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ORIGINAL ARTICLE

Phytosociological Analysis and Diversity of Woody Vegetation in Tropical Dry Deciduous Forests of Jalaun District of Bundelkhand Region, Uttar Pradesh, India

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ABSTRACT
The present inventory study reveals information on the range of woody plant species and stand configuration in the tropical dry deciduous forests of Jalaun district. Due to biotic interferences and climate change, the tropical dry deciduous forests of the Bundelkhand area are under severe pressure. The rainfall has significantly decreased as a result of climate change in this region. Intense and frequent droughts might render forests less capable to defend themselves towards the changes that biotic interferences have already inflicted. The objective of the present investigation is to evaluate the phyto-sociological analysis, comprising species diversity, dominance, equitability etc. of five distinct forests in the Jalaun district of Bundelkhand region of Uttar Pradesh, India. In the terms of IVI all the five distinct forest communities were dominated by Prosopis juliflora followed by Balanites aegyptiaca, Holoptelea integrifolia, Acacia leucophloea etc. The results reveal that the species diversity (H') of woody plant species was higher in the Ekona-Forest (3.3896) and lower in the Dang-Khairai Forest (3.1346). Higher species dominance values were observed in Dang-Khairai Forest (0.080016), whereas Simiriya-Forest (0.066951) had lower value. The species equitability values were recorded higher in the Ekona-Forest (0.8384) communities while lower in Lohai-Forest (0.8067) community.
Keywords: *Quantitative analysis, Diversity, woody species, Jalaun district, Bundelkhand region*

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INTRODUCTION

Trees that vary in species diversity based on the location dominate the forest ecosystem. By offering goods and services, it substantially assists in the economic growth of our community. By altering the life-supporting system, they also have a significant impact on enhancing the quality of the environment. In nature, forests feature prominently. They restore the ecological balance of all ecosystems, preserve biological variety, serve as catchments for the conservation of soil and water, prevent floods, and protect the future of tribal people. Deforestation and degradation of forests, which serve as a significant sink for atmospheric carbon, may enable that carbon to be liberated [23]. There is broad consensus on the relevance of structurally diverse forests for the conservation of biodiversity and the provision of a wide range of ecosystem services. Tools to reliably and quantitatively measure structural diversity of forests across a wide range of forest types and regions are still necessary, for instance to assist biodiversity monitoring. The approaches that are currently used to measure forest structural diversity are predicated on restricted geographic areas [57]. Assessing the dynamics of a forest ecosystem and protecting vulnerable and economically important species are facilitated by understanding of the forest structure and tree composition [31]. Tropical dry deciduous forests are a prominent biome in India, accounting for 46% of total forest cover. The majority of these forests is under severe anthropogenic strain and requires management intervention to ensure overall biodiversity, productivity, and sustainability. Among the various types of forests in India, tropical dry deciduous covered by forests the most land in central India. Although there is a diversity of life forms in deciduous forests, these are not considered species rich. The fact that these forests are India's most exploited and endangered environment lends them an especially

substantial role in conservation. Given the severity of the loss, restoring tropical deciduous forests is essential for mass extinction prevention, mitigating the consequences of climate change, and regaining numerous ecological functions. Understanding the dynamics of deciduous forests naturally as well as the impacted ecological processes would be necessary for this. Most of the previous studies done in these areas, particularly in terms of floristics characteristics, are actually descriptive but the phytosociological studies of forests of this region have not been carried out so far. Therefore, the present study was undertaken to understand the quantitative characters of the woody plant species along the disturbance gradient in tropical dry deciduous forests of Jalaun district.

MATERIALS AND METHODS

Study area

The Bundelkhand region is located in the south-west part of Uttar Pradesh. Bundelkhand is divided into seven districts of Uttar Pradesh *viz.,* Chitrakoot, Banda, Jalaun, Hamirpur, Lalitpur, Jhansi, and Mahoba and seven districts of Madhya Pradesh *viz.,* Datia, Tikamgarh, Niwari, Chhatarpur, Panna, Damoh, Sagar, and two sub-divisions Lahar and Bhander of Bhind and Gwalior districts respectively. It is situated in a transitional zone between Upper Gangetic Plain and Central India and has an interesting floral diversity. The district is surrounded to the north-east by the river 'Yamuna,' to the south-east by the river 'Betwa,' and to the west by the river 'Pahuj.' It has a remarkable floral diversity and is located in a transitional zone between the Upper Gangetic Plain and Central India. This area is restricted to the banks of these rivers, but the high terrain that once served as an old flood plain is now known for its very productive agro-ecosystem. The district of Jalaun has a range of forests, including tropical riparian forests, dry mixed deciduous forests, *Anogeissus pendula* scrub forests, Boswellia forests, and Ravinus thorn forests [2]. The climate of the study region may be classified as monsoonal based on the temperature and precipitation, with three distinct seasons: rainy, winter, and summer.

