Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/4n44ex15

UNCOVERING THE EFFECTS OF GEOGRAPHICAL FACTORS ON VEGETATION DISTRIBUTION IN DISTRICT GUJRAT, PUNJAB, PAKISTAN

Syeda Saba Tassadduq[1*], Shamim Akhtar[2]

[1*]Department of Botany, University of Gujrat, Hafiz Hayat Campus Gujrat, Punjab Pakistan
[2]Department of Botany, Rawalpindi Women University 6th Road, Satellite Town Rawalpindi Pakistan

***Corresponding Author:** Syeda Saba Tassadduq
*(18036106-002@uog.edu.pk)

Abstract
Vegetation distribution in any region is directly related to biotic and abiotic environmental factors. Present study aimed at recording the diversity patterns, richness and distribution of wild vegetation in relation to ecological gradients in the district Gujrat, Punjab, Pakistan during 2020 to 2022. For this, a randomized sample technique was applied across the district of Gujrat through GIS to record data on wild flora and linked it with environmental factors After evaluation of the IVI (importance value index), for each wild species along with the ecological data, the data were assessed via multivariate analysis (ordination and cluster analysis) performed by the use of R studio and Canoco software. In total, 119 plant species belonging to 36 families were identified. Reproductive phenological results showed that the maximum number of plant species reached the flowering stage during March-April (49 spp.) followed by August-September (40 spp.). The mean minimum temperature, wind speed, precipitation and soil moisture significantly differed (p-adj. <0.05), which is important for determining flowering phenological responses. To record vegetation, 90 elevational transects (grids 5×5 km^2) containing 270 sampling stations were explored by using the raster vegetation sampler method. Soil features data was calculated from 90 selected plots by soil sampling in triplicates through handheld Global Positioning System (GPS). Canonical correspondence analysis revealed significant contributions of soil features. In 1st quadrat soil pH, in 2nd quadrat EC, moisture, and calcium carbonate, in 3rd quadrat soil saturation, and in 4th quadrat N, P, K and SOM were found to have a strong influence on vegetation in various microhabitats of research district. Findings of this research depicted that dynamics in phenology, topography and soil factors influence on diversity pattern of wild flora of district Gujrat significantly. The impact of these abiotic environmental challenges might impose the enduring challenge to wild vegetation of research district highlighted the requirement for making conservation efforts.

Keywords: District Gujrat, Environmental gradients, Vegetation, Multivariate approaches, CCA

1. Introduction
Vegetation of any area describes the distinctive features of human activities in terrestrial ecosystems, variations in their activities and the process of climate change (Akram *et al.*, 2022; Vojtkó *et al.*, 2020). Vegetation studies provide valuable data for the identification and classification of different types of vegetation, plant communities, vegetation-community mapping and environmental linkages

(Parkes *et al;* 2003, Gill *et al.,* 2017). However, it also provides information about vegetation as a habitat for birds, insects and animals. There is also a necessity to illustrate different vegetation variations due to climax with time and succession. Vegetation studies are also beneficial for management purposes, biodiversity conservation, and the evaluation of environmental influences, the use of vegetation and the assessment of probable upcoming fluctuations (Molina *et al.,* 2023). It reflects the plant assembly of any certain area. Vegetation structure describes floral formation, vegetative composition, species diversity-related structure and the development of plant communities associated with species (Booth & Grime, 2003). Vegetation of any area can be accurately identified by the phenology of plants, vegetation cover, edaphology and biomass (Yang *et al.,* 2023).

Phenology relates time and biological life events such as flowering and fruiting in plants. To study ecosystems, biodiversity and its correlation with plant communities provides insight into how these components interact with each other. Fruiting phenology varies among different plant life forms, such as trees, shrubs, herbs and climbers (Bhat & Murali, 2001; Joshi & Janardanam, 2004; Ramirez & Briceno, 2011). Climatic factors such as rainfall, humidity, and temperature also have a strong impact on the fruiting phenology of all life forms, nutrient concentrations and spatial scales (Naeem & wright, 2003). The phenology of trees and shrubs has been well studied (Dahlgren *et al.,* 2007; Gariglio *et al.*, 2012; Kikim & Yadava, 2001); however, the phenology of herbs still needs to be explored (Kudo, 1992; Risberg & Granstrom, 2009).

Phyto-ecological features in term of life form and leaf size spectra highlight the indicators of existing climatic, edaphic conditions and outcome of microclimatic adaptation of vegetation (Haq *et al.,* 2022). Wild vegetation is habitually influenced at the fine-scale level by topographical and edaphological variables including latitude, longitude, altitude and soil nutrients, potentially harmful metals, soil humidity, soil texture, soil pH, erosion, and soils electrical conductivity (Jamil *et al.,* 2022; Majeed *et al.*, 2022a; Godoy *et al.,* 2009; Singh & Kushwaha, 2006). With the passage of time, the arrangement of vegetation has been rehabilitated, the socioeconomic, cultural and aesthetic ethics of natural resources have been increasingly distressed by environmental variations, and there is a need to explore the response of plants to this stressful environment (Kumar & Kumar, 2008; Kremen, 1992). Limited literature is available to record and analyze the plant communities and the sites associated with the plant communities (Li *et al.*, 2020). Hence, it is necessary to examine various vegetation parameters, particularly in floristically rich unexplored areas, to document and conserve biodiversity (Woodcock & Pywell, 2010).

District Gujrat lies between two rivers (Jhelum and Chenab) in Punjab, Pakistan. It is a floristically rich region and contains a diverse range of resourceful biomes with varying climates, maximum seasonality and a wide variety of plant communities. Species of different eco-zones in research area remain unexplored because of their isolation, shifting topography and unclear geopolitical situation (Tassadduq *et al.,* 2022). Despite the fact that Gujrat is home to a wide variety of plant life in various habitats, the area was neglected by ecologists and researchers. Research district lacks scientific records on the phenological patterns and environmental gradients impact on wild plant species. This is the pioneering study of wild native flora of district Gujrat by using multivariate approaches (Tassadduq et al., 2022) and it uncovers the impact of environmental factors on vegetation distribution in district Gujrat. The correlation between plant species and environmental factors is well known for a long time; however, recent technology along with geographical information systems and multivariate tools, has provided quantitative data and continuous geographical information on a wide range of environmental characteristics. It will also help researchers, botanists, foresters, range land managers and Phyto sociologists to effectively conserve plant species and correlate their findings in future studies.

2. Materials and Methods

2.1 Study area

District Gujrat is situated in northeastern Punjab. It lies at 32°34′23.7″ N latitude and 74°4′57.6″ E longitude. The district is established at the confluence of the Chenab River to the southeast and the Jhelum River to the northwest. It shares a border with the Azad Jammu and Kashmir territories to the northeast, the Jhelum River to the northwest, the Chenab River to the east and south, and the Mandi Bahauddin district to the west (Figure 1). The 3,192 kilometers (km^2) of land area of Gujrat are home to more than 2.4 million people. The district has a mild climate. Due to the proximity of the Azad Kashmir and Jammu Mountain ranges, the hottest days of the summer reached 45°C, with brief periods of extreme heat. The lowest temperature recorded throughout the winter was less than 2°C. The average annual rainfall measured was 778 mm. Groundwater is the main source for households and agricultural facilities. Soil surveys conducted in the area revealed an alluvial complex composed of fine to moderate particles of clay, silt, and sand (Tassauddhuq *et al.,* 2022). Agricultural and industrial use of land has increased over the years. There is an unsupervised land use system that is compressing the vegetation. The significant compression in the area of vegetation cover occurred from 85.1% in 1985 to 79.6% by 2015 (Mehdi *et al*., 2021).

