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PLANT COMMUNITY STRUCTURE AND ABUNDANCE ALONG ROADSIDES IN THE EASTERN HINDU KUSH: IMPLICATIONS FOR LOCAL LIVELIHOODS AND SUSTAINABLE DEVELOPMENT

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Abstract

Roadside vegetation in mountainous rangelands contributes to ecosystem functioning, livestock grazing resources, and the ecological well-being of local communities. This study assessed plant community structure and abundance along roadsides in the Eastern Hindu Kush, with particular emphasis on density, frequency, cover, biomass, and carrying capacity under contrasting vegetation conditions. The study was conducted at two sites, Kandow and Bahadur Sar, in Shangla District, Khyber Pakhtunkhwa, Pakistan. A quantitative quadrat method was used, and a total of 100 sample plots, 50 at each site, were established at 5 m intervals to assess and compare roadside vegetation characteristics. Several plant species were recorded, with "Cyperus rotundus" and "Rumex dentatus" among the prominent species observed in the study area. The results showed differences in vegetation density, frequency, cover, biomass, and carrying capacity between the two study sites. Vegetation characteristics were generally higher in the more abundant roadside areas, whereas lower density, frequency, and biomass were associated with areas experiencing greater human and livestock disturbance. "Cyperus rotundus" showed the highest values for several vegetation parameters, indicating its dominance within the sampled plant communities. The estimated carrying capacity also differed between the two sites, reflecting variation in vegetation productivity and forage availability. The findings suggest that anthropogenic activities, including livestock grazing and dependence on surrounding natural resources, may contribute to vegetation degradation and reduced resource availability. These changes have potential implications for the resources that support local livelihoods, particularly livestock-based activities, and highlight the importance of sustainable vegetation and rangeland management in the Eastern Hindu Kush. The study provides baseline information for vegetation conservation, sustainable grazing management, and the maintenance of ecosystem resources that contribute to local livelihood security.

Keywords: Plant Community Structure, Roadside Vegetation, Abundance, Density, Frequency, Biomass, Carrying Capacity, Livestock Grazing, Local Livelihoods, Eastern Hindu Kush, Sustainable Rangeland Management.

1. Introduction

1.1 Background

Vegetation is a unit which possesses characteristics in physiognomy and structure, sufficiently large enough to permit its differentiation from other such units (Hussain & Ilahi, 1991). Plant species are not evenly or randomly distributed throughout the world; rather, they are scattered along unique geographical units (Zeb et al., 2021). Physiographic elements, as well as edaphic environments, play an important impact in the spread of plant species across a region. The identification of the most successful elements is critical in the long-term management of a forest ecosystem. The purpose of this research is to look into the interactions between understory vegetation and several environmental parameters in natural forest ecosystems (Mataji et al., 2010).

Long-term planning requires comparing a region's flora and its biogeographical affinities to other places, as well as classifying its vegetation into different phytogeographic elements (Pourrezaei et al., 2017).

Many Phyto-geographers have studied the flora of different nations all around the world. In Pakistan, the field of phytogeography is as new as the country itself. Pakistan is one of those nations that has an unique flora consisting of roughly 6000 species (Shinwari & Qaiser, 2011).

There are relationships between the soil, plants, and climate. Any change in one of these elements could result in a change in the other element that is related to them. A community's development and existence are an indication of the kind of plant and the conditions of its environment (Khan et al., 2018).

One of the most fundamental aspects of plant communities is the interaction between plants and their surroundings. The humid mountainous areas constitute a complex ecosystem with different levels of water erosion disturbance. The area can be divided into an upper and lower hill slope area the sections can be further broken down into micro-scale geo-morphological units at a finer level of detail. There are crest slope, upper side slope, head hollow, and other features in the upper hill slope region, and lower hill slope area has lower side slope, foot slope, flood terrace, and river bed, among other features. Two fundamental functional land area types for determining species composition and forest structure are the upper and lower hill slopes (Yang & Da, 2006).

Topography influences plant dispersal in both direct and indirect ways. Understanding the relationship between topographic characteristics and vegetation could therefore contribute in species kind selection for ecological management in various kinds of rangeland habitats. As a result, the impact of topographic factors on vegetation changes has been examined in this study. First, using GIS software, a map of the lithology and the maps of slope, height, and aspect were superimposed to create the land unit's map. After identifying plant groups in random plots within land units, sampling was carried out. The size and number of plots were calculated using a statistical method and the least area approach. Following that, field surveying and the overlaying of maps of land units and plant communities enabled the recording of topography information as well as plant characteristics in each community. Plant communities were also coordinated by DCA and CCA. The findings demonstrated that distinct plant communities displayed varying associations with physiographic parameters. For example, shrubs exhibited a stronger correlation with aspect and altitude than grasses, but no discernible correlation with slope. Invasive species have lessened this association, which has a detrimental impact on the ecological relationships in populations that are overgrazed (Tamartash et al., 2010).

Vegetation indices are mathematical transformations of spectral reflectance that are used to analyze vegetation biomass and cover (Rahman et al., 2003). The goal of the current study is to assess how various anthropogenic disturbances, such as stone crushing, grazing, and tree cutting for fuel, affect the growth and development of various plant communities in the disturbed ecosystem of the area. Fixed methods were used to gather data for density, frequency, cover, and other derived metrics. Employing the quadrate approach and the canonical correspondence analysis tool for analysis. The results showed that 80% of the disruption was disturbed by stone crushing, 10% by grazing, and 5% by harvesting, and the balance by fire and other factors. Environmental conditions have a big impact on native plant species' growth and distribution patterns. The organization and makeup of communities are profoundly impacted by anthropogenic activity, particularly stone crushing, and pattern dispersion as stress increases (Iqbal et al., 2016).

1.2 Economic Importance

Roadside verges and vegetation can play an essential role in addressing microclimate, soil stabilization, and pollution control issues. Roadside plants can considerably help to mitigate the negative impacts of gaseous and particle pollution in the roadside environment. Similarly, roadside plants can absorb many of the particles that would otherwise spread across agricultural land and crops. As a result, they may aid in the protection of the food chain against the accumulation of dangerous contaminants. Roadside vegetation, particularly trees, shrubs, and dense hedges, can help to purify the air (Ramsay, 1993).

The economic viability of rangelands is determined by the price of meat, the cost of maintaining herds and plots, salaries, and the availability of human resources. A mismatch between income and spending may jeopardize rangelands' economic sustainability. From a societal standpoint, there is a continuing debate about the desire to preserve and sustain rangelands for public benefit, particularly in light of increasing population density, urbanization, and decreased availability and access to open spaces. Despite the importance of socioeconomic forces and the challenges they may pose to rangeland sustainability, this article concentrates on ecological rangeland sustainability, leaving economic and social aspects of rangeland sustainability out of the scope of this study. There are two reasons for this: (a) the environmental (b) remote sensing (Svoray et al., 2013).

