



Assessment of Plant Diversity in Nawab Wajid Ali Shah Zoological Garden, Lucknow, Uttar Pradesh, India

Anjali Verma^{a*} and Neelam Khare^a

^a Department of Silviculture and Agroforestry, College of Forestry, Sam Higginbottom University of Agriculture Technology and Sciences, Allahabad–211007, U.P., India.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2023/v35i193620

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/103769>

Original Research Article

Received: 06/06/2023

Accepted: 10/08/2023

Published: 28/08/2023

ABSTRACT

The present study entitled "Assessment of Plant Diversity in Nawab Wajid Ali Shah Zoological Garden, Lucknow, Uttar Pradesh" was conducted in Nawab Wajid Ali Shah Zoological Garden, Lucknow, Uttar Pradesh state in order to investigate the plant diversity of trees, shrubs and herbs present. A total 85 tree species belonging to 32 families, 23 shrub species belonging to 16 families and 15 grass and herb species 8 families were recorded. Fabaceae is the largest family in 20 species followed by Moraceae (11), Rutaceae, Meliaceae, Rubiaceae in tree species, Asparagaceae is the largest family in 6 species followed by Apocynaceae (5), Rubiaceae (3) in shrub species and Asteraceae is the largest family in 4 species followed by Poaceae (3), Amaranthaceae (3) in grass and herb species. Overall, Site-III (South-East) showed the highest IVI parameter of dominant tree species for *Sarasa asoca* (51.21), Site-IV (South-West) showed the highest IVI parameter of dominant shrub species for *Murraya paniculata* (164.42) and Site-II (North-East) showed the highest IVI parameter of dominant grass & herb species for *Rivina humilis* (62.13).

*Corresponding author: E-mail: vermanjali543@gmail.com;

Keywords: Diversity; IVI; dominant; parameter; species.

1. INTRODUCTION

India is one of the most diverse nations in the world. It ranks ninth in terms of plant species richness in the world. Two of the world's twenty-five biodiversity hotspots are found in India. The country consists of ca. 19294 flowering plants [1] out of which ca. 2560 species have been estimated as trees [2].

Plant species diversity is complex in nature and its structure and composition differ from place to place. Because of varying climatic condition and topography [3,7-10]. Compared to the other ecosystems, tropical Forest ones, the most complex terrestrial ecosystems are harshly exploited ecosystems of the biosphere (Bahuguna 1999). It covers 7% of the earth's land surface but harbours more than half of the world's plant and Animal biodiversity [4].

Plant diversity is a critical component of the earth's biodiversity and plays an important role in maintaining the balance of the ecosystem [5,19,21-24]. The number of plant species in the world is estimated to be around 390,000, and they are found in a wide range of habitats, including deserts, rainforests, and alpine regions (Wagner, 2016). Each species has its own unique adaptations and characteristics that allow it to thrive in its environment (Raven, *et.al.*, 1999). Some plants have deep roots to access water in arid regions, while others have developed strategies to protect themselves from herbivores [37,38,41].

Uttar Pradesh is one of the largest provinces of India occupying an area of about 2,41,286 sq. Km out of which 21,291 sq. Km consists of forest and tree cover which is only about 3% of the total forest cover of the country because agricultural fields and dense human population have occupied the maximum land. Although the forest cover is very minimal, however, it harbours a good number of flowering plants due to its varied climatic conditions [18,25-29,40].

The geographical position, climate and Physiography of the state favour high amount of biological diversity. It is bestowed with a wide range of floristic elements including many therapeutically and economically valuable plant Species. The majority of its area belongs to the Gangetic plains, which support an agriculture-based Economy, dense human settlements and

rich cultural diversity [11-17]. It is important to document the Floristic wealth of such a large geographical land and one of the diverse agro-economic Zone for the optimum utilisation of these natural resources. Several institutes, universities and Departments are engaged in documenting the floristic diversity of the state [39,30-35]. Botanical Survey of India has also taken initiatives in publishing the State Flora of Uttar Pradesh in three volumes [36]. The present work is aimed at compiling the bibliographic references Available which are pertaining to the floristic documentation of Uttar Pradesh. The introductory Chapter highlights the physiography, climate, topography, forest types and floristic composition of the state for ready reference.

Lucknow is the capital of Uttar Pradesh and it is situated on the northern Gangetic Plains of India. It is surrounded on the eastern side by District Barabanki, on the Western side by District Unnao, on the southern side by Raebareli and on the northern side by Sitapur and Hardoi districts. It is situated 123 mts above sea level. It is situated at 26.30 & 27.10 North latitude and 80.30 & 81.13 East longitude. Lucknow covers an Area of 3,244 sq. km. The distance from the sea gives Lucknow an extreme type of continental climate with the prevalence of continental air during major parts of the year. Only during the four months from June to September does the air of oceanic origin penetrate this region and causes increased humidity, cloudiness and rain. About 75 % of the total rainfall is realized during these four months. The temperature may rise up to about 46 degrees Celsius in summers, though the average temperature is around 38-39 °C. The city stands at an elevation of approximately 123mt (404 ft) above sea level. Lucknow district covers an area of 2,528 square km (976 sq mi).

1.1 Study Site

The study site is located at Hazratganj in Lucknow, Uttar Pradesh. The study site is *Nawab Wajid Ali Shah Prani Udyan*, earlier known as Prince of Wales Zoological Gardens or popularly known as Lucknow Zoological Garden which was constituted in the year 1921 with 71.6-acre (29 ha) area. This campus is a lush green arboretum having more than 5000 trees of 100 species and acts as the lung of the city. The management body has added one of the best Nature Interpretation Centre in the Country, which give

comprehensive information related to wild animals and their habitats of the state. No detailed study in phytosociology in the study area is found in the literature; however, reports suggest that the site is very diverse. So, it

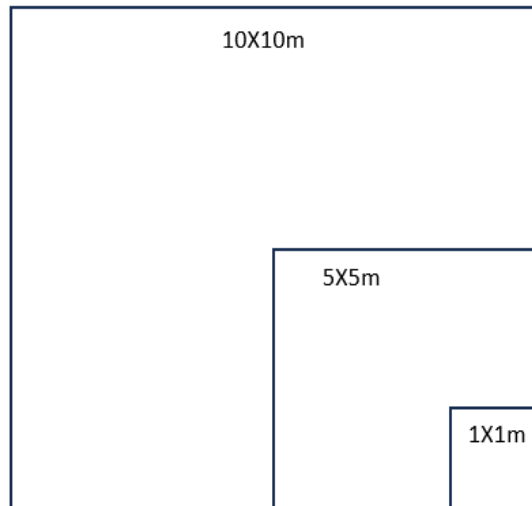
becomes imperative to conduct detailed research work on the site. The present study is designed to gather information about existing flora in the study area enabling us to better understand the biodiversity of the zoological park.



