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Floristic composition, life history traits and phytogeographic distribution of forest vegetation in the Western Himalaya

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Introduction: Scientific documentation of the qualitative forest vegetation parameters of a biogeographical area provides baseline information to guide conservation strategies and design policies for biodiversity management regulations.

Methods: We present one of the most comprehensive qualitative vegetation analyses to evaluate the entire structure and function of an ecosystem in the remote northern part of the Kashmir Himalaya, India. Several multivariate ecological community analyses were conducted after determining the presence of plant species in the various habitats using a random sampling technique.

Results: In total, 155 plant species belonging to 120 genera and 49 families occurred in the area. Asteraceae was the largest family (12% of plant species) followed by Rosaceae (11%). The patterns of species distribution across families were uneven, with 50% of the species belonging to only 7 families, and 23 families being monotypic. In terms of functional groups, the herbaceous growth form dominated. Therophytes were the dominant life form, indicating that the vegetation was disturbed. According to the phytogeographical research, 65% of the species documented in the study area were native, 15% were invasive, 14% naturalized, and 5% being casual. The majority (30%) of exotic species were reported along roadsides. Of all the species found, 39% grew in their natural habitats, such as forests, and 11% were scattered along roadsides. Plant species were grouped in five different clusters based on their floristic similarity. According to the estimated diversity indices, natural forest has the greatest values for Shannon's and Simpson's index. We found that the study area serves as the natural habitat for several significant, endangered medicinal plants, including *Arnebia benthamii, Bergenia ciliata, Delphinium roylei, Gentiana kurroo, Phytolacca acinosa, Saussurea costus*, and *Trillium govanianum*. Therefore, we recommend that human intervention in natural regeneration efforts be prioritized in these habitats to increase the population of these species.

Conclusion: Examining species features from the perspective of functional groups contributes to our understanding of the ecological aspects of the flora. It may also be useful in developing management plans to ensure long-term management of forest landscapes in this remote Himalayan region.

KEYWORDS

plant invasion, habitat diversity, hotspots of biodiversity, ecological traits, Kashmir Himalaya

Introduction

Floristic diversity is an important element of ecosystems (Hua et al., 2022). This diversity includes the plant species diversity of a particular area representing the local flora of a given area (Qian et al., 2021). Taxonomy is concerned with their identification and classification of species (Barkley et al., 2004). Floristic and taxonomic studies provide efficient information about different aspects of an ecosystem, including nomenclature, distribution, ecology and utility of plant species of an area (Grime et al., 2014; Haq et al., 2022d). While information on plants of many regions has long been available online via checklists (Safidkon et al., 2003), comprehensive floristic studies are still necessary to document the whole plant diversity of any geographic region (Noss, 1983). Lack of such studies strongly limits the scientific inquiry into plants (Kier et al., 2005), and is needed to ultimately understand how plant communities are structured and distributed.

Among the various ecological attributes of plant communities, floristic composition and ecological diversity are the most important ones that are influenced by a variety of biotic and abiotic factors (Khan et al., 2018; Solefack et al., 2018). The understanding of linkages among plants diversity and its ecological functions is critical for understanding the adjustment of plant communities, and how they adopt toward specific habitats (Rahman et al., 2019a; Altaf et al., 2022). Lifeform and habit are the two important physiognomic features that are being widely used while investigating vegetation (Haq et al., 2019). Studying functional plant traits of a given region is an important tool that helps in understanding the relationship between environmental variables and plant community structure and distribution, ultimately revealing the biological functions of individual species in a community (Vakhlamova et al., 2016).

The Himalayan Mountain Range is a prominent biogeographic ecoregion that shows great variation in topography and climate, and thus harbors significant plant diversity (Olson et al., 2001). This mountain ecosystem has been recognized as a global biodiversity hotspot due to its significant biodiversity and huge endemism (Myers et al., 2000). The Kashmir Himalaya, part of Indian Himalayan Region, has been considered as a promising floristic region with high endemism (Mahar et al., 2009). Nonetheless, many remote areas of this biodiversity-rich region have not received much attention as far as floristic and ecological investigations are concerned, which is especially the case of remote mountains region in Kashmir Himalayas. The capability and productivity of the Himalayan forest ecosystem have decreased as a result of numerous stressors, including anthropogenic factors (such as over-exploitation of forest resources and the spread of invasive species), environmental (climate, slope, soil), fire incidences, and declining biological diversity (Haq et al., 2020). Floristic and ecological studies are crucial to advancing our understanding of the distribution and composition of plant communities in biodiversity hotspots. It is crucial and most effective to record qualitative forest vegetation parameters in order to preserve floristic diversity in the future and utilize biological resources sustainably. Keeping this in view, we focused on the following objectives: (i) to record the floristic composition of the vegetation in the region. (ii) What are the patterns of the emergent ecological traits groups in the flora in this region (iii) to find out the contribution of native and alien elements in the region vegetation and (iv) to find out the forest species pool shows habitat filtering in the region.

Given the ecological and economic significance of the forest vegetation under consideration, the findings of this study can guide sustainable biodiversity management and habitat restoration, particularly in invaded habitats in this Himalayan region, with global implications.

Materials and methods

Research area

The study area one of the remotest Tehsil of District Bandipore, Jammu and Kashmir, India. The Gurez valley is situated in the high-altitude Kashmir Himalaya, about 86 kms from Bandipore and 146 kms from the regions summer capital (Srinagar) (**Figure 1**). The Gurez valley is at an altitude of ranges from 2,400 to 3,500 masl and is mostly inhabited by Pahari and Gujjar tribes. The study area includes fifteen Panchayats (village administrative units) with about 30,000 inhabitants. Dawar is known as the main town in the area. Due to heavy snowfall (approx. 1.5–1.8 m), the area remains disconnected from the rest of the region for about 6 months a year, as Razdan Pass is completely closed in the winter. It has a dry and mild climate. The valley is vital for wildlife tourism because it is surrounded by high mountains and steep gorges that are drained by the Kishanganga River. It also supports a variety of vegetation, dense forests, and a wealth of species.

Field survey

Frequent surveys were conducted to obtain a better understanding of the research area and field data were collected during in various expeditions 2019–2021. Sites for the floristic studies were chosen using a random sampling technique to guarantee that plant species from various habitats had an equal chance of being sampled. The quadrat method was used to record

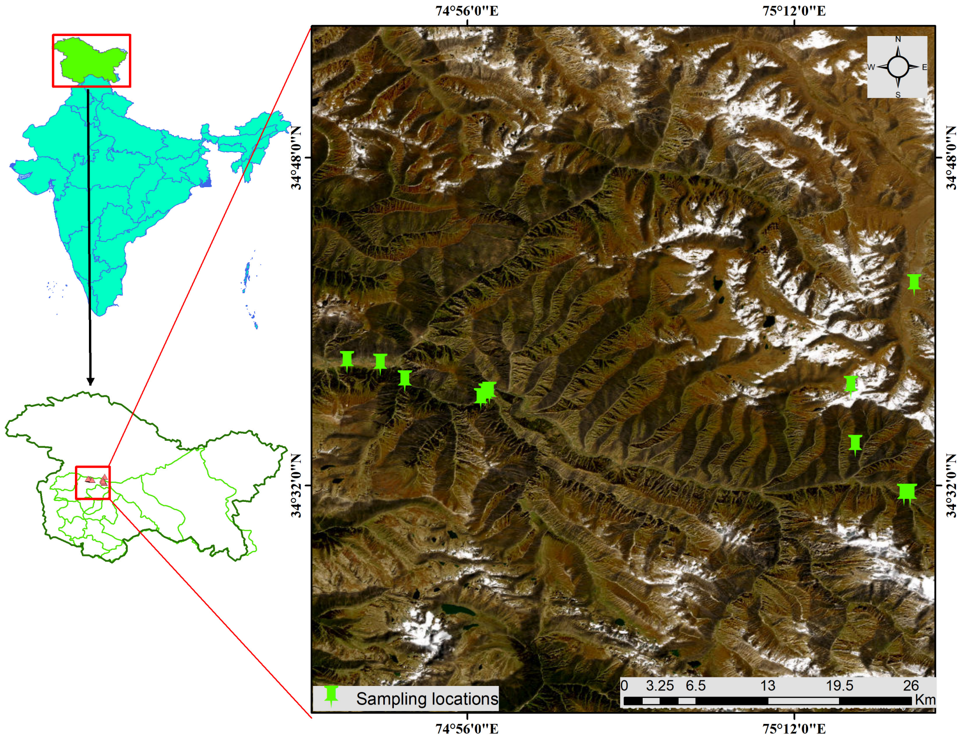

FIGURE 1
Map of study area **(A)** India **(B)** Jammu and Kashmir **(C)** Bandipora district and point showing the Gurez Valley in the Kashmir Himalaya, India (generated using ArcGIS version,10.5).

floristic composition and functional characteristics to improve vegetation documentation (Haq et al., 2020). We set up 36 0.1 ha plots for field sampling across different habitats in the study area. Within each 0.1 ha plot, two 5 m^2 plots were placed in opposite corners estimate shrub diversity. For the herbaceous layer, 5 plots of size 1 m^2 were laid (4 in each corner 0.1 ha plot and one in the center). In total, 32 plots for trees, 64 (2 plots × 32 = 64) plots for shrubs and 160 (5 plots × 32 = 160) plots for herbs were sampled in the present study. Field data about each specimen of plant material was meticulously recorded during field studies. In order to serve as herbarium voucher specimens, plant specimens were collected from the field, identified using taxonomic literature, and then authenticated by comparing the plant specimens with material in the KASH herbarium. Ecological traits (like Raunkiaer's life-form, plant habit, phyto-geographical, life span) of each species were recorded during sampling, following Raunkiaer (1934), and Pérez-Harguindeguy et al. (2016). Furthermore, habitat characteristics of each plant species were categorized as Dry slope (DS), Moist places (MP), Natural forest (FR), Shady places (SP), Riparian vegetation (RV), Rock crevice (RC), Roadside (RS), Crop fields (CF), Vegetable garden (VG) (**Plate 1**). The range of native phyto-geographically reported plant specimens was acquired by using secondary sources like manuals, Flora and specified internet web pages (GRIN: Germplasm Resource Information Network).[1] Based on the available data, all plant specimens were categorized into native and exotic species.