1.3 Problem Statement

Severe rangeland degradation and/or conflicts over rangeland use produce serious social, economic, and environmental difficulties in many developing nations where rangelands are a prominent land type and vital to the lives of a large section of the people. Because there is little monitoring, it is difficult to determine the exact level of degradation in emerging nations, but there is reason for concern that the growing human population is placing a great deal of stress on rangeland ecosystems. The major land use in a given region is cattle grazing, which is commonly linked to modifications in the overall structure of ecosystems (Bedunah & Angerer, 2012).

Stressful growth circumstances and sensitive ecosystems are created by topographic, edaphic, and climatic variables. Nonetheless, woods continue to be an essential resource for local inhabitants in these ecosystems. Historically, the vulnerability of this resource has motivated people to construct traditional forest and pastoral control mechanisms (Hammi et al., 2010).

1.4 Justification of the Study

There is an urgent need to study, document, and map the vegetation of Pakistan's different locations in accordance with international standards in order to establish a foundation for successful plant conservation policies and sustainable development. The Shangla district is one of such vital places, hence it was chosen for the current study.

1.5 Objectives of the Study

1. To determine the species composition, frequency, relative frequency, density, relative density, cover, relative cover and biomass and carrying capacity of the study area.
2. To find out the effect of human and livestock on the ground vegetation in abundant and non-abundant areas.

2. Review of Literature

2.1 Vegetation Analysis Methods and Techniques

2.1.1 Environmental Factors and Plant Coverings. Understanding environmental conditions and how they affect plant coverings is crucial for range management. The Dizaj and Batchi rangelands in Khoy were the study sites for this investigation, which aimed to identify and assess the key environmental and management variables influencing plant distributions. Following the identification of indicator plant types inside the regions, 100-meter transects within 1-meter-square plots were sampled using a random, systematic technique, and data on the density and percentage of canopy of various plant species were gathered. The dominating plant canopy variations and statistical methods were used to calculate the area and number of samples, respectively. Then, each transect of soil sample was taken at the beginning and conclusion of this study at a depth of 0 to 15 cm (Motamedi et al., 2013).

2.1.2 Multivariate Analysis in Vegetation Studies. Multivariate analysis is used in this work to assess the vegetation composition of the understory species in the Malam Jabba Forest. Using the point-centred quarter approach, thirteen stands were quantitatively sampled. Recorded environmental variables were correlated with the characteristics of the vegetation. 49 understory species were found in 13 stands (Siddiqui et al., 2016).

2.1.3 Agglomerative Cluster Analysis and PCA. In order to evaluate the vegetative groupings and underlying group structure, multivariate approaches were used. Four major groupings of vegetation are shown by agglomerative cluster analysis (Ward's approach), and principal component analysis (PCA) clearly ordinates these groups on all three axes. While these species were found in three categories, namely Punica granatum and Plantago amplexicaulis, the most common species dispersed in all four groups were Adiantum capillus veneris, Adiantum venestum, Berberis lyceum, Chrysopogon aucheri, Oxalis corniculata, Pteris cretica, and Trifolium repens.

First Group has 23 species, of which the dominant species were Androsace rotundifolia, Aristida cynantha, Berberis lyceum, Dryopteris filix, Oxalis corniculata, Pteris cretica, and Trifolium repens; Group 2 has 18 species, of which the dominant species were Pteris cretica, Adiantum venestum, and Duchesnea indica; other species included Berberis lyceum, Chrysopogon aucheri, Dryopteris juxtapostia, and Morus Alba. Groups 3 and 4 each contain 31 species, of which 18 were common. These species include Prunus avium, Pteris cretica, Punica granatum, Rosa macrophylla, Dryopteris filix, Dryopteris juxtapostia, Arisaema jacquemontii, Berberis lyceum, Chrysopogon aucheri, Oxalis corniculata, Plantago amplexicaulis, Dryopteris juxtapostia, Duchesnea indica, Oxalis corniculata, Plantago amplexicaulis, Dryopteris filix, Dryopteris juxtapostia, and Polygala erioptera. When it came to the distribution of plants, height and slope were the two most important environmental factors (Lepš & Hadincová, 1992).

2.1.4 Sampling Error and Relevé Method Assessment. Two sets of 40 relevés were compared, each made independently by two observers on the same 5m x 5m sample plots, to estimate the sampling error and assess the effect of this sampling error on (1) estimates of species richness and diversity, (2) multivariate analysis results, and (3) estimation of species turnover in repeated sampling. The relevés were created using the Braun-Blanquette method. The sampling error was calculated for (1) species recording in sample plots and (2) visual estimation of degree of cover (or general population number). Despite the fact that the sample plots were exhaustively searched for 30 - 40 minutes, the number of missed species was substantial, with a 13% disparity between comparable relevés.

In multivariate analysis, the error introduced by missing species was at least as significant as the error introduced by visual assessment of species cover. When the estimations of degree of cover using the Braun-Blanquet scale are subjected to ordinal transformation, they are sufficiently reliable for use in multivariate analysis. When average cover values are employed, the discovered patterns are purely based on dominants. The relevés could be used to properly predict species richness and diversity, but the estimates of equitability are extremely unreliable. The traditional relevé approach is still one of the most effective survey methods for identifying vegetation types at the macro-community and landscape sizes.

2.1.5 Quadrate Method and Floral Composition Assessment. The purpose of this study was to evaluate the floral composition of the Alno communal mixed forest in the Philippines. For the evaluation of trees, shrubs, saplings, and seedlings, a quadrate method of vegetation analysis was applied. This shared woodland was home to 78 species from 43 different groups. The line intercept approach was used to assess grasses, herbs, ferns, and other low-lying flora. Using this strategy, 31 species from 20 families were discovered. For the quadrate technique and the line intercept approach, the diversity (Shannon-Wiener) indices of this common forest are 3.2129 and 2.3870, respectively. Pinus kesiya Royle ex Gordon (Benguet pine) is the most important species in this area, accounting for 64.19% of the total (Lumbres et al., 2014).

2.1.6 Point Quadrates and Statistical Treatment. We used vertical pins or point quadrates in vegetation analysis and presented the statistical treatment of results obtained from data collected in various locations in Victoria. The proportion of the ground covered by each species ("percentage cover"), the average number of layers of leaves covering each point of ground ("cover repetition"), and the proportion of each species in the vegetation as a whole ("percentage of sward") are used to express the results (Goodall, 1952).