Fig. 1. Map of Study area

2. METHODS

The study on plant diversity was carried out in Nawab Wajid Ali Shah Zoological Garden, Lucknow during the month of January to March 2023. The study area was divided into 5 sites viz., Site-I (North-West), Site-II (North-East), Site-III (South-East), Site-IV (South-West) and Site-V (Centre). A total of 25 quadrates of tree species of size (10×10)mt, 25 quadrates of shrub species of size (5×5)m and 25 quadrates of herb species of size (1×1)mt were taken in all five sites. The quadrates were taken by random sampling method.



2.1 Data Analysis

$$\text{Basal area} = \pi r^2$$

$$\text{Density} = \frac{\text{Total no of individual of a spp in all quadrate}}{\text{Total no of quadrate studied}}$$

$$\text{Frequency} = \frac{\text{no. of quadrate in which spp occurred}}{\text{Total no of quadrate studied}} \times 100$$

$$\text{Abundance} = \frac{\text{Total number of individual of a species in all quadrate}}{\text{Total number of quadrate in which species occurred}}$$

$$\text{Relative Density} = \frac{\text{Density of a spp}}{\text{Total density of all the spp}} \times 100$$

$$\text{Relative Frequency} = \frac{\text{value of frequency of a spp}}{\text{Total frequency of all the spp}} \times 100$$

$$\text{Relative Dominance} = \frac{\text{Total basal area of a spp}}{\text{Total basal area of all the spp}} \times 100$$

2.2 Importance Value Index (for Tree Species)

IVI = relative density+ relative frequency+ relative dominance.

2.3 Importance Value Index (for Shrub and Herb Species)

IVI = Relative density+ relative frequency+ relative abundance

Species Diversity: It is defined as the number of species and abundance of each species that live in a particular location. It is calculated by using the formula (Shannon Wiener, 1963) [20].

$$\text{Diversity Index}(H) = \sum P_i (\log P_i)$$

Where, $P_i = n/N$ (proportion of the important species in the community).
 $n =$ no. of individual species
 $N =$ Total no. of individuals.

Species richness: - the species richness is based solely on the number of species found in the given area (Magurran, 1988).

$$\text{Species Richness} = \frac{(S - 1)}{\log N}$$

Where, $S =$ number of species
 $N =$ total number of individuals in all sample

Index of species evenness: - Species evenness (E) is the relative distribution of individuals among the species present in a community. The index of species evenness (E) was calculated by the formula developed by Pielou [6] as provided below:

$$E = \frac{H'}{\ln S}$$

Where, $E =$ Index of evenness,
 $H' =$ Shannon-Wiener index and
 $S =$ Total number of Species
 $\ln =$ Bits per individuals

3. RESULTS AND DISCUSSION

3.1 Tree Specie

A total of 85 species of trees species belonging to 34 families were recorded. The dominant family from the tree species was Fabaceae with a total of 17 species followed by Moraceae, Rutaceae, Arecaceae and Rubiaceae with a total of 10,7,4 and 4 respectively.

The graph shows the comparative study of Shannon – Weiner Diversity Index, Margaret’s Species Richness Index and Pielou’s Species Evenness Index for tree species. According to this study work (South-West) site IV shows highest value of Diversity Index (H’) (3.19) but (South-East) site III showed lowest value of Diversity Index (H’) (2.59). On the other hand (South-West) site IV shows highest species richness (5.4) followed by (North-West) site IV (4.88) while South-East site (3.31) shows lowest species richness. In terms of species Evenness North-West site & Centre. site (0.96) shows highest as well as same values while South-East site (0.91) shows lowest value for species Evenness Index.

3.2 Shrub Species

A total of 23 species of trees species belonging to 17 families were recorded. The dominant family from the tree species was Apocynaceae and Asparagaceae with a total of 4 species followed by Rubiaceae with a total of 3 species.

The graph shows the comparative study of Shannon – Weiner Diversity Index, Margaret’s Species Richness Index and Pielou’s Species Evenness Index for shrub species. According to this study work site V (Centre) shows highest value of Diversity Index (H’) (2.22) but site IV (South-West) showed lowest value of Diversity Index (H’) 19.17). On the other hand, site V (Centre) shows highest species richness (2.1) followed by site I (North-West) (1.61) while site IV (South-West) (1.4) shows lowest species richness. In terms of species Evenness site V (Centre) (0.86) shows highest values while site IV (South-West) (0.53) shows lowest value for species Evenness Index.

Table 1. Phyto-sociological attributes of Site-I (North-West)

S.No.	Tree Species	BA (cm ²)	F	D	A	RF	RD	RDo	IVI
1	<i>Acacia arabica</i>	660.18	20	0.2	1	1.83	1.47	3.31	6.61
2	<i>Albizia lebbeck</i>	379.94	50	0.5	1	4.58	3.67	3.31	11.57
3	<i>Albizia procera</i>	182.67	60	0.8	1.3	5.50	5.88	4.30	15.69
4	<i>Alstonia scholaris</i>	490.62	10	0.1	1	0.91	0.73	3.31	4.96
5	<i>Aegle marmelos</i>	1412.57	70	0.7	1	6.42	5.14	3.31	14.88
6	<i>Anthocephalus indicus</i>	235.75	30	0.3	1	2.75	2.20	3.31	8.26
7	<i>Azadirachta indica</i>	637.61	30	0.5	1.6	2.75	3.67	5.29	11.72
8	<i>Bauhinia variegata</i>	244	60	0.8	1.3	5.50	5.88	4.30	15.69
9	<i>Butea monosperma</i>	182.56	70	0.8	1.1	6.42	5.88	3.64	15.94
10	<i>Cassia fistula</i>	188.71	30	0.4	1.3	2.75	2.94	4.30	9.99
11	<i>Citrus maxima</i>	277.45	50	0.6	1.2	4.58	4.41	3.97	12.97
12	<i>Delonix regia</i>	837.34	60	0.6	1	5.50	4.41	3.31	13.22
13	<i>Embllica officinalis</i>	191.62	50	0.8	1.6	4.58	5.88	5.29	15.76
14	<i>Ficus benghalensis</i>	5671.62	50	0.5	1	4.58	3.67	3.31	11.57
15	<i>Ficus religiosa</i>	17662.5	50	0.5	1	4.58	3.67	3.31	11.57
16	<i>Jacaranda mimosifolia</i>	371.35	30	0.4	1.3	2.75	2.94	4.30	9.99
17	<i>Leucaena leucocephala</i>	551.26	30	0.4	1.3	2.75	2.94	4.30	9.99
18	<i>Mangifera indica</i>	1074.66	30	0.3	1	2.75	2.20	3.31	8.26
19	<i>Moringa olefera</i>	600.58	40	0.5	1.2	3.66	3.67	3.97	11.31
20	<i>Phoenix sylvestris</i>	624.26	50	0.5	1	4.58	3.67	3.31	11.57
21	<i>Saraca asoca</i>	276.15	70	1.6	2.2	6.42	11.76	7.28	25.47
22	<i>Syzygium cumini</i>	221.55	50	0.5	1	4.58	3.67	3.31	11.57
23	<i>Terminalia arjuna</i>	867.86	30	0.4	1.3	2.75	2.94	4.30	9.99
24	<i>Zizyphus mauritania</i>	346.18	20	0.3	1.3	1.83	2.20	4.30	8.34
25	<i>Zizyphus xylopyra</i>	268.66	50	0.6	1.2	4.58	4.41	3.97	12.97
Total		34457.74	1090	13.6	30.2	100	100	100	300