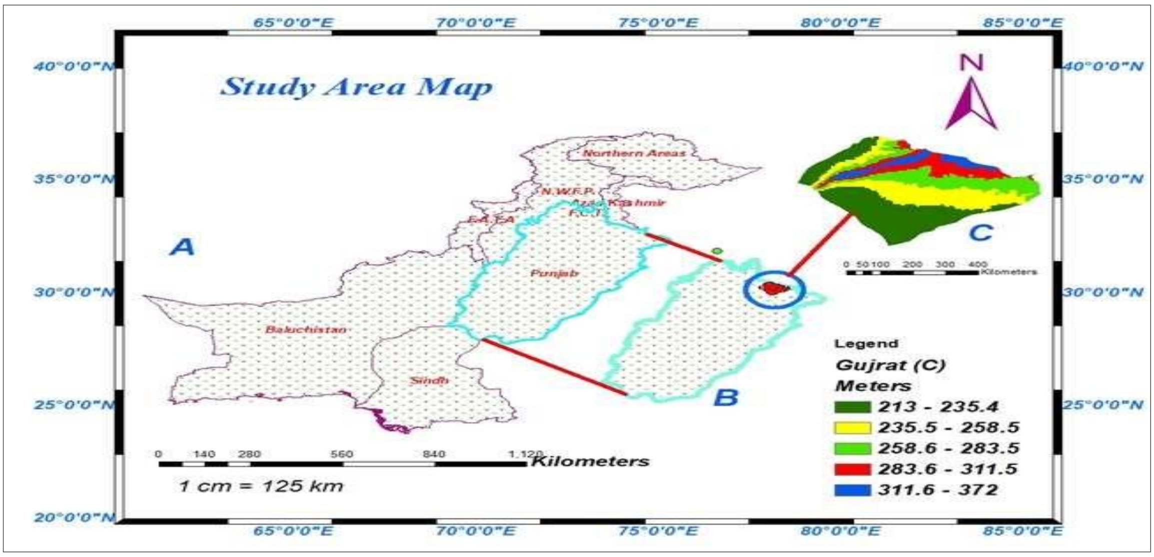

Figure 1: Map of district Gujrat for wild flora and soil samples collection

2.2 Vegetation data collection

Data on plant species was collected using a random selection flora sample method, which included the use of quadrats. Sites for new communities and quadrates were chosen using a stratified random sample plot approach to gather data on vegetation in the district Gujrat during 2020 to 2022. A total of 90 grids and / altitudinal transects (equally separated by 5 km^2 of 200 m^2 from road distance) and latitudinal gradients were established across the whole research area. The 90 transects bring forth 270 randomly sampled distinct points on the basis of heterogeneity of vegetation, physiography and morphology of habitats from which the ecological data was collected. The plant species modest range method was used for each site, and triplet quadrats (for each tree, shrub and herb layer) with different dimensions were established (the quadrat size for each layer of trees was 10×10 m2, the shrub size was 5×5 m^2, and the herb size was 1×1 m^2). The average frequency, cover, and density of all plant species were measured using relevant formulas (Hussain, 1989) and translated to comparative values to create an importance value index (IVI). The Shannon and Simpson diversity indices for vegetation were also noted, as was the maturity of the vegetation community by using PAST (Tassaduq et al., 2022). MODIS-derived time-series vegetation indices were used to study the phenological patterns of vegetation cover in the district of Gujrat, Punjab, Pakistan.

Density

Density of vegetation was calculated by formula presented as (Hussain, 1989)

$$D = \frac{No.of\ each\ species}{Total\ no.of\ quadrats}$$

Frequency (F)

Frequency was calculated by formula as (Hussain, 1989)

$$F = \frac{No. of\ times\ in\ which\ a\ species\ \ found\ in\ a\ quadrats}{Total\ no. of\ quadrats} \times 100$$

Cover

Cover was recorded as the area covered with above ground mass of every species (Hussain, 1989).

$$A = \frac{C2}{12.56\ \times Size\ of\ quadrat\ \times\ Total\ no. of\ quadrate} \times 100$$

2.3 Measurement of geographic features

The location, as well as the elevation, of the area being surveyed were recorded using GPS. The GPS and altitude were utilized to determine the exact location of each sample. A clinometer was used to record the angle of the slope, while a compass was used to determine the direction. Considering the most current indicators of soil damage, such as gullies, water bodies, and a lack of plant cover, we may categorize the degree of soil erosion on a scale from 0 to 4 (low, medium, high, and severe) (Shaheen *et al*., 2012).

2.4 Life form and Leaf size spectra

Plants were categorized into the following life forms (therophytes, mesophytes, microphytes, nanophnerophytes, phnerophytes, chameophytes, and hemicryptophytes) and leaf size spectral types: by the use of diagram of Raunkiaer (1934):

i. *L: leaf size (25 mm^2)*
ii. N: *size of leaf (225 mm^2)*
iii. *Microphyl* (*Mi*): *size of leaf (2025 mm^2)*
iv. *Mesophyl* (*Me*): *size of leaf (18225 mm^2)*
v. *Megaphyl* (*Ma*): *size of leaf (164025 mm^2)*

2.5 Soil sampling and measurement of edaphic variables

To gather the location data for 90 selected plots, a handheld Global Positioning System (GPS) system was used for collection of soil samples in triplicates. The spatial distribution of plant communities is influenced by edaphic factors (Khan et al., 2017). Soil samples were collected from each sampling site from a depth of 9 to 12 cm and placed in polythene bags. The dust was first finely mixed and then air-dried. The soil samples were sieved to remove particles larger than 2 mm in size. The soil samples were analyzed to determine the soil moisture, soil pH, electrical conductivity, organic matter, and the levels of macronutrients such as $CaCO_3$, N, P, and K and the soil saturation. The electrical conductivity and pH were measured with a conductivity meter and a pH meter, respectively. The total nitrogen (N) content was determined following the Kjeldahl method (Lü et al., 2019), and the Walkley–Black method was used to measure the organic matter (OM) content (Rasheed et al., 2022). The levels of phosphorus (P) and potassium (K) were calculated, and $CaCO_3$ was assessed using the acid–base neutralization method. The moisture content of the soil samples was measured using a ScalTec moisture analyzer, which was set to 110°C (Abdullah et al., 2013). The following formula was used to calculate the percentage of saturation:

$$\%\ moisture = \frac{Wet\ soil - Dry\ soil}{Dry\ soil} \times\ 100$$

2.6 Data analysis

Species of plants and ecological data were recorded in excel workbooks for easy administration and linked to multivariate analytic software such as PC-ORD (McCune and Mefford, 2005), the R statistical package and CANOCO (Ter Braak & Šmilauer, 2012). Although vegetation groups are clearly distinguished based on shared structural features, biologically significant clusters were developed using hclust package in R studio (McCune & Grace, 2002). This was performed by counting the quantity and significance of average p values at each cluster level. The best quality score was assigned to the number of plant communities with the highest number of significant p values ($p<0.05$) or the lowest average p values. Species were classified into several plant groups using indicator species analysis. Hierarchical cluster analyses (with distance techniques including the link method, e.g., Ward and Euclidean methods) were used to analyze the relationships between the various plant communities. The degree of similarity between each floral group and its diagnostic and occasional plant members was determined. Detrended correspondence analysis verified the vegetation categorization findings (DCA). Canonical correspondence analysis (CCA) was used to further explore the roles of environmental factors in the observed shifts in the wild vegetation data. This allowed us to examine the relationship between native vegetation structure and environmental conditions (Majeed et al., 2022b).