2.2 Regional Vegetation Studies and Community Structure

2.2.1 Vegetation Types in Arid-Tropical Zones of Pakistan. Environmental variables influence the composition of vegetation and/or the coexistence of plant species in any region. The ecological knowledge and order of importance of selected environmental variables are significant in plant resource conservation and management. Based on significant information gaps, the research region of district Jhelum, Pakistan, which lies in an arid-tropical zone, was chosen to investigate vegetation types and the environmental factors that drive them using the most recent multivariate statistical methodologies. From January 2018 to December 2020, the entire district was ecologically examined in order to collect natural wild plant and environmental data. The research area was divided into 171 grids (5×5 km²). Three sites were randomly picked in each grid (i.e. 513 samples), and nine plots were then set at each sampling site (i.e. 1539 plots). To determine the potential number of vegetation types, plant species composition, classification of the studied samples, order of importance of the considered predictors, and groups of environmental variables, various statistical tests such as the Monte Carlo permutation test, Indicator Species Analysis (ISA), hierarchical classification, ordination, and variation partitioning were used (Majeed et al., 2022).

2.2.2 Herbaceous Vegetation in Margalla Hills National Park. The growth, distribution, categorization, and association of herbaceous vegetation edaphic elements in Margalla Hills National Park, Islamabad, were investigated. The vegetation and soil were sampled using a random sampling method. In 30 quadrates, 52 herbaceous plant species from 26 families were identified. The study's goal was to classify and identify plant species, as well as to understand the soil conditions that influence community makeup (Ahmad, 2009). TWINSPAN was utilized to detect unique plant communities, leading to the identification of four vegetation groupings. The communities of *Malvastrum coromandelianum* and *Cicer arietinum* were found in agricultural crop fields, *Cynodon dactylon* and *Cerastium fontanum* were found in humid stands, and *Micromeria biflora* and *Grewia tenax* were found in the majority of regions. *Lepidium pinnatifidum* (Zeb et al., 2021).

2.2.3 Vegetation Along River Panjkora. Plant species distributions on the earth's surface are not random or even but are geographically unique and characterized by specific sets of environmental and climatic conditions. The current study used Multivariate statistical approaches to classify the vegetation along the River Panjkora in the district Dir Lower, Khyber-Pakhtunkhwa, Pakistan into various phytogeographic groups. Quadrate quantitative ecological approaches were used to sample the vegetation. For herbs, bushes, and trees, quadrates of various sizes were gathered, namely 1 × 1m², 5 × 5m², and 10 × 10m². 215 plant species from 22 different phytogeographic elements were studied and reported.

2.2.4 Natural Vegetation of Kabul Valley, Swat. The natural vegetation of Kabul valley district Swat, Pakistan, was studied between 2009 and 2013. 314 relevés' vegetation data were collected using a stratified random sampling design and recorded in the TURBOVEG database software. The data was analyzed using modified Two-Way Indicator Species Analysis (TWINSPAN) and associated with edaphic, topographic, and environmental variables using Detrenched Correspondence Analysis (D.C.A) in the host application JUICE (Ilyas et al., 2015). Nine distinct plant communities were identified based on topographic and edaphic factors: 1) Nasturtium-Paspalum-Veronica Wetland, 2) Abies-Picea-Viburnum Coniferous Forest, 3) Pinus-Quercus-Berberis Mixed Forest, 4) Pinus-Indigofera Blue Pine Forest, 5) Celtis-Olea-Cynodon Forest, 6) Diosperos-Pinus-Quercus Mid Hill Degraded Forest, Sacred Groves Broad Leafed Forest, 7) Dodonaea-Isidon-Berberis established in Xeromorphic Scrub, 8) Pinus-Quercus-Galium in Protected Chir Pine Forest, and 9) Isodon-Berberis-Indigofera in Montane Scrub.

2.2.5 Non-Native Species Invasion Along Roadsides. Preventing non-native species impacts is viewed as a cost-effective management action. However, if little is known about the properties of successfully invading non-native species or environmental qualities that make native plants more resistant to invasion, targeted prevention can be difficult. We investigated whether different species traits are beneficial during primary invasion (i.e. spread of non-native species along roadside dispersal corridors) and secondary invasion (i.e. percolation from roadsides into natural adjacent vegetation), as well as whether specific habitat characteristics increase biotic resistance to invasion. We discovered that primary invasion along mountain routes is dominated by longer-lived, non-ruderal species lacking seed dispersal feat (McDougall et al., 2018).

2.2.6 Woody Vegetation in Semi-Arid Lowlands of Kasur. Around the world, arid places have less variety of plants. On the other hand, semi-arid areas are noteworthy for their plant diversity and vegetation structure, as well as their extremely high species richness. This study's main objective was to evaluate the variety and composition of woody species in the semi-arid lowlands of Kasur, Punjab, Pakistan, in relation to their edaphic qualities. In the years 2020–2022, extensive field surveys were carried out in the Kasur region of Punjab to investigate the botanical diversity of the woody flora. 120 sampling sites were chosen based on vegetation richness and geography, and each site included five randomly chosen 500 m² transects. Consequently, 25 quadrates were gathered from each sampling site in order to investigate the ecological diversity of woody vegetation. Samples of soil were taken between nine and twelve feet down (Waheed et al., 2022).

2.2.7 Phytosociological Study of Koh-e-Safaid Range. Based on elevation, habitats, and physiognomic contrast, seven communities of herbs, shrubs, and trees were planted at seven monitoring locations as part of this Phytosociological study, which was carried out between 2015 and 2018. Five quadrates (10 × 10 m²) for trees, ten quadrates (5 × 5 m²) for shrubs, and fifteen quadrates (1 × 1 m²) for herbs were collected at each location using the quadrate method. Standard techniques were employed to calculate edaphic attributes. With a FIV of (374.39), Pinaceae was the largest family according to family importance values, followed by Lamiaceae (350.33), Asteraceae (204.43), and Poaceae (193.67). In the Sub-Tropical zone, seven communities were established: Indigofera-Quercus-Dichanthium; Berberis-Themeda-Periploca; and Seriphidium-Salvia-Thymus. The Temperate Zone is home to the Quercus-Juniperus and Juniperus-Picea-Abies communities. In the Sub-Alpine zone, the Abies-Picea-Rhododendron community was created, whereas the Juniperus-Rheum-Kobresia community (Hussain et al., 2019).

