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RESEARCH ARTICLE

Vegetation composition and anthropogenic impact on *Nannorrhops* communities in Shurku Valley, District Kurram, Pakistan

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Abstract

Phytosociological studies were conducted in the previously unexplored Shurku Valley, Lower Kurram, Khyber Pakhtunkhwa, Pakistan, between 2021 and 2024. The research revealed that *Nannorrhops* vegetation is under significant ecological and anthropogenic pressure, primarily due to deforestation and habitat degradation. Understanding these pressures is essential for developing effective conservation strategies aimed at preserving this unique vegetation and maintaining the ecological balance of the region. Vegetation analysis was conducted using the quadrat method with standardized plot sizes for trees, shrubs and herbs. Four distinct plant communities were identified: *Nannorrhops-Heteropogon-Olea*, *Nannorrhops-Olea-Parthenium*, *Hyparrhenia-Olea-Quercus* and *Olea-Nannorrhops-Leptorhabdos*, classified based on quantitative characteristics. Soil properties across the sites varied from silty loam to sandy textures with near-neutral pH levels. Silty loam was more conducive to *Nannorrhops* growth, while sandy soils presented ecological challenges requiring adaptive management. Organic matter was moderate and although certain nutrients such as potassium and micronutrients were present in favorable amounts, limitations in nitrogen and inconsistent phosphorus levels highlighted the need for targeted soil interventions. Overall, *Nannorrhops* vegetation is under considerable biotic stress, emphasizing the urgent need for conservation measures, including habitat restoration, sustainable land management and public awareness efforts. Protecting these plant communities is crucial for sustaining the valley's biodiversity and ecological resilience.

Keywords: edaphic variable; Kurram; Pakistan; phytosociology; Shurku; vegetation

Introduction

Nannorrhops ritchiana (Griff) Aitch is a hardy, drought-resistant shrub native to Pakistan, Afghanistan and Iran. It thrives in harsh environments-tolerating strong winds, extreme temperatures and limited water. In Pakistan, it grows widely across arid and semi-arid regions, including Sindh, Punjab, Khyber Pakhtunkhwa and Balochistan, particularly in sandy depressions between 600 m and 1100 m elevation in the Suleiman Range. Locally referred to as "Tal" in Pashto, it forms a patchy but ecologically important vegetation type. Vegetation structure is influenced by both environmental and anthropogenic factors. Quantifying vegetation composition and mapping plant communities is essential for understanding ecosystem services and guiding conservation efforts (1-7). Studying vegetation provides crucial insights for species conservation, particularly for those at risk (8) and helps clarify the relationship between plant communities and environmental variables. Environmental factors such as soil nutrients, climate, topography and land use strongly influence plant species distribution, especially in arid regions (9). Soil characteristics, including nitrogen, phosphorus and potassium availability, are particularly important in determining species richness and distribution (10). Understanding these interactions is critical for predicting vegetation dynamics under environmental change (2-4). However, human activities like agriculture, overgrazing, deforestation and fuelwood collection are leading causes of habitat degradation and biodiversity loss in Pakistan (11). In Shurku Valley, plant communities are disrupted by fire, grazing, tree cutting and dust pollution, negatively affecting both local vegetation and livelihoods (1, 12-14). Broader threats such as poverty, rapid population growth and lack of awareness further exacerbate forest degradation (15-17).

In montane ecosystems, vegetation composition and structure vary significantly across elevations and substrates, influencing biomass production, carbon storage and biodiversity conservation value. Tropical elevational gradients have received global research attention due to their ecological importance (18-21) and conserving mountain ecosystems is increasingly recognized as vital for maintaining biodiversity and regulating water resources (22, 23). In Ethiopia, exclosures that restrict grazing have shown promise in promoting natural vegetation recovery, especially when supported by additional conservation measures (24). However, in many mountainous regions of South Asia-particularly Pakistan comprehensive ecological data remain scarce. Despite the ecological significance of Pakistan's montane zones, there is a critical lack of baseline information on vegetation patterns, anthropogenic impacts and soil characteristics across different elevations. This knowledge gap severely limits the development of targeted conservation and land management strategies. The Shurku Valley in Lower Kurram, a region rich in biodiversity yet increasingly threatened by human activities, exemplifies this challenge. To address this gap, the present study investigates the composition and structure of vegetation, evaluates human-induced disturbances on plant communities, assesses soil physicochemical properties and provides essential baseline data to inform future ecological research and conservation planning in this understudied region.

Materials and Methods

Study area

The Kurram Valley is well-known for its natural beauty, mostly Upper and central Kurram where there are numerous stunning views. It is located between 33°20′ and 34°10′ north latitudes and 69°50′ and 70°50′ east longitudes. It is surrounded by Orakzai and Khyber District in the east, Hangu in the southeast and the tribal District North Waziristan in the South's Nangarhar and Pukthia provinces of Afghanistan to the west (25-29) (Fig. 1).

The Upper, Central and Lower Kurram are the three administrative subdivisions that make up District Kurram (26-30). The area understudy is lower Kurram, Shurku Valley, which is completely ecologically unexplored. Based on the types of vegetation, altitude, facing slopes and soil type, the area's is divided into four ecological zones, namely Makhora, Mukam Thang, Sanzallai Danda (Qawmi Patak) and Wali Cheena (Shurkai) (Fig. 1).

