw-Hill Book Comp. Inc. New York.

Hocking GM. 1958. Pakistan Medicinal Plants-1.*QualitasPlantarumetMateriaVegetabiles*, 6(2), 121-136. http://doi.org/10.1186/s13002-017-0172-9

Hopping KA, Yangzong C, Klein JA. 2016. Local knowledge production, transmission, and the importance of village leaders in a network of Tibetan pastoralists coping with environmental change. Ecology and Society 21(1). https://www.doi.org/10.1186/1746-4269-5-10

Hussain F, Shaukat SS, Abid M, Usman F. 2012. Some important medicinal plants associated with the vegetation in District Mirpurkhas, Sindh. International Journal of Biology and Biotechnology 9:405-20.

Iqbal H, Sher Z. 2011. Medicinal plants from salt range pind dadan khan, district Jhelum, Punjab, Pakistan. Journal of Medicinal Plants Research 5:2157-2168.

Iqbal T, Rehman HU, Jan RU, Khan MG, Ahmad N, Nisar J, Khattak L, Iqbal A, Khurshid S, Ullah A, Ahmad W. 2014. Ethnomedicinal study of flora of District Karak, Khyber Pakhtunkhwa, Pakistan. International Journal of Advanced Research 2(9):88-93.

Jain SK, Rao RR. 1977. *A handbook of field and herbarium technique*. Today and Tomorrow Publishers, New Delhi, India.

Jan PS, Sadia B, Yousaf A, Naz N, Rehmat N, Tahira B, Sajjad N, Hameed S, Bazai ZA. 23. 2021. Ethnobotanical study of flora of Gulistan, district Killa Abdullah, Balochistan, Pakistan. Pure and Applied Biology (PAB) 5(2):361-8.http://dx.doi.org/10.19045/bspab.2016.50047

Kassam KA. 2009. Viewing change through the prism of indigenous human ecology: findings from the Afghan and Tajik Pamirs. Human Ecology 37(6):677-90. doi: 10.1007/s10745-009-9284-8

Kent M. 1992. *Vegetation Description and Data Analysis: A Practical Approach,* (1st Edition). John Wiley & Sons.

Kent M. 2011. *Vegetation description and data analysis: a practical approach.* John Wiley & Sons.

Kent M. 2011. *Vegetation description and data analysis: a practical approach.* John Wiley & Sons.

Khan TY, Badshah L, Ali A. 2018. Ethnobotanical survey of some important medicinal plants of area Mandan district Bannu, Khyber Pakhtunkhwa, Pakistan. International Journal of Herbal Medicine 6:15-21.

Khanum H, Ishtiaq M, Bhatti KH, Hussain I, Azeem M, Maqbool M, Hussain T, Mushtaq W, Thind S, Bashir R, Muzamil M. 2022. Ethnobotanical and conservation studies of tree flora of Shiwalik mountainous range of District Bhimber Azad Jammu and Kashmir, Pakistan. PloS One 17(2):e0262338. https://www.doi.org/10.1371/journal.pone.0262338

Khoja AA, Haq SM, Majeed M, Hassan M, Waheed M, Yaqoob U, Bussmann RW, Alataway A, Dewidar AZ, Al-Yafrsi M, Elansary HO. 2022. Diversity, Ecological and traditional knowledge of pteridophytes in the western Himalayas. Diversity, 14(8):628.