Table 2. Phyto-sociological attributes of Site-II (North-East)

S. No.	Tree species	BA	F	D	A	R F	RD	RDo	IVI
1	<i>Acacia catechu</i>	409.5	60	0.7	1.1	6.12	5.38	4.38	15.88
2	<i>Artocarpus heterophyllus</i>	329.89	50	0.5	1	5.10	3.84	3.98	12.93
3	<i>Artocarpus lacucha</i>	626.03	40	0.4	1	4.08	3.07	3.98	11.14
4	<i>Azadirachta indica</i>	889.4	30	0.3	1	3.06	2.30	3.98	9.35
5	<i>Bauhinia variegata</i>	743.71	50	0.7	1.4	5.10	5.38	5.57	16.06
6	<i>Cassia fistula</i>	337.66	60	0.8	1.3	6.12	6.15	5.17	17.45
7	<i>Delonix regia</i>	824.06	50	0.5	1	5.10	3.84	3.98	12.93
8	<i>Embllica officinalis</i>	254.34	30	0.4	1.3	3.06	3.07	5.17	11.31
9	<i>Ficus elastica</i>	147.33	60	0.7	1.1	6.12	5.38	4.38	15.88
10	<i>Ficus glomera</i>	530.66	50	0.7	1.4	5.10	5.38	5.57	16.06
11	<i>Ficus labor buch ham</i>	254.34	40	0.4	1	4.08	3.07	3.98	11.14
12	<i>Phoenix canariensis</i>	561.26	60	0.8	1.3	6.12	6.15	5.17	17.45
13	<i>Pongamia pinnata</i>	520.06	40	0.4	1	4.08	3.07	3.98	11.14
14	<i>Psidium guajava</i>	226.86	60	0.6	1	6.12	4.61	3.98	14.72
15	<i>Putranjiva roxburghii</i>	500.09	30	0.5	1.6	3.06	3.84	6.34	13.28
16	<i>Saraca asoca</i>	198.45	80	2.1	2.6	8.16	16.15	10.35	34.67
17	<i>Sesbania grandiflora</i>	520.09	30	0.4	1.3	3.06	3.07	5.17	11.31
18	<i>Tamarindus indica</i>	730.24	40	0.4	1	4.08	3.07	3.98	11.14
19	<i>Tectona grandis</i>	556.27	70	1.1	1.5	7.14	8.46	5.97	21.58
20	<i>Terminalia arjuna</i>	547.94	50	0.6	1.2	5.10	4.61	4.78	14.49
Total		9708.18	980	13	25.1	100	100	100	300

Table 3. Phyto-sociological attributes of Site-III (South-East)

S. No.	Tree Species	BA	F	D	A	RD	RF	RDo	IVI
1	<i>Albizia odoratissima</i>	660.18	20	0.4	2	3.22	2.5	7.93	13.66
2	<i>Annona squamosaa</i>	379.94	20	0.3	1.5	2.41	2.5	5.95	10.87
3	<i>Averrhoa carambola</i>	323.80	40	0.8	2	6.45	5	7.93	19.38
4	<i>Bombax ceiba</i>	626.47	40	0.4	1	3.22	5	3.96	12.19
5	<i>Citrus aurantium</i>	263.75	50	0.6	1.2	4.83	6.25	4.76	15.85
6	<i>Dalbergia sissoo</i>	204.49	70	0.7	1	5.64	8.75	3.96	18.36
7	<i>Eucalyptus Hybrida</i>	275.97	50	0.8	1.6	6.45	6.25	6.34	19.05
8	<i>Gravillea robusta</i>	400.94	40	0.5	1.2	4.03	5	4.76	13.79
9	<i>Grewia subinaequalis</i>	484.75	60	0.7	1.1	5.64	7.5	4.36	17.51
10	<i>Madhuca indica</i>	293.31	60	0.6	1	4.83	7.5	3.96	16.30
11	<i>Olea europaea</i>	66.44	30	0.5	1.6	4.03	3.75	6.34	14.13
12	<i>Pitrus decumana</i>	283.38	40	0.4	1	3.22	5	3.96	12.19
13	<i>Populous Species</i>	262.02	80	1.1	1.3	8.8	10	5.15	24.02
14	<i>Pyrus communis</i>	422.88	60	0.7	1.1	5.64	7.5	4.36	17.51
15	<i>Saraca asoca</i>	228.46	70	3.1	4.4	25	8.75	17.46	51.21
16	<i>Shorea robusta</i>	415.26	40	0.5	1.2	4.03	5	4.76	13.79
17	<i>Terminalia chebula</i>	630.03	30	0.3	1	2.41	3.75	3.96	10.13
Total		6222.15	800	12.4	25.2	100	100	100	300

Table 4. Phyto-sociological attributes of Site-IV (South-West)