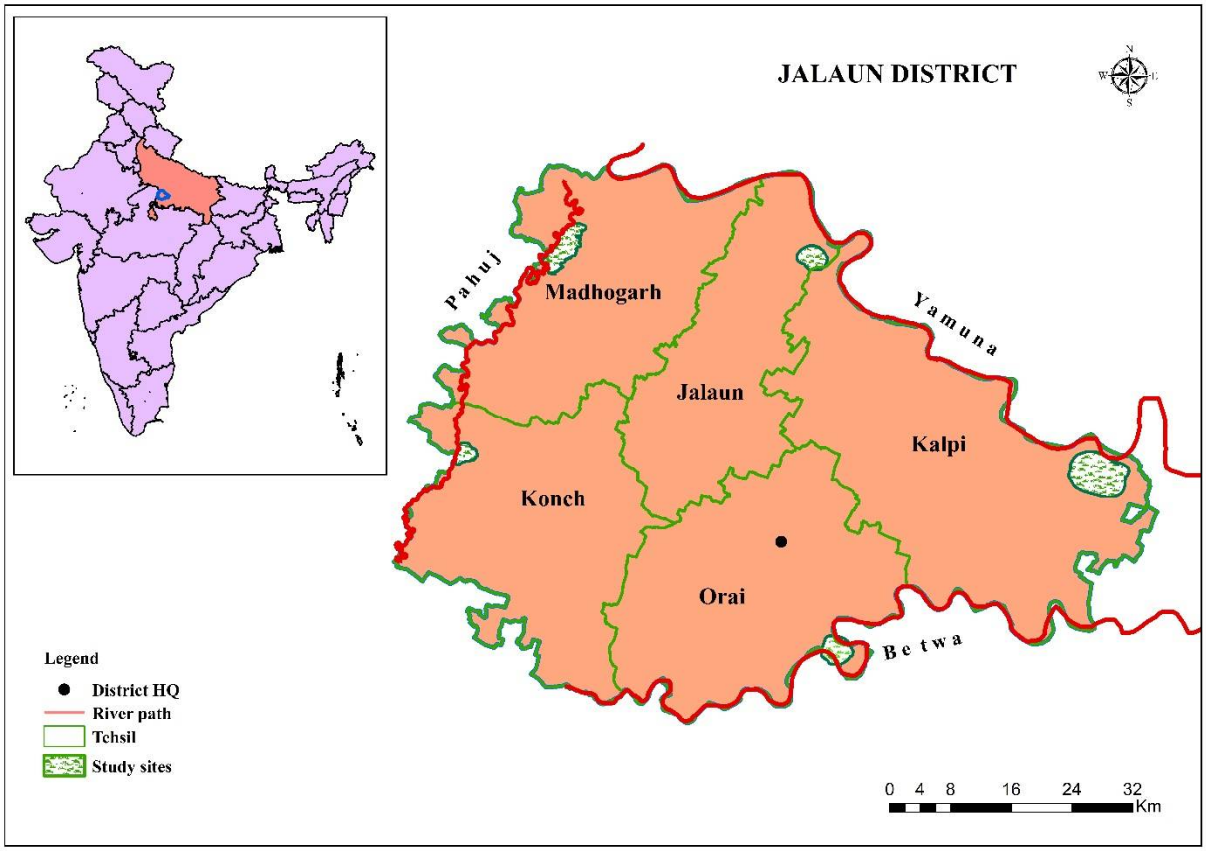

Figure 1. The study area map showing the locations of the study sites in Jalaun district.

Five forest sites were considered for the vegetation analysis of woody plant species i.e. Ekona Forest of Kadaura range, Lohai-Forest of Jalaun range, Rampura-Forest of Madhogarh range, Dang-Khairai Forest of Konch range and Simiriya-Forest of Orai range with the forest area, about 1258.19, 795.87, 955.11, 348.88 and 509.54 hectare respectively. The above selected study sites represent the five tehsils and four directions of the district.

Vegetation analysis

Broad and intensive field surveys of the study regions were conducted out every two weeks all during seasons. A stroll survey was conducted to get a glimpse of the full vegetation that is found in the studied area. The data were obtained through using quadrate sampling method. The size and total number of studied quadrates were estimated using the species-area curve method and the minimum quadrate-number method, with fifty quadrates of 10x10 m size being randomly placed on each study site [19], [26].

Phytosociological analysis

All woody species having its circumference measured at breast height (1.37 m above the ground level). Vegetation data were quantitatively analysed for frequency, density and basal area [5]. Relative values of frequency, density and dominance were determined following [26]. The sum of all relative values represented as Importance Value Index (IVI). On the basis of IVI, dominant, co-dominant and main associate species were recognized [30]. Following indices indicating the phyto-diversity were calculated for each forest sub-types

Species richness

Species richness has been merely defined as the total number of species encountered in that particular forest type.

Shannon-Wiener's index (information measures)

Species diversity (*H'*) was estimated using the Shannon-Wiener Index [47].

$$H' = - \sum pi \ln (pi)$$

where, *H'* is Shannon-Wiener diversity index, *pi* is the extent of individuals found in species and ln is regular log

Species dominance (probability measure)

Species dominance (*D*) was calculated following the equation of Simpson [50].