2.3 Rangeland Management and Anthropogenic Impacts

2.3.1 Impact of Nomadic Grazing on Medicinal Plants. Coniferous forests are essential to the rural poor's means of subsistence and offer valuable ecological services that sustain ecosystem health. In this regard, the current study was started with the intention of assessing how nomadic grazing affects plant variety, with a focus on medicinal flora in particular. Two locations were compared; one was shielded from grazing for roughly seven years, while the other was subjected to ongoing nomadic grazing. The survey's findings indicated that there is a significant risk to the occurrence from nomadic grazing (Sher et al., 2010).

2.3.2 Carrying Capacity Assessment of Dhrabi Watershed. In order to ascertain the carrying capacity and productive potential of the Dhrabi watershed in Chakwal, Pakistan, a quantitative vegetation assessment was carried out in the winter of 2008–09. Twelve watershed sites were chosen utilizing the stratified sample with line transects method based on altitude variation. The location with the greatest value (73.41%) in the upper zone and the lowest overall grass cover percentage was 64.09%. In the lowest range, 56.33%. The middle zone had the highest value (29.72%) of trees and bushes, followed by the top zone, with an average cover of 19.74%. lower zone (7.95%) and upper zone (21.54%). The range's overall carrying capacity of 2.41 ha/AU/4month was determined to be in good condition. The primary the three most common plant species in the area were *Desmostachya*, *Cynodon dactylon*, and *Heteropogon contortus* (Sariala ghaas). *Bipinnata* (Ghaas Dab) (Khan & Qureshi, 2011).

2.4 Biomass Assessment and Forest Productivity

2.4.1 Correlation Between Biomass and Vegetation Indices. The forest plays a crucial role in sustaining global climatic balance and the global carbon cycle. Biomass assessment can provide information on forest ecosystem productivity. The assessment of forest biomass aids in understanding the resources and changes in the forest ecosystem. Because 47.5-50% of forest dry biomass is carbon, biomass assessment is vital for determining the amount of carbon sequestered by a forest. The purpose of this study is to analyse the link between aboveground biomass and several vegetation indices and to select the most likely vegetation indicator that best correlates with biomass. In the current study, stratified random sampling was employed to estimate biomass in the Sindhudurg district. There was a substantial link between biomass and vegetation indices (Das & Singh, 2012).

3. Material and Methods

3.1 Study Area

The study area of our research is abundant and non-abundant roadside areas of Kandow and Bahadur Sar regions in Shangla. Shangla district is located between 34°31' to 33°08' North latitudes, and 72°33' to 73°01' East longitudes. Shangla district is bounded on the northeast by Datagram district and on the southeast by Kala Dhaka district, on the west by swat and on the south by Bunker district and is located western of Himalayan and eastern to Hindukush. The Kandow and Bahadur Sar regions are located at western extremities of the Himalayan and eastern Hindukush Mountain series, generally termed as Hindu-Himalayas, in the Khyber Pakhtunkhwa province of Pakistan. The Kandow region is located in 35°0' 0'' on the north and 72° 41' 24'' on the east. Temperature is between 20 and 30°C from June to August, and between 0 and 10°C from December to February. The study site of Kandow region is comprises of ground vegetation in which *Trifolium repens* and grass is abundant in nature and also there are many other species. While the study area of Bahadur Sar is composed of homogeneous ground vegetation in which *Rumex*, grass and *Trifolium* is abundant and also there are many other ground vegetation and Bahadur Sar is located at N=34°58'04'' and E=72°41'10'' about 2911m above sea level as shown in figure 1.

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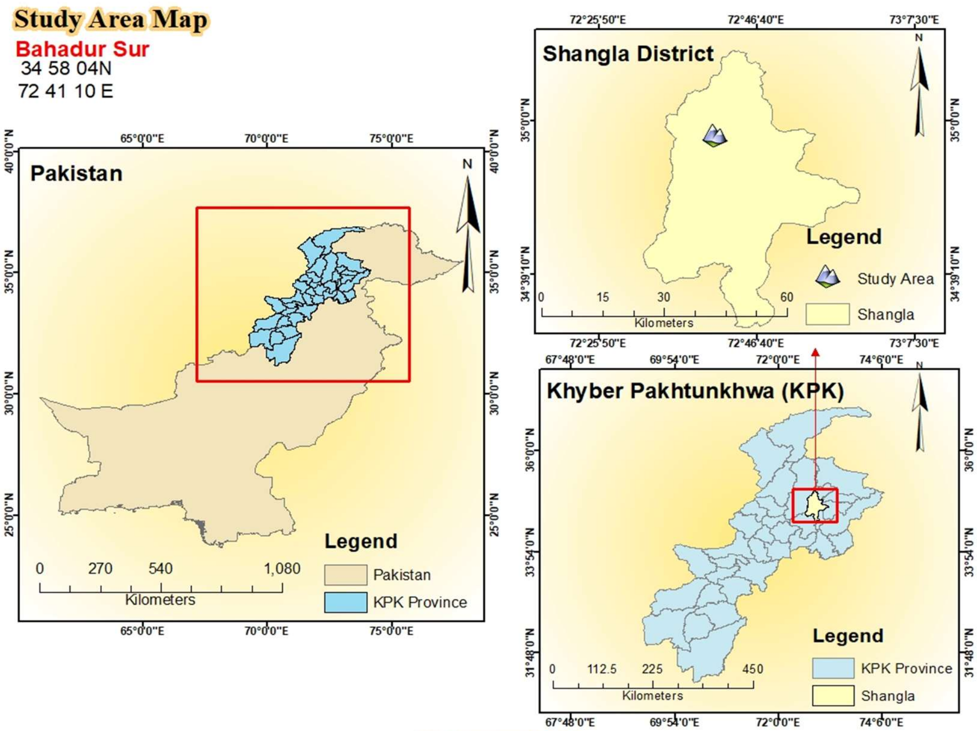
Figure 1
Map of Study Area



3.2 Meteorological Data

Temperature in Kandow is between 20 and 30°C from June to August, and between 0 and 10°C from December to February. It means severe cold in winter and moderate in summer. In comparison to lower-lying places, higher elevations such as the peaks of the Hindu Kush Mountains experience colder temperatures and greater snowfall. The elevation of Kandow region is about 2672 meter and that of Bahadur Sar is about 2803 meter. Snowfall generally starts at the end of November on the top of the high hills and continues till February and may, while the rainfall occurs in every month from January to December.

Table 3.1
Meteorological Data

Months	Minimum	Monthly Maximum	Millimeter	Humidity %
January	-2.4	11.2	111.4	69.7
February	-1.3	12.1	172.6	69.2
March	3.1	16.2	242.2	66.4
April	7.7	22.4	167.9	57.4
May	11.6	27.6	88	47.9
June	15.7	32.5	51.3	41.7
July	19.3	31.4	145.7	60.3
August	18	30.2	159.8	69.2
September	13.6	29	81.8	64.1
October	7.6	25	53.7	59.5
November	2.5	19	50.7	59.5
December	-0.9	13.8	90.7	67.4

Source: District Census report of Shangla, July 2000.