S. No.	Tree Species	BA	F	D	A	RF	RD	RDo	IVI
1	<i>Acacia auriculiformis</i>	254.34	40	0.4	1	3.88	2.70	2.10	8.69
2	<i>Acacia leucophloea</i>	232.23	40	0.5	1.2	3.88	3.37	2.53	9.79
3	<i>Ailanthus axcelsa</i>	307.75	50	0.5	1	4.85	3.37	2.10	10.34
4	<i>Azadirachta indica</i>	547.11	40	0.5	1.2	3.88	3.37	2.53	9.79
5	<i>Bauhinia variegata</i>	335.06	30	0.6	2	2.91	4.05	4.21	11.18
6	<i>Ficus Benjamina</i>	452.16	30	0.3	1	2.91	2.02	2.10	7.04
7	<i>Borassus flabellifer</i>	340.92	50	0.7	1.4	4.85	4.72	2.95	12.53
8	<i>Cyclamen syprium</i>	477.37	30	0.3	1	2.91	2.02	2.10	7.04
9	<i>Cyclamen syprium</i>	464.29	30	0.3	1	2.91	2.02	2.10	7.04
10	<i>Cyclamen syprium</i>	346.18	30	0.3	1	2.91	2.02	2.10	7.04
11	<i>Delonix regia</i>	314	10	1.6	16	0.97	10.81	33.75	45.53
12	<i>Diospyros melanoxyton</i>	346.18	30	0.4	1.3	2.91	2.70	2.74	8.35
13	<i>Ficus carica</i>	314	40	0.5	1.2	3.88	3.37	2.53	9.79
14	<i>Ficus elastica</i>	165.04	60	1	0.1	5.82	6.75	0.21	12.79
15	<i>Ficus glomera</i>	254.34	50	0.9	1.8	4.85	6.08	3.79	14.73
16	<i>Ficus racemosa</i>	336.36	40	0.7	1.7	3.88	4.72	3.58	12.19
17	<i>Holoptelea integrefolia</i>	374.43	60	0.7	1.1	5.82	4.72	2.32	12.87
18	<i>Livistona chinensis</i>	268.66	30	0.4	1.3	2.91	2.70	2.74	8.35
19	<i>Morus alba</i>	314	30	0.4	1.3	2.91	2.70	2.74	8.35
20	<i>Nephellium litchi</i>	254.34	50	0.5	1	4.85	3.37	2.10	10.34
21	<i>Pithecellobium dulce</i>	362.86	40	0.4	1	3.88	2.70	2.10	8.69
22	<i>Prosopis juliflora</i>	397.4	30	0.4	1.3	2.91	2.70	2.74	8.35
23	<i>Prunus cummunis</i>	333.12	50	0.5	1	4.85	3.37	2.10	10.34
24	<i>Putranjaya roxburghii</i>	671.15	30	0.4	1.3	2.91	2.70	2.74	8.35
25	<i>Sepindus emarginatus</i>	386.87	40	0.5	1.2	3.88	3.37	2.53	9.79
26	<i>Tamarix aphylla</i>	615.44	30	0.4	1.3	2.91	2.70	2.74	8.35
27	<i>Terminalia chebula</i>	291.79	40	0.7	1.7	3.88	4.72	3.58	12.19
Total		9757.39	1030	14.8	47.4	99.99	99.99	100	299.99

Table 5. Phyto-sociological attributes of Site-V (Centre)

S. No.	Tree Species	BA	F	D	A	RF	RD	RDo	IVI
1	<i>Acacia nilotica</i>	240.4	50	0.5	1	5.37	3.64	2.94	11.97
2	<i>Albizia lebbeck</i>	168.7	60	0.6	1	6.45	4.37	2.06	12.89
3	<i>Bauhinia racemosa</i>	325.4	60	0.8	1.3	6.45	5.83	3.98	16.28
4	<i>Carica papaya</i>	196.46	40	0.6	1.5	4.30	4.37	2.40	11.08
5	<i>Cassia auriculata</i>	362.86	30	0.4	1.3	3.22	2.91	4.44	10.59
6	<i>Citrus sinensis</i>	165.04	30	0.4	1.3	3.22	2.91	2.02	8.16
7	<i>Dendrocalamus strictus</i>	490.62	40	0.6	1.5	4.30	4.37	6.01	14.69
8	<i>Eleodenron glaucum</i>	305.88	40	0.4	1	4.30	2.91	3.75	10.97
9	<i>Feronia limonia</i>	421.06	50	0.6	1.5	5.37	4.37	5.16	14.91
10	<i>Gardenia letifolia</i>	354.14	60	0.9	1.5	6.45	6.56	4.34	17.36
11	<i>Gardenia letifolia</i>	500.09	60	0.8	1.3	6.45	5.83	6.13	18.42
12	<i>Herperethusa crenulata</i>	565.5	50	0.7	1.4	5.37	5.10	6.93	17.41
13	<i>Meria azedarach</i>	379.94	30	0.5	1.6	3.22	3.64	4.65	11.53
14	<i>Miliusa tomentosa</i>	188.64	40	0.4	1	4.30	2.91	2.31	9.53
15	<i>Millingtonia hortensis</i>	397.4	40	0.4	1	4.30	2.91	4.87	12.09
16	<i>Mimusops elengi</i>	176.62	30	0.4	1.3	3.22	2.91	2.16	8.31
17	<i>Morinda tinctoria</i>	394.58	50	0.7	1.4	5.37	5.10	4.83	15.32
18	<i>Nyctanthes arbortristris</i>	320.31	40	0.5	1.2	4.30	3.64	3.92	11.87
19	<i>Saraca asoca</i>	165.04	40	0.6	1.5	4.30	4.37	2.02	10.70
20	<i>Tectona grandis</i>	1017.36	30	0.5	1.6	3.22	3.64	12.47	19.34
21	<i>Terminalia arjuna</i>	548.77	30	2	0.6	3.22	14.59	6.72	24.55
22	<i>Tonnage ciliata</i>	471.19	30	0.4	1.3	3.22	2.91	5.77	11.92
Total		8156	930	13.7	28.1	99.99	99.99	99.99	299.99