1 www.efloras.org

Data analysis

To investigate the relationships between ecological variables and plant compositions, heat map and clustering analysis were employed (Rahman et al., 2019a; Haq et al., 2021d). The heat map displayed the distribution of species using presence/absence data, and the clustering algorithm grouped species with similar habitat categories. The Sørensen (1948) similarity coefficient based on presence/absence data was used to identify significant differences among different habitat types and microclimatic similarities (Dalirsefat et al., 2009). In order to identify hypothetical variables (components) that explain the majority of the variance in our multidimensional data, Non-Metric Multidimensional Scaling (NMDS) was utilized. The contribution of various Raunkiaer's life forms was visualized using chord diagrams generated with the circlize package (Gu et al., 2014). Subsequently, we computed three diversity indices, namely, species richness, Shannon and Simpson, based on presence/absence of species for all habitats, and all plots and analyses were performed using R software version 4.0.0 (R Core Team, 2020).

Results

Floristic composition and distribution

Based on the present investigation, 155 plant species from 120 genera and 49 families were reported in the current study area (**Table 1**). The distribution of the species among the 49 families was

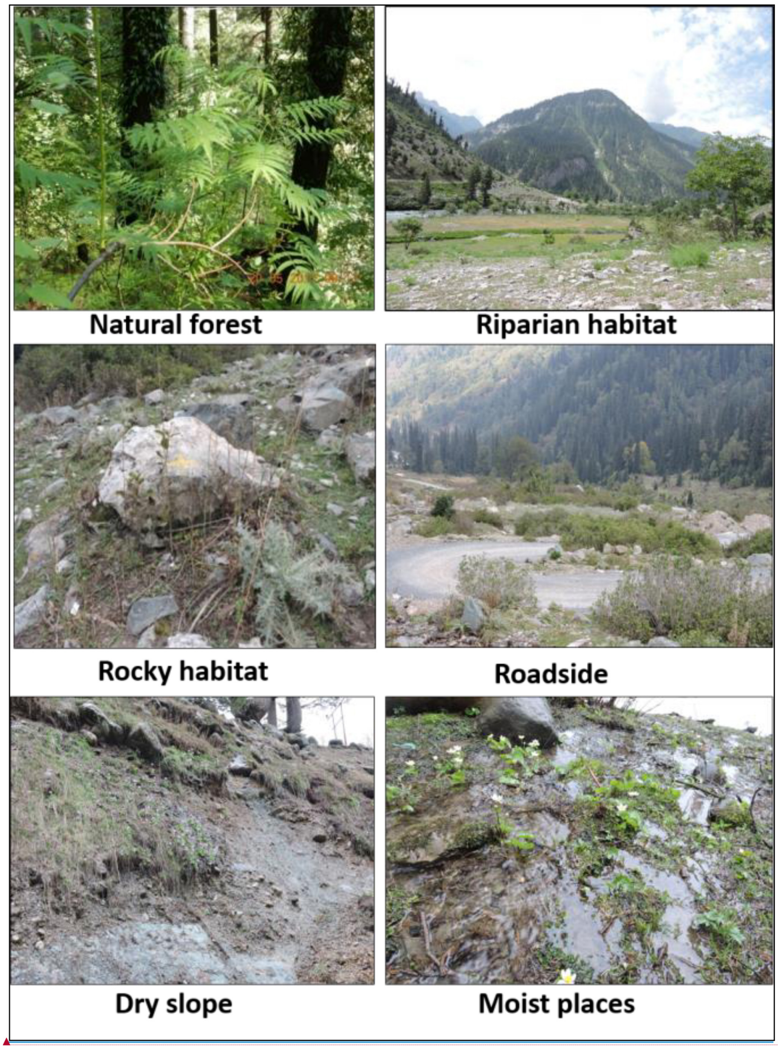

PLATE 1
Representation of different habitats in the study area.

unequal; just 7 families held half of the species, while 42 families held the other half. 23 families were monotypic (Figure 2). The top five plant families were Asteraceae (19 species, or 12% of all species), Rosaceae (17 species, or 11% of all species), Lamiaceae (15 species, or 10%), Ranunculaceae (10 species, or 6%), and Apiaceae (8 species, or 5%) (Table 1).

Species distribution among growth form types

In the current study, the highest number of plant species (111) were herbaceous plants (72% of all species), followed by 21 tree species (13%), 15 shrubs (10%), four climbers (3%), and four sub-shrubs (2%) (Table 1). Most of the tree species growing in the valley were deciduous (e.g., *Aesculus indica, Acer caesium, Betula utilis, Celtis australis, Prunus armeniaca*, *Prunus cornuta, Populus nigra, and Ulmus villosa*). A few coniferous tree species (e.g., *Abies pindrow, Cedrus deodara, Picea smithiana, Pinus wallichiana,* and *Taxus wallichiana*) were also reported. Shrubs included *Rosa webbiana, Berberis lyceum, Rubus ulmifolius, Parrotiopsis jacquemontiana, and Indigofera heterantha.* Important medicinal herbs reported from the valley were *Ajuga parviflora, Bergenia ciliate, Delphinium roylei, Gentiana kurroo, Heracleum candicans, Phytolacca acinosa, Saussurea costus*, *Taraxacum officinale,* and *Trillium govanianum* (Table 1). The representative plants species documented in the different habitats of the study area are shown in Plate 2.

Species distribution among life-form traits

About 35% of the species (54 species) were therophytes which constituted the dominant life form, followed by 29 species of hemicryptophytes (19%), chamaephytes and geophytes with 15 species each (10%), megaphanerophytes with 13 species (8%), nanophanerophytes with 12 species (8%), cryptophytes and mesophanerophytes with 7 species each (4%), microphanerophytes with 2 species (1%), and parasitic forms with a single species (1%)

TABLE 1 Floristic composition and life span traits of the forest vegetation in Gurez Valley of Kashmir Himalaya, India.