3.3 Research Design

3.3.1 Selection of Study Area. The study area was selected in the grassland of Shangla. The site was completely covered with grass and herbs. We select the site randomly because there is grassland all over the region.

3.3.2 Site Selection for Study. We select two sites for study abandoned and non-abandoned roadsides in Bahadur Sar and the Kandow region in Shangla district. The elevation ranges about 2803m and 2672m above sea level.

3.3.3 Method of Data Collection. We collect data by using quadrate method in both the abandoned and non-abandoned roadsides. A total of 100 plots were taken at 5m distance, in each site 50 sample plots were taken for finding the vegetation at there.

Instruments Used in Data Collection:

1. **GPS:** For finding coordinates, elevation, and orientation.
2. **Clinometers:** Used for measuring the slope.
3. **Scissor:** For cutting the vegetation sampling.
4. **Polythene bags:** Used for storing the vegetation samples.
5. **Weight balance:** Use for finding fresh and dry weight.
6. **Note book:** Used for note the vegetation structure inside the quadrate i.e. density, cover etc. also use for note the coordinate and orientation, slope of the area.
7. **Quadrate:** 1m² in size used for finding density, frequency, cover etc.

3.4 Field Sampling

The study was carried out in the summer season of the year in the month of July and the data was collected through 1m² Quadrate using line transit quadratic method. Using the line transect method, one hundred sample plots of vegetation were placed. A GPS device was used to measure elevation. Paper bags were used for plants collection to calculate wet and dry weight to determine biomass of species. All plants in the herbarium were sampled, and samples were identified at the University of Peshawar's Department of Botany. Herbarium collections of the *Cyperus rotundus, Thymus linearis, Narcissus poeticus, Medicago lupulina, Plantago himalaica, Artemisia vulgaris, Bergenia ciliata* and *Athyrium filix-femina* were made for conformation.

3.5 Plot Description

As we did research in two areas of Shangla district, the Bahadur Sar and Kandow region, having elevation of about 2803 and 2672m above sea level. Both sites have different slope, the upward and downward slope in Bahadur Sar region was 26 and -16, and in Kandow 24 and -15.

The temperature of both the sites are little bit change as the current temperature of Kandow region is 21°C and in Bahadur Sar is about 23°C. The mean annual temperature of both of the sites are same 20 to 30°C in summer and -5 to -15°C in winter as shown in Table 3.2.

Table 3.2

Plot Description

	Kandow Region		**Bahadur Sar**
Quadrants	N=35.0001	E=72.6901	N=34.9858541 E=72.6956835
Slope	Upward= 27	Downward=-15	UP=26 D= -16
Temperature	21°C		23°C
Elevation	2672m		2803m

3.6 Data Collection

We collect different data for the analysis of density, cover, frequency, composition, biomass, and carrying capacity of vegetation. Data was through one meter² quadrate which consists of 100 grids and each grid represents 1 percent. This data was comprised of frequency, cover, and wet and dry weight through directs method.

3.7 Statistical Analysis

Our study is to calculate frequency, density, cover, relative density, relative cover, biomass, carrying capacity IVI of the roadsides vegetation in the selected study areas.

Firstly, the vegetation cover is calculated by visual observation and it is represented in percentage. And the relative frequency is calculated by formula:

Relative cover = cover of each species × 100 / total cover of all species

Frequency is simply calculated through quadrate as we know that there are 100 grids in 1m² quadrate so 1 grid represents 1 percent frequency. And the relative frequency was calculated by formula. The following are the formulas for calculating the different parameters.

Relative frequency = frequency of a species × 100 / total frequency

Biomass is calculated by finding weight of all the species in study areas through weight balance. And the dry weight is calculated after completely dry through air. The moisture is removed through air dry process by kept it on the ground for direct sunlight. And the average biomass is calculated through formula:

Dry biomass / wet biomass × 100

Density is simply finding through calculating the numbers of plant species in a respective quadrate. And the relative density is calculated through the formula:

Relative density = density of a species × 100 / sum of density of all the species

3.8 Limitations and Problems in Both Study Areas

Short Growing Season: Both the sites have short growing season there for we conducted our research in the month of July.

Threats from Wild Animals: Wild animals were present in the study area, and open camping in such areas or night stay in camps are little bit dangerous.

Data Collection Challenges: In high elevation limited infrastructure and logistics, it's difficult to preserve samples.

No Proper Management: There is no proper management system for grazing i.e., rotational grazing and also for watershed management.

Not Accessible: There is no proper access road because of very high elevation.

Less Availability of Resources: The resources such as food, clean water was very less.

4. Results

Our main objective of the study is to calculate cover, density, frequency and IVI of the vegetation along the roadsides in the two selected sites to calculate different parameters such as biomass and carrying capacity etc.

4.1 Cover and Relative Cover

In Kandow, the dominant specie was the *Cyperus rotundus* L and the less area covered by *Aquilegia vulgaris*. *Trifolium repens* L, *Rumex dentatus*, *Fragaria nobicula* Hook.f, *Medicago lupulina*, *Conyza newii* Oliv were also covered a large area. The detail of which is given in the Table 4.1.

Table 4.1

Cover and Relative Cover of Vegetation in Kandow/50 Plots

Species	Total Cover	Relative Cover %
Trifolium repens	820	24.4047619
Rumex dentatus	818	24.3452381
Cyperus rotundus	1423	42.35119048
Fragaria nobicula	170	5.05952381
Medicago lupulina	115	3.422619048
Conyza newii oliv	4	0.119047619
Aquilegia vulgaris	10	0.297619048
Total	**3360**	**100**

While, at Bahadur Sar site, the dominant specie was the *Cyperus rotundus* having a cover percentage of 645 and that of relative cover 18.08749299 while the less area was covered by *Indigofera heterantha* having cover of 50 and relative cover is 1.402131239. The detail of which is given in the Table 4.2.

