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VEGETATIONAL AND STRUCTURAL TRAITS OF SOME MAJOR AREAS OF THARPARKER DESERT, PAKISTAN.

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Abstract

Tharparker is the only fertile and one of the most densely populated deserts in the world. This study aims to evaluate the vegetational and structural attributes of different areas of Tharparker desert. The sampling was carried out at 18 sites in18 union councils belonging to 04 talukas of two districts; Tharparker and Umerkot in Tharparker desert. The average rainfall (237±78.47 mm) was recorded during study because the sustainability of life in this hot desert rotates around the annual rainfall. The results reveal that the major proportion (69.23%)of the vegetation is herbaceous followed by trees (30.76%). The density/ha graph indicates that *Salvadore persica* is the most dominant species in terms of density, while *P. cineraria* and *A. senegal* are less prevalent. *Ziziphus nummularia* shows moderate presence, with some areas favoring its growth more than others. the density per hectare of various tree species across different locations. *S. persica* shows the highest density (966±246) across most locations, with Alamsar having the peak density (3000/ha) followed by Saghror (2500/ha). The areas which exhibit higher tree densities across all species, suggesting that these areas might be with more favorable conditions for tree growth. The graph provides insights into the distribution and abundance of different tree species, highlighting the dominance of *Z. mauritiana* and the variability in tree composition across different locations. The equation y = 0.1259x suggests a significant increase in basal area with increasing density, and the R-squared value indicates that the linear model fits the data very well. The overall plot combines all data, resulting in a moderate correlation. The range of density and basal area varies significantly among the species, *S. persica* reaching higher densities and *Z. nummularia* having a much larger basal area compared to others. The results concluded that Tharparker has a specific characteristic with a variety of environmental stresses including low precipitation, high temperature, low rainfall, extreme aridity, low availability of nutrients and high evaporation-transpiration rate. The vegetation of the region is adapted to these edapho-climatic extremities, which helps some plant species to grow and sustained in the adverse xerophytic conditions.

Introduction

Pakistan largely contains arid and semi-arid land including Thar Desert which has been resulted from Geo tectonic and climatic changes since a long time ago (Ahmed, 1969). The degradation and loss of natural habitats have been occurring for thousands of years, but the process has been accelerated in the last few decades due to rapid development activities and population expansion (Gibson, 2009). Recently, with the development of the canal system, an extensive area in the Indus plains has come under the cultivation of agricultural crops after the clearing of forests including the riverine forests of Punjab and Sindh. The protection of forest land and establishment of rangeland in the Thar Desert is the need of the hour to protect the natural ecosystem. However, the knowledge of the present rangeland system and effect of human activity as well as the environment (i.e., global warming, rain fall pattern etc.) is the prerequisite to design a comprehensive rangeland and grasses system in the Thar Desert for a sustainable ecosystem (Black, 1999).

Tharparkar is reckoned as the dry natural resource, significantly in indigenous coal, granite, salt mines, livestock and China clay. Most of the area is deserted except1.5% observed as agriculture land. Tharparker, also known as the Great Indian Desert, is a large, arid region in the northwestern part of the Indian subcontinent, with an area of more than 20,000 sq. km., it is the seventeenth largest desert in the world. It lies mostly in the Indian state of Rajasthan, and extends into the southern portion of Haryana and Punjab states and into northern Gujarat state. In Pakistan, the desert covers eastern Sind province and the southeastern portion of Pakistan's Punjab province. Tharparker is bounded on the northwest by the Sutlej River, on the east by the Aravalli Range, on the south by the salt marsh known as the Rann of Kutch and on the west by the Indus River. Its boundary to the large thorny steppe to the north is ill-defined. The desert presents an undulating surface, with high and low sand dunes separated by sandy plains and low barren hills, or bhakars, which rise abruptly from the surrounding plains. The prevailing southwest monsoon winds that bring rain to much of the subcontinent in summer tend to bypass the Thar to the east. The amount of annual rainfall in the desert is generally low, the mean annual rainfall variesfrom less than 100 mm in the west to 200 mm in the east. Rain usually falls during monsoon, winter and spring. Tharparker is one of the hottest regions of Pakistan. Temperatures are high in summer and mild in winter. Precipitation amounts fluctuate widely from year to year. May and June are the hottest months of the year, with temperatures rising to 122 °F (50 °C). During January, the coldest month, the mean minimum temperature ranges between 41 and 50 °F (5 and 10 °C), and frost is frequent. It is reported that the consequences of climate change may be very adverse for the biological diversity of the desert (Abdullah et al., 2013).