3. Results

3.1 Family–Species relationships of vegetation in the study area

A total of 119 species were recorded from 36 different families. Compositae and Leguminosaea were observed as prominent families with 14 species each. There were 13 and 12 Amaranthaceae and Euphorbiaceae species, respectively. There were 8 species of Solanaceae and 5 species each of Apocynaceae and Convolvulaceae. There were 4 species of Brassicaceae. There are 3 families of Boraginaceae, Malvaceae, Nyctaginaceae, and Verbenaceae in the study area. Aizoaceae, Caryophyllaceae, Cyperaceae, Geraniaceae, Moraceae, Rhamnaceae, Tamaricaceae, and Zygophyllaceae had 2 species each. All other remaining families contributed 1 species each (Figure 2).

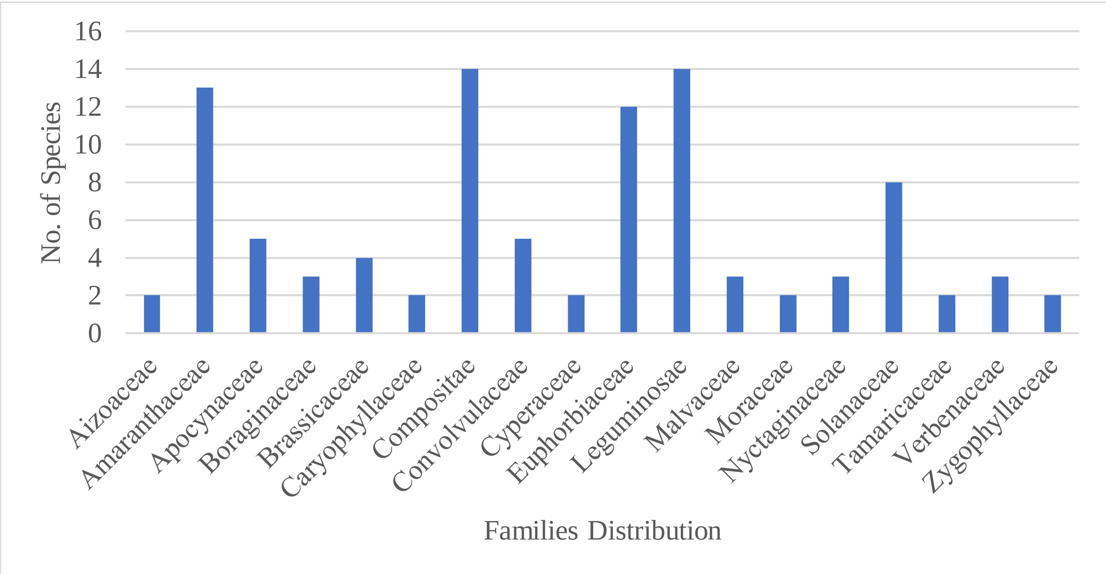

Figure 2: Family distribution of vegetation of district Gujrat

3.2 Ecological features of vegetation

The life forms and leaf size spectra of the plant species were observed and analyzed. The leading life form was Therophytes, with 51 species (43%). Other life forms observed were Chaemophytes with 24 species (20%), Nanophnerophytes with 21 species (18%), Megaphnerophytes with 18 species (15%), Lianas with 4 species (3%), and Hemicryptophytes with 1 species (1%) (Figure 3). With respect to the leaf size spectra, nanophylls were the most dominant leaf size spectral class, with 47 species (39%), microphylls with 35 species (29%), leptophylls with 19 species (16%), mesophylls with 14 species (12%), megaphylls with 2 species (2%), and aphyllous with 2 species (2%) (Figure 4). The dominant life cycle was perennial, with 64 species (54%), followed by annual, with 54 species (45%). Only one (1%) species exhibited a Biennial life cycle (Figure 5). The spring was the dominant flowering season, with 49 species (41%), followed by the monsoon season, with 40 species (34%) (Figure 6).