Maden K. 2004. Plant collection and herbarium techniques. Our Nature 2(1):53-7. doi: 10.3126/on.v2i1.327

Majid A, Ahmad H, Saqib Z, Rahman IU, Khan U, Alam J, Shah AH, Jan SA, Ali N. 2020 Exploring threatened traditional knowledge; ethnomedicinal studies of rare endemic flora from Lesser Himalayan region of Pakistan. Revista Brasileira de Farmacognosia 29:785-92. doi: 10.1016/j.bjp.2019.03.005

Mamedov N, Gardner Z, Craker LE. 2005. Medicinal plants used in Russia and Central Asia for the treatment of selected skin conditions. Journal of Herbs, Spices & Medicinal Plants11(1-2):191-222. doi: 10.1300/J044v11n01_07

Mamun AA. 2010. Understanding the value of local ecological knowledge and practices for habitat restoration in human-altered floodplain systems: a case from Bangladesh. Environmental Management 45(5):922-38. doi: 10.1007/s00267-010-9464-8

Mattalia G, Stryamets N, Pieroni A, Sõukand R. 2020. Knowledge transmission patterns at the border: Ethnobotany of Hutsuls living in the Carpathian Mountains of Bukovina (SW Ukraine and NE Romania). Journal of Ethnobiology and Ethnomedicine 16(1):1-40. doi: 10.1186/s13002-020-00391-3

Mattalia G, Stryamets N, Pieroni A, Sõukand R. 2020. Knowledge transmission patterns at the border: Ethnobotany of Hutsuls living in the Carpathian Mountains of Bukovina (SW Ukraine and NE Romania). Journal of Ethnobiology and Ethnomedicine 16:1-40.

Memon AH, Rind FM, Laghari MG, Mughal UR, Memon N, Gilal RA, Khuhawar MY, Almani F. 2008. Common folk medicinal and ethnomedicinal uses of thirty medicinal plants of districts Dadu and Jamshoro, Sindh, Pakistan. Sindh University Research Journal (Science Series) 40(2):89-108.

Mukhtar N. 2021. Herbs variation at different canal bank of Tehsil Depalpur. International Journal of Biological Research 4(1):12-24.

Murad W, Azizullah A, Adnan M, Tariq A, Khan KU, Waheed S, Ahmad A. 2013. Ethnobotanical assessment of plant resources of Banda Daud Shah, district Karak, Pakistan. Journal of Ethnobiology and Ethnomedicine 9(1):1-0. doi: 10.1186/1746-4269-9-77

Muthu C, Ayyanar M, Raja N, Ignacimuthu S. 2006. Medicinal plants used by traditional healers in Kancheepuram District of Tamil Nadu, India. Journal of Ethnobiology and Ethnomedicine 2(1):1-0. http://doi.org/10.1186/1746-4269-2-43.

Naess LO. 2013. The role of local knowledge in adaptation to climate change. Wiley Interdisciplinary Reviews: Climate Change 4(2):99-106. doi: 10.1002/wcc.204

Naples NA. 2009. Crossing borders: Community activism, globalization, and social justice. Social Problems 56(1):2-0. doi: 10.1525/sp.2009.56.1.2

Naples, N.A., 2009. Crossing borders: Community activism, globalization, and social justice. Social Problems 56, 2-20.

Nasir E, Ali S, Stewart RR. 1972. *Flora of West Pakistan: an annotated catalogue of the vascular plants of West Pakistan and Kashmir*. Fakhri Press Karachi.

Nasir E, Ali SI, 1970. editors. Flora of Pakistan. Department of Botany, University of Karachi

Noman A, Hussain I, Ali Q, Ashraf MA, Haider MZ. 2013. Ethnobotanical studies of potential wild medicinal plants of Ormara, Gawadar, Pakistan. Emirates Journal of Food and Agriculture 24:751-9. doi: 10.9755/ejfa.v25i10.16401

Ozturk M, Altay V, Altundağ E, Ibadullayeva SJ, Aslanipour B, Gönenç TM.2018. Herbals in Iğdır (Turkey), Nakhchivan (Azerbaijan), and Tabriz (Iran). In; Plant and Human Health, Volume 1(pp. 197-266). Springer, Cham. doi: 10.1007/978-3-319-93997-1_6

Phillips O, Gentry AH, Reynel C, Wilkin P, Gálvez-Durand B C. 1994. Quantitative ethnobotany and Amazonian conservation. Conservation Biology 8(1):225-48. doi: 10.1046/j.1523-1739.1994.08010225.x

Phillips, O., Gentry, A.H., Reynel, C., Wilkin, P., Galvez-Durand, B., 1994. Quantitative ethnobotany and Amazonian conservation. Conservation biology 8, 225-248.

