

## Research Article

# Ethnobotanical Study of Munda Khazana, District Dir Lower, Khyber Pakhtunkhwa

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**Abstract** | The study aimed to gather comprehensive information on ethnobotanically significant plants, focusing on medicinal species, in Khazana Munda, District Dir Lower, Khyber Pakhtunkhwa. The study was conducted in 30 isolated villages of the research area through questionnaires to collect information from 500 native people of different ages (35 to 75 years old) who were interviewed and included men and women, who were involved in the compilation and utilization of plants. The study region was carefully visited in all four seasons of the year and 183 plant species belonging to 73 families were collected which is composed of 9.6% of species were shrubs, 65.4% of species were herbs, 25% of species of trees, were collected from September 2018 to August 2020. Among the collected plant species, 68 were used for medicinal purposes, followed by those used as vegetables and food sources. Additionally, 12 species served as fuel and timber, 10 were utilized for furniture-making, 4 for thatching, 2 as hedges, 2 for fruit, and 6 species were valued for ornamental purposes. The dominant plant families in the study area included Rosaceae with 10 species, followed by Fabaceae and Poaceae, each represented by 9 species. The families Lamiaceae and Solanaceae each included 8 species. Additionally, Brassicaceae, Cucurbitaceae, Moraceae, Papilionaceae, Ranunculaceae, and Rutaceae were represented by 5 species each, while Euphorbiaceae, Labiatae, Malvaceae, and Rhamnaceae each had 4 species. The leaves of the plants were predominantly used in preparing therapeutic remedies, most commonly administered orally as decoctions. However, traditional collection practices and inadequate post-harvest handling often reduced the quality of these medicinal plants. Deforestation, soil erosion, and population growth pose serious threats to the valuable plant species of this region. This study represents an initial effort to document and preserve these important plant resources. The flora of Khazana Munda Valley necessitates effective conservation efforts to ensure a sustainable future for the region.

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**Keywords** | Ethnobotany, Biodiversity conservation, Medicinal plants, Invasive flora, Munda, Dir Lower



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## Introduction

Lower Dir is situated in the Malakand region at coordinates 34°30'10.95"N latitude and 71°54'16.43"E longitude (or 34.503041 and 71.904565, respectively). It represents the lower part of the Dir district. Historically, the region was under the leadership of Shah Jehan Khan in 1947 and was known for its monastic heritage. Lower Dir was annexed to Pakistan in 1969, and in 1970, it was established as a separate province, subsequently divided into Upper Dir and Lower Dir (Abdin *et al.*, 2022). The district, covering a total area of 1,583 square kilometers, is characterized by its hilly terrain. It is bordered by Swat to the east, Afghanistan to the west, Bajaur to the south, and Chitral and Malakand to the north (Abdullah *et al.*, 2021). District Dir comprises six tehsils and 37 union councils (UCs), with representatives in the Khyber Pakhtunkhwa assembly. Peshawar is accessible from Dir via Charsadda and Malakand, while another route connects through Mardan and Malakand (Ullah, 2017).

### *Topography, tribes ethnic groups, and languages*

The regions feature hills and mountains from the southern Hindu Kush, with the highest peaks located in northern Dir. The lower valleys of Dir include Timergara, Medan, Jandool, and Chakdara (Ahmad *et al.*, 2019). The Pashto language is the mother tongue of a monastery, and Kohistan and Roma speak the language of Roma and Kohistani. Some people speak Hindko (an alternative to Punjabi, Gujjari, and Khowar Chitrali). Most of the inhabitants of this region belong to the Izazai and Ismail Zai tribes (Ullah *et al.*, 2019a; Ahmad *et al.*, 2018).

### *Climate, land and water*

The province's area ranges between 1,200 and 2,800m at the top of sea level. The region largely depends on the height. July is the hottest month with temperatures from 15.76 to 32.62 °C. January as well as February are the chilliest months and temperatures are commonly down to the sub-zero point. The maximum temperature is 11.22 °C, and the minimum is about 2.39°C (Akhtar *et al.*, 2013). The chilly period starts from mid-November to March. In January, the humidity peaks in February, August, and December. Most of the rain started in March (242.22 mm) and rarely rained in July, October, and November. Snow falls from December to June as well as July in elevated peaks, accumulating the

good looks of the valley (Amjad *et al.*, 2020). The climate features mild temperatures, with snowfall in winter and heat in May and June. Northern regions are typically colder and receive more precipitation, while southern areas face significant degradation (Aziz *et al.*, 2021). Annual precipitation ranges from 700 mm to 1200 mm (Ullah *et al.*, 2019b), with 55% falling from December to April and 35% from July to September. Maximum temperatures can reach 38°C, while minima can drop to 0°C. Except for small southwest areas, Dir is a challenging mountainous region, with elevations ranging from 5,000 meters (16,000 feet) in the northeast to 3,000 meters (9,800 feet) along watersheds, bordered by Swat to the east and Afghanistan and Chitral to the west and north, respectively (Bano *et al.*, 2013). Lower Dir villages face severe drinking water shortages due to the closure of water supply networks (Ullah *et al.* 2023a).

### *Agriculture*

Agriculture is the primary livelihood for over 85% of the population in Dir, with many directly or indirectly reliant on it. The main sources of income are remittances from abroad and agricultural products, although fluctuations in local markets pose challenges for farmers. Additionally, tobacco is cultivated in a small area in the lower region of the province (Bibi *et al.*, 2014; Ullah *et al.*, 2024).

### *Ethnobotany*

It is the study of association as well as the connection between plants and people in space with time (Hussain *et al.*, 2021). The ethnobotanical definition can be making a shower in four words vegetation, persons, use, and association. The origin of ethnobotany is attached to basic botany because the botanical study was initiated to use vegetation for the cure of diseases (Shah *et al.*, 2023). Humans cannot live without plants. Without plants, no life on the earth is possible (Hussain *et al.*, 2022). The villagers have more knowledge of the advantages of plants. Poverty is common here so; they use plants for medical purposes (Hussain *et al.*, 2023). Herbal medicine uses plant leaves, flowers, fruits, seeds, stems or bark, gum, and roots to treat various ailments (Irfan *et al.*, 2018). Worldwide, herbal medicines are utilized to treat, prevent, and promote diverse ailments at an early age (Sajid *et al.*, 2023). According to the World Health Organization (WHO, 2001), sixty percent (60%) of the world's population depends on conventional drugs as well and eighty percent (80%) of the populace

of mounting countries depends almost wholly on conventional medical practices, especially herbal medicine, in basic health care (Ullah *et al.*, 2019c). While synthetic drugs are effective, they can have side effects. Consequently, interest in herbal medicine has grown recently (Ullah *et al.*, 2021a; Khan *et al.*, 2015). The current research work is designed to attain the following objectives: To construct a checklist of valuable plants in the research area. To investigate local recipes for the remedial plant in the research area, describe its ethnobotanical significance, and create a comprehensive record of the plant's local applications. Employing various statistical tools will ensure the authenticity and reliability of the ethnobotanical data for the plants in the region.