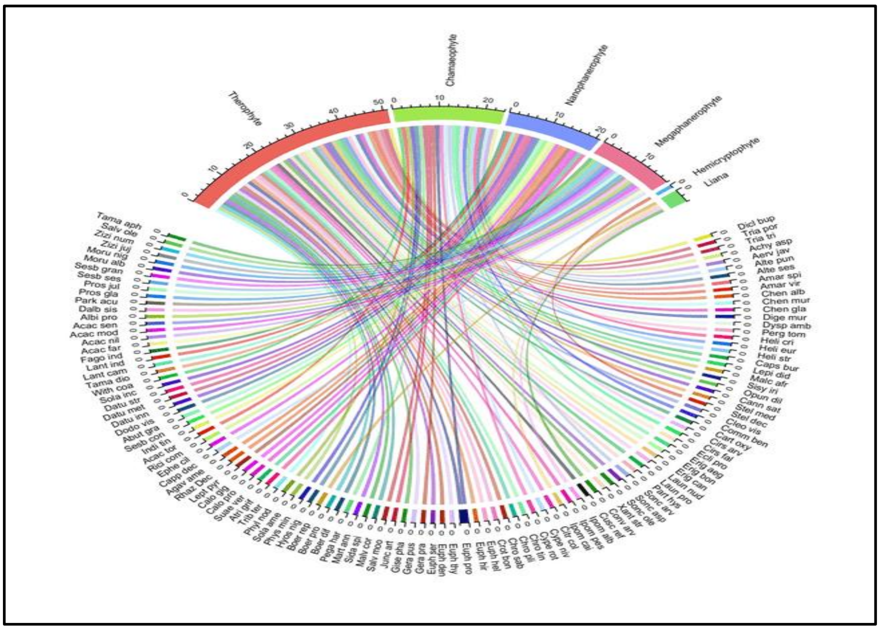

Figure 3: Chord diagram of life form of vegetation in District Gujrat

Figure 4: Chord diagram of leaf size spectra of vegetation in District Gujrat

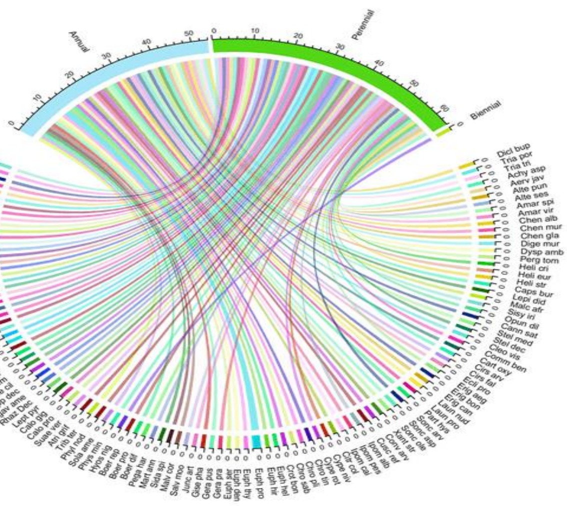

Figure 5: Chord diagram of life cycle of vegetation in District Gujrat

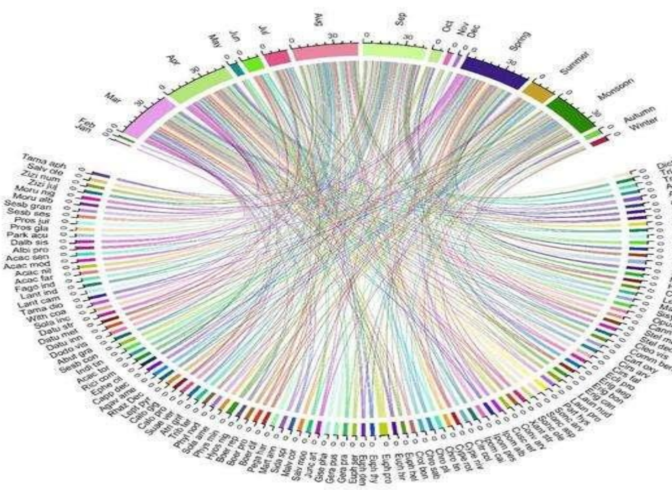

Figure 6: Chord diagram of seasonal phenology of vegetation in District Gujrat

3.3 Vegetation distribution pattern determined by Detrended Correspondence Analysis (DCA)

The ordination plot was plotted through CANOCO. The spatial distribution of vegetation and the effects of environmental variables on species diversity and composition were evaluated via DCA. The cumulative variance in the species data was 19.3% and 31.5% on the first two axes, respectively (Table 1). The first DCA axis reveals the elevation gradient between the native species and habitat types.

The first axis of the DCA showed the complex altitudinal, latitudinal, and environmental gradients among the vegetation and habitats. The sites and species present in mesic habitats at lower altitudes and latitudes are clustered on the left side, while the sites and species present in xeric habitats at higher altitudes and latitudes are clustered on the right side. The sites and species present in the center include vegetation at lower-middle altitudes and latitudes (Table 1).

Table 1. Description of the first four axes of the DCA for the vegetation data

Summary					
Axes:	1	2	3	4	Total inertia
Eigenvalues:	0.218	0.136	0.046	0.026	1.126
Lengths of gradient:	1.585	1.599	1.457	1.143	
Cumulative percentage variance of species data:					
	19.3	31.5	35.5	37.8	
Sum of all eigenvalues:	1.126				

3.4 Loading plot (PCA) among different microhabitats

Roadside, graveyard, forest, riverine landscapes, sandy land, scrub land and dry land were present on 1st quadrant of loading plot having resembling plant species with different richness whereas other habitats including shady places, canal banks, and wet land also share resembling species on 2nd axis. Grassland was a sole type of natural microhabitat compared with other microhabitats on the basis of vegetation distribution (Figure 7).

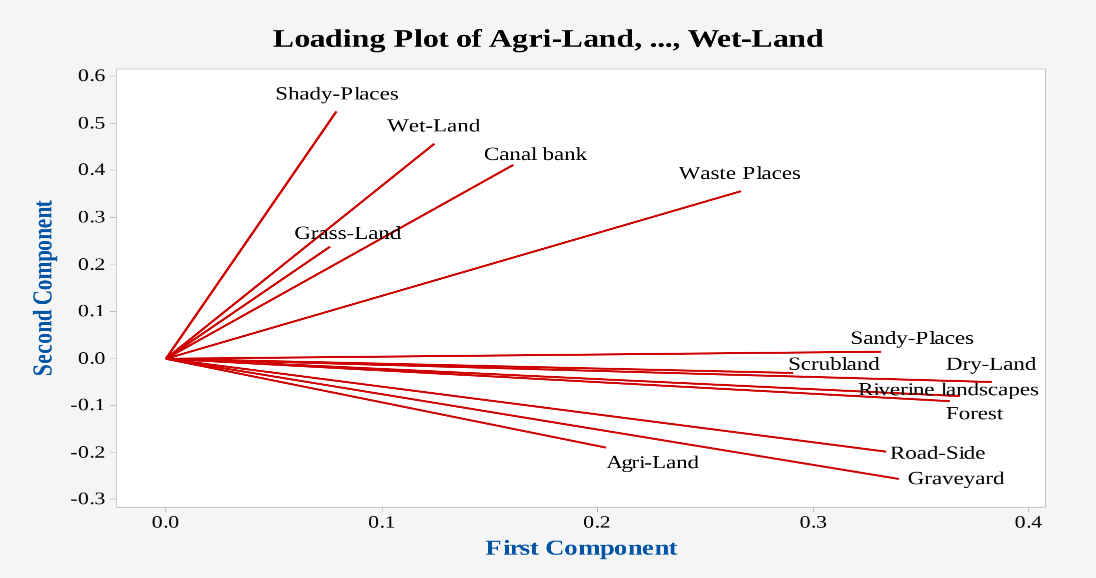

Figure 7: PCA plot representing the native species distribution in various microhabitats

3.5 Vegetation link to geographical variables

The CCA (biplot) showed the significant impact of various edaphic variables on the vegetation of the study area (Figure 8). These edaphic variables include soil pH, EC, SOM, saturation, moisture, N, P, K, and $CaCO_3$ (Table 2 and Table 3).

Table 2. Soil characteristic values with respect to their microhabitat

	Soil Parameters								
Microhabitats	Moisture	Soil pH	Saturation	EC	N	P	K	O.M	CaCo3
Agri-Land	0.18	0.08	0.28	0.0091	0.051	4.7	156	0.0078	0.0159
Dry-Land	0.17	0.0769	0.32	0.0169	0.053	4	156	0.0064	0.0259
Forest	0.17	0.0789	0.38	0.0159	0.077	2.9	160	0.0069	0.0249
Grass-Land	0.18	0.0791	0.34	0.0201	0.054	4.8	166	0.0059	0.0213
Graveyard	0.15	0.0788	0.32	0.0169	0.053	3.4	154	0.0064	0.0259
Riverine landscapes	0.14	0.0765	0.32	0.0139	0.051	5.1	206	0.0078	0.0311
Canal bank	0.25	0.0798	0.24	0.0206	0.033	1.2	120	0.0041	0.0266
Road-Side	0.15	0.0762	0.34	0.017	0.053	5	166	0.007	0.019
Sandy-Places	0.4	0.0768	0.34	0.0098	0.057	0.52	172	0.0078	0.0141
Scrubland	0.9	0.0756	0.28	0.0065	0.043	2.1	116	0.0046	0.023
Shady-Places	0.14	0.0805	0.3	0.0191	0.051	5.4	154	0.0062	0.028
Waste Places	0.41	0.0808	0.33	0.017	0.044	5.2	80	0.0055	46
Wet-Land	0.35	0.082	0.4	0.0315	0.055	4.7	166	0.0062	0.0282

Table 3. Description of the first four axis of the CCA for the vegetation data (using the matrix species with their Importance Value Index (IVI)

Summary					
Axes	1	2	3	4	Total inertia
Eigenvalues:	0.193	0.172	0.118	0.089	1.125
Species-environment correlations:	0.984	0.959	0.957	0.961	
Cumulative percentage variance of species data:					
	17.2	32.5	43.0	50.9	
Cumulative percentage variance of species-environment relation:					
	24.9	47.1	62.4	73.9	
Sum of all eigenvalues:	1.125				
Sum of all canonical eigenvalues:	0.775				

