P-ISSN: 2618-0723
E-ISSN: 2618-0731

NAAS Rating: 5.04
www.extensionjournal.com

International Journal of Agriculture Extension and Social Development

Volume 8; Issue 4; April 2025; Page No. 82-85

Received: 07-01-2025
Accepted: 11-02-2025

Indexed Journal
Peer Reviewed Journal

Assessment of floral diversity of woody tree species in Nandyal district of Andhra Pradesh

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DOI: https://www.doi.org/10.33545/26180723.2025.v8.i4b.1737

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Abstract

This study was conducted in the Nandyal district of Andhra Pradesh, India, with the aim of evaluating the floral diversity and species dominance within its forest ecosystem, a critical component of the region's ecological framework. Trees in this semi-arid landscape play an indispensable role in sustaining biodiversity, regulating environmental conditions, and supporting local livelihoods dependent on forest resources. Through systematic surveys, a total of 56 tree species across 22 families were identified and recorded, culminating in the compilation of a comprehensive species checklist for the district. The Shannon diversity index, calculated at 1.36, indicates a moderate level of species richness and evenness, while the Simpson index of 0.97 reflects a well-balanced community structure with limited dominance by any single species. These metrics collectively highlight the ecological resilience of the area, despite its challenging climatic conditions. The findings illuminate the intricate relationship between floral diversity and species distribution, emphasizing their pivotal roles in maintaining ecosystem stability in Nandyal. Moreover, the study reveals the vulnerability of this semi-arid forest to anthropogenic pressures and climate variability, underscoring the pressing need for robust conservation strategies. Such measures are essential not only to preserve the existing biodiversity but also to enhance the ecosystem's capacity to adapt to future environmental changes, ensuring the long-term sustainability of this vital natural resource.

Keywords: Floral diversity, species dominance, semi-arid region, forest ecosystem, biodiversity conservation

Introduction

Andhra Pradesh's forests, spanning a substantial portion of the state's land area, are predominantly deciduous, interspersed with mixed forests and tropical dry ecosystems that collectively support a rich array of tree species. These forests are repositories of ecological wealth, harboring medicinal plants, commercially significant timber species, and unique biodiversity hotspots (Subramanian *et al*., 2001) [4]. Amidst this natural abundance, rapid urbanization poses a stark contrast: cities, though occupying less than 3% of the global terrestrial surface, drive 78% of carbon emissions, 60% of residential water consumption, and 76% of industrial wood use. Historical shifts underscore this trend—while only Beijing exceeded a million residents in 1800, by 2000, 326 cities surpassed this mark (Brown, 2013) [3]. Urban populations have surged from 10% globally in 1900 to over 50% today, with projections estimating a rise to 67% within the next 50 years (Grimm *et al*., 2008) [5]. Developing nations in Asia and Africa are poised to cross this urban majority threshold, aligning with Latin America's trajectory (UN-Habitat, 2009) [17].

Within Andhra Pradesh, forest diversity manifests across varied landscapes—from the moist deciduous forests of the Eastern Ghats to the dry thorn forests in the western regions (Bhandari *et al*., 1997) [2]. This study, conducted in the Nandyal district, exemplifies this ecological richness in a semi-arid context. Systematic surveys documented 56 tree species across 22 families, resulting in a comprehensive species checklist. The Shannon diversity index of 1.36 indicates moderate species richness and evenness, while the Simpson index of 0.97 reflects a balanced community with minimal dominance by any single species. These metrics highlight the resilience of Nandyal's forest ecosystem despite its arid conditions. Comparatively, the central Western Ghats, spanning parts of Karnataka, showcase even greater ecological diversity due to varied climate, soil, and topography, supporting distinct flora and fauna (Ramachandra *et al*., 2012) [13].

Beyond ecological value, these forests sustain human communities. Rural populations across the tropics, including in Andhra Pradesh, depend on medicinal plants—approximately 700 species in South India alone—for their efficacy, cultural significance, and the scarcity of modern healthcare alternatives (Balick *et al*., 1996; Soni *et al*., 2009) [1, 14]. Indigenous forest-dwellers possess profound knowledge of these resources, embedding them in traditional and folk medicine. India's agroforestry heritage further enriches this landscape, with practices like trees on farmlands, community forestry, and ethno-forestry tailored to local needs and conditions. Understanding these systems requires analyzing land use patterns, species composition, and phytodiversity (Umrao *et al*., 2024) [16]. This study emphasize the critical interplay between floral diversity, species dominance, and human reliance on forests in Nandyal, amplifying the need for targeted conservation strategies. Such efforts are vital to safeguard biodiversity, bolster ecosystem resilience against climate and anthropogenic pressures, and ensure the sustainability of these invaluable resources for future generations. Understanding the structure, composition, and phyto diversity of existing sites requires a close examination of their land use patterns (Umrao *et al.*, 2024) [16].

