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Floristic composition, biological spectrum, and phytogeographic distribution of the Bin Dara Dir, in the western boundary of Pakistan

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This study assessed the floristic composition, biological spectrum, and phytogeographical elements of the Bin Dara western boundary of Pakistan. The flora consisted of 140 plant species belonging to 47 families. The most dominant family was Poaceae (with 14 species), followed by Asteraceae (11 species). The biological spectrum showed the therophytes (71 species, 50.71%) as the dominant life form class, followed by mega -phanerophytes (27 species, 19.28%), nano-phanerophytes (15 species, 10.71%), geophytes (10 species, 7.14%), chamaephytes (9 species, 6.42%), and hemi-cryptophytes (8 species, 5.71%). Leaf size classes comprised of nanophylls (48 species, 34.28%), microphylls (32 species, 22.85%), mesophylls (22 species, 15.71%), macrophylls (17 species, 12.14%), leptophylls (12 species, 8.57), megaphylls (8 species, 5.75%), and aphyllous (1 species, 0.71%). Cosmopolitan was the most prominent form of phytogeographic elements (with 17 species, 12.14%), followed by pantropical and Euro-Siberian Mediterranean Irano-Turanian (14 species, 10%) each. The pluriregional represented (13 species, 9.28%), Holarctic and Mediterranean Irano-Turanian (10 species, 7.14%), Irano-Turanian and Western Himalayan (9 species, 6.42%) each. It is recommended that further study is needed to map the vegetation, its indicators, and rare species that face a huge threat of endangerment.

KEYWORDS

life form, leaf size, floristic elements, western Himalayan, plants distribution

Introduction

The floristic composition of any area gives us essential information about different plant species diversity and their distribution (Ali et al., 2018; Bano et al., 2018; Gul et al., 2018). It leads to the proper identification of plant species and thereby conservation in a scientific and systematic way. The distribution of plant species is a valuable source of information for environmental factors and ecosystem services in a particular habitat (Angyalossy et al., 2022; Flores-Argüelles et al., 2022; Magray et al., 2022; Shannon et al., 2022; Wani et al., 2022b; Watts et al., 2022). Floristic diversity is used to interpret plant species of any geographical area, whether cultivated or wild in their nature (Farooq et al., 2019; Khan and Badshah, 2019; Ca et al., 2020; Wani and Pant, 2021; Wani et al., 2022a). The presence of all plant species found in a particular area is termed flora while vegetation is related to the relative importance of plant species, their life and leaf form, population, and distribution in relation to space and time. Floristic inventory can help us to understand the features of vegetation characteristics (Mehmood et al., 2015, 2017; Rahman et al., 2016; Li et al., 2021; Zhao et al., 2021) and it is important for human existence, economic health, ecosystem function, and stability (Khan et al., 2016; Wani et al., 2021; Su et al., 2022; Wani and Pant, 2022).

The biological spectrum of an area also gives the climate picture of that region. It tells about weather patterns, especially the rainfall and temperature phenomena, and their distribution over the year. Climatic conditions over a longer period give rise to phytogeographic consistency among the floristic elements. According to Takhtajan (1969a) and Ali and Qaiser (1986), there are three phytogeographical regions in Pakistan i.e., Irano-Turanian, Saharo-Sindian, and the Indian regions (Khan et al., 2020). But Kitamura (1960) and Hara (1966) also recognized the Sino-Japanese region. Thus, four phytogeographical regions are recognized in Pakistan. Each region is delimited based on certain criteria, apart from others, by Zohary (1950), and characterized by the presence of a component of the flora or phytogeographical elements.

In the Irano-Turanian Region, there are both diurnal and annual plant species characterized by extreme temperature and low precipitation. There is a considerable difference of opinion so far as the subdivision of the region is concerned. Two sub-regions, i.e. Western and Eastern Irano-Turanian sub-regions were recognized because of the climatic and physiognomic factors (Zohary, 1950). The Eastern Irano-Turanian sub-region occurs at 35°-36° north latitude and the Western Irano-Turanian sub-region is at 29°-30° north latitude. The western Himalayas are situated in the Western Irano-Turanian subregion, which has many endemic plant species. The western boundaries of the Sino-Japanese region in the Himalayas touch western Nepal (Takhtajan, 1969b) and according to the findings of Zohary (1950), Kitamura (1960), and Hara (1966) it further spreads through Pakistan into Afghanistan to their western limit. This is supported by the interruption of the maximum rainfall (180 cm) areas (Haq et al., 2020). Before glaciation, the present Sino-Japanese flora had changed relatively little from the vegetation of the north-temperate regions that surrounded the whole northern hemisphere (Axelrod and Raven, 1978). While the name "Saharo-Sindian" was given by Eig (1931), the area spreads from the Atlantic coast of north Africa through the Sinai Peninsula, the entire Sahara, most of Arabia, more than half of Palestine, part of Syria, south Iran, south Iraq, southern Baluchistan, Sindh, most parts of Punjab in Pakistan and the Rajasthan desert in India (Eig, 1931).

The Indian region comprises the flanks of the Himalayas, the Gangetic plain, the Indian peninsula proper, and Sri Lanka. The territory of this region is not continuous in Pakistan. It lies between 27° and 28° north latitude in the southeastern part and between 29° and 32° north latitude in the eastern Punjab province. Distribution of phytogeographic elements helps in tracing plant migration, origination, evaluation, plant speciation, distribution range, conservation plans, perception of ecological nature, diversification, and plant wealth.

However, very little attention has been given to the assessment of phytogeographic elemental distribution patterns in these areas. Therefore, the present study was conducted to find out the floristic composition, biological spectrum, and phytogeographic distribution of the Bin Dara, in the western boundary of Pakistan. The results might be helpful to ecologists, plant geographers, conservationists, and ethnobotanists in understanding the vegetation structure, conservation status, and characteristics in the region. The procedure adopted in the current study can be followed for the assessment of phytogeographic elements of any ecosystem of the world.

Materials and methods

Study area

The Bin Dara lies at 35°5′ 23.82″ to 35°6′ 1.41″ N latitude and 71°40′ 48.28″ to 71°41′ 52.66″ E longitude with an elevation range of 1,553–2,764 m in the western Himalaya floristic region in Pakistan (Figure 1). It has rigid topography, dominated by hills with hard rocks. Its temperature remains moderate and warm in the summer season. June and July are the hot months of the year (Manan et al., 2020). The area's mean annual minimum and maximum temperatures are 10 and 27°C, respectively.

The current study was conducted through the detailed methodology as follows.