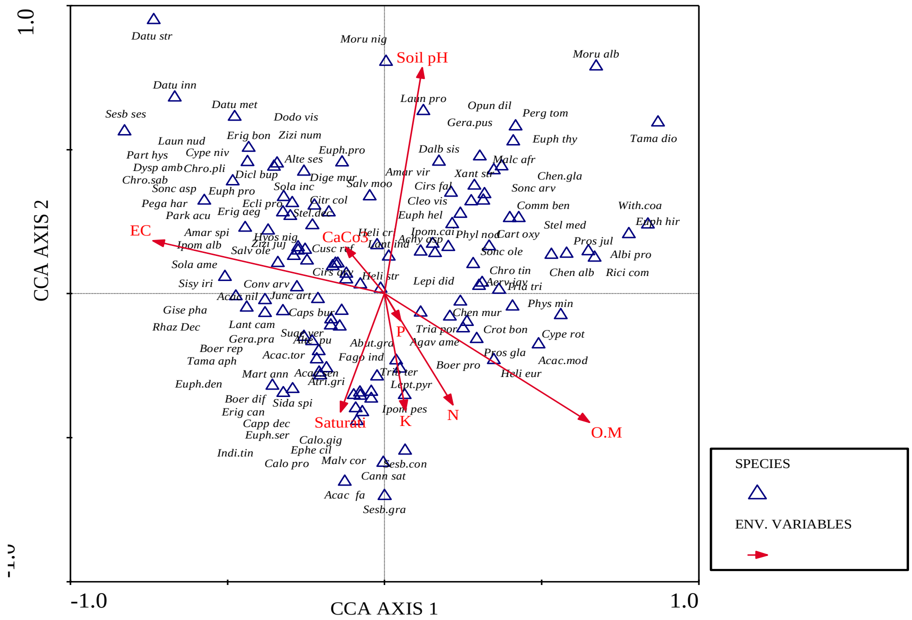

Figure 8: CCA biplot representing the species distribution correlation with edaphic factors

The CCA triplot represented a collective interrelation of species distribution, environmental variables, and microhabitats. Microhabitats include wet lands, agricultural lands, canal banks, forests, roadside areas, dry lands, graveyards, scrublands, grasslands, shady places, sandy places, and riverine landscapes. Soil pH was the main influencing factor according to the first quadrat of the CCA. The second quadrat showed a strong influence of EC, moisture, and $CaCO_3$. The third quadrat represents the impact of soil saturation. The fourth quadrat confirmed the strong effect of N, P, K, and SOM on the vegetation of the study area. Similarly, graveyards, scrublands, agricultural lands, and shady places showed a significantly strong correlation with vegetation in the first quadrat. In the second type of quadrat waste, grassland, wet land and canal banks are the main microhabitats affecting vegetation. Dry-land, roadside, and riverine landscapes are linked to vegetation in the third quadrat. The fourth quadrat shows the association of vegetation with forest and sandy places. Variation was recorded in ascending order (Figure 9 and Table 4).

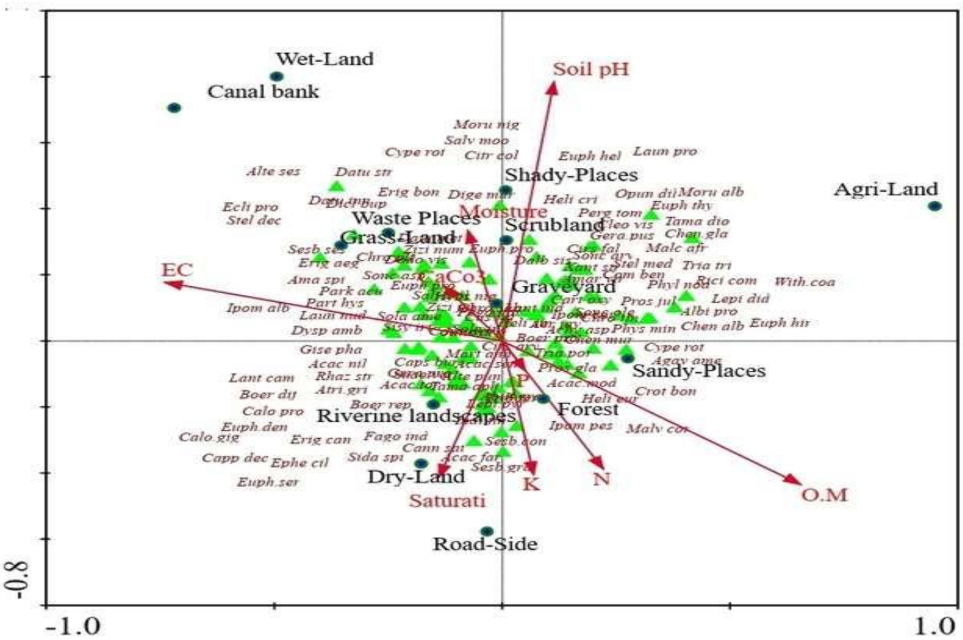

Figure 9: CCA triplot representing the species distribution correlation with edaphic factors and microhabitats

Table 4. Description of the first four axis of the CCA for the vegetation data (using the matrix species with their Importance Value Index (IVI)

Summary					
Axes:	1	2	3	4	Total inertia
Eigenvalues:	0.193	0.17	0.119	0.096	1.125
Species-environment correlations:					
	0.984	0.960	0.957	0.984	
Cumulative percentage variance of species data:					
	17.2	32.5	43.1	51.6	
Cumulative percentage variance of species-environment relation:					
	22.3	42.4	56.1	67.2	
Sum of all eigenvalues:		1.125			
Sum of all canonical eigenvalues:			0.864		

3.6 Diversity indices of plant Species

The diversity indices of vegetation in the study area revealed differences among the various microhabitats. The maximum dominance was recorded in canal banks and wetlands. Forests and shady places showed the highest Simpson and Shannon indices (Table 5). The highest richness was present in forest and riverine landscapes, while sandy places showed the greatest evenness. Forests with minimum dominance exhibited vulnerability (Figure 10,11,12,13 and 14 and Table 5).

