



Exploring Tree Communities in the Ecologically Significant Banas River Corridor of Gujarat: A Phytosociological Analysis

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The findings of a phytosociological study conducted in the Banas River Corridor of Gujarat, India, are presented in this article. The primary objectives of the study were to identify, characterize, and classify the naturally occurring vegetation community in the area. Quadrature method used for vegetation sampling, which resulted in the documentation of 70 tree species. The IVI value indicated that *Prosopis juliflora* was the most successful and well-established species in the area. The recorded species were found to have contiguous distribution within the study area, and the overall vegetation community was observed to be heterogeneous. However, human activities such as fire incidence, livestock grazing, and other disturbances have led to the depletion of the forest's old and uneven age structure. The study provides crucial baseline information on the dry forests of the Banas River Corridor, highlighting the need for appropriate conservation and management practices to improve the botanical value of the area and its significance for other life forms.

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1. INTRODUCTION

The Banas River corridor in Gujarat, India, is an ecologically important region that harbors a rich variety of plant species. According to a study [1], a total of 520 Angiospermic species, distributed among 340 genera and 101 families, have been documented in this area. The vegetation in the region is influenced by factors such as the river's flow, soil type, and other environmental conditions. The Banas River corridor boasts a diverse range of plant species, as evident from the results of previous alpha diversity analysis [2]. These findings indicate the presence of a flourishing and stable ecosystem characterized by a vibrant assortment of plant species.

Phytosociology is the study of plant communities and their interactions with the environment. It is a vital tool for understanding the distribution, abundance, and diversity of plant species in a given area. Phytosociological analysis of the trees in the Banas River corridor can provide valuable insights into the structure and composition of this region's plant communities.

Several studies have been conducted on the vegetation of the Banas River corridor, including studies on the distribution and diversity of plant species [3,4]. However, there is a lack of research specifically focused on the phytosociology of the tree species in this area.

Therefore, the aim of this study is to conduct a phytosociological analysis of the trees in the Banas River corridor of Gujarat, India. The study will provide valuable information on the structure and composition of the tree communities in this region, including their species richness.

The findings of this study will contribute to our understanding of the ecological importance of the Banas River corridor and the conservation of its biodiversity. It will also provide a baseline for future studies on the vegetation of this area and serve as a reference for the development of management and conservation strategies.

2. STUDY SITE

The Banas River basin has a catchment area of 8,674 km², with 3,269 km² located in Rajasthan and the remaining 5,405 km² located in Gujarat [5]. For the study area, only the area located within Gujarat state is considered. The Banas River originates in the Aravalli Hills of Rajasthan and flows in a south-western direction, covering a total length of 266 km, of which 78 km is in Rajasthan and 188 km is in Gujarat [5]. The Banas River corridor location map is presented in Fig. 1, which depicts that the majority of the basin area, around 62.3%, falls within the Banaskantha district of Gujarat [5].

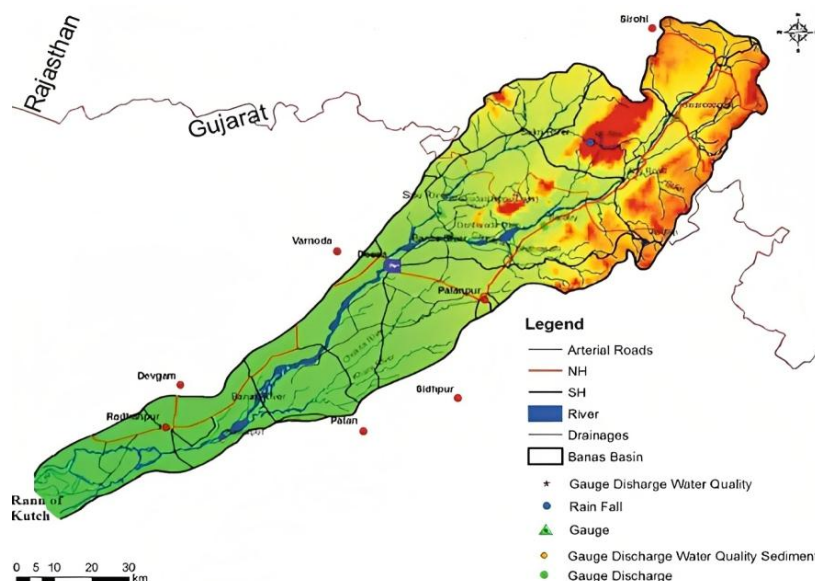


Fig. 1. Location Map of Banas River Corridor
(Sources: <http://cgwb.gov.in/watershed/>)

3. METHODOLOGY

Table 1. Zonation of the Study site

Zones	Location
Zone - 1	Amirgadh - Dantiwada
Zone – 2	Dantiwada – Deesa – Kakrej
Zone – 3	Kankrej – Harij – Sami
Zone - 4	Sami – Radhanpur – Santalpur (The Little Rann of Kachchh)

The geomorphology of the entire *Banas* corridor varies significantly with very few trees visible and a salt marsh dominating the entire eastern border. To investigate the status of plant diversity and community structures, the study area was divided into four zones based on gradient (Table 1).

The fieldwork spanned three years from January 2019 to December 2022 and community analysis was conducted during mid-monsoon and post-monsoon seasons when the plants were at their peak growth, as well as pre-monsoon season. Belt transect sampling was employed in this study to determine the distribution and density of plant species across the study area, with transects randomly placed to minimize bias and ensure representative sampling [6]. A total of 207 belt transects measuring 1km X 5m were randomly placed on opposite sides of the corridor in the study site. To study Tree species in each transect, a total of 5 quadrates of 5 X 5 m² were laid down. For collecting information in the field, separate data formats were developed for recording various parameters.