Family	Scientific name	Habitat#	Altitude (m)	Nativity**	Invasion status	Growth form	Raunkiaer life-form*	Life cycle	Abbreviation of plant used
Acoraceae	*Acorus calamus* L (4225-KASH)	MP	2,000–2,200	N	RN	Herb	CRP	Perennial	Aco.cal
Apiaceae	*Bunium persicum* (Boiss.) B. Fedtsch. (2974-KASH)	DS, RS	2,000–2,500	N	RN	Herb	GEO	Perennial	Bun.per
	Bupleurum falcatum L. (8075-KASH)	DS, RS	2,500–3,200	E	NT	Herb	HCP	Perennial	Bup.fal
	Chaerophyllum reflexum Aitch. (8095-KASH)	FR, MP	2,000–2,500	N	RN	Herb	HCP	Perennial	Cha.ref
	Ferula jaeschkeana Vatke (8015-KASH)	DS, MP	2,200–2,500	N	RN	Herb	HCP	Perennial	Fer.jae
	Heracleum candicans Wall. ex DC. (3446-KASH)	FR, MP	2,000–2,800	N	RN	Herb	HCP	Perennial	Her.can
	Pleurospermum candollei (DC.) Benth. ex C.B. Clarke	FR, DS	2,200–2,600	N	RN	Herb	HCP	Perennial	Ple.can
	Selinum conioides (Lange) E.H.L. Krause (8118-KASH)	DS, RS	3,000–3,500	E	NT	Herb	HCP	Perennial	Sel.con
Asteraceae	*Achillea millefolium* L (4097-KASH)	CF, DS, RS	2,000–2,800	N	RN	Herb	CHA	Perennial	Ach.mil
	Anaphalis royleana DC. (3808-KASH)	DS, RC	2,700–3,200	N	NT	Herb	HCP	Annual	Ana. Roy
	Anthemis cotula L. (4244-KASH)	RS, CF	2,000–2,500	E	IN	Herb	THE	Annual	Ant.cot
	Artemisia absinthium L. (4224-KASH)	RS, CF	2,000–2,500	E	IN	Herb	THE	Perennial	Art.abs
	Artemisia japonica Thunb (8092-KASH)	FR, DS	2,200–2,500	N	RN	Herb	HCP	Perennial	Art.jap
	Artemisia martima L. (8045-KASH)	FR, DS	2,400–2,800	N	RN	Shrub	NOP	Perennial	Art.mar
	Artemisia rutifolia Spreng. (8062-KASH)	DS, FR	2,200–2,600	N	RN	Herb	HCP	Perennial	Art.rut
	Artemisia vulgaris L. (4210-KASH)	DS, FR	2,000–2,500	N	RN	Shrub	CHA	Perennial	Art.vul
	Aster thomsonii C.B. Clarke (8067-KASH)	SP, FR	2,800–3,000	N	RN	Herb	THE	Perennial	Ast.tho
	Calendula officinalis L (8046-KASH)	RS	2,000–2,500	E	IN	Herb	THE	Annual	Call.off
	Centaurea iberica Trevir. ex Spreng. (4084-KASH)	RS, DS	2,000–2,400	E	IN	Herb	THE	Perennial	Cen.ibe
	Cichorium intybus L. (4222-KASH)	MP, RS	2,000–2,400	N	RN	Herb	THE	Perennial	Cic.int
	Galinsoga parviflora Cav. (8064-KASH)	RS, FR	2,000–2,500	E	IN	Herb	THE	Annual	Gal.par
	Inula racemosa Hook. f.(8119-KASH)	FR, SP	2,800–3,200	N	RN	Herb	THE	Perennial	Inu.rac
	Saussurea costus (Falc.) Lipschitz (4211-KASH)	FR, SP	2,800–3,200	N	RN	Herb	CHA	Annual	Sau.cos
	Saussurea sacra Edgew. (8128-KASH)	FR, SP	2,800–3,200	N	RN	Herb	CHA	Perennial	Sau.sac
	Senecio chrysanthemoides DC. (4102-KASH)	RS, MP	2,000–2,900	E	CS	Herb	THE	Perennial	Sen.chr
	Taraxacum officinale Wigg. (6259-KASH)	DS, FR	2,000–2,500	E	IN	Herb	CHA	Annual	Tar.off
Asparagaceae	*Asparagus officinalis* L. (8125-KASH)	FR, SP	2,200–2,700	E	NT	Climber	CRP	Perennial	Asp.off
	Polygonatum acuminatifolium Kom. (4230-KASH)	FR, SP	2,000–2,400	E	NT	Herb	GEO	Perennial	Pol.cum
Amaranthaceae	*Amaranthus caudatus* L. (4217-KASH)	RS, CF	2,000–2,400	E	IN	Herb	THE	Annual	Ama.cau
	Amaranthus retroflexus L.(6244-KASH)	RS, CF	2,000–2,400	E	NT	Herb	THE	Annual	Ama.ret
	Amaranthus spinosus L. (3361-KASH)	RS, CF	2,000–2,400	E	NT	Herb	THE	Annual	Ama.spi
	Chenopodium album L. (4805-KASH)	RS, CF	2,000–2,500	E	IN	Herb	THE	Annual	Che.alb
	Chenopodium botrys L. (4089-KASH)	DS, RS	2,000–2,500	N	RN	Herb	THE	Annual	Che.bot
Balsaminaceae	*Impatiens glandulifera* Royle (2989-KASH)	RV, FR	2,000–2,400	N	RN	Herb	THE	Annual	Imp.gla
Berberidaceae	*Berberis lycium* Royle (4101-KASH)	FR, DS	2,100–2,600	N	RN	Shrub	NOP	Perennial	Ber.lyc

(Continued)

TABLE 1 (Continued)

Family	Scientific name	Habitat#	Altitude (m)	Nativity**	Invasion status	Growth form	Raunkiaer life-form*	Life cycle	Abbreviation of plant used
Betulaceae	*Betula utilis* D. Don (4105-KASH)	FR	2,800–3,300	N	RN	Tree	MSP	Perennial	Bet.uti
Boraginaceae	*Arnebia benthamii* Wall. ex G. Don (4096-KASH)	RC, FR	3,000–3,300	N	RN	Herb	HCP	Annual	Arn.ben
	Cynoglossum wallichii var. *glochidiatum* (Wall. ex Benth.) Kazmi (4083-KASH)	DS, FR	2,000–2,500	N	RN	Herb	THE	Biennial	Cyn.wal
	Pseudomertensia echioides Riedl (8085-KASH)	FR	2,300–2,800	N	RN	Herb	THE	Perennial	Pse.ech
Brassicaceae	*Brassica juncea* (L.) Czern (4086-KASH)	RS, DS, CF	2,000–2,400	E	NT	Herb	THE	Annual	Bra.jun
Cannabaceae	*Celtis australis* L. (3380-KASH)	FR	2,000–2,500	E	IN	Tree	MGP	Perennial	Cel.aus
Campanulaceae	*Codonopsis rotundifolia* Benth. (7093-KASH)	FR, MP	2,200–2,700	N	RN	Herb	HCP	Perennial	Cod.rot
Caryophyllaceae	*Dianthus angulatus* Royle (4229-KASH)	DS, FR	2,000–2,400	N	RN	Herb	THE	Perennial	Dia.ang
	Gypsophila cerastioides D. Don (8073-KASH)	FR, MP	2,600–3,000	N	RN	Herb	HCP	Perennial	Gyp.cer
	Silene conoidea L. (7101-KASH)	FR, SP	2,700–2,900	N	RN	Herb	THE	Annual	Sil.con
	Silene vulgaris Garcke (3441-KASH)	FR, SP	2,000–2,600	N	RN	Herb	THE	Perennial	Sil.vul
	Stellaria media L. (4249-KASH)	MP, FR	2,000–2,700	N	RN	Herb	THE	Annual	Ste.med
Caprifoliaceae	*Valeriana pyrolifolia* Decne.(4221-KASH)	MP, SP	2,000–2,700	N	RN	Herb	GEO	Perennial	Val.pyr
	Viburnum grandiflorum Wall. ex DC (4241-KASH)	FR	2,000–3,000	N	RN	Shrub	NOP	Perennial	Vib.gra
Convolvulaceae	*Cuscuta reflexa* Roxb. (4082-KASH)	RS	2,000–2,400	E	IN	Climber	PAR	Perennial	Cus.ref
Datiscaceae	*Datisca cannabina* L. (4235-KASH)	FR, DS	2,000–2,500	N	RN	Herb	HCP	Perennial	Dat.can
Dioscoreaceae	*Dioscorea deltoidea* Wall. ex Griseb. (6237-KASH)	FR, SP	2,200–2,600	N	RN	Climber	HCP	Perennial	Dio.del
Euphorbiaceae	*Euphorbia helioscopia* L (4237-KASH)	MP, FR	2,000–2,400	E	IN	Herb	THE	Annual	Eup.hel
	Euphorbia wallichii Hook. f. (4216-KASH)	MP, FR	2,700–3,100	N	RN	Herb	THE	Perennial	Eup.wal
Fabaceae	*Astragalus grahamianus* Benth.(3805-KASH)	DS, RS	2,200–2,600	N	RN	Sub-shrub	CHA	Perennial	Ast.gra
	Lathyrus emodi (Wall. ex Fritsch) Fritsch ex T. Durand and B.D. Jacks. (3806-KASH)	FR, SP	2,300–2,600	N	RN	Herb	THE	Perennial	Lat.emo
	Indigofera heterantha Brandis (4221-KASH)	DS, FR	2,000–2,700	N	RN	Shrub	NOP	Perennial	Ind.het
	Medicago polymorpha L. (4232-KASH)	DS, FR	2,000–2,500	E	NT	Herb	THE	Perennial	Med.pol
	Oxytropis sericea Nutt. (8062-KASH)	FR, DS	2,100–2,400	E	IN	Herb	HCP	Perennial	Oxy.ser
Fumariaceae	*Corydalis govianiana* Wall. (3810-KASH)	RC, SP, FR	2,300–2,900	N	RN	Herb	GEO	Perennial	Cor.gov
Gentianaceae	*Gentiana kurroo* Royle (8066-KASH)	FR, SP	2,000–2,500	N	RN	Herb	THE	Perennial	Gen.kur
	Swertia petiolata Royle (7094-KASH)	RV, FR	2,700–3,000	N	RN	Herb	GEO	Perennial	Swe.pet
Geraniaceae	*Geranium pratense* L. (4098-KASH)	FR, SP	2,800–3,200	N	RN	Herb	THE	Perennial	Ger.pra
	Geranium wallichianum D. Don (4112-KASH)	FR, SP	2,000–2,700	N	RN	Herb	CHA	Perennial	Ger.wal
Hamamelidaceae	*Parrotiopsis jacquemontiana* Rehder (6258-KASH)	DS, FR	2,200–2,700	N	RN	Shrub	NOP	Perennial	Par.jac
Juglandaceae	*Juglans regia* L. (8053-KASH)	DS, CF	2,000–2,800	N	RN	Tree	MSP	Perennial	Jug.reg
Lamiaceae	*Ajuga parviflora* Benth. (4095-KASH)	FR, SP	2,000–2,500	N	RN	Herb	HCP	Annual	Aju.par
	Dracocephalum nutans L. (6261-KASH)	FR, SP	2,100–2,400	E	NT	Herb	CHA	Perennial	Dra.nut