Field survey

Regular field surveys were conducted throughout Bin Dara, Dir, using standard ecological techniques (Ahmad et al., 2016;

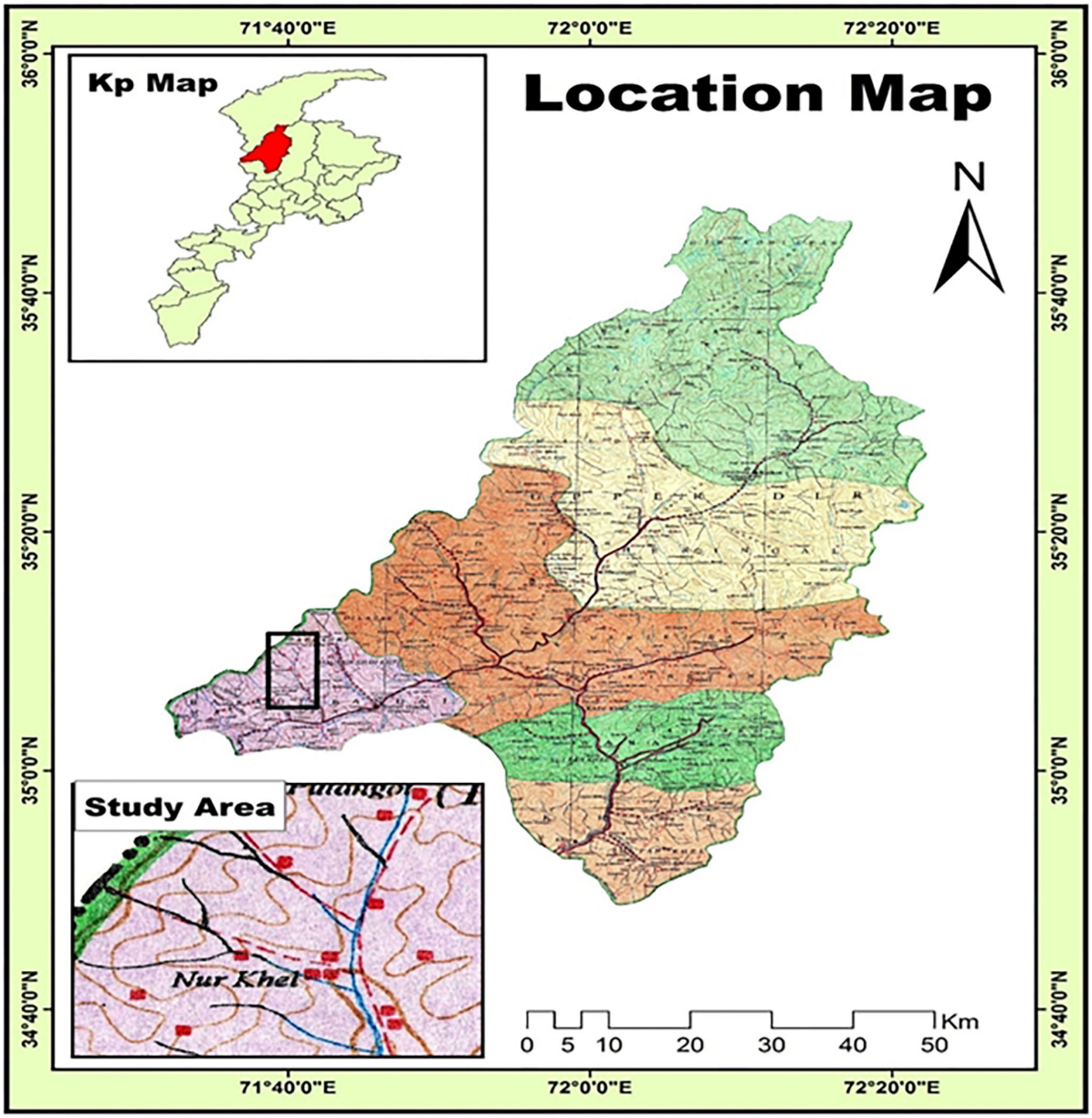

FIGURE 1
Map showing Bin Dara, western boundary of Pakistan.

Amri et al., 2019; Mumshad et al., 2021; Ur Rahman et al., 2021; Ali et al., 2022). We followed the standard taxonomic procedures for collecting, drying, and further processing the herbarium specimens (Bridson and Forman, 1998). Plant specimens were collected, labeled, placed in blotting papers, pressed with a plant presser, and poisoned using mercuric chloride plus ethyl alcohol solution. Specimens were then fixed on the standard herbarium sheets, having a size of $17.5'' \times 11.5''$. All the plant species were identified with the help of "Flora of Pakistan" and other available literature (Nasir and Ali, 1972). Complete floristic lists of species along with ecological descriptions were prepared for further analyses.

Life form classification

All recorded plant species were classified into different life form classes using the Raunkiaer (1934) method. Its detailed descriptions are as follows:

Phanerophytes (Ph)

Plants with perennating buds emerging at least 25 cm above the ground surface are called Phanerophytes. Based on height, Phanerophytes are further divided into the following subclasses.

Megaphanerophytes: (Mg). > 30 m.
Mesophanerophytes: (Ms). 7.6–30 m.
Microphanerophytes: (Mp). 2–7.5 m.
Nanophanerophytes: (N). 0.25–2 m.

Chamaephytes (Ch)

These are perennial plants in which their shoots or buds lie up to 25 cm on an upright stem from the ground. Chamaephytes are also called surface plants. They are characteristically found in cool and dry climates.

Hemicryptophytes (He)

These are plants whose perennial buds lie near the ground where they are covered by soil and litter. Such plants are found in cold and moist climates. They include a multitude of grasses and forbs.

Geophytes/cryptophytes (G/Cr)

The plant's perennial buds lie beneath the ground level or underwater (hydrophytes). The underground reproductive parts (rhizome, corn, bulb, and tuber) are drying and freezing.

Therophytes (Th)

These plants survive unfavorable conditions in the form of seeds. They are annual herbs and usually grow in the rainy season only from seeds. Therophytes are typically found in desert grasslands.

Climbers and Liana

These plants use rocks, manmade structures, and other plants for their support and growth. Liana is a woody climber that is generally rooted in soil, but its leaves are often in full sun. They are often many meters from the ground.

$$\text{Raunkiar Biological Spectrum} = \frac{\text{No. of individual of a species of a particular life form class}}{\text{Total No. of all species in a single strand}} \times 100$$

Leaf size spectra

The leaf size spectrum gives the idea of the adaptations and physiology of plant leaves. Plants are classified into different leaf size spectra using Raunkiaer (1934) method. Detailed leaf size classes descriptions are as follows:

Leptophyll (L): 25 sq. mm
Nanophyll (N): 9 × 25 sq. mm
Microphyll (Mic): 9^2 × 25 sq. mm
Mesophyll (Mes): 9^3 × 25 sq. mm
Macrophyll (Mac): 9^4 × 25 sq. mm
Megaphyll (Ma): Larger than class Macrophyll.

$$\text{Raunkiar leaf size spectrum} = nonumber \frac{\text{No. of individual of a species of a particular leaf size class}}{\text{Total No. of all species for that strand}} \times 100$$

Floristic elements classification

Vegetation of the study area is described and classified into various floristic elements based on Brummitt et al. (2001) as defined in Table 1.

