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VEGETATION PATTERN AND PLANT COMMUNITY ANALYSIS OF THAR DESERT, THARPARKAR DISTRICT, SINDH PROVINCE, PAKISTAN

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Abstract

Tharparkar District is the part of the Thar Desert, situated within Sindh Province, Pakistan. The area is inhabited by a population of more than 1.77 million individuals, predominantly residing in rural settings and depending on livestock rearing and rain-fed agriculture for their livelihoods. The Thar Desert (Tharparkar) is facing growing threats to its biodiversity because of new development in the area. For this reason, a detailed study was needed to examine plant community. This study aimed to assess plant diversity and identify threatened taxa of the study area. Surveys were conducted at sixty-four distinct sites encompassing various habitat types, in three separate phases. Plant data were collected using ten quadrats with a radius of 12.6 feet at each site, and the structure of plant communities was analysed. Forty-two plant families were identified, with grasses (Poaceae) being the most dominant, followed by Fabaceae and Malvaceae. The vegetation of the Tharparkar Desert was found to be dominated by perennial herbaceous species, accounting for around 62% of the total community, while trees and shrubs comprised less than 25%. TWINSPAN classification clustered the vegetation plots based on the soil and identified 27 plant groups. It recognized *Leptadenia pyrotechnica, Aerva javanica*, and *Prosopis cineraria* as indicator species of sandy deserts. A significant proportion of the plants were Therophytes and Phanerophytes. *Acacia senegal, Leptadenia pyrotechnica, Prosopis juliflora* , and *Ziziphus nummularia* were the core tree and shrub species. The study area is home to two globally endangered plant species. *Commiphora wightii* (Gugar) and *Tecomella undulata* (Desert Teak) are listed as critically endangered (CR) and endangered (EN) taxa, respectively, in the IUCN red list species. Many species, including *Justicia vahlii, Farsetia hemaltoni, Blepharis scindica, Acacia leucophloea, Moringa concanensis* and *Sterculia urens* are on the verge of local extinction due to overuse for medicinal or commercial purposes. The study findings highlight the pressing need for the implementation of a comprehensive conservation plan aimed at safeguarding species of special concern within the study area. Key priority actions to be undertaken include identification of biodiversity hotspots and community-based strategies for conservation of species to mitigate the impact on the natural ecosystem.

Key words: Thar Desert; Tharparkar; Plant diversity; Threatened species

Introduction

Thar Desert is one of the most densely populated deserts in the world and is home to a variety of important flora and fauna (Varghese, 2023). A portion of this desert, referred to as the Tharparkar Desert, lies in the District Tharparkar, in the southeast corner of Sindh province, Pakistan. Tharparkar Desert stretches over 22000 sq. km and the majority of the area (ca. 97%) consists of sandy desert. Despite inhospitable conditions, this region is home to more than 1.77 million people who are deeply linked to nature and rely on the natural resources of this desert for their survival (Anon., 2025). The community relies heavily on livestock rearing and rain-fed agriculture for its primary means of subsistence (Channa *et al*., 2020). The climate of the region is distinguished by low and irregular rain, spells of drought and hot temperatures which pose a threat to the livelihood of its inhabitants. This ecosystem depends on rain as a source of water for life. Southwest monsoon winds contribute 90 percent of the total rainfall in late summer, occurring during a few storms with significant runoff (Hussain *et al*., 2023). However, recently a few small dams were constructed in the Nagarparkar area to halt the major runoff and store water. Water is a particularly valuable resource in the Thar Desert, as it is the only resource that keeps the desert alive. Water availability, whether near natural lakes or dug wells, determines human settlements. Lack of water leads people and their livestock to move from their settlements to other places, in most cases, to neighboring districts for their survival and return with the onset of monsoon rain (Salik *et al*., 2020).

The Tharparkar Desert is home to a variety of flora and fauna. Little research has been conducted on vegetation in the Tharparkar Desert. A few studies have, however, documented the species inventories of certain parts of the Tharparkar Desert (Chaudhri & Chuttar, 1966; Leghari *et al*., 2007; Saand *et al*., 2019; Anon., 2021). A preliminary study on the vegetation of the Thar Desert reported 122

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plant species (Chaudhri & Chuttar, 1966). To our knowledge, the phytosociology of the Tharparkar Desert has not yet been fully documented. In contrast to this, the Indian part of the Thar Desert has received extensive attention (Sharma & Mehra, 2009; Charan & Sharma, 2016; Singh *et al*., 2016; Bano & Deora, 2018). In addition, there has also been considerable research on the ethnobotanical knowledge of desert medicinal plants (Dhir & Shekhawat, 2012; Garg & Mittal, 2013; Yaseen *et al*., 2015; Islam *et al*., 2019, Khaskheli *et al*., 2022).

The Tharparkar Desert has sparse vegetation due to a lack of water and deprived soil. These plants provide significant therapeutic benefits, as well as fodder for livestock and wood for local people (Mahmood *et al*., 2011; Yaseen *et al*., 2015; Majid *et al*., 2019, Mangi *et al.,* 2023). Desert plants have good nutritional value for populations and livestock (Manzoor *et al*., 2007; Khaskheli *et al*., 2019). There is a major drought problem in deserts that affects the vegetation patterns in these areas. A few recent studies have applied remote sensing and geospatial techniques to identify drought stress (Atif and Mahboob, 2016; Usman & Nichol, 2020). Remote sensing techniques are particularly valuable for measuring green cover. However, they cannot help identify the species that are under threat. Many plant species in Tharparkar District are threatened by land-use changes, drought, low rainfall, and anthropogenic activities (Jatoi *et al*., 2019). Two desert species, *Commiphora wightii* (Indian Bdellium tree) and *Tecomella undulata* (Desert Teak), are listed as threatened by the IUCN because of their exploitation (Ved *et al*., 2015; Plummer, 2021). A growing number of scientists and other stakeholders are concerned about the population decline of these species. Therefore, efforts are underway to propagate these species through tissue culture and to preserve them in their native habitats (Ahmad *et al*., 2013; Fatima *et al*., 2016).

Tharparkar Desert has experienced a significant change in recent times, owing to the newest coal development. Accessibility to the natural environment of Thar has risen due to the growth of the road network, as has the intrusion of biotic components. Such accessibility has increased local people's reliance on other cities. Desert natural resources, however, are subject to human exploitation. It is, therefore, crucial to record the floral diversity of this area and understand how these plants contribute to the wellbeing of inhabitants of this desert.

Materials and Methods

We surveyed 64 random sites throughout the Tharparkar Desert in all possible habitats (Fig. 1) in three phases on the dates 24 October – 02 November 2020, 21-27 March 2021 and 22-28 October 2021.On each site, ten circular quadrats of size 12.6 ft radius, with a distance at least 50 m apart, were measured in the soil gradient, in order to document all possible variations in the vegetation with relation to the topography of the area. The plants were identified on the site whenever possible. A collection of unidentified taxa was taken to the Herbarium, Centre for Biodiversity and Conservation, Shah Abdul Latif University, Khairpur for identification. Herbarium sheets were prepared following an established protocol on the specimens (Bridson & Forman, 1992). Plant species were identified using taxonomic literature, online databases, and the Flora of Pakistan (Anon., 2021; Qureshi, 2012; Batanouny, 1987; Bhandari, 1987). The dried plant specimens (herbarium sheets) were deposited in the Herbarium of the Centre for Biodiversity and Conservation.

The number of plant species was observed in each quadrat and the expected number of species present was calculated by rarefaction analysis using software EstimateS 9.0 (Colwell, 2013). In addition to taxonomic identification, a variety of data were compiled on the habits, life forms, and life span of plant species. Plant's life forms were classified based on Raunkiaer's (1934) classification. Depending on the position of perennating buds on a plant's body, it could be classified into Therophyte, Phanerophyte, Chamaephyte, and Hemicryptophyte. Phytosociological attributes of the plant community were calculated using data collected from quadrats and the core species of ecosystem were identified. The term 'core species' is used for locally common and abundant species in the context of their ecological distribution. The vegetation data were analysed using two-way indicator species analysis (TWINSPAN) in R using the TWINSPAN package (Hill *et al*., 1979; Oksanen & Hill, 2024; R Core Team, 2024). The analysis was performed using default options recommended by the program. Community attributes such as relative frequency and relative density were determined using the following equations:

$$\text{Relative frequency (RF)} = \frac{\text{Frequency value of a species}}{\text{Total frequency value of all species}} \times 100$$

$$\text{Relative density} = \frac{\text{Total no. of individuals of species occur in all quadrats}}{\text{Total no. of quadrats studied}} \times 100$$

The tree height was measured by holding a 'foot-ruler' at arm's length towards the tree and by moving forward or backward until the base of the 'foot–ruler'(B) and its top (A), are in line with the base of the tree (D) and the tree-top (E). The distance between the points where the observer is standing (C) and the point where the tree base is standing (D) was measured. The height of the tree was calculated with this formula: ED (height of the tree) = AB divided by CD.