Quantitative analysis

Phytosociological studies were conducted at four different monitoring sites during 2021-2024. At each monitoring site, vegetation was examined using 5 (10 × 10 m) quadrats for trees, 10 (5 × 5 m) quadrats for shrubs and 15 (1×1 m) quadrats for herbs. The density, cover and frequency of each species were determined using formulae and then converted to relative values to get importance value (IV) and family importance value (FIV). Geographical co-ordinates of each site were noted using GPS. The plant species were collected from respective habit type; vernacular names, family names and other relevant information were recorded in the field notebooks.

Density

The species density and its relative value were calculated using standard formulae (31, 32).

$$\text{Density (D)} = \frac{\text{Number of individual of a species in quadrats}}{\text{Total number of quadrats}}$$

$$\text{Relative Density (RD)} = \frac{\text{Density of a species}}{\text{Density of all the species in a stand}} \times 100$$

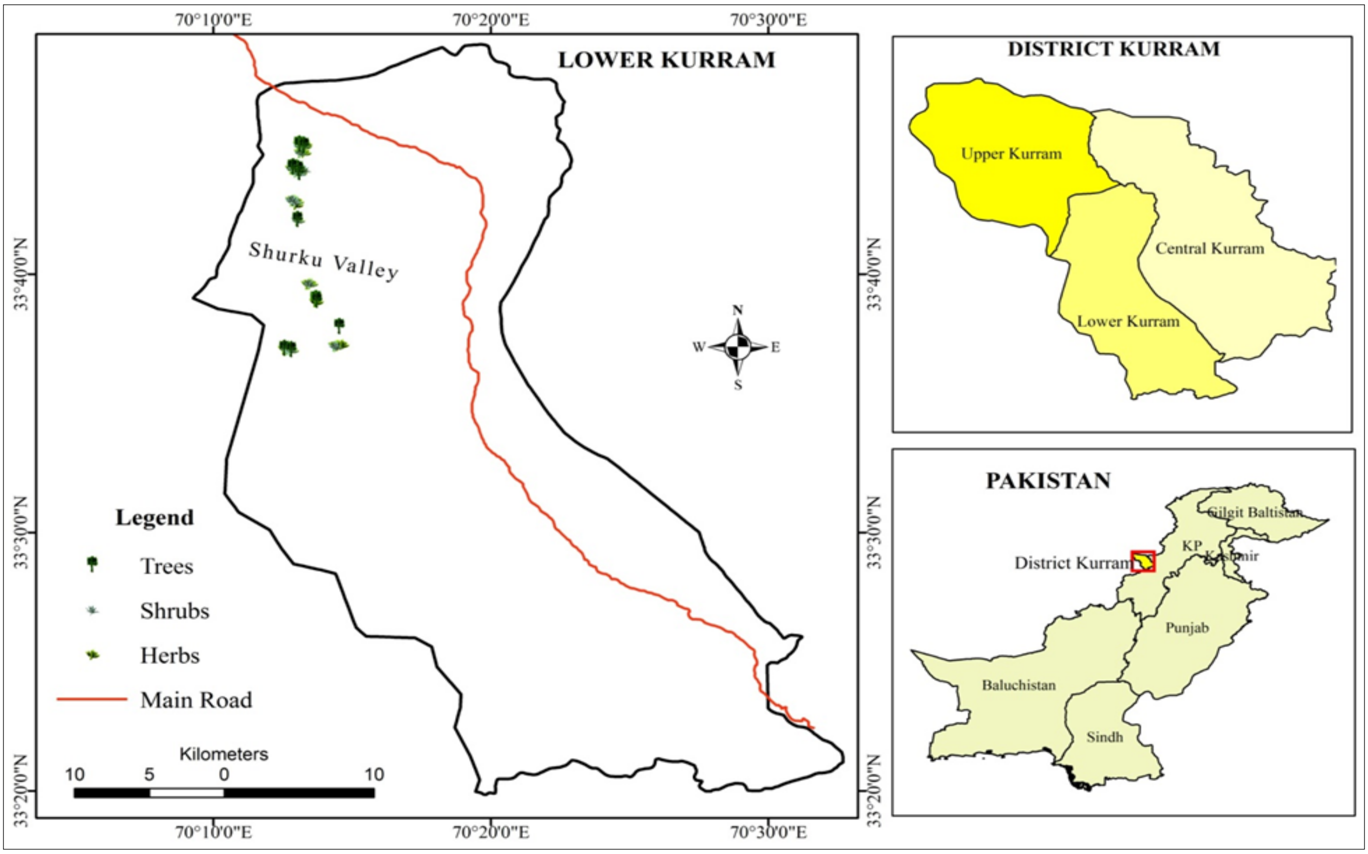

Fig. 1. Map of the study area.

