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Assessing seasonal shifts in vegetation composition using important value index (IVI)

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Abstract
Understanding of seasonal changes in vegetation is key to assessment of ecosystem structure and function in arid and semi-arid areas. In the present study we look at the seasonal change in plant community composition which we looked at using the Important Value Index in the Taranagar region of Churu district. We chose 11 sampling sites which we studied before and after the monsoon season. Quantitative parameters such as frequency, density and abundance were measured and IVI used for evaluation of species dominance. We found that which species dominated and which species made up the community changed by season. Drought tolerant species like *Verbesina encelioides, Aerva persica* and *Calotropis procera* had higher IVI values in the pre-monsoon season which we take as an indication of their adaptation to low moisture conditions. In that which followed the monsoon post monsoon we saw an increase in the dominance of species like *Aerva persica, Calotropis procera* & *Prosopis cineraria* which in turn is an indication of better growth conditions due to the rain. Also, we noted great variation in IVI values between species some which had large scale improvement in dominance, some which did not do as well or at all and which in the end did not even show up in the next season which indicates a seasonal shift. The study also underlined the ecological significance of herbaceous plants in semi-arid conditions by highlighting the spatial variance among sites and their abundance. The observed fluctuations in vegetation form and species composition are largely determined by seasonal rainfall and other environmental conditions.
Overall, the finding offers worthwhile knowledge regarding the dynamics of plant communities and ecological adaptability in arid areas. The study gives baseline data for biodiversity conservation, ecological monitoring and sustainable land management in semi-arid conditions.

Keywords: IVI, vegetation dynamics, seasonal variation, plant community, Rajasthan, biodiversity

Introduction

Plants are the foundation of life on land. They show how weather, soil and live beings all interact together and affect one another. Understanding the structure and organization of plant communities is vital to knowing about biodiversity trends, ecological stability and ecosystem functioning. In phytosociological assessments, measures such as Frequency (how often a plant occurs), Density (how many plants are in a space), Dominance (how much room they take up) are widely employed to define species distribution. However, the Important Value Index (IVI) gives a more thorough assessment by incorporating these traits into a single quantitative measure of species value within a community (Curtis & McIntosh, 1950) [3].

Seasonal fluctuation is one of the greatest things that determine how plants develop and alter. This is especially true in dry locations, like deserts, where the weather and environment can change a lot during the year. Changes in rain patterns, temperature and soil moisture which in turn affect how plants grow, reproduce and survive. Because the environmental circumstances constantly changing, the species of plant life in a habitat as well as the dominating plants in such a habitat keep changing (Singh & Singh, 1992) [13]. These seasonal fluctuations are quite clear to notice in dry locations. To survive, the plants there have developed adaptive techniques such as sleep during dry periods (dormancy), some grow and make seeds very quickly when it rains (rapid life cycle) and others, referred to as drought resistant capacity, are built to tolerate protracted drought conditions (Mueller-Dombois & Ellenberg, 1974) [7].

The north-western region of Rajasthan, notably the Churu district, displays a typical semi-arid ecosystem represented by sandy plains, low and unpredictable precipitation, and harsh temperature regimes. The Taranagar region supports a variety of xerophytic vegetation, including drought-tolerant shrubs, ephemeral herbs and sparsely dispersed trees adapted to extreme weather conditions (Forest Survey of India, 2021) [4]. The area is exceptionally well-suited for investigating vegetation dynamics and species resilience to environmental stress because of these biological characteristics. In the Thar Desert region, vegetation is often sparse and dominated by xerophytic species, with great spatial and temporal heterogeneity across sites (Sharma, 2003; Bhandari, 1990) [1, 11, 12].

Although various studies have recorded the varieties of plants and how local people use them in the dry areas of Rajasthan, relatively few have really quantified the plant life across different seasons. Most present research depends on single-time observations; hence, they may miss how the plant groups vary throughout the year. Also, there have been relatively few research on the seasonal fluctuations of Important Value Index (IVI) within short periods of time, particularly at small-scale levels that involve numerous study sites. This is an essential subject that has been overlooked by most researchers and deserves additional exploration.

In this respect, the current study was carried out at the Taranagar region of Churu district, where a total of eleven study sites were methodically selected to represent spatial variability. By comparing vegetation data collected over two unique seasonal periods within one year, this study employs the Important Value Index (IVI) to analyse changes in the composition and organization of plant communities.

The specific objectives are-

1. To quantify phytosociological features of plant species across specified locales.
2. To evaluate seasonal variations in IVI values.
3. To identify dominant and ecologically significant species during different time periods.

The conclusions of this study are expected to contribute to a deeper understanding of vegetation dynamics in semi-arid environments and to promote biodiversity conservation and sustainable land management techniques.

Study Area

The present study was conducted out in the north-western region of Rajasthan, specifically in the Churu district, which sits within the dry and semi-arid zone of the Thar Desert. The study area primarily covers the Taranagar city & its surrounding regions.

Climate of Churu district is arid to semi-arid with extreme variations in temperature and limited and erratic rainfall. Summers are very hot, with temperatures sometimes rising above 45°C and winters can be very cold, with temperatures sometimes falling near 0°C (India Meteorological Department, 2020) [5]. Average annual rainfall in the region is about 250–350 mm with most of the rains falling during the southwest monsoon period (July to September). The availability of soil moisture and vegetation dynamics are very strongly influenced by high rates of evapotranspiration and prolonged dry periods, which results in a strong seasonal variation in plant growth and species composition.

The soils of the study area are mostly sandy to loamy sand, typical of desert and semi-desert areas. These soils are generally nutrient-poor, permeable, have a low capacity to retain water and contain little organic matter. There are also some areas with saline patches and calcareous layers, these also influence plant distribution and growth patterns (NBSS & LUP, 2012). The edaphic conditions together with climatic stress are strongly influencing the composition and organization of the local vegetation.

Natural vegetation of the study area belongs to the tropical thorn forest and scrub vegetation as classified by Champion and Seth (1968) [2]. The vegetation is characterised by a sparse tree cover with xerophytic shrubs and seasonal growth of herbaceous species, especially during the monsoon period. Common tree species include *Prosopis cineraria*, *Acacia senegal*, and *Salvadora persica*, while shrubs such as *Ziziphus nummularia* and *Capparis decidua* are widely distributed. The herbaceous flora is mainly ephemeral grasses and forbs that quickly spring up after rains.

High turnover of vegetation within the season is observed with a marked increase in species diversity and coverage of the ground during the rainy period and then a decrease during the dry period. These adaptations are an example of the ability of plant communities to endure in difficult environmental conditions where water is scarce (Sharma, 2003) [11, 12].

Materials and Methods

Study Design and Site Selection

The present study was carried out using a comparative seasonal research design to assess variations in vegetation composition & structure. A total of eleven study sites were selected to cover spatial heterogeneity and variability of vegetation. These sites include Sahwa, Kohina, Bhaleri, Satyun, Hadiyal, Jorji Ka Bass, Changoi, Banyan, Dabri, Dheerwas, and Taranagar itself. The sites have been selected keeping in view various physical features, land-use patterns and vegetation characteristics in each of them.

The sites were chosen to represent variation in habitat conditions, land use practices and vegetation types. The fieldwork was done in two different seasons in a year i.e. pre-monsoon season and post-monsoon season to study the changes in plant life through time.

Sampling Method

The vegetation was sampled using the nested quadrat method, which is frequently used in investigations of stratified vegetations (Mueller-Dombois & Ellenberg, 1974) [7]. This approach facilitates the evaluation of trees, shrubs and herbs at once in one sampling plot.

Quadrats of different sizes were used for different vegetation strata:

- **Trees:** 20 m × 20 m
- **Shrubs and Herbs:** 1 m × 1 m (nested within the larger quadrats)

At each study site, a total of 10 quadrats were laid using random sampling to ensure unbiased representation of vegetation. The same quadrats and sampling procedure were maintained during both seasons to ensure comparability of data.

Data Collection

All species of plants within each quadrat were noted and identified using standard regional floras and taxonomic keys. For each species, the following measurements were taken:

- Number of individuals (for density estimation)
- Presence or absence in quadrats (for frequency)
- Number of individuals per occupied quadrat (for abundance)

Field surveys were carried out during the proper growth periods to ensure accurate species identification and documentation.

Phytosociological Analysis

Standard phytosociological techniques were used to quantitatively analyse the vegetation (Curtis & McIntosh, 1950) [3]. The following parameters were calculated:

- Frequency (%) = (Number of quadrats in which a species occurs / Total number of quadrats) × 100
- Density = Total number of individuals of a species / Total number of quadrats
- Abundance = Total number of individuals of a species / Number of quadrats in which the species occurs
- Relative values were calculated as: Relative Frequency (RF), Relative Density (RD), Relative Abundance (RA)
- Important Value Index (IVI)- The ecological significance of each species was determined using the Important Value Index (IVI), calculated as: IVI = RF + RD + RA

This index provides a comprehensive measure of species importance within the plant community and facilitates comparison of vegetation structure across different seasons.

Results

Table 1: Species-wise Phytosociological Table (Pre-Monsoon)

S. No.	Species Name	Total Individuals	Quadrat Occurrence	No. of Total Quadrat Study	(F)	(D)	(A)	Frequency Class	RF	RD	RA	IVI
1	*Verbesina encelioides* (Cav.) Benth. & Hook.f. ex A.Gray	30	16	110	14.55	0.27	1.88	A	3.59	3.32	0.97	7.87
2	*Aerva persica* (Burm.f.) Merr.	31	12	110	10.91	0.28	2.58	A	2.69	3.43	1.33	7.45
3	*Calotropis procera* (Aiton) W.T.Aiton	27	14	110	12.73	0.25	1.93	A	3.14	2.99	1	7.12
4	*Corchorus tridens* L.	27	11	110	10	0.25	2.45	A	2.47	2.99	1.27	6.72
5	*Tribulus terrestris* L.	25	12	110	10.91	0.23	2.08	A	2.69	2.77	1.08	6.53
6	*Solanum virginianum* L.	24	12	110	10.91	0.22	2	A	2.69	2.65	1.03	6.38
7	*Sesamum indicum* L.	23	12	110	10.91	0.21	1.92	A	2.69	2.54	0.99	6.22
8	*Acacia tortilis* (forssk.) hayne	22	11	110	10	0.2	2	A	2.47	2.43	1.03	5.93
9	*Citrullus colocynthis* (L.) Schrad.	20	13	110	11.82	0.18	1.54	A	2.91	2.21	0.79	5.92
10	*Crotalaria burhia* Buch.-Ham.	23	9	110	8.18	0.21	2.56	A	2.02	2.54	1.32	5.88

Table 2: Species-wise Phytosociological Table (Post-Monsoon)

S. No.	Species Name	Total Individuals	Quadrat Occurrence	No. of Total Quadrat Study	(F)	(D)	(A)	Frequency Class	RF	RD	RA	IVI
1	*Aerva persica* (Burm.f.) Merr.	65	29	110	26.36	0.59	2.24	B	4.65	5.01	1.49	11.16
2	*Calotropis procera* (Aiton) W.T.Aiton	60	29	110	26.36	0.55	2.07	B	4.65	4.62	1.38	10.66
3	*Prosopis cineraria* (L.) Druce	59	29	110	26.36	0.54	2.03	B	4.65	4.55	1.36	10.56
4	*Arnebia hispidissima* DC.	51	25	110	22.73	0.46	2.04	B	4.01	3.93	1.36	9.30
5	*Saccharum munja* Roxb.	49	24	110	21.82	0.45	2.04	B	3.85	3.78	1.36	8.99
6	*Crotalaria burhia* Buch.-Ham.	47	24	110	21.82	0.43	1.96	B	3.85	3.62	1.30	8.78
7	*Ziziphus nummularia* DC.	45	24	110	21.82	0.41	1.88	B	3.85	3.47	1.25	8.57
8	*Acacia tortilis* (forssk.) hayne	42	20	110	18.18	0.38	2.10	A	3.21	3.24	1.40	7.84
9	*Chenopodium album* L.	37	19	110	17.27	0.34	1.95	A	3.05	2.85	1.30	7.20
10	*Launaea procumbens* (Roxb.) Amin	38	17	110	15.45	0.35	2.24	A	2.73	2.93	1.49	7.15

Table 3: Comparative IVI Table (Seasonal Comparison)

S. No.	Species Name	IVI (Pre-Monsoon)	IVI (Post-Monsoon)	Change in IVI	% Change	Rank (Pre)	Rank (Post)
1	*Verbesina encelioides* (Cav.) Benth. & Hook.f. ex A.Gray	7.87	4.22	-3.65	-46.33	1	27
2	*Aerva persica* (Burm.f.) Merr.	7.45	11.16	3.71	49.73	2	1
3	*Calotropis procera* (Aiton) W.T.Aiton	7.12	10.66	3.54	49.65	3	2
4	*Prosopis cineraria* (L.) Druce	5.33	10.56	5.23	98.03	12	3
5	*Acacia tortilis* (forssk.) hayne	5.93	7.84	1.91	32.28	8	8
6	*Crotalaria burhia* Buch.-Ham.	5.88	8.78	2.90	49.27	10	6

Table 4: Site-wise Summary Table

Site Name	Total Species (Pre)	Total Species (Post)	Dominant Species (Pre)	Dominant Species (Post)	Max IVI (Pre)	Max IVI (Post)
Sahwa	22	17	*Aerva javanica* Juss.	*Ziziphus mauritiana* Lam.	24.28	24.12
Kohina	21	16	*Aerva persica* (Burm.f.) Merr.	*Pupalia lappacea* (L.) Juss.	21.35	30.49
Bhaleri	15	22	*Sisymbrium irio* L.	*Gossypium arboreum* L.	30.98	19.26
Satyun	16	17	*Heliotropium strigosum* Willd.	*Arnebia hispidissima* DC.	25.28	25.84
Hadiyal	15	20	*Aerva persica* (Burm.f.) Merr.	*Solanum xanthocarpum* Schrad. & J.C.Wendl.	27.87	19.98
Jorji Ka Bass	15	17	*Vigna radiata* (L.) R.Wilczek	*Rumex dentatus* L.	35.45	25
Changoi	17	19	*Tribulus terrestris* L.	*Aerva persica* (Burm.f.) Merr.	25.92	21.4
Banyan	21	18	*Trianthema portulacastrum* L.	*Crotalaria burhia* Buch.-Ham.	21.68	21.75
Dabri	16	16	*Chrozophora tinctoria* (L.) A.Juss.	*Aerva persica* (Burm.f.) Merr.	28.8	26.54
Dheerwas	19	18	*Chenopodium album* L.	*Ocimum sanctum* L.	27.39	24.76
Taranagar	17	15	*Heliotropium europaeum* L.	*Fagonia schweinfurthii* Hadidi.	28.7	23.7

Table 5: Top Dominant Species Table

Rank	Species Name	IVI (Pre-Monsoon)	IVI (Post-Monsoon)	Remark (Increase/Decrease)
I	*Verbesina encelioides* (Cav.) Benth. & Hook.f. ex A.Gray	7.87	4.22	Decreased
II	*Aerva persica* (Burm.f.) Merr.	7.45	11.16	Increased dominance
III	*Calotropis procera* (Aiton) W.T.Aiton	7.12	10.66	Increased dominance
IV	*Corchorus tridens* L.	6.72	NR	Absent in post-monsoon
V	*Tribulus terrestris* L.	6.53	NR	Absent in post-monsoon
VI	*Solanum virginianum* L.	6.38	NR	Absent in post-monsoon
VII	*Sesamum indicum* L.	6.22	NR	Absent in post-monsoon
VIII	*Acacia tortilis* (forssk.) hayne	5.93	7.84	Slight increased
IX	*Citrullus colocynthis* (L.) Schrad.	5.92	NR	Absent in post-monsoon
X	*Crotalaria burhia* Buch.-Ham.	5.88	8.78	Increased dominance

Table 6: Life-form Wise Distribution

Life Form	No. of Species (Pre)	No. of Species (Post)
Trees	22	12
Shrubs	18	20
Herbs	55	39
TOTAL	95	71

Discussion

Significant seasonal changes in vegetation composition and structure were revealed in the present study across the study sites of Taranagar region of Churu district. Phytosociological analysis based on Important Value Index (IVI) is a common methodology used for determination of species dominance & ecological importance in the plant communities (Curtis & McIntosh, 1950) [3]. The observed variations are certainly indicative of a seasonal change in species dominance and vegetation structure.

In pre-monsoon, vegetation was dominated by drought tolerant species like *Verbesina encelioides, Aerva persica* and *Calotropis procera* with comparatively higher IVI values. They are well adapted to live in dry and semi-dry environments and are able to survive in moisture-deficient conditions. Similar patterns of dominance of xerophytic species under dry conditions have been reported for arid ecosystems (Mueller-Dombois & Ellenberg, 1974) [7].

In post monsoon, there was a significant change in species composition with species such as *Aerva persica, Calotropis procera*, and *Prosopis cineraria* becoming dominant with higher IVI values. The increase in IVI of these species is attributed to improved soil moisture and favourable growth conditions after rainfall. Plant growth and dominance increase seasonally after monsoon, which is well documented in semi-arid regions (Singh & Singh, 1992) [13].

The IVI comparative analysis showed positive and negative shifts in the species dominance. For instance, *Aerva persica* showed a substantial increase in IVI (49.73%), indicating enhanced growth and reproductive success under favourable conditions. Similarly, *Prosopis cineraria* exhibited a remarkable increase (98.03%), reflecting its strong ecological adaptability and competitive ability in arid landscapes. In contrast, *Verbesina encelioides* showed a significant decline in IVI (–46.33%), suggesting reduced competitiveness in post-monsoon conditions, possibly due to increased interspecific competition and changes in resource availability.

One unique feature of the present study is the partial species replacement, where some of the species encountered during pre-monsoon period such as *Corchorus tridens, Tribulus terrestris* and *Citrullus colocynthis* were absent in post-monsoon period. This pattern illustrates the way in which many herbaceous plants of arid regions are ephemerals, rapidly completing their life cycles in relation to seasonal conditions. Such desert ecosystems are characterised by seasonal turnover, which is primarily driven by fluctuations in rainfall and the availability of soil moisture (Odum, 1971) [9].

Spatial heterogeneity in vegetation composition is also indicated by variation in dominating species across sites. Microhabitat conditions, soil properties and anthropogenic disturbances (grazing and land use) could have an effect on species distribution and dominance patterns. These similar results have been reported for dryland ecosystems, in which dynamic vegetation structure is largely controlled by local environmental factors (Kent, 2012) [6].

Herbaceous species had the highest proportion of vegetation in both seasons followed by shrubs and trees in the analysis of life-form distribution. However, reduction in total number of species from pre-monsoon (95 species) to post-monsoon (71 species) was observed. This may be the consequence of the death of some annual and ephemeral plants after their life cycle. In the same line, some previous ecological studies have also highlighted the dominant role of herbaceous plant species in arid regions, as they play an important role in nutrient recycling (Raunkiaer, 1934) [10].

Overall, the study points out that seasonal variations, especially rainfall, are strong drivers of vegetation dynamics in semi-arid regions. The changes in IVI values and species composition are indicative of the adaptive strategies of plant species to cope with environmental stress. These results are consistent with previous studies showing high temporal variability in plant communities of arid and semi-arid ecosystems in response to climatic factors. (Whittaker, 1975) [14].

Conclusion

The present study is a detailed assessment of seasonal variation in vegetation composition and structure in Taranagar region of Churu district. The Important Value Index (IVI) based analysis revealed significant changes in the dominance of species between pre-monsoon and post-monsoon seasons indicating the dynamic nature of plant communities in semi-arid ecosystems.

The results suggest that some species show greater dominance in the post-monsoon season as moisture levels are high but drought tolerant species are dominant in the pre-monsoon season. The species such as *Aerva persica, Calotropis procera* and *Prosopis cineraria* exhibited a significant increase in IVI, which is indicative of their ecological adaptation and competitive advantage in favourable circumstances. In contrast, some plant species declined or disappeared in post-monsoon, reflecting a high degree of seasonal replacement in some herbaceous species.

The study also revealed significant spatial heterogeneity among the sites, suggesting that environment, soil and human activity are of great importance to determine the distribution of plants. The dominance of herbaceous species in both seasons also indicates their ecological importance in semi-arid environments, especially in terms of rapid growth response to rainfall and contribution to ecosystem functioning.

In summary, this study reveals the effects of climatic seasonality particularly rainfall on vegetation dynamics in the study site. The differences in IVI values and species composition are the adjustments that the plant species do to survive in stress and low availability of resources. This information can provide important baseline information on plant community dynamics, and may be useful for efforts to conserve biological diversity and sustainably manage ecosystems.

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Author Contributions

GKS: Conceived the research design, collected and analysed the data, wrote the manuscript; A. Dubey: Guided the research work, analysed the data and edited the manuscript also gave the administrative support. Authors read and approved the manuscript.

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