Results

Plant species composition

A total of 140 plant species were recorded belonging to 50 families. Out of which 46 families were Dicotyledons, two families Monocotyledons, and one family of Gymnosperm and Pteridophyte each. The most dominant family was Poaceae (with 14 species) followed by Asteraceae (11 species) and Lamiaceae (10 species). Regarding the habitat of the plant species, 101 were herbs, 12 were shrubs and 27 were trees (Figure 2).

Raunkiaer life form classification

Based on the Raunkiaer life form system of classification, Therophytes were the dominant plant species along with 71 members (50.71% of the total vegetation), followed by Megaphanerophytes (27 species, 19.28%), Nanophanerophytes (15 species, 10.71%), Geophytes (10 species, 7.14%), Chamaephytes (9 species, 6.42%) and Hemicryptophytes (8 species and 5.71%) (Table 2).

Raunkiaer life size classification

The leaf size of the region was dominated by Nanophylls containing a total of 48 species (34.28%), followed by Microphyllous with 32 species (22.85%), Mesophylls with 22 species (15.71%), Macrophylls with 17 species (12.14%), and Leptophylls with 12 species (8.57%). Furthermore, Megaphylls

TABLE 1 A description of the floristic elements in Bin Dara, Pakistan.

Floristic elements	Description
Central Asian	Central Asian elements are distributed in temperate central Asia, western Asia, Caucasus, Siberia and Tien-Shan; the distribution centers are mainly in temperate Asia
Cosmopolitan	These species are distributed on almost all continents (Having worldwide distribution)
Eurasian	These species are widely distributed through the temperate zone of Europe and Asia. Some of the species may range into the northernmost part of Africa
Holarctic	These species are primarily distributed in the cold temperate regions of Europe, Asia and North America
Irano-Turanian	These elements have a center of diversity in western Asia: Anatolia, Mesopotamia, Irano-Armenia and extend up to Tien-Shan
Neotropical	These elements occur in and nearby the tropical and subtropical regions of the world; some taxa may extend to temperate regions
Mediterranean	These elements are distributed across the Mediterranean region in southern Europe, North Africa and western Asia
Palaeotropical	Taxa are distributed in the tropics of Asia, Australia and Africa, also called the old World's tropics
Circumboreal	Many of these species extend their ranges southward in the mountains, Arizona, Mexico and some species may also found in Arctic flora
Pantropical	Taxa are distributed in the tropical and subtropical regions of the world, some may extend to temperate region
Western Himalayan	Species with a center of diversity in northwest Himalayas, however, occasionally may extend eastward to eastern Himalayas or northwards to central Asia and Afghanistan

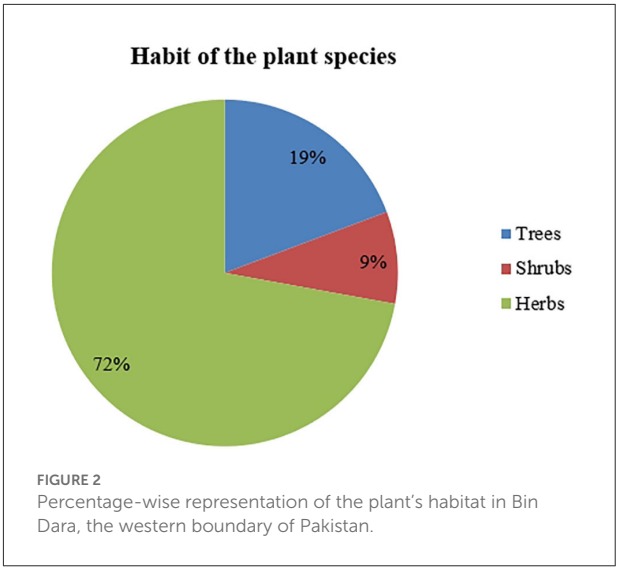

FIGURE 2
Percentage-wise representation of the plant's habitat in Bin Dara, the western boundary of Pakistan.

TABLE 2 Life form spectra of the Bin Dara vegetation.

Life form	No. of species	Percentage (%)
Megaphanerophytes	27	19.28
Nannophanerophytes	15	10.71
Chamaephytes	09	6.42
Hemicrytophyte	08	5.71
Geophytes	10	7.14
Therophytes	71	50.71

TABLE 3 Life form spectra of the Bin Dara, Dir, vegetation.

Life size	No. of species	Percentage (%)
Megaphylls	8	5.71
Macrophylls	17	12.14
Mesophylls	22	15.71
Microphylls	32	22.85
Nanophylls	48	34.28
Leptophylls	12	8.57
Aphyllous	1	0.71

with 8 species (5.75%), and Aphyllous with 1 species (0.71%) were the least concentrated in the area (Table 3, Figure 3).

Phytogeographic/floristic elements

The vegetation of the present study recognized 27 different floristic elements. Cosmopolitan (12.14%) was the highest percentage of elements, followed by Pantropical and Euro Siberian-Mediterranean-Irano-Turanian (ES-M-IT) with 10% each. The Pluriregional (PL) represents 9.28%, holarctic and Mediterranean- Irano-Turanian (7.14%), IT and WH 6.42% each (Figure 4). The other elements were less represented in the study area. Six species (4.28%) were endemic or nearly endemic to the western Himalayan region. These endemic species were *Parrotiopsis jacquemontiana, Cedrus deodra, Pinus wallichiana, Quercus baloot, Viburnum cotinifolium,* and *Bistorta amplexicaulis* (Table 4).