Figure 10: Shannon index for wild flora in dynamic habitats of district Gujrat

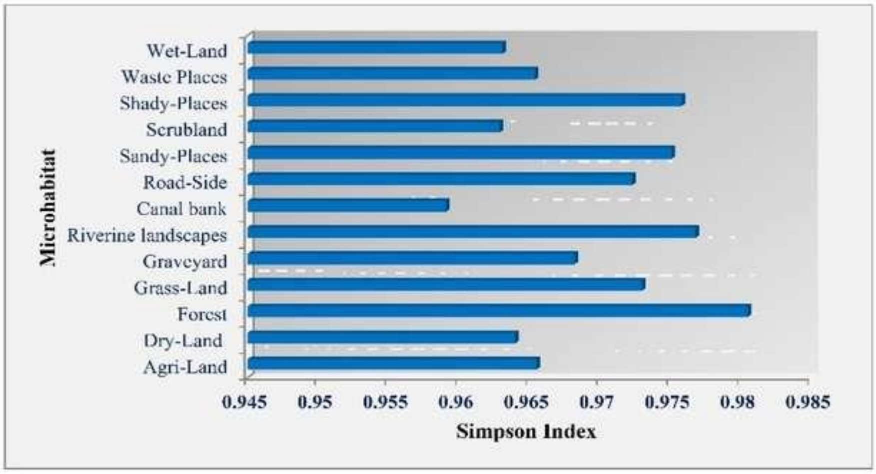

Figure 11: Simpson index for wild flora in dynamic habitats of district Gujrat

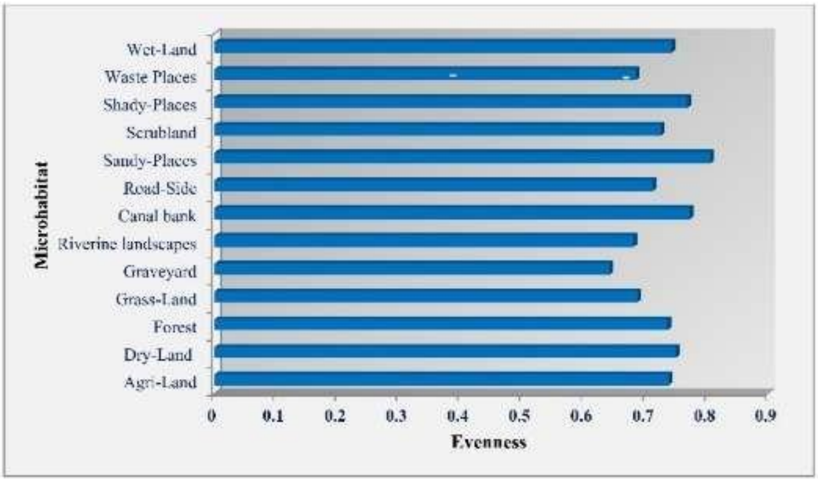

Figure 12: Evenness for wild flora in dynamic habitats of district Gujrat

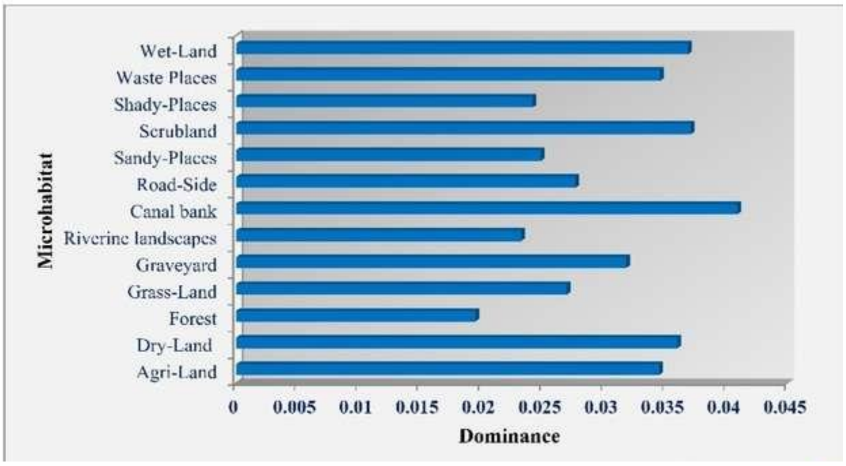

Figure 13: Dominance for wild flora in dynamic habitats of district Gujrat

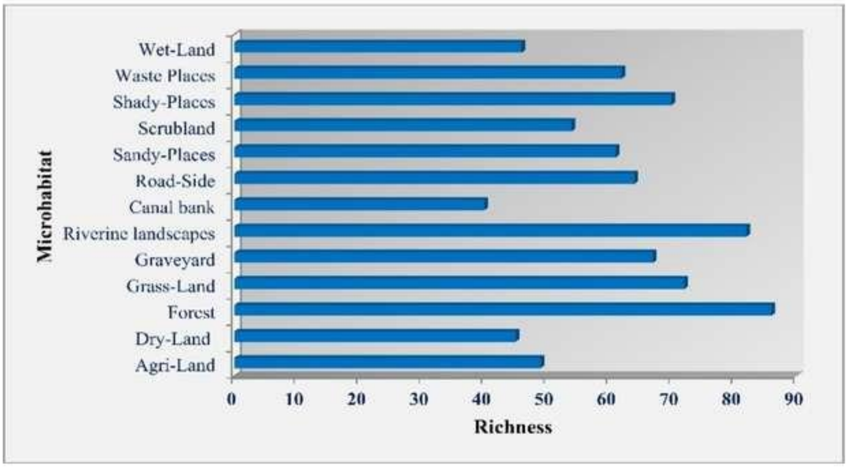

Figure 14: Richness for wild flora in dynamic habitats of district Gujrat

4. Discussion

The diversity, composition, and spread of wild species are heavily impacted by environmental conditions. It is crucial to understand the correlation of plant communities and environmental gradients. Current study was planned to Vegetation covers large area in the district Gujrat, so the current research is the most comprehensive analysis of the relationship between plant species and environmental variables. In the study are 119 wild plant species were recorded. Compositae

(Asteraceae) and Leguminosae were observed as prominent families having 14 species of each followed by Amaranthaceae with 13 and Euphorbiaceae with 12 species, respectively.

Likewise, 110 species from 51 families and 98 genera were reported in the Nikyal Valley of Jammu and Kashmir, Pakistan by Amjad et al, (2016). The leading families were Poaceae, Asteraceae, and Lamiaceae with 18, 10, and 8 species respectively. Similar findings were found for 96 plants from 34 families in the district of Sheikhupura, Punjab, Pakistan. They found that the Poaceae was the most abundant family, with 16 species, followed by the Leguminosae with 15 spp. The species of these families not only aid in the prevention and treatment of a wide range of illnesses but also play an important role in the care of cattle (McCune & Grace, 2002, Amjad *et al.*, 2016, Majeed *et al.*, 2021). Due to their extensive ecological range and adaptability, Leguminosae and Compositae have established themselves as the dominant plant families (Ibrahim *et al.*, 2019).

The leading life form in our research area was therophytes, with 51 apecies accounted for 44% of total species and leading leaf size spectral class was that of nanophylls, accounting for 39% of the total species. Short vegetative growing season of annual species, high adaptation in xeric climatic conditions and extreme amplitude of ecology are dominant ecological features of wild vegetation of research district. Haq *et al.,* (2022) also found the therophytes as leading life form during his research work in forest of Shawilks mountain range from western Himalayas.

Leading flowering season was recorded in term of spring season with 40% of species and monsoon season with 34% of species signified that the moderate temperature favors the vegetation of research district. Similar findings were evaluated by Khan *et al.,* (2018) in western Himalayan flora of Muzaffarabad district, AJK, Pakistan. Sudden rise or decrease in temperature leads to decline of vegetation in the research district.