4. PHYTOSOCIOLOGICAL MEASURES

To determine the existing species richness and diversity in the study area, standard protocols outlined by Curtis & McIntosh [7] and Muller-Dombois & Ellenberg [8] were employed. The calculation of frequency, density, abundance, and Important Value Index (IVI) requires the use of the following formulas.

$$\text{Density} = \frac{\text{Total No. of Individuals in all Sampling units}}{\text{Total No. of Sampling unit Studied}}$$

$$\% \text{Frequency} = \frac{\text{No. of Sampling unit in which Species Occured}}{\text{Total No. of Sampling units}} \times 100$$

$$\text{Abundance} = \frac{\text{Total No. of Individuals in all Sampling units}}{\text{No. of Sampling units in which Species Occured}}$$

$$\% \text{Relative Density} = \frac{\text{Density value of Species}}{\text{Sum of Density value of all Species}} \times 100$$

$$\% \text{Relative Frequency} = \frac{\text{Frequency value of Species}}{\text{Sum of Frequency value of all Species}} \times 100$$

$$\% \text{Relative Abundance} = \frac{\text{Abundance value of Species}}{\text{Sum of Abundance value of all Species}} \times 100$$

$$\% \text{Relative Dominance} = \frac{\text{Total Basal Area of the Species}}{\text{Total Basal Area of all Species}} \times 100$$

$$\text{Basal Area} = \pi \times \frac{(\text{DBH})^2}{4}, \text{ Where DBH} \\ = \text{Diameter at Breast Height}$$

$$\text{IVI} = \text{Relative Frequency} + \text{Relative Density} \\ + \text{Relative Dominance}$$

5. RESULTS AND DISCUSSION

5.1 Zone-1

5.1.1 Density and frequency

In this particular zone, a total of 66 tree species were documented. Among them, the top five species with the highest density were *Butea monosperma*, *Wrightia tinctoria*, *Derris indica*, *Diospyros melanoxylon*, and *Anogeissus latifolia*. *Terminalia bellirica* and *Terminalia crenulata* had the lowest density. *Butea monosperma* was found to be the most frequently occurring species, with a frequency of 100%, followed by *Wrightia tinctoria*, which had a frequency of 50%. On the other hand, *Terminalia bellirica* and *Terminalia crenulata* were found to have the lowest frequency, with only 1.43% each (Appendix 1).

Table 2 shows the distribution of frequency in Raunkiaer's classes [9]. The majority of species (90.90%) belong to class A while 6.06% of species belong to class B, and 1.51% of species belong to class C and class E each (Table 2).

The studied area is characterized by a mixed deciduous forest that exhibits a considerable variety of tree species. However, the distribution of these species is not evenly spread, as some have a greater density than others. The variation in tree density can be attributed to various factors such as micro-habitat conditions, topography, soil quality, and other environmental characteristics. Additionally, the level of canopy cover in this forest also varies across different parts of the area.

Table 2. Frequency class of Trees of Zone-1

Class	Range	No. of Species	%
A	0-20	60	90.90
B	21-40	4	6.06
C	41-60	1	1.51
D	61-80	0	0
E	81-100	1	1.51
Total		66	100

5.1.2 Abundance

Table 3. %Relative Abundance of Trees of Zone-1

Sr. No.	% Relative Abundance	No. of Species	%
1	Very Rare – 1 – 5%	66	100
2	Rare – 6 – 10%	0	0
3	Not Common – 11 – 20%	0	0
4	Common – 21 – 40%	0	0
5	More Common – 41 – 60%	0	0
6	Abundant - 61-80 %	0	0
7	Most Abundant-81-100%	0	0
Total		66	100

Two species of the *Acacia* Genus, *Acacia nilotica* and *Acacia senegal* recorded with the highest abundance of 2.40 while a total of 18 species with the lowest abundance of 1.00 is recorded from this particular zone (Appendix 1).

In this specific zone, all the species, which account 100%, are categorized as very rare, (Table 3).

5.1.3 Basal Area

The maximum basal area was recorded in *Ficus benghalensis* (6007.41 cm²) followed by *Madhuka indica* (4054.38 cm²). While the minimum was recorded in *Zizyphus mauritiana* (467.36 cm²) followed by *Zizyphus nummularia* (591.93 cm²) in the area (Appendix 1).

5.1.4 IVI

During the study, it was observed that *Butea monosperma* exhibited the highest percentage of IVI (28.40%), implying that it is the most dominant species in the zone. *Wrightia tinctoria* was the second most dominant species, with a percentage of 19.65%, indicating that it is also well-adapted to the environmental conditions of the area. Conversely, *Parkinsonia aculeate* and *Morus alba* had the lowest percentage of IVI,

with 1.17% and 1.40%, respectively, indicating that they are less adapted to the environmental conditions of the zone compared to the other species.

5.2 Zone-2

5.2.1 Density and frequency

In this particular zone, a total of 58 tree species were documented. Among them, the top specie with the highest density is *Prosopis juliflora* followed by *Acacia nilotica*. While 8 species had the lowest density of 0.03. *Acacia nilotica* was found to be the most frequently occurring species, with a frequency of 28.57%, followed by *Prosopis juliflora* and *Ficus racemosa*, which had a frequency of 25.71%. On the other hand, 8 species were found to have the lowest frequency, with only 2.86% each (Appendix 1).

87.93% of species belong to class A while 12.06% of species belong to class B (Table 4). The high density and frequency of *Prosopis juliflora* in the area indicate that this alien species has proliferated in the zone. The majority of species belong to low-frequency range class which indicates the scattered distribution of trees in this zone.

Table 4. Frequency class of Trees of Zone-2

Class	Range	No. of Species	%
A	0-20	51	87.93
B	21-40	7	12.06
C	41-60	0	0
D	61-80	0	0
E	81-100	0	0
Total		58	100

5.2.2 Abundance

Prosopis juliflora was recorded with the highest abundance of 4.11 followed by *Acacia nilotica* (3.10) and *Prosopis cineraria* (2.75). while a total of 21 species with the lowest abundance of 1.00 is recorded from this particular zone (Appendix 1).