$D = \sum (pi)^2$

where, *pi* is the same as Shannon-Wiener diversity index

Equitability or Evenness

The equitability or species evenness index (range 0-1) was calculated following Pielou [36].

$$E = H'/\log s$$

where, E = Species evenness index, H′ = Shannon's diversity index, and S = Total number of species

Similarity index (community co-efficient)

The mathematical representations of community similarity are frequently referred to as indices of similarity. The similarity percentage of woody plant species of different forest was determined according to Sorenson [56]

$$\text{Similarity coefficient (S)} = 2C / (A+B) \times 100$$

where, S = Similarity index (%), C = Number of common species in A and B both community, A = Number of species in community-I, B = Number of species in community-II

Dominance-diversity (d-d curve) curves were generated to determine how resources were distributed among different species in various types of forests. The relative importance value is seen as an illustration of the relative niche size that expresses the species' niche [68].

RESULTS AND DISCUSSION

The woody plant species of Jalaun district comprise 107 species (103 dicots and 04 monocots) belonging to 82 genera under 40 families from the entire study sites after a three-year extensive field survey. Mimosaceae is the most abundant family, with 11 species followed by Caesalpiniaceae with 09 species, Moraceae with 08 species, Tiliaceae and Verbenaceae with 05 species each (Figure 2). *Ficus* is the dominant genus with 06 species followed by *Grewia* with 05 species, *Acacia* and *Ziziphus* with 04 species each, *Capparis* with 03 species (Figure 3).

Table 1. Importance Value Indices (IVI) of different forest communities in Jalaun district.

S. No.	Species name	Family	IF	LF	RF	DF	SF
1	Abrus precatorius L.	Fabaceae	-	3.20	-	3.44	-
2	Abutilon indicum (L.) Sweet	Malvaceae	3.62	4.68	2.33	4.87	2.52
3	Acacia auriculiformis A. Cunn. ex Benth.	Mimosaceae	-	-	1.24	-	0.82

4	Acacia catechu (L.f.) Willd.	Mimosaceae	7.68	8.01	7.59	19.3	7.27
5	Acacia leucophloea (Roxb.) Willd.	Mimosaceae	11.9	12.12	8.65	14.71	20.3
6	Acacia nilotica (L.) Willd. ex Delile	Mimosaceae	6.30	7.12	6.65	4.85	8.39
7	Adina cordifolia (Roxb.) Hook.f.	Rubiaceae	-	-	-	-	1.04
8	Aegle marmelos (L.) Corr.	Rutaceae	3.83	2.65	1.87	2.18	1.28
9	Ailanthus excelsa Roxb.	Simaroubaceae	-	-	2.05	-	2.86
10	Alangium salviifolium (L f.) Wang.	Cornaceae	-	-	-	0.87	-
11	Albizia lebbeck (L.) Benth.	Mimosaceae	4.67	-	4.16	4.72	4.05
12	Albizia procera (Roxb.) Benth.	Mimosaceae	-	-	1.05	4.47	-
13	Alstonia scholaris (L.) R. Br.	Apocynaceae	-	0.86	-	-	-
14	Anogeissus pendula Edgew.	Combretaceae	-	-	-	-	4.74
15	Artocarpus heterophyllus Lam.	Moraceae	-	1.08	-	-	-
16	Asparagus racemosus Willd.	Liliaceae	1.34	-	-	-	-
17	Azadirachta indica A. Juss.	Meliaceae	3.44	2.91	4.21	4.69	3.45
18	Balanites aegyptiaca (L.) Delile	Balanitaceae	15.60	15.91	16.20	24.09	22.10
19	Bambusa vulgaris Schrad. ex J.C. Wendl.	Poaceae	3.99	-	-	-	0.69
20	Bauhinia racemosa Lam.	Caesalpiniaceae	-	2.19	-	-	2.94
21	Bauhinia variegata L.	Caesalpiniaceae	4.30	-	2.17	5.18	-
22	Bombax ceiba L.	Bombacaceae	4.36	3.85	7.88	-	2.48
23	Borassus flabellifer L.	Arecaceae	-	-	-	1.90	-
24	Boswellia serrata Roxb.	Burseraceae	-	-	-	1.35	1.03
25	Butea monosperma (Lam.) Taub.	Fabaceae	-	-	-	-	0.79
26	Callistemon lanceolatus (Sm.) Sweet	Myrtaceae	-	0.82	-	-	-
27	Calotropis gigantea (L.) Dryand.	Asclepiadaceae	2.11	1.61	0.89	5.22	-
28	Calotropis procera (Aiton) W. T. Aiton	Asclepiadaceae	-	1.69	-	-	2.95
29	Capparis decidua (Forssk.) Edgew.	Capparaceae	13.10	15.06	10.10	17.20	15.50
30	Capparis sepiaria L.	Capparaceae	3.86	8.21	14.2	-	16.9
31	Capparis zeylanica L.	Capparaceae	-	-	-	11.37	-
32	Carissa carandas L.	Apocynaceae	-	7.48	8.42	-	9.13
33	Cassia fistula L.	Caesalpiniaceae	6.11	5.78	1.39	-	1.84
34	Clerodendrum phlomoides Hort. Ital. ex DC.	Verbenaceae	-	-	-	1.24	-
35	Cordia dichotoma G. Forst.	Boraginaceae	3.45	-	4.78	-	3.48
36	Cordia sinensis Lam.	Boraginaceae	-	0.96	-	-	-
37	Crateva religiosa G. Forst.	Capparaceae	0.93	-	-	-	-