Table 4.2

Vegetation Cover at Bahadur Sar/50 Plots

Species	Total Cover	Relative Cover
Fragaria nobicula	293	8.216489063

Species	Total Cover	Relative Cover
Plantago himalaica	120	3.365114975
Thymus serpyllum	114	3.196859226
Onnychium crypytogrammoides	335	9.394279305
Aquilegia vulgaris	469	13.15199103
Cyperus rotundus	645	18.08749299
Trifolium repens	153	4.290521593
Indigofera heterantha	50	1.402131239
Conyza newii oliv	127	3.561413348
Ariesima jacquementii	310	8.693213685
Medicago lupulina	230	6.449803702
Chaerophylum vilosum	357	10.01121705
Rumex dentatus	258	7.234997196
Bistorta amphilexicale	105	2.944475603
Total	**3566**	**100**

4.2 Frequency and Relative Frequency

In the respective study area, the maximum frequency is that of the *Cyperus rotundus* specie which was about 1423 and that of the less frequency one was the *Conyza newii oliv* specie. The other species such as *Rumex dentatus*, *Trifolium repens*, *Fragaria nobicula*, *Aquilegia vulgaris* also have a contribution. The total frequency in the area of 50 plots is 3360.

The relative frequency is also maximum for the *Cyperus rotundus* which is 42.35119048 and the minimum is for *Aquilegia vulgaris* which is about 0.297619048.

Table 4.3

Frequency and Relative Frequency at Kandow Site/50 Plots

Species	Frequency	Relative Frequency
Trifolium repens	820	24.4047619
Rumex dentatus	818	24.3452381
Cyperus rotundus	1423	42.35119048
Fragaria nobicula	170	5.05952381
Medicago lupulina	115	3.422619048
Conyza newii oliv	4	0.119047619
Aquilegia vulgaris	10	0.297619048
Total	**3360**	**100**

4.3 Vegetation Frequency in Bahadur Sar Site

In Bahadur Sar, the maximum frequency is 645 which is *Cyperus rotundus* specie and the less frequency occupy by *Indigofera heterantha* which is 50. *Cyperus rotundus* has a maximum relative frequency of 18.08749299 while *Indigofera heterantha* have less relative frequency 1.402131239. A total frequency in 50 plots was about 3566 as shown in the Table 4.4.

Table 4.4

Vegetation Frequency in Bahadur Sar Site/50 Plots

Species	Frequency	Relative Frequency
Fragaria nobicula	293	8.216489063
Plantago himalaica	120	3.365114975
Thymus serpyllum	114	3.196859226
Onnychium crypytogrammoides	335	9.394279305
Aquilegia vulgaris	469	13.15199103
Cyperus rotundus	645	18.08749299
Trifolium repens	153	4.290521593

Species	Frequency	Relative Frequency
Indigofera heterantha	50	1.402131239
Conyza newii oliv	127	3.561413348
Ariesima jacquementii	310	8.693213685
Medicago lupulina	230	6.449803702
Chaerophylum vilosum	357	10.01121705
Rumex dentatus	258	7.234997196
Bistorta amphilexicale	105	2.944475603
Total	**3566**	**100**

4.4 Density and Relative Density at Kandow Site

At Kandow, the maximum density and relative density were recorded for *Cyperus rotundus* which was 4269 and 36.50590046. And the less specie is that of *Conyza newii oliv* which was 8 and 0.068411151. The other species found at there also have a contribution i.e. *Rumex dentatus*, *Cyperus rotundus*, *Fragaria nobicula*, *Aquilegia vulgaris* etc, a total of 50 plots were taken and the total density occupied by vegetation was 11694 as shown in Table 4.5.

Table 4.5

Vegetation Density at Kandow Region/50 Plots

Species	Density	Relative Density
Trifolium repens	2460	21.03642894
Rumex dentatus	3272	27.98016077
Cyperus rotundus	4269	36.50590046
Fragaria nobicula	850	7.268684796
Medicago lupulina	805	6.883872071
Conyza newii oliv	8	0.068411151
Aquilegia vulgaris	30	0.256541816
Total	**11694**	**100**

4.5 Bahadur Sar Vegetation Density

In Bahadur Sar, the maximum density and relative density were recorded for *Cyperus rotundus* which was 3870 and 26.51593. And the less specie is that of *Indigofera heterantha* which was 100 and 0.685166. The other species found at there also have a contribution i.e. *Rumex dentatus, Cyperus rotundus, Fragaria nobicula*, *Aquilegia vulgaris* etc. A total of 50 plots were taken and the total density occupied by vegetation was 14595 as shown in Table 4.6.

Table 4.6

Bahadur Sar Vegetation Density

Species	Density	Relative Density
Fragaria nobicula	1465	10.03768
Plantago himalaica	480	3.288798
Thymus serpyllum	342	2.343268
Onnychium crypytogrammoides	1675	11.47653
Aquilegia vulgaris	1407	9.640288
Cyperus rotundus	3870	26.51593
Trifolium repens	459	3.144913
Indigofera heterantha	100	0.685166
Conyza newii oliv	254	1.740322
Ariesima jacquementii	620	4.24803
Medicago lupulina	1610	11.03118
Chaerophylum vilosum	1071	7.338129
Rumex dentatus	1032	7.070915

Species	Density	Relative Density
Bistorta amphilexicale	210	1.438849
Total	**14595**	**100**

4.6 IVI of Kandow Site

In Kandow site, the highest value of IVI was reported for the *Cyperus rotundus* which is 99.03268889 and the minimum value is the *Aquilegia* specie 0.546384198.

Table 4.7

Kandow Site IVI

S.No	Species	IVI (%)
1	*Trifolium repens*	57.06732599
2	*Rumex dentatus*	56.92813739
3	*Cyperus rotundus*	99.03268889
4	*Fragaria nobicula*	10.98353112
5	*Medicago lupulina*	8.576653238
6	*Conyza newii oliv*	0.198612506
7	*Aquilegia vulgaris*	0.546384198
	Total	**233.3333333**

4.7 IVI of Bahadur Sar Vegetation

In Bahadur Sar, the highest value of IVI was reported for the *Cyperus rotundus* which is 50.63258743 and the minimum value is the *Indigofera heterantha* 2.554674472. The total IVI of 50 plots were 233.33333333 as shown in Table 4.8.

Table 4.8

IVI of Bahadur Sar Vegetation

Species	IVI
Fragaria nobicula	20.99300289
Plantago himalaica	7.7756175
Thymus serpyllum	6.605747211
Onnychium crypytogrammoides	24.0022388
Aquilegia vulgaris	27.1762758
Cyperus rotundus	50.63258743
Trifolium repens	8.865608098
Indigofera heterantha	2.554674472
Conyza newii oliv	6.488873159
Ariesima jacquementii	15.83898173
Medicago lupulina	19.63091333
Chaerophylum vilosum	20.6864189
Rumex dentatus	16.71757762
Bistorta amphilexicale	5.364816391
Total	**233.3333333**

4.8 Biomass

The total biomass of Bahadur Sar was 512g which was calculated from fresh weight of 50 sampling units while the total biomass of Kandow region was 530g. The fresh weight of 50 sample units in Bahadur Sar was reported 1183g and in Kandow it was reported as 1327g. Then from biomass we calculated allowable dry biomass which was 51.2 at Bahadur Sar and at Kandow 265 removing moisture content from vegetation through, while allowable dry air biomass was calculated by multiplying with form factor i.e., 0.5.