(Continued)

TABLE 1 (Continued)

Family	Scientific name	Habitat#	Altitude (m)	Nativity**	Invasion status	Growth form	Raunkiaer life-form*	Life cycle	Abbreviation of plant used
	Leucas lanata Benth. (6240-KASH)	FR, MP	2,200–2,500	N	RN	Herb	THE	Perennial	Leu.lan
	Mentha arvensis L. (4234-KASH)	FR, RV	2,000–2,400	E	RN	Herb	GEO	Perennial	Men.arv
	Mentha longifolia L. (4251-KASH)	RV, FR	2,000–2,600	E	IN	Herb	GEO	Perennial	Men.lon
	Nepeta connata Royle ex Benth. (6233-KASH)	FR, MP	2,000–2,400	N	RN	Herb	THE	Perennial	Nep.con
	Nepeta erecta (Royle ex Benth.) Benth. (6241-KASH)	FR, MP	2,100–2,500	N	RN	Herb	THE	Perennial	Nep.ere
	Nepeta govaniana (Wall. ex Benth.) Benth. (8047-KASH)	FR, MP	2,200–2,500	N	RN	Herb	THE	Perennial	Nep.gov
	Nepeta laevigata (D. Don) Hand.-Mazz. (8056-KASH)	FR, MP	2,000–2,500	N	RN	Herb	THE	Perennial	Nep.lae
	Nepeta linearis Royle ex Benth. (8046-KASH)	FR, MP	2,200–2,600	N	RN	Herb	THE	Perennial	Nep.lin
	Prunella vulgaris L. (4254-KASH)	RV, RS	2,000–2,500	E	IN	Herb	THE	Perennial	Pru.vul
	Salvia hains Royle ex Bentham (8049-KASH)	FR, RC	2,700–2,900	N	RN	Herb	THE	Biennial	Sal.hai
	Salvia moorcroftiana Wall. ex Benth. (6256-KASH)	RS, DS	2,000–2,500	N	RN	Herb	CHA	Perennial	Sal.moo
	Thymus linearis Benth. (4107-KASH)	DS, FR, RS	2,000–3,000	N	RN	Sub-shrub	HCP	Perennial	Thy.lin
	Thymus serpyllum L. (8055-KASH)	DS, RS	2,400–2,800	E	NT	Sub shrub	HCP	Annual	Thy.ser
Liliaceae	*Allium cepa* L. (3813-KASH)	CF, VG	2,000–2,500	E	NT	Herb	GEO	Perennial	All.cep
	Fritillaria roylei Hook. f. (4086-KASH)	FR, MP	3000–3400	N	RN	Herb	GEO	Perennial	Fri.roy
Malvaceae	*Lavatera cashemiriana* Cambess. (4099-KASH)	FR, SP	2,300–2,700	N	RN	Herb	CHA	Perennial	Lav.cas
	Malva neglecta Wallr. (4114-KASH)	VG, FR	2,000–2,600	E	IN	Herb	THE	Perennial	Mal.neg
Melanthiaceae	*Trillium govanianum* Wall. (6230-KASH)	FR, SP	2,200–3,000	N	RN	Herb	THE	Perennial	Tri.gov
Oxalidaceae	*Oxalis corniculata* L. (4113-KASH)	SP, VG,RS	2,000–3,500	E	IN	Herb	THE	Perennial	Oxa.cor
Papaveraceae	*Meconopsis latifolia* (Prain) Prain (7093-KASH)	FR, MP	2,800–3,100	N	RN	Herb	HCP	Perennial	Mec.lat
Primulaceae	*Androsace rotundifolia* Hardw.(4240-KASH)	DS, FR	2,700–3,200	N	RN	Herb	CRP	Perennial	And.rot
	Anagallis arvensis L. (4239-KASH)	SP, FR	2,000–2,700	N	RN	Herb	HCP	Perennial	Ana.arv
	Primula denticulata Sm. (3810-KASH)	FR	2,100–2,700	N	RN	Herb	GEO	Perennial	Pri.den
Pinaceae	*Abies pindrow* Royle (2965-KASH)	FR	2,300–3,100	N	RN	Tree	MGP	Perennial	Abi.pin
	Cedrus deodara G. Don (4228-KASH)	FR	2,000–2,400	N	RN	Tree	MGP	Perennial	Ced.deo
	Pinus wallichiana A.B. Jacks. (4227-KASH)	FR	2,000–3,000	N	RN	Tree	MGP	Perennial	Pin.wal
	Picea smithiana Boiss. (2967-KASH)	FR	2,200–2,900	N	RN	Tree	MGP	Perennial	Pic.smi
Phytolaccaeae	*Phytolacca acinosa* Roxb. (4253-KASH)	FR, SP	2,200–2,600	N	RN	Herb	GEO	Perennial	Phy.aci
Plantaginaceae	*Veronica laxa* Benth. (3809-KASH)	FR	2,100–2,900	N	RN	Herb	CRP	Perennial	Ver.lax
	Veronica beccabunga L. (4210-KASH)	MP, RS	2,200–2,600	E	CS	Herb	HCP	Perennial	Ver.bec
Poaceae	*Poa bulbosa* L. (4230-KASH)	CF, FR, VG	2,000–2,400	E	IN	Herb	THE	Perennial	Poa.bul
	Poa pratensis L. (4235-KASH)	CF, FR, VG,	2,000–2,600	E	IN	Herb	HCP	Perennial	Poa.pra
	Stipa sibirica Lam. (4236-KASH)	DS, FR	2,200–2,700	N	RN	Herb	HCP	Perennial	Sti.sib
Polygonaceae	*Polygonum viviparum* L. (8066-KASH)	RS, DS	2,200–2,600	E	IN	Herb	THE	Perennial	Pol.viv

(Continued)

TABLE 1 (Continued)

Family	Scientific name	Habitat#	Altitude (m)	Nativity**	Invasion status	Growth form	Raunkiaer life-form*	Life cycle	Abbreviation of plant used
	Rheum emodi Wall.ex Meissn. (4212-KASH)	RC, FR	2,700–3,200	N	RN	Herb	GEO	Perennial	Rhe.emo
	Rumex dentatus L. (4247-KASH)	RS, DS	2,000–2,500	N	RN	Herb	THE	Annual	Rum.den
Pteridaceae	*Pteris cretica* L. (8073-KASH)	MP, FR	2,000–2,600	E	CS	Herb	HCP	Perennial	Pte.cre
Saxifragaceae	*Bergenia ciliata* (Haw) Sternb. (4213-KASH)	RC, FR	2,400–3,100	N	RN	Herb	CRP	Perennial	Ber.cil
	Bergenia stracheyi (Hook. f. and Thomson) Engl. (2973-KASH)	RC, FR	2,500–3,200	N	RN	Herb	CRP	Perennial	Ber.str
Sapindaceae	*Acer caesium* Wall. ex Brandis (6261-KASH)	FR	2,200–2,700	N	RN	Tree	MGP	Perennial	Ace.cae
	Aesculus indica Hook. (4111-KASH)	FR	2,200–2,800	N	RN	Tree	MGP	Perennial	Aes. Ind
Salicaceae	*Populus alba* L. (6262-KASH)	CF	2,000–2,400	E	NT	Tree	MSP	Perennial	Pop.alb
	Populus ciliata Wall. ex Royle (6234-KASH)	CF, FR	2,000–2,500	E	IN	Tree	MSP	Perennial	Pop.cil
	Populus nigra L. (6235-KASH)	DS, CF	2,000–2,600	N	RN	Tree	MSP	Perennial	Pop.nig
	Salix denticulata Andersson (6239-KASH)	MP, FR	2,700–3,200	N	RN	Tree	MSP	Perennial	Sal.den
Sambucaceae	*Sambucus wightiana* Wall. ex Wt. and Arn. (6243-KASH)	RS, DS	2,200–2,900	N	RN	Sub-shrub	THE	Perennial	Sam.wig
Scrophulariaceae	*Euphrasia aristulata* Penn. (6248-KASH)	FR, DS	2,200–2,500	N	RN	Herb	THE	Annual	Eup.ari
	Picrorhiza kurroa Royle ex Benth. (6246-KASH)	FR, SP	2,000–2,500	N	RN	Herb	HCP	Perennial	Pic.kur
	Verbascum thapsus L. (4242-KASH)	RS, DS	2,000–2,800	N	RN	Herb	HCP	Perennial	Ver.tha
Simaroubaceae	*Ailanthus altissima* Swingle.	DS	2,000–2,400	E	NT	Tree	MGP	Perennial	Ail.alt
Solanaceae	*Atropa acuminata* Royle ex Lindl. (4252-KASH)	FR, SP	2,200–2,800	N	RN	Herb	THE	Perennial	Atr.acu
	Datura stramonium L. (4085-KASH)	RS	2,000–2,400	E	IN	Herb	THE	Annual	Dat.str
	Hyoscyamus niger L. (4106-KASH)	RS	2,200–2,700	E	NT	Herb	CRP	Biennial	Hyo.nig
	Solanum tuberosum L. (8092-KASH)	CF, VG	2,000–2,400	E	NT	Herb	GEO	Perennial	Sol.tub
Ranunculaceae	*Aquilegia fragrans* Benth. (8082-KASH)	FR, SP	2,500–2,900	N	RN	Herb	CHA	Perennial	Aqu.fra
	Aconitum chasmanthum Stapf ex Holmes (4109-KASH)	DS, RC	3,000–3,200	N	RN	Herb	HCP	Perennial	Aco.cha
	Aconitum heterophyllum Wall. ex Royle (4094-KASH)	FR	2,700–3,200	N	RN	Herb	CHA	Perennial	Aco.het
	Clematis montana Buch. -Ham. ex DC. (8120-KASH)	FR	2,200–2,500	N	RN	Climber	CHA	Perennial	Cle.mon
	Delphinium roylei Munz (7106-KASH)	FR, MP	2,000–2,600	N	RN	Herb	THE	Perennial	Del.roy
	Ranunculus palmatifidus Riedl (7104-KASH)	MP, FR, SP	2,000–2,600	N	RN	Herb	GEO	Perennial	Ran.pal
	Ranunculus hirtellus Royle (7105-KASH)	MP, SP, CF	2,700–3,000	N	RN	Herb	THE	Perennial	Ran.hir
	Ranunculus laetus Wall. ex Hook. (7118-KASH)	CF, FR,RS	2,000–2,500	E	IN	Herb	GEO	Perennial	Ran.lae
	Ranunculus sceleratus L. (8117-KASH)	RV, RS	2,200–2,600	E	CS	Herb	THE	Annual	Ran.sce
	Thalictrum cultratum Wall. (8115-KASH)	FR	2,300–2,700	N	RN	Herb	CHA	Perennial	Tha.cul
Rosaceae	*Cotoneaster affinis* Lindl. (8125-KASH)	FR	2,600–3,100	N	RN	Shrub	MGP	Perennial	Cot.aff
	Cotoneaster nummularius Fisch. and C.A. Mey. (8070-KASH)	RS	2,000–2,800	E	NT	Shrub	NOP	Perennial	Cot.num