In this specific zone, the majority of species, which accounts for 96.55%, are categorized as very rare, while 3.44% of species are classified as rare (Table 5).

5.2.3 Basal area

Maximum basal area was recorded in *Madhuka indica* (5975.86 cm²) followed by *Sterculia urens* (6500.59 cm²) while the minimum area was recorded in *Zizyphus nummularia* (426.95 cm²) followed by *Bridelia retusa* of 440.93 cm² (Appendix 1).

5.2.4 IVI

highest percent of IVI of *Acacia nilotica* (15.66%) and *Prosopis juliflora* (15.34%) represents their

ecological successfulness for this zone. While *Acacia farnesiana* occurred with the lowest percentage of IVI (1.22%) followed by *Vitex negundo* (1.28%) in the Zone.

5.3 Zone-3

5.3.1 Density and frequency

In this particular zone, a total of 41 tree species were documented. Among them, the top specie with the highest density is *Prosopis juliflora* followed by *Acacia nilotica* and *Zizyphus mauritiana*. While 5 species had the lowest density of 0.02. *Prosopis juliflora* was found to be the most frequently occurring species, with a frequency of 77.59% indication its invasion to this zone also, followed by *Zizyphus mauritiana* (34.48%) and *Acacia nilotica* (32.76%). On the other hand, 8 species were found to have the lowest frequency, with only 1.72% each (Appendix 1).

87.80% of species belong to class A while 9.75% of species belong to class B and 2.43% of species belong to class D (Table 6).

Table 5. %Relative Abundance of Trees of Zone-2

Sr. No.	% Relative Abundance	No. of Species	%
1	Very Rare – 1 – 5%	56	96.55
2	Rare – 6 – 10%	2	3.44
3	Not Common – 11 – 20%	0	0
4	Common – 21 – 40%	0	0
5	More Common – 41 – 60%	0	0
6	Abundant - 61-80 %	0	0
7	Most Abundant-81-100%	0	0
Total		58	100

Table 6. Frequency class of Trees of Zone-3

Class	Range	No. of Species	%
A	0-20	36	87.80
B	21-40	4	9.75
C	41-60	0	0
D	61-80	1	2.43
E	81-100	0	0
Total		41	100

5.3.2 Abundance

Prosopis juliflora was recorded with the highest abundance of 4.42 followed by *Acacia nilotica* (2.74) and *Wrightia tinctoria* (2.50). while a total of 13 species with the lowest abundance of 1.00 is recorded from this particular zone (Appendix 1).

In this specific zone, the majority of species, which accounts for 97.56%, are categorized as very rare, while 2.43% of species are classified as rare (Table 7) contributing to the scattered tree vegetation of this area.

5.3.3 Basal area

Maximum basal area was recorded in *Sterculia urens* (6500.59 cm²) followed by *Madhuka indica* (5975.86 cm²) while the minimum area was recorded in *Zizyphus nummularia* (426.95 cm²) followed by *Bridelia retusa* of 440.93 cm² (Appendix 1).

5.3.4 IVI

In this Zone, *Prosopis juliflora* occurred with the highest percent of IVI (58.40%) while *Acacia nilotica* occurred as the second highest dominant species in the zone with (19.86%). As compared to the highest IVI,

Kirganelia reticulate occurred with the lowest percentage of IVI (1.52%) followed by *Acacia farnesiana* (1.97%) making them least adept in the zone.

5.4 Zone-4

5.4.1 Density and frequency

In this particular zone, a total of 20 tree species were documented. Among them, the top specie with the highest density is *Prosopis juliflora* followed by *Acacia nilotica* and *Zizyphus nummularia*. While the lowest density is of *Acacia ferruginea* followed by *Ailanthus excels* and *Pithecellobium dulce*. *Prosopis juliflora* was found to be the most frequently occurring species, with a frequency of 95.45%, followed by *Butea monosperma* (31.82%) and *Acacia senegal* (22.73%). On the other hand, *Acacia ferruginea* was found to have the lowest frequency, with only 4.55% (Appendix 1). This zone zone is also heavily proliferated by *Prosopis juliflora*.

50% of species belong to class A while 45% of species belong to class B indicating scattered vegetation of this 95% species and 5% of species belong to class E (Table 8) indicating normal distribution of this 5% tree species.

Table 7. %Relative Abundance of Trees of Zone-3

Sr. No.	% Relative Abundance	No. of Species	%
1	Very Rare – 1 – 5%	40	97.56
2	Rare – 6 – 10%	1	2.43
3	Not Common – 11 – 20%	0	0
4	Common – 21 – 40%	0	0
5	More Common – 41 – 60%	0	0
6	Abundant - 61-80 %	0	0
7	Most Abundant-81-100%	0	0
Total		41	100

Table 8. Frequency class of Trees of Zone-4

Class	Range	No. of Species	%
A	0-20	10	50
B	21-40	9	45
C	41-60	0	0
D	61-80	0	0
E	81-100	1	5
Total		20	100

Table 9. % Relative Abundance of Trees of Zone-4

Sr. No.	% Relative Abundance	No. of Species	%
1	Very Rare – 1 – 5%	10	80
2	Rare – 6 – 10%	3	15
3	Not Common – 11 – 20%	1	5
4	Common – 21 – 40%	0	0
5	More Common – 41 – 60%	0	0
6	Abundant - 61-80 %	0	0
7	Most Abundant-81-100%	0	0
Total		20	100

5.4.2 Abundance

Prosopis juliflora was recorded with the highest abundance of 4.17 followed by *Acacia nilotica* (2.92). while a total of 3 species with the lowest abundance of 1.00 is recorded from this particular zone (Appendix 1).