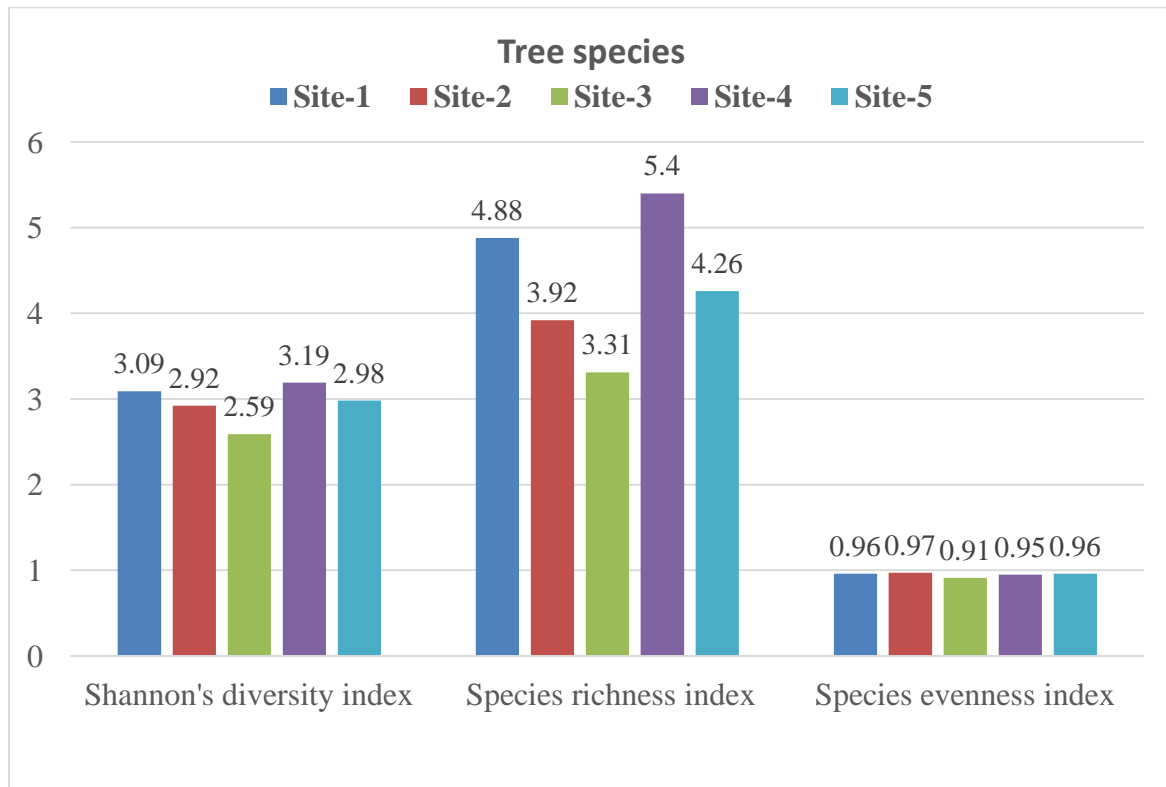


Fig. 2. Diversity parameters of tree species in all V sites

Table 6. Phyto-sociological attributes of Site-I (North-West)

S.no.	Shrub species	D	F	A	RD	RF	RDo	IVI
1	<i>Bougainvillea glabra</i>	1.3	40	3.25	4.90	10.25	5.22	20.38
2	<i>Calotropis gigantea</i>	0.7	30	2.33	2.64	7.69	3.75	14.08
3	<i>Gardenia jasminoides</i>	1	40	2.5	3.77	10.25	4.02	18.05
4	<i>Hibiscus rosasinensis</i>	3.5	70	5	13.20	17.94	8.04	39.19
5	<i>Ixora coccinea</i>	1.5	40	3.75	5.66	10.25	6.03	21.94
6	<i>Jasminum sambac</i>	0.5	30	1.66	1.88	7.69	2.68	12.25
7	<i>Lantana camara</i>	1.4	20	7	5.28	5.12	11.25	21.66
8	<i>Murraya paniculata</i>	13.3	50	26.6	50.18	12.82	42.77	105.78
9	<i>Tecoma stans</i>	2.2	30	7.33	8.30	7.69	11.79	27.78
10	<i>Zamia furfuracea</i>	1.1	40	2.75	4.15	10.25	4.42	18.82
Total		26.5	390	62.18	100	100	100	300

Table 7. Phyto-sociological attributes of Site-II (North-East)

S. no.	Shrubs species	D	F	A	RD	RF	RDo	IVI
1	<i>Allamanda cathartica</i>	1.1	60	1.83	3.26	13.33	3.00	19.60
2	<i>Calliandra riparia</i>	1.2	50	2.5	3.56	11.11	4.10	18.77
3	<i>Codiaeum variegatum</i>	2.9	40	7.25	8.60	8.88	11.89	29.39
4	<i>Hibiscus rosasinensis</i>	3.2	70	4.57	9.49	15.55	7.50	32.55
5	<i>Ixora coccinea</i>	1.2	40	3	3.56	8.88	4.92	17.37
6	<i>Jasminum sambac</i>	0.7	30	2.33	2.07	6.66	3.82	12.57
7	<i>Lantana camara</i>	0.4	10	4	1.18	2.22	6.56	9.97
8	<i>Murraya paniculata</i>	20.1	70	28.71	59.64	15.55	47.12	122.32
9	<i>Thuja occidentalis</i>	2.2	50	4.4	6.52	11.11	7.22	24.86
10	<i>Zamia furfuracea</i>	0.7	30	2.33	2.07	6.66	3.82	12.57
Total		33.7	450	60.93	100	100	100	300

Table 8. Phyto-sociological attributes of Site-III (South-East)

S.No.	Shrubs species	D	F	A	RD	RF	RDo	IVI
1	<i>Calliandra riparia</i>	1.2	30	4	3.65	7.89	6.33	17.88
2	<i>Calotropis proera</i>	1.9	30	6.33	5.79	7.89	10.02	23.71
3	<i>Carissa spinarum</i>	0.8	30	2.66	2.43	7.89	4.22	14.55
4	<i>Hibiscus rosasinensis</i>	1.9	50	3.8	5.79	13.15	6.01	24.96
5	<i>Ixora coccinea</i>	0.6	30	2	1.82	7.89	3.16	12.88
6	<i>Jasminum sambac</i>	0.7	30	2.33	2.13	7.89	3.69	13.72
7	<i>Lantana camara</i>	1.1	30	3.66	3.35	7.89	5.80	17.05
8	<i>Murraya paniculata</i>	21.5	70	30.71	65.54	18.42	48.61	132.58
9	<i>Tibouchina semidecandra</i>	1.1	30	3.66	3.35	7.89	5.80	17.05
10	<i>Zamia furfuracea</i>	2	50	4	6.09	13.15	6.33	25.58
	Total	32.8	380	63.18	100	100	100	300

Table 9. Phyto-sociological attributes of Site-IV (South-East)

S. No.	Shrubs species	D	F	A	RD	RF	RDo	IVI
1	<i>Calotropis procera</i>	0.7	20	7	2.31	6.45	2.31	11.07
2	<i>Carissa spinarum</i>	0.6	30	6	1.98	9.67	1.98	13.63
3	<i>Codiaeum variegatum</i>	2.6	40	26	8.58	12.90	8.58	30.06
4	<i>Gardenia jasminoides</i>	1	40	10	3.30	12.90	3.30	19.50
5	<i>Ixora singaporensis</i>	1	20	10	3.30	6.45	3.30	13.05
6	<i>Jasminum sambac</i>	0.6	20	6	1.98	6.45	1.98	10.41
7	<i>Lantana camara</i>	0.2	10	2	0.66	3.22	0.66	4.54
8	<i>Murraya paniculata</i>	21	80	210	69.30	25.80	69.30	164.42
9	<i>Zamia furfuracea</i>	2.6	50	26	8.58	16.12	8.58	33.29
	Total	30.3	310	303	100	100	100	300

Table 10. Phyto-sociological attributes of Site-V (Centre)