38	Dalbergia sissoo DC.	Fabaceae	4.55	1.37	7.57	4.13	3.59
39	Delonix regia (Bojer ex Hook.) Raf.	Caesalpiniaceae	2.04	-	-	3.31	-
40	Dichrostachys cinerea (L.) Wight & Arn.	Mimosaceae	2.98	-	1.71	-	-
41	Diospyros melanoxylon Roxb.	Ebenaceae	1.43	-	-	-	-
42	Ehretia laevis Roxb.	Boraginaceae	-	-	0.72	-	-
43	Eucalyptus globulus Labill.	Myrtaceae	-	-	1.97	3.72	-
44	Feronia limonia (L.) Swingle	Rutaceae	3.57	1.95	1.89	-	-
45	Ficus benghalensis L.	Moraceae	5.25	-	3.96	6.63	1.75
46	Ficus carica L.	Moraceae	1.40	-	-	-	-
47	Ficus racemosa L.	Moraceae	5.98	6.16	11.3	12.10	14.3
48	Ficus palmata Forssk.	Moraceae	-	-	-	-	1.59
49	Ficus religiosa L.	Moraceae	4.08	2.09	2.77	3.79	3.51
50	Ficus rumphi Bl.	Moraceae	2.49	-	1.78	-	3.51
51	Flacourtia indica (Burm.f.) Merr.	Flacourtiaceae	7.19	10.34	9.69	11.91	10.10
52	Grewia asiatica L.	Tiliaceae	-	2.47	-	-	-
53	Grewia hirsuta Vahl.	Tiliaceae	-	2.48	3.88	6.09	3.12
54	Grewia rothii DC.	Tiliaceae	5.27	2.75	-	-	-
55	Grewia tiliifolia Vahl	Tiliaceae	3.36	-	0.49	-	-
56	Grewia villosa Willd.	Tiliaceae	-	-	0.90	-	-
57	Gymnema sylvestre (Retz.) R.Br. ex Sm.	Asclepiadaceae	-	-	-	0.86	-
58	Helicteres isora L.	Sterculiaceae	4.80	-	3.32	3.07	2.49
59	Heterophragma adenophyllum Wall ex G. Don	Bignoniaceae	-	-	1.29	-	0.64
60	Holoptelea integrifolia (Roxb.) Planch.	Ulmaceae	5.46	5.42	17.02	3.79	6.72
61	Jatropha gossypiifolia L.	Euphorbiaceae	-	1.20	-	1.41	-
62	Justicia adhatoda L.	Acanthaceae	2.83	-	-	4.22	-
63	Kigelia africana (Lam.) Benth.	Bignoniaceae	-	-	2.77	-	-
64	Lannea coromandelica (Houtt.) Merr.	Anacardiaceae	-	-	-	1.41	-
65	Lantana camara L.	Verbenaceae	-	7.94	-	-	-
66	Lantana indica Roxb.	Verbenaceae	4.53	-	4.75	4.77	7.39
67	Lawsonia inermis L.	Lytharaceae	3.12	7.17	-	-	1.72
68	Leucaena leucocephala (Lam.) de Wit.	Mimosaceae	4.08	-	2.51	2.39	3.23
69	Madhuca longifolia (L.) J.F. Macbr.	Sapotaceae	8.42	5.74	4.47	-	4.75
70	Mangifera indica L.	Anacardiaceae	-	1.49	1.60	-	-
71	Melia azedarach L.	Meliaceae	1.76	-	-	-	-

72	Millingtonia hortensis L.f.	Bignoniaceae	-	-	2.84	-	1.28
73	Miliusa tomentosa (Roxb.) Finet & Gagnep.	Annonaceae	0.88	-	-	-	-
74	Mitragyna parvifolia (Roxb.) Korth.	Rubiaceae	-	-	8.15	-	-
75	Morinda pubescens Sm.	Rubiaceae	-	-	1.75	-	1.31
76	Moringa oleifera Lam.	Moringaceae	2.66	-	-	2.39	3.03
77	Morus alba L.	Moraceae	0.81	-	-	-	-
78	Murraya koenigii (L.) Spreng.	Rutaceae	-	-	0.38	-	-
79	Nerium indicum Mill.	Apocynaceae	-	1.49	-	-	1.18
80	Nyctanthes arbor-tristis L.	Oleaceae	-	4.04	-	-	-
81	Parkinsonia aculeata L.	Caesalpiniaceae	-	2.77	2.85	2.08	-
82	Peltophorum pterocarpum (DC.) K. Heyne	Caesalpiniaceae	-	3.36	2.88	-	-
83	Phoenix sylvestris (L.) Roxb.	Arecaceae	2.54	1.98	-	4.94	3.79
84	Phyllanthus emblica L.	Euphorbiaceae	-	1.47	-	-	0.95
85	Pithecellobium dulce (Roxb.) Benth.	Mimosaceae	2.12	-	0.79	2.23	-
86	Polyalthia longifolia (Sonner) Thwaites	Annonaceae	-	1.03	-	-	-
87	Pongamia pinnata (L.) Pierre	Fabaceae	4.52	6.40	3.63	-	4.74
88	Prosopis juliflora (Sw.) DC.	Mimosaceae	46.62	60.66	45.29	48.55	46.30
89	Prosopis spicigera L.	Mimosaceae	4.94	5.27	0.99	3.54	1.21
90	Salvadora oleoides Decne.	Salvadoraceae	-	1.35	-	-	-
91	Senna occidentalis L.	Caesalpiniaceae	3.35	-	-	-	-
92	Senna siamea Lam.	Caesalpiniaceae	5.47	-	1.72	-	-
93	Sterculea foetida L.	Sterculiaceae	-	-	3.36	2.01	1.14
94	Sterculea urens Roxb.	Sterculiaceae	-	1.88	-	-	-
95	Syzygium cuminii L.	Myrtaceae	4.80	3.57	3.05	3.23	3.31
96	Tamarindus indica L.	Caesalpiniaceae	6.96	3.93	4.45	-	-
97	Tectona grandis L.f.	Verbenaceae	-	-	1.89	-	1.06
98	Terminalia arjuna Roxb. ex DC.	Combretaceae	-	-	4.42	3.22	5.49
99	Thespesia populnea (L.) Sol. ex Correa	Malvaceae	-	-	0.82	-	-
100	Tinospora cordifolia (Willd.) Miers	Menispermaceae	2.82	3.45	-	1.86	0.99
101	Vitex negundu L.	Verbenaceae	-	0.95	-	-	2.18
102	Woodfordia fruticosa (L.) Kurz	Lytharaceae	4.97	6.05	4.03	5.09	4.20
103	Xylosma longifolia Clos	Flacourtiaceae	0.74	-	-	-	-
104	Ziziphus mauritiana Lam.	Rhamnaceae	4.98	4.85	2.07	3.50	-
105	Ziziphus nummularia (Burm.f.) Wight & Arn.	Rhamnaceae	3.82	9.75	4.00	1.92	1.94
106	Ziziphus oenoplia (L.) Mill.	Rhamnaceae	11.90	9.57	8.34	10.25	8.89
107	Ziziphus xylopyrus Sedgw.	Rhamnaceae	-	1.42	-	-	2.09

