

Assessment of Tree Species Composition and Diversity in Assisted Natural Regeneration Area of Bilaspur Forest, Chhattisgarh, India.

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ABSTRACT

The present study the tree species composition, structure and diversity have been assessed for Khondra Forest's Assisted Natural Regeneration (ANR) area of Bilaspur, Chhattisgarh, India. In this forested site, Compartment 22, Compartment 26, Compartment 31, and Compartment 32 were considered for the. The vegetation inventory was conducted from October 2019 to February 2021. A total of 24 quadrats 31.62 m 31.62m (0.1ha size) were randomly established cover entire forest area and tree species density, frequency and diversity were enumerated. We identified a total 1861 individual tree based on dbh >10 cm counting which belongs to 49 species and 24 family. The Fabaceae family had the most occurring species (7 species), followed by Anacardiaceae (4 species) and Rubiaceae (4 species). The number of tree species encountered vary from 107 to 158 populations, stem density from 340 to 1240 stem ha⁻¹, and basal area from 0.0017m² to 19.91m² in the study. The diversity index of Shannon-Wiener, Margalef, and Simpson index were 3.892, 6.45, and 0.886 respectively. Tree species belonging to Dipterocarpus had the greatest Importance Value Index (61.93), followed by Phyllanthaceae (36.21) and Lamiaceae (36.20). The plant population in this forest growing in their natural setting found to be highly diverse and stable based on patterns in diversity indexes. The study sites were found densely vegetated with high level of species community structure, however intensive level of cattle ranching and human pressure for NTPF collections exposed some of the valuable species to poor abundance and degrading populations.

Keywords: Species diversity, IVI assessment, Tree species composition, FVI

Journal of Economic Literature (JEL) Classification Number: Q23

Mathematics Subject Classification: 62P12, 62G07

1. INTRODUCTION

In light of the effects of climate change on the dynamics of forest communities, it is crucial to identify the different types of forest communities in order to prioritise options and targets for species and

community conservation (Latt and Park, 2022). Chhattisgarh state of central India has unique forest diversity and tree species consists of 55717 km² (very dense forest 7068 km², moderate dense forest 32279 km², open forest 16370 km²) which is 41.21 % of its geographical area and it is 7.80 % of the total forest cover of India. This forest comprises has been categorised as tropical dry deciduous and tropical moist deciduous forest types with higher level of floral and faunal structure. When compared to other forests, tropical dry forests are more diversified, with a high diversity of species and life forms (Sundarapandian, 2014, Tamilselvan, 2021), and has potential supporting greater livelihood and climate change mitigation (Chandra et al., 2021). These forests vary with a variety of their structure, composition, and functioning influenced by climatic circumstances such as sporadic wet and dry periods, and alter with latitude, longitude, and altitude, and rainfall volume. Species richness and plant distribution are influenced by how biotic and abiotic factors, such as soil characteristics and site index, interact (Hawkins et al., 2003; Rahman et al., 2020). Owing to the diverse and dynamic forest community and vegetational structure of the forest, the fundamental research relation to community ecology, soil change, forest fire incidence (Chandra and Bhardwaj, 2015), distribution patterns and compositions require a floristic assessment for understanding future forest in current scenario of climate change and higher anthropocene (Yam, 2016, Chetan and Nagaraja, 2020, Chandra et al., 2021).

Numerous techniques have been evolved for studying the forest species dynamics and tree species composition structure (Dibaba et al., 2021). Quantitative floristic sampling also provides context for long-term ecology study planning and interpretation (Singh, 2016). Floristic inventory, for example, can assist in determining how to stratify sample effort for monitoring forest processes, as well as interpreting the ecosystem relevance of results from individual species-level experimental manipulations. On a larger scale, inventories are important for protected-area and development planning, which necessitates geographically referenced, repeatable, and comparable samples to inform decisions on where to focus conservation resources or development activities. Large areas of tropical flora, on the other hand, are chronically understudied (Prance et al. 2000, Nur et al., 2016, Chandra et al., 2021). Because of their richness in plant species composition and fauna variety, tropical forests are the main source of livelihood (Zakaria, 2016). They are dominated by a diverse range of broad-leaved trees, which produce very dense cover and contributes to one of the most complex ecosystems (Lawal, 2013). Tropical forests are important ecosystems that provide raw materials, ecosystems reservoirs, and ecosystems for a wide range of species of animals, soil conservation, timber sources, medicinal plants, carbon sequestration, as well as watershed protection, and also providing a source of income for many different human settlements, including 60 million indigenous people (FAO, 2021).

The greatest threat to tropical forests shows increasing human populations, which causes multiple changes in land use, land cover, and fire regimes (Cauwer, 2016). Understanding the composition of vegetation, species variety, and the structure of a forest is viewed as critical in assessing forest sustainability, species conservation, ecological relevance, and the formulation of forest ecosystem management policy (Kanagaraj, 2017). These forests are disappearing at alarming rates results of deforestation for the extraction of lumber and other forest products, particularly in forest overexploitation operations such as fuel wood collecting, habitat damage, and grazing (Padal et al., 2009; Premavani et al., 2014; Naidu and Kumar, 2016; Chandra et al., 2021, Latt and Park, 2022).

The development of climate change adaptation methods, effective forest management, and land use planning decisions is hampered by a lack of information. Because fire scars, shrub, and grass cover all have a lot of intra- and inter-annual variation, broad forests are affected by them (Cauwer 2015). Map distributional patterns and look for concentrations of diversity and endemism to protect plant

biodiversity. Furthermore, forest necessitates an awareness of a forest's composition in connection to other forests, the implications of previous influences on current condition, and the forest's current relationship with neighbouring land uses (Devi, 2006, Feroz, 2017). The roles and quality of forests used to provide habitat for wild animals have been declining, either in terms of number, type, or importance to humans and wildlife (Brandt, 2017).

Assisted natural regeneration (ANR) is most effective tool for proper management of forest area so that it may sustain the biodiversity as well as local people residing in or near the forest area (Chandra et al., 2001). ANR is a low-cost forest restoration methodology that may quickly regenerate deforested areas into more productive forests while also providing ecosystem services that humans and plant require, such as clean water and nutritious soil. Local people use their land knowledge and family practices that will help forests and natural plant life regenerate organically by removing barriers and dangers to their growth. These sustainably regenerating forests protect biodiversity, provide a diverse range of ecosystem goods and services, and benefit rural economies and livelihoods (Chazdon, 2020). After the termination of prior land use, regeneration can occur naturally without human interference, or the recovery process can be aided in a variety of ways to overcome existing limits (hereafter termed assisted natural regeneration). Assisting natural regeneration may not be enough to overcome restrictions, thus active restoration including site preparation and tree planting is required (Holl et. al. 2011, Holl et al 2018). Now a day, it is also integrated with working plan for proper management of forest through JFM as a tool. Natural regenerating forests on former agricultural land can help with biodiversity conservation, climatic condition mitigation and adaptation strategies, and many ecosystem goods and services (Houghton et al 2015, Locatelli et al 2015, Ahmad, 2015)

The current study aims to conduct a large-scale quantitative inventory on tree structure and biodiversity richness in Bilaspur tropical reserve forest. This research provides baseline data on tree species richness, population structure, and distribution patterns, which can be used to build conservation strategies to safeguard diminishing resources. Foresters can increase its ecosystem's goods and services by maintaining or protecting a desirable structure of the forest at the stands and overall area when they have very complete understanding on forest composition and structure (Bhutia, 2019). The study was conducted with aim to enumerate the species composition and diversity of forest trees in ANR forest of Bilaspur, Chhattisgarh, India so as to suggest strategies for reducing forest degradation and future forest.

2. MATERIAL AND METHODS

2.1 Study site

Reconnaissance survey was made to the study area in order to get general information about physiognomy of the vegetation, surrounding people, and accessibility to the forests and select sampling methods. Information about the study area was collected from Khondra Forest, Bilaspur Division (lies between 22°16'50.52" north latitude and 82°21'44.29" east longitudes). The Khondra Forest comprises the Reserved Forests of four village namely Khondra, Korbi, Kanai and Banka of Khondra Forest circle. The Forest comprises a total area of 6308.067 ha.

2.2 Vegetation sampling

Random Sample method was used for the inventory of the tree species. The whole forest was divided into four areas namely compartment 26, compartment 31, compartment 32 and compartment 22. Sample plots of 31.62m × 31.62m in size were taken from the four sites randomly to cover a total sample area of 0.1 ha in order to assess the tree species diversity. In each plot, all the tree species were identified by their local and/or scientific names and enumerate their numbers, measure total height and diameter of the trees having diameter at breast height of ≥10 cm.

2.3 Data Analysis

Foresters typically inventory a forest by selecting locations in the forest and sample a particular location around certain points, instead of estimating all the trees. Quadrat is just the name given to this location. Tree species composition and diversity of the tree species was determined using the Shannon-Wiener's diversity index (Shannon and Wiener, 1949), Simpson's diversity index, Margalef's diversity index (Uddin, 2020), species evenness. The relative density, relative frequency, relative basal area and Importance Value Index (IVI) were calculated for each tree species using the following formula. The Importance Value Index of a species in a specific forest area is a measure of its dominance. There will be three types of data collected: relative frequency, relative density, and relative basal area. Each of these numbers is a percentage that ranges from 0 to 100. The summation of these three parameters is the Importance Value index, which can range from 0 to 300. Family Important Value Index (FIVI) was also calculated to measure the family dominance in the study area.

Species diversity index

$$S_{Di} = \frac{S}{N}$$

Shannon-Wiener's diversity index,

$$H = \sum_{i=1}^n p_i \ln p_i$$

Simpson's diversity index,

$$D = \sum_{i=1}^n p_i^2$$

Margalef's index,

$$R = \frac{(S - 1)}{\ln(N)} z$$

Species evenness index,

$$E = \frac{H}{\ln(S)}$$

Here:

S = Total number of species,

N = Total number of individuals of all the species,

H = Shannon-Wiener's diversity index

Pi = Number of individuals of one species/Total number of individuals in the samples

IVI = Relative density + Relative frequency + Relative basal area

3. RESULTS

3.1 Tree species composition

Forest having different composition of tree species was observed in the study site. They show different phytosociological attributes such as diversity, density, frequency, basal area and IVI etc. A total of 1861 individual tree stems of 49 tree species belonging to 20 families were identified from the studied sites of the reserve forest of ANR forest. Stem density ranges from 340 to 1240 stem ha^{-1} , and basal area from 0.0017m^2 to 19.91m^2 in the study. Trees having highest density in the study area were *Cleistanthus collinus*, *Tectona grandis* and *Pterocarpus marsupium* while the most frequent tree species identified were *Cleistanthus collinus*, *Lagerstroemia parviflora*, *Lannea coromandelica* and *Cassia fistula* (Table 1). The dominated tree species based on relative basal area were *Shorea robusta* followed *Cleistanthus collinus*, *Tectona grandis*. *Shorea robusta* showed the lower density and frequency but rendered the highest basal area. This are the indicative of mature tree species having climax stage but poor number of age gradation population and regeneration. Similarly *Cleistanthus collinus* were the most dense and frequent occurring species occupying the massive area but has lesser basal area due to preponderance of larger population covering small and medium size stems. The least encountered trees were *Aegle marmelos*, *Chloroxylon swietenia*, *Schleichera oleosa*, *Madhuca longifolia*, *Gmelina arborea*, etc.

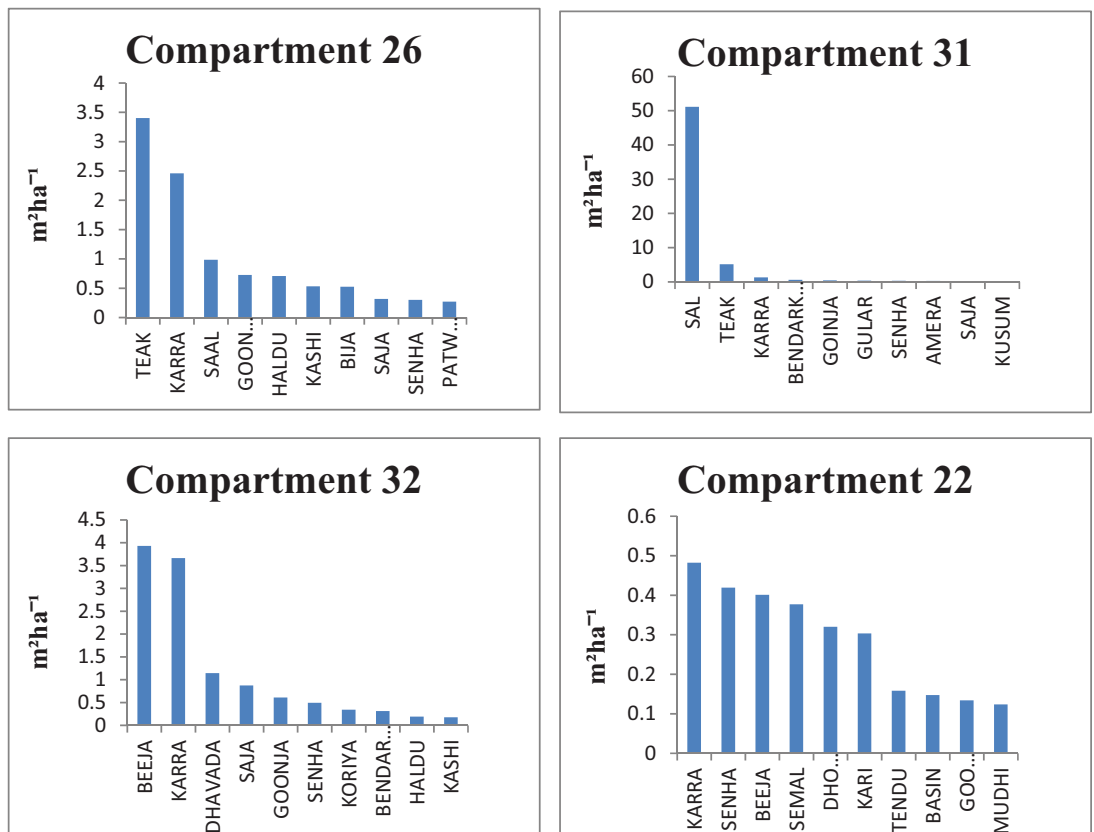


Figure 1. Basal Area of all sites

3.2 Importance Value Index (IVI)

The species such as *Shorea robusta*, *Cleistanthus collinus*, *Tectona grandis*, *Pterocarpus marsupium*, *Lannea coromandelica*, *Lagerstroemia parviflora*, *Holarrhena pubescens*, *Anogeissus latifolia*, *Terminalia tomentosa*, *Adina cordifolia* were dominated in ANR protected forests due to higher score of IVI. The *Shorea robusta* contributed 61.93% IVI followed *Cleistanthus collinus* (36.31%), *Tectona grandis* (32.76%). The Basal area, density, frequency, relative density, relative frequency, relative basal area, and Importance Value Index (IVI) of the recorded tree species are shown in table 1 and figure 1. Among the 49 tree species, 5 dominant tree species represents the 34.93% of the stand density (650 individuals out of total 1861 stems/populations). Similarly, 81.18% of the basal area, 55.32% of the relative density, 11.21% of the relative frequency and 52.51% of the IVI were occupied by the 5 dominant tree species. Top 03 tree species whose IVI ranged 32.76 -61.93% were scored highest IVI were *Shorea robusta*, *Cleistanthus collinus* and *Tectona grandis*, while 6 tree species exhibited IVI from 8.23 – 16.61 and the ivi of 40 tree species were below 6.41%. The IVI is a cumulative value of relative density, frequency and basal area that indicates the status of forest species composition and structure in site specific forest. This value also guide forest managers regarding the adaptation of silvicultural and management practices so as to maintain diversity on sustainable manners keeping in mind about the species richness and IVI patterns.

In this forest, numerous tree species contains valuable produces including fruit, flower, leave and medicinal properties, resulted to a heavy exploitation by local communities without considering their future prospects. Over utilization of forest species and various land uses and increased human settlement around forests altering the tree species composition, density and community pattern. Heavy and free grazing of cattle's damaging the new recruits and collection of important species seeds, barks and other plant materials not only causing heavy loss in existing tree species population but also influencing growth, development and regeneration. ANR (Assisted Natural Regeneration) program was initiated in this forest to improve the regeneration of *Shorea robusta* and other forest species. Necessary protections were provided to the forests and other measures were also undertaken such as moisture conservation work, prohibition of trespass to local communities, however, the results showed that were not enough et al. This resulted into uneven distribution of forest species and appearance of open space, clustering of individual species rather than mixed occupancy and barren patches.

Some domestic tree species e. g. *Madhuca longifolia*, *Moringa oleifera*, *Cleistanthus collinus*, *Mangifera indica* etc. were found to grow in the vicinity of the forests. *Tectona grandis*, *Terminalia bellirica* were also recorded from the plantation activities of the Forest Department through ANR programme to maintain the gap between tree to tree which is increased by extraction from forest.

Table 1. List of tree species with their botanical name and Importance Value Index

S. No	Species	Botanical name	RD	RF	RBA	IVI
1	Sal	<i>Shorea robusta</i>	2.64	1.72	57.57	61.93
2	Karra	<i>Cleistanthus collinus</i>	24.01	3.45	8.75	36.21
3	Teak	<i>Tectona grandis</i>	20.72	2.59	9.46	32.76
4	Bija	<i>Pterocarpus marsupium</i>	7.95	3.45	5.41	16.81
5	Goonja	<i>Lannea coromandelica</i>	4.24	3.45	2.11	9.80
6	Senha	<i>Lagerstroemia parviflora</i>	4.44	3.45	1.70	9.59

7	Koriya	<i>Holarrhena pubescens</i>	5.20	3.45	0.73	9.38
8	Dhawda	<i>Anogeissus latifolia</i>	4.04	3.45	1.71	9.19
9	Saja	<i>Terminalia tomentosa</i>	3.10	3.45	1.68	8.23
10	Haldu	<i>Adina cordifolia</i>	2.44	2.59	1.09	6.12
11	Bendarkushi	*	1.85	2.59	1.24	5.68
12	Semel	<i>Bombax ceiba</i>	1.20	3.45	0.73	5.38
13	Kashi	<i>Bridelia retusa</i>	1.60	2.59	0.92	5.11
14	Patwan	<i>Diospyros montana</i>	1.91	2.59	0.51	5.01
15	Tendu	<i>Diospyros melanoxylon</i>	1.12	3.45	0.42	4.99
16	Khair	<i>Acacia catechu</i>	0.79	3.45	0.47	4.71
17	Kaari	<i>Milusa tomentosa</i>	1.31	2.59	0.37	4.26
18	Kusum	<i>Schleichera oleosa</i>	0.49	3.45	0.26	4.20
19	Amaltash	<i>Cassia fistula</i>	0.49	3.45	0.17	4.11
20	Kachnar	<i>Bauhinia variegata</i>	1.04	2.59	0.45	4.07
21	Dhobin	<i>Dalbergia paniculata</i>	0.85	2.59	0.61	4.05
22	Chirhut	*	1.02	2.59	0.15	3.76
23	Mudhi	<i>Mitragyna parvifolia</i>	0.77	2.59	0.26	3.62
24	Maatch	<i>Hymenodictyon orixense</i>	0.50	2.59	0.29	3.38
25	Chaar	<i>Buchanania cochinchinensis</i>	0.39	2.59	0.11	3.08
26	Gular	<i>Ficus racemosa</i>	0.69	1.72	0.40	2.82
27	Amera	<i>Spondias pinnata</i>	0.57	1.72	0.33	2.63
28	Basin	*	0.30	1.72	0.25	2.28
29	Mahua	<i>Madhuca longifolia</i>	0.17	1.72	0.06	1.95
30	Baheda	<i>Terminalia bellirica</i>	0.15	1.72	0.06	1.93
31	Ghata	*	0.14	1.72	0.04	1.91
32	Akol	<i>Alangium salviifolium</i>	0.61	0.86	0.10	1.58
33	Katjamni	<i>Syzygium salicifolium</i>	0.48	0.86	0.22	1.56
34	Khishali	*	0.48	0.86	0.13	1.48
35	Saliha	*	0.31	0.86	0.29	1.46
36	Ghmhar	<i>Gmelina arborea</i>	0.31	0.86	0.26	1.43
37	Beal	<i>Aegle marmelos</i>	0.31	0.86	0.14	1.31
38	Bhelwa	<i>Semecarpus anacardium</i>	0.33	0.86	0.10	1.29
39	Bhirha	<i>Chloroxylon swietenia</i>	0.24	0.86	0.11	1.22
40	Ghotar	*	0.18	0.86	0.09	1.13
41	Rohina	<i>Syomida febrifuga</i>	0.13	0.86	0.09	1.08
42	Shisham	<i>Dalbergia latifolia</i>	0.12	0.86	0.04	1.02
43	Kapsauwa	<i>Mallotus nudiflorus</i>	0.10	0.86	0.02	0.98
44	Tewar	*	0.07	0.86	0.03	0.96
45	Dhamin	<i>Grewia tiliifolia</i>	0.05	0.86	0.01	0.92
46	Neem	<i>Azadirachta indica</i>	0.04	0.86	0.01	0.91
47	Doodh Koriya	*	0.04	0.86	0.01	0.91
48	Paprel	*	0.04	0.86	0.00	0.91
49	Ladoo	*	0.04	0.86	0.00	0.90

RD = relative density, RF = relative frequency, RBA = relative basal area, IVI = importance value index,
* unidentified species

3.3 FIVI

The five most dominant families in all four sites were Phyllanthaceae, Lamiaceae, Combretaceae, Apocynaceae and Ebenaceae (Table 2). Overall, Phyllanthaceae was the important family with Family Important Value Index (FIVI) of 52.24. Phyllanthaceae individuals were of large stature. The total basal area of 21.52 % of the entire basal area of this forest. The 09 most important families constituted 76.16% of the total FIVI were Lamiaceae, Apocynaceae, Combretaceae, Ebenaceae, Lythraceae, Leguminosae, Anacardiaceae, Rubiaceae and Annonaceae respectively (Table 2).

Table 2. Family value Index of study site

S.No	Family	RD	RF	RBA	FVI
1	Alangiaceae	1.44	1.43	4.97	7.85
2	Anacardiaceae	4.65	5.71	4.00	14.36
3	Annonaceae	2.01	4.29	2.31	8.60
4	Apocynaceae	14.57	5.71	12.55	32.83
5	Bombacaceae	0.69	5.71	0.59	7.00
6	Caesalpiniaceae	1.38	5.71	1.19	8.29
7	Combretaceae	6.41	5.71	5.52	17.64
8	Dipterocarpaceae	1.70	2.86	2.92	7.47
9	Ebenaceae	5.46	5.71	4.70	15.88
10	Euphorbiaceae	1.38	4.29	1.59	7.25
11	Lamiaceae	17.21	4.29	19.75	41.25
12	Leguminosae	5.28	5.71	4.54	15.53
13	Lythraceae	5.40	5.71	4.65	15.77
14	Malvaceae	0.06	1.43	0.22	1.71
15	Meliaceae	0.13	2.86	0.22	3.20
16	Mimosoideae	0.57	5.71	0.49	6.77
17	Moraceae	0.50	2.86	0.87	4.22
18	Myrtaceae	0.38	1.43	1.30	3.10
19	Phyllanthaceae	25.00	5.71	21.52	52.24
20	Rubiaceae	4.65	5.71	4.00	14.36
21	Rutaceae	0.25	1.43	0.87	2.55
22	Sapindaceae	0.57	5.71	0.49	6.77
23	Sapotaceae	0.19	2.86	0.32	3.37
24	Verbenaceae	0.13	1.43	0.43	1.99

RD = relative density, RF = relative frequency, RBA = relative basal area, FVI = Family value index

3.4 Species Diversity indices

A diversity index is a numerical indicator of overall number of different types (such as species) in a dataset (a community), and also the evolutionary relationships among the individuals spread throughout, such as richness, divergence, and evenness. The Shannon-Wiener's index in the area was 2.73 with Shannon's maximum diversity index of 3.892. The amount of various species present in an ecological community, landscape, or area is known as species richness. The species evenness index was 0.702. Margalef's diversity index was 6.449. The Simpson's diversity index was 0.886 (Table 3). The values of Shannon-Wiener's and Margalef's diversity index indicate proficient presence of plant species in the area. Lower value of Simpson's index also stands for diverse tree species. (Table 3). Overall, the studied site showed higher Shannon – Wiener's index and maximum diversity index due to occurrence of higher number of forest trees dominated with trees such as *Shorea robusta*, *Cleistanthus collinus* and *Tectona grandis* and families Phyllanthaceae, Apocynaceae and Lamiaceae.

Table 3. Tree diversity indices

Parameters	Total evaluation of Khondra forest
Shannon-Wiener's index	2.73
Shannon's maximum diversity index	3.892
Shannon's species evenness index	0.702
Margalef's diversity index	6.449
Simpson's diversity index	0.886

4. DISCUSSIONS AND CONCLUSION

Globally, the structure and operations of forest ecosystems have been changed by climate change. The enormous increase in global temperature may change a variety of environmental factors, which could change the local species composition and the structure of the forest communities (Latt and Park, 2022). We conducted floristic enumeration to determine IVI and diversity of the ANR forest of Bilaspur, Chhattisgarh, India, so as to find out the pattern of species composition, structure and species diversity and their relation to biotic factor and regeneration status. The diverse number of species belonging 49 species and 20 families co-existing in ANR forests. The forest is dominated by *Shorea robusta*, *Tectona grandis* and its associates such as *Cleistanthus collinus*, *Terminalia tomentosa*, *Madhuca latifolia*, *Pterocarpus marsupium*, etc. The variation in IVI and other attributes of the species and families in the forest was propounded due to changes in resource availability, plant life-history features, and a plant's ability to adapt to its environment, the pattern of tree species composition and the forest community may alter between plant groups and between geographic locations (Cornwell and Grubb, 2003; Nepali et al 2021). The IVI indicates the structural importance or ecological significance of species in a given ecosystem (Abunie, 2018). The species such as *Cleistanthus collinus* occurring in pure clusters through profuse regeneration now covering a larger areas of *S. robusta* dominated dry deciduous and mixed forest areas of Bilaspur, Chhattisgarh. Mohan and Harikrishna (2019) identified poisonous compound in *C. collinus* might help in colonization of the species at new sites due to allelopathic effects and suppression of neighbouring species. In the present study, *Shorea robusta* showed the highest IVI solely due to higher basal area, while the density and frequency were lower as compared to other high IVI scored tree species such as *C. collinus* and *T. grandis*. It is indicative of high number of mature stems and uneven distribution of all age gradation stems. *S. robusta* dominates in central region of the country forest and are in climax state, however facing problems such as poor seed regeneration due to recalcitrant seed, requirement of mycorrhizae for establishment (Tapwal et al., 2015) and collection of seed by local communities for oil extraction (Pradhan et al., 2015). This resulted to a poor plant population of middle and small age in tropical dry deciduous forest of Chhattisgarh region. Some important species such as *Pterocarpus marsupium*, *Soymida febrifuga*, *Madhuca latifolia*, *Terminalia bellirica*, etc. were unscientifically extracted by local communities for their higher demand as Non-Timber forest Products resulted into low IVI in the study sites. In this forest selection cum improvement felling system is done to facilitate high quality timber and promote important tree species, that also impact diversity of the area results uneven distribution of tree species. The topographic and edaphic differences in the communities, which have an impact on how different tree species disperse, could be attributed to this variance (Dibaba et al., 2021).

A similar study was conducted in Chhattisgarh and Madhya Pradesh shows that stem density ranged from 136 ha⁻¹ to 594 ha⁻¹, while total basal cover was ranged from 19.58 m² ha⁻¹ to 29.03 m² ha⁻¹ (Chaubey et al. 2015). However, stem density and basal area of Khondra forest ranged from 340 to 1240 m² ha⁻¹, and 0.0017m² ha⁻¹ to 19.91m² ha⁻¹ respectively. The higher stem density but lower basal

area indicates that the exploitable diameter trees and important tree species are being felled regularly results lower basal area due to less number of mature trees in that area except *S. robusta*. This result shows that the stem density was higher in study area as compare to other Southern Moist Mixed Deciduous forest type. Species composition, density, and diversity index can be considered important factors to judge the status of a forest (Nur et al, 2015) while the IVI provides a comprehensive view of specie's floristic nature in the community. The IVI helps to identify dominant forest species, especially tree composition density, basal area, and height class distribution (Manohar, 2015). Study area consist *Shorea robusta*, *Tectona grandis* and *Pterocarpus marsupium* as a most economically important timber species which has also higher IVI as compared to others. The species such as *Mallotus nudiflorus*, *Cleistanthus collinus*, *Azadirachta* and *Gmelina arborea*, among others being used by the locals over years to produce fuel wood and small timber as also observed by other scientist (Dash, 2020). Aside from the observations mentioned above, multiple cutting stumps were noticed, showing that impact of anthropogenic activity on this species is much greater as compare to timber species. A comprehensive study of regeneration status of different ANR forest dominated by *S. robusta*, *T. grandis* and mixed forest of Madhya Pradesh in relation to species composition, abundance, diversity and soil characteristics was conducted (Chandra et al., 1998, Chandra et al., 2001). They also indicated the importance of forest protection from biotic interferences and measures for soil conservation for maintain biological diversity and improve regeneration of forest species.

The area requires management intervention in order for plant species to regenerate quickly. The phytosociological analysis reveals that habitat does have great potential, and tree species with low IVI, tree saplings, and seedlings deserve special attention to ensure strict adherence to the rules and better monitoring in order to improve the ecosystem stability of this protected area (Sathish, 2013). For manage this sanctuary's forestry management issues, researchers will have to collect and analyse brief ecologically data through research baseline studies which include all structural parameters that determine the ecosystem's current level of ecological health.

The study area is higher value of FIVI of *Dipterocarpaceae* family (63.4) hence the site consist more of timber yielding species. Most of the forest scientists and managers around the world are looking to *dipterocarp* forests as models for long-term forest management in the moist tropical and to secure a constant supply of industrial wood in the future. Plans to plant *dipterocarps* are frequently reported throughout Southeast Asia, and significant reforestation initiatives are frequently predicated on the planting of species from this family (Appanah S. and Turnbull J.M. 1998). According to the preceding statement, the study location is abundant in the same family of trees. This finding indicates that forest management will be considerably easier in the future.

Shannon-Wiener diversity index and Simpson's evenness index are the widely used to study ecological diversity, because it takes into account both species richness and evenness in the forest community (Onyekwelu JC, 2005). The higher the value, the greater the species richness (IIRS, 2002). The Shannon index of khondra forest is much lower than Dudhpukuria - Dhopachori Wildlife Sanctuary (4.45) (Hossain et al. 2014), Kanagaraj (2017) found Achamalai Reserve Forest in the Eastern Ghats of Tamil Nadu State have Shannon-Weiner index 3.916 is also high from Khondra forest, Suspense Averti Ifo 2016 shows that value of Shannon index was obtained 4.46. Results obtained revealed high biodiversity of trees of the forest of Bilaspur. According to the study, the majority of those who reside close to forests are impoverished and rely on the forest for their livelihood. It has been noted that there is a significant supply and demand imbalance for fuel wood and other related timber in this region, which eventually puts more pressure on theft and illegal logging of forest trees.

Assessment of diversity and composition of tree species is important for their sustainable utilization, management, and conservation and to understand the forest status looking future forest in context climate change mitigation strategies. In this study, species specific IVI identifies the most ecologically significant species in Bilaspur Reserve Forests, as well as those that should be targeted for conservation efforts. Timber producing species were important components of the forest ecosystem and have an impact on the total species diversity of forest communities, however, their low frequency and density are the serious concern for future prospects. Similarly highly important NTFP species are now vulnerable due to high degree of overexploitation. The study revealed that Khondra forest Bilaspur is under threat of over-extraction and illegal cutting which in the future may reduce both tree density and diversity drastically. For the conservation of tree species and diversity of the forest, a comprehensive approach to forestry management that includes protective measures are immediately needed, besides management for soil moisture conservation and cattle ranching, improvement in regeneration. Large-scale regeneration programmes can be implemented to reduce these issues and maintain the complexity, species diversity, normal composition, and natural ecosystem of the Khondra forest. Artificial planting in available gaps can also be proposed that conservation efforts be enhanced by ecological restoration to sustain diversity. Common residents' livelihood need could be met by supplementing fuel wood and livestock fodder from regions outside these forests. As a result, for its protection and long-term use, an effective management strategy is intended. However, there is a lack of relevant knowledge and information regarding the sustainable management of the study area's available and potential resources. Therefore, a comprehensive database on these forest resources is required for the protection of forests and the preservation of biodiversity.

5. REFERENCES

- Abdulrasyid Tolangara, Ahmad H., Liline S., 2019, The Composition and Important Value Index of Trees for Wildlife Feed in Bacan Island, South Halmahera, IOP Conf. Series: Earth and Environmental Science 276, 1-6.
- Abunie, A.A., Dalle, G., 2018. Woody species diversity, structure and regeneration status of yemrehane kristos church forest of Lasta Woreda, north Wollo zone, Amhara region, Ethiopia. *Int. J. Financ.* Volume 2018, Article ID 5302523, 8 pages
- Ahmad A., 2015, Conservation of Isand Biodiversity in Brunei Darussalam: the Role of Ecotourism in Environmental Education, *International Journal of Ecology and Development* 30(1).
- Appanah S. and Turnbull J.M., 1998, Dipterocarps: A Review of Taxonomy, ecology and silviculture, Center for International Forestry Research.
- Ashis K. Dash, Upadhyay V.P., Patra H.K., 2020, Floristic assessment of semi evergreen forests of a peripheral site in Hadagarh Sanctuary, Odisha, India, 12(2), 104-112.
- Averti S., Marie Moutsambote J., Koubouana F., Yoka J., Ndzaï S. F., Bouetou-Kadilamio L.N.O., Mampouya H., Jourdain C., Bocko Y., Mantota A.B., Mackline Mbemba, Sokath D.M., Odende R., Mondzali L.R., Wenina Y.E.M., Ouissika B.C., and Joel L.J., 2016, Tree Species Diversity, Richness, and Similarity in Intact and Degraded Forest in the Tropical Rainforest of the Congo Basin: Case of the Forest of Likouala in the Republic of Congo, *International Journal of Forestry Research*, Volume 2016, Article ID 7593681, 12 pages

- Brandt J.S., Allendorf T., Radeloff V. and Brooks J., 2017, Effects of national forest management regimes on unprotected forests of the Himalaya Conservation Biology 31(12), 71–82
- Cauwer D., 2015, Towards estimation of growing stock for the timber tree *Pterocarpus angolensis* in Namibia. Bridging the gap between forest information needs and forest inventory capacity. University of Goettingen, Pietermaritzburg
- Chandra K.K., Sharma M.C. and Tiwari K.P., 1998, Regeneration status in different ANR areas situated in various forest ecosystems. Journal of Tropical Forestry. 14(4), 262-264.
- Chandra K.K., Wadhwa S.L. and Pandey