## Materials and Methods

The study area of Munda Khazana is situated in the district Dir Lower. Ethnobotanical information and data regarding the valuable plant were collected from January 2019 to December 2020. Information about the use and locally prepared recipe data were collected through interviews, structured questionnaires, and mutual discussion (Khan *et al.*, 2011). About four hundred people were interviewed for ethnobotanical data, the ages of these people ranged from 25- to 65 years old. Males and females were equally interviewed (Parvaiz *et al.*, 2013). The collected information was cross-checked in every survey. Plants were also composed in these trips chasing the typical process with minor alters (Ullah *et al.*, 2018; Qureshi *et al.*, 2009). The study has gathered detailed data on plant habitats, growth habits, local names, usage areas, and ethnobotanical practices in Manda Valley, District Lower Dir. This enhanced understanding of the region's biodiversity and cultural plant uses and supports conservation and sustainable use efforts (Rahim *et al.*, 2023).

### *Plant collection, preservation and identification*

The collected plants were dried properly and labeled on herbal cards using standard methods (Sahar and Ali, 2024). The plants were identified using standard methods, and the tropics project and flora are accessible online with the assistance of Philippa of Pakistan (Rashid *et al.*, 2015; Subhan *et al.*, 2024). Preserved plant specimens were collected at the herbarium of Botany Bacha Khan University, Charsadda.

### *Tabulation and analysis*

The collected data were organized and tabulated.

Plants were classified into six groups based on local information: Timber, fuel, furniture, thatching, edible, agricultural tools, and other uses (Ullah *et al.*, 2019a; Sarangzai *et al.*, 2012).

### *Important quantitative indices*

Some important quantitative indices were calculated from the collected data i.e., relative importance, relative frequency citation, and use of vale (Ullah *et al.*, 2019b, 2021b; Shah *et al.*, 2013).

### *Relative importance*

RI is a measure of the common practice of a species. It was calculated as  $RI = \frac{NUC}{NT}$  Where NUC shows the Number of utilized classes as well as NT shows the Number of employ attributes. The value of NUC is calculated as  $NUC = \frac{NUCS}{NUCVS}$  where NUCS shows some use categories of a particular taxon and NUCVS shows several use classes of the mainly versatile taxon. The value of NT is calculated as  $NT = \frac{NTS}{NT.MIT}$  where NTS indicates several entireties uses of every category attributed to a species and NT.MIT indicates several whole uses of every classis of mostly versatile species (Siraj *et al.*, 2018; Ullah *et al.*, 2024).

### *Relative frequency citation*

This guide explains the local significance of individual taxon. It was calculated through the following formula.  $RFC = \frac{FC}{N}$ , Where FC = Frequency Citation and N is the total number of interviewees. The FC signifies the number of uses mentioned by all the users of a meticulous species. Value of RFC deceit amid 0 and 1; 0 shows the plant not mentioned via still a single individual, and 1 shows that each candidate mentioned the meticulous plant chosen helpful (Ullah *et al.*, 2023b; Subhan *et al.*, 2024).

### *Use value (UV)*

To know the relative significance of a plant species, Use Value is a good quantitative matrix. Its value was calculated through the following formula.  $UV = \frac{\sum U_i}{N}$  Where  $U_i$  indicates the total number of uses of a meticulous species stated through one informant as well and N is the whole number of interviewees (Sultan *et al.*, 2020; Tufail *et al.*, 2020; Ullah, 2017, 2023a).

## Results and Discussion

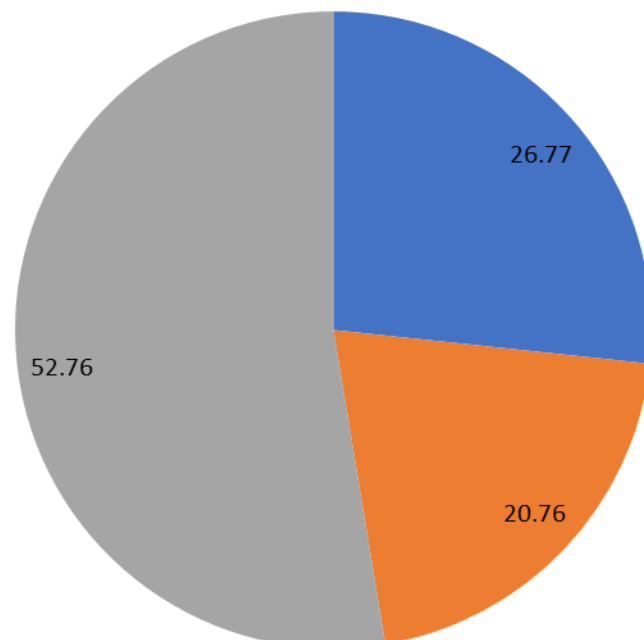
In the current study, the ethnobotanical significance

of plants in Munda Khazana, District Lower Dir, was investigated. A total of 183 valuable plant species were collected from the study area, representing 73 botanical families. Herbs were the most abundant, with 96 species (52.45%), followed by shrubs (38 species, 20.76%) and trees (49 species, 26.77%). Detailed information on each plant including local names, botanical names, habits, families, plant parts used, and ethnobotanical applications is provided below. The data was showed in the [Table 1](#).

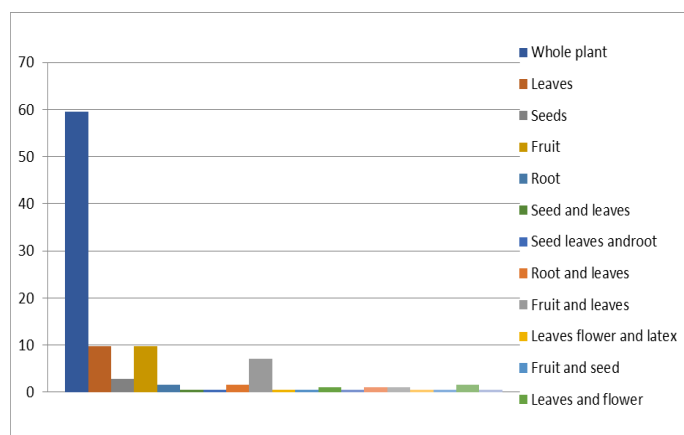
The largest family identified in this study was Asteraceae, represented by 12 plant species. Rosaceae included 10 species, while Fabaceae and Poaceae each comprised 9 species. Lamiaceae and Solanaceae were each represented by 8 species. Families with 5 species included Brassicaceae, Cucurbitaceae, Moraceae, Papilionaceae, Ranunculaceae, and Rosaceae. Families with 4 species included Euphorbiaceae, Labiatae, Malvaceae, and Rhamnaceae. Additionally, Amaranthaceae, Amaryllidaceae, Apocynaceae, Asclepiadaceae, Chenopodiaceae, Liliaceae, Myrtaceae, Pinaceae, and Polygonaceae each contained 3 species. Families represented by 2 species included Apiaceae, Aceraceae, Convolvulaceae, Cupressaceae, Fumariaceae, Mimosaceae, Nyctaginaceae, Papaveraceae, Plantaginaceae, Portulacaceae, Salicaceae, and Urticaceae. Finally, Acanthaceae, Agaricaceae, Anacardiaceae, Berberidaceae, Betulaceae, Boraginaceae, Cactaceae, Cannabaceae, Cannaceae, Caryophyllaceae, Cyperaceae, Ebenaceae, Fagaceae, Primulaceae, Juglandaceae, Malvaceae, Morchelaceae, Oleaceae, Oxalidaceae, Paeoniaceae, Platanaceae, Podaceae, Pteridaceae, Punicaceae, Rubiaceae, Simaroubaceae, Sapotaceae, Scrophulariaceae, Tamaricaceae, Thymelaeaceae, Typhaceae, Valerianaceae, Violaceae, Vitaceae, and Zygophyllaceae each had one species represented. Among these plants, herbs were the most widely utilized by the local population, followed by shrubs as the second most commonly used plant type. The data is shown in [Figure 1](#).