(IF= Ekona-Forest, **LF**= Lohai-Forest, **RF**= Rampura-Forest, **DF**= Dang-Khairai Forest, **SF**= Simiriya-Forest)

In terms of the IVI values, *Prosopis juliflora* predominated in Ekona-Forest (46.62), Lohai-Forest (60.66), Rampura-Forest (45.29), Dang-Khairai Forest (48.55) and Simiriya-Forest (46.30) of the Jalaun district (Table 1). It is followed by *Balanites aegyptiaca, Capparis decidua, Holoptelea integrifolia, Acacia leucophloea, Ziziphus oenoplia, Capparis sepiaria, Ficus racemosa, Flacourtia indica, Madhuca longifolia, Acacia catechu, Ziziphus nummularia, Grewia hirsuta, Acacia nilotica, Lantana indica, Terminalia arjuna* etc. The results also show that only a few numbers of species dominated in these forest communities, whereas the greater proportion of woody species exhibit lower IVI values. Due to their immense basal areas, dominant woody species contributed the higher value to IVI, which was a reflection of their ecological success in the respective forest ranges [70]. In accordance with assessments conducted at the study sites, the total density of all woody plant species was 2106 individuals ha^{-1} (Ekona-Forest), 2090 individuals ha^{-1} (Lohai-Forest), 2146 individuals ha^{-1} (Rampura-Forest), 1720 individuals ha^{-1} (Dang-Khairai Forest) and 1564 individuals ha^{-1} (Simiriya-Forest) in five forest communities of Jalaun district (Table 2). Tree density has been estimated to range from 550 to 1800 individuals ha^{-1} in various tropical forests [20], [66], and to 3700 individuals ha^{-1} in lowland neotropical dry forests [12]. Verma *et al.* has reported the total density for tree species from 5.88 to 7.15 plants/100m^2 and 39.22 to 49.21 plants/100m^2 for the lower group species in the different tropical dry deciduous forests of Bundelkhand region of India [64]. These tree density values, which range within 702 to 4600 stems ha^{-1} [9], [13], [15], [59] have been illustrated to be comparable of other tropical dry deciduous forests in India. This range of stand density was higher than that which was observed in the Servarayan and Kalrayan hills [17], [18], the tropical montane evergreen forest (shola) of the Nilgiri Mountains [28], and the Eastern Ghats of northern Andhra Pradesh [41]. The stand density indicates that the existence of higher number of trees per hectare can be ascribed to closely spaced trees with thinner stems and a higher number of species of ground flora (shrubs, lianas, etc.). Tree diversity fluctuates in tropical forests because of variances in biogeography, habitat adequacy, climate change responses and individual stresses [67]. The total basal area of the different study forests was calculated to be 67.64 m^2 ha^{-1} (Ekona-Forest), 55.19 m^2 ha^{-1} (Lohai-Forest), 88.56 m^2 ha^{-1} (Rampura-Forest), 35.76 m^2 ha^{-1} (Dang-Khairai Forest) and 49.27 m^2 ha^{-1} (Simiriya-Forest) (Table 2). These basal area values were found within the range of the tropics i.e., 7 to 104.9 m^2 ha^{-1} [14], [15], [40], [51], [64]. The basal area has been found higher than the tropical evergreen forests ranging from 11 to 82.76 m^2 ha^{-1} [3], [24], [58], [60], [66], and tropical deciduous forest ranging from 7 to 61 m^2 ha^{-1} [14], [49], [52], [62], [63] in India. While it was 55 to 94 m^2 ha^{-1} evergreen forest of Western Ghats India [11]. The differences in basal area values of trees in various forest range were primarily influenced by species composition, age, and development patterns for individual trees, while the degree of disturbances have an effect on the ensuing species succession resulting in variations in basal area values. The woody plant species richness in the Jalaun district was found to be 57 in the Ekona-Forest, 55 in Lohai-Forest, 61 in Rampura-Forest, 48 in Dang-Khairai Forest, and 57 in Simiriya-Forest (Table 3). One of the distinct characteristics of tropical forests is their abundance of species. It is the most accessible approach to define regional as well as local diversity, and this alterable number of species provides the basis for many ecological models of community structure [46]. Rao *et al.* observed 61 tree and shrub species in tropical forest of Chitrakoot district of central India [40]. Verma *et al.* have reported maximum species richness 59 and 40 for the tree and lower group's species respectively for the tropical dry deciduous forests of Bundelkhand region [64]. The species richness diversity of five forests are comparable to tropical forest of eastern Ghats, Andhra Pradesh [41], tropical semi-evergreen forest of Manipur [7], tropical evergreen forest of Courtallum reserve forest of Western Ghats [35]. However, the species richness of studied forest communities is lower than those reported for sub-tropical Kandi Siwaliks of Jammu [48], moist evergreen forest of Western Ghats of Karnataka [8]. The diversity of woody species in these forest communities was also studied in the present study (Table 3). In accordance with the results, Ekona-Forest (H'=3.3896) and Rampura-Forest (H'=3.3369) had more species diversity compared to Simiriya Forest (H'=3.2638), Lohai Forest (H'=3.2326), and Dang-Khairai Forest (H'=3.1346). Species diversity is one of the most important features of a community. It is an ensemble that promotes stability [25]. According to the results, there is just a tiny variation in species diversity among these five forests. Positive correlation exists between species diversity and species abundance in the five forests. Monk noted that once a community is made up of 12 to 15 species, diversity attends to reach a maximum level in a deciduous forest community [29].