Pieroni A, Cianfaglione K, Nedelcheva A, Hajdari A, Mustafa B, Quave CL. 2014. Resilience at the border: traditional botanical knowledge among Macedonians and Albanians living in Gollobordo, Eastern Albania. Journal of Ethnobiology and Ethnomedicine 10(1):1-31. doi: 10.1186/1746-4269-10-31

Pieroni A, Giusti ME, Quave CL. 2011. Cross-cultural ethnobiology in the Western Balkans: medical ethnobotany and ethnozoology among Albanians and Serbs in the Pešter Plateau, Sandžak, South-Western Serbia. Human Ecology 39(3):333-49. doi: 10.1007/s10745-011-9401-3

Qureshi R, Maqsood MU, Arshad MU, Chaudhry AK. 2011. Ethnomedicinal uses of plants by the people of Kadhi areas of Khushab, Punjab, Pakistan. Pakistan Journal of Botany 43(1):121-33.

Qureshi R, Waheed A, Arshad M, Umbreen T. 2009. Medico-ethnobotanical inventory of tehsil Chakwal, Pakistan. Pakistan Journal of Botany 41(2):529-38.

Qureshi R. 2004. *Floristic and Ethnonotanical Study of Desert-Nara Region, Sindh* (Doctoral dissertation, Shah Abdul Latif University).

Qureshi RA, Ghufran MA, Gilani SA, Yousaf Z, Abbas G, Batool A. 2009. Indigenous medicinal plants used by local women in southern Himalayan regions of Pakistan. Pakistan Journal of Botany;41(1):19-25. https://ethnobotanyjournal.org/era/index.php/era/article/view/143

Qureshi RA, Gilani SA, Ghufran MA. 2007. Ethnobotanical studies of plants of Mianwali district Punjab, Pakistan. Pakistan Journal of Botany 39(7):2285-90.

Ragupathy S, Newmaster SG. 2009. Valorizing the'Irulas' traditional knowledge of medicinal plants in the Kodiakkarai Reserve Forest, India. Journal of Ethnobiology and Ethnomedicine 5(1):1-3. doi: 10.1186/1746-4269-5-10

Raja R, Bokhari TZ, Ahmad S, Malik SA, Hussain K, Nadeem K. 2020. Ethno-medicinal survey for some wild plants of Muzaffarabad, Azad Jammu & Kashmir, Pakistan. Journal of Bioresource Management 7(3):1. doi: 10.35691/JBM.0202.0136

Rauf F, Qureshi R, Shaheen H. 2012. Folk medicinal uses of indigenous plant species of Barroha, Bhara Kahu and Maanga in Islamabad, Pakistan. Journal of Medicinal Plants Research 6(11):2061-70. doi: 10.5897/JMPR10.803

Razzaq A, Rashid A, Ali H, Ahmad H, Islam M. 2010. Ethnomedicinal potential of plants of Changa Valley, Distt; Shangla. Pakistan Journal of Botany 42(5):3463-75.

Rehman S, Iqbal Z, Qureshi R, Shah GM, Irfan M. 2023. Ethnomedicinal plants uses for the treatment of respiratory disorders in tribal District North Waziristan, Khyber Pakhtunkhawa, Pakistan. Ethnobotany Research and Applications 25:1-6. https://ethnobotanyjournal.org/index.php/era/article/view/4297

Rexhepi B, Mustafa B, Hajdari A, Rushidi-Rexhepi J, Quave CL, Pieroni A. 2013. Traditional medicinal plant knowledge among Albanians, Macedonians and Gorani in the Sharr Mountains (Republic of Macedonia). Genetic Resources and Crop Evolution 60(7):2055-80. http://dx.doi.org/10.1007/s10722-013-9974-3

Robbins P. 2000. Sacred ecology: traditional ecological knowledge and resource management. Economic Geography 76(4):395.