Of the 183 collected plants, 109 (59.56%) were used entirely. Specific parts were utilized as follows: Leaves in 18 plants (9.83%), seeds in 5 plants (2.73%), and fruits in another 18 plants (9.83%). Roots were used in 3 plants (1.63%), while 3 plants combined seeds and leaves (0.54%). One plant included roots, leaves, and seeds (0.54%), and another used roots and leaves (1.63%). Three plants combined fruit and leaves

(7.10%), and 13 utilized leaves, flowers, and latex (0.54%). Other combinations included fruit and seed (0.54%), leaves and flowers (1.09%), root and bark (0.54%), wood and fruit (1.09%), flowers only (1.09%), seed and latex (0.54%), root and fruit (0.54%), root and leaves (1.63%), and leaves and stems (0.54%). The data is shown in [Figure 2](#).



**Figure 1:** *Habite-wise representation of plant species of the research area.*



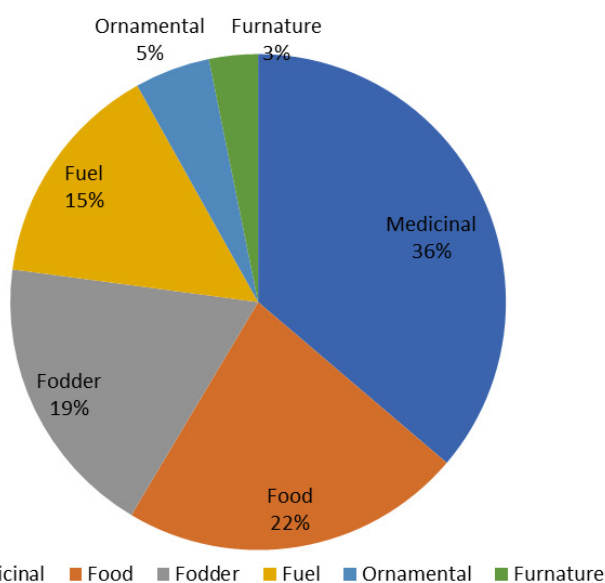
**Figure 2:** *Plant parts used in the research area.*

Plants are used for various purposes, including wood, timber, furniture, fruit, fuel, fodder, and vegetables. Due to the lack of essential health facilities, residents primarily rely on plants for treating ailments. The community uses various plant parts such as leaves, seeds, bark, flowers, fruits, roots, wood, and stems for medicinal purposes. A recent study identified 183 plants, of which 125 have therapeutic properties; these include 64 herbs, 30 shrubs, and 27 trees from 74 families. It was noted that older



individuals are more likely to use plants as their primary healthcare compared to younger people. The utilization of plants for medicinal purposes not only showcases the biodiversity within local ecosystems but also underscores the deep-rooted knowledge that community members have acquired over generations. This traditional knowledge, often passed down orally, encompasses various preparation methods such as decoction, infusion, poultice, and tincture, highlighting the complex understanding of plant properties and their therapeutic potential. In particular, the study revealed that the most frequently used plants include well-known species such as aloe vera, neem, and turmeric, valued for their anti-inflammatory and healing properties. The data is shown in Figure 3.

*altissima*, which were also used as fuel by locals' peoples. Another study in Hazara Forest, District Malakand, Pakistan, documented 50 collected plant species, 23 of which (12.56%) are used as food. Key species include *Praecitrullus fistulosus*, *Luffa acutangula*, *Cucumis sativus*, *Cucumis melo*, *Lagenaria siceraria*, *Vigna unguiculata*, *Diospyros kaki*, *Cymbopogon citratus*, *Pyrus communis*, and *Prunus persica*, all of which hold significant local value of ethnobotany (Yaseen et al., 2018). Research in Village Thana, District Malakand, KPK, identified several food plants, with 14 (7.65%) also serving as fodder, including *Sonchus asper*, *Cyperus rotundus*, *Melilotus officinalis*, *Vicia faba*, *Pennisetum glaucum*, *Desmostachya bipinnata*, *Portulaca quadrifida*, and *Typha angustata*. These findings align with those of (Ullah et al., 2019) researcher, who collected 11 fodder plant species from Kot Manzaray Baba Valley, Malakand Agency, Pakistan (Ullah et al., 2021b; Yaseen et al., 2018). A total of 13 (7.10%) plant species were found to be used for ornamental purposes, with *Narcissus poeticus*, *Plumeria rubra*, *Tagetes minuta*, *Ipomoea hederacea*, *Thuja orientalis*, *Salvia moorcroftiana*, *Callistemon acuminatus*, and *Mirabilis jalapa* being the most commonly cultivated by locals (Ullah et al., 2023b). Further ethnobotanical research in Ranyal Hills, District Shangla, Pakistan, recorded seven ornamental species. *Populus alba*, *Morus laevigata*, and *Platanus orientalis* are important species used locally for furniture, a trend also observed in Thana Village, District Malakand, KPK. These findings highlight the need for sustainable management, particularly for the medicinal plants that require conservation in the region (Ullah et al., 2018, 2019a, 2023a; Usman et al., 2021). Ethnobotany is vital in understanding the relationship between local communities and plant resources, especially in regions like Munda Khazana. This field of study provides insights into how indigenous knowledge and practices shape the use of plants for medicinal, nutritional, and cultural purposes. By documenting plant species, their local names, and traditional uses, ethnobotany helps preserve cultural heritage and biodiversity while identifying plants with potential applications in healthcare, agriculture, and conservation. In areas where traditional plant knowledge is deeply ingrained, ethnobotanical research supports sustainable management and conservation strategies, protecting valuable plant species that serve as essential resources for local communities (Sultan et al., 2020; Shah et al., 2013).