Table 2. Total density and Total Basal Area of woody species of five forest communities.

S. No.	Study sites	No. of species	Total Density (individuals ha^{-1})	Total Basal Area ($m^2 ha^{-1}$)
1	Ekona-Forest	57	2106	67.64
2	Lohai-Forest	55	2090	55.19
3	Rampura-Forest	61	2146	88.56
4	Dang-Khairai Forest	48	1720	35.76
5	Simiriya-Forest	57	1564	49.27

Table 3. Species richness, species diversity, dominance and equitability of woody species of different forest communities of Jalaun district.

S. No.	Study sites	Species richness (*R*)	Species diversity (*H'*)	Equitability (*E*)	Species dominance (*D*)
1	Ekona Forest	57	3.3896	0.8384	0.06789
2	Lohai Forest	55	3.2326	0.8067	0.07779
3	Rampura Forest	61	3.3369	0.8117	0.06897
4	Dang-Khairai Forest	48	3.1346	0.8097	0.08002
5	Simiriya Forest	57	3.2638	0.8073	0.06695

Table 4. Similarity matrix of different study sites in Jalaun district.

Study sites	Ekona Forest	Lohai Forest	Rampura Forest	Dang-Khairai Forest	Simiriya Forest
Ekona Forest	-				
Lohai Forest	57.14	-			
Rampura Forest	67.79	56.89	-		
Dang-Khairai Forest	62.86	50.49	62.39	-	
Simiriya Forest	63.16	62.5	69.49	59.05	-

The values of species diversity for temperate forests were found to range from 1.16 to 3.40 [29], [33], [42], [54]. The diversity index for tropical forests has been reported to be 5.06 for young stands and 5.40 for older stands, respectively [21]. The degree of species diversity that have recently been investigated are significantly lower than those that previously reported for tropical forests [21]. However, these are approximate to values generally reported for other tropical forests [6], [15], [31], [34], [43], [55], [61], [64]. The species diversity values of the studied forests are average in comparison with those reported as 1.855 to 2.029 for Rampara forest in Saurastra, Gujrat [32], 3.069 for tropical evergreen forest in Courtallum reserve forest of Western Ghats [35], 4.56 for moist evergreen forest in Western Ghats [8], and 2.305 to 2.869 for tropical semi evergreen forest of Kalrayan hills, Eastern Ghats [17]. Some other forests of Madhya Pradesh such as Seoni, Balaghat and Mandla also exhibited higher species diversity than those of this study [37]. Diversity is a manifestation of the interaction of two variables, which are the existence of a large number of species (species richness) and the evenness or equity of the distribution of individuals among the species. Despite of the selected index, populations of one species are regarded to have a diversity of zero. Therefore, the term "species diversity" refers to the differences that occur between the many forms.