In this specific zone, the majority of species, which accounts for 80%, are categorized as very rare, while 15% of species are classified as rare, and the remaining 5% are categorized as not common (Table 9).

5.4.3 Basal Area

The maximum basal area was recorded in *Ficus benghalensis* (7156.90 cm²) followed by *Alianthus excelsa* (5849.82 cm²) while the minimum area was recorded in *Zizyphus nummularia* (589.13 cm²) followed by *Samanea saman* of 931.25 cm² (Appendix 1).

5.4.4 IVI

It was observed that *Prosopis juliflora* occurred with the highest percent of IVI (69.00%) while *Ficus benghalensis* occurred as the second highest dominant species in the zone with (19.73%) indicating the availability of a suitable niche for this species in the zone. As compared to the *Acacia ferruginia* occurred with the lowest percentage of IVI (4.29%) followed by *Pithecellobium dulce* (5.33%) in the zone.

6. CONCLUSION

At the research site, a total of 70 species of trees were identified. Moving from Amirgadh (Zone-1) to Santalpur (Zone-4), the diversity of tree species was observed to decrease. *Prosopis juliflora*, due to its excessive growth and adaptability to different ecosystems, had a significantly high population density in three of the four studied zones. The seeds of this species

have a high germination rate, as they are dispersed by both domesticated and wild herbivores. The frequency and abundance of different species can indicate their distribution pattern, with high frequency and low abundance suggesting regular distribution, and low frequency and high abundance suggesting contiguous distribution [10]. However, human activities such as commercial logging, conversion of pastures, shifting agriculture or mismanagement, industrialization, and urbanization are major contributors to changes in forest communities' composition and the depletion of forest cover, which poses a threat to biodiversity conservation. It is therefore essential to address these issues and take steps toward sustainable forest management practices.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX 1

Phytosociological Attributes of Banas River Corridor, Gujarat

Zone-1										
Sr. No.	Species Name	%F	D	A	BA	% RF	% RD	% RA	% RDo	IVI
1	<i>Acacia chundra</i>	4.29	0.06	1.33	1160.55	0.63	0.47	1.28	1.13	2.24
2	<i>Acacia farnesiana</i>	4.29	0.09	2.00	1314.44	0.63	0.71	1.91	1.28	2.62
3	<i>Acacia ferruginia</i>	4.29	0.04	1.00	790.50	0.63	0.36	0.96	0.77	1.76
4	<i>Acacia nilotica</i>	14.29	0.34	2.40	1234.74	2.11	2.84	2.30	1.21	6.15
5	<i>Acacia senegal</i>	7.14	0.17	2.40	2863.81	1.05	1.42	2.30	2.80	5.27
6	<i>Adina cordifolia</i>	7.14	0.07	1.00	1308.02	1.05	0.59	0.96	1.28	2.92
7	<i>Aegle marmelos</i>	10.00	0.11	1.14	1403.26	1.47	0.95	1.09	1.37	3.79
8	<i>Albizia lebbek</i>	5.71	0.07	1.25	3286.08	0.84	0.59	1.20	3.21	4.64
9	<i>Albizia procera</i>	8.57	0.09	1.00	2491.74	1.26	0.71	0.96	2.43	4.41
10	<i>Alianthus excelsa</i>	7.14	0.09	1.20	2613.49	1.05	0.71	1.15	2.55	4.31
11	<i>Anogeissus latifolia</i>	31.43	0.64	2.05	713.11	4.63	5.33	1.96	0.70	10.65
12	<i>Anogeissus pendula</i>	14.29	0.24	1.70	1004.96	2.11	2.01	1.63	0.98	5.10
13	<i>Anogeissus sericea</i>	5.71	0.11	2.00	779.91	0.84	0.95	1.91	0.76	2.55
14	<i>Bauhinia purpurea</i>	5.71	0.07	1.25	1435.31	0.84	0.59	1.20	1.40	2.84
15	<i>Bauhinia racemosa</i>	4.29	0.07	1.67	1224.80	0.63	0.59	1.60	1.20	2.42
16	<i>Bombax cieba</i>	2.86	0.06	2.00	1952.70	0.42	0.47	1.91	1.91	2.80
17	<i>Boswellia serrata</i>	5.71	0.09	1.50	1203.80	0.84	0.71	1.44	1.18	2.73
18	<i>Bridelia retusa</i>	7.14	0.11	1.60	782.88	1.05	0.95	1.53	0.76	2.76
19	<i>Butea monosperma</i>	100.00	1.50	1.50	1261.03	14.74	12.43	1.44	1.23	28.40
20	<i>Caesalpinia pulcherrima</i>	5.71	0.13	2.25	1090.99	0.84	1.07	2.15	1.07	2.97
21	<i>Cassia fistula</i>	10.00	0.26	2.57	2324.81	1.47	2.13	2.46	2.27	5.87
22	<i>Cassia siamea</i>	8.57	0.09	1.00	3217.37	1.26	0.71	0.96	3.14	5.11
23	<i>Cordia dichotoma</i>	10.00	0.16	1.57	1161.15	1.47	1.30	1.50	1.13	3.91
24	<i>Cordia gharaf</i>	18.57	0.40	2.15	1351.97	2.74	3.31	2.06	1.32	7.37
25	<i>Crataeva religiosa</i>	7.14	0.09	1.20	859.01	1.05	0.71	1.15	0.84	2.60
26	<i>Dalbergia latifolia</i>	4.29	0.04	1.00	1400.17	0.63	0.36	0.96	1.37	2.35
27	<i>Dalbergia peniculata</i>	4.29	0.07	1.67	1700.29	0.63	0.59	1.60	1.66	2.88
28	<i>Dalbergia sisoo</i>	10.00	0.16	1.57	838.37	1.47	1.30	1.50	0.82	3.59
29	<i>Derris indica</i>	28.57	0.67	2.35	2613.49	4.21	5.56	2.25	2.55	12.32