The vegetation structure of Tharparkar is dominated by herbaceous and stunted shrub, with drought-resistant trees scattered, especially in the eastern parts. There are at least 89 plant species from 26 families native to Tharparkar, with many herbs growing during the wet season and desert shrubs and drought-resistant trees growing year-round (Kalroo et al., (2021)). It has been observed that in Thar, the native plant species have disappeared due to extensive grazing and cutting of trees for fire and sale in the market. This scenario demands immediate attention to resolve the issue (Roberts, 1997 **;** Sala and Paruelo, 1997**;** Sala et al., 1998**;** Sergelenkhuu et al., 2012**;** Wadia, 1960). Therefore, the present study was designed to collect base line data about vegegational and structural data to chalk out the management strategy in Tharparker desert.

Materials & Methods

The study was conducted in Tharparker desert, Pakistan located between 69° 3′ 35″ E and 71° 7′ 47″ E longitudes, and between 24° 9′ 35″ N and 25° 43′ 6″ N latitudes (Fig. 1). Several sites' surveys were conducted during 2020-21, in order to know site conditions, accessibility, plant assemblages before collecting data. The study was carried out at 18 sites in18 union councils belonging to 04 talukas of two districts; Tharparker and Umerkot in Tharparker desert to check the variations in data and to avoid errors. Quadrat method (Mueller- Dombois and Ellenberg, 1974) was applied for quantitative sampling. Eighteen stands were sampled in a random manner having three replicates of 100 m^2 quadrats. All the trees within a quadrat were counted, only absolute values (density and basal area) were calculated. The associated herbs/shrubs species were also recorded.

Results & Discussion

Table 1 shows 18 sampling sites belonging to two districts of Sindh, Pakistan Tharparkar and Umerkot, along with their corresponding 04 talukas (sub-districts) and 18 union councils. The annual rainfall data ranged between 185 mm to 297 mm with the average recorded rainfall (237 mm) (Figure 1). The image shows a line graph depicting rainfall (in millimeters) across different study sites. The graph indicates that rainfall is relatively high at the initial study sites, then it decreases and stabilizes at a lower level for the remaining sites.

Table 1. Sampling sites with co-ordinates of Tharparker desert.

Stand No.	Districts	Taluka	Union Council	Villages
1	Tharparkar	Mithi	Bakou	Alamsar
2	Tharparkar	Diplo	Jhirmriyo	Sarh Juneja
3	Tharparkar	Mithi	Joruo	Gane Bheej Ji Dhani
4	Tharparkar	Mithi	Mithrio Bhatti	Godhiyar
5	Tharparkar	Mithi	Malanhor Veena	Malanhor Veena
6	Tharparkar	Diplo	Bhador	Kharoro
7	Tharparkar	Diplo	Sobhiyar	Saghror
8	Tharparkar	Diplo	Diplo	Khari Passaya
9	Tharparkar	Diplo	Bolhari	Narori
10	Tharparkar	Mithi	Posarko	Rohiro
11	Tharparkar	Dahli	Laplo	Jujhare Jo Par
12	Tharparkar	Dahli	Perane Jo Par	Perane Jo Par
13	Tharparkar	Dahli	Parno	Baghal
14	Tharparkar	Dahli	Jasi Jo par	Bitwaro
15	Tharparkar	Dahli	Kamanhor	Khario Fazal
16	Umerkot	Umerkot	Mehandry Jo Par	Mehendre Jo par
17	Umerkot	Umerkot	Sekharo	Jhimrari
18	Umerkot	Umerkot	Jaokir	Ramsar