Saini I, Chauhan J, Kaushik P. 2020. Medicinal value of domiciliary ornamental plants of the Asteraceae family. Journal of Young Pharmacists 12(1):3. https://dx.doi.org/10.5530/jyp.2020.12.2

Sarangzai AM, Ahmed A, Laghari SK. 2013. Traditional uses of some useful medicinal plants of Ziarat District Balochistan, Pakistan. FUUAST Journal of Biology 25;3(1):101-7.

Shah S, Khan S, Bussmann RW, Ali M, Hussain D, Hussain W. 2020. Quantitative ethnobotanical study of Indigenous knowledge on medicinal plants used by the tribal communities of Gokand Valley, District Buner, Khyber Pakhtunkhwa, Pakistan. Plants 9(8):1001. doi: 10.3390/plants9081001

Shah, I.A., Burni, T., Badshah, L., Uza, N.U., Bussmann, R.W., 2023. Quantitative ethnobotanical study and conservation status of herbal flora of Koh-e-Suleman range, Razmak valley, North Waziristan, Pakistan. Ethnobotany Research and Applications 25, 1-18.

Shaheen H, Qaseem MF, Amjad MS, Bruschi P. 2017. Exploration of ethno-medicinal knowledge among rural communities of Pearl Valley; Rawalakot, District Poonch Azad Jammu and Kashmir. PloS One 8; 12(9):e0183956. doi: 10.1371/journal.pone.0183956

Sher Z, Khan Z, Hussain F.2011. Ethnobotanical studies of some plants of Chagharzai valley, district Buner, Pakistan. Pakistan Journal of Botany 43(3):1445-52.

Shinwari MI, Khan MA. 2000. Folk use of medicinal herbs of Margalla hills national park, Islamabad. Journal of Ethnopharmacology 69(1):45-56. doi: 10.1016/S0378-8741(99)00135-X

Shinwari MI, Maryum (Ibrar) Shinwari, Shah M. 2007. *Medicinal Plants of Margallah Hills National Park Islamabad.* Higher Education Commission.

Shinwari ZK. 2010. Medicinal plants research in Pakistan. Journal of Medicinal Plants Research 4;4(3):161-76.

Smith PJ. 2013. The tilting triangle: Geopolitics of the China–India–Pakistan relationship. Comparative Strategy 1;32(4):313-30. doi: 10.1080/01495933.2013.821850

Smith, P.J., 2013. The tilting triangle: Geopolitics of the China–India–Pakistan relationship. Comparative Strategy 32, 313-330.

Sossou-Agbo AL. 2013. Importance of Borders in West African Economic Space. Eurasia Border Review 4(2):75-81.

Sõukand R, Pieroni A. 2016. The importance of a border: Medical, veterinary, and wild food ethnobotany of the Hutsuls living on the Romanian and Ukrainian sides of Bukovina. Journal of Ethnopharmacology 185(5):17-40. doi: 10.1016/j.jep.2016.03.009

Sõukand, R., Pieroni, A., 2016. The importance of a border: Medical, veterinary, and wild food ethnobotany of the Hutsuls living on the Romanian and Ukrainian sides of Bukovina. Journal of ethnopharmacology 185, 17-40.

Ssenku JE, Okurut SA, Namuli A, Kudamba A, Tugume P, Matovu P, Wasige G, Kafeero HM, Walusansa A. 2022. Medicinal plant use, conservation, and the associated traditional knowledge in rural communities in Eastern Uganda. Tropical Medicine and Health 50(1):39. doi: 10.1186/s41182-022-00428-1

Tahir M, Asnake H, Beyene T, Van Damme P, Mohammed A. 2023. Ethnobotanical study of medicinal plants in Asagirt District, Northeastern Ethiopia. Tropical Medicine and Health. 51(1):1-3. doi: 10.1186/s41182-023-00493-0

Taran PA. 2001. Human rights of migrants: challenges of the new decade. International Migration 38(6):7-51.