Zone-1										
Sr. No.	Species Name	%F	D	A	BA	% RF	% RD	% RA	% RDo	IVI
30	<i>Diospyros melanoxylon</i>	30.00	0.67	2.24	669.32	4.42	5.56	2.14	0.65	10.64
31	<i>Emblica officinalis</i>	4.29	0.06	1.33	1799.61	0.63	0.47	1.28	1.76	2.86
32	<i>Erythrina suberosa</i>	4.29	0.04	1.00	780.57	0.63	0.36	0.96	0.76	1.75
33	<i>Ficus benghalensis</i>	8.57	0.09	1.00	6007.41	1.26	0.71	0.96	5.86	7.84
34	<i>Ficus hispida</i>	4.29	0.09	2.00	3239.52	0.63	0.71	1.91	3.16	4.50
35	<i>Ficus recemosa</i>	17.14	0.21	1.25	3076.23	2.53	1.78	1.20	3.00	7.30
36	<i>Ficus religiosa</i>	7.14	0.11	1.60	3091.97	1.05	0.95	1.53	3.02	5.02
37	<i>Gmelina arborea</i>	2.86	0.03	1.00	1034.39	0.42	0.24	0.96	1.01	1.67
38	<i>Helicteres isora</i>	8.57	0.16	1.83	779.91	1.26	1.30	1.75	0.76	3.33
39	<i>Holarrhena antidysenterica</i>	7.14	0.14	2.00	825.08	1.05	1.18	1.91	0.81	3.04
40	<i>Holoptelea intrigrifolia</i>	14.29	0.31	2.20	664.75	2.11	2.60	2.11	0.65	5.36
41	<i>Kirganelia reticulata</i>	4.29	0.04	1.00	1289.72	0.63	0.36	0.96	1.26	2.25
42	<i>Leucaena leucocephala</i>	2.86	0.04	1.50	1172.65	0.42	0.36	1.44	1.14	1.92
43	<i>Limonia acidissima</i>	8.57	0.17	2.00	2440.70	1.26	1.42	1.91	2.38	5.07
44	<i>Madhuka indica</i>	4.29	0.04	1.00	4054.38	0.63	0.36	0.96	3.96	4.94
45	<i>Melia azedirach</i>	7.14	0.09	1.20	836.32	1.05	0.71	1.15	0.82	2.58
46	<i>Mitragyna parvifolia</i>	5.71	0.09	1.50	1076.99	0.84	0.71	1.44	1.05	2.60
47	<i>Morinda tomentosa</i>	8.57	0.16	1.83	891.52	1.26	1.30	1.75	0.87	3.44
48	<i>Morus alba</i>	2.86	0.03	1.00	761.70	0.42	0.24	0.96	0.74	1.40
49	<i>Parkinsonia aculeata</i>	1.43	0.03	2.00	742.75	0.21	0.24	1.91	0.73	1.17
50	<i>Pithecellobium dulce</i>	5.71	0.07	1.25	1362.41	0.84	0.59	1.20	1.33	2.76
51	<i>Prosopis cineraria</i>	4.29	0.10	2.33	1169.62	0.63	0.83	2.23	1.14	2.60
52	<i>Prosopis juliflora</i>	5.71	0.13	2.25	1701.75	0.84	1.07	2.15	1.66	3.57
53	<i>Sapindus emarginatus</i>	5.71	0.06	1.00	2700.26	0.84	0.47	0.96	2.64	3.95
54	<i>Soymida febrifuga</i>	4.29	0.04	1.00	1258.09	0.63	0.36	0.96	1.23	2.21
55	<i>Sterculia urens</i>	7.14	0.07	1.00	1278.71	1.05	0.59	0.96	1.25	2.89
56	<i>Syzygium cumini</i>	11.43	0.19	1.63	949.57	1.68	1.54	1.56	0.93	4.15
57	<i>Tamarindus indica</i>	11.43	0.24	2.13	2290.76	1.68	2.01	2.03	2.24	5.93
58	<i>Tecomella undulata</i>	4.29	0.04	1.00	1485.42	0.63	0.36	0.96	1.45	2.44
59	<i>Terminalia arjuna</i>	4.29	0.04	1.00	1336.81	0.63	0.36	0.96	1.31	2.29
60	<i>Terminalia bellirica</i>	1.43	0.01	1.00	1424.59	0.21	0.12	0.96	1.39	1.72
61	<i>Terminalia crenulata</i>	1.43	0.01	1.00	1293.96	0.21	0.12	0.96	1.26	1.59
62	<i>Tectona grandis</i>	5.71	0.07	1.25	773.98	0.84	0.59	1.20	0.76	2.19

Zone-1										
Sr. No.	Species Name	%F	D	A	BA	% RF	% RD	% RA	% RDo	IVI
63	<i>Wrightia tinctoria</i>	50.00	1.37	2.74	937.60	7.37	11.36	2.63	0.92	19.65
64	<i>Zizyphus mauritiana</i>	12.86	0.29	2.22	467.36	1.89	2.37	2.13	0.46	4.72
65	<i>Zizyphus nummularia</i>	25.71	0.54	2.11	591.93	3.79	4.50	2.02	0.58	8.86
66	<i>Zizyphus xylopyra</i>	5.71	0.10	1.75	792.83	0.84	0.83	1.68	0.77	2.44
	TOTAL	678.58	12.06	104.4	102434	100.00	100.00	100.00	100.00	300.00