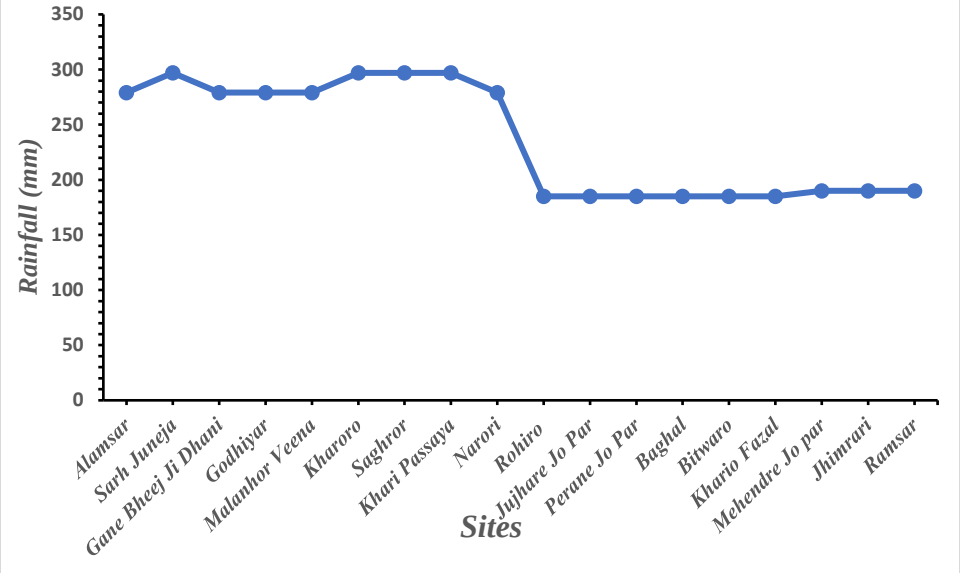


Figure 1. showing the annual rainfall data with the study sites.

Vegetation Survey

Vegetation diversity plays a vital role in maintaining ecological balance in any natural ecosystem. Therefore, ecological studies and systemic floristic inventory must be carried out on regular interval to assess changes in diversity due to natural as well as anthropogenic factors. Keeping in view of the importance of ecological study to considerate the mutual relationship between nature and inhabitants, the information on floral diversity was collected in relation to different habitats of Tharparker desert (Fig.2). Many workers have done a remarkable work on the floral diversity of the Tharparker. In current vegetation survey a total 7 families belonging to 11 genera and 13 species were documented from the study sites (Table 2).

Among the existing families, Asclepiadaceae is the largest family with 4 species followed by Fabaceae (3 species), Poaceae (2 species), Salvadoraceae, Rhamnaceae, Amaranthaceae and Capparaceae are represented with single species. The study shows that the herbaceous vegetation (69.23 %) (shrubs= 38.16% and herbs= 31.07%) were highest prevailing vegetation in Thar desert followed by trees (30.76 %). The herbs/shrubs form the main natural resources of Thar desert which provide nutritive pasturage as well as medicines used locally by the inhabitants. A total nine species of herbs/shrubs were recorded and placed in Table 2 with their local name and status (Fig.2).

Table 2. showing the presence of herb/shrubs with local names and families in Tharparker desert.

Scientific Name	English/Common Name	Local name	Family	Status
Cenchrus biflorus	Indian sandbur	Bhurat	Poaceae	Herb
Prosopis juliflora	Vilayati Kikar	Devi	Fabaceae	Shrub
Leptadenia pyrotechnica	Broom Brush	Khipp	Asclepiadaceae	Shrub
Aerva javanica	Desert cotton/Kapok bush	Booh	Amaranthaceae	Herb
Capparis spinosa	Flinders rose	Kirar	Capparaceae	Shrub
Aristida depressa	Six weeks threeaw	Lumb	Poaceae	Herb
Calotropis gigantea	Crown flower	Aak	Asclepiadaceae	Shrub
Acacia jacquemontii	Bable/ Kikri	Bawari	Asclepiadaceae	Shrub
Cassia obovata	Senna	Ghorawal	Asclepiadaceae	Herb

Four tree species *Salvadora persica*, *Prosopis cineraria*, *Ziziphus nummularia* and *Acacia senegal* belonging to three families were recorded from sampling sites (Table 3) (Fig.3). The vegetation of Thar desert is xeric, adapted to extremely high temperature, low moisture contents and increased salinity coupled with wide variation of edaphic factors. The desert vegetation is mostly herbaceous or stunted scrub; drought-resistant trees occasionally dot the landscape, especially in the sampling sites. It might be due to the interdunal flats of Thar desert holds hard and compacted surfaces as these flats retain the rainwater for longer time. (Charan and Sharma, 2016).