Discussion

Ecological sampling and analyses are of prime importance for the vegetation of any geographic zone. Its precise interpretation can help in successfully achieving this aim. Many such sampling-based studies frequently interpret the vegetation

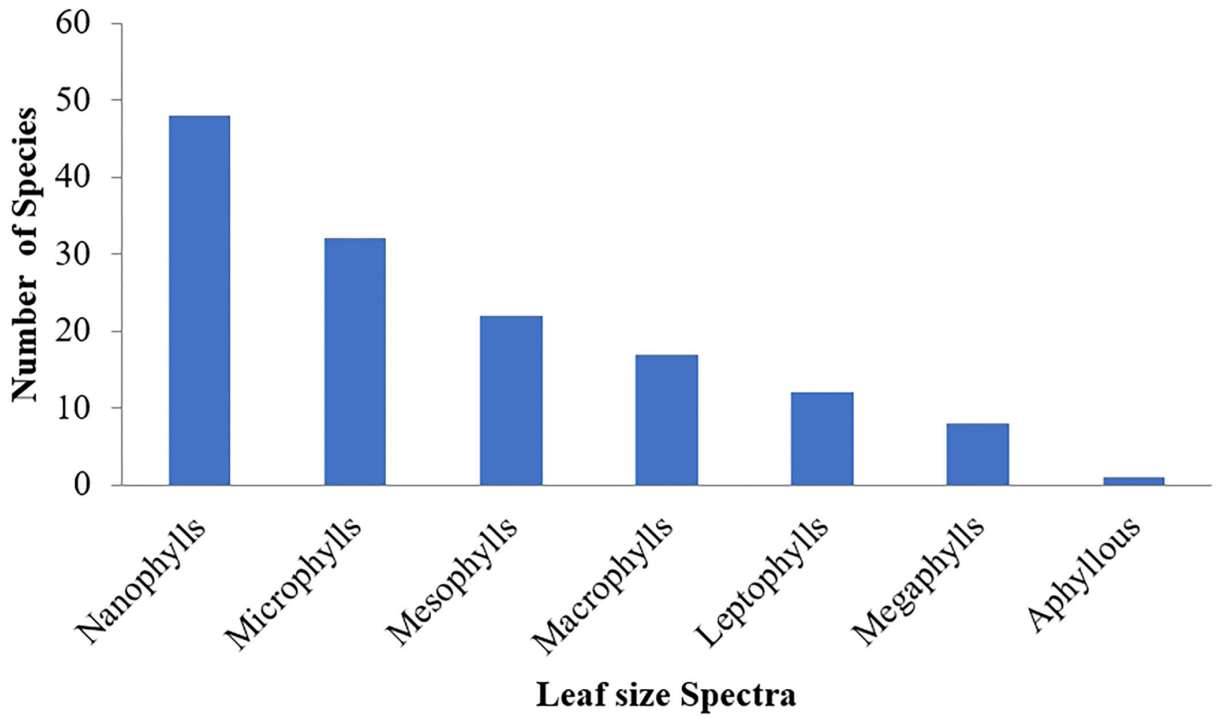

FIGURE 3
Leaf size spectrum in Bin Dara, western boundary of Pakistan.

at habitats, ecosystems, and regional and global levels (Khan et al., 2011; Longo et al., 2019; Abbas et al., 2021; Ahmad et al., 2022b; Anwar et al., 2022; Haq et al., 2022; Munyasya et al., 2022; Rasheed et al., 2022; Yang et al., 2022). Such studies interpret the intricate vegetation structure more meaningfully in relation to the abiotic environment (Khan et al., 2017; Miao et al., 2018; Ahmad et al., 2021, 2022a; Iqbal et al., 2021; Ali et al., 2022a,b; Hussain et al., 2022; Khan S. A. et al., 2022). The present study revealed that the dried condition of the Bin Dara, Dir, is reflected in its vegetation in the form of stunted growth, small leaf size, sparse distribution, dwarf height, and isolated individuals of plant species that in turn are characteristics of the xerophytic flora. Our findings are also supported by some of the studies from adjacent areas (Abbas et al., 2019; Ahmad et al., 2019; Ahmed et al., 2019; Anwar et al., 2019; Hussain et al., 2019; Kamran et al., 2020; Khan, 2022). Furthermore, biological spectra are used to assess the life form and leaf sizes for better interpretations of the climatic conditions of an ecosystem. These physiognomic characteristics are considered indicators of biotic interaction, and climatic and habitat deterioration. A similar biological spectrum of different areas shows similar climatic conditions. According to Raunkiaer (1934), the climate and habitat of an area are characterized by the life form and biological spectrum of an area, though, the proportion of life forms can be altered due to biological disturbances.

The overall vegetation of the study region is dominated by therophytes with 71 species (50.71%) followed by megaphanerophytes with 27 species (19.28%). The dominance of therophytes shows that the study area is under huge anthropogenic and biotic pressure like grazing pressure and human disturbance (Ullah and Badshah, 2017; Manan et al., 2020; Bedair et al., 2021). Hence, as a result, hemicryptophytes cannot survive in such type of environment. Our results are similar to the finding of Al-Yemeni and Sher (Al-Yemeni and Sher, 2010), who reported that therophytes are a dominant life form spectra due to different environmental gradients in the Asir Mountain, Saudi Arabia. In addition, similar studies being carried out in the adjacent area like Sher and Khan (2007), Khan et al. (2013), Sharma et al. (2014), and Hussain et al. (2015) reported that therophytes, along with hemicryptophytes and megaphanerophytes, are the dominant vegetation in their respective regions.

The leaf size spectrum identified nanophyll and microphyll as the dominant leaf size spectra in the current project area. Similarly, Nasir and Sultan (2002) reported Nanophylls as the dominant life form from the Botanical Garden at Azakhel, District Nowshera, Pakistan. Whereas Hussain et al. (2014) studied the flora of Sarsawa Hills, District Kotli in Azad Kashmir. They stated that Leptophylls, Nanophylls, and Microphylls were the dominant classes. Microphylls are characteristic of steppes,

