

Soil Properties and Vegetation Dynamics: Interactions Shaping Angiosperm Diversity in the Pasturelands of Mavli Block, Udaipur, Rajasthan

Mohan Singh Rathore¹, Kiran Nagda²

Department of Botany
Bhupal Nobles' University
Udaipur, Rajasthan, India.

Abstract:

Pasturelands in semi-arid regions like Rajasthan are critical for biodiversity conservation and rural livelihoods, yet they face degradation from overgrazing, climate variability, and invasive species. This study investigates soil-vegetation interactions in five pastureland sites (Naharmagra, Salera Kala, Bheemaal, Mavli Village, and Namri) in Mavli Block, Udaipur district, Rajasthan. Soil properties—nitrogen (N), phosphorus (P), water holding capacity (WHC), pH, and organic carbon (OC)—were analyzed across seasons (Rainy 2022, Summer 2022, Rainy 2023), alongside vegetation sampling using quadrats to assess species composition, density, frequency, and ecological indices (Shannon-Weaver Diversity Index H' , Simpson Dominance Index D , Species Evenness e). Results reveal significant seasonal peaks in soil fertility during rainy seasons (e.g., N up to 320 kg/ha in Mavli Village), correlating with higher vegetation density. However, high fertility sites like Mavli Village showed low diversity ($H' = 1.587$) due to invasive dominance (*Parthenium hysterophorus* RD: 46.63%), while nutrient-poor Bheemaal exhibited high diversity ($H' = 1.943$) and evenness ($e = 0.843$). *Cynodon dactylon* dominated across sites (RD: 24.87–51.87%), underscoring its role in soil stabilization. Findings highlight the need for site-specific management: invasive control in fertile areas and nutrient enrichment in degraded ones. This research provides insights for sustainable pasture management in semi-arid ecosystems.

Keywords: Soil properties, Angiosperm diversity, Pasturelands, Mavli Block, Invasive species, Ecological indices.

1. INTRODUCTION

The biosphere is undergoing rapid changes due to human activities, with biodiversity loss accelerating from habitat destruction and unsustainable exploitation (CBD, 2006). Rajasthan, India's largest state, boasts rich plant diversity owing to varied climates, soils, and habitats, ranging from arid deserts to semi-arid grasslands. The Udaipur region, including Mavli Block, is noted for its floristic diversity, supported by tropical climates and cultural significance of plants. Angiosperms, comprising nearly 90% of terrestrial plants (approximately 350,000 species), are vital for ecosystem services like primary productivity, soil stabilization, and nutrient cycling.

In semi-arid pasturelands, soil-vegetation interactions are pivotal, as soil properties influence plant composition and diversity. Grazing pressure, seasonal rainfall variability, and invasives like *Parthenium hysterophorus* exacerbate degradation. Despite Rajasthan's pasturelands covering 10–15% of its area, studies on soil-vegetation dynamics are limited. This research addresses this gap by examining how soil parameters (N, P, WHC, pH, OC) shape angiosperm diversity in Mavli Block's pasturelands.

Objectives:

1. Assess spatial and seasonal variations in soil properties.
2. Evaluate vegetation composition and ecological indices.
3. Analyze soil-vegetation interactions and implications for management.

2. MATERIALS AND METHODS

2.1 Study Area

Mavli Block (24.58°N–24.90°N, 73.55°E–73.85°E) in Udaipur district features a semi-arid climate with 600–800 mm annual rainfall, hot summers (>40°C), and mild winters. Soils are sandy loam to clayey loam, supporting tropical dry deciduous vegetation including *Acacia senegal*, *Prosopis juliflora*, and *Azadirachta indica*. Five sites were selected: Naharmagra (S1), Salera Kala (S2), Bheemaal (S3), Mavli Village (S4), and Namri (S5), representing varied topography and grazing intensity.

2.2 Data Collection

Soil Sampling: Samples were collected from 0–15 cm depth across seasons. N was measured via Kjeldahl method, P by Olsen's method, WHC gravimetrically, pH electrometrically, and OC by Walkley-Black method.