Table 3. showing the presence of tree species with local names in Thar desert.

Botanical Name	English/common name	Local name	Family
Salvadora persica	Tooth Brush Tree/Miswak	Khabbar	Salvadoraceae
Prosopis cineraria	Ghaf/Jandi	Kandi	Fabaceae
Ziziphus nummularia	Wild Jujube	Ber	Rhamnaceae
Acacia senegal	Gum Arabic	Kumbhat	Fabaceae

Cenchrus biflorus

Leptadenia pyrotechnica

Aristida depressa

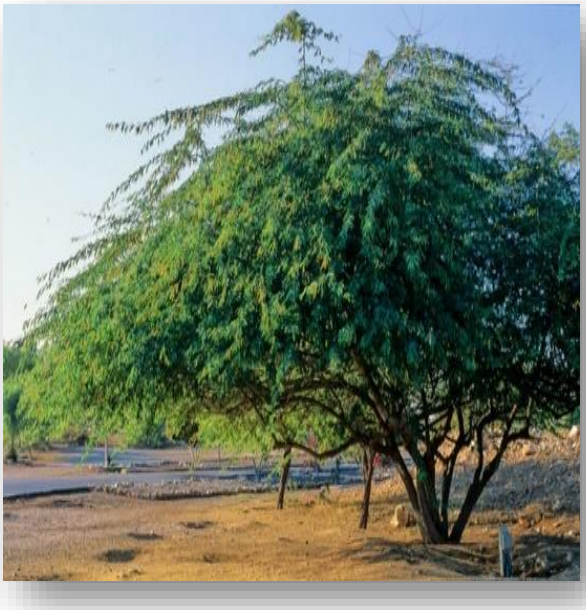
Aerva javanica

Capparis spinosa

Cassia obovata

Acacia jacquemontii

Calotropis gigantea



Prosopis juliflora

Figure 2. Herbs/shrubs recorded from different study sites at Thar desert

Salvadora persica

Prosopis cineraria

Aacia senegal

Ziziphus nummulari

Figure 3. Tree species recorded from different study sites at Tharparker desert

Structural Attributes

Fig. 4 The graph provides a comparative view of tree species distribution and density across different geographical areas, highlighting the ecological variations and dominant species in each location. The results shows that *S. persica* exhibits the highest density (3000/ha) at Alamsar followed by Saghror (2500/ha). *A. senegal* exhibits the lowest density across all locations. *Z. nummularia* has intermediate mean density values (816±201), generally higher than mean values *(105±42)* of *P. cineraria* but lower than *S. persica*. *A. senegal* is the most important native tree of Thar, low density of this specie might be due to the harvesting practices for income generation and fodder for livestock. Fig.5 illustrates the basal area (m²/ha) of four tree species across different locations. The basal area of *S. persica and P. cineraria* is relatively low across all locations, generally below 20 m²/ha. However, *Z. mauritiana* shows a significant spike in basal area, particularly at Godhiyar, reaching over 100 m²/ha. Other locations also show an increase but to a lesser extent. The basal area drops sharply, returning to low levels similar to *Salvadora persica* and *Prosopis cineraria*. The variations in tree basal area among different species and locations, with *Z. mauritiana* showing the most significant growth in certain areas. The other three species maintain relatively low basal areas across all locations. *S. persica* and *P. cineraria* have low basal areas across all locations, typically below 20 m²/ha. *Z. mauritiana* shows a significant spike in basal area, particularly in the Godhpur location, where it reaches over 100 m²/ha. Other locations also show increased basal area for this species, but not as pronounced. *A. senegal* basal area for this species is generally low, similar to *S. persica* and *P. cineraria*, with most locations showing values below 10 m²/ha. The graph suggests that *Z. mauritiana* is the dominant tree species in the studied areas, especially in Godhpur. This could be due to favorable environmental conditions or specific land management practices in that location. *S. persica, P. cineraria, and A. senegal* show relatively consistent but low basal areas, indicating they are less dominant or possibly face different environmental pressures across the locations. For instance, Godhpur might have conditions particularly suited for *Z. mauritiana*. The overall variations in density and basal area across locations suggest that environmental factors or management practices significantly influence tree growth and distribution.