(Continued)

TABLE 1 (Continued)

Family	Scientific name	Habitat#	Altitude (m)	Nativity**	Invasion status	Growth form	Raunkiaer life-form*	Life cycle	Abbreviation of plant used
	Crataegus songarica K. Koch (3381-KASH)	FR	2,000–2600	N	RN	Tree	MCP	Perennial	Cra.son
	Filipendula vestita (Wall. ex G. Don.) Maxim.	FR, SP	2200–2,600	N	RN	Shrub	CHA	Perennial	Fil.ves
	Fragaria nubicola (Lindl. ex Hook. f.) Lacaita (4087-KASH)	FR, DS	2,000–3,000	N	RN	Herb	HCP	Perennial	Fra.nub
	Malus domestica Borkh. (4248-KASH)	CF	2,000–2,500	N	RN	Tree	MGP	Perennial	Mal.dom
	Potentilla multifida L. (7088-KASH)	RS, DS	2,200–2,800	E	IN	Herb	HCP	Perennial	Pot.mul
	Potentilla nepalensis Hook. (7098-KASH)	DS, RS	2,200–2,500	E	NT	Herb	THE	Perennial	Pot.nep
	Prunus avium L.(7101-KASH)	CF	2,000–2,600	E	CS	Tree	MGP	Perennial	Pru.avi
	Prunus cornuta Steud. (3431-KASH)	FR	2,300–2,800	N	RN	Tree	MGP	Perennial	Pru.cor
	Prunus persica Batsch (8059-KASH)	CF	2,000–2,500	E	CS	Tree	MCP	Perennial	Pru.per
	Rosa indica L. (8084-KASH)	FR, SP	2,000–2,400	N	RN	Shrub	NOP	Perennial	Ros.ind
	Rosa webbiana Wall. ex Royle (6245-KASH)	DS, FR	2,000–2,800	N	RN	Shrub	NOP	Perennial	Ros.web
	Rubus ellipticus Sm. (6255-KASH)	FR, DS	2,000–2,600	N	RN	Shrub	NOP	Perennial	Rub.ell
	Rubus niveus Thunb. (6252-KASH)	FR, DS	2,400–2,900	N	RN	Shrub	NOP	Perennial	Rub.niv
	Rubus ulmifolius Schott (6252-KASH)	FR, DS	2,000–2,500	E	CS	Shrub	NOP	Perennial	Rub.ulm
	Sorbaria tomentosa Rehder (8086-KASH)	FR	2,400–3,000	N	NT	Shrub	NOP	Perennial	Sor.tom
Taxaceae	*Taxus wallichiana* Zucc.(8094-KASH)	FR	2,400–2,700	N	RN	Tree	MSP	Perennial	Tax.wal
Ulmaceae	*Ulmus villosa* Brandis ex Gamble (8091-KASH)	FR, CF	2,000–2,500	N	RN	Tree	MGP	Perennial	Ulm.vil
Urticaceae	*Urtica dioica* L. (4219-KASH)	RS, DS	2,000–3,100	E	NT	Herb	THE	Perennial	Urt.dio
Verbenaceae	*Verbena officinalis* L. (4117-KASH)	MP, RS	2,000–2,500	E	IN	Herb	THE	Perennial	Ver.off
Violaceae	*Viola canescens* Wall. ex Roxb. (3458-KASH)	FR, SP	2,000–2,500	N	RN	Herb	THE	Perennial	Vio.can
	Viola odorata L. (3462-KASH)	FR, SP	2,000–2,600	E	NT	Herb	THE	Perennial	Vio.odo

*THE, therophytes; HCP, hemicryptophytes; MGP, magaphanerophytes; NOP, nanophanerophytes; CHA, chamaephytes; GEO, geophytes; MSP, mesophanerophytes; CRP, cryptophytes; MCP, microphanerophytes; PAR, parasitic. **N = native, E = exotic. #Dry slope (DS), Moist places (MP), Natural forest (FR), Shady places (SP), Riparian vegetation (RV), Rock crevice (RC), Roadside (RS), Crop fields (CF), Vegetable garden (VG), Regional native (RN), Naturalized (NT), Invasive (IN), Casual (CS).

(Figure 3). Majority of the plant species (129) in the studied valley were represented by perennials (83%) followed by annuals with 23 species (15%), and biennials with three species (2%). According to the phyto-geographical research, 65% of the species documented in the study area were native, with the remaining 15% being invasive, 14% being naturalized, and 5% being casual (Figure 4 and Table 1). The majority (30%) of exotic species were reported on the roadside, followed by natural forests (23%), crop fields (17%), dry slopes (16%), shady areas (5%), moist places, and riparian zones (4% each).

Habitat-wise distribution

Of all species encountered 39% grew in the natural forests, 17% on dry slopes, 11% in shady places, 10% in moist places, 2% in riparian zones, 3% in rock crevices, and the remaining species were dispersed in highly distributed habitats, e.g., 11% along roadsides, 6% in crop fields, and 1% in vegetables gardens (Table 1 and Plate 2). Based on their floristic similarity, cluster analysis identified five clusters of various habitat types (Figure 5). Natural forests made up the first cluster, dry slopes and roadside vegetation made up the second, wet and shady areas made up the third, crop fields and vegetable gardens made up the fourth, and riparian vegetation and rock crevices made up the fifth (Figure 5).

Similar to this, the NMDS revealed significant variation in habitat types, with some species groups having a stronger association with particular habitat types than others (Figure 6). In the biplot, five clusters of habitats based on species presence/absence can be identified: dry slope; natural forest; roadside; moist places and rocky crevice; and crop fields, riparian vegetation, shady places, and vegetable gardens. The major plant species richness was detected in rich and optimally moisturized natural forest habitats and middle richness in moist places as well as less distributed habitations.