Vegetation Sampling: Five 1 m² quadrats for herbs/grasses and 25 m² for shrubs/trees per site. Parameters: density, relative density (RD), frequency, relative frequency (RF), abundance. Species identified using regional floras.

Ecological Indices:

- $H' = -\sum (p_i \ln p_i)$, where p_i is species proportion.
- $D = \sum (n_i/N)^2$, where n_i is individuals of species i , N total individuals.
- $e = H'/\ln S$, where S is species richness.

2.3 Data Analysis

ANOVA tested site/seasonal differences; Pearson correlations analyzed soil-vegetation links. Analyses used SPSS.

3. RESULTS

3.1 Soil Properties Across Sites and Seasons

Soil parameters varied significantly ($p < 0.05$). Rainy seasons showed peaks: Mavli Village (S4) had highest N (320 kg/ha, Rainy 2023), P (34 mg/kg), WHC (27%), OC (1.3%), and slightly acidic pH (5.9). Bheemaal (S3) recorded lowest: N (180 kg/ha, Summer 2022), P (13 mg/kg), WHC (13%), OC (0.4%), neutral pH (7.0). Moderate values in S1, S2, S5 (N: 245–295 kg/ha, P: 19–31 mg/kg, WHC: 19–25%, OC: 0.7–1.1%, pH: 6.1–6.9). Year-on-year OC increased ~0.1% across sites, indicating recovery (Table 1).

Table 1: Summary of Soil Properties (Average Across Seasons)

Site	N (kg/ha)	P (mg/kg)	WHC (%)	pH	OC (%)
S1 (Naharmagra)	260	25	22	6.5	0.9
S2 (Salera Kala)	245	19	19	6.1	0.7
S3 (Bheemaal)	210	15	15	6.8	0.5
S4 (Mavli Village)	295	31	25	6.2	1.1
S5 (Namri)	270	27	23	6.9	0.9

Seasonal trends: Rainy > Summer, with 20–30% nutrient/WHC increase in monsoons.

3.2 Vegetation Composition

Ten species per site, mix of grasses (e.g., *Cynodon dactylon*, *Cenchrus setigerus*), herbs (e.g., *Parthenium hysterophorus*, *Tridax procumbens*), shrubs (e.g., *Lantana camara*, *Ziziphus nummularia*). *Cynodon dactylon* dominant (density: 17.2–24.4 ind/m², RD: 41.38–51.87%). *Parthenium hysterophorus* high in S4 (density: 18 ind/m², RD: 46.63%). S3 had five constant species (100% frequency) (Table 2).

Table 2: Dominant Species and RD (%) Across Sites

Species	S1	S2	S3	S4	S5
<i>Cynodon dactylon</i>	49.59	41.75	41.38	24.87	51.87
<i>Parthenium hysterophorus</i>	15.85	29.13	10.00	46.63	-
<i>Cenchrus setigerus</i>	16.26	-	11.72	-	17.76
<i>Lantana camara</i>	2.44	4.85	0.69	7.77	3.27

3.3 Ecological Indices

S3 highest H' (1.943), e (0.843), lowest D (0.262). S4 lowest H' (1.587), e (0.689), highest D (0.352). Moderate in others (H' : 1.684–1.768) (Table 3).

Table 3: Ecological Indices

Site	H'	D	e
S1	1.732	0.316	0.752
S2	1.684	0.325	0.731
S3	1.943	0.262	0.843
S4	1.587	0.352	0.689
S5	1.768	0.300	0.768

3.4 Soil-Vegetation Relationships

Positive correlations: WHC/OC with grass density ($r = 0.72-0.85$, $p < 0.01$). High N/P in S4 correlated with invasive RD ($r = 0.68$). Low nutrients in S3 with high H' ($r = -0.62$ for N vs. H'). Acidic pH in S4 linked to reduced evenness.