Cover

The cover and relative cover of species were determined with specified formulae (32, 33).

$$\text{Cover (C)} = \frac{\text{Sum of the mid points of a species}}{\text{Total area sampled}}$$

$$\text{Relative Cover (RC)} = \frac{\text{Cover of a species}}{\text{Cover of all the species in a stand}} \times 100$$

Basal area

Measuring tape is used for diameter of crown and recorded the value in square feet. The basal area was measured through using table of basal area (32, 33).

$$\text{Basal Area (BA)} = \frac{\text{Area of a species calculated from circumference at DBH}}{\text{Total area sampled}}$$

$$\text{Relative Basal Area (RBA)} = \frac{\text{Basal area of particular species}}{\text{Total base area for all the species in stand}} \times 100$$

Frequency

The frequency and relative frequency of the plants were determined by using the formulae given (32).

$$\text{Frequency (F)} = \frac{\text{Number of quadrats in which a species was present}}{\text{Total number of quadrats}} \times 100$$

$$\text{Relative frequency(RF)} = \frac{\text{Frequency of a particular species}}{\text{Total frequency for all the species in stand}} \times 100$$

Importance value (IV)

The IV were created by combining the relative values of each parameter, namely density, cover, frequency for each species. The community names were assigned of the three most important species with the IV values:

$$IV = RD + RC + RF$$

Family importance value (FIV)

The sum of the IV of each species in a given family was used to calculate the FIV for each quantitatively documented family.

Cluster analysis

Cluster analysis was carried out using the PCA method and the PAST application. This method of classification is used to put related objects together. A hierarchical tree-like structure resembles the dendrogram that results. By using these cluster sample units, various biotic communities can be represented.

Species diversity

The Simpson-Wiener index of similarity was employed to assess species diversity within the stands, as introduced (34).

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

Where, (D) stands for diversity index, (N) represents total number individuals of all species and (n) denoted number of individuals of a species.

Species richness

Using Menhinick's method, species richness was determined (35, 36).

$$D = \frac{S}{\sqrt{N}}$$

Where, (S) represents total number of species in the stand, (N) stand for total number of individuals in the stand and (D) is denoted species richness.

Similarity index

The calculation of the similarity index involved the application of Sorensen's index (36), as modified in the previous study (37).

$$IS = \frac{2W}{A + B} \times 100$$

Where, 'IS' represents the similarity index, 'W' stands for the sum of lowest quantitative value of the species pair common to both communities, 'A' and 'B' denote the species values in communities A and B respectively.

Soil analysis

Soil samples were collected in March 2022 from different areas of four sites in the study area. We dug 0-15 cm deep to get 1 kg soil from 4 different sites of the study areas. Clear polythene bags were used to collect each samples and they were properly labeled and sealed on the spot. Before analyzing the soil, we made sure to remove any unwanted materials like stones, plant roots and other contaminants were screened out of soil samples and using a 2.5 mm sieve. Finally, we tested and studied the soil samples at the Department of Soil and Environment Sciences, University of Agriculture, Peshawar (4).

Results

Vegetation composition

The study was conducted from 2021 to 2024 in Shurku Valley, Lower Kurram, Khyber Pakhtunkhwa, Pakistan. Based on vegetation type, altitude, slope and soil, the area was divided into four ecological zones: Makhora, Mukam Thang, Sanzallai Danda (Qawmi Patak) and Wali Cheena (Shurkai). A total of 41 plant species were recorded 3 tree species, 11 shrubs and 27 herbs. Four plant communities were identified across the zones based on IV. Poaceae had the highest FIV of 337.13, followed by Arecaceae, Oleaceae, Lamiaceae and others, with remaining families showing FIVs ranging from 30.09 to 1.51.

Classification of communities

The communities were categorized according to their species' IV. The first community; *Nannorrhops-Heteropogon-Olea* are founded, where mostly agricultural practices were noticed. The second community, *Nannorrhops-Olea-Parthenium*, was identified. The third community, known as *Hyparrhenia-Olea-Quercus* and the fourth community, *Olea-Nannorrhops-Leptorhabdos*, were also identified.

Site No.1 (Wali Chena or Shurkai)

This community was found at elevations of 1190-1277 m with silt loam soil (11 % clay, 56 % silt, 33 % sand). Soil analysis showed

0.09 % nitrogen, 1.10 mg/kg phosphorus, 122 mg/kg potassium, 8.63 mg/kg iron, 3.18 mg/kg zinc, 6.71 mg/kg manganese and 2.78 mg/kg copper. Soil pH was 7.18, organic matter 2.21 % and electrical conductivity 0.46 dS/m (Table 1 and 2) (Fig. 2).

Table 1. Soil texture and physiochemical characteristics of different sites of Shurku Valley, District Lower Kurram

Locality	Clay	Silt	Sand	PH	EC	SOM
		%			ds/m	%
Lower District Kurram Wali Chena	13	40	47	7.58	0.43	3.24
Lower District Kurram Sanzallai Danda	15	28	57	7.45	0.67	2.42
Lower District Kurram Mukam Thang	13	54	33	7.63	0.39	4.00
Lower District Kurram Makhora	11	56	33	7.18	0.46	2.21

Notes: pH: power of hydrogen; EC: electrical conductivity; OM: organic matter.

Table 2. Soil macro and micronutrients in different sites of study area

Locality	Total N	AB-DTPA Ext. P	AB-DTPA K	Zn	Cu	Fe	Mn
	%			mg/kg			
Lower District Kurram Wali Chena	0.22	0.73	133	3.16	1.08	3.74	3.27
Lower District Kurram Sanzallai Danda	0.18	1.06	156	5.11	1.30	3.91	2.68
Lower District Kurram Mukam Thang	0.13	4.79	201	4.96	1.97	7.70	6.59
Lower District Kurram Makhora	0.09	1.10	122	3.18	2.78	8.63	6.71

Notes: N: nitrogen; P: phosphorus; K: potassium; Zn: zinc; Cu: copper; Fe: iron; Mn: manganese.