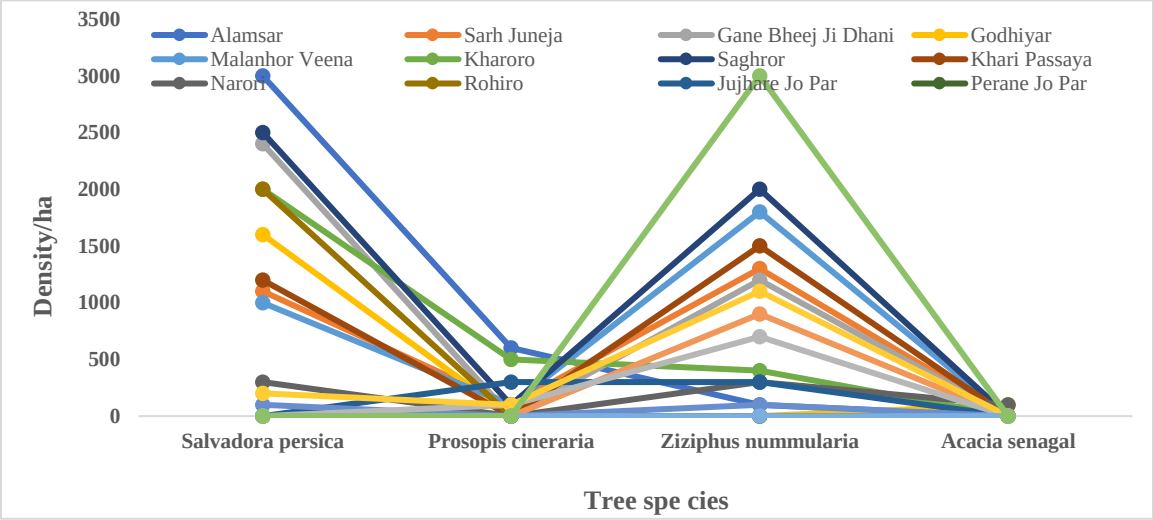


Figure 4. Density/ha of four species at different sites.

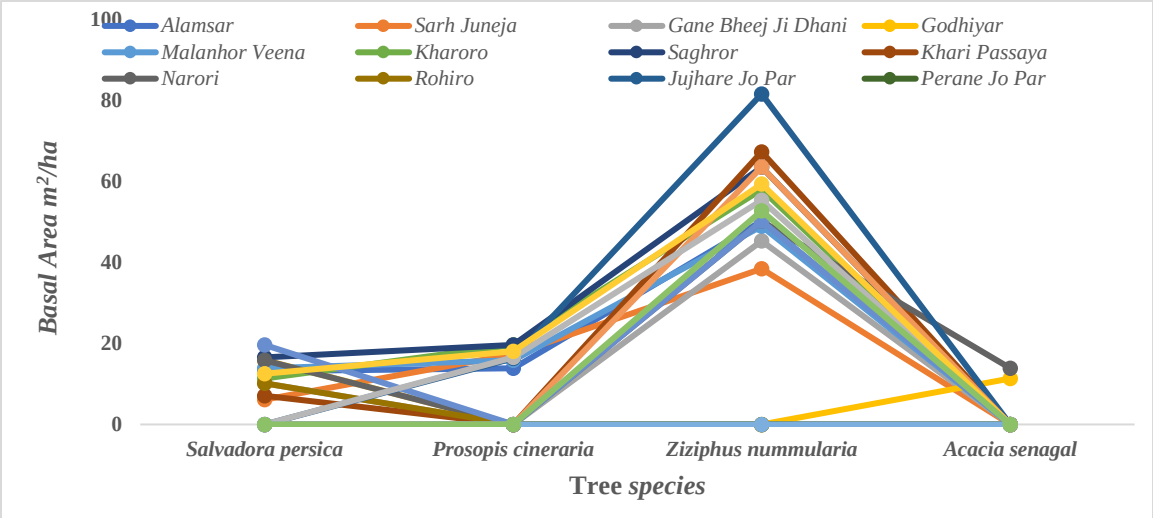


Figure 5. Basal Area (m^2/ha) of four species at different sites.