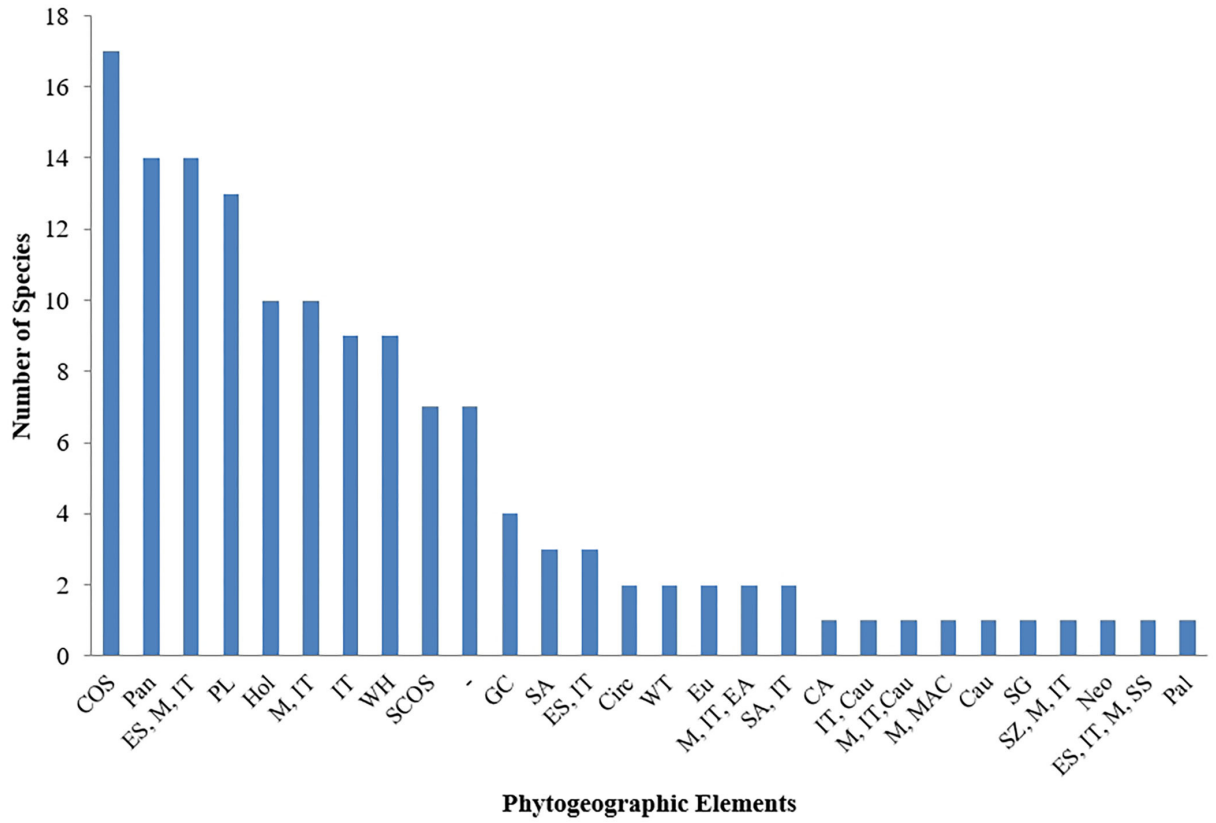

FIGURE 4
Floristic elements in Bin Dara, western boundary of Pakistan.

while Nanophylls are characteristic of hot deserts (Tareen and Qadir, 1993; Badshah et al., 2013). Large leaf species occur in warm moist climates while smaller leaves are characteristic of dry and cold climates and degraded habitats.

In the present study, the dominance of cosmopolitan elements can be attributed to dispersal mechanisms and geological activities in the past. These species are distributed on almost all continents (having worldwide distribution). The flora of the western Himalayan province is transitional between the eastern Asiatic and ancient Mediterranean (Takhtajan, 1986; Khan et al., 2020; Zeb et al., 2021; Khan S. M. et al., 2022). Bin Dara, being part of the western Himalayas, receives the monsoon rains during summer and heavy snowfall in winter; the plants renew growth at the approach of spring in the months of March–April (Manan et al., 2020). Ullah et al. (2015) also reported the dominance of Cosmopolitan, Pantropical, Euro-Siberian, Mediterranean, Irano-Turanian, and Pluriregion elements in Myankaleh Wildlife Refuge, Mazandaran Province, Iran. Siadati et al. (2010) also found the dominance of Euro-Siberian and Pluriregion elements in Hyrcanian forests in northern Iran. Some of the unique floristic elements in the study region might be due to the collision of Eurasian and Indian tectonic plates. Further studies are recommended to study the edapho-physiological pattern of the area to understand the underlying mechanisms of the present-day vegetation for its future management and conservation purposes. This study also covers the three sustainable development goals including life on land, climate action, good and wellbeing (Ejaz et al., 2022; Shehzadi et al., 2022).

Conclusion

Therophytes and nanophylls are the dominant life form and leaf form spectra of the Bin Dara, Dir, in the western boundary of Pakistan. Cosmopolitan, pantropical, Euro-Siberian, Mediterranean, Irano-Turanian, and pluriregion were the dominating phytogeographic elements in the studied region. The dominance of therophytes indicates that the study area is under immense anthropogenic pressure and an accelerated rate of deforestation. It is therefore recommended that the eastern and western Himalayan regions should be given more focus on the proper management and conservation of vegetation in the current scenario of climate change in the studied mountainous regions. It is also recommended that the methodology adopted in the current study can be

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TABLE 4 Life form, geographical distribution, leaf size, and floristic elements of the Bin Dara, in the western boundary of Pakistan.

S. No	Family	Plant species	Life form	Leaf size	Habit	Geographical distribution	Floristic elements
1	Amaranthaceae	*Amaranthus lividus* L.	Th	N	Herb	Throughout the warmer regions of the world	Pan
		Amaranthus tricolor L.	Th	N	Herb	Asia, India, China, Japan and Indonesia	M, IT
		Amaranthus viridis L.	Th	N	Herb	Widely distributed in tropical and subtropical regions of the world	COS
		Chenopodium album L.	Th	N	Herb	Cosmopolitan	COS
2	Amaryllidaceae	*Allium cepa* L.	G	N	Herb	Cosmopolitan	SCOS
		Allium sativum L.	G	N	Herb	Cultivated widely in Europe, Asia and North America	IT
3	Apiaceae	*Coriandrum sativum* L.	Th	L	Herb	Cosmopolitan	COS
		Cuminum cyminum L.	Th	N	Herb	North Africa, Central Asia, Mediterranean region, Middle East and Western Pakistan	–
		Daucus carota L.	Th	N	Herb	Cosmopolitan	COS
		Foeniculum vulgare Mill.	Th	N	Herb	Cosmopolitan	COS
		Torilis leptophylla (L.) Rchb.f.	Th	N	Herb	Europe, Africa, United State America and Central Asia	ES, IT
4	Araliaceae	*Hedera nepalensis* K.Koch	Mp	Mes	Shrub	West Asia, Japan, Afghanistan and Himalaya	WH
5	Asparagaceae	*Polygonatum verticillatum* (L.) All.	Th	N	Herb	Europe, Russia, Afghanistan, Pakistan (Chitral, Dir, Swat, Hazara, Gilgit), Kashmir, India, Nepal, Sikkim, Bhutan and China	M, IT
6	Asteraceae	*Conyza canadensis* (L.) Cronquist	Th	Mic	Herb	North America, South America, Europe, Asia, and Africa	SCOS
		Helianthus annuus L.	Th	Mac	Shrub	Widely cultivated in China (native to North America).	M, IT
		Lactuca sativa L.	Th	Mac	Herb	Cultivated throughout China (probably originating from Mediterranean to South West Asia).	ES, M, IT
		Matricaria chamomilla L.	Th	N	Herb	Europe, North America, Mongolia, Russia and Uzbekistan	–
		Parthenium hysterophorus L.	Th	Mic	Herb	Native to tropical America, a widely introduced weed in the tropics and China (Guangdong, Guangxi, Guizhou, Yunnan).	Pan
		Setaria pumilla (Poir.) Roem. & Schult.	Th	Mic	Herb	Tropical and warm temperate regions of the World, Pakistan and introduced to North America	PL
		Sonchus asper (L.) Hill	Th	Mic	Herb	Madagascar and Africa	M, IT
		Sonchus oleraceus L.	Th	N	Herb	Europe and Mediterranean region	PL
		Taraxacum officinale F. H Wigg.	Th	Mic	Herb	Cosmopolitan weed of temperate areas	COS
7	Brassicaceae	*Brassica rapa* L.	Th	N	Herb	Europe and Central Asia	PL
		Brassica napus L.	Th	N	Herb	Europe, China and Pakistan	PL
		Capsella bursa-Pastoris (L.) Medik.	Th	Mic	Herb	Widely distributed in temperate regions	COS
		Cardaria chalepensis L.	Th	Mic	Herb	Europe, Central and Western Asia	CA
		Cardaria draba (L.) Desv.	Ch	Mic	Herb	Europe, Central and Western Asia	COS
		Coronopus didymus (L.) Smith	Th	L	Herb	South America, but widely introduced in the world	SCOS
		Neslia apiculata Fisch.	Th	L	Herb	South Europe, Southern and Central Asia,	ES, M, IT