***Nannorrhops-Heteropogon-Olea* community (NHO):** *Nannorrhops ritchiana* was the dominant species in the community, with an IV of 86.11, which is associated with *Heteropogon contortus* with IV of 49.77 and *Olea ferruginea* with an IV 22.56. These were followed by *Teucrium stocksianum* (IV 16.46), *Hyparrhenia hirta* (IV 15.25), *Aristida cyanantha* (IV 15.21) and *Parthenium hysterophorus* (IV 15.13). *Lespedeza juncea* and *Themeda anathera* held the same IV value of 12.82. In addition to these, *Saccharum spontaneum*, *Daphne mucronata*, *Asparagus adscendens*, *Cotoneaster microphyllus*, *Dodonaea viscosa*, *Xanthium strumarium*, *Acantholimon ulicinum*, *periploca aphylla* and *Polygonum* had IV value ranging from 11.81 to 1.51 (Table 3).

Site No.2 (Sanzallai Danda or Qawmi Patak)

This community occurred at elevations of 1277-1345 m with silt loam soil (13 % clay, 54 % silt, 33 % sand). Soil analysis showed 0.13 % nitrogen, 4.79 mg/kg phosphorus, 201 mg/kg potassium, 7.70 mg/kg iron, 4.96 mg/kg zinc, 6.59 mg/kg manganese and 1.97 mg/kg copper. Soil pH was 7.63, organic matter 4.00 % and electrical conductivity 0.39 dS/m (Table 1 and 2).

***Nannorrhops-Olea-Parthenium* community (NOP):** The leading species of this community were *Nannorrhops ritchiana* with an IV of 63.46. The other dominant species were *Olea ferruginea* with an IV of 38.2 and *Parthenium hysterophorus* of 28.33 IV value. *Parthenium hysterophorus* is invasive species made of thick randomly distributed patches in flooded and along road side. The other associated species were *A. cyanantha* (24.74 IV) followed by *Heteropogon contortus* (18.69 IV), *H. hirta* (17.48 IV) and *Daphne mucronata* (17.31 IV). Other members of the community were *Pistacia khinjuk*, *Cotoneaster microphyllus*, *S. spontaneum*, *Salvia reflexa*, *Dodonaea viscosa*, *Themeda anathera*, *Perovskia abrotanoides*, *Tagetes minuta*, *Caragana brevispina*, *Xanthium strumarium*, *P. aphylla* and *Asparagus adscendens*, which exhibited IV values ranging from 16.92 to 1.5 (Table 3).

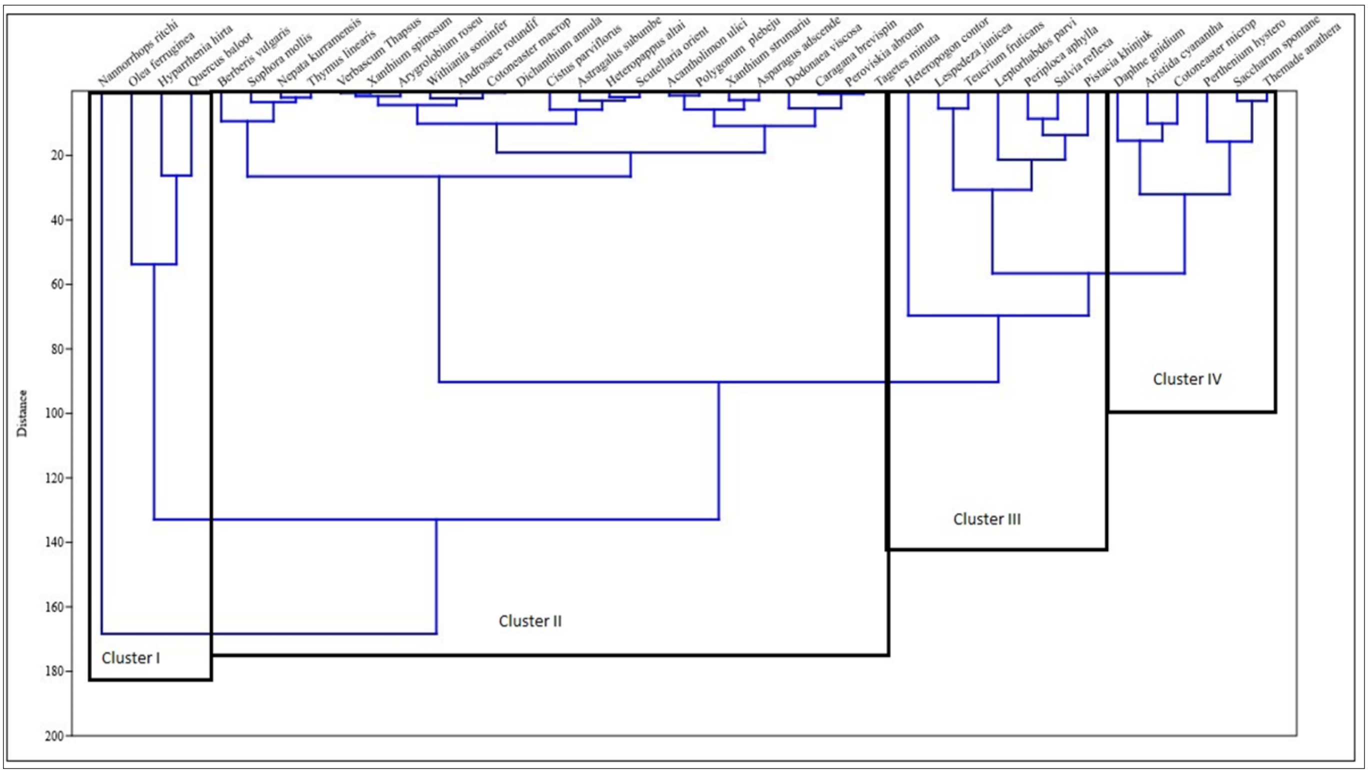

Fig. 2. Cluster dendrogram illustrates the relationships among species based on their importance values, highlighting patterns of ecological association.