Different herb/shrubs species collected in the study sites, the most dominant and distributive species was *A.javanica* ranked first with higher frequency (83.33%), found in most of the stands except Kharoro, Perane Jo Par and Mehendre Jo Par while *A. jacquemontii* was the least recorded species (11.11%), only reported from two sites Khari Passaya and Perane Jo Par. The presence/absence of the tree species with frequency % among sites. *Z.nummularia* ranked first (72.22%) followed by *S.persica* (61.66%), *P.cineraria* (*44.44%)* and *A.senegal (11.11%)* ranked second, third and fourth respectively. The detail study is highly recommended for knowing the status of these important herb/shrubs species.

Table 4. presents data related to different sites, analyzing their frequency, density, basal area, and height. Each row in the table corresponds to a specific site, with the associated values for frequency, density, basal area, and height. The values are presented with mean ± standard deviation. For example, Alamsar has a frequency of 11%, a density of 925±704 ha^{-1}, a basal area of 19.32±10.79 m^2ha^{-1}, and a height of 4.83±0.18 ft. The site "Perane Jo Par" and "Jhimrari" have 0 value for Frequency, Density, Basal area and Height. The structural characteristics of the desert dominating species revealed that 66.66% study sites dominated as *S.persica* (50%) followed by *Z.nummularia (46%), P.cineraria (4%)* and *A.senagal (1%).* This could indicate an absence of data or no recorded presence at the time of measurement. The data in the table could be used for ecological studies, environmental monitoring, or resource management, providing insights into the characteristics and attributes of different sites.

Table 4. Showing the structural attributes of all trees at selected sites.

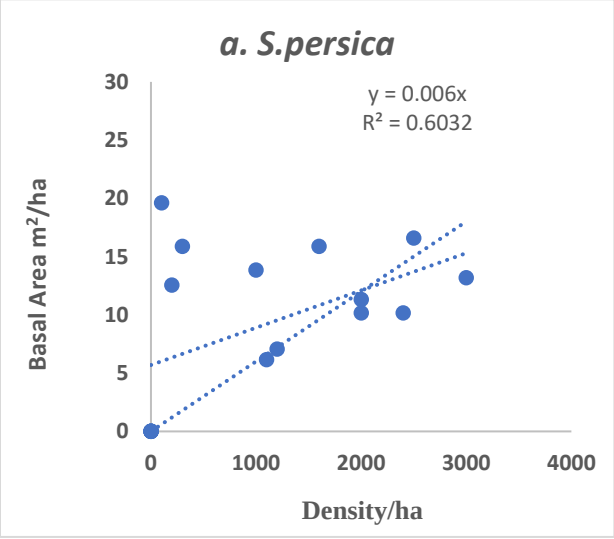
Site	Frequency (%)	Density (ha^{-1})	Basal Area (m^2ha^{-1})	Height (ft)
Alamsar	11	925±704	19.32±10.79	4.83±0.18
Sarh Juneja	07	625±335	15.49±8.46	5.78±0.34
Gane Bheej Ji Dhani	11	900±574	13.88±10.76	1.00±0.66
Godhiyar	05	425±392	6.81±4.04	3.50±0.87
Malanhor Veena	08	725±423	19.69±10.39	5.90±0.15
Kharoro	08	725±438	22.26±12.49	5.05±0.71
Saghror	13	1150±643	24.96±13.58	5.35±0.67
Khari Passaya	08	675±394	30.03±7.72	1.80±0.10
Narori	02	175±75	20.00±10.68	5.75±0.15
Rohiro	06	500±54	2.54±2.54	0.68±0
Jujhare Jo Par	02	150±86	24.50±9.67	3.70±0.98
Perane Jo Par	00	0±0	0±0	0±0
Baghal	01	50±28	17.47±7.67	1.18±0.80
Bitwaro	03	225±56	15.90±7.56	0.40±0
Khario Fazal	02	200±68	18.00±6.56	3.33±0.33
Mehendre Jo par	04	350±53	22.52±5.67	5.58±1.15
Jhimrari	00	0±0	0±0	0±0
Ramsar	09	750±56	13.20±5.56	0.38±0