According to the estimated diversity indices, Natural forest had the greatest values for all three indices (Table 2). Shannon's

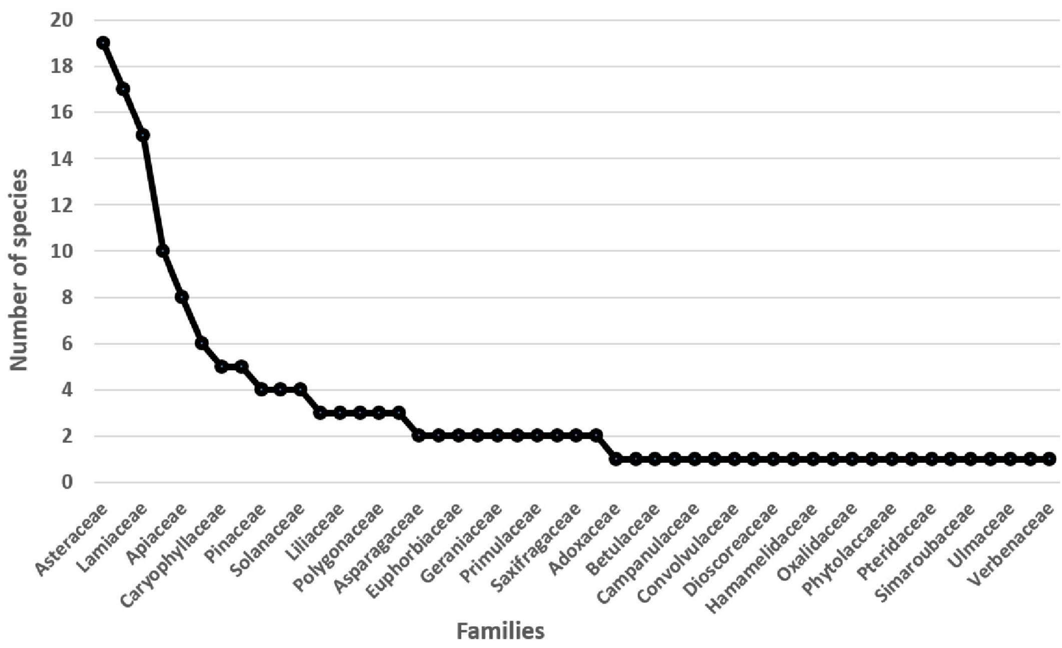

FIGURE 2
Species- family relationship of documented species in the study area.

index for this habitat was 4.73, and Simpson's was 0.99. There were 113 species present. After that, Dry slope and Shady areas held 46 and 31 specie (3.83 and 3.43 for Shannon index, and 0.98 and 0.97 for Simpson index, respectively) (**Table 2**) lowest values were recorded for Rock crevice and Vegetable garden (**Table 2**).

Discussion

In this study, we provide an in-depth evaluation of the qualitative vegetation of remote region of Kashmir Himalaya. The study revealed (i) 155 plant species belonging to 120 genera and 49 families, with (ii) an uneven distribution within families, with 50% of the species belonging to just 7 families and 23 families being monotypic. (iii) Therophytes were the most prevalent form of life, showing that the vegetation was disturbed (iv) Exotic species made up the remaining 35% and most exotic plants were found along roadsides. Finally, (v) natural forests scored the highest values for all three estimated diversity indices, compared to other human-modified habitats. Vegetation analysis helps to develop a comprehensive image of the plant communities of a particular region (Chhetri and Shrestha, 2019). Assessing the floristic diversity of hotspots of biodiversity is essential to understand the conservation status of these areas, which have a significant role in making the conservation strategies as well as policies. The vegetation of region was found to be very diverse due to ecological zonation, different microhabitats, and topographic features. 49 families and 155 species were found in the current investigation. In comparison to past studies conducted in other Himalayan locations (Qureshi and Bhatti, 2010; Semwal et al., 2010; Shaheen and Qureshi, 2011; Dangwal et al., 2012; Singh and Rawat, 2012) the number of plant species recorded in the current research area was higher. Numerous interrelated factors, including elevation, regional climate, topography, competition, regional species pool, regional species dynamics, and human activity have an impact on the regional patterns of species richness (Rahman et al., 2020; Mitchell et al., 2023). However, Khan et al. (2012) reported a higher number of plant species (198) from the Naran valley forest of Pakistan Himalaya but distributed in a lower number of families (68) when compared to our study. Similarly, Verma and Kapoor (2011) reported 160 vascular plant species belongs to 51 families from Ropa-Giavung valley in the cold deserts of District Kinnaur, Himachal Pradesh, India (also see Manzoor et al., 2016; Haq et al., 2022d; Ullah et al., 2022). However, at the region level the species richness of our study was comparatively higher than report in previous studies from Kashmir Himalayas (Bhat et al., 2014). Thus, the slight but predictable fluctuation in species number might be attributed to both abiotic environmental and biotic causes. Apart from elevation, microhabitats that reflect or predict vegetation patterns across landscapes. Together with the previously described findings, our findings demonstrate that while various studies have analyzed the floristic composition of the Himalayan region, each micro-region has unique functional groups that can significantly affect the structuring of the local plant community. Our study showed a smaller number of species than several other studies, but had a larger number of families, which may also represent an important result for the analysis of biodiversity in these regions. Asteraceae, Rosaceae, Lamiaceae, Ranunculaceae, and Apiaceae were reported as the families with the largest number of plant species. Due to wide range of ecological amplitudes, the plant species of Asteraceae are varied in habitats (Rahman et al., 2019a; Rashid et al., 2021; Waheed et al., 2022). Similar findings were observed by Haq et al. (2021d) in Kashmir Himalaya, India and Rahman et al. (2018) in Manoor

PLATE 2
Representative plant species growing in different habitats of the study area.

valley, Pakistan. Many researchers have reported Asteraceae as the dominant family from different regions (Verma and Kapoor, 2011; Hussain et al., 2015; Ali et al., 2016; Amjad et al., 2017; Khan et al., 2018; Rahman et al., 2019a). This demonstrates the family's strong capacity for adaptation to a variety of environments and temperatures. Additionally, in agreement with our findings, two other studies—Suyal et al. (2010) in the Garhwal Himalaya, India, and Khan et al. (2015) in Kabal (Swat), Pakistan—reported Lamiaceae as the dominant family.

The current study emphasizes the uneven distribution of plant species throughout families, with 23 families being identified as monotypic. The large variety of families, which revealed a varied distribution of flora in the area, is explained by variances in microhabitat, morphological features, life duration, and dynamic ecological niche (Haq et al., 2022a; Khoja et al., 2022). The diversity and structure of these plant communities can be influenced by various abiotic and biotic factors, which has also been shown by earlier research in the Western Himalayan region, and some species and/or families may not be as able to inhabit particular habitats as others (Rahman et al., 2018). The growth form of trees had higher proportion (13%) than shrubs (10%), an expression of a functioning forest ecosystem (Khan et al., 2015). The present results agreed with Khan et al. (2015), who found that a large diversity of microhabitats was favorable to tree species in the region. The findings of Sharma and Raina (2018) from other Himalayan forests further support these findings. Herbaceous species (111) were the dominant habit similar to other areas of the Northwestern Himalaya (Dar and Sundarapandian, 2016; Rahman et al., 2019b; Haq et al., 2021a; Nafeesa et al., 2021). Previous research in the Western Himalayan region has shown that certain species and/or families rarely have the same ability to occupy specific habitats as others, where varied abiotic and biotic effects can alter the diversity and organization of these plant communities (Haq et al., 2021b; Nafeesa et al., 2021).

It has been observed that the most promising approaches for predicting the species composition of any forest communities revolves around their functional traits. Therefore, studying functional groups usually provides clear information on the direct physiological adaptations of plant communities to particular