Zone-2										
Sr. No.	Species Name	%F	D	A	BA	%RF	% RD	% RA	%RDo	IVI
1	<i>Acacia farnesiana</i>	2.86	0.03	1.00	471.20	0.49	0.26	1.08	0.48	1.23
2	<i>Acacia ferruginia</i>	2.86	0.03	1.00	3347.31	0.49	0.26	1.08	3.40	4.15
3	<i>Acacia nilotica</i>	28.57	0.89	3.10	2702.95	4.88	8.04	3.35	2.74	15.66
4	<i>Acacia senegal</i>	11.43	0.23	2.00	803.12	1.95	2.07	2.16	0.82	4.84
5	<i>Adina cordifolia</i>	8.57	0.09	1.00	1580.22	1.46	0.78	1.08	1.60	3.85
6	<i>Aegle marmelos</i>	8.57	0.11	1.33	1831.32	1.46	1.04	1.44	1.86	4.36
7	<i>Albizia lebbbeck</i>	14.29	0.20	1.40	2116.81	2.44	1.81	1.51	2.15	6.40
8	<i>Albizia procera</i>	11.43	0.14	1.25	1119.27	1.95	1.30	1.35	1.14	4.38
9	<i>Alianthus excelsa</i>	11.43	0.11	1.00	2372.47	1.95	1.04	1.08	2.41	5.40
10	<i>Anogeissus latifolia</i>	17.14	0.43	2.50	869.27	2.93	3.89	2.70	0.88	7.70
11	<i>Anogeissus pendula</i>	11.43	0.26	2.25	857.17	1.95	2.33	2.43	0.87	5.16
12	<i>Anogeissus sericea</i>	5.71	0.11	2.00	769.06	0.98	1.04	2.16	0.78	2.79
13	<i>Bauhinia racemosa</i>	2.86	0.03	1.00	2426.72	0.49	0.26	1.08	2.46	3.21
14	<i>Bombax cieba</i>	2.86	0.06	2.00	4235.00	0.49	0.52	2.16	4.30	5.31
15	<i>Boswellia serrata</i>	5.71	0.09	1.50	882.72	0.98	0.78	1.62	0.90	2.65
16	<i>Bridelia retusa</i>	8.57	0.09	1.00	440.93	0.98	0.52	1.08	0.45	1.94
17	<i>Butea monosperma</i>	31.43	0.74	2.36	1087.64	5.37	6.74	2.56	1.10	13.21
18	<i>Caesalpinia pulcherrima</i>	8.57	0.09	1.00	1474.06	1.46	0.78	1.08	1.50	3.74
19	<i>Cassia fistula</i>	11.43	0.14	1.25	1424.59	1.95	1.30	1.35	1.45	4.69
20	<i>Cassia siamea</i>	8.57	0.14	1.67	1551.00	1.46	1.30	1.80	1.57	4.33
21	<i>Cordia dichotoma</i>	11.43	0.23	2.00	1643.05	1.95	2.07	2.16	1.67	5.69
22	<i>Cordia gharaf</i>	8.57	0.14	1.67	2959.42	1.46	1.30	1.80	3.00	5.76
23	<i>Dalbergia latifolia</i>	8.57	0.11	1.33	441.86	1.46	1.04	1.44	0.45	2.95
24	<i>Dalbergia sisoo</i>	11.43	0.20	1.75	600.87	1.95	1.81	1.89	0.61	4.38

Zone-2										
Sr. No.	Species Name	%F	D	A	BA	%RF	% RD	% RA	%RDo	IVI
25	<i>Derris indica</i>	8.57	0.14	1.67	1756.27	1.46	1.30	1.80	1.78	4.54
26	<i>Diospyros melanoxylon</i>	22.86	0.57	2.50	714.21	3.90	5.19	2.70	0.73	9.81
27	<i>Emblica officinalis</i>	5.71	0.09	1.50	2109.06	0.98	0.78	1.62	2.14	3.89
28	<i>Ficus benghalensis</i>	14.29	0.20	1.40	3907.97	2.44	1.81	1.51	3.97	8.22
29	<i>Ficus recemosa</i>	25.71	0.31	1.22	1268.59	4.39	2.85	1.32	1.29	8.53
30	<i>Ficus religiosa</i>	14.29	0.23	1.60	4247.98	2.44	2.07	1.73	4.31	8.83
31	<i>Gmelina arborea</i>	2.86	0.03	1.00	725.47	0.49	0.26	1.08	0.74	1.48
32	<i>Grewia tenax</i>	5.71	0.06	1.00	1133.54	0.98	0.52	1.08	1.15	2.65
33	<i>Grewia tiliaefolia</i>	11.43	0.14	1.25	1217.06	1.95	1.30	1.35	1.24	4.48
34	<i>Helicteres isora</i>	8.57	0.14	1.67	824.06	1.46	1.30	1.80	0.84	3.60
35	<i>Holarrhena antidysenterica</i>	5.71	0.14	2.50	2147.20	0.98	1.30	2.70	2.18	4.45
36	<i>Kirganelia reticulata</i>	8.57	0.11	1.33	824.06	1.46	1.04	1.44	0.84	3.34
37	<i>Leucaena leucocephala.</i>	5.71	0.09	1.50	812.24	0.98	0.78	1.62	0.82	2.58
38	<i>Limonia acidissima.</i>	8.57	0.17	2.00	1446.97	1.46	1.56	2.16	1.47	4.49
39	<i>Madhuka indica</i>	5.71	0.06	1.00	5975.86	0.98	0.52	1.08	6.07	7.56
40	<i>Melia azedirach</i>	5.71	0.06	1.00	839.39	0.98	0.52	1.08	0.85	2.35
41	<i>Morinda tomentosa</i>	8.57	0.09	1.00	963.46	1.46	0.78	1.08	0.98	3.22
42	<i>Morus alba</i>	5.71	0.06	1.00	692.44	0.98	0.52	1.08	0.70	2.20
43	<i>Parkinsonia aculeata</i>	2.86	0.03	1.00	2289.06	0.49	0.26	1.08	2.32	3.07
44	<i>Pithecellobium dulce</i>	5.71	0.06	1.00	2732.59	0.98	0.52	1.08	2.77	4.27
45	<i>Prosopis cineraria</i>	11.43	0.31	2.75	4103.42	1.95	2.85	2.97	4.17	8.97
46	<i>Prosopis juliflora</i>	25.71	1.06	4.11	1337.63	4.39	9.59	4.45	1.36	15.34
47	<i>Samanea saman</i>	5.71	0.06	1.00	791.33	0.98	0.52	1.08	0.80	2.30
48	<i>Sapindus emarginatus</i>	2.86	0.03	1.00	1074.67	0.49	0.26	1.08	1.09	1.84
49	<i>Sterculia urens</i>	2.86	0.03	1.00	6500.59	0.49	0.26	1.08	6.60	7.35
50	<i>Syzygium cumini</i>	5.71	0.11	2.00	2363.84	0.98	1.04	2.16	2.40	4.41
51	<i>Tamarindus indica</i>	14.29	0.29	2.00	2466.16	2.44	2.59	2.16	2.50	7.54
52	<i>Tecomella undulata</i>	5.71	0.06	1.00	626.48	0.98	0.52	1.08	0.64	2.13
53	<i>Tectona grandis</i>	5.71	0.06	1.00	1368.30	0.98	0.52	1.08	1.39	2.88
54	<i>Vitex negundo</i>	2.86	0.03	1.00	530.66	0.49	0.26	1.08	0.54	1.29
55	<i>Wrightia tinctoria</i>	22.86	0.54	2.38	996.12	3.90	4.93	2.57	1.01	9.84
56	<i>Zizyphus mauritiana</i>	14.29	0.37	2.60	662.08	2.44	3.37	2.81	0.67	6.48
57	<i>Zizyphus nummularia</i>	22.86	0.49	2.13	426.95	3.90	4.41	2.30	0.43	8.74