Table 3. IV value of vegetation data of Shurku Valley District Lower Kurram Pakistan

Name of species	Site I	Site II	Site III	Site IV
Acantholimon ulicinum Boiss.	3.47	0	0	0
Androsace rotundifolia Hardw	0	0	2.27	0
Aristida cyanantha Steud.	15.21	24.74	18.09	3.79
Argyrolobium roseum Jaub. & Spach	0	0	4.8	1.4
Asparagus adscendens Roxb.	8.65	1.5	0	0
Astragalus subumbellatus Klotzsch	0	0	6.57	3.52
Berberis vulgaris L.	0	0	9.93	10.76
Caragana brevispina var. catenate (Kom.) Ali	0	3.49	0	0
Cistus parviflorus Lam.	0	0	0	7.25
Cotoneaster macrophyllus Rehder & E.H.Wilson	0	0	1.56	0
Cotoneaster microphyllus var. (Wall. ex Lindl.) Dippel	5.3	15.86	14.45	0
Daphne mucronate Royle	10.23	17.31	20.24	15.24
Dichanthium annulatum (Forssk.) Stapf	0	0	1.91	0
Dodonaea viscosa Jacq.	4.89	7.91	0	0
Heteropappus altaicus (Willd.) Novopokr.	0	0	3.17	2.96
Heteropogon contortus Beauv. exRoem. & Schult.	49.77	18.69	2.32	5.59
Hyparrhenia hirta Stapf	15.25	17.48	58.81	14.85
Leptorhabdos parviflora (Benth.) Benth.	0	0	0	30.35
Lespedeza juncea (L.f.) Pers.	12.86	0	8.73	11.34
Nannorrhops ritchiana (Griff.) Aitch.	86.11	63.46	10.25	40.14
Nepeta kurramensis Rech.f.	0	0	12.11	0
Olea ferruginea hort. ex Steud.	22.56	38.2	47.1	54.48
Periploca aphylla Decne.	2.73	2.46	0	15.89
Perovskia abrotanoides Kar.	0	4.68	0	0
Parthenium hysterophorus L.	15.13	28.33	0	0
Pistacia khinjuk Stocks	0	16.92	3.67	19.5
Polygonum L.	1.51	0	0	0
Quercus baloot Griff.	0	0	33.96	0
Saccharum spontaneum L.	11.81	11.58	0	1.98
Salvia reflexa Hornem.	0	11.57	0	8.3
Scutellaria orientalis L.	0	0	4.39	5.35
Sophora mollis Span.	0	0	7.79	0
Tagetes minuta L.	0	4.55	0	0
Teucrium stocksianum Boiss.	16.46	0	10.21	17.92
Themeda anathera Hack.	12.86	7.81	0	0
Thymus linearis Benth.	0	0	10.02	2.01
Verbascum thapsus L.	0	0	4.09	0
Withania somnifera (L.) Dunal	0	0	0	1.74
Xanthium spinosum L.	0	0	3.2	0
Xanthium strumarium L.	4.87	2.97	0	0

Site I (Wali Chena or Shurkai), Site II (Sanzallai Danda or Qawmi Patak), Site III (Mukam Thang) and Site IV (Makhora).

Site No.3 (Mukam Thang)

This community was recorded at elevations of 1345-1353 m with sandy soil (15 % clay, 28 % silt, 57 % sand). Soil analysis showed 0.18 % nitrogen, 1.06 mg/kg phosphorus, 156 mg/kg potassium, 3.91 mg/kg iron, 5.11 mg/kg zinc, 2.68 mg/kg manganese and 1.30 mg/kg copper. Soil pH was 7.45, organic matter 2.42 % and electrical conductivity 0.67 dS/m (Table 1 and 2).

***Hyparrhenia-Olea-Quercus* community (HOQ):** This community comprises a total of 24 distinct species, with *H. hirta* taking the lead position with an IV of 58.81. Following closely are *Olea ferruginea* (IV 47.1), *Quercus baloot* (IV 33.96), *Daphne mucronata* (IV 20.24), *A. cyanantha* (IV 18.09), *C. microphyllus* (IV 14.45) and *Nepeta kurramensis* (IV 12.11). The remaining species within this community exhibit lower IV values ranging from 10.25 to 1.56 (Table 3).

Site No.4 (Makhora)

This community was found at elevations of 1307-1353 m with sandy soil (13 % clay, 40 % silt, 47 % sand). Soil analysis showed 0.22 % nitrogen, 0.73 mg/kg phosphorus, 133 mg/kg potassium, 3.74 mg/kg iron, 3.16 mg/kg zinc, 3.27 mg/kg manganese and 1.08 mg/kg copper. Soil pH was 7.58, organic matter 3.24 % and electrical conductivity 0.43 dS/m (Table 2 and 3).