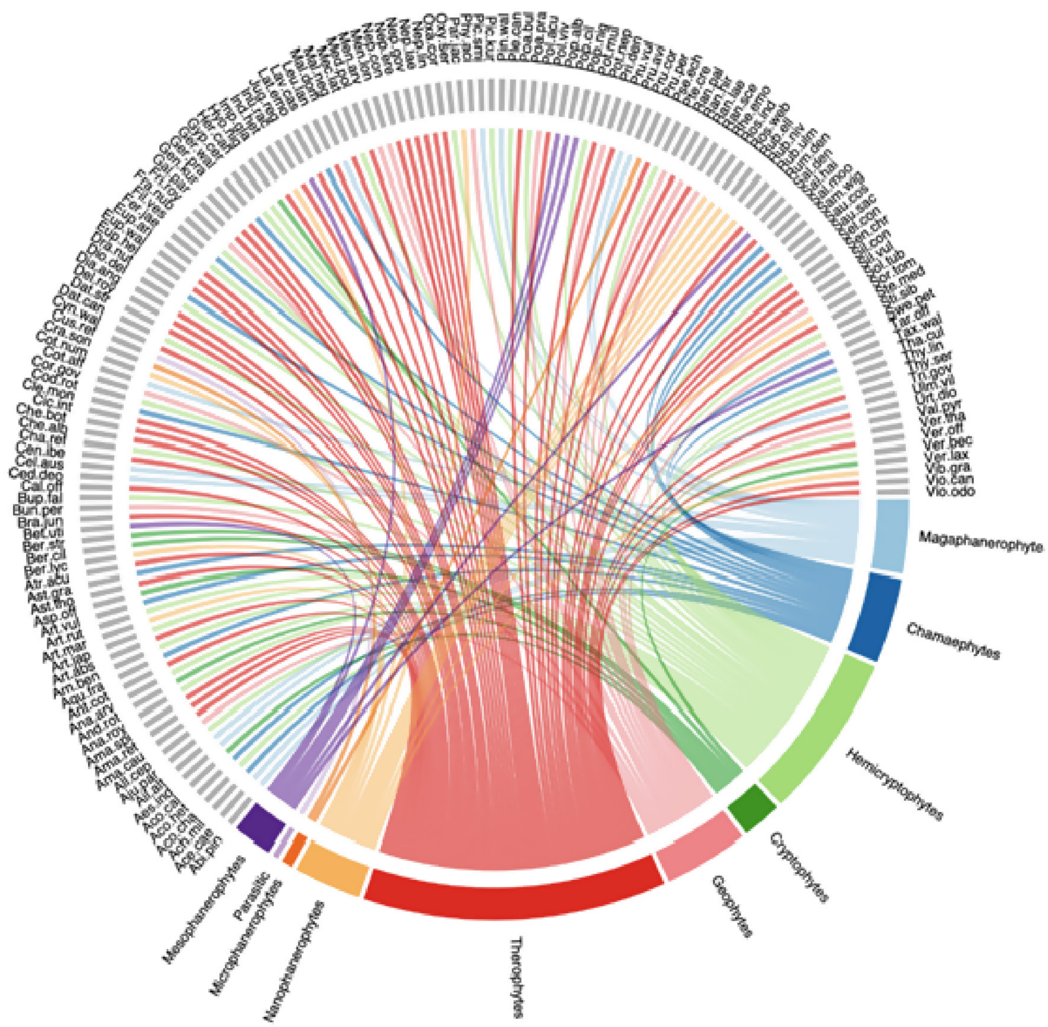

FIGURE 3
Plant species distribution according to Raunkiaer's life form of the vegetation in Gurez valley, Kashmir Himalaya, India.

environments conditions (Haq et al., 2019). The most common life form class were therophytes, followed by hemicryptophytes, magaphanerophytes, chamaephytes, and geophytes. Such biological variety represents the adaptation of plant species to the climatic factors (Khan et al., 2018). Hemi-cryptophytes predominate in the study area due to the cold and mountainous climate. In general, they withstand water scarcity by remaining dry or developing physiological, morphological, and anatomical traits that allow them to tolerate water loss. The fact that therophytes were found as the dominant life form in the studied area, which indicates high biotic disturbance levels on the habitat via grazing, human settlements, agricultural practices, and road constructions, since this life form is commonly associated with the unfavorable dry environmental condition, resulting in adopted strategies for their survival (Vakhlamova et al., 2016). The current findings agreed with Asim et al. (2016), Rahman et al. (2018, 2019b), Wali et al. (2022) who also documented the dominance of therophytes in the respective research areas. The high biotic disturbance significantly alters composition of the herbaceous layer and favored the abundant growth of alien annual weedy species such as such as *Anthemis cotula, Amaranthus caudatus, Centaurea iberica, Datura stramonium,* and *Galinsoga parviflora*, all of which are therophytes (Haq et al., 2021d). The second most prevalent type of life was hemicryptophytes. The association of hemicryptophytes with a cold, mountainous climate is a likely explanation for their predominance (Shimwell, 1971). Because of the soil and climate in the subalpine zones, chamaephytes are more common (Khan et al., 2018). Some habitats are more suited to plant development than others based on the diversity of species found in the forest environments of different geographic regions (Medvecká et al., 2018). Comparing natural forest habitats to other types of habitat, the current study found that natural forest environments harbored the highest diversity of species. However, anthropogenic disturbances are fragmenting, destroying, and degrading natural forest habitats, which is affecting the composition and layout of forest communities including in this area of the Himalayan region (Chakraborty et al., 2017; Rahman et al., 2022). Qureshi and Bhatti (2010), who recorded the highest number of plant species in natural forest habitats from Pakistan, provide additional support for our findings. Moreover, the resemblance in the plant species pool in human modified habitats provides an evidence toward the indication of

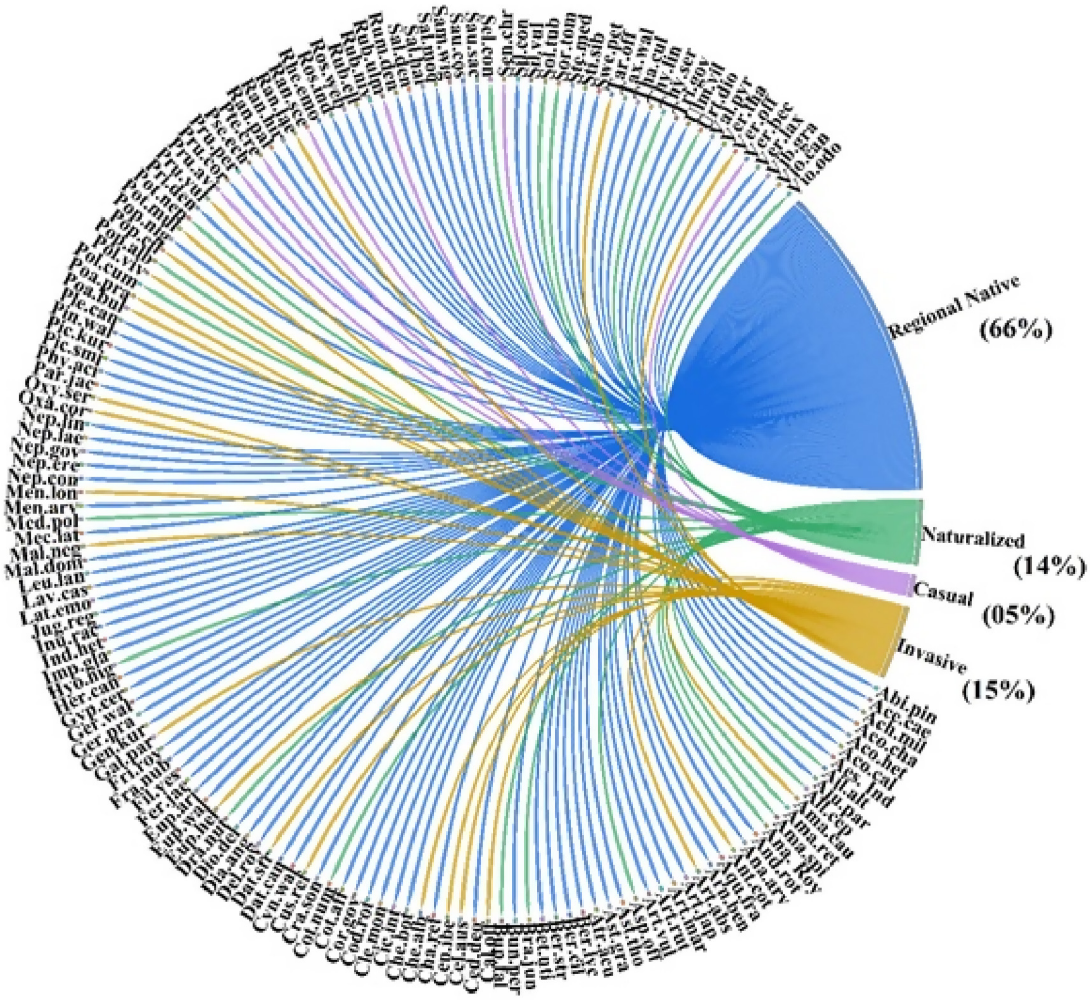

FIGURE 4
Plant species distribution according to nativity range of the vegetation in Gurez valley, Kashmir Himalaya, India.

ecological filtration that occurs in the region (Gardner et al., 2009). Anthropogenic disturbances common in this Himalayan region include overgrazing, deforestation, over-exploitation and fragmentation of natural intact forests due to linear development such as road networks and transmission lines (Haq et al., 2022b). Out of the total reported plant species, 35% were exotic, mostly in human modified habitats. Such numbers are comparable with those documented by Kohli et al. (2004) from the forests of Himachal Pradesh of Indian Himalayas. The most common invasive species growing in forest ecosystems of Jammu and Kashmir included trees like *Aesculus indica, Ailanthus altissima, Juglans regia, Populus ciliate,* subshrub *Sambucus wightiana,* and herbs such as *Anthemis cotula, Amaranthus caudatus, Centaurea iberica* and *Datura stramonium* (Haq et al., 2019, 2023b). The invasion of plant species is typically facilitated by disturbance because it overwhelms environmental and physical barriers. The parameters that cause the disturbances have been seen to be able to filter the makeup of a community and affect species concurrence by altering resource and safe spot availability (Davis et al., 2000; Haq et al., 2022c, 2023a). Generally, those species having wide niches and can pass via these filters and likely to overrun newly ecosystems after these are disturbed (Dukes and Mooney, 1999). Furthermore, invasions of exotics into forests might be facilitated by the incursion of other plant species generating conditions that encourage other invasive plant species over native species (Niu et al., 2007). When alien species invade a newly range, innate plant species, adaptation to the new environment, is sometimes evacuated (van Boheemen et al., 2019). The vegetation composition variations rise via a variety of procedure sensuing the disappearance of the diversity of plant species such as communities change from native desired plant species to monospecific positions of the invasive plant species (Pérez-Ramos et al., 2019; Haq et al., 2021c). Invasive species have broad consequences in affecting potential management to decrease the effects of climate changes (Kraft et al., 2015).