**Figure 3:** Plant species used for different purposes.

In the Munda Khazana area, a total of 183 valuable plants were collected, among which 125 (68.30%) were used for medicinal purposes. Notable medicinal plants included *Acacia nilotica*, *Acacia modesta*, *Dodonea viscosa*, *Cucumis prophetorum*, *Mentha longifolia*, *Fagonia indica*, *Plantago major*, *Justicia adhatoda*, *Amaranthus viridis*, *Allium sativum*, *Coriandrum sativum*, *Funiculum vulgare*, *Phoenix dactylifera*, *Calotropis procera*, *Psidium guajava*, *Myrtus communis*, *Teucrium stocksianum*, *Solanum virginianum*, *Withania coagulans*, and *Punica granatum*, which are particularly valued by locals (Usman et al., 2021; Ullah et al., 2018). Additionally, research on the ethnobotany of Tehsil Kabal in Swat District, KPK, Pakistan recorded 93 medicinal plants, including *Dalbergia sissoo*, *Pinus gerardiana*, *Acacia modesta*, *Acacia nilotica*, *Alnus nitida*, *Ailanthus*

**Table 1:** Plant botanical name, family local name ethnobotanical uses, and important values relative to the frequency and use value of the research.

S. No.	Plant name	Family name	Local name	Ethnobotanically uses	Importance value	Relative frequency	Use value
	<i>Justicia adhatoda</i> L.	Acanthaceae	Baikana	For fuels Diarrhea, cough, pain, and asthma	1.16	0.7	1.3
	<i>Agaricus campestris</i> L.	Agaricaceae	Kharery	Used as tonic and food	0.83	0.7	0.9
	<i>Amaranthus viridis</i> L.	Amaranthaceae	Chorlai	For Diuretics, lithiasis, headache swelling, and used food and fodder.	1.58	0.9	3
	<i>Beta vulgaris</i> L.	Amaranthaceae	Chaqandr	Used as a vegetable.	0.41	0.7	0.7
	<i>Achyranthes aspera</i> L.	Amaranthaceae	Sappy booty	It's used in the treatment of mucus, cough, and asthma.	0.75	0.9	1.9
	<i>Narcissus Poeticus</i> L.	Amayrpidaeae	Goli Nargis	Flowers are used for ornamental purposes.	0.41	0.9	0.9
	<i>Allium sativa</i> L.	Amayrpidaeae	Ouaga.	Use as a food. Arteries, high blood pressure, and heart diseases.	1.16	0.9	1.8
	<i>Asparagus gracilis</i> Royle.	Amayrpidaeae	Tendorry	Used as a tonic, food, and vegetable.	0.83	0.8	1.6
	<i>Mangifera indica</i> L.	Anacardiaceae	Aam (Mango)	Used as a tonic. Dried flower is used for constipation.	0.58	0.8	1.2
	<i>Coriandrum sativum</i> L.	Apiaceae	Dania	Used as food and fodder. skin disease, Asthma, blood purifier, cardiac and respiratory disease.	1.91	0.8	2.1
	<i>Funiculum vulgar</i> Mill.	Apiaceae	Kaaga, Kagelany	Used chest pain, abdominal pain, dysentery	0.75	0.7	1.2
	<i>Nerium odorum</i> L.	Apocinaceae	Gandhari	Use for fodder beatification and shelter. Asthma, heart attack.	1.41	0.8	2
	<i>Plumeria rubra</i> L.	Apocinaceae	Rambil chambil	Used for ornamental purposes	0.41	0.6	0.6
	<i>Rhazya stricta</i> Decne.	Apocinaceae	Ghandechar	Used as animal fodder and also for fuel.	0.83	0.8	1
	<i>Phoenix dactylifera</i> L.	Areaceae	Khajoor	Used as an aphrodisiac and tonic.	0.58	0.6	0.8
	<i>Nannorrhops ritchiana</i> (Griff.)	Areaceae	Mezary	Used for dysentery and diarrhea	0.58	0.7	1.1
	<i>Calotropis procera</i> (Willd.) R. Br.	Asclipdaceae	Spulmay	Remove Intestinal pain, inflammation, and respiratory disease.	0.75	0.9	1.5
	<i>Periploca aphylla</i> Decne.	Asclipdaceae	Barrah	Stem is used as a laxative. Milky juice of shoot is used in fever.	0.58	0.8	1
	<i>Caralluma tuberculata</i> N.E. Brown.	Asclipdaceae	Pamunkey	Vegetable, Juice is used for diabetes.	0.83	0.9	1.4
	<i>Sonchus aspera</i> L.	Asteraceae	Shodapii	Used as fodder for cattle	0.41	0.9	0.9
	<i>Xanthium strumarium</i> L.	Asteraceae	Gee shy.	Used as fodder, fuel, tonic, and for digestive problems.	1.41	0.5	0.5
	<i>Teraxicum officinale</i> (L.) Weber ex F.H.Wigg.	Asteraceae	Ziar gully	Roots are used in diabetes and for kidney problems	0.58	0.5	0.8
	<i>Artemisia maritime</i> L.	Asteraceae	Tharkha	Use as shelter, fuel, Cough, cold, and anemia.	1.58	0.6	1.3
	<i>Bellis perennis</i> L.	Asteraceae	Kangaya	Used for ornamental purposes	0.41	0.4	0.4
	<i>Helianthus annuus</i> L.	Asteraceae	Nomar parast	Seeds are used for oil and leaves are used for animal fodder	0.83	0.6	1
	<i>Artemisia scoparia</i> Waldst. and Kitam.	Asteraceae	Jawakay	Used as food and fodder.	0.83	0.6	0.7

Table continued on next page.....