The species were influenced by a number edaphic factors including organic material, soil type, calcium carbonate, electrical conductivity (EC), nitrogen, and pH. The complex relationships between soil variables and the physiological tactics adopted by bioindicator plants was evaluated using multivariate methods. CCA (canonical correspondence analysis) has been utilized to assess the bonding between soil factors and wild plants in many studies (Jabeen &Ahmad, 2009). Diverse plant species in the Gujrat district could be linked to the soil's slightly acidic pH. According to the CCA ecological gradient procedures for forest habitat species, the first axes was predominantly related to the soil pH while the second axes was primarily connected to soil moisture, calcium carbonate and EC. Microhabitats including scrubland, shady places, graveyards, agricultural lands and shady places recorded acidic pH for vegetation diversity in research district whereas the forest land in the fourth quadrant of CCA confirmed the presence and impact N, P, K, and SOM on vegetation. Forests and shady places showed maximum diversity and richness of species highlighted favorable environment of research district. To correlate edaphic variables with vegetation, research has been conducted in mount Eelum District Swat, Pakistan (Khan *et al.,* 2017). District kasur, Pakistan was also explored to find correlations between vegetation and edaphic factors (Waheed *et al.,* 2022). Recording variations in species richness over dynamic environmental variables can support in investigating the value of the different predictors (Khan *et al.*, 2022, Majeed *et al.*, 2022b).

Vegetation coverage, species richness, and floristic diversity were all found to be very high in this area. The region's adaptable topography, ecological diversity, and nutrient-dense soil make it one of its own kind. The results demonstrated that organic carbon, electrical conductivity, and phosphorus in the soil influenced the composition, variety, and distribution of the wild flora.

Research outcomes of the current research depicted those dynamics in phenology, ecology and soil factors influenced greatly on diversity pattern of wild flora in district Gujrat significantly. The research will be useful to botanists, foresters, conservationists and ecologists to develop the bioresources and socioeconomic circumstances of the public and to make conservation polices to conserve or restore the threatened vegetation of research district.

5. Conclusion

A total of 119 wild plant species from 36 families were recorded from distrcit Gujrat, Punjab, Pakistan, signifying the influence of edaphic and ecological variations resulting in diversified vegetation in the area. Compositae and Leguminosaea were observed as prominent families with 14 species each, wheras Aizoaceae, Caryophyllaceae, Cyperaceae, Geraniaceae, Moraceae, Rhamnaceae, Tamaricaceae, and Zygophyllaceae had 2 species each. All other remaining families contributed 1 species each. The leading form of therophytes and nanophyll species in term of life form and leaf size spectra were recorded in the research district Gujrat. The dominant life cycle was perennial with 54% of the species having long life span in the research area environment, followed by annual with 45% of the species. The spring was the dominant flowering season with 41% of the species, followed by the monsoon season with 40 species (34%). The findings showed the significant impact of soil factors on vegetation patterns. The species diversity and species richness were interlinked by spatial scale. Leading phenological period in spring and monsoon season highlighted the moderate temperature favors the vegetation of research district. Sudden rise or decrease in temperature leads to decline of vegetation. Multivariate statistical analysis by using Canoco and R packages revealed a link between leading environmental gradients (pH, N, K, calcium carbonate, electrical conductivity) and vegetation of research district. This study may aid in predicting ecosystem functions that can further help to improve ecological services. It will also help researchers, botanists, foresters, range land managers and phytosociologists to effectively correlate their findings in future ecological and vegetational studies.

Data Availability Statement: Species occurrence data is available on request to first author as based on PhD research work.

Acknowledgments

Author Contributions: Syeda Saba Tassadduq collected the data, analyzed the data, field work, and drafted the manuscript. Dr. Shamim Akhtar has thoroughly reviewed the manuscript, evaluated, and corrected it to her best at her mistakes.

Authors have no **Conflict of Interest**.

References

1. Amjad, M.S., M. Arshad, H. M. Sadaf, F. Akrim, and A. Arshad. (2016). Floristic composition, biological spectrum and conservation status of the vegetation in Nikyal valley, Azad Jammu and Kashmir. Asian Pac. J. Trop. Dis**.** 6(1): 63-69. https://doi.org/10.1016/S2222-1808(15)60986-0
2. Bhat, D.M. and K. S. Murali. (2001) Phenology of understory species of tropical moist forest of Western Ghats region of Uttara Kannada district in South India. Curr. Sci. 81: 799–805.
3. Booth, R.E. and J.P. Grime. (2003). Effects of genetic impoverishment on plant community diversity. J. Ecol. 91(5): 721-730. https://doi.org/10.1046/j.1365-2745.2003.00804.x
4. Dahlgren, J.P., H.V Zeipel, and N. J. Ehrlé. (2007). Variation in vegetative and flowering phenology in a forest herb caused by environ-mental heterogeneity. Am.J. Bot. 94(9): 1570–1576. https://doi.org/10.3732/ajb.94.9.1570
5. Gariglio, N., Weber, M., Casto, D., Micheloud, N. (2012) Influence of the environmental conditions, the variety and different cultural practices on the phenology of peach in the central area of Santa Fe (Argentina). Intech Publication, 217–240.
6. Gill, T., K. Johansen, S. Phinn, R. Trevithick, P. Scarth and J. Armston. (2017) A method for mapping Australian woody vegetation cover by linking continental-scale field data and long-term Landsat time series. Int. J. Remote Sens. 38(3): 679-705. https://doi.org/10.1080/01431161.2016.1266112
7. Godoy, O., P. Castro-Díez, F. Valladares and M. Costa-Tenorio. (2009). Different flowering phenology of alien invasive species in Spain: evidence for the use of an empty temporal niche. Plant Biol. 1: 1–9. https://doi.org/10.1111/j.1438-8677.2008.00185.x