4. DISCUSSION

4.1 Soil Properties and Vegetation Dynamics

High soil fertility in S4 (N: 295 kg/ha, P: 31 mg/kg) favored invasives like *Parthenium hysterophorus*, reducing diversity via competitive exclusion (Tilman et al., 1996). Nutrient enrichment likely boosted invasive growth, aligning with studies on grassland invasions (Hector et al., 1999). Conversely, S3's low fertility (N: 210 kg/ha) limited invasives, promoting native species coexistence and high diversity, as low resources reduce dominance (Naeem et al., 1994).

Seasonal patterns: Rainy peaks in WHC/OC enhanced nutrient availability, supporting dense *Cynodon dactylon* (density up 20–30%), vital for erosion control. Summer declines stressed vegetation, favoring drought-tolerant species. Year-on-year OC gains suggest resilience, possibly from reduced grazing or better rains. pH variations: Acidic in S4 (6.2) may increase nutrient availability but stress natives, while neutral in S3 (6.8) supports broader diversity.

4.2 Ecological Implications

Cynodon dactylon dominance underscores its adaptability, stabilizing soils and aiding grazing (Katewa & Sharma, 1998). Invasives like *Lantana camara* indicate woody encroachment from overgrazing, altering structure (Gupta & Saxena, 1972). High evenness in S3 reflects balanced communities under stress, per resource utilization theories (Tilman, 1997).

Comparative: Similar to Aravalli Hills grasslands, where overgrazing reduces phytosociology (Katewa, 1996). Soil-vegetation links echo global patterns, where fertility gradients shape biodiversity (Reich et al., 2001).

4.3 Management Implications

Site-specific strategies: Invasive control (manual removal, biocontrol) in S4; nutrient amendments (compost) and mulching in S3 for forage boost. Rotational grazing to curb encroachment, promote grasses. Community involvement, as in FES restorations, integrates local knowledge for sustainability. Monitor pH via liming to prevent deficiencies. These enhance biodiversity, carbon sequestration (OC up to 1.3%), and livelihoods in Mavli's agro-pastoral economy.

5. CONCLUSION

This study demonstrates that soil properties profoundly influence angiosperm diversity in Mavli Block's pasturelands. High fertility drives invasive dominance and low diversity, while nutrient scarcity fosters resilient native communities. Seasonal moisture amplifies these dynamics, with *Cynodon dactylon* emerging as a keystone species. Recommendations include invasive management in fertile sites, fertility enhancement in degraded ones, and rotational grazing for sustainability. Integrating scientific and traditional approaches can restore these ecosystems, supporting biodiversity and rural prosperity in semi-arid Rajasthan. Future research should explore long-term climate impacts and restoration efficacy.

REFERENCES:

1. CBD. (2006). Global Biodiversity Outlook 2. Convention on Biological Diversity.
2. Gupta, R. K., & Saxena, S. K. (1972). Potential grassland types and their ecological successors in Rajasthan desert. *Annals of Arid Zone*, 11(3), 198-218.

3. Hector, A., et al. (1999). Plant diversity and productivity experiments in European grasslands. *Science*, 286(5442), 1123-1127.
4. Katewa, S. S. (1996). Ecology of grazing lands in Aravali hills of Southeast Rajasthan. Ph.D. Thesis, M.L. Sukhadia University, Udaipur.
5. Katewa, S. S., & Sharma, R. (1998). Effects of overgrazing on phytosociology of grassland ecosystem in Aravali hills of Rajasthan. *Journal of Environmental Biology*, 19(4), 325-330.
6. Naeem, S., et al. (1994). Declining biodiversity can alter the performance of ecosystems. *Nature*, 368(6473), 734-737.
7. Reich, P. B., et al. (2001). Plant diversity enhances ecosystem responses to elevated CO₂ and nitrogen deposition. *Nature*, 410(6830), 809-812.
8. Tilman, D. (1997). Community invasibility, recruitment limitation, and grassland biodiversity. *Ecology*, 78(1), 81-92.
9. Tilman, D., et al. (1996). Productivity and sustainability influenced by biodiversity in grassland ecosystems. *Nature*, 379(6567), 718-720.