(Continued)

TABLE 4 (Continued)

S. No	Family	Plant species	Life form	Leaf size	Habit	Geographical distribution	Floristic elements
						Northern Africa, North West Himalaya and Pakistan	
		Raphanus sativus L.	Th	Mac	Herb	China and Mediterranean region	Circ
		Sisymbrium irio L.	Th	N	Herb	Europe, Asia and North Africa	ES, M, IT
8	Cannabaceae	*Cannabis sativa* L.	Th	Mic	Herb	Russia, China, India, Pakistan and Iran	IT
9	Caryophyllaceae	*Silene vulgaris* (Moench) Garcke	Th	N	Herb	Europe, North Africa, temperate Asia and Arabia	M, IT
		Stellaria media (L.) Vill.	Th	N	Herb	Cosmopolitan	COS
10	Compositae	*Artemisia absinthium* L.	Th	N	Herb	Eurasia, North Africa, United State America and Canada	M, IT
		Artemisia maritima L.	Th	Mic	Herb	United Kingdom, Native to France, Italy, Belgium, Germany, Denmark, Sweden and Russia	ES, M, IT
		Artemisia scoparia Waldest.	Ch	N	Herb	Central and Eastern Europe, Iraq, Turkey, Iran, Afghanistan, Pakistan (Baluchistan, Khyber Pakhtunkhwa and Punjab), India, China, Mongolia and Russia	ES, M, IT
11	Convolvulaceae	*Convolvulus arvensis* L.	Th	N	Herb	Temperate and tropical regions of the world, except Australia	COS
12	Cucurbitaceae	*Citrullus colocynthis* (L.) Schrad.	Th	Mic	Herb	North Africa, Atlantic Islands, North West India, Pakistan and Australia	SA
		Cucumis sativus L.	Th	Mg	Herb	Throughout the tropical and subtropical countries of the world	IT
		Cucurbita maxima Duchesne	Th	Mg	Herb	South American, India, Pakistan and elsewhere	Pan
		Cucurbita moschata Duchesne	Th	Mg	Herb	Tropical and subtropical countries	Pan
		Cucurbita pepo L.	Th	Mg	Herb	North America, China and Pakistan	–
		Lagenaria siceraria (Molina.) Standl.	Th	Mg	Herb	Asia, Africa and Pakistan	SG
		Momordica charantia L.	Th	Mg	Herb	South Africa, South East and Far East Asia to Australia	Pan
13	Cyperaceae	*Cyperus esculentus* L.	Ch	N	Herb	Tropical and Sub tropical Africa, Mediterranean region	Pan
		Cyperus rotundus L.	Ch	N	Herb	Tropical and subtropical areas of all continents	COS
14	Ebenaceae	*Diospyros kaki* L.	Mp	Mg	Tree	Eastern Asia, Japan and China	GC
		Diospyros lotus L.	Mp	Mes	Tree	Iran, Afghanistan, Pakistan, India, China and Japan	Cau
		Diospyros virginiana L.	Mp	Mg	Tree	South Atlantic and Gulf states	GC
15	Equisetaceae	*Equisetum arvense* L.	G	Ap	Herb	Central and South West Asia, Japan, Korea, Mongolia, Europe, Nepal, Russia, North India	Circ
16	Euphorbiaceae	*Euphorbia helioscopia* L.	Th	N	Herb	Europe, North Africa and Asia; introduced into North America	ES, M, IT
17	Fabaceae	*Medicago polymorpha* L.	Th	N	Herb	Cosmopolitan	M, IT
		Medicago sativa L.	Th	N	Herb	Europe, North Africa, Central Asia, Pakistan and, India	ES, M, IT

(Continued)

TABLE 4 (Continued)