S. No.	Plant name	Family name	Local name	Ethnobotanically uses	Importance value	Relative frequency	Use value
	<i>Cichorium intybus</i> L.	Asteraceae	Kashnee	It's used as a tonic. Useful in asthma.	0.58	0.6	0.9
	<i>Duchesnea indica</i> (Andr)	Asteraceae	Balmangai	Used as nerve tonic, aphrodisiac, diuretic.	0.75	0.7	1
	<i>Tagetes minuta</i> L.	Asteraceae	Dambar gully	Different plants can be safe from nematodes.	0.41	0.9	0.9
	<i>Parthenium hysterophorus</i> L.	Asteraceae	Zanglely tarkh	Fodder and fuel	0.83	0.7	0.9
	<i>Cirium arvense</i> (L.)	Asteraceae	Azghakey	Fodder and diarrhea	0.83	0.7	1
	<i>Berberis lycium</i> Royle.	Berberidiaceae	Kwary	Used for fuel. Cough liver diseases, depression, and bleeding.	0.83	0.8	1.8
	<i>Alnus nitida</i> (Spach)	Betulaceae	Gherey	Used as timber. And for fuel.	1.33	0.9	1
	<i>Trichodesma indicum</i> (L.) Lehm.	Boringeaceae	Gulab booty	Use for snake bites and as children with dysentery and used as an antidiuretic.	1	0.5	0.6
	<i>Sisymbrium irio</i> L.	Brassicaceae	Ginger	Seeds used in dropsy.	0.41	0.6	0.6
	<i>Brassica campestris</i> L.	Brassicaceae	Sharrsham	Used as food and fodder. Beautification skin disease, Asthma, cough, disease.	2	0.8	1.9
	<i>Eruca sativa</i> Mill.	Brassicaceae	Toor Pak	Used for humans and fuel. Digestive, tonic, therapeutic.	1.58	0.7	1.5
	<i>Nasturtium officinale</i> R	Brassicaceae	Tarmira	Vegetable used in tetanus.	0.83	0.7	1
	<i>Capsella bursa pastaris</i> (L.) Medik	Brassicaceae	Bmmesa	Used stimulant and antiscorbic.	0.58	0.7	1
	<i>Opuntia dillenii</i> (Ker Gawler)	Cactaceae	Inzar Ghana	Used for diabetics and food.	0.83	0.9	1.1
	<i>Cannabis sativa</i> L.	Canabaceae	Bhang	Pleasant excitement and astringent.	0.75	0.7	1.1
	<i>Canna indica</i> Linn	Cannaceae	Tasfaboty	Used as ornamentally.	0.41	0.6	0.6
	<i>Silene conidial</i> L.	Caryophyllaceae	Mangooty	Used as a vegetable.	0.41	0.5	0.5
	<i>Chenopodium album</i> L.	Chenopodiaceae	Sarmay	Use as fodder, urinary problem, and worm killer.	1	0.7	1
	<i>Chenopodium botrys</i> L.	Chenopodiaceae	Kharwa	Vegetables should only be eaten in small quantities.	0.41	0.5	0.5
	<i>Chenopodium ambrosioides</i> L.	Chenopodiaceae	Kamasal Bhang	used for fever, especially for malarial fever.	0.58	0.5	0.7
	<i>Convolvulus arvensis</i> L.	Convonulaceae	Parvathy	Use for fuel young plants are grazed by the cattle and skin disorders.	1.25	0.7	1
	<i>Ipomoea hederacea</i> (L.) Jacq	Convonulaceae	Speaker gul	Used for ornamental purposes.	0.41	0.6	0.6
	<i>Praecitrullus fistulosus</i> stocks.	Cucurbitaceae	Tenda	Used for vegetable	0.41	0.5	0.5
	<i>Luffa acutangula</i> L.	Cucurbitaceae	Toray	Used for vegetable	0.41	0.5	0.5
	<i>Cucumis sativus</i> L.	Cucurbitaceae	Badrang	Used as salad		0.5	0.5
	<i>Cucumis melo</i> L.	Cucurbitaceae	Khataky	Used as food	0.41	0.7	0.7
	<i>Lagenaria siceraria</i> Molina.	Cucurbitaceae	Kaddu	Used as a vegetable	0.41	0.6	0.6
	<i>Thuja orientalis</i> L.	Cupressaceae	Warrah Sarwa	Used for ornamental purposes	0.41	0.6	0.6
	<i>Cupressus sempervirens</i> L.	Cupressaceae	Ghata Sarwa	Used as a warming agent and astringent and used for fuel	1	0.7	1

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S. No.	Plant name	Family name	Local name	Ethnobotanically uses	Importance value	Relative frequency	Use value
	<i>Cuscuta reflexa</i> Roxb.	Cuscutaceae	Mencha Boty	Used for liver, and stomach relaxation and fever problems	0.75	0.7	1
	<i>Cyperus rotundus</i> L.	Cyperaceae	Drab	Used for fodder and fuel	0.83	0.5	0.6
	<i>Diospyros kaki</i> L. F	Ebenaceae	Amlook	Fruit is edible; Leaves are used as food as well as for fuel.	0.83	0.8	1.1
	<i>Ricinus communis</i> L.	Euphorbiaceae	Arhanda	Leaves are narcotic, poisonous, and purgative.	0.75	0.6	1
	<i>Euphorbia helioscopia</i> L.	Euphorbiaceae	Manddaro	Used as fuel and skin disease, analgesic, and respiratory disease.	1.16	0.7	1
	<i>Chrozophora tinctoria</i> (L.) A. Juss.	Euphorbiaceae	Sheengatay	Used for panting and flavonoids.	0.58	0.6	0.7
	<i>Euphorbia hirta</i> Linn	Euphorbiaceae	Orejakai	Used in respiratory infections such as cough, flu, and asthma.	0.91	0.8	1
	<i>Dalbergia sissoo</i> Roxb.	Fabaceae	Shawa	Use for food and fuel.	0.83	0.6	0.7
	<i>Trifolium vesipinatum</i> L.	Fabaceae	Shaftal	Used like food for livestock. The seeds are also utilized for pimples.	0.83	0.6	0.9
	<i>Medicago denticulate</i> Willd.	Fabaceae	Feshitary	Used as food and for sugar control.	0.83	0.8	0.9
	<i>Vigna unguiculata</i> L.	Fabaceae	Lobyra	Used as food and for kidney stone	0.83	1	1.2
	<i>Peterocarpus marsupium</i> Roxb.	Fabaceae	Kenu	Used as food and fuel	0.83	0.6	0.7
	<i>Sophora flavescens</i> Aiton	Fabaceae	Kayay	Used as fuel and also for fodder.	0.83	0.9	1.1
	<i>Melilotus officinalis</i> (L.) Pall	Fabaceae	Terangrray	The seeds are eaten by game birds, including grouse.	0.41	0.8	0.9
	<i>Vicia sativa</i> L.	Fabaceae	Mater palli	Fodder, seeds are used for bitter taste.	0.83	0.5	0.6
	<i>Lathyrus aphacal</i> L.	Fabaceae	Marghai khapa	Food and Seeds are used as narcotics.	0.83	0.6	0.7
	<i>Quercus incana</i> Roxb.	Fagaceae	Serray	Used for food fodder and fuel, and used for Diarrhea, and asthma dysentery.	1.5	1	2
	<i>Anagallis arvensis</i> L.	Frimulaceae	Shen goly	Used for cerebral affection, and stomach inflammation.	0.58	0.7	0.8
	<i>Famaria indica</i> (Hausskn.) Pugsley	Fumariaceae	Krachy	Use for blood cleaning and also for fodder.	0.83	0.8	1
	<i>Juglan regia</i> L.	Juglandaceae	Ghooz	Used for food furniture and fuel also used for Diarrhea, stomach, and asthma disease.	1.5	0.9	1.8
	<i>Mentha longifolia</i> (L.) L.	Labiataeae	Enally	Leaves are utilized to relieve abdominal pain as well as to reduce gastric acidity.	0.58	0.6	0.8
	<i>Mentha piprata</i> L.	Labiataeae	Fodina	For food and fodder. Skin, abdominal pain, asthma disease, and wound healing.	1.75	0.8	1.6
	<i>Silene moorcroftiana</i> Wall. ex Benth	Labiataeae	Kharghwag	Leaves are used to relieve pain.	0.41	0.9	1.7
	<i>Allium cepa</i> L.	Liliaceae	Pyaz	For food and fodder, and also used sexual, swelling.	1.25	0.7	0.7
	<i>Aloe barbadensis</i> Mill.	Liliaceae	Zooqam	Used for skin diseases	0.41	0.6	0.9
	<i>Tulipa clusiana</i> DC.	Liliaceae	Ghantool	Used as ornamentally.	0.41	0.7	0.8
	<i>Ajuga parviflora</i> Benth	Lamiaceae	Kauri Booti	Used in curing pimples, headache, stomach acidity, and measles.	0.91	0.7	0.7