4.9 Carrying Capacity

The carrying capacity was measured based on cover of area 3360, proper use factor 0.5, range area 65m² and forage required for one animal unit 270kg. The carrying capacity was reported as 404.4444. The carrying capacity of Bahadur Sar was measured based on cover of area 3571, proper use factor 0.5, range area 65m² and forage required for one animal unit 270kg. The carrying capacity was reported as 429.

5. Discussion

5.1 Anthropogenic Pressure on Vegetation in Kandow Region

The findings show that there is significant anthropogenic pressure on the vegetation in the non-abundant area (Kandow) region. This pressure may be brought on by factors such as an increase in human and livestock populations, poverty, a lack of awareness, inadequate education, and seasonal use, which led to overexploitation and degradation of the native vegetation. While this pressure is less in roadside areas in Bahadur Sar region because of less human population.

5.2 Impact of Grazing on Species Composition and Biomass

Grazing animals have an impact on species composition, biomass change, and biodiversity distribution. Khan and Qureshi (2011) states in his study that, good cover percentage in the upper zone was due to high elevation and less number of livestock calculated from a survey conducted in the watershed, that's why the range in this zone is in very good condition with carrying capacity of 1.87 ha/AU/4month, while in the lower zone the cover was with lowest value due to more livestock pressure for grazing and the range is in fair to good condition with carrying capacity of 3.29 ha/AU/4month. Another factor is the dependence of local people on natural resources.

5.3 Methodology: Line Transect Quadrate Method

We carried out a line transect quadrate method of sampling. Canfield (1941) in his study states that, the line interception method presented below was designed for determining the density and composition of herbaceous plants and shrubs. It is mostly based on the line transect. It does, however, include a new technique for getting a vegetation inventory using line measuring of individual plants on a randomly selected sample. It seems to provide a feasible, quick, and statistically sound method for sampling vegetation on vast and small range areas, as well as small patches employed in detailed and extensive studies.

5.4 Sampling Design and Plot Characteristics

A quadrate size is 1m². And we took different samples in both the abundant and non-abundant roadsides areas. In non-abundant Kandow region we took 50 sample plots. The space between each sample plot was 5m. Each sample plot is consisting of different vegetation and for each sample plot we measured different characteristics for e.g., density, cover, frequency, IVI.

5.5 Dominant Species and Vegetation Cover Distribution

Result revealed that the *Cyperus rotundus* were dominating in the area with reference cover (1423) in non-abundant and (645) in abundant roadside vegetation followed by other vegetation having a total of (3360) and (3566) in both the sites. Good cover percentage in the upper zone was due to high elevation and a smaller number of livestock, that's why the range in this zone is in very good condition with a carrying capacity of (429.8426), while in the lower zone (Kandow region) the cover was with lowest value due to more livestock pressure of grazing and the range is in fair to good condition with carrying capacity of (404.4444).

5.6 Species Frequency and Environmental Suitability

As a result of study, the specie density (plant/100m²), specie frequency (%), cover (%) carrying capacity and biomass were determined. Survey was done in the month of July 2023. The overall results show that the frequency of *Trifolium repens*, *Cyperus rotundus*, and *Plantago himalaica* were found the highest rate because the condition in the study area were suitable to these species i.e., these species prefer temperature in between 20°C to 30°C and full sunlight. These species grow well in moist condition and in well-drained soil, while the specie *Rumex dentatus* found very less in the study area because the condition in the study area were not favourable for the mentioned species, as it does not grow well in full sun light and it could not bear very cold or hot temperature as well.

5.7 Local Population Dependency and Deforestation

Another factor is the local population means dependency of local people on natural resources. As the population have a great dependency on forest resources, so the vegetation density is lesser in the lower zone as compared to the upper zone because of deforestation and grazing activities and livestock rearing. When we compare different vegetation characters then the lower zone is facing more grazing pressure and deforestation as indicated by less cover percentage, low density and low carrying capacity. Khan et al. (2012) in his study states that, the main reasons for deforestation in Kabul valley are fuel wood extraction, timber wood extraction, occasional fires and clearing of forest for terrace cultivation. Deforestation is the forerunner of many associated and subsequent ecological problems which ultimately merges with the socioeconomic problems.

6. Conclusion

The main objective of our study is to find out the frequency, cover, density, species composition, biomass etc. of the underground vegetation of the sites. During our research, we observed that some species were widespread in the study area because they are adapted to the climate and habitat, while some were in small numbers because the majority of the region was open to direct sunlight and the species preferred partial shade and sunlight.

The carrying capacity was measured based on cover of area 3360, proper use factor 0.5, range area 65m² and forage required for one animal unit 270kg. The carrying capacity was reported as 404.4444.

The biomass was calculated by weighting the vegetation of both the sites which was about 512g in Bahadur Sar and 530g in Kandow and the dried biomass was calculated by drying the fresh weight of the vegetation, simply by removing the moisture content through air dry method.

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Conflict of Interests

The authors declare no conflict of interests.

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Data Availability

The datasets generated during and analysed during the current study are available from the corresponding author on reasonable request.

References

Ahmad, S. S. (2009). Ordination and classification of herbaceous vegetation in Margalla Hills National Park Islamabad Pakistan. *Biological Diversity and Conservation, 2*(2), 38–44.

Bedunah, D. J., & Angerer, J. P. (2012). Rangeland degradation, poverty, and conflict: How can rangeland scientists contribute to effective responses and solutions? *Rangeland Ecology & Management, 65*(6), 606–612. https://doi.org/10.2111/REM-D-11-00155.1

Canfield, R. H. (1941). Application of the line interception method in sampling range vegetation. *Journal of Forestry, 39*(4), 388–394. https://doi.org/10.1093/jof/39.4.388

Das, S., & Singh, T. (2012). Correlation analysis between biomass and spectral vegetation indices of forest ecosystem. *International Journal of Engineering Research and Technology, 1*(5), 1–13.