The canopy cover of a tree is the approximate area of shade during the mid-day, when the shade of the tree is approximately equal to the canopy of the tree. To measure shade, a string was laid on the periphery of the shade. The length of the string was measured twice. The folded length of the rope was multiplied by four. The approximate area of shade was estimated in square meters or square ft., which is equal to the tree cover.

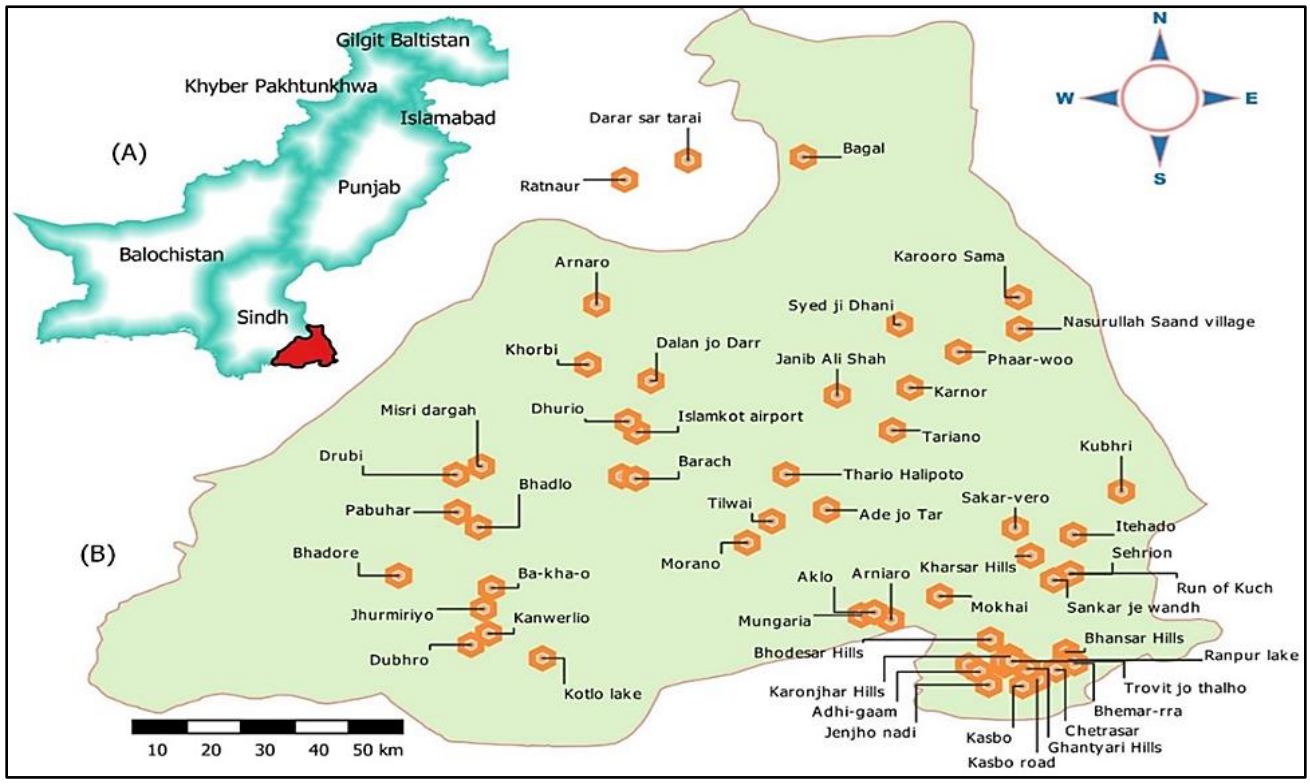


Fig. 1. Study locations, (A) map of Pakistan illustrating the provincial boundaries and the geographical positioning of Tharparkar District, highlighted in red. (B) A map specifically depicting the study location of vegetation within Tharparkar District, Sindh Pakistan.

Results

Plant community of the Tharparkar Desert: The study identified 149 plant species, representing 42 plant families (Table 1), dominated by grasses (Poaceae, 34 spp.), followed by Fabaceae (21 spp.) and Malvaceae (11 spp.). About 50% of the families were represented by a single taxon in the species inventory. Species accumulation curve revealed the efficacy of sampling efforts. In the first hundred quadrats, the most prevalent plant species were catalogued (Fig. 2). There were, however, several species that, due to their lower abundance, did not fall within the sampling points. All such species are included in Table 1. Moreover, the surveys took place during spring and post-monsoon season in a variety of habitats distributed across the Tharparkar District Desert. We observed that the diversity of plants varied over time and in space, leading us to continuously add species to our inventory. The vegetation of Thar Desert (of Tharparkar) is dominated by perennial species which contribute to about 62% of the total community (Fig. 3), whereas trees and shrubs consist of less than 25% of the species inventory. Annual and perennial herbs were commonly found in the plant community (Fig. 3). The vegetation of Tharparkar had a significant proportion of Therophytes (37%) and Phanerophytes (24%) (Fig. 3).

At the first level of vegetation plot classification, TWINSPAN divided the plots into two main groups, containing 19 and 45 plots (Fig. 4). This initial division, with an eigenvalue of 0.413, broadly separated the plots from sandy dry deserts and dry rain streams originating from the hills on the right side, while clustering all vegetation plots from rocky hills and wetlands on the left side. *Leptadenia pyrotechnica, Aerva javanica,* and *Prosopis cineraria*, being broadly distributed, were identified as indicator species of sandy desert habitats at this first division level. Conversely, *Aristida funiculata* serves as an indicator species for hilly areas.

TWINSPAN analysis classified 149 species into 27 groups (Fig. 5). At the first level of classification, with an eigenvalue of 0.861, the analysis grouped 59 species on the right-hand side (RHS) and 90 species on the left-hand side (LHS). Three species in the LHS cluster—*Aerva javanica, Tecomella undulata,* and *Crotalaria burhia* and two species in the RHS cluster, *Achyranthes aspera* and *Aristida funiculata*, did not cluster with other species and each remained the sole member of their group. This indicates their broad adaptability to the different microclimatic conditions within the Thar Desert. The largest species cluster contained 34 members, predominantly grass species. *Commiphora wightii*, a critically endangered plant, showed a close association with *Aeluropus lagopoides, Euphorbia caducifolia,* and *Fagonia indica*.

The core herb and grass species were *Aerva javanica, Aristida adscensionis, Boerhavia procumbens, Cenchrus biflorus, Crotalaria burhia, Dactyloctenium aegyptium, Eragrostis ciliaris, Eragrostis minor, Euphorbia prostrata, Indigofera cordifolia, Mollugo cerviana,* and *Tephrosia uniflora* (Table 2). The species like *Barleria acanthoides, Citrullus colocynthis, Convolvulus prostratus, Ochthochloa compressa, Panicum turgidum, Tribulus longipetalus* were among the top 25% most frequent species found in the region but their abundance was relatively low in the quadrats. On the other hand, the species, *Cressa cretica, Bolboschoenus glaucus, Dactyloctenium aristatum, Eragrostis cillianensis, Tragus roxburghii*, had high abundance but their distribution was restricted to fewer locations (Table 2). The core species among the shrubs and trees were *Acacia senegal*, *Leptadenia pyrotechnica, Prosopis juliflora* (Mesquite), and *Ziziphus nummularia* (Wild Jujube) (Table 3).

Table 1. List of the plant species recorded in Tharparkar District. The scientific name and recent position of taxa are updated with the online version of Flora of Pakistan (Anon., 2021).