8. Hussain, F. (1989). Field and laboratory manual of plant ecology. National Academy of Higher Education, University Grants Commission.
9. Hussain, S., L. Lu, M. Mubeen, W. Nasim, S. Karuppannan, S. Fahad and M. Aslam. (2022). Spatiotemporal variation in land use land cover in the response to local climate change using multispectral remote sensing data. Land, 11(5): 595-614.
10. Hussain, T. (2009). A floristic description of flora and ethnobotany of Samahni Valley (AJK), Pakistan. Ethnobotanical Leaflets, (7): 873-99. https://doi.org/10.3390/land11050595
11. Ibrahim, M., H. Shaheen and Z. Ullah. (2019). Spatial patterns and diversity of the alpine flora of Deosai plateau, western Himalayas. Pak. J. Bot. 51(1): 205-212. http://dx.doi.org/10.30848/PJB2019-1(39)
12. Jamil, M. D., Waheed, M., Akhtar, S., Bangash, N., Chaudhari, S. K., Majeed, M., ... & Jones, D. A. (2022). Invasive plants diversity, ecological status, and distribution pattern in relation to edaphic factors in different habitat types of district Mandi Bahauddin, Punjab, Pakistan. Sustainability, 14(20), 13312. https://doi.org/10.3390/su142013312
13. Joshi, V.C. and M.K. Janardanam. (2004). The diversity of life-formtype, habitat preference and phenology of the endemics in the Goaregion of the Western Ghats, India. J. Biogeogr. 31(8) :1227–1238. https://doi.org/10.1111/j.1365-2699.2004.01067.x
14. Khan, A.M., Q. Li, Z. Saqib, N. Khan, T. Habib, N. Khalid, M. Majeed and A. Tariq. (2022) MaxEnt Modelling and Impact of Climate Change on Habitat Suitability Variations of Economically Important Chilgoza Pine (Pinus gerardiana Wall.) in South Asia, Forests, 13: 715-737. https://doi.org/10.3390/f13050715
15. Khan, A.M., R. Qureshi, M. Arshad and S.N. Mirza. (2018) Climatic and flowering phenological relationships of Western Himalayan flora of Muzaffarabad district, Azad Jammu and Kashmir, Pakistan, Pak. J. Bot. 50(3):1093-1112.
16. Khan, M., S.M. Khan, M. Ilyas, A.A. Alqarawi, Z. Ahmad, E.F. Abd_Allah, E. F. (2017). Plant species and communities' assessment in interaction with edaphic and topographic factors; an ecological study of the mount Eelum District Swat, Pakistan. Saudi J. Biol. Sci. 24(4): 778-86. https://doi.org/10.1016/j.sjbs.2016.11.018
17. Kikim, A. and P.S. Yadava. (2003). Phenology of tree species in subtropical forests of Manipur in northeastern India. Trop. Ecol. 42(2): 269–276.
18. Kremen, C. (1992). Assessing the indicator properties of species assemblages for natural areas monitoring. Ecol. Appl. 2(2): 203-217. https://doi.org/10.2307/1941776
19. Kudo, G. (1992) Performance and phenology of Alpine herbs along asnow melting gradient. Ecol. Res. 7:297–304. https://doi.org/10.1007/BF02347098
20. Kumar, M. and P. Kumar. (2008). Valuation of the ecosystem services: a psycho-cultural perspective. Ecological Economics, 64(4), 808-819. https://doi.org/10.1016/j.ecolecon.2007.05.008
21. Li, W., J. Yang, H. Li and C. Zhang. (2020). Effects of environmental factors on species diversity among the plant communities in the mount Lao nature reserve. Pak. J. Bot., 52(4): 1205-1213.
22. Lü, X.T., Y.Y. Hu, A.A.Wolf and X.G. Han. (2019).Species richness mediates within-species nutrient resorption: Implications for the biodiversity–productivity relationship. J. Ecol. 107(5), 2346-2352.
23. Majeed, M., K.H. Bhatti, and M.S. Amjad. (2021). Impact of climatic variations on the flowering phenology of plant species in Jhelum district, Punjab, Pakistan, Appl.Ecol.Environ. Res. 19: 3343-3376. http://dx.doi.org/10.15666/aeer/1905_33433376
24. Majeed, M., S.M. Haq, M. Waheed, H.A Sahito, S. Fatima and M. Aslam. (2022a). Spatiotemporal distribution patterns of climbers along an abiotic gradient in Jhelum district, Punjab, Pakistan. Forests, 13(8), 1244-1260. https://doi.org/10.3390/f13081244
25. Majeed, M., A.M. Khan, T. Habib, M.M Anwar, H.A. Sahito, N. Khan and K. Ali. (2022b). Vegetation analysis and environmental indicators of an arid tropical forest ecosystem of Pakistan, Ecol. Indic., 142, 109291. https://doi.org/10.1016/j.ecolind.2022.109291

26. McCune, B., Grace, J.B. (2022) Analysis of Ecological Communities. MJM Software, Gleneden Beach, Oregon, United State of America. 2002. https://doi.org/10.1016/S0022-0981(03)00091-1
27. McCune, B. and M.J. Mefford. (2005). Multivariate analysis of ecological data (PCORD Version 5.10 Mj-M Software) Gleneden Beach, Oregon, United State of America.
28. Mehdi, S. S., Miandad, M., Anwar, M. M., Rahman, G., & Ashraf, H. (2021). Temporal variation in land use and land cover in gujrat (Pakistan) from 1985 to 2015. Geogr. Nat. Resour., 42(4), 386-394.
29. Molina, J.A., J.P. Martín-Sanz, I. Valverde-Asenjo, A. Sanchez-Jimenez and J.R. Quintana. (2023). Mediterranean grassland succession as an indicator of changes in ecosystem biodiversity and functionality. Biodivers. Conserv. 32(1), 95-118. https://doi.org/10.1007/s10531-022-02481-y
30. Naeem, S. and J.P. Wright. (2003). Disentangling biodiversity effects on ecosystem functioning: deriving solutions to a seemingly insur-mountable problem. Ecol. Lett. 6, 567–579. Naeem, S. and J.P. Wright. (2003). Disentangling biodiversity effects on ecosystem functioning: deriving solutions to a seemingly insur-mountable problem. Ecol. Lett. 6, 567–579.
31. Parkes, D., G. Newell and D. Cheal .(2003). Assessing the quality of native vegetation: the 'habitat hectares approach. Ecol. Manag. & Restor. 4, S29-S38. https://doi.org/10.1046/j.1442-8903.4.s.4.x
32. Ramirez, N. and M. Briceno .(2011). Reproductive phenology of 233 species from four herbaceous and shrubby communities in great savanna plateau of Venezuela. AOB Plants, 1–17. https://doi.org/10.1093/aobpla/plr014
33. Rasheed, S., S.M. Khan, Z. Ahmad, G. Mustafa, Z.U. Haq, H. Shah, L.U. Ansari and T.A. Jatt. (2022). Ecological assessment and indicator species analyses of the Cholistan desert using multivariate statistical tools. Pak. J. Bot. 54(2), 683-94.
34. Raunkiaer, C. (1934) The life forms of plants and statistical plant geography; being the collected papers of C. Raunkiær.
35. Risberg, L. and A. Granstrom . (2009).The effect of timing of forest fire on phenology and seed production in the fire-dependent herbs *Geranium bohemicum* and *G. lanuginosum* in Sweden. For. Ecol. Manag, 257, 1725–1731. https://doi.org/10.1016/j.foreco.2009.01.031
36. Shaheen, H., Z. Ullah, S.M. Khan and D.M. Harper. (2012). Species composition and community structure of western Himalayan moist temperate forests in Kashmir. For. Ecol. Manag. 278: 138-145. https://doi.org/10.1016/j.foreco.2012.05.009
37. Singh, K.P. and C.P. Kushwaha. (2006). Diversity of flowering and fruiting phenology of trees in a tropical deciduous forest in India. Ann. Bot. 97:265–276. https://doi.org/10.1093/aob/mcj028
38. Tassadduq, S.S., S. Akhtar, M. Waheed, N. Bangash, D.E. Nayab, M. Majeed, and K.Yessoufou. (2022). Ecological distribution patterns of wild grasses and abiotic factors. Sustainability, 14(18), 11117-11133. https://doi.org/10.3390/su141811117
39. Ter Braak, C.J., and P. Šmilauer. (2012). Canoco reference manual and user's guide: software for ordination, version 5.0.
40. Vojtkó, A., F. de Bello, W. Durka, I. Kuehn and L. Goetzenberger. (2020). The neglected importance of floral traits in trait-based plant community assembly. J. Veg, Sci., 31(4): 529-539. https://doi.org/10.1111/jvs.12877
41. Waheed, M., F. Arshad, M. Majeed, S. Fatima, N. Mukhtar, R. Aziz, ... and H.G. Abdo. (2022). Community structure and distribution pattern of woody vegetation in response to soil properties in semi-arid lowland District Kasur Punjab, Pakistan. Land, 11(12), 2145-2162. https://doi.org/10.3390/land11122145
42. Woodcock, B.A. and R. F. Pywell. (2010). Effects of vegetation structure and floristic diversity on detritivore, herbivore and predatory invertebrates within calcareous grasslands. Biodivers. Conserv. 19: 81-95.

43. Yang, X., Q. Yang, H. Zhu, L. Wang, C. Wang, G. Pang and S. Hussain. (2023). Quantitative evaluation of soil water and wind erosion rates in Pakistan. Remote Sens. 15(9): 2404-2426. https://doi.org/10.3390/rs15092404