S.No.	Shrubs species	D	F	A	RD	RF	RDo	IVI
1	<i>Allamanda cathartica</i>	1.1	50	2.2	4.38	10.41	3.24	18.04
2	<i>Calotropis procera</i>	2.7	50	5.4	10.75	10.41	7.96	29.14
3	<i>Carissa spinarum</i>	1	30	3.33	3.98	6.25	4.91	15.15
4	<i>Cascabela thevetia</i>	1.4	40	3.5	5.57	8.33	5.16	19.07
5	<i>Gardenia jasminoides</i>	1.5	30	5	5.97	6.25	7.37	19.60
6	<i>Hibiscus rosasinensis</i>	1.5	10	15	5.97	2.08	22.12	30.18
7	<i>Jasminum sambac</i>	0.6	20	3	2.39	4.16	4.42	10.98
8	<i>Murraya paniculata</i>	1.9	40	4.75	7.56	8.33	7.00	22.91
9	<i>Solanum chenopodioides</i>	8.4	70	12	33.46	14.58	17.70	65.75
10	<i>Tecoma stans</i>	1.1	30	3.66	4.38	6.25	5.40	16.04
11	<i>Thuja occidentalis</i>	2.3	50	4.6	9.16	10.41	6.78	26.36
12	<i>Tibouchina semidecandra</i>	0.9	30	3	3.58	6.25	4.42	14.26
13	<i>Zamia furfuracea</i>	0.7	30	2.33	2.78	6.25	3.44	12.48
	Total	25.1	480	67.78	100	100	100	300

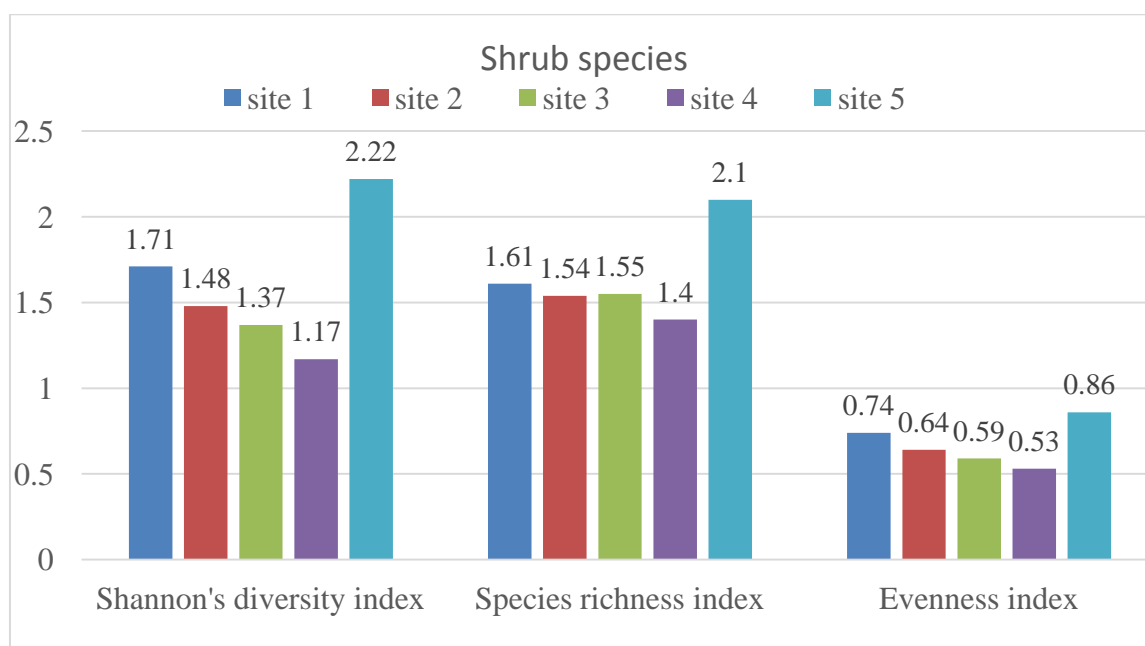


Fig. 3. Diversity parameters of Shrub species in all V sites

Table 11. Phyto-sociological attributes of Site-I (North-West)

S.no.	Grass and Herbs species	D	F	A	RD	RF	RDo	IVI
1	<i>Ageratum conyzoides</i>	10.9	50	21.8	15.79	15.15	14.68	45.63
2	<i>Ageratum houstonianum</i>	9.9	40	24.75	14.34	12.12	16.67	43.14
3	<i>Brachiaria eruciformis</i>	12.9	60	21.5	18.69	18.18	14.48	51.35
4	<i>Chloris barbata</i>	7.8	70	11.14	11.30	21.21	7.50	40.02
5	<i>Cynodon dactylon</i>	5.9	30	19.66	8.55	9.09	13.24	30.88
6	<i>Parthenium hysterophorus</i>	4.8	30	16	6.95	9.09	10.77	26.82
7	<i>Rivina humilis</i>	16.8	50	33.6	24.34	15.15	22.63	62.13
Total		69	330	148.45	100	100	100	300

Table 12. Phyto-sociological attributes of Site-II (North-East)

S.no.	Grass and Herbs species	D	F	A	RD	RF	RDo	IVI
1	<i>Ageratum conyzoides</i>	12.8	50	25.6	20.28	19.23	16.73	56.24
2	<i>Ageratum houstonianum</i>	10.9	30	36.33	17.27	11.53	23.74	52.56
3	<i>Alternanthera bettzickiana</i>	11.3	70	16.14	17.91	26.92	10.55	55.38
4	<i>Cynodon dactylon</i>	10.9	40	27.25	17.27	15.38	17.81	50.47
5	<i>Parthenium hysterophorus</i>	5.6	30	18.66	8.87	11.53	12.20	32.61
6	<i>Rivina humilis</i>	11.6	40	29	18.38	15.38	18.95	52.72
Total		63.1	260	152.99	100	100	100	300

Table 13. Phyto-sociological attributes of Site-III (South-East)

S. no.	Grass and Herbs species	D	F	A	RD	RF	RDo	IVI
1	<i>Acalypha indica</i>	7	50	1.4	8.40	10.41	8.89	27.71
2	<i>Ageratum conyzoides</i>	7.8	40	1.95	9.36	8.33	12.39	30.08
3	<i>Ageratum houstonianum</i>	11.5	50	2.3	13.80	10.41	14.61	38.83
4	<i>Alternanthera bettzickiana</i>	11.6	60	1.93	13.92	12.5	12.28	38.71
5	<i>Alternanthera pungens</i>	9.8	60	1.63	11.76	12.5	10.37	34.64
6	<i>Alysicarpus bupleurifolius</i>	5.6	50	1.12	6.72	10.41	7.11	24.25
7	<i>Amaranthus viridis</i>	10.5	70	1.5	12.62	14.58	9.53	36.72
8	<i>Argemone mexicana</i>	7.5	50	1.5	9.00	10.41	9.53	28.95
9	<i>Parthenium hysterophorus</i>	12	50	2.4	14.40	10.41	15.25	40.07
Total		83.3	480	15.73	100	100	100	300

Table 14. Phyto-sociological attributes of Site-IV (South-West)