Implications for forest management and policy

According to our findings, 35% of plant species were deemed to be alien, indicating that a large number of non-native species

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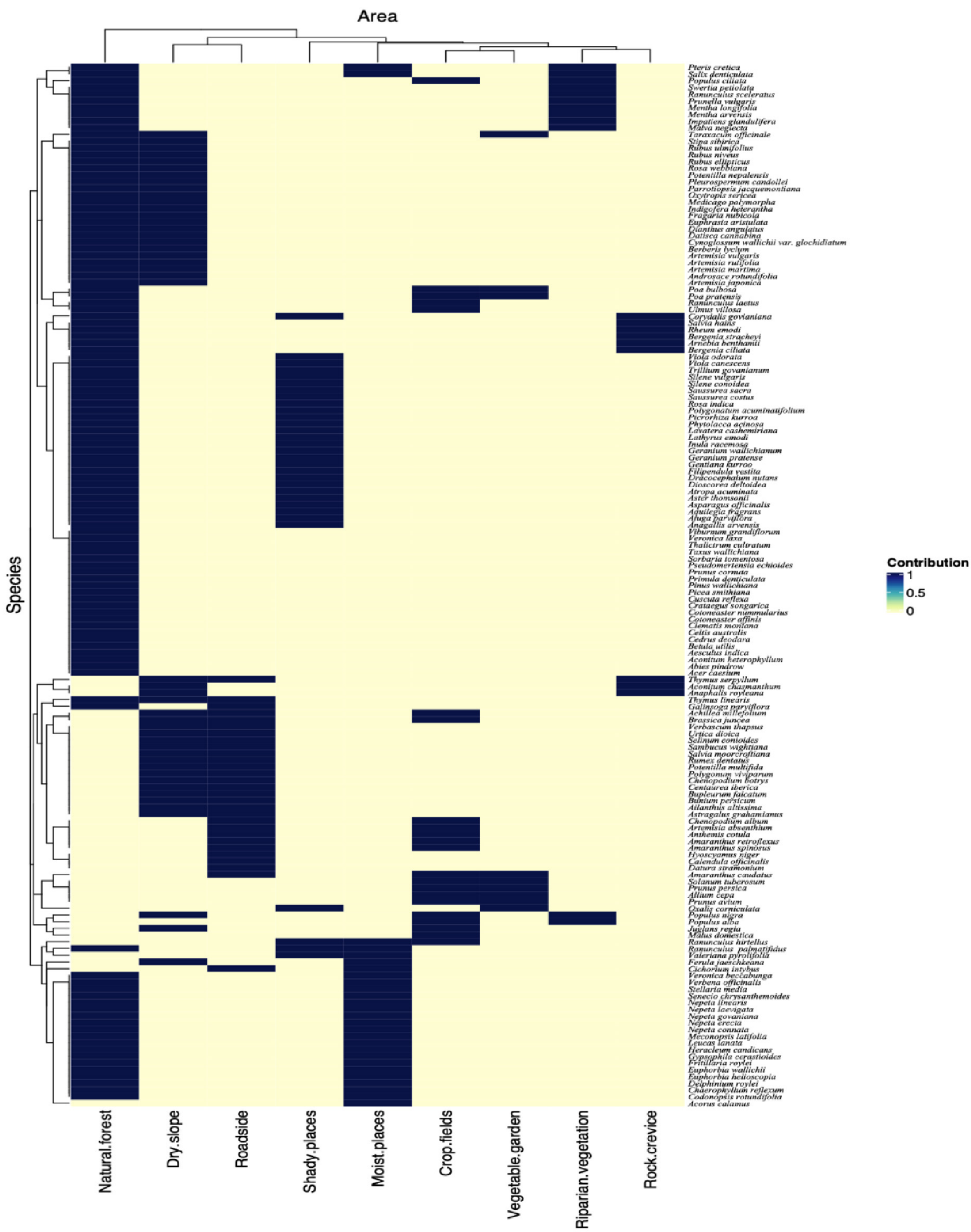

FIGURE 5
Heat map based on Sørensen's (1948) similarity index of plant species in Gurez valley, Kashmir Himalaya, India.

have spread to the inaccessible and isolated Himalaya region. We discovered a high percentage of exotic species (such as *Aesculus indica, Ailanthus altissima, Sambucus wightiana, Anthemis cotula, Amaranthus caudatus, Centaurea iberica,* and *Datura stramonium*) in disturbed forest habitats such as roadsides, and we propose that tunnels, rather than roads, are the best opinions of connectivity in fragile mountain ecosystems. The elements that threaten biodiversity must be minimized in order to keep ecosystems operating and their members intact. Regulations that limit alien species like *Anthemis cotula, Artemisia absinthium, Bupleurum falcatum, Cuscuta reflexa, Galinsoga parviflora, and Senecio chrysanthemoides,* introductions, and boost recovery, such as modifying structure through enhanced species regeneration and planting native species (*Abies pindrow*, *Cedrus deodara*,

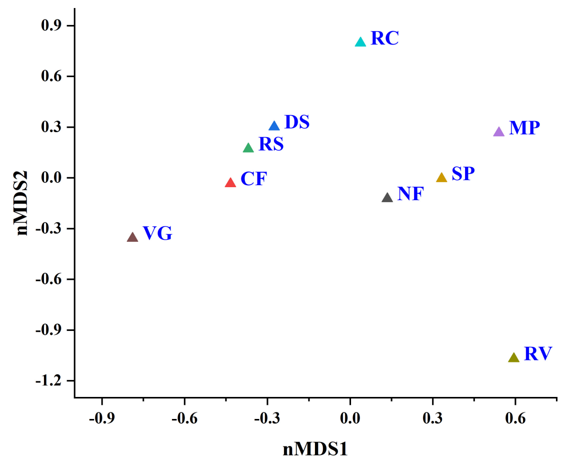

FIGURE 6
Non-Metric Multidimensional Scaling (NMDS) (plot of different habitat types in Gurez valley, Kashmir Himalaya, India. Full name of habitat is depicted in Table 1.

TABLE 2 Variation of diversity indices between habitat types in Gurez valley, Kashmir Himalaya, India.

Habitats	Richness	Shannon	Simpson
Crop fields	22	3.09	0.95
Dry slopes	46	3.83	0.98
Moist places	27	3.30	0.96
Natural forests	113	4.73	0.99
Riparian vegetation	12	2.48	0.92
Roadsides	29	3.37	0.97
Rock crevices	9	2.20	0.89
Shady places	31	3.43	0.97
Vegetable gardens	9	2.20	0.89

Pinus roxburghii, P. wallichiana, Taxus wallichiana, Betula utilis, Ulmus villosa, Trillium govanianum, Ajuga parviflora). We found that the study area serves as the natural habitat for several significant, endangered medicinal plants, including *Arnebia benthamii, Bergenia ciliata, Delphinium roylei, Gentiana kurroo, Phytolacca acinosa, Saussurea costus,* and *Trillium govanianum.* Therefore, we recommend that human intervention in natural regeneration efforts be prioritized in these habitats to increase the population of these species. Finally, existing knowledge of threats to the forest flora can be used to guide management in the face of future climate change. The forest management strategy could be organized so that potential hazards (like forest fragmentation, invasion of exotic species) are addressed before they become a problem. Furthermore, the majority of species recovery initiatives should focus on managing forest restoration in human modified habitats through by planting and reseeding native species like, *Ulmus villosa, Betula utilis, Aconitum heterophyllum, Trillium govanianum, Fritillaria roylei, Arnebia benthamii,* to lessen susceptibility to future threats in the landscape.

Conclusion

The identification of areas with a high value for biodiversity and the prioritization of these areas for conservation are crucial for preserving biodiversity. The present investigation described qualitative vegetation characteristics in a remote region of the Kashmir Himalaya. The dominance of few families, especially the Asteraceae, is a result of actual and potential dominating invaders in zones with significant disturbance. Therophytes emerged to be the primary form of life in the research area. The presence of a large fraction of therophytes indicates major anthropogenic disruptions. The study examined how environmental factors affect plant communities and placed special emphasis on the idea of habitat filtration as it relates to plant species' abiotic tolerance. Furthermore, by examining species features from a functional groups standpoint, it may be possible to predict an ecosystem functionality more accurately. The study's findings suggest that decision-makers and planners should place a greater emphasis on ecologically sustainable development in forest landscapes, considering species composition and the preservation of ecosystem function. Similar approaches should undoubtedly ensure that development activities do not contribute to biodiversity loss in fragile ecosystems.

Data availability statement

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

Author contributions

SH, FL, and AK collected the data. SH and MW analyzed and interpreted the data and results. SH wrote initial draft of the manuscript. SH, RB, EM, HE, and FL revised the manuscript. All authors read and approved the final manuscript.

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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.

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