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S. No.	Plant name	Family name	Local name	Ethnobotanically uses	Importance value	Relative frequency	Use value
	<i>Ajuga bracteosa</i> Wall. ex Benth.	Lamiaceae	Gooti	Fuel and fodder. Antioxidant, antipyretic, for chest diseases	1.41	0.6	0.9
	<i>Ocimum bacilicum</i> L	Lamiaceae	Kashmally	Used food, shelter, and fodder. Antioxidants, skin, and antipyretic disease.	1.58	1	1.8
	<i>Teucrium stocksainum</i> Boiss.	Lamiaceae	Speer botay	For used diarrhea, cough, and abdominal pain.	0.75	0.6	0.9
	<i>Micromeria biflora</i> Benth	Lamiaceae	Shomakay	Leaves used as antiemetic and flue.	0.58	0.6	0.8
	<i>Vitex negundo</i> L.	Lamiaceae	Marvandai	Used as digestive problems and fuel.	0.83	0.6	0.6
	<i>Otostegia limbata</i> (Benth)	Lamiaceae	Spenazghy	Used to expel warm.	0.41	0.6	0.6
	<i>Salvia moorcroftiana</i> Wall. ex Benth.	Lamiaceae	Sofeed qarqara	Used as ornamentally	0.41	0.5	0.5
	<i>Lamium amplixicula</i> L.	Lamiaceae	Gulabi gulli	Laxative and stimulant	0.58	0.6	0.7
	<i>Malva neglecta</i> Wall.	Malvaceae	Panerak	Food and pain.	0.83	0.7	0.8
	<i>Abelmoschus esculentus</i> L.	Malvaceae	Benday	Vegetable and stomach cleaning.	0.83	0.6	0.7
	<i>Abutilom megapotamicum</i> (A.Spreng.)	Malvaceae	Charg starga	Used as a vegetable.	0.41	0.6	0.6
	<i>Grewia optiva</i> J.R. Drumm.	Malvaceae	Pastawony	Used in stomach gas and fodder for cattle.	0.83	0.7	0.9
	<i>Acacia nilotica</i> (L.)	Mimosaceae	Kikar	Used for fuel and fodder.	0.83	0.6	0.7
	<i>Acacia modesta</i> Wall.	Mimosaceae	Palosa	Used for furniture, fodder and fuel.	1.25	0.6	0.8
	<i>Melia azedarach</i> L.	Meliaceae	Toora shandai	Leaf extract is utilized for antimicrobial agents, blood purification, and also used for animal food.	1	0.6	0.8
	<i>Morus nigra</i> L.	Moraceae	Toor Toot	Used for a cooling agent, astringent, and cleaning throat.	0.75	0.6	1.3
	<i>Morus alba</i> L.	Moraceae	SpenToot	Fruits are addible, wood used for furniture, and throat infection	1.25	0.4	0.9
	<i>Morus lavaegata</i> Wall.	Moraceae	ShahToot	Fruit is suitable for eating. Leaves are used as a food for livestock.	0.83	0.6	1.1
	<i>Myrtus communis</i> L	Moraceae	Manrro	It is used as fodder .it also practiced to cure animal respiratory and digestive disorders.	1	0.6	1.4
	<i>Ficus carica</i> L	Moraceae	Inzar	Use fuel and fodder for the shelter. Diabetic, migraine, diarrhea	1.58	0.6	1.5
	<i>Morchella esculenta</i> L.	Morchelaceae	Khossy	Used as a food and also used for anti-tumor and antiviral effects.	1	0.7	1
	<i>Eucalyptus camaldulensis</i> Dehnh.	Myrtaceae	Lachie	Leaves are used to prepare Joshanda to relieve flue. Leaves are used to cure Diarrhea.	0.58	0.6	0.8
	<i>Psidium guajava</i> L.	Myrtaceae	Am rood	Used as a tonic.it is also useful for expelling abdominal worms.	0.58	0.7	0.8
	<i>Callistemon acuminatus</i> Cheel.	Myrtaceae	Batal brush	It is used for ornamental purposes and fuel and shelter.	1.25	0.7	1.2
	<i>Boerhavia procumbense</i> Banks ex Roxb.	Nyctaginaceae	Insat	Used as fodder and rarely used as Sag.	0.83	0.6	0.7