Zone-2										
Sr. No.	Species Name	%F	D	A	BA	%RF	% RD	% RA	%RDo	IVI
58	<i>Zizyphus xylopyra</i>	8.57	0.17	2.00	600.58	1.46	1.56	2.16	0.61	3.63
	TOTAL	558.55	11.08	92.47	98484	100.00	100.00	100.00	100.00	300.00

Zone-3										
Sr. No.	Species Name	%F	D	A	BA	%RF	% RD	% RA	%RDo	IVI
1	<i>Acacia farnesiana</i>	1.72	0.03	2.00	916.38	0.43	0.36	2.93	1.17	1.97
2	<i>Acacia nilotica</i>	32.76	0.90	2.74	1717.74	8.23	9.44	4.02	2.20	19.86
3	<i>Acacia senegal</i>	15.52	0.31	2.00	2455.25	3.90	3.27	2.93	3.14	10.30
4	<i>Aegle marmelos</i>	5.17	0.07	1.33	2007.61	1.30	0.73	1.95	2.57	4.59
5	<i>Albizia lebbek</i>	3.45	0.03	1.00	5941.67	0.87	0.36	1.46	7.59	8.82
6	<i>Albizia procera</i>	3.45	0.03	1.00	3471.47	0.87	0.36	1.46	4.44	5.67
7	<i>Alianthus excelsa</i>	8.62	0.12	1.40	2092.14	2.16	1.27	2.05	2.67	6.11
8	<i>Anogeissus latifolia</i>	6.90	0.14	2.00	507.12	1.73	1.45	2.93	0.65	3.83
9	<i>Anogeissus pendula</i>	1.72	0.03	2.00	1084.37	0.43	0.36	2.93	1.39	2.18
10	<i>Bauhinia purpurea</i>	1.72	0.02	1.00	1163.57	0.43	0.18	1.46	1.49	2.10
11	<i>Bombax cieba</i>	1.72	0.02	1.00	2163.66	0.43	0.18	1.46	2.77	3.38
12	<i>Bridelia retusa</i>	3.45	0.03	1.00	1133.54	0.87	0.36	1.46	1.45	2.68
13	<i>Butea monosperma</i>	27.59	0.64	2.31	2152.57	6.93	6.72	3.39	2.75	16.39
14	<i>Cassia fistula</i>	6.90	0.12	1.75	2052.72	1.73	1.27	2.56	2.62	5.63
15	<i>Cordia dichotoma</i>	6.90	0.07	1.00	1634.09	1.73	0.73	1.46	2.09	4.55
16	<i>Cordia gharaf .</i>	5.17	0.10	2.00	2145.38	1.30	1.09	2.93	2.74	5.13
17	<i>Dalbergia sisoo</i>	12.07	0.19	1.57	1392.81	3.03	2.00	2.30	1.78	6.81
18	<i>Derris indica</i>	20.69	0.40	1.92	2458.01	5.19	4.17	2.81	3.14	12.51
19	<i>Diospyros melanoxylon</i>	5.17	0.09	1.67	559.62	1.30	0.91	2.45	0.72	2.92
20	<i>Ficus benghalensis</i>	5.17	0.05	1.00	5560.96	1.30	0.54	1.46	7.11	8.95
21	<i>Ficus hispida</i>	1.72	0.03	2.00	1256.00	0.43	0.36	2.93	1.61	2.40
22	<i>Ficus recemosa</i>	3.45	0.03	1.00	2163.66	0.87	0.36	1.46	2.77	3.99
23	<i>Ficus religiosa</i>	6.90	0.07	1.00	5129.21	1.73	0.73	1.46	6.56	9.01
24	<i>Holarrhena antidysenterica</i>	3.45	0.07	2.00	2746.50	0.87	0.73	2.93	3.51	5.10
25	<i>Holoptelea intrigrifolia</i>	5.17	0.07	1.33	1045.82	1.30	0.73	1.95	1.34	3.36
26	<i>Kirganelia reticulata</i>	1.72	0.02	1.00	706.50	0.43	0.18	1.46	0.90	1.52
27	<i>Leucaena leucocephala</i>	5.17	0.12	2.33	1384.74	1.30	1.27	3.41	1.77	4.34