Materials and Methods

Study area

The study was conducted in the Nandyal district of Andhra Pradesh, India. Nandyal district is located at an average elevation of 319 meters above sea level. It lies at approximately 15.48° N latitude and 78.48° E longitude. The district is bordered by Kurnool district to the north, Kadapa district to the south, Anantapur district to the west, and the state of Telangana to the east. Nandyal district is characterized by its semi-arid climate, with distinct wet and dry seasons. The district falls under the Rayalaseema Plateau, which is known for its rocky terrain, deciduous forests, and a mix of agricultural and dryland areas.

Sampling and data analysis

The study was conducted in Nandyal district from 2022-23. The analysis of vegetation was carried out by using the quadrates in random sampling method. Quadrates of 20 m×20 m (400 m^2) size were randomly laid to assess tree species at desired site.

Distribution Pattern

The parameters of each tree species of study site was analyzed by using following.

Distribution Pattern = Abundance/Frequency

$$\text{Frequency} = \frac{\text{Number of sample plots in which species occurred}}{\text{Total number of sample plots studied}} \times 100$$

$$\text{Abundance} = \frac{\text{Total number of Individuals of the species}}{\text{Total number of plots of occurrence}}$$

Dominance = Density for a species X Average basal area for species

$$\text{Relative Dominance} = \frac{\text{Basal area of a species}}{\text{Basal area of all species}} \times 100$$

$$\text{Relative Density} = \frac{\text{Number of Individuals of a species}}{\text{Number of individuals of all species}} \times 100$$

$$\text{Basal Area} = \frac{\sum \pi D^2}{4}$$

$$\text{Relative Frequency} = \frac{\text{Number of occurrence of a species}}{\text{Number of occurrence of all species}} \times 100$$

$$\text{Importance Value Index (IVI)} = \text{Relative Density} + \text{Relative Frequency} + \text{Relative Dominance}$$

Table 1: Floral diversity of individual tree species found in Nandyal district of Andhra Pradesh, India.

Sr. No	Tree species	Family	F	Ab	D	B.A	RF	RD	RDO	IVI
1.	*Acacia chundra*	Fabaceae	10	1.5	0.1	0.04	1.67	1.91	0.22	3.8
2.	*Acacia leucophloea*	Fabaceae	10	1	0.1	0.69	1.67	1.27	3.7	6.64
3.	*Acacia nilotica*	Fabaceae	10	1.5	0.1	0.18	1.67	1.91	0.96	4.54
4.	*Adina cordifolia*	Rubiaceae	10	1	0.1	0.3	1.67	1.27	1.61	4.55
5.	*Aegle marmelos*	Rubiaceae	5	1	0.1	0.24	0.83	0.64	1.27	2.74
6.	*Alangium salvifolium*	Alangiaceae	10	1	0.1	0.35	1.67	1.27	1.88	4.82
7.	*Albizia amara*	Fabaceae	15	1.3	0.2	0.01	2.5	2.55	0.06	5.11
8.	*Albizia julibrissin*	Fabaceae	5	1	0.1	0.14	0.83	0.64	0.74	2.21
9.	*Albizia lebback*	Fabaceae	20	1.3	0.2	0.33	3.33	3.18	1.77	8.28
10.	*Anacardium occidentale*	Anacardiaceae	5	1	0.1	0.24	0.83	0.64	1.27	2.74
11.	*Annona squamosa*	Annonaceae	5	1	0.1	0.11	0.83	0.64	0.6	2.07
12.	*Anogeissus latifolia*	Combretaceae	5	1	0.1	0.75	0.83	0.64	4.02	5.49
13.	*Azadirachta indica*	Meliaceae	10	1.5	0.1	1.08	1.67	1.91	5.72	9.3
14.	*Bombax ceiba*	Malvaceae	20	1.8	0.2	0.65	3.33	4.46	3.46	11.26
15.	*Boswellia serrata*	Burseraceae	5	1	0.1	0.75	0.83	0.64	4.02	5.49
16.	*Butea monosperma*	Fabaceae	5	1	0.1	0.22	0.83	0.64	1.17	2.65
17.	*Cassia fistula*	Fabaceae	5	1	0.1	0.13	0.83	0.64	0.67	2.14
18.	*Chloroxylon swietenia*	Rutaceae	10	1	0.1	0.16	1.67	1.27	0.85	3.79
19.	*Citrus aurantium*	Rutaceae	25	1.6	0.3	0.03	4.17	5.1	0.17	9.43
20.	*Grewia rotundifolia*	Malvaceae	5	1	0.1	0.07	0.83	0.64	0.38	1.85
21.	*Gyrocarpus asiaticus*	Hippocastanaceae	5	1	0.1	0.66	0.83	0.64	3.54	5.01
22.	*Hardwickia binata*	Fabaceae	5	1	0.1	0.44	0.83	0.64	2.35	3.82
23.	*Holoptelea integrifolia*	Ulmaceae	5	1	0.1	0.3	0.83	0.64	1.61	3.08
24.	*Hymenodictyon orixense*	Rubiaceae	5	1	0.1	0.28	0.83	0.64	1.51	2.98
25.	*Ixora arborea*	Rubiaceae	5	1	0.1	0.03	0.83	0.64	0.14	1.61
26.	*Lagerstroemia parviflora*	Lythraceae	10	1	0.1	0.11	1.67	1.27	0.6	3.54
27.	*Lannea coromandelica*	Anacardiaceae	5	1	0.1	0.21	0.83	0.64	1.13	2.6
28.	*Madhuca longifolia*	Sapotaceae	25	1.2	0.3	0.45	4.17	3.82	2.42	10.4
29.	*Mangifera indica*	Anacardiaceae	25	1.2	0.3	0.75	4.17	3.82	4.02	12
30.	*Mimusops elangi*	Sapotaceae	5	1	0.1	0.18	0.83	0.64	0.96	2.43
31.	*Morinda umbellate*	Rubiaceae	10	1.5	0.1	0.07	1.67	1.91	0.38	3.95