Taran, P.A., 2001. Human rights of migrants: challenges of the new decade. International Migration 38, 7-51.

Tareen NM, Rehman MA, Shinwari ZK, Bibi TA. 2016. Ethnomedicinal utilization of wild edible vegetables in district Harnai of Balochistan Province-Pakistan. Pakistan Journal of Botany 48(3):1159-71.

Tareen RB, Bibi T, Khan MA, Ahmad M, Zafar M, Hina S. 2010. Indigenous knowledge of folk medicine by the women of Kalat and Khuzdar regions of Balochistan, Pakistan. Pakistan Journal of Botany 42(3):1465-85.

Umair M, Altaf M, Bussmann RW, Abbasi AM. 2019. Ethnomedicinal uses of the local flora in Chenab riverine area, Punjab province Pakistan. Journal of Ethnobiology and Ethnomedicine 15(1):1-31. doi: 10.1186/s13002-019-0285-4

Umair, M., Altaf, M., Abbasi, A.M., 2017. An ethnobotanical survey of indigenous medicinal plants in Hafizabad district, Punjab-Pakistan. PloS one 12, e0177912.

Waheed M, Arshad F, Iqbal M, Fatima K, Fatima K. 2020. Ethnobotanical assessment of woody flora of district Kasur (Punjab), Pakistan. Ethnobotany Research and Applications, 20: 1-13.

Waheed M, Haq SM, Arshad F, Bussmann RW, Pieroni A, Mahmoud EA, Casini R, Yessoufou K, Elansary HO. 2023. Traditional Wild Food Plants Gathered by Ethnic Groups Living in Semi-Arid Region of Punjab, Pakistan. Biology 12:269. doi: 10.3390/ biology12020269.

Waheed, A., Wahab, A.A., Ahmed, F., Umer, M., Saleem, S.S.A., Batool, S.A., Hassan, W.U., Saleem, T., Raza, H.A., Farmers' perception about the impact of plant clinic on potato productivity: Implications for agriculture extension service in Punjab Pakistan.

Wali S, Jan HA, Haq SM, Yaqoob U, Bussmann RW, Rahim F. 2021. The Traditional phyto-recipes used to cure various ailments by the local people of Shishi Koh valley, Chitral, Pakistan. Ethnobotany Research and Applications 22:1-32. https://ethnobotanyjournal.org/era/index.php/era/article/view/3245

Westley F, Olsson P, Folke C, Homer-Dixon T, Vredenburg H, Loorbach D, Thompson J, Nilsson M, Lambin E, Sendzimir J, Banerjee B. 2011. Tipping toward sustainability: emerging pathways of transformation. Ambio 40(7):762-80. doi: 10.1007%2Fs13280-011-0184-y

Yaseen G, Ahmad M, Sultana S, Alharrasi AS, Hussain J, Zafar M. 2015. Ethnobotany of medicinal plants in the Thar Desert (Sindh) of Pakistan. Journal of Ethnopharmacology 163:43-59. doi: 10.1016/j.jep.2014.12.053

Yousaf MZ. 2014. Ethnobotanical studies of Khushab District, Punjab, Pakistan. European Journal of Applied Science 1(4):110-9. http://dx.doi.org/10.22161/ijeab/3.4.15

Yousaf Z, Shinwari ZK, Ali SM. 2004. Medicinally important flora of dhibbia karsal village (Mianwali district Punjab). Asian Journal of Plant Sciences 3(6):752-762. https://dx.doi.org/10.3923/ajps.2004.757.762

Zereen A, Sardar AA. 2013. Ethnobotanical studies of wild herbs of central Punjab, Pakistan. Bangladesh Journal of Plant Taxonomy 20(1):67-76. doi: 10.3329/bjpt.v20i1.15466