S.No.	Grass and Herbs species	D	F	A	RD	RF	RDo	IVI
1	<i>Anagallis arvensis</i>	8.3	50	16.6	15.74	15.15	17.10	48.00
2	<i>Brachiaria eruciformis</i>	9.5	50	19	18.02	15.15	19.57	52.75
3	<i>Chloris barbata</i>	8.3	50	16.6	15.74	15.15	17.10	48.00
4	<i>Chromolaena odorata</i>	9.9	70	14.14	18.78	21.21	14.56	54.56
5	<i>Cynodon dactylon</i>	8.7	50	17.4	16.50	15.15	17.92	49.58
6	<i>Rivina humilis</i>	8	60	13.33	15.18	18.18	13.73	47.09
Total		52.7	330	97.07	100	100	100	300

Table 15. Phyto-sociological attributes of Site-V (Centre)

S. No.	Grass and Herb species	D	F	A	RD	RF	RDo	IVI
1	<i>Acalypha indica</i>	6.2	40	15.5	11.9	7.84	16.60	36.34
2	<i>Ageratum conyzoides</i>	6.4	60	10.66	12.28	11.76	11.42	35.47
3	<i>Alternanthera pungens</i>	6.1	60	10.16	11.70	11.76	10.89	34.36
4	<i>Alysicarpus bupleurifolius</i>	3.5	50	7	6.71	9.80	7.49	24.02
5	<i>Argemone Mexicana</i>	6.2	50	12.4	11.9	9.80	13.28	34.98
6	<i>Chloris barbata</i>	4.6	50	9.2	8.82	9.80	9.85	28.48
7	<i>Cynodon dactylon</i>	4.7	60	7.83	9.02	11.76	8.39	29.17
8	<i>Parthenium hysterophorus</i>	7.4	70	10.57	14.20	13.72	11.32	39.25
9	<i>Rivina humilis</i>	7	70	10	13.43	13.72	10.71	37.87
Total		52.1	510	93.33	100	99.99	99.99	299.99

3.3 Grass and Herb Species

A total of 15 species of grass and herb species belonging to 8 families were recorded. The dominant family from the Grass and herb species was Asteraceae with a total of 4 species followed by Poaceae and Amaranthaceae with a total of 3 species.

The graph shows the comparative study of Shannon – Weiner Diversity Index, Margaret's Species Richness Index and Pielou's Species Evenness Index for herb and grass species. According to this study work site III (South-East) shows the highest value of Diversity

Index (H') (2.16) but site I (North-West) and site V (Centre) showed the lowest as well as the same value of Diversity Index (H') (1.76). On the otherhand site-I (North-West) shows the highest species richness (1.27) followed by site III (South-East) (1.18) while site V (Centre) (0.72) shows the lowest species richness value. In terms of species Evenness site II (North-East) (0.99) shows the highest values followed by site I (North-West), site III (South-East) and site V (Centre) (0.98) shows the same values for species Evenness Index while site IV (South-West) (0.96) shows lowest value for species Evenness Index.

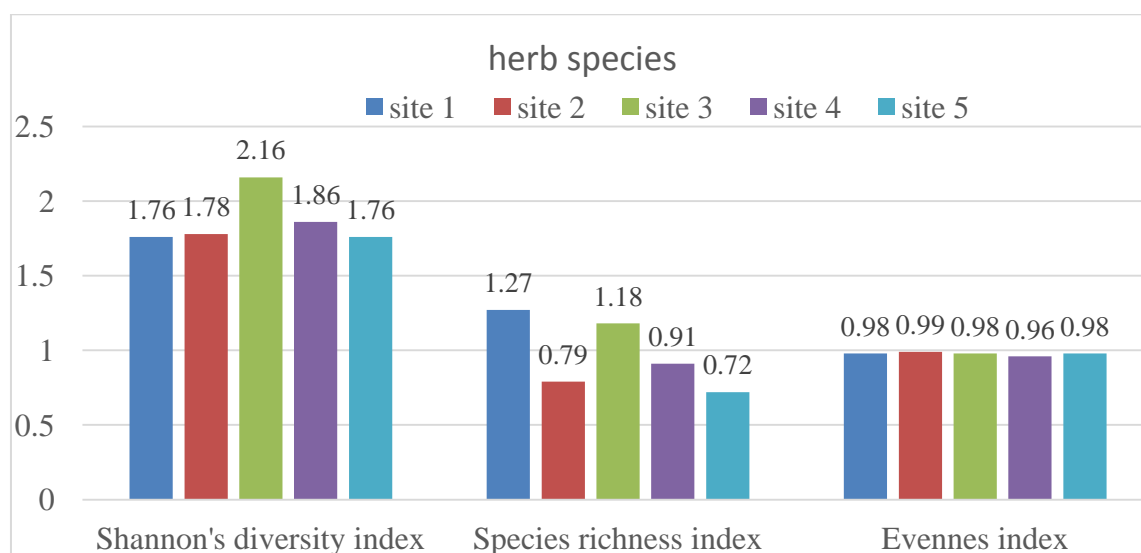


Fig. 4. Diversity parameters of Herb Species in all V sites

4. CONCLUSION

From the present research work it can be concluded based on the results, the study area is abundantly populated by *Murraya paniculata*. Overall, Site-III (South-East) showed the highest IVI parameter of dominant tree species for *Saraca asoca* (51.21), Site-IV (South-West) showed the highest IVI parameter of dominant shrub species for *Murraya paniculata* (164.42) and Site-II (North-East) showed the highest IVI parameter of dominant grass & herb species for *Rivina humilis* (62.13). The result of the phytosociological aspects for all the sites concluded that Site-IV (South-West) showed the highest value for Shannon-Weiner Diversity Index (H') (3.19) for trees species, Site-V (Centre) showed the highest value for Shannon-Weiner Diversity Index (H') (2.22) for shrub species and Site-III (South-East) showed the highest value for Shannon-Weiner Diversity Index (H') (2.16) for grass & herb Species.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

- Karthikeyan S. A Statistical analysis of flowering plants of India. In: Singh, N. P. et al. (eds.), Flora of India, Intro. 2000;(pt. 2):201-217.
- Rao RR. Biodiversity in India (Floristic Aspects). Bishen Singh Mahendra Pal Singh, Dehra Dun; 1994.
- Raturi GP. Forest community structure along an altitudinal gradient of district Rudra Prayag of Garhwal Himalaya, India. *Ecologia*. 2012;2(3):76–84.
- Wilson EO. The current state of biological diversity. In: Wilson EO & Peter FM (eds) Biodiversity. National Academy Press, Washington DC, USA. 1988;3–18.
- Myers N, Mittermeier RA, Mittermeier CG, da Fonseca GAB, Kent J. Biodiversity hotspots for conservation priorities. *Nature*. 2000; 403: 853–858.
- Pielou EC. The measurement of diversity in different types of biological collections. *Journal of Theoretical Biology*. 1966; 13:131–144.
- Adekunle VAJ, Olagoke AO, Akinele SO. Tree species diversity and structure of a Nigerian strict nature reserve. *Trop Ecology*. 2013; 54: pp 275-289.
- AK. Phytosociological studies of tree vegetation of Moraghat forest range, India. *Asian Journal of Biological and Life Sciences original research*; 2015.
- Anbarasu C, Balsubramanian P. Tree diversity of the tropical montane evergreen forest (Shola) in the Nilgiri mountains, Western Ghats, India. *Indian Forester*. 2015;141(5):490-495.
- Bhadra AK, Dhal NK, Rout NC, Reddy VR. Phytosociology of the community of Gannadha mar dan hill ranges. *Indian Forester*. 2010;136(5):610-620.