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S. No.	Plant name	Family name	Local name	Ethnobotanically uses	Importance value	Relative frequency	Use value
	<i>Mirabilis jalapa</i> L.	Nyctaginaceae	Gula basi	The leaves are eaten as a vegetable, and also used for ornamental purposes.	0.83	0.6	0.7
	<i>Olea ferruginea</i> Royle.	Oleaceae	Khuna	It is used for fuel, powder, and shelter. Mouth sores, toothache, pain.	1.58	0.8	2
	<i>Oxalis corniculata</i> L.	Oxalidaceae	Turkey	It is used as food, shelter, and also used for fodder. Asthma, digestive, diarrhea, and skin disease.	1.75	0.8	2.1
	<i>Picrorhiza kurroa</i> Royle.	Paeoniaceae	Mamaikh	It is used for digestive complaints and heart disease	0.58	0.4	0.5
	<i>Papaver somniferum</i> L.	Papaveraceae	Doda, Kash.	Used as fodder, and fuel and also used for Dysentery, diarrhea, and pain.	1.58	0.6	1.8
	<i>Papaver pavoninum</i> Schren	Papaveraceae	Sur gully	Flowers are used as a sedative. and also used as fodder	0.83	0.6	0.7
	<i>Fumaria parviflora</i> Lam.	Papaveraceae	Shahtra	Used fodder and fuel Shoots are used in diarrhea, blood purifiers, and fever.	1.58	0.5	1.6
	<i>Vicia faba</i> L.	Papilionaceae	Marghai khpa	Used as food and also used for fodder	0.83	0.5	0.6
	<i>Indigofera articulate</i> Gouan (L)	Papilionaceae	Ghwarega	Use as fuel and shelter and also used as fodder for cattle. Pain, respiratory diseases, diarrhea, wound healing.	1.75	0.6	2.7
	<i>Pinus roxburghii</i> Sarg.	Pinaceae	Nakhtar	Fuel and furniture. Back pain, anti-filamentary, respiratory disease.	1.58	0.7	1.7
	<i>Cedrus deodara</i> (Roxb)	Pinaceae	Diyar	Used as a fodder and fuel. Diarrhea, dysentery, and urinary problems.	1.58	0.7	1.9
	<i>Pinus gerardiana</i> Wall. ex Lamb	Pinaceae	Chilghoza	Used for Timber, fuel, furniture, and food.	1.41	0.7	1.4
	<i>Plantago lanceolate</i> L.	Plantaginaceae	Ghwa jabbi	Used for Respiratory, skin, insect, and infection.	0.91	0.6	1.3
	<i>Plantago major</i> L.	Plantaginaceae	Aspaghool	Used for Digestive, constipation, vomiting and diarrhea	0.75	0.6	1.4
	<i>Platanus orientalis</i> L.	Platanaceae	Chinnor	It is used as food, shelter, and also used for fodder. Wound healing and urinary disease.	1.41	0.6	1.8
	<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	Kabal	Used for animal and also use for cough, dysentery and stones.	1.16	0.6	1.4
	<i>Avena sativa</i> L.	Poaceae	Jawdar	Used for animal food and also for fuel. Anti-flummery and antioxidant.	1.41	0.7	1.5
	<i>Pennisetum glanucum</i> (L.) R.Br.	Poaceae	Bajra	It is used as a food for chicken and also used for animal food	0.41	0.8	0.9
	<i>Zea mays</i> L.	Poaceae	Jowar	Used as a food and fodder and also loss appetites.	1.25	0.8	1.4
	<i>Desmostachya bipinnata</i> L.	Poaceae	Dela	It is used for animal food.	0.41	0.7	0.7
	<i>Oryza sativa</i> L.	Poaceae	Shohola	It is used for heart diseases, and diabetes and also used for a portion of food and fodder.	1.41	0.6	1.2
	Saccharum bengalense Retz.	Poaceae	Sharghasy	The leaf ash is used to cure sore eyes. Stem juice is used to treat sore throats.	0.58	0.6	1.1
	<i>Cymbopogon citratus</i> (DC.) Stapf	Poaceae	Shen chai (green tea)	It's used ornamentally and used for green tea.	0.83	0.6	0.7
	<i>Phalaris minor</i> Retz.	Poaceae	Wakha	Commonly used as fodder	0.41	0.6	0.6

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S. No.	Plant name	Family name	Local name	Ethnobotanically uses	Importance value	Relative frequency	Use value
	<i>Adiantum capillus</i> Sw.	Podiaceae	Aisha Bibi Sana	It's used for bronchitis problems.	0.41	0.6	0.6
	<i>Rumix hastatus</i> D. Don.	Polygonaceae	Tar okay	Leaves are used as diuretic as well as carminative. Leaves are cooked like vegetables as well as eaten fresh.	1.16	0.8	1.8
	<i>Rumix crispus</i> L.	Polygonaceae	Shalkhy	Cooked like vegetables and used to care for constipation in livestock.	0.83	0.6	0.9
	<i>Polygonum barbatum</i> L.	Polygonaceae	Pulpulak	Used for fish hunting.	0.41	0.8	0.8
	<i>Portulaca oleracea</i> L.	Portulacaceae	War harray	Used for food and fodder.	0.83	0.7	0.9
	<i>Portulaca quadrifida</i> L.	Portulacaceae	Zangley War Khary	Used as vegetable and for animals' food.	0.83	0.5	0.6
	<i>Pteris cretica</i> L.	Pteridaceae	Sana	Used as ornamentally	0.41	0.6	0.6
	<i>Punica granatum</i> L.	Punicaceae	Anangorray	Used for human and fuel. Antipyretic and analgesic.	1.41	0.7	1.4
	<i>Ranunculus sceleratus</i> L.	Ranunculaceae	Babonay	The whole plant has anti-inflammatory and analgesic.	0.58	0.7	0.9
	<i>Zizyphus Jujube</i> Mill.	Rhamaceae	Berra	It is used as food and fodder, Shelter, fuel, sugar, and skin disease.	1.83	0.8	2.3
	<i>Zizyphus sativa</i> Gaertn	Rhamaceae	Markhanrry	It is used for humans and Furniture. Blood pressure and wounds.	1.41	0.6	0.9
	<i>Zizyphus nummularia</i> Burm. f.	Rhamaceae	Karkanda	It is used treatment of colds, mental retardation, and fever and is also used in ulcers.	0.91	0.6	1.2
	<i>Sajaretia thea</i> Brongn.	Rhamaceae	Mamanrra	It is used as food and fodder. Asthma, skin, and pain disease.	1.58	0.6	1.3
	<i>Zizyphus oxyphylla</i> Edgew	Rhamaceae	Elanaiy	Used to eye-related diseases and high blood pressure. Use as a fuel.	0.41	0.7	1.2
	<i>Gallium aparine</i> L.	Rubiaceae	Jalakai	Used as Ant diuretic.	0.83	0.6	0.6
	<i>Pyrus communis</i> L.	Rosaceae	Naashpaty	Food is edible and used as fuel	1.66	0.6	0.7
	<i>Prunus dulcis</i> Mill.	Rosaceae	Badaam	Used for food, fuel, and fodder and also to stimulate brain activity.	1.25	0.6	1.1
	<i>Prunus armeniaca</i> L.	Rosaceae	Khobani	Fruit is suitable for eating; wood is used for fuel and leaves are used for food.	1.25	0.6	1.1
	<i>Prunus persica</i> L.	Rosaceae	Shaltalo	Fruit is edible, wood is utilized as fuel and leaves are used for fodder	0.83	0.6	0.9
	<i>Prunus domestica</i> L.	Rosaceae	Aloocha	Fruit is edible, wood is used for fuel as well as leaves are used for fodder.	0.41	0.7	1.2
	<i>Eriobotrya japonica</i> (Thunb.) Lindl.	Rosaceae	Law kat	Food and fuel.	0.58	0.6	0.8
	<i>Rosa moschata</i> Mill	Rosaceae	Zangley Gulab	Used for making hedges and for ornamental purposes.	1	0.5	0.6
	<i>Duchesnea indica</i> (Andr) Folke.	Rosaceae	Da Zmake tooth	Fruit is used as a stimulant, especially as a cooling agent.	1	0.6	0.7
	<i>Rosa indica</i> L.	Rosaceae	Gulab	Used for ornamental purposes, used for cough and throat infection.	0.75	0.6	1.2
	<i>Malus pumila</i> Mill.	Rosaceae	Manrra	Used as food, fodder, timber, and fuel.	1.75	0.5	1.2
	<i>Citrus sinensis</i> (L.) Osbeck	Rutaceae	Malta	Fruit is used as a stimulant, and appetizer given to constipating patients.	1.58	0.6	0.9
	<i>Citrus medica</i> L.	Rutaceae	Nemboo	Fruits, fuel, shelter. Anti-diabetic, analgesic, healing agent, and cough.	1	0.6	2