	Family-Species	Local name	English name	Habit	Life span	Life form	IUCN status
	Acanthaceae						
1.	*Barleria acanthoides*	Kinari		Undershrub	Perennial	Chamaephyte	NE
2.	*Blepharis ciliaris*	Utagan	Blepharis	Herb	Perennial	Chamaephyte	NE
3.	*Blepharis scindica*	Utagan	Blepharis	Herb	Annual	Therophyte	NE
4.	*Justicia vahlii*			Herb	Annual	Therophyte	NE
	Aizoaceae						
5.	*Sesuvium sesuvioides*			Herb	Annual	Therophyte	NE
6.	*Zaleya pentandra*	Waho		Herb	Perennial	Chamaephyte	NE
	Amaranthaceae						
7.	*Achyranthes aspera*	Ubatkandri	Prickly-Chaff-flower	Herb	Perennial	Chamaephytes	NE
8.	*Aerva javanica*	Booh	Kapok bush	Herb	Perennial	Phanerophyte	NE
9.	*Digera muricata*		False amaranth	Herb	Annual	Therophyte	NE
10.	*Pupalia lappacea*		Forest Burr	Herb	Perennial	Phanerophyte	NE
11.	*Suaeda fruticosa*		Bush seepweed	Herb	Perennial	Chamaephyte	NE
	Apocynaceae						
12.	*Calotropis procera*	AK	French-cotton	Shrub	Perennial	Phanerophyte	NE
13.	*Leptadenia pyrotechnica*	Khip	Broom Brush	Shrub	Perennial	Phanerophyte	NE
14.	*Pergularia daemia*			Climber	Perennial	Phanerophyte	NE
	Asparagaceae						
15.	*Asparagus racemosus*		Asparagus-fern	Climber	Perennial	Phanerophyte	NE
	Asteraceae						
16.	*Launaea procumbens*	Bhattar	Creeping Launaea	Herb	Annual	Therophyte	NE
17.	*Launaea nudicaulis*	Bhattar	Naked Launaea	Herb	Annual	Therophyte	NE
18.	*Oligochaeta ramosa*			Herb	Perennial	Chamaephyte	NE
19.	*Pluchea arguta*			Shrub	Perennial	Phanerophyte	NE
20.	*Pulicaria angustifolia*			Herb	Perennial	Chamaephyte	NE
	Bignoniaceae						
21.	*Tecomella undulata*	Rohiro	Desert teak	Tree	Perennial	Phanerophyte	EN
	Boraginaceae						
22.	*Arnebia hispidissima*		Arabian primrose	Herb	Annual	Therophyte	NE
	Brassicaceae						
23.	*Farsetia hamiltonii*	Lathi		Herb	Perennial	Chamaephyte	NE
	Burseraceae						
24.	*Commiphora wightii*	Gugar	Indian Bdellium tree	Shrub	Perennial	Phanerophyte	CR
	Capparaceae						
25.	*Capparis decidua*	Kirar	Caper Berry	Shrub	Perennial	Phanerophyte	NE
26.	*Crateva adansonii*			Tree	Perennial	Phanerophyte	LC
	Cleomaceae						
27.	*Cleome scapos*		Cleome	Herb	Annual	Therophyte	NE
28.	*Gynandropsis gynandra*		Spider wisp	Herb	Annual	Therophyte	NE
	Ceratophyllaceae						
29.	*Ceratophyllum demersum*		Rigid Hornwort	Herb	Perennial	Cryptophyte	LC
	Convolvulaceae						
30.	*Convolvulus arvensis*	Narro/ Haranchapri	European bindweed	Climber	Perennial	Hemicryptophyte	NE
31.	*Convolvulus prostratus*		Bindweed	Herb	Perennial	Hemicryptophyte	NE
32.	*Cressa cretica*	Oin	Cretan Alkaliweed	Herb	Perennial	Chamaephyte	LC
33.	*Ipomoea eriocarpa*		Morning glory	Climber	Annual	Therophyte	NE
34.	*Merremia aegyptia*			Climber	Perennial	Therophyte	NE
	Cordiaceae						
35.	*Cordia sinensis*			Shrub	Perennial	Phanerophyte	LC
	Cucurbitaceae						
36.	*Citrullus colocynthis*	Trooh	Colocynth	Climber	Perennial	Chamaephyte	NE
37.	*Cucumis melo*	Chibbar	Wild melon	Climber	Annual	Therophyte	NE
38.	*Luffa echinata*	Toori		Climber	Annual	Therophyte	NE
39.	*Momordica dioica*		Spiny gourd	Climber	Perennial	Chamaephyte	NE
40.	*Mukia maderaspatana*	Akhrori	Madras pea pumpkin	Climber	Perennial	Hemicryptophyte	NE
	Cyperaceae						
41.	*Bolboschoenus glaucus*		Tuberous Bulrush	Sedge	Perennial	Cryptophyte	LC
42.	*Cyperus alopecuroides*		Foxtail Sedge	Sedge	Perennial	Cryptophyte	LC
43.	*Cyperus arenarius*		Dwarf Sedge	Sedge	Perennial	Cryptophyte	LC
44.	*Cyperus atkinsoni*			Sedge	Perennial	Cryptophyte	NE
45.	*Cyperus aucheri*	Wenjhool		Sedge	Perennial	Cryptophyte	NE
46.	*Cyperus bulbosus*			Sedge	Perennial	Cryptophyte	LC

Table 1. (Cont'd.).

	Family-Species	Local name	English name	Habit	Life span	Life form	IUCN status
47.	*Cyperus rotundus*	Nangermotha		Sedge	Perennial	Cryptophyte	NE
48.	*Schoenoplectiella roylei*			Sedge	Annual	Cryptophyte	LC
	Euphorbiaceae						
49.	*Euphorbia caducifolia*	Dandathoor	Euphorbia	Shrub	Perennial	Phanerophyte	NE
50.	*Euphorbia clarkeana*	Kheera Wal		Herb	Annual	Therophyte	NE
51.	*Euphorbia granulata*		Euphorbia	Herb	Annual	Therophyte	NE
52.	*Euphorbia prostrata*	Kheera Wal		Herb	Annual	Therophyte	NE
	Fabaceae						
53.	*Acacia glandulosa*			Tree	Perennial	Phanerophyte	NE
54.	*Acacia jacquemontii*	Banwar	Desert acacia	Shrub	Perennial	Phanerophyte	NE
55.	*Acacia nilotica*	Sindhi Babur	Babul acacia	Tree	Perennial	Phanerophyte	LC
56.	*Acacia leucophloea*	Safed babul	Whitebark acacia	Tree	Perennial	Phanerophyte	LC
57.	*Acacia senegal*	Koonbhat	Gum Arabic Tree	Tree	Perennial	Phanerophyte	NE
58.	*Bauhinia racemosa*			Tree	Perennial	Phanerophyte	LC
59.	*Cassia italica*	Ghora Wal	Italian Senna	Herb	Perennial	Chamaephyte	NE
60.	*Cassia senna*			Under shrub	Perennial	Chamaephyte	NE
61.	*Crotalaria burhia*	Chaq Makhan Booti.	Rattlebox	Herb	Perennial	Chamaephyte	NE
62.	*Crotalaria medicaginea*			Herb	Perennial	Chamaephyte	LC
63.	*Indigofera argentea*	Gokaro	Wild-indigo	Herb	Annual	Therophyte	NE
64.	*Indigofera cordifolia*	Mahori/ vekar		Herb	Annual	Therophyte	NE
65.	*Indigofera hochstetteri*			Herb	Annual	Therophyte	LC
66.	*Indigofera linifolia*			Herb	Annual	Therophyte	LC
67.	*Indigofera sessiliflora*	Dhakri		Herb	Annual	Therophyte	LC
68.	*Mimosa hamata*	Hermo		Shrub	Perennial	Phanerophyte	LC
69.	*Prosopis cineraria*	Kandi	Ghaf	Tree	Perennial	Phanerophyte	NE
70.	*Prosopis juliflora*	Devi	Mesquite	Tree	Perennial	Phanerophyte	NE
71.	*Rhynchosia minima*	Wanverhi	Least snout bean	Herb	Perennial	Chamaephyte	LC
72.	*Rhynchosia pulverulenta*			Herb	Perennial	Chamaephyte	LC
73.	*Tephrosia uniflora*	Andhari		Herb	Annual	Therophyte	NE
	Heliotropiaceae						
74.	*Heliotropium crispum*	Kharsan		Herb	Annual	Therophyte	NE
75.	*Heliotropium rariflorum*			Herb	Perennial	Chamaephyte	NE
76.	*Heliotropium strigosum*		Heliotropio	Herb	Perennial	Chamaephyte	NE
77.	*Heliotropium subulatum*			Herb	Perennial	Chamaephyte	NE
	Lamiaceae						
78.	*Leucas urticifolia*			Herb	Annual	Therophyte	NE
	Limeaceae						
79.	*Limeum indicum*	Khirwal		Herb	Annual	Therophyte	NE
	Malvaceae						
80.	*Abutilon fruticosum*			Under shrub	Perennial	Phanerophyte	NE
81.	*Abutilon indicum*	Pat-teer	Abutilon	Shrub	Perennial	Phanerophyte	NE
82.	*Corchorus aestuans*			Herb	Annual	Therophyte	NE
83.	*Corchorus depressus*	Mundheri	Wild-jute	Herb	Perennial	Hemicryptophyte	NE
84.	*Corchorus tridens*	Datehri	Wild jute	Herb	Annual	Therophyte	NE
85.	*Grewia tenax*	Gherati		Shrub	Perennial	Phanerophyte	LC
86.	*Grewia villosa*	Gherati	Mallow-raisin	Shrub	Perennial	Phanerophyte	LC
87.	*Hibiscus lobatus*		Hibiscus	Herb	Annual	Therophyte	NE
88.	*Hibiscus obtusilobus*			Herb	Annual	Therophyte	NE
89.	*Sida cordifolia*			Under shrub	Perennial	Chamaephyte	NE
90.	*Sterculia urens*	*Ka-rra-yo*		Tree	Perennial	Phanerophyte	NE
	Meliaceae						
91.	*Azadirachta indica*	*Neem*		Tree	Perennial	Phanerophyte	LC
	Menispermaceae						
92.	*Cocculus pendulus*			Shrub	Perennial	Phanerophyte	NE
	Molluginaceae						
93.	*Mollugo cerviana*	Hazar dani		Herb	Annual	Therophyte	NE
	Moringaceae						
94.	*Moringa concanensis*	Jabali Saringoo	Wild moringa	Tree	Perennial	Phanerophyte	NE
	Nyctaginaceae						
95.	*Boerhavia procumbens*	Dakhri/Satori		Herb	Perennial	Chamaephyte	NE
96.	*Commicarpus boissieri*			Herb	Perennial	Chamaephyte	NE
	Orobanchaceae						
97.	*Cistanche tubulosa*			Parasite	Annual	Therophyte	NE
98.	*Striga gesnerioides*		witchweed	Parasite	Annual	Therophyte	NE