32.	*Moringa oleifera*	Moringaceae	20	1.5	0.2	0.11	3.33	3.82	0.6	7.76
33.	*Phyllanthus emblica*	Phyllanthaceae	25	1.6	0.3	0.07	4.17	5.1	0.38	9.64
34.	*Pongamia pinnata*	Fabaceae	5	4	0.1	0.42	0.83	2.55	2.23	5.61
35.	*Psidium guajava*	Myrtaceae	25	1.4	0.3	0.04	4.17	4.46	0.2	8.83
36.	*Pterocarpus marsupium*	Fabaceae	5	2	0.1	0.66	0.83	1.27	3.54	5.65
37.	*Pterocarpus santalinus*	Fabaceae	15	1.3	0.2	0.75	2.5	2.55	4.02	9.06
38.	*Pterospermum xylocarpum*	Sterculiaceae	5	1	0.1	0.3	0.83	0.64	1.61	3.08
39.	*Sesbania grandiflora*	Fabaceae	5	1	0.1	0.06	0.83	0.64	0.33	1.8
40.	*Shorea roxburghii*	Dipterocarpaceae	20	1.3	0.2	0.31	3.33	3.18	1.66	8.18
41.	*Siamese cassia*	Fabaceae	10	2	0.1	0.3	1.67	2.55	1.61	5.82
42.	*Strychnos nux-vomica*	Loganiaceae	5	1	0.1	0.2	0.83	0.64	1.09	2.56
43.	*Strychnos potatorum*	Loganiaceae	10	1	0.1	0.11	1.67	1.27	0.6	3.54
44.	*Tamarindus indica*	Fabaceae	20	1.5	0.2	0.68	3.33	3.82	3.62	10.77
45.	*Tectona grandis*	Lamiaceae	20	1.5	0.2	0.25	3.33	3.82	1.31	8.47
46.	*Terminalia alata*	Combretaceae	5	1	0.1	0.58	0.83	0.64	3.09	4.56
47.	*Terminalia arjuna*	Combretaceae	20	1.3	0.2	0.66	3.33	3.18	3.54	10.06
48.	*Terminalia bellerica*	Combretaceae	10	1	0.1	0.77	1.67	1.27	4.1	7.04
49.	*Terminalia chebula*	Combretaceae	15	1.3	0.2	0.53	2.5	2.55	2.81	7.86
50.	*Terminalia elliptica*	Combretaceae	10	1.5	0.1	0.52	1.67	1.91	2.74	6.32
51.	*Terminalia latifolia*	Combretaceae	5	1	0.1	0.66	0.83	0.64	3.54	5.01
52.	*Wrightia arborea*	Apocynaceae	5	1	0.1	0.11	0.83	0.64	0.6	2.07
53.	*Wrightia tinctoria*	Apocynaceae	10	1	0.1	0.05	1.67	1.27	0.24	3.18
54.	*Xylia xylocarpa*	Fabaceae	10	1.5	0.1	0.33	1.67	1.91	1.77	5.34
55.	*Ziziphus mauritiana*	Rhamnaceae	10	1	0.1	0.22	1.67	1.27	1.17	4.12
56.	*Ziziphus xylopyrus*	Rhamnaceae	10	1	0.1	0.08	1.67	1.27	0.43	3.37
							100	100	100	300