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S. No.	Plant name	Family name	Local name	Ethnobotanically uses	Importance value	Relative frequency	Use value
	<i>Zanthoxylum armatum</i> Dc.	Rutaceae	Dambara	It is used as food and fodder. And also used for Blood purification, nerves respiratory and digestive disease.	0.83	0.7	2
	<i>Carthamus oxycantha</i> M. Bieb.	Rutaceae	Kareza Ghana	Young leaves are used vegetables. Flowers are used for male infertility and bronchitis.	1.25	0.6	0.9
	<i>Citrus maxima</i> (Burm.) Merr.	Rutaceae	Galgal	Used for food and fodder.	0.83	0.6	0.9
	<i>Populus alba</i> L.	Salicaceae	Sufedad	Used as timber, fuel, fodder, and furniture.	1.25	0.5	1
	<i>Salix babylonica</i> L.	Salicaceae	Walla	Leaves are used for animal food. The wood used is a fuel and shelter.	0.83	0.6	0.8
	<i>Ailanthus altissima</i> Mill.	Simaroubaceae	Kharra shandy	For fuel and fodder.	0.83	0.6	0.9
	<i>Monotheca buxifolia</i> (Falc.) A. DC.	Sapotaceae	Gurgora	Fruits are used as human food and fodder Asthma, is antipyretic.	1.41	0.6	1.1
	<i>Verbascum Thapsus</i> L.	Scrophulariaceae	Khurdug	Fruits, fuel, shelter. Tuberculosis, cough, asthma.	1.41	0.6	1.7
	<i>Solanum nigrum</i> L.	Solanaceae	Kaach Maacho	Younger leaves as used for fever curing flue and cough. Desiccated fruits are utilized for stomach diseases.	0.91	0.6	1.4
	<i>Withania somnifera</i> (L.) Dunal.	Solanaceae	Kotilal	Root paste is applied in painful, bleeding wounds swelling, and ulcers. To treat asthma,	0.91	0.5	1.2
	<i>Datura alba</i> Nees	Solanaceae	Datura	Leaves are smoked to cure asthma.	0.41	0.7	0.7
	<i>Datura innoxia</i> Mill.	Solanaceae	Batura	Fuel and shelter. Tonic Dysentery and diabetic disease.	1	0.6	1.4
	<i>Solanum lycopersicum</i> L.	Solanaceae	Tamater	Used is a salad, also used for a food and gives strength to the muscle.	0.83	0.5	0.6
	<i>Solanum melongena</i> L.	Solanaceae	Bengan	Used as food. Various plant parts are used in decoction and skin infections.	1	0.6	1.2
	<i>Cestrum nocturnum</i> L.	Solanaceae	Rat ki rani	Used for ornamental purposes.	0.41	0.5	0.5
	<i>Solanum surattense</i> Burm.f.	Solanaceae	Maraghoonay	Used for a cure to finish the sterile habit of females.	0.41	0.7	0.7
	<i>Tamarix aphylla</i> (L.) H. Karst.	Tamariaceae	Ghaz	Used for a piece of furniture, fuel, and used for burnt parts of the body.	1.25	0.7	0.9
	<i>Daphne macronata</i> Royle	Thymeleaceae	Lighonay	Shoot is used as a fuel and fruit is used as food for birds	0.83	0.5	0.6
	<i>Typha angustata</i> Bory and Chab.	Typhaceae	Lokha	The plant is used like thatching substances. Leaves are used as a food.	0.41	0.5	0.6
	<i>Debregeasia saneb</i> F.	Uritiaceae	Karwarra	Used as fruit fodder, fuel, and for blood purification, and stomach.	1.66	0.6	1
	<i>Urtica dioica</i> L.	Uritiaceae	See zonkey	Vegetables and used for the treatment of jaundice.	0.83	0.5	0.6
	<i>Celtis australis</i> L.	Valmaceae	Thaghagay	Used for food and fodder. And wood used is a fuel and shelter.	1.25	0.5	1.2
	<i>Voila canescens</i> Wall.	Violaceae	Benofsha	Used for treatment of fever and flue.	0.58	0.6	0.7
	<i>Vitis vinifera</i> L.	Vitaceae	Angoor	Fruit is used as a common stimulant as well as a laxative.	0.58	0.6	0.7
	<i>Tribulus terrestris</i> L.	Zygophyllaceae	Markondii	Open the inhalation through the nose.	0.41	0.9	0.9



## Conclusions and Recommendations

The ethnobotanical study of Munda Khazana in District Lower Dir highlights a rich diversity of plant species, with 183 distinct plants across 73 families, predominantly herbs, followed by shrubs and trees. The study shows that the local population relies extensively on these plants, particularly for medicinal purposes, with 125 species (approximately 68%) being used to treat various ailments. The Asteraceae family emerged as the most represented, while herbs were the primary plant type utilized, underscoring the region's dependence on plant-based healthcare in the absence of formal medical facilities. Various plant parts, from leaves and seeds to entire plants, are employed through diverse preparation methods, demonstrating the depth of traditional knowledge held within the community. This reliance on plants for health and daily needs highlights the importance of conserving both the plant resources and the cultural knowledge systems in the area. As younger generations appear less inclined toward traditional plant use, documentation and conservation of these practices are crucial for maintaining the region's ethnobotanical heritage.

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## Novelty Statement

This study presents a comprehensive ethnobotanical survey of Munda Khazana, District Lower Dir, documenting an extensive array of 183 plant species used by local communities for medicinal, nutritional, and functional purposes. Unlike previous studies in the region, this research uniquely focuses on the breadth of plant families, individual plant part usage, and preparation methods within traditional medicine, providing new insights into the diverse ethnobotanical practices rooted in the cultural heritage of the area.

## Author's Contribution

**Rehan Ullah:** Performed research.

**Fazli Rahim:** Supervision.

**Muhammad Sajid:** Technical review.

**Shakir Ullah:** Helped in paper research.

**Shahab Ali:** Wrote the manuscript.

**Lubna Shakir:** Helped in statistics and graph-making.

**Ghani Subhan:** Helped in research.

**Mohammad Sohail:** Provided technical support.

## Conflict of interest

The authors declare that they have no conflict of interest. They have no financial, personal, or professional interests that could influence the design, execution, or interpretation of the study.

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