***Olea-Nannorrhops-Leptorhabdos* community (ONL):** Tree species were found dominant in this community based on IV such as *O. ferruginea* (IV 54.48). The second dominant species were *N. ritchiana* with an IV of 40.14 and *L. parviflora* of 39.35. It's worth mentioning that within this community, *O. ferruginea* also exhibited a shrubby habit and held an IV of 20.54. The other associated species were *P. khinjuk* (IV 19.5) followed by *Teucrium stocksianum* (17.92 IV), *P. ahylla* (15.89 IV), *D. mucronata* (15.24 IV), *H. hirta* (14.85 IV) and *Lespedeza juncea* (11.34 IV). The remaining species in the community had low IV value ranging from 10.76 to 1.4 (Table 3).

Cluster analysis

Cluster analysis was performed using the Clustering tool in PAST software. The identified clusters are determined by the IV of the dominant species across all monitoring sites and the cumulative IV of each individual species.

Cluster I

This cluster was predominated by tree species. The associated species included *N. ritchiana* (combined IV 199.96), *O. ferruginea* (combined IV 162.64), *H. hirta* (combined IV 106.39) and *Q. baloot* (combined IV 33.96) (Fig. 2).

Cluster II

This cluster was composed of numerous species of shrubs and herbaceous plants. Based on the combined IV, the leading species were *Dodonaea viscosa* (12.8), *N. kurramensis* (12.11), *Thymus linearis* (12.03), *A. adscendens* (10.15) and *Astragalus subumbellatus* (10.09). The other coexistence species were *A. ulicinum*, *A. roseum*, *C. brevispina*, *Cistus parviflorus*, *C. macrophyllus*, *Dichanthium annulatum*, *Scutellaria orientallis*, *Sophora mollis*, *T. minuta*, *Verbascum Thapsus*, *Withiania sominfera*, *X. spinosum* and *X. strumarium* (Fig. 2).

Cluster III

This cluster consist of *Teucrium fruticans* with combined IV 44.59, *P. khinjuk* 40.09, *L. juncea* 32.93, *P. aphylla* 21.08, *S.reflexa* 19.87 and *Heteropappus altaicus* 6.13 (Fig. 3).

Cluster IV

Based on the combined IV, in this cluster, the associated species *D. mucronata* (63.02), *A. cyanantha* (61.83), *P. hysterophorus* (43.46), *C. microphyllus* (35.61), *S. spontaneum* (25.37) and *T. anathera* (20.67) (Fig. 2).

Principal component analysis

In PCA plot 1, the *T. stocksianum*, *H. altaicus*, *P. khinjuk*, *P. aphylla* and *L. parviflora* shows positive correlation with origin except the *O. ferruginea*. The *O. ferruginea* form an isolated community while the other species shows random type of distribution. Similarly, in PCA plot 2, the related species display a weak positive

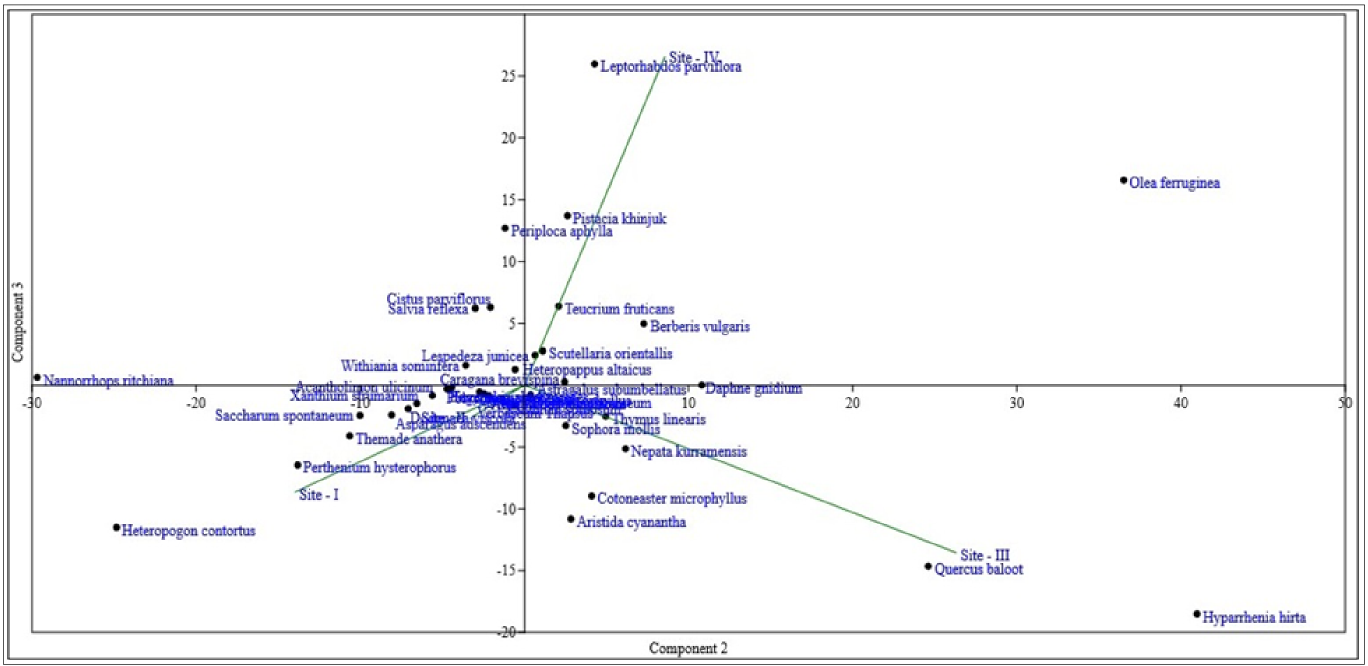

Fig. 3. PCA biplot illustrating the relationships among species based on their importance values, highlighting key ecological associations.