Zone-3										
Sr. No.	Species Name	%F	D	A	BA	%RF	%RD	%RA	%RDo	IVI
28	<i>Limonia acidissima</i>	5.17	0.10	2.00	829.16	1.30	1.09	2.93	1.06	3.45
29	<i>Melia azedirach</i>	3.45	0.03	1.00	829.16	0.87	0.36	1.46	1.06	2.29
30	<i>Morus alba</i>	3.45	0.03	1.00	637.62	0.87	0.36	1.46	0.81	2.04
31	<i>Parkinsonia aculeata</i>	5.17	0.09	1.67	1187.87	1.30	0.91	2.45	1.52	3.72
32	<i>Pithecellobium dulce</i>	5.17	0.07	1.33	1296.51	1.30	0.73	1.95	1.66	3.68
33	<i>Prosopis juliflora</i>	77.59	3.43	4.42	2192.60	19.48	36.12	6.48	2.80	58.40
34	<i>Samanea saman</i>	6.90	0.12	1.75	545.93	1.73	1.27	2.56	0.70	3.70
35	<i>Sterculia urens</i>	1.72	0.02	1.00	3737.39	0.43	0.18	1.46	4.78	5.39
36	<i>Tamarindus indica</i>	25.86	0.57	2.20	2157.84	6.49	5.99	3.22	2.76	15.24
37	<i>Terminalia arjuna</i>	1.72	0.02	1.00	2695.66	0.43	0.18	1.46	3.45	4.06
38	<i>Wrightia tinctoria</i>	3.45	0.09	2.50	1365.03	0.87	0.91	3.66	1.74	3.52
39	<i>Zizyphus mauritiana</i>	34.48	0.81	2.35	1184.48	8.66	8.53	3.44	1.51	18.70
40	<i>Zizyphus nummularia</i>	15.52	0.29	1.89	643.95	3.90	3.09	2.77	0.82	7.80
41	<i>Zizyphus xylopyra</i>	5.17	0.09	1.67	1900.20	1.30	0.91	2.45	2.43	4.63
	TOTAL	398.26	9.56	68.13	78247	100.00	100.00	100.00	100.00	300.00

Zone-4										
Sr. No.	Species Name	%F	D	A	BA	%RF	%RD	%RA	%RDo	IVI
1	<i>Acacia ferruginia</i>	4.55	0.05	1.00	1297.15	1.09	0.49	2.93	2.72	4.29
2	<i>Acacia nilotica</i>	27.27	0.80	2.92	2227.64	6.52	8.50	8.55	4.67	19.69
3	<i>Acacia senegal</i>	22.73	0.36	1.60	2024.40	5.43	3.89	4.69	4.25	13.57
4	<i>Albizia lebbek</i>	25.00	0.27	1.09	3693.20	5.98	2.91	3.20	7.75	16.64
5	<i>Alianthus excelsa</i>	6.82	0.09	1.33	5849.82	1.63	0.97	3.91	12.27	14.87
6	<i>Butea monosperma</i>	31.82	0.50	1.57	1602.01	7.61	5.34	4.61	3.36	16.31
7	<i>Cassia fistula</i>	27.27	0.39	1.42	1435.90	6.52	4.13	4.15	3.01	13.66
8	<i>Cordia dichotoma</i>	11.36	0.11	1.00	2537.95	2.72	1.21	2.93	5.32	9.25
9	<i>Dalbergia sisoo</i>	6.82	0.14	2.00	3381.57	1.63	1.46	5.87	7.09	10.18
10	<i>Derris indica</i>	22.73	0.39	1.70	1901.57	5.43	4.13	4.99	3.99	13.55
11	<i>Ficus benghalensis</i>	13.64	0.14	1.00	7156.90	3.26	1.46	2.93	15.01	19.73
12	<i>Ficus religiosa</i>	22.73	0.25	1.10	3069.98	5.43	2.67	3.23	6.44	14.54
13	<i>Leucaena leucocephala</i>	18.18	0.39	2.13	1088.26	4.35	4.13	6.23	2.28	10.76
14	<i>Parkinsonia aculeata</i>	9.09	0.14	1.50	1863.69	2.17	1.46	4.40	3.91	7.54

Zone-4										
Sr. No.	Species Name	%F	D	A	BA	%RF	%RD	%RA	%RDo	IVI
15	<i>Pithecellobium dulce</i>	6.82	0.09	1.33	1298.75	1.63	0.97	3.91	2.72	5.33
16	<i>Prosopis cineraria</i>	15.91	0.30	1.86	1932.42	3.80	3.16	5.45	4.05	11.01
17	<i>Prosopis juliflora</i>	95.45	3.98	4.17	1757.76	22.83	42.49	12.22	3.68	69.00
18	<i>Samanea saman</i>	9.09	0.16	1.75	931.25	2.17	1.70	5.13	1.95	5.83
19	<i>Tamarindus indica</i>	13.64	0.16	1.17	2047.51	3.26	1.70	3.42	4.29	9.25
20	<i>Zizyphus nummularia</i>	27.27	0.68	2.50	589.13	6.52	7.28	7.33	1.24	15.04
	Total	418.19	9.39	34.14	47687	100.00	100.00	100.00	100.00	300.00

Note: F = Frequency, D = Density, A = Abundance, BA = Basal Area, RF = Relative Frequency, RD = Relative Density, RA = Relative Abundance, RDo = Relative Dominance, IVI = Importance Value Index

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