The relative abundance of different species in any given area is described by the biodiversity measure referred to as species evenness. The highest species evenness or equitability values in the current study were found in the Ekona-Forest (0.8384) community, followed by Rampura Forest (0.8117), Dang-Khairai Forest (0.8097), Simiriya Forest (0.8073), and Lohai Forest (0.8067) within five forests that are approximately comparable with the values of the other forests in India (Table 3). Verma *et al.* have observed maximum equitability 0.9339 and 0.8744 for the tree and understory species respectively [64]. Species evenness values (0.46 to 0.90) for the trees in subtropical and temperate regions in the central Himalaya [16], 0.37 to 0.91 in Hollongapar Gibbon Wildlife Sanctuary, Assam [45], and 0.5 to 0.90 for tree in moist tropical montane of Garhwal Himalaya [10]. The species dominance (*D*) of woody species on an individual basis was higher in Dang-Khairai Forest (0.080016) followed by Lohai-Forest (0.077789),

Rampura-Forest (0.068965), Ekona-Forest (0.067886) and Simiriya-Forest (0.066951) of the Jalaun district (Table 3). Concentration of dominance (*Cd*) values was in the range of 0.10 to 0.99 for temperate vegetation [42]. The present values are in consistent with the tropical forest's average *Cd* value of 0.06 [21]. Similar to that, the *Cd* value was 0.068 [61] in the tropical dry deciduous forests of central India. The results obtained for the five forests showed a small range of variation. The environmental stress could be accountable for the raised value of concentration of dominance in the Dang-Khairai Forest. These relatively higher values for concentration of dominance in this study than the reported average value (0.06) of tropical forests is consistent with low species diversity at the studied sites because species diversity (*H'*) and dominance (Simpson index) have an inverse relationship [4].

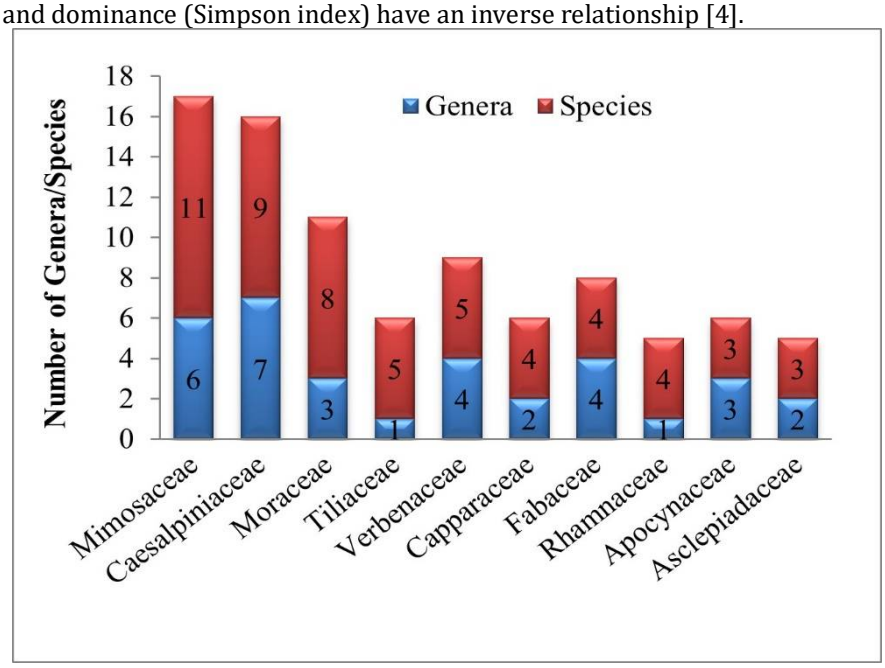

Figure 2. Five dominant families of woody plants in Jalaun district.

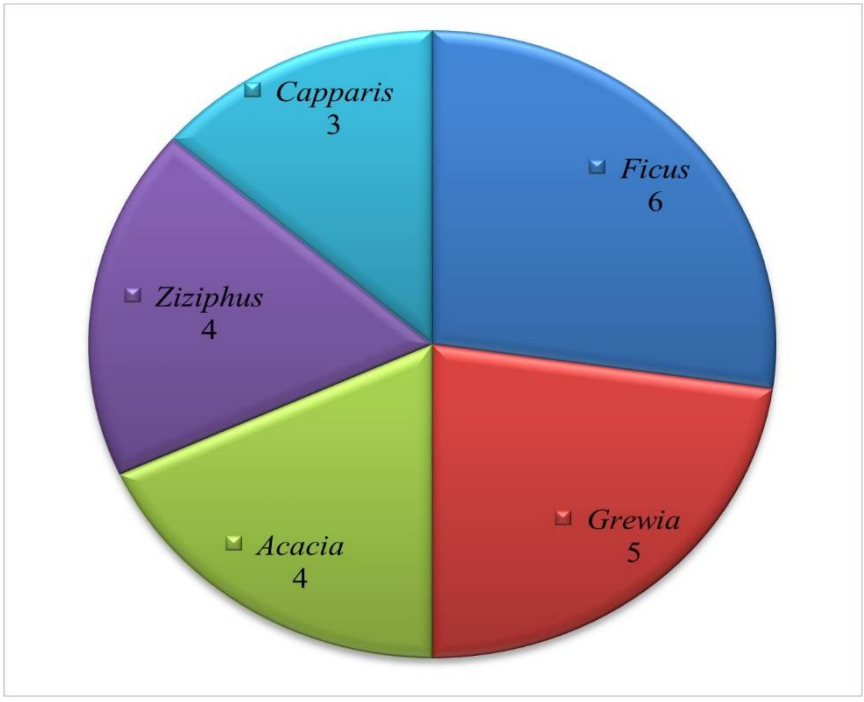

Figure 3. Five dominant genera of woody plants in Jalaun district.