S. No	Family	Plant species	Life form	Leaf size	Habit	Geographical distribution	Floristic elements
		Mimosa pudica L.	Np	L	Herb	South America and Pakistan	Pan
		Robinia pseudoacacia L.	Mp	N	Tree	North America, China except Hainan and Xizang regions	Hol
		Trifolium repens L.	Th	N	Herb	Central Asia, Pakistan, India, Russia, Afghanistan, Siberia and Kashmir	ES, M, IT
		Vicia sativa L.	Th	N	Herb	Pakistan, Kashmir, India, Orient, Europe, Russia and Far East	ES, M, IT
18	Fagaceae	*Quercus baloot* Griff.	Mp	Mes	Tree	Pakistan, Afghanistan and Kashmir	WH
		Quercus incana Bartram	Mp	Mes	Tree	North West Himalayas to Nepal and Upper Burma	Hol
19	Geraniaceae	*Geranium rotundifolium* L.	Th	N	Herb	Africa, Western and Central Europe, Siberia, Turkey, Iran and Afghanistan	ES, M, IT
20	Hamamelidaceae	*Parrotiopsis jacquemontiana* (Decne.) Rehder	Np	Mes	Shrub	Pakistan (Murree, Hazara division, Swat, Dir and Kurram) and Kashmir	WH
21	Hypericaceae	*Hypericum perforatum* L.	Th	N	Herb	Europe, Africa, East Asia, West China, north west India, America and Australia	PL
22	Juglandaceae	*Juglans regia* L.	Mp	Mac	Tree	Central America, Southern Europe, Caucasus, Syria, Northern Iran, Afghanistan, West Pakistan, Tibet, Nepal, West China and Upper Burma	PL
23	Lamiaceae	*Ajuga integrifolia* Buch.-Ham.	H	Mic	Herb	Afghanistan, Pakistan, Kashmir, China, Bhutan, Burma, China and Malaysia	Hol
		Lallemantia royleana (Benth.) Benth.	Th	Mic	Herb	South Russia, South West and Central Asia, West China	IT
		Marrubium vulgare L.	H	Mic	Herb	Europe, Asia, North America, South Africa and Australia	SZ, M, IT
		Mentha arvensis L.	H	Mic	Herb	Eurasia and tropical Asia	Eu
		Mentha longifolia L.	G	Mic	Herb	Europe, Asia and South Africa	PL
		Ocimum basilicum L.	Ch	N	Herb	Subtropical and tropical Asia, Africa and South East Asia	Pan
		Origanum vulgare L.	Ch	Mi	Herb	South Europe, Southern and Central Asia, Mediterranean countries, Macaronesia, Himalaya, China and Taiwan	ES, IT
		Phlomis cashmeriana Benth.	G	N	Herb	Central Asia, Afghanistan, Pakistan and Kashmir	IT
		Prunella vulgaris L.	Th	L	Herb	Europe, North and South Africa, North America, Asia and Australia	PL
		Salvia nubicola Wall. ex Sweet	Ch	Mes	Herb	Eastern Afghanistan, Pakistan, Kashmir, North India, Nepal, Tibet, Sikkim and Bhutan	WT
24	Leguminosae	*Astragalus lentiginosus* Hook.	Ch	L	Herb	North America, California Coast Ranges, south to Mexico and north to British Columbia	SA
		Bauhinia tomentosa L.	Mp	Mes	Tree	Tropical Africa, India, China, Western Pakistan and in tropics	PL
25	Moraceae	*Ficus carica* L.	Np	Mes	Tree	North Africa, Europe, Middle East, India, Pakistan, Afghanistan, Russia and Iran	M, IT, Cau

(Continued)

TABLE 4 (Continued)

S. No	Family	Plant species	Life form	Leaf size	Habit	Geographical distribution	Floristic elements
		Morus alba L.	Mp	Mes	Tree	North Africa, South and Central Europe, China, Malaya, Burma, India and Pakistan	IT
		Morus nigra L.	Mp	Mes	Tree	North Africa, Central Asia, Central and Southern Europe, Northern Pakistan,	Pan
26	Onagraceae	*Oenothera macrocarpa* Nutt.	Th	N	Herb	Southern and central United States	–
		Oenothera rosea L'Hér. ex Aiton.	Th	N	Herb	Central and Southern Texas United State America, throughout Mexico, Central and South America	Neo
27	Orchidaceae	*Dactylorhiza hatagirea* D.Don.	Th	N	Herb	Bhutan, Himalaya region from Chitral to Nepal and Tibet	IT, Cau
28	Oxalidaceae	*Oxalis corniculata* L.	G	Mic	Herb	Cosmopolitan	COS
29	Papaveraceae	*Fumaria indica* Hausskn, Pugsley	Th	N	Herb	Central Asia, India, Pakistan and Afghanistan	M, IT
		Papaver hybridum L.	Th	Mic	Herb	Europe, North Africa, South West and Central Asia, Afghanistan and West Pakistan	M, IT, EA
		Papaver somniferum L.	Th	Mac	Herb	Asia and Europe	M, IT, EA
30	Pinaceae	*Cedrus deodara* Roxb.	Mp	L	Tree	Afghanistan, Pakistan (Kurram eastward) to Kashmir and Western Nepal	WH
		Pinus roxburghii Sarg.	Mp	L	Tree	Afghanistan, Himalaya from Chitral eastward to Bhutan, Sikkim.	WH
		Pinus wallichiana A. B. Jacks.	Mp	L	Tree	Afghanistan, Chitral eastward to West Nepal	WH
31	Plantaginaceae	*Plantago lanceolata* L.	Th	N	Herb	Europe, North Africa, South Asia to the mountains of Tien Shan and introduced all over the world	ES, IT, M, SS
		Plantago major L.	Th	Mic	Herb	Throughout Europe, northern and central Asia, introduced all over the world	SCOS
32	Platanaceae	*Platanus mexicana* Moric.	Mp	Mac	Tree	United State America (Arizona, New Mexico)	M, IT
		Platanus orientalis L.	Mp	Mac	Tree	Central and West Asia, Southern Europe to Turkey, North Iran, Afghanistan, India and Pakistan	SCOS
33	Poaceae	*Arundo donax* L.	Np	Mes	Shrub	Pakistan (Baluchistan, Punjab, Khyber Pakhtunkhwa and Kashmir), Mediterranean region eastwards to Burma and North Africa	ES, M, IT
		Avena sativa L.	Th	N	Herb	Cultivated in non-tropical regions of both hemispheres	PL
		Cynodon dactylon (L.) Pers.	H	L	Herb	Tropical and warm temperate regions throughout the world	COS
		Dichanthium annulatum (Forssk.) Stapf	Ch	N	Herb	Pakistan, Kenya, Tanzania and Senegal	SA
		Hemarthria compressa (L.f) R. Br.	Th	L	Herb	Pakistan, Iraq, Afghanistan India, China, Taiwan and Thailand	WH
		Heteropogon contortus (L.) P.Beauv.	H	Mic	Herb	Tropical and warm temperate regions generally	Pan
		Hordeum vulgare L.	Th	Mic	Herb	Cultivated worldwide in all non-tropical countries and in montane areas of tropics	ES, M, IT
		Oryza sativa L.	Th	Mic	Herb	Africa, Asia, South Europe, South America and Australia	–

(Continued)

TABLE 4 (Continued)