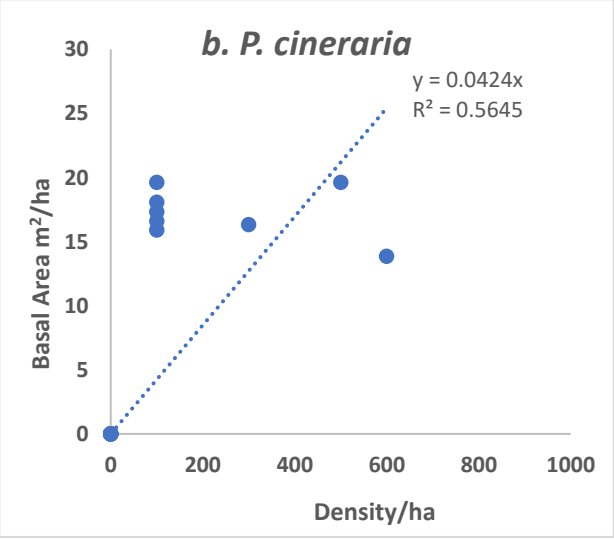
The overall tree species mean frequency (13%) was recorded from Saghoor followed by Alamsar and Godhiyar. The maximum stand density of *S. persica* (3000 trees/ha) at Alamsar while *A.senegal* occupied the minimum density (100 tree/ha) at Godhiyar and Narori. The maximum basal area (19.63 m^2/ha) of *S.persica* was recoded from Baghal followed by Saghror (16.61 m^2/ha) and Narori 15.90m^2/ha). The similar value of basal area (19.63 m^2/ha) of the other co-dominant species *P.cineraria was found at two sites Malanhor Veena and Kharoro.* The maximum basal area of other associated species *Z. nummularia* and *A.senagal* were found in Jujhare Jo Par and Narori. The overall maximum density (1150±643 trees/ha) and basal area (30.03±7.72 m^2/ha) was found at Saghror and Khari Passaya respectively. The maximum average height of the trees (5.9 feet) was found at Malanhor Veena; however , there was no tree species was found at two sites, Perane jo Par and Jhimari might be due to variable rainfall. The density of each tree species varies

significantly by location, indicating environmental or management influences specific to each site. This study will help to compare the distribution and abundance of these tree species across the study area, which can inform conservation and management strategies.

Correlation among variables

Fig. 6 (a-d & e) shows a series of scatter plots, each examining the relationship between density (trees per hectare) and basal area (square meters per hectare) for different tree species and an overall. Each plot includes a trendline and the corresponding equation and R-squared value, indicating the strength and direction of the linear relationship. *S. persica* (R^2 = 0.6032) *and P. cineraria* (R^2 = 0.5645) show a weak positive correlation with density ranging up to 4000 trees/ha and1000 trees/ha with basal area up to 25 m²/ha respectively. The equations y = 0.006x and y = 0.0424x, suggest a slight and modest increase in basal area with increasing density. *Z. nummularia e*xhibits a weak positive correlation (R^2 = 0.5903) as well, with the equation y = 0.035x, with density extending to 4000 trees/ha and basal area up to 120 m²/ha. *A. senagal shows* a strong positive correlation (R^2 = 0.9901), the strongest among the species, with density up to 150 trees/ha and basal area around 20 m²/ha (*Fig. a-d).* The overall regression analysis indicates a moderate positive correlation (R^2 = 0.6842) across all species, with density up to 1500 trees/ha and basal area up to 35 m²/ha. Comparing the graphs, *A. senagal* has the strongest linear relationship between density and basal area, while the other individual species show weaker correlations. The equation y = 0.1259x suggests a significant increase in basal area with increasing density, and the R-squared value indicates that the linear model fits the data very well. The overall plot combines all data, resulting in a moderate correlation. The range of density and basal area varies significantly among the species, *S. persica* reaching higher densities and *Z. nummularia* having a much larger basal area range compared to others. Tharparker has a specific characteristic with a variety of environmental stresses including low precipitation, high temperature, extreme aridity, low availability of nutrients and high evaporation-transpiration rate. The vegetation of the region is adapted to these edapho-climatic extremities, which helps the plants to grow and sustained in the adverse xerophytic conditions (Saroj et al.,2020).