The observed *Cd* values of studied forests are comparable with the result of other studies [6], [27], [53], but are lower to those of the Rampura forest in Saurashtra, Gujarat [32], and the central Western Ghats region of Karnataka [22]. The IVI of the first three relatively significant species in a community had an

important effect on the concentration of dominance or Simpson's index [1]. The degree of community diversity has an inverse relationship with index value. It is commonly recognized that a community has less diversity when one or a small number of species predominate, but a community has a high level of diversity when a number of species are abundant. Results revealed that Rampura and Simiriya Forest communities had the most of similarity between woody species (69.49%) followed by Ekona and Rampura Forest (67.79%), Ekona and Simiriya Forest (63.16%), Ekona and Dang-Khairai Forest (62.86%) and Lohai and Simiriya Forest (62.50%) communities. In the Lohai and Dang-Khairai Forest communities in the Jalaun district, there was a minimum similarity (50.49%) among the woody species. All five forest communities have an aggregate of about 19 woody species that are commonly prominent (Table 4).

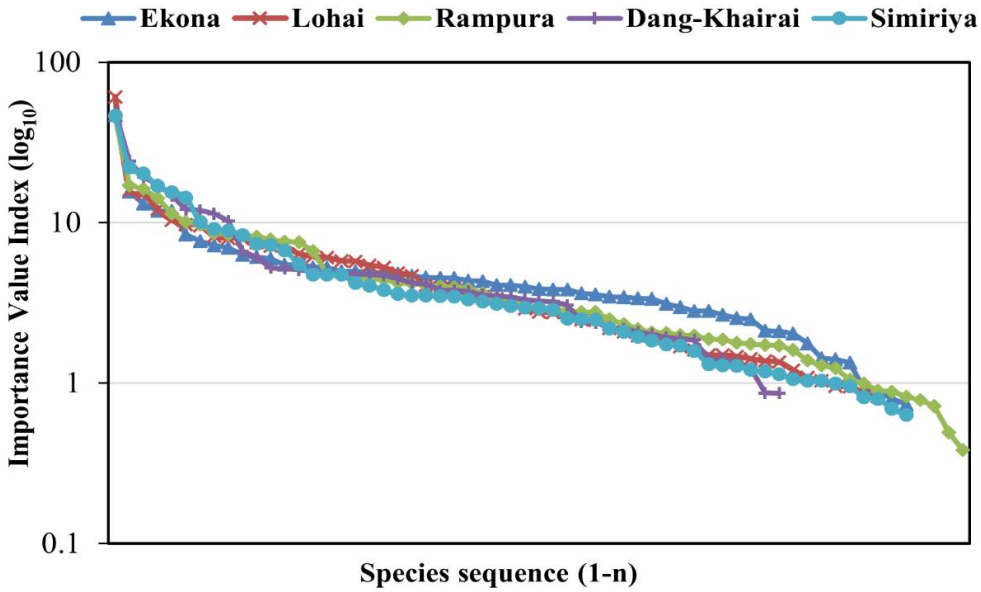

Figure 4. Dominance-diversty curve in different study sites.

Dominance-diversity (d-d) curves have been used frequently for assessing community composition in terms of resource sharing and niche space. This is predicated on the idea that there is some correlation between a species' use of a community's resources and the proportion of that community's niche space that it has [69]. Under circumstances of high diversity, the community occupies its resources proficiently. Dominance-diversity curves d-d curves for woody species (trees, shrubs, lianas, and woody grasses) based on IVI (log_{10}) have been constructed for existing forest communities (Figure 4). The d-d curves of existing communities approximated Preston's normal distribution model [38], with lower number of species in the higher IVI range. Similar type of d-d curves has been observed in prior studies for several tropical dry deciduous forests in India [10], [39], [44], [65].

CONCLUSION

The economic development of a country or region has been profoundly influenced by its forests. They are a vital source of food, employment, revenue, and raw materials for a range of manufacturing processes. They serve an important role in ecological harmony, environmental stability, biodiversity conservation, food security, and sustainability. The biological diversity of tropical forests is quite diverse. The management of biogeochemical cycles is promoted by these types of forests, which also provide a number of conservation-related rewards. The number of species that may be found in tropical dry deciduous forests that are valuable commercially is astounding. Other types of tropical forests, as well as dry deciduous forests, have well-understood vegetation composition, species diversity, and their habitats. It has been observed that a number of tree species present in the studied forests have been more resilient to anthropogenic effects and have a greater potential for natural regeneration. However, in order to sustain these species, biotic disruptions like logging, trampling, and illegal extraction must be averted. The high plant density and low basal cover of the different forest types, where the majority of the species have younger plants, readily demonstrate the emerging character of these forest types. The dry deciduous forests are one of its most overused and threatened habitats. This investigation will be a significant contribution to preserving and monitoring the phytodiversity of tropical dry deciduous forests in Uttar Pradesh and other regions of the world with similar types of forest territories. The present study will

make an important contribution to protecting and conserving phytodiversity. It could be also help in understanding the risks associated to tropical forests and inspire conservation strategy.

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CONFLICTS OF INTEREST
Authors declare no conflicts of interest.

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