Results and Discussion

The floral diversity of tree species in the Nandyal district of Andhra Pradesh, India, was assessed, and the results are presented Weird n Table 1. A total of 56 tree species belonging to 22 families were recorded, reflecting a diverse arboreal community in this semi-arid region. Key ecological parameters, including frequency (F), abundance (Ab), density (D), basal area (B.A.), relative frequency (RF), relative density (RD), relative dominance (RDO), and importance value index (IVI), were calculated for each species to evaluate their distribution and ecological significance. Among the species, *Mangifera indica* (mango) exhibited the highest IVI of 12, driven by its substantial basal area (0.75 m²), high frequency (25), and relative dominance (4.02). Other notable species with high IVI values included *Bombax ceiba* (11.26), *Tamarindus indica* (10.77), *Madhuca longifolia* (10.4), and *Terminalia arjuna* (10.06), indicating their prominence within the ecosystem. These species also showed relatively high basal areas and frequencies, suggesting their ecological importance and widespread distribution. Conversely, species such as *Sesbania grandiflora* (IVI = 1.8), *Grewia rotundifolia* (IVI = 1.85), and *Ixora arborea* (IVI = 1.61) recorded the lowest IVI values, reflecting their limited presence and influence in the community.The Fabaceae family dominated the species composition, represented by 18 species (e.g., *Acacia nilotica*, *Albizia lebbeck*, *Pongamia pinnata*), underscoring its ecological adaptability to the semi-arid conditions of Nandyal. Other families with significant representation included Rubiaceae (5 species), Combretaceae (7 species), and Anacardiaceae (3 species). Species like *Azadirachta indica* (neem, IVI = 9.3) and *Phyllanthus emblica* (amla, IVI = 9.64) were notable for their high relative dominance and frequency, reflecting their ecological and cultural significance.

Discussion

The results reveal a moderately diverse tree community in Nandyal district, characterized by a mix of ecologically and economically significant species. The high IVI of *Mangifera indica* aligns with its widespread cultivation and natural occurrence in semi-arid regions, where it contributes to both biodiversity and local livelihoods. Similarly, *Bombax ceiba* and *Tamarindus indica* demonstrate ecological prominence, likely due to their adaptability to dry conditions and utility as timber and fruit-bearing trees. The substantial basal area of *Azadirachta indica* (1.08 m²) and its high IVI (9.3) reflect its dominance and resilience, consistent with its known tolerance to arid environments and value in traditional medicine and agroforestry (Singh *et al*., 2015). The dominance of the Fabaceae family, accounting for nearly one-third of the species, highlights its ecological versatility. Species like *Albizia lebbeck* (IVI = 8.28) and *Pterocarpus santalinus* (IVI = 9.06) thrive in Nandyal's semi-arid climate, likely due to their nitrogen-fixing capabilities and drought resistance, which enhance soil fertility and ecosystem stability (Rao & Reddy, 2010). This family's prevalence is a common feature in dry deciduous and thorn forests, as noted in similar studies across South India (Bhandari *et al*., 1997) [2].

Species with lower IVI values, such as *Sesbania grandiflora* and *Grewia rotundifolia*, indicate restricted distribution or lower competitive ability, possibly due to habitat specificity or anthropogenic pressures like grazing and deforestation. In contrast, species like *Terminalia* spp. (*T. arjuna*, *T. bellerica*, *T. chebula*) exhibit higher IVI values (ranging from 7.86 to 10.06), reflecting their ecological importance and widespread use in traditional medicine and timber production. Their significant basal areas suggest mature stands, contributing to canopy cover and habitat provision. The diversity indices derived earlier (Shannon = 1.36, Simpson = 0.97) corroborate the findings from Table 1, indicating a balanced community with moderate richness and minimal dominance by any single species. However, the presence of high-IVI species like *Citrus aurantium* (IVI = 9.43) and *Psidium guajava* (IVI = 8.83) suggests localized concentrations, possibly linked to human cultivation rather than natural dominance. This interplay between natural and anthropogenic factors underscores the complexity of Nandyal's forest ecosystem. These findings emphasize the need for conservation strategies tailored to preserve both high-IVI species, which anchor the ecosystem, and low-IVI species, which contribute to overall diversity. The reliance of local communities on medicinal and timber species further highlights the ecological and economic significance of the forest resources in Nandyal district. Targeted efforts to mitigate deforestation, promote reforestation, and integrate agroforestry practices could enhance the resilience of this semi-arid ecosystem, ensuring the sustainability of its biodiversity and the well-being of dependent communities

Conclusion
This study highlights the dominance of species like *Bombax ceiba*, *Madhuca longifolia*, and *Tamarindus indica*, which contribute significantly to forest structure and function. The predominance of Fabaceae suggests enhanced soil fertility through nitrogen fixation. Overall, the forest maintains a balance of dominant and subordinate species, supporting biodiversity and ecosystem stability. Further research on regeneration and interspecific interactions is recommended for understanding long-term ecological sustainability.

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