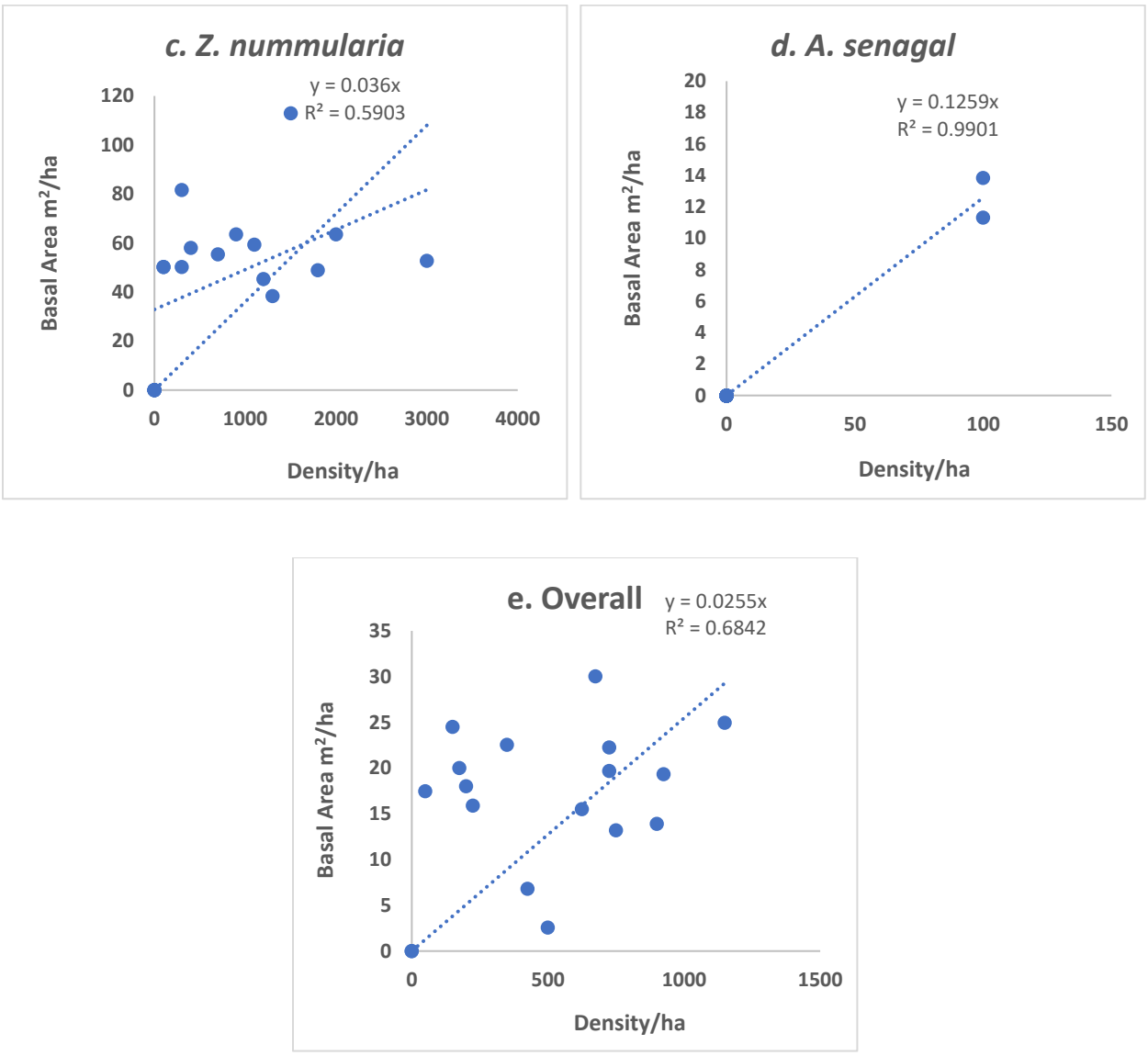


Figure 6 (a-e). showing the relationship between density/ha and basal area m^2/ha of all sites.

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