Goodall, D. W. (1952). Some considerations in the use of point quadrats for the analysis of vegetation. *Australian Journal of Biological Sciences, 5*(1), 1–41. https://doi.org/10.1071/BI9520001

Hammi, S., Simonneaux, V., Cordier, J. B., Genin, D., Alifriqui, M., Montes, N., & Auclair, L. (2010). Can traditional forest management buffer forest depletion? Dynamics of Moroccan High Atlas Mountain forests using remote sensing and vegetation analysis. *Forest Ecology and Management, 260*(10), 1861–1872. https://doi.org/10.1016/j.foreco.2010.08.033

Hussain, F., & Ilahi, I. (1991). *Ecology and vegetation of lesser Himalayas Pakistan*. Department of Botany, University of Peshawar.

Hussain, W., Badshah, L., & Ali, A. (2019). Quantitative aspects of the Koh-e-Safaid range vegetation across the altitudinal gradient in upper Kurram Valley, Pakistan. *Applied Ecology & Environmental Research, 17*(4).

Ilyas, M., Qureshi, R., Akhtar, N., Munir, M., & Haq, Z. (2015). Vegetation analysis of Kabal valley, district Swat, Pakistan using multivariate approach. *Pakistan Journal of Botany, 47*, 77–86.

Iqbal, M., Iftikhar, M., Ahmad, M. S. A., Hameed, M., Noreen, A., Ikram, M., Muneeb, A., & Ahmad, I. (2016). Vegetation dynamics of anthropogenically disturbed ecosystem in hilly areas around Sargodha, Pakistan. *International Journal of Agriculture & Biology, 18*(4).

Khan, I., & Qureshi, R. (2011). Vegetation analysis and winter season carrying capacity of sub-tropical, sub humid rangelands of Dhrabi watershed, Pakistan. *Pakistan Journal of Botany, 43*(3), 1669–1672.

Khan, S. M., Page, S., Ahmad, H., & Harper, D. (2012). Anthropogenic influences on the natural ecosystem of the Naran Valley in the western Himalayas. *Pakistan Journal of Botany, 44*, 231–238.

Khan, W., Khan, S. M., Ahmad, H., Alqarawi, A. A., Shah, G. M., Hussain, M., & Abd-Allah, E. (2018). Life forms, leaf size spectra, regeneration capacity and diversity of plant species grown in the Thandiani forests, district Abbottabad, Khyber Pakhtunkhwa, Pakistan. *Saudi Journal of Biological Sciences, 25*(1), 94–100.

Lepš, J., & Hadincová, V. (1992). How reliable are our vegetation analyses? *Journal of Vegetation Science, 3*(1), 119–124. https://doi.org/10.2307/3236006

Lumbres, R. I. C., Palaganas, J. A., Micosa, S. C., Laruan, K. A., Besic, E. D., Yun, C.-W., & Lee, Y.-J. (2014). Floral diversity assessment in Alno communal mixed forest in Benguet, Philippines. *Landscape and Ecological Engineering, 10*, 361–368.

Majeed, M., Khan, A. M., Habib, T., Anwar, M. M., Sahito, H. A., Khan, N., & Ali, K. (2022). Vegetation analysis and environmental indicators of an arid tropical forest ecosystem of Pakistan. *Ecological Indicators, 142*, 109291.

Mataji, A., Moarefvand, P., Kafaki, S. B., & Kermanshahi, M. M. (2010). Understory vegetation as environmental factors indicator in forest ecosystems. *International Journal of Environmental Science & Technology, 7*, 629–638.

McDougall, K. L., Lembrechts, J., Rew, L. J., Haider, S., Cavieres, L. A., Kueffer, C., Milbau, A., Naylor, B. J., Nuñez, M. A., & Pauchard, A. (2018). Running off the road: Roadside non-native plants invading mountain vegetation. *Biological Invasions, 20*, 3461–3473. https://doi.org/10.1007/s10530-018-1787-z

Motamedi, J., Alilou, F., Sheidai Karkaj, E., Keivan Behjou, F., & Goreishi, R. (2013). Investigation on relationship environmental factors and grazing intensity with vegetation cover in Khoy rangeland ecosystems. *Journal of Plant Ecosystem Conservation, 1*(3), 73–90.

Pourrezaei, J., Khajeddin, S. J., Karimzadeh, H. R., Vahabi, M. R., Mozaffarian, V. A., & Esfahani, M. T. (2017). Phytogeographical distribution of roadside flora along the plain to mountainous natural areas (Northern Khorasan Province, Iran). *Flora, 234*, 92–105. https://doi.org/10.1016/j.flora.2017.07.002

Rahman, A. F., Gamon, J. A., Sims, D. A., & Schmidts, M. (2003). Optimum pixel size for hyperspectral studies of ecosystem function in southern California chaparral and grassland. *Remote Sensing of Environment, 84*(2), 192–207. https://doi.org/10.1016/S0034-4257(02)00107-4

Ramsay, D. (1993). *Roads and nature conservation*. English Nature.

Sher, H., Ahmad, A., Eleyemeni, M., Fazl-i-Hadi, S., & Sher, H. (2010). Impact of nomadic grazing on medicinal plants diversity in Miandam, Swat-Pakistan (Preliminary results). *International Journal of Biodiversity and Conservation, 2*(6), 146–154.

Shinwari, Z. K., & Qaiser, M. (2011). Efforts on conservation and sustainable use of medicinal plants of Pakistan. *Pakistan Journal of Botany, 43*(1), 5–10.

Siddiqui, M. F., Arsalan, A., Ahmed, M., Hussain, M., Iqbal, J., & Wahab, M. (2016). Assessment of understorey vegetation of Malam Jabba Forest, KPK after cleanup operation using multivariate techniques. *Jurnal Teknologi, 78*, 9–17.

Svoray, T., Perevolotsky, A., & Atkinson, P. M. (2013). Ecological sustainability in rangelands: The contribution of remote sensing. *International Journal of Remote Sensing, 34*(17), 6216–6242. https://doi.org/10.1080/01431161.2013.793867

Tamartash, R., Yousefian, M., Tatian, M. R., & Ehsani, M. (2010). Vegetation analysis in rangelands of Lasem, Iran. *Agriculture and Environment Science, 7*, 397–401.

Waheed, M., Arshad, F., Majeed, M., Fatima, S., Mukhtar, N., Aziz, R., Mangrio, W. M., Almohamad, H., Al

Dughairi, A. A., & Al-Mutiry, M. (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. https://doi.org/10.3390/land11122145

Yang, Y.-C., & Da, L.-J. (2006). A brief review of studies on differentiation of vegetation pattern along a topographic gradient in hilly regions. *Chinese Journal of Plant Ecology, 30*(3), 504.

Zeb, S. A., Khan, S. M., Ahmad, Z., & Abdullah. (2021). Phytogeographic elements and vegetation along the river Panjkora—Classification and ordination studies from the Hindu Kush Mountains range. *The Botanical Review*, 1–25.