11. Bhuyan P, Khan ML, Tripathi RS. Tree diversity and population structure in undisturbed and human-impacted stands of tropical wet evergreen forest in Arunachal Pradesh, Eastern Himalayas India. *Biodiversity Conservation*. 2003; 12:1753-1773.
12. Chaudhary LB, Kushwaha AK, Bajpai O. *Trees of Uttar Pradesh- Part 1*. CSIR, NBRI, Lucknow; 2016.
13. Chittibabu CV, Parthasarathy N. Attenuated tree species diversity in human-impacted tropical evergreen forest sites at Kolli hills, Eastern Ghats, India; 2000.
14. Devi LS, Yadav PS. Floristic diversity assessment and vegetation analysis of tropical semi-evergreen forest of Manipur, north-east India tropical ecology. 2006; 47(1):89-98.
15. Devi NL, Das AK. Tree species diversity in Ingkhol – A traditional Meitei home garden of Barak Valley, Assam University J. Of Science and Technology; 2012.
16. Gonmadje CF, Doumenge C, McKey D, Tchouto GPM, Sunderland TCH, Malinga MPB, Sonke B. Tree diversity and conservation value of Ngovayang's lowland forests, Cameroon; 2011.
17. Gopalakrishna SP, Kaonga ML, Somashekar RK, Suresh HS, Suresh R. Tree diversity in the tropical dry forest of Bannerghatta National Park in Eastern Ghats, southern India; 2015.
18. Kamal Kishor, Abhinandan Mani Tripathi, Sribash Roy and Lal Babu Chaudhary. Assessment and Preservation of Tree Diversity of Uttar Pradesh, India; 2011.
19. Simpson EH. Measurement of diversity. *Nature*. 1949;163, 688.
20. Shannon CE. A mathematical theory of communication. *The Bell System Technical Journal*. 1948; 27: pp 379-423.
21. Gordon JE, Newton AC. The potential misapplication of rapid plant diversity assessment in tropical conservation; 2006.
22. Ihuma JO, Chima UD, Chapman HM. Trees species diversity in a Nigerian Montane Forest ecosystem and adjacent fragmented forests. *ARPN Journal of Agricultural and Biological Science*. 2011; 6(2):17-22.
23. Kharkwal G. Qualitative analysis of tree species in evergreen forests of Kumaun Himalaya, Uttarakhand, India. *African J. Plant Sci*. 2009;3 (3):049-052.
24. Kumar A, Bruce G.M, Ajai S. Tree species diversity and distribution patterns in tropical forests of Garo Hills. *Current Science*. 2006;(91):1370-81.
25. Kumar M, et al. Tree species diversity and distribution patterns in tropical forests of Garo Hills. *Current Science*. 2006; 91:1370-1381.
26. Kumar V, Desai BS. Biodiversity and phytosociological analysis of plants around the Chikhali Taluka, Navsari district Gujarat, India; 2016.
27. Kumar's OA, Naidu MT. Tree diversity, stand structure and community composition of tropical forests in Eastern Ghats of Andhra Pradesh, India; 2016.
28. Tchouto MGP. Plant diversity in a Centre African rainforest. Implications for biodiversity conservation in Cameroon, University of Edinburgh/Royal Botanic Garden of Edinburgh; 2004.
29. Marbaniang G. A study on the diversity of plant species and their associated phytosociological aspect in Nongkhylllem Reserved Forest, Meghalaya; 2019.
30. Padalia H, Chauhan N, Porwal MC, Roy PS. Phytosociological observations on tree species density of Andaman Islands, India; 2004.
31. Panda PC, Mahapatra AK, Acharya PK, Debata AK. Plant diversity in tropical deciduous forests of Eastern Ghats, India: A landscape-level assessment. *International Journal of Biodiversity Conservation*. 2013; 5: pp 625–639.
32. Rao DS, et al. Plant biodiversity and phytosociological studies on tree species diversity of Khammam District, Telangana state, India. *Journal of Pharmaceutical Science and Research*. 2015;7(8):518-522.
33. Sagar R, Singh JS. Tree density, basal area and species diversity in a disturbed dry tropical forest of northern India: implications for conservation. *Environmental Conservation* Sarkar; 2006.
34. Singh G, Rawat GS. Qualitative analysis of tree species diversity in different Oak (*Quercus Species*.) dominated forests in Garhwal Himalaya, India *Notulae Scientia. Biologicae*. 2012;4(4):132-140.
35. Singh L, Sharma B, Agrawal R, Puri S. Diversity and dominance of a tropical moist deciduous forest in achanakmar wildlife sanctuary. *Bulletin of National Institute of Ecology*. 2005; 15: pp 1-9.

36. Singh KP, Khanna KK, Sinha GP. (Eds.). Flora of Uttar Pradesh. (Ranunculaceae–Apiaceae). Vol. I. Botanical Survey of India, Kolkata; 2016.
37. Solbrig OT, Jain S, Johnson GB, P.H. Future Directions in Plant Population Biology. In: Topics in Plant Population Biology New York: Columbia University Press. 1976;461–481.
38. Srinivasa Rao D, Prayaga Murthy P and Venkaiah M. Phytosociological observations on tree species diversity of tropical forest of Srikakulam district, Andhra Pradesh, India *Journal of Plant Science*. 2013;2(4):89-108.
39. Srivastava SK. Floristic diversity in Uttar Pradesh- an overview. *J. Econ. Taxon. Bot.* 2004;28(2):292-334.
40. Tomar JMS, et al. Studies on phytosociological attributes of upper Shipra watershed in Meghalaya, Indian J.Hid Farmg. 2001;14(2):105-112.
41. Upadhaya K, Pandey HN, Law PS, Tripathi RS. Tree diversity in sacred groves of the Jaintia hills in Meghalaya, northeast India, *Biodiversity and conservation*. N. 2003; (33):256-262.

© 2023 Verma and Khare; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:

The peer review history for this paper can be accessed here:

<https://www.sdiarticle5.com/review-history/103769>