S. No	Family	Plant species	Life form	Leaf size	Habit	Geographical distribution	Floristic elements
		Poa annua L.	Th	L	Herb	Cosmopolitan	SCOS
		Secale cereale L.	Th	Mic	Herb	Largely cultivated in Europe as a cereal forming a staple food	SCOS
		Sorghum halepense (L.) Pers.	H	Mic	Herb	Mediterranean region and Pakistan	PL
		Triticum aestivum L.	Th	Mes	Herb	Pakistan, India, Nilgiri and Palini	COS
		Zea mays L.	Th	Mac	Herb	Tropical America and cold regions of Pakistan	–
34	Polygonaceae	*Bistorta amplexicaulis* (D.Don) Greene	Th	Mes	Herb	Afghanistan, Northern Pakistan and Kashmir	WH
		Persicaria glabra (Willed.) M.Gomez	H	N	Herb	Africa, Tropical Asia, Pakistan, India extending up to Malaysia and Philippine	Pan
		Persicaria hydropiper (L.) Delarbre	H	N	Herb	North America, Widely distributed in North West Africa, Temperate Asia, Pakistan, India and extending to far east up to Japan	Pan
		Rumex dentatus L.	G	Mes	Herb	East Asia, Afghanistan, Pakistan and India	SA, IT
		Rumex hastatus D. Don	G	Mes	Herb	Northern Pakistan, North Eastern Afghanistan and South West China	SA, IT
35	Primulaceae	*Myrsine africana* L.	Np	N	Shrub	Asia and Africa	Eu
36	Ranunculaceae	*Clematis graveolens* Lindl.	Np	N	Herb	Afghanistan, Pakistan, Kashmir eastward to Nepal	COS
37	Rhamnaceae	*Ziziphus jujuba* Mill.	Mp	N	Tree	South Europe, South and East Asia, Mediterranean region, Afghanistan, Iran, Pakistan, India, Mongolia, Japan, China and Tibet	Pal
38	Rosaceae	*Cydonia oblonga* Mill.	Np	Mac	Shrub	South America, Mediterranean regions of Europe, China and elsewhere	M, IT
		Malus pumila Mill.	Mp	Mac	Tree	North West and South West China (Bhutan, Native to South West Asia and Europe).	Hol
		Prunus armeniaca L.	Mp	Mes	Tree	North America in the western United States, mostly in the San Joaquin Valley of California	Hol
		Prunus domestica L.	Mp	Mac	Tree	Widely cultivated in China (native to South West Asia and Europe).	Hol
		Rosa brunonii Lindl.	Np	N	Shrub	Nepal, India, Afghanistan, Bhutan South West China and Northern Pakistan	IT
		Rosa indica L.	Np	Mic	Shrub	West China, Nepal, India and Pakistan	IT
39	Rubiaceae	*Galium tricornutum* Dandy	Th	N	Herb	Europe, North Africa, Western Asia, Pakistan, Iran, Afghanistan and Caucasia	WT
40	Salicaceae	*Populus afghanica* Aitch.	Mp	Mac	Tree	Pakistan (Kurram, South Waziristan, Quetta, Kalat); Afghanistan, Tajikistan, Uzbekistan, Kirgyzstan, Kazakistan, North Africa and east Mediterranean region	IT
		Populus alba L.	Mp	Mes	Tree	Europe, North Africa, South West and West Central Asia including Kashmir and Pakistan (Khyber Pakhtunkhwa, Murree, Baluchistan).	ES, IT
		Populus ciliata Wall. ex Royle	Mp	Mac	Tree	Pakistan (Chitral) eastwards to Kashmir, along with Himalayas through India, Nepal, Sikkim, Bhutan and Myanmar	Hol

(Continued)

TABLE 4 (Continued)

S. No	Family	Plant species	Life form	Leaf size	Habit	Geographical distribution	Floristic elements
		Populus nigra L.	Mp	Mac	Tree	West and Central Asia, Europe and North Africa, Native to China (Xinjiang), widely cultivated in Pakistan, Kashmir and China	Hol
		Salix alba L.	Mp	Mes	Tree	Europe, Western and Central Asia, Siberia, Mediterranean region	ES, M, IT
		Salix tetrasperma Roxb.	Mp	Mes	Tree	Pakistan (Khyber Pakhtunkhwa, Punjab, Baluchistan), India, Myanmar, China, Thailand, Indonesia, Malaysia, Philippines and Vietnam	ES, M, IT
41	Simaroubaceae	*Ailanthus altissima* (Mill.) Swingle	Np	Mic	Tree	Native to China and cultivated in temperate and subtropical regions of the world. It is cultivated as a roadside tree in Pakistan	Pan
42	Solanaceae	*Capsicum frutescens* L.	Th	Mic	Herb	Tropical America	Pan
		Datura stramonium L.	Th	Mac	Herb	Mostly in temperate and subtropical regions of both the hemispheres	COS
		Lycopersicum esculentum Mill.	Th	Mic	Herb	Native to Central and South America	–
		Solanum melongena L.	Np	Mes	Herb	Asia, Africa and America (Native to India)	GC
		Solanum nigrum L.	Th	Mic	Herb	Cosmopolitan but absent from the arctic and subarctic regions	COS
		Solanum tuberosum L.	G	Mes	Herb	Native to the mountainous areas of Mexico, Chile and Peru (South America), cultivated throughout the world	GC
43	Thymelaeaceae	*Daphne mucronata* Royle	Np	Mic	Shrub	North Africa, South Europe, Afghanistan, west Pakistan and Iran	M, MAC
44	Urticaceae	*Urtica dioica* L.	G	Mic	Herb	Widespread in the temperate regions of both hemispheres	PL
45	Verbenaceae	*Verbena officinalis* L.	Np	N	Herb	Europe and Asia, North Africa; introduced in North America and South Africa	PL
46	Viburnaceae	*Viburnum cotinifolium* D. Don	Np	Mes	Shrub	Afghanistan and Pakistan Himalaya	WH
		Viburnum grandiflorum Wall. ex DC.	Mp	Mac	Shrub	Himalaya from Swat eastward to Bhutan and South Tibet	Hol
47	Vitaceae	*Vitis vinifera* L.	Np	Mac	Shrub	South Asia, North and South Africa, cultivated extensively in Central Europe, Mediterranean region, Iran, China, Japan, Australia, India, Afghanistan and Pakistan	Hol

Pal, Palaeotropical; M, Mediterranean; SA, South Arabian; CA, Central Asian; GC, Guineo-Congolian; Hol, Holarctic; MAC, Macaronesian; SG, Sudano/Guinean transition; SCOS, Sub Cosmopolitan; Cau, Caucasian; WT, wide temperate; PL, Pluriregional; SZ, Sudano-Zambezian; Eu, Eurasian; ES, Euro-Siberian; SS, Saharo-Sindian; TR, Tropical; WH, Western Himalayan; Pan, Pantropical; Neo, Neotropical; Circ, Circumboreal; IT, Irano-Turanian.

followed to assess the phytogeographic elements of any habitat in the world.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

This work was conducted and written jointly by FM, SK, ZM, ZA, AA, AuR, and AR. Funding acquisition: HH, AA-M, and NC-B. Project administration: HH. Writing—review and

editing: AA-M and NC-B. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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