correlation with the origin and clumpy species distribution. In the PCA plot 3, the species *A. adscendens*, *D. mucronata*, *T. anathera* and *P. hysterophorus* all exhibit clumpy distribution and display a strong negative correlation with the origin. While the *Heteropogon contortus* form an isolated community. In PCA plot 4, the species association indicates a weak negative correlation with species dispersion of a random type. The *H. hirta* and *Quercus baloot* display to form an isolated community (Fig. 3).

Species diversity

The species diversity at each site was determined using Simpson's diversity index. Species diversity holds crucial significance in vegetation, serving as a key indicator of the health and productivity of plant life. It quantifies the complexity and functioning within a community. The calculation of Simpson's diversity for four communities resulted in values of 0.76 for Site I, 0.85 for Site II, 0.89 for Site III and 0.91 for Site IV (Table 4). Site IV has the highest species diversity with a Simpson's diversity index of 0.91, attributed to favorable factors. Its higher elevation offers cooler temperatures, promote a variety of plant species. Effective erosion control and balanced soil texture contribute to improved soil health, supporting diverse plant life. Favorable climatic conditions enhance plant growth, while well-managed grazing and minimal human activities, like deforestation and contribute to a balanced ecosystem, supporting diverse plant life. The diversity of species stands out as a prominent characteristic of plant communities, reflecting their overall structure and composition (Table 4).

Species richness

In the current study, species richness was documented at each site of the area. The West Facing Slope exhibited the highest species richness (0.99), followed by the South Facing Slope (0.96),

Table 4. Species diversity among different communities of Shurku Valley Lower Kurram

Sites	Communities	Species richness
Site I	*Nannorrhops-Heteropogon-Olea*	0.76
Site II	*Nannorrhops-Olea-Parthenium*	0.85
Site III	*Hyparrhenia-Olea-Quercus*	0.89
Site IV	*Olea-Nannorrhops-Leptorhabdos*	0.91

the East Facing Slope (0.94) and the North Facing Slope (0.90). The West Facing Slope recorded the highest species richness (0.99), indicating a diverse arrangement of plant life. The high species richness on the West Facing Slope is directly linked to the favorable environmental conditions, soil quality and diverse habitats present there. The presence of well-balanced soil texture, optimal nutrient levels, good drainage and diverse habitats collectively stimulate an environment beneficial to the flourishing of various plant species (Table 5).

Table 5. Species richness among different communities of Shurku valley Lower Kurram

Sites	Communities	Species richness
Site I	*Nannorrhops-Heteropogon-Olea*	0.96
Site II	*Nannorrhops-Olea-Parthenium*	0.94
Site III	*Hyparrhenia-Olea-Quercus*	0.99
Site IV	*Olea-Nannorrhops-Leptorhabdos*	0.90

Similarity index

Based on Motyka's index of similarity (37), the *Nannorrhops-Heteropogon-Olea* community of Wali Chena or Shurkai was found to be 1.73 % like *Nannorrhops-Olea-Parthenium* community of Sanzallai Danda or Qawmi Patak. The similarity between *Nannorrhops-Heteropogon-Olea* community of Wali Chena or Shurkai and *Hypharrhenia-Olea-Quercus* community of Mukam Thang was observed 6.59 %. The current analysis shows that similarity between *Nannorrhops-Heteropogon-Olea* community of Wali Chena or Shurkai and that of *Olea-Nannorrhops-Leptorhabdos* community of Makhora was 4.64 %. The community of Sanzallai Danda or Qawmi Patak i.e. *Nannorrhops-Olea-Parthenium* community was 6.87 % similar to *Hypharrhenia-Olea-Quercus* community of Mukam Thang. The *Nannorrhops-Olea-Parthenium* community of Sanzallai Danda or Qawmi Patak was found 4.56 % similar to *Olea-Nannorrhops-Leptorhabdos* community of Makhora. Comparison of *Hypharrhenia-Olea-Quercus* community of Mukam Thang and *Olea-Nannorrhops-Leptorhabdos* community of Makhora was show 2.06 % (Table 6).

Table 6. Similarity index for four different communities

	NHO	NOP	HOQ	ONL
NHO	X	X	X	X
NOP	1.73	X	X	X
HOQ	6.59	6.87	X	X
ONL	4.64	4.56	2.06	X

Notes: NHO: *Nannorrhops-Heteropogon-Olea* community; NOP: *Nannorrhops-Olea-Parthenium* community; HOQ: *Hyparrhenia-Olea-Quercus* community; ONL: *Olea-Nannorrhops-Leptorhabdos* community.

Discussion

The vegetation structure in the present study was classified into four distinct communities based on IV. Historically, the Shurku Valley was densely forested, but it has since transitioned into shrub-dominated vegetation. The once-abundant population of *N. ritchiana* has significantly declined due to environmental stressors, human activities, overcutting, fire and drought. Human-induced pressures have led to a clumped vegetation distribution rather than a uniform one, primarily due to unsustainable deforestation of fuel and construction. Trees are now sparsely distributed and mostly clustered, with dense shrub cover, especially near the foothills, an indication of strong environmental and biotic influences. Overgrazing, fire, cutting and road construction are the main drivers of the current distribution of species. Similar studies were reported from their respective study areas (1, 2, 4).

The *Nannorrhops-Heteropogon-Olea* community was recorded at the South Facing Slope. This site had a uniformly spread thick *Nannorrhops ritchiana* mixed with *H. contortus*, while *O. ferruginea* was sparsely distributed across the area. *Nannorrhops-Olea-Parthenium* community was reported at the East Facing Slope. In this community invasive species *Parthenium hysterophorus* is also reported, that make thick randomly distribution patches along roadsides. The *Hypharrhenia-Olea-Quercus* community was documented on the West Facing Slope. *Quercus baloot* was noted on the same slope at Site III, where only a small population of these trees remains, making them nearly endangered. On the North Facing Slope The *Olea-Nannorrhops-Leptorhabdos* Community was recorded. This site had a thick and scattered community of *O. ferruginea* that was mixed with *N. ritchiana*. The present findings are consistent with those of previous studies (2-4, 23, 33) which reported that similarities among the plant communities is due soil properties, natural and biotic variables.

Anthropogenic activities often trigger a chain reaction leading to deforestation, habitat degradation and subsequent changes in vegetation structure and biodiversity loss, as supported in the previous studies (2-4). Site III recorded the highest species richness (0.99), while Site IV showed the highest diversity index (0.91). Variations in similarity index among communities were linked to environmental factors. *S. reflexa*, identified as an invasive species (4) rapidly forms dense patches in areas like floodplains, gullies, roadsides and sandy or clay soils, outcompeting native flora and altering plant community composition.

The selected sites had soil textures ranging from silty loam to sandy, with pH values between 7.18 and 7.63. Organic matter content varied from 2.21 % to 4.00 % and electrical conductivity ranged from 0.39 to 0.67 dS/m. These properties influence the growth of *Nannorrhops*, with silty loam offering favorable conditions and sandy soils presenting challenges that may require adaptive management. Nutrient levels also varied: nitrogen (0.09-0.22 %), phosphorus (0.73-4.79 mg/g) and potassium (122-201 mg/g). Micronutrients included iron (3.74-8.63 mg/g), manganese (2.68 -6.71 mg/g), copper (1.08-2.78 mg/g) and zinc (3.16-5.11 mg/g). These soil characteristics directly affect plant growth, nutrient availability and species composition. Variations in pH, organic matter, salinity and nutrient concentrations influence vegetation health, diversity and resilience across study sites.

Plant species composition is heavily influenced by human activities such as trampling, overgrazing, deforestation and soil erosion. Our study found that *W. coagulans*, *A. tuberculata*, *A. kurramense* and *N. ritchiana* are under significant threat from climate change and unsustainable practices, including deforestation, uprooting, erosion, fires and road building and mining. *N. ritchiana*, widely used for making mats, fans, baskets and other crafts, faces a high risk of endangerment if protective measures are not taken (1). Similar studies have been conducted in different areas of Kurram, North Waziristan, South Waziristan, Bajour and Khyber Pakhtukhwa highlighting comparable patterns of vegetation change and anthropogenic impacts (1, 3-4, 22, 29, 33, 38). Invasive species such as *P. hysterophorus*, *S. reflexa*, *X. strumarium*, *X. spinosum*, *T. minuta* and *Prosopis juliflora* pose a severe threat to the native plant communities of Shurku Valley. These species spread aggressively, outcompeting native flora for essential resources, altering soil chemistry and disrupting ecosystem balance. Their unchecked growth leads to reduced biodiversity, degradation of natural habitats and long-term ecological instability. Effective monitoring and management are crucial to prevent irreversible damage to the valley's already vulnerable vegetation.

Conclusion

The phytosociological study conducted in Shurku Valley, Lower Kurram (2021-2024) provided valuable insights into the status of *Nannorrhops* vegetation in this previously unstudied region. Findings revealed that *Nannorrhops* is under significant ecological and anthropogenic pressures, particularly due to deforestation and human disturbances. Four distinct plant communities were identified, influenced by varying soil textures, ranging from silty loam to sandy soils, which directly affected species distribution and growth. While silty loam soils generally supported vegetation, sandy soils presented challenges, especially under low nitrogen and variable phosphorus conditions. A key limitation of this study is its single-season sampling, which may not capture seasonal dynamics of plant communities. To ensure sustainable conservation, stakeholders should prioritize the integration of findings into regional land-use policies, implement targeted habitat restoration programs and conduct local awareness campaigns on the ecological value of *Nannorrhops*. Future research should focus on long-term monitoring, multi-seasonal assessments and the impacts of land-use change on plant community dynamics in the region.

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Authors' contributions

WH conceptualized the study. IH, SMS and AA carried out data collection and wrote the original draft. NA assisted with clustering of data using PAST software. SU and AH contributed to review and editing. LK performed soil testing. WH and RWB provided overall review and KH prepared the map of the study area. WH supervised the project. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

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