Table 1. (Cont'd.).

	Family-Species	Local name	English name	Habit	Life span	Life form	IUCN status
	Pedaliaceae						
99.	*Sesamum indicum*			Herb	Annual	Therophyte	NE
100.	*Pedalium murex*			Herb	Annual	Therophyte	NE
	Plantaginaceae						
101.	*Bacopa monnieri*			Herb	Perennial	Chamaephyte	LC
	Poaceae						
102.	*Aeluropus lagopoides*			Grass	Perennial	Hemicryptophyte	LC
103.	*Aristida adscensionis*	Lumb Gaah	Annual-bristle grass	Grass	Annual	Therophyte	NE
104.	*Aristida funiculata*	Lumb Gaah		Grass	Annual	Therophyte	NE
105.	*Brachiaria ovalis*			Grass	Annual	Therophyte	LC
106.	*Brachiaria ramosa*	Sawri	Signalgrass	Grass	Annual	Therophyte	LC
107.	*Cenchrus biflorus*	Bhourt	Indian sandbur	Grass	Annual	Therophyte	NE
108.	*Cenchrus ciliaris*	Bhourt	Buffelgrass	Grass	Perennial	Hemicryptophyte	LC
109.	*Cenchrus prieurii*			Grass	Annual	Therophyte	LC
110	*Cenchrus setiger*		Birdwood	Grass	Perennial	Hemicryptophyte	LC
111.	*Chloris barbata*	Sawari		Grass	Perennial	Hemicryptophyte	NE
112.	*Cymbopogon commutatus*			Grass	Perennial	Hemicryptophyte	NE
113.	*Cymbopogon jwarancusa*	Katan	Oilgrass	Grass	Perennial	Hemicryptophyte	NE
114.	*Cymbopogon martini*			Grass	Perennial	Hemicryptophyte	NE
115.	*Cynodon dactylon*			Grass	Perennial	Hemicryptophyte	NE
116.	*Dactyloctenium aristatum*	GandheerGaah	Crowfoot grass	Grass	Annual	Therophyte	NE
117.	*Dactyloctenium aegyptium*	GandheerGaah	Egyptian grass	Grass	Annual	Therophyte	NE
118.	*Desmostachya bipinnata*	Drabh	Deep root grass	Grass	Perennial	Hemicryptophyte	LC
119.	*Digitaria ciliaris*	Pachar Gaah	Crabgrass	Grass	Annual	Therophyte	NE
120.	*Digitaria pennata*			Grass	Perennial	Hemicryptophyte	NE
121	*Eragrostis ciliaris*	SawriGhahh	Gophertail lovegrass	Grass	Annual	Therophyte	NE
122.	*Eragrostis cillianensis*		Grey love grass	Grass	Annual	Therophyte	NE
123.	*Eragrostis minor*	SawriGhahh	Little lovegrass	Grass	Annual	Therophyte	NE
124.	*Eragrostis tremula*	Bhurbhuri		Grass	Annual	Therophyte	NE
125.	*Lasiurus scindicus*		Sewan grass	Grass	Perennial	Hemicryptophyte	NE
126.	*Ochthochloa compressa*	Ghander	Ochthochloa	Grass	Perennial	Hemicryptophyte	NE
127.	*Panicum antidotale*	Murt	Blue Panicum	Grass	Perennial	Hemicryptophyte	NE
128.	*Panicum turgidum*	Murt	Panic grass	Grass	Perennial	Hemicryptophyte	NE
129.	*Pennisetum orientale*	Bhurut	Oriental fountain grass	Grass	Perennial	Hemicryptophyte	NE
130.	*Phragmites australis*			Grass	Perennial	Cryptophyte	NE
131.	*Phragmites karka*			Grass	Perennial	Cryptophyte	NE
132.	*Sporobolus arabicus*	Bhangari.		Grass	Perennial	Hemicryptophyte	NE
133.	*Sporobolus helvolus*			Grass	Perennial	Hemicryptophyte	NE
134.	*Tetrapogon tenellus*			Grass	Annual	Therophyte	NE
135.	*Tragus roxburghii*			Grass	Annual	Therophyte	NE
	Polygonaceae						
136.	*Calligonium polygonoides*	Phog	Hackenkopf	Shrub	Perennial	Phanerophyte	NE
	Pteridaceae						
137.	*Actiniopteris radiata*		Ray fern	Herb	Annual	Cryptophyte	NE
	Rhamnaceae						
138.	*Ziziphus nummularia*	Jhangoori be	Wild Jujube	Shrub	Perennial	Phanerophyte	NE
	Salvadoraceae						
139.	*Salvadora oleoides*	Jar/Peroon	Salvadora	Tree	Perennial	Phanerophyte	NE
	Scrophulariaceae						
140.	*Anticharis glandulosa*	Gaamesh		Herb	Annual	Therophyte	NE
	Solanaceae						
141.	*Lycium edgeworthii*			Shrub	Perennial	Phanerophyte	NE
142.	*Solanum cordatum*			Under shrub	Perennial	Phanerophyte	NE
	Tamaricaceae						
143.	*Tamarix indica*	Lawi	Tamarisk	Shrub	Perennial	Phanerophyte	NE
	Typhphaceae						
144.	*Typha elephantina*			Herb	Perennial	Cryptophyte	LC
	Vitales						
145.	*Cayratia trifolia*			Climber	Perennial	Phanerophyte	NE
	Zygophyllaceae						
146.	*Fagonia indica*	Dramaaho		Herb	Annual	Therophyte	NE
147.	*Tribulus longipetalus*	Bakhro/Bhurt		Herb	Annual	Therophyte	NE
148.	*Tribulus terrestris*	Tikandi	Puncture vine	Herb	Annual	Therophyte	NE
149.	*Zygophyllum simplex*	Pat lani	Simple-leaved bean caper	Herb	Annual	Therophyte	NE

CR= Critically Endangered, EN= Endangered, LC Least Concerned, NE= Not evaluated

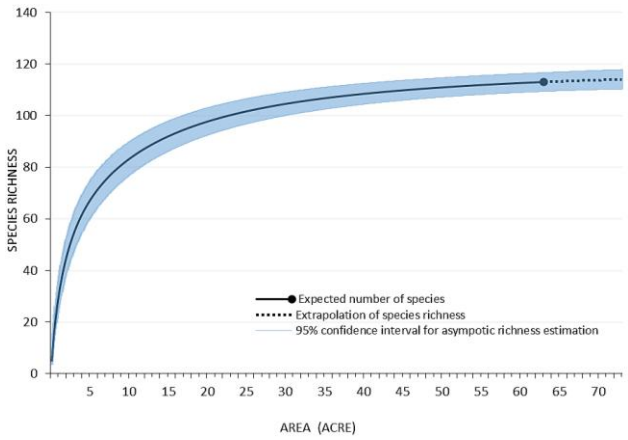


Fig. 2. Species accumulation curves in relation to sampling area. Solid curve indicates interpolation and dash curve showing extrapolation with 95% confidence intervals. The solid circle indicates the total number of species recorded in given sampling area.

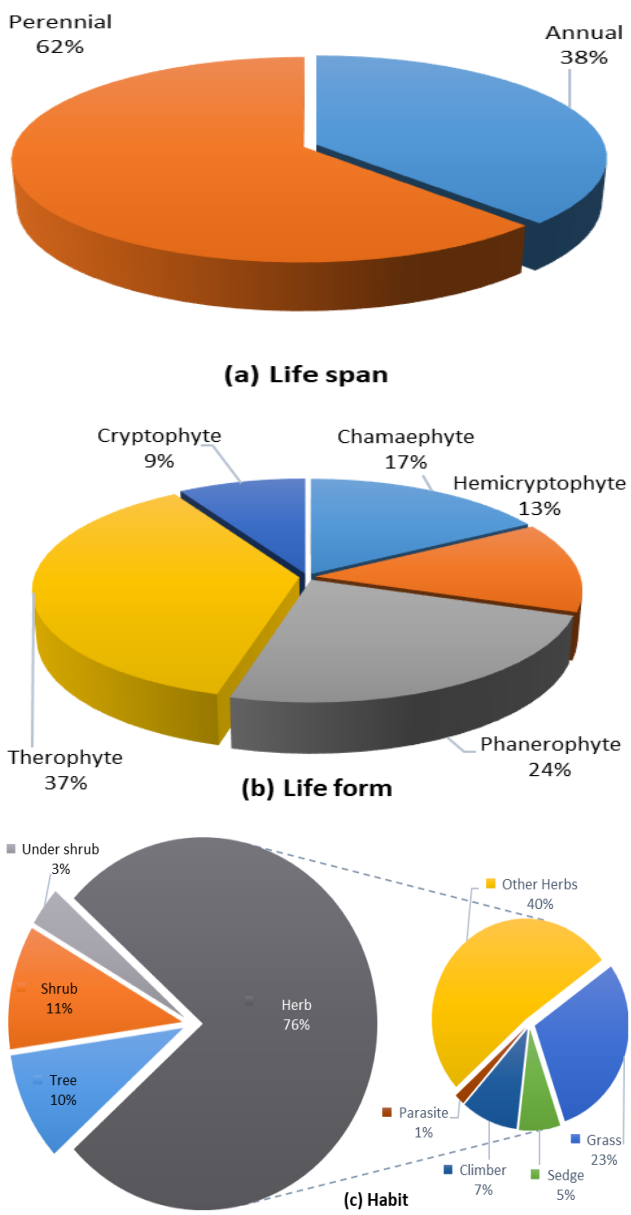


Fig. 3. Physiognomic characteristics of the vegetation at Tharparkar District. (a) The life span of the species (b) Raunkiaer's Life form (c) Habit of the plant.

Prosopis cineraria was the tallest tree in the region (Table 4). The growth of *Commiphora wightii* (Indian Bdellium) was found stunt; about half the size of a normal *Commiphora wightii* (Indian Bdellium) shrub was observed in the field. On the other hand, *Leptadenia pyrotechnica, Calotropis procera* (Apple of sodom), and *Salvadora oleoides* were found with vigorous growth and were among the least affected plants.

The monsoon rain had a significant impact on vegetation of Tharparkar Desert. Before monsoon, sparse vegetation was encountered in the study region in spring. There were 10 species on average per site, with the most species-rich site having as many as 15 species. The frequency of species richness on study sites (Fig. 6) indicates that there are relatively few species on each site, thereby reducing the diversity of plant species (Fig. 6). The surveys conducted after the monsoon (in October 2020 and October 2021) revealed a significant increase in plant species richness (Fig. 6), with an average of nineteen species per site and an increase in the diversity index of plant species on each site (Fig. 6).

Threatened flora of Tharparkar Desert: The desert is the home to two globally threatened species.

Tecomella undulata (Desert Teak) locally named Rohiro has been declared endangered by IUCN (Plummer, 2021). We recorded this tree growing in the interdunal flat areas that are used for cultivation (Fig. 2). The trees were planted with a uniform distance between them, suggesting that these trees were planted for a purpose, potentially for timber production.

Commiphora wightii (Gugar) is listed in the red list of threatened species as Critically Endangered (Ved *et al*., 2015). The scattered population of this species was recorded from Nagarparkar Hills, Kharsar Hills, Ghantyari Hills, Sankar je wandh, Kotlo, Aklo and Dubhro areas.

Sterculia urens (Indian katuria): This tree is native to the Indian subcontinent. In Pakistan, it is seldom found, perhaps confined to the Karojhar Hills, where it has taken refuge in cliffs where access is difficult. It is locally called Karrayo. It is on the verge of local extinction as only a few scattered trees are located in Karonjhar Hills.

Moringa concanensis (Wild moringa): There is a small population of this tree distributed in the hills of Nagarparkar. The tree is at the verge of extirpation.

Discussion

Desert plant communities generally consist of perennial shrubs - though trees, grasses, annuals, succulents may have a greater presence in some habitats (Sandquist, 2014). Grasses were abundant in study areas. Most of the species thriving in this desert have also been observed in the Kirthar Range Mountains (Sirohi *et al*., 2019). Grasses are essential in desert habitats for stabilising shifting sands and soil formation. Grazing goats, sheep, and cattle on desert grasses provides nutrients to the ecosystem through their dung and urine, thereby enhancing soil development. The plants of the Fabaceae family were also frequently recorded in the Tharparkar Desert, such species provide a unique ecological role in nitrogen fixation from the environment. Nitrogen is a component of all proteins and is required for plant and animal metabolism. Nitrogen compounds are generated as a result of a complicated metabolic interaction between the host plant and the bacteria. Compound nitrogen is obtained by animals through consuming plants or other animals (Sandquist, 2014).

Table 2. Dominance of herbs and grasses in the Tharparkar Desert recorded during surveys in year 2020 and 2021. Species having high frequency and density are highlighted in bold.

Habit	Species	Relative frequency	Relative density
Climber	*Cayratia trifolia*	0.09	0.00
Climber	*Mukia maderaspatana*	0.68	0.06
Grass	*Aeluropus lagopoides*	0.38	0.33
Grass	*Aristida adscensionis*	2.89	2.71
Grass	*Aristida funiculata*	1.57	17.21
Grass	*Brachiaria ramosa*	1.40	2.73
Grass	*Cenchrus biflorus*	3.70	5.71
Grass	*Cenchrus ciliaris*	1.36	1.29
Grass	*Cenchrus setiger*	0.13	0.08
Grass	*Chloris barbata*	0.21	0.06
Grass	*Cymbopogon jwarancusa*	0.38	0.03
Grass	*Cynodon dactylon*	0.30	0.19
Grass	*Dactyloctenium aristatum*	0.94	2.80
Grass	*Dactyloctenium aegyptium*	3.36	3.14
Grass	*Desmostachya bipinnata*	0.26	0.19
Grass	*Digitaria ciliaris*	1.23	0.60
Grass	*Digitaria large*	0.26	0.04
Grass	*Eragrostis ciliaris*	3.15	9.81
Grass	*Eragrostis cillianensis*	0.51	1.40
Grass	*Eragrostis minor*	2.94	5.72
Grass	*Eragrostis tremula*	0.30	0.12
Grass	*Lasiurus scindicus*	0.04	0.00
Grass	*Ochthochloa compressa*	2.04	1.28
Grass	*Panicum antidotale*	0.13	0.01
Grass	*Panicum turgidum*	1.96	0.24
Grass	*Pennisetum orientale*	0.21	0.15
Grass	*Sporobolus helvolus*	0.00	0.00
Grass	*Sporobolus arabicus*	0.26	0.05
Grass	*Tetrapogon tenellus*	0.09	0.41
Grass	*Tragus roxburghii*	1.06	3.61
Herb	*Achyranthes aspera*	0.04	0.00
Herb	*Aerva javanica*	12.43	1.56
Herb	*Anticharis glandulosa*	0.09	0.02
Herb	*Blepharis ciliaris*	0.17	0.01
Herb	*Blepharis scindica*	0.26	0.01
Herb	*Boerhavia procumbens*	4.21	1.36
Herb	*Cassia italica*	0.55	0.07
Herb	*Citrullus colocynthis*	1.79	0.12
Herb	*Commicarpus boissieri*	1.15	0.10
Herb	*Convolvulus arvensis*	0.26	0.05

Table 2. (Cont'd.).

Habit	Species	Relative frequency	Relative density
Herb	*Convolvulus prostratus*	4.13	0.65
Herb	*Corchorus depressus*	1.32	0.34
Herb	*Corchorus tridens*	1.23	0.38
Herb	*Cressa cretica*	1.11	1.80
Herb	*Crotalaria burhia*	6.94	1.50
Herb	*Crotalaria medicaginea*	0.04	0.00
Herb	*Cucumis melo*	1.28	0.09
Herb	*Euphorbia granulata*	0.55	0.13
Herb	*Euphorbia clarkeana*	0.26	0.02
Herb	*Euphorbia prostrata*	3.23	1.98
Herb	*Fagonia indica*	1.36	0.07
Herb	*Farsetia hamiltonii*	0.38	0.21
Herb	*Heliotropium crispum*	1.11	1.01
Herb	*Heliotropium strigosum*	1.11	0.60
Herb	*Hibiscus lobatus*	0.04	0.01
Herb	*Indigofera hochstetteri*	0.26	0.06
Herb	*Indigofera argentea*	0.09	0.01
Herb	*Indigofera cordifolia*	5.62	12.17
Herb	*Indigofera linifolia*	0.09	0.02
Herb	*Indigofera sessiliflora*	0.47	0.13
Herb	*Justicia vahlii*	0.64	0.15
Herb	*Launaea procumbens*	0.26	0.03
Herb	*Launaea nudicaulis*	0.26	0.03
Herb	*Limeum indicum*	0.04	0.00
Herb	*Mollugo cerviana*	2.43	2.21
Herb	*Oligochaeta ramosa*	0.13	0.01
Herb	*Pulicaria angustifolia*	0.60	0.02
Herb	*Pupalia lappacea*	0.26	0.02
Herb	*Rhynchosia minima*	0.13	0.01
Herb	*Tephrosia uniflora*	5.19	3.66
Herb	*Tribulus longipetalus*	1.74	1.03
Herb	*Tribulus terrestris*	0.60	1.11
Herb	*Zaleya pentandra*	0.47	0.11
Herb	*Zygophyllum simplex*	0.17	0.02
Sedge	*Bolboschoenus glaucus*	0.51	4.60
Sedge	*Cyperus arenarius*	0.26	0.28
Sedge	*Cyperus aucheri*	0.34	0.76
Sedge	*Schoenoplectus lupulinus*	0.17	1.12
Under shrub	*Abutilon fruticosum*	0.26	0.01
Under shrub	*Barleria acanthoides*	2.17	0.31
Under shrub	*Cassia senna*	0.04	0.01

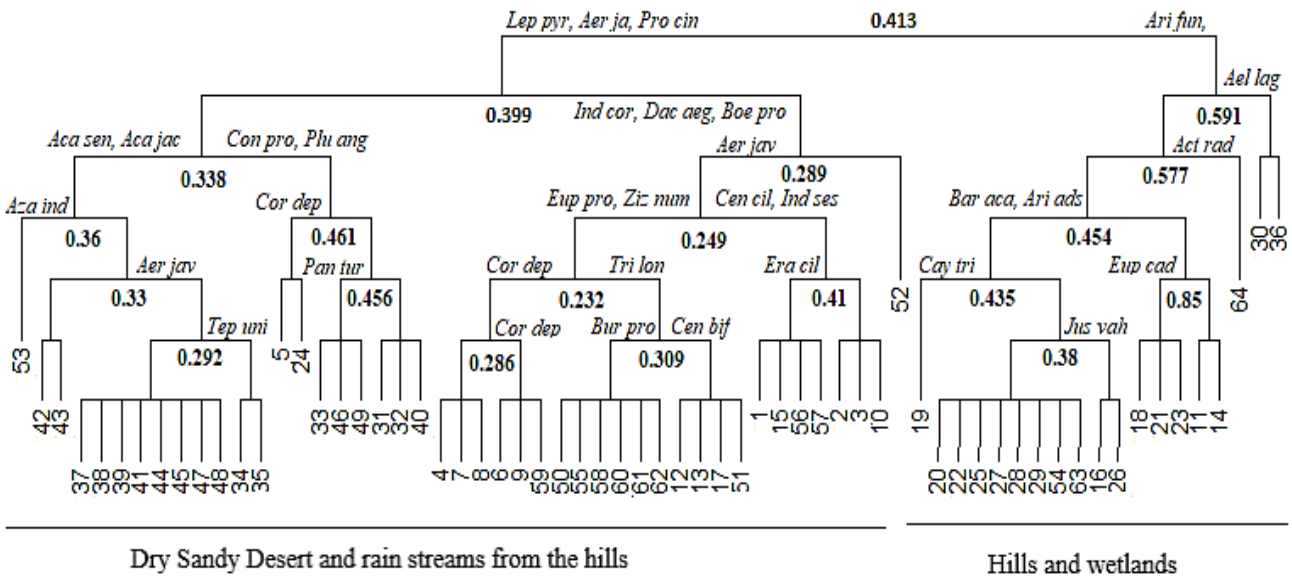


Fig. 4. Classification of vegetation plots in TWINSPAN. The decimal numbers indicate the eigenvalues at each division level. Indicator species are displayed for each cluster at each division level. Aca jac = *Acacia jacquemontii*, Aca sen = *Acacia senegal*, Act rad = *Actiniopteris radiate*, Ael lag = *Aeluropus lagopoides*, Aer jav = *Aerva javanica*, Ari ads = *Aristida adscensionis*, Ari fun = *Aristida funiculate*, Aza ind = *Azadirachta indica*, Bac aca = *Barleria acanthoides*, Boe pro = *Boerhavia procumbens*, Cay tri = *Cayratia trifolia*, Cen bif = *Cenchrus biflorus*, Cen cil = *Cenchrus ciliaris*, Con pro = *Convolvulus prostrates*, Cor dep = *Corchorus depressus*, Dac aeg = *Dactyloctenium aegyptium*, Era cil = *Eragrostis ciliaris*, Eup cla = *Euphorbia clarkeana*, Eup pro = *Euphorbia prostrata*, Ind cor = *Indigofera cordifolia*, Ind ses = *Indigofera sessiliflora*, Jus vah = *Justicia vahlii*, Lep pyr = *Leptadenia pyrotechnica*, Pan tur = *Panicum turgidum*, Plu arg = *Pluchea argute*, Pro cin = *Prosopis cineraria*, Ziz num = *Ziziphus nummularia.*

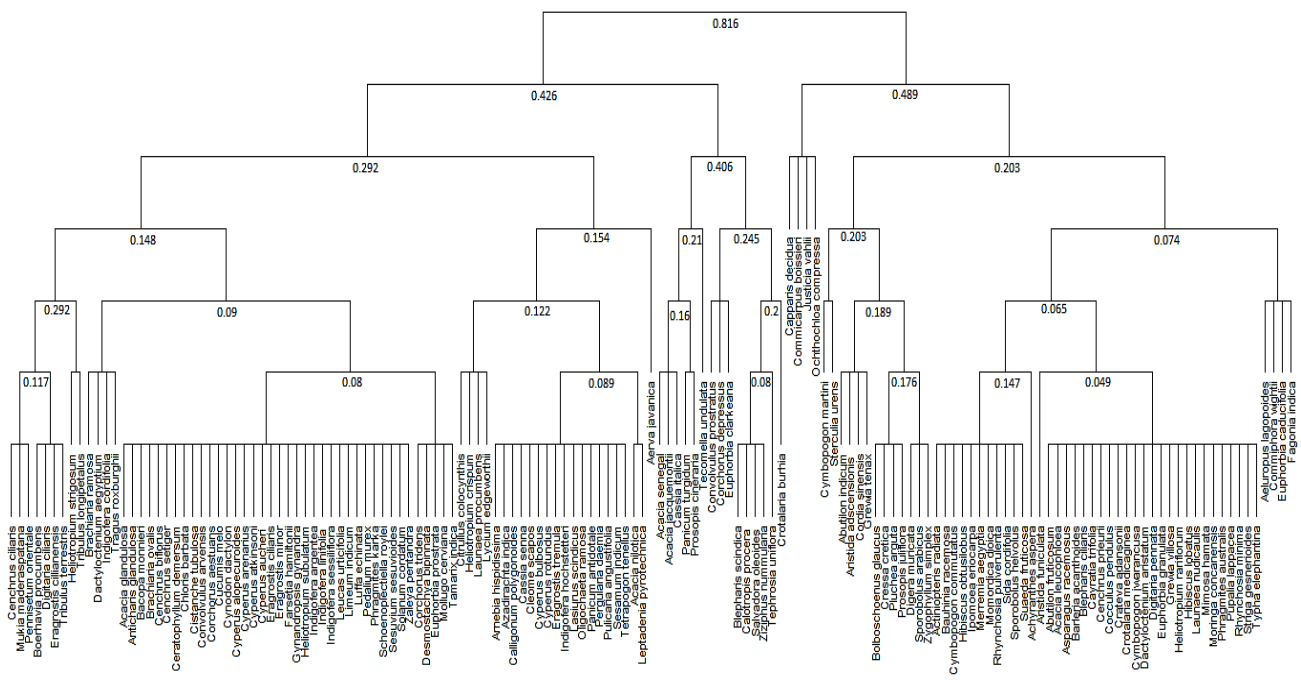


Fig. 5. Classification of plant species on the basis of TWINSPAN. The decimal numbers indicate the eigenvalues at each division level.

Biological spectrums represent how plants respond to the environment and therefore are a good indicator of surrounding conditions. Plants can withstand an unfavourable season with perennating buds. A variety of herbs, known as Therophytes, live in the desert as seeds during the unfavourable season. When the season becomes more favourable, the seed grows, and the plant undergoes its life cycle. Therophytes are indicative of biotic effects on vegetation and develop in areas that have been perturbed by anthropogenic activities (Barbero *et al*., 1990). A higher proportion of therophytes is evidence of the influence of man and animals on the environment. Phanerophytes, Chamaephytes, and Geophytes appear to be vulnerable to disturbance since their perennating buds are exposed to the environment and grazing. Unlike other lifeforms, Therophytes take advantage of the disturbance by completing their life cycle in a short span of time and seed dispersal strategy. Annual plants of the region are *drought escaping* since they are active only during favourable conditions and dormant during a drought. Trees and shrubs

in the area are drought resistant by adopting various strategies to survive in the absence of water. *Acacia* trees, for example, are the most common trees found in Tharparkar, as they have smaller leaves to minimize water loss and thereby extend their growing season. Other plants, like *Euphorbia*, store water in their body parts.

TWINSPAN analysis underscores the complexity and diversity of the plant communities of the Thar Desert. This classification revealed key patterns in species distribution and association. Notably, some species demonstrated unique adaptability, without clustering with others. Specifically, *Aerva javanica, Tecomella undulata, Crotalaria burhia, Achyranthes aspera,* and *Aristida funiculata* formed solitary groups. This solitary clustering suggests that these species possess a broader adaptability to varying microclimatic conditions within the Thar Desert, enabling them to thrive independently of the associations of other species. *Aerva javanica* and *Crotalaria burhia* have a broad distribution across the sandy desert of Tharparkar and are pioneer species in this environment. They quickly occupy sandy, abandoned agricultural land and exhibit wide adaptability, thriving under extreme climatic conditions. In contrast, *Tecomella undulata* is an endangered tree found only in cultivated fields and is likely to be left by locals for wood cultivation. Similarly, *Achyranthes aspera* and *Aristida funiculata* were more abundant in the hilly and wet areas of Nagarparkar Hills. The largest cluster, comprising 34 species, was predominantly composed of grasses, indicating a significant grass component in this ecosystem. This clustering reflects the ecological importance and prevalence of grasses in the Thar Desert, likely due to their adaptability to arid conditions and their role in maintaining soil stability and providing habitats for other organisms. Of particular interest is the close association of *Commiphora wightii*, a critically endangered plant, with other species such as *Aeluropus lagopoides, Euphorbia caducifolia,* and *Fagonia indica*. This association highlights potential mutualistic relationships or shared environmental preferences that could be critical for the conservation of *Commiphora wightii*. Understanding these associations is crucial for developing effective conservation strategies for this endangered species, as preserving the associated species may be essential for its survival.

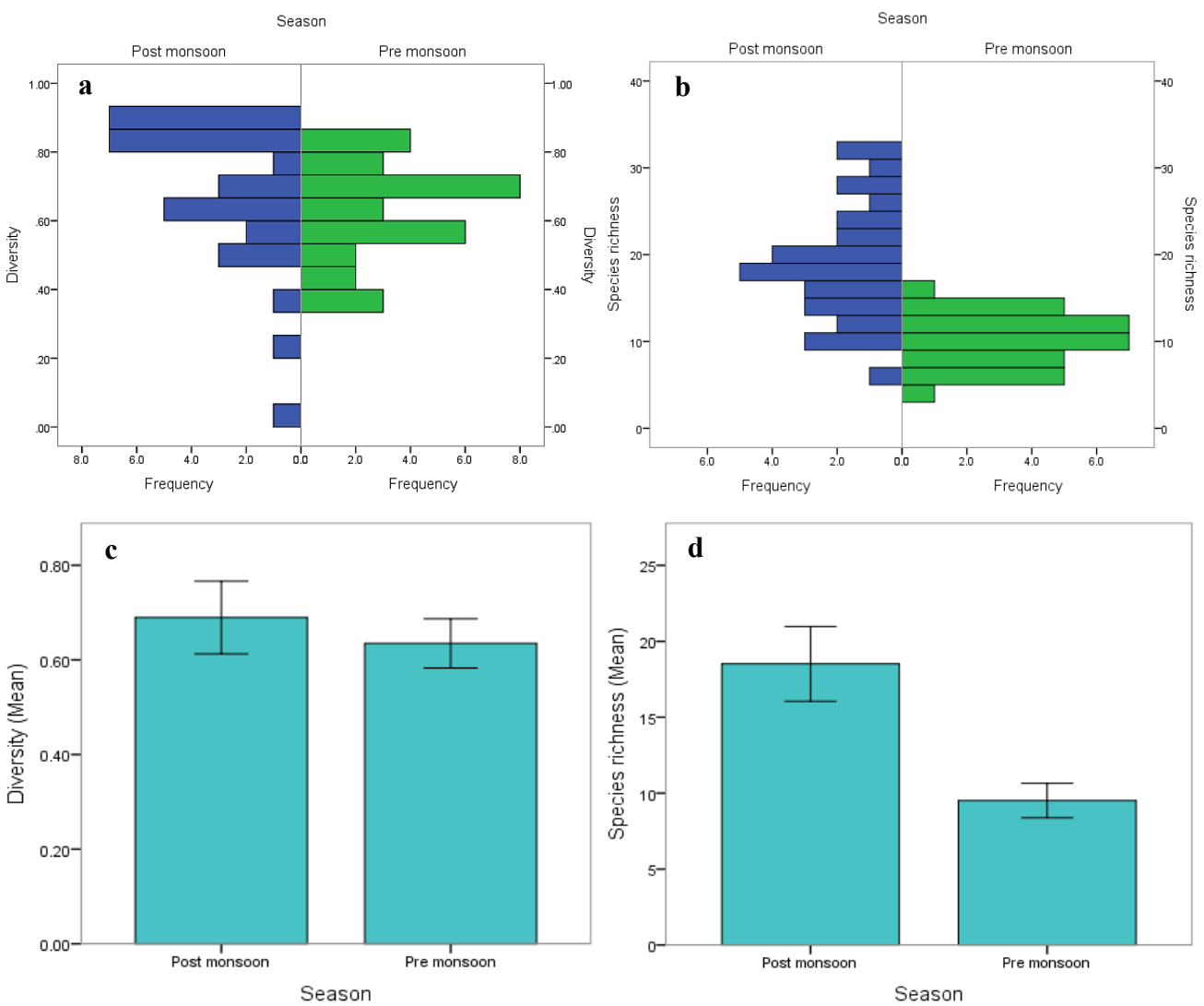


Fig. 6. The variation in plant community in pre-monsoon (March) and post-monsoon season (October) of Tharparkar District (a) Frequency of species diversity (Simpson diversity calculated for each site) at pre and post-monsoon season, (b) frequency of species richness on sites in pre-monsoon and post-monsoon season, (c) Species diversity difference in pre-monsoon and post-monsoon season, (d) Difference in species richness at sites in pre-monsoon and post-monsoon season (T-test, t=6.774, df=60, p<0.01, mean difference 09).

Table 3. Dominance of shrubs and trees in Tharparkar Desert recorded during surveys in year 2020 and 2021. Species with high frequency and density are highlighted in bold.

Habit	Species	Relative frequency	Relative density
Shrub	*Abutilon indicum*	2.50	2.50
Shrub	*Acacia jacquemontii*	1.41	1.53
Shrub	*Calotropis procera*	5.48	3.94
Shrub	*Capparis decidua*	2.03	3.96
Shrub	*Euphorbia caducifolia*	4.69	4.04
Shrub	*Grewia tenax*	5.16	4.20
Shrub	*Grewia villosa*	0.78	0.48
Shrub	***Leptadenia pyrotechnica***	29.11	42.54
Shrub	*Lycium edgeworthii*	5.32	5.57
Shrub	*Mimosa hamata*	0.16	0.08
Shrub	*Tamarix indica*	0.78	2.02
Shrub	***Ziziphus nummularia***	10.49	7.35
Tree	***Acacia senegal***	7.20	4.76
Tree	*Acacia nilotica*	0.31	0.16
Tree	*Commiphora wightii*	4.85	3.07
Tree	*Prosopis cineraria*	2.50	1.37
Tree	***Prosopis juliflora***	9.23	7.27
Tree	*Salvadora oleoides*	3.91	2.26
Tree	*Tecomella undulata*	4.07	2.91

Table 4. Average height and ground cover of Trees and Shrubs.

Habit	Species	Height (m) Mean ± SD	Canopy/area cover (sq. m) Mean ± SD
Tree	*Acacia nilotica*	4.9 ± 0.8	61.5 ± 13.8
Tree	*Acacia senegal*	4.8 ± 1.8	124.9 ± 63.8
Tree	*Prosopis cineraria*	7.9 ± 1.7	160 ± 39.1
Tree	*Prosopis juliflora*	4.4 ± 0.4	28.1 ± 16.6
Tree	*Salvadora oleoides*	5.3 ± 2.7	105.5 ± 43.7
Tree	*Tecomella undulata*	4.3 ± 0.5	36.6 ± 7.7
Shrub	*Acacia jacquemontii*	1.6 ± 0.1	19.7 ± 0.9
Shrub	*Calotropis procera*	1.9 ± 0.5	55.8 ± 56.7
Shrub	*Commiphora wightii*	1.3 ± 0.4	20.6 ± 10.4
Shrub	*Capparis decidua*	2.8 ± 1.1	39.9 ± 32.9
Shrub	*Euphorbia caducifolia*	2.6 ± 0.9	182.9 ± 32.6
Shrub	*Leptadenia pyrotechnica*	1.4 ± 0.5	20.1 ± 11.9
Shrub	*Lycium edgeworthii*	0.6 ± 0.2	3.81 ± 2.9
Shrub	*Tamarix indica*	1.7 ± 0.1	14.0 ± 0.1
Shrub	*Ziziphus nummularia*	1.9 ± 1.1	19.8 ± 14.6

The height of the trees is an indicator of the habitat's potential to support vegetation. The sandy desert of Tharparkar is covered with scattered shrubs and trees of *Acacia* spp., *Lycium* spp., *Salvadora oleoides*, *Leptadenia pyrotechnica*, *Calotropis procera* (Apple of Sodom), and *Ziziphus nummularia* (Wild Jujube). Such species can withstand harsh environmental conditions. The size of some trees in the region was found quite low (Table 4). For example, about half the size of a normal *Commiphora wightii* (Indian Bdellium) shrub was observed in the field. The height of Indian Bdellium may reach more than 16 feet (Sinha *et al*., 2012). It is evident that mature plants are used for gum tapping, which eventually dies off soon (Ahmad *et al*., 2013). In contrast, *Leptadenia pyrotechnica*, *Calotropis procera* (Apple of sodom), and *Salvadora oleoides* were found with vigorous growth and were among the least affected plants. Plants that thrive in arid or semi-arid regions have evolved morphological and physiological adaptations that support their survival. As is the case with *Calotropis procera*, which responds to abiotic stress through a variety of processes. *Calotropis procera* is deep rooted shrub. Regardless of the soil type, *Calotropis procera* is drought and salt tolerant, thrives the best on sandy soil that drains freely (Hassan *et al*., 2015). A strong ability to respond quickly to water availability allows *Calotropis procera* to adjust water availability and losses very rapidly in response to drought (Ramadan *et al*., 2014).

Structural variability in tree stands of a population and occurrence of species in lower growth phases, such as seedling and sapling, indicates the regeneration of the species in the habitats. We seldom recorded trees in early growth stages except for *Prosopis juliflora* (Mesquite) and regeneration of *Ziziphus nummularia(*Wild Jujube) and *Tecomella undulata* (Desert teak) at agricultural fields where their trunks were chopped down for the land to be used in cultivation. Young plants were grazed badly in the interdunal flat areas that are largely used for cultivation. Due to these reasons, plant communities are undoubtedly under pressure from the high grazing and habitat loss.

There were relatively fewer species on each site before monsoon. These were mostly trees and shrubs with low palatability. The density of trees and shrubs do not differ in seasons as these are perennial plants. The monsoon season brings life to this desert, resulting in relatively dense vegetation. In the post-monsoon period, herbaceous plants, including ephemerals and grasses, were more abundant, contributing to the higher species richness. Most of these species are palatable and provide plentiful fodder for livestock. Low levels of diversity in the spring season were expected due to grazing pressure on palatable plants. The annual grasses and herbs in the drought season remain in their dormant phase; in the form of seeds. These seeds germinate in the following rainy season when the environment becomes favourable for their growth. The higher grazing pressure also adversely affects the number and density of the herbs and grasses. The intensity of grazing can cause perennial grass species to become confined to their rootstocks. Grasses can tolerate high levels of grazing intensity since their sprouting buds lie close to the ground, which can regrow under favourable conditions. In contrast, herbs reproduce through some fallen seeds. These become more vulnerable if they are grazed before they produce seeds (Ansari *et al*., 2017). The species richness also benefits the herbivore arthropods who depend on them. The arthropod diversity in the ecosystems is reduced due to higher grazing of their host plants (Hertzog *et al*., 2016); Consequently, resulting in an adverse cascading effect on ecological functions such as nutrient cycling, growth of plants, and community structure of the ecosystems.

The increasing population of the area has a direct and indirect impact on the ecosystem. There are two plant species that has been listed in the red list of species. *Commiphora wightii* (Gugar) is a slow growing shrub. The taxon is listed in the red list as Critically Endangered (CR-A2cd); There is a rapid decline in *C. wightii* population for the last couple of decades (Ved *et al*., 2015). There are wide varieties of microhabitats where this plant can grow, for example, rocky hills, rocky plateaus, undulated sandy soil, and dunes. The ecologists are concerned about the protection of this species; in this regard, a few conservation measures were taken to protect the population of this shrub (Ahmad *et al*., 2013) However, long time sustainability

measures are required to stabilize the population of threatened species. The taxon is heavily exploited for its medicinal use. The gum extracted from this plant is very expensive and sold at the rate of about eighty thousand for 40 kilos of gum (personal communication). The seeds and gum of this shrub are used to cure various ailments such as inflammation, backache, arthritis, insect & snake repellent, cardiovascular disease, lipid disorders, and obesity (Urizar & Moore 2003; Wang *et al*., 2004; Yaseen *et al*., 2015). *Tecomella undulata* (Desert Teak, locally named Rohiro) is found in drier parts of Sindh, Baluchistan, Khyber Pakhtunkhwa and parts of Northwest India. This species is named Ironwood for having strong and durable wood, which is used in furniture and building materials. The plant also possesses curative properties against various diseases (Jain *et al*., 2012). The population of this species has declined. *T. undulata* is declared endangered in literature due to its overuse as timber and medicine (Dhir & Shekhawat, 2012; Kalia *et al*., 2014).

There are few important species that has taken refuge to the Karoonjhar hills and face the threat of local extinction. *Sterculia urens* (Indian katuria): This is a very important gum producing tree that is native to the Indian subcontinent. This is perhaps the first report of this important tree from the study area. In Pakistan, it is seldom found, perhaps confined to the Karojhar Hills, where it has taken refuge in cliffs where access is difficult. It is locally called Karrayo. This tree produces Karaya-gum which is used for various ailments by the locals. In India, Karaya-gum is used extensively in international trade (Arora & Ramawat, 2014). The gum exudes from the stem when tapped after removing the bark. The gum is collected in late spring and after monsoon. It is used in the food industry in various food items (BeMiller, 2018). *Moringa concanensis* (Wild moringa) is a wild medium-sized tree locally called Jabli Saringoo, perhaps found solely in the Nagarparkar hills and Khirthar range in Pakistan. In addition to its native range (Thar Desert) in Pakistan and India, it has also been introduced to Bangladesh. As a medicinal plant, the tree has been used as a remedy for urinary bladder disorders, jaundice, joint pain, gastric problems, sexual disorders, and body tonics (Yaseen *et al*., 2015). A high-quality edible oil may be produced from the seeds of this plant (Manzoor *et al*., 2007). An isolated population of this tree was observed in the Karojhar hills and Kharsar hills of Nagarparkar. The population of this tree is on the verge of local extinction as the tree is being indiscreetly used for fuel wood and medicinal purpose.

The Thar Desert (Tharparkar) is home to a rich and diverse flora, including many endemic and rare species. These incredible plants offer a vital role in maintaining the region's fragile balance of nature. They offer critical resources to local populations, including food, medicine, fuel, and shelter. However, this unique ecosystem faces challenges. Key priority actions should focus on identifying biodiversity hotspots and developing community-based conservation strategies aimed at reducing impacts on the natural ecosystem and safeguarding species. Protecting these important resources is fundamental to the long-term sustainability of the desert and the well-being of its people. Implementing a sustainable development strategy is essential for preserving this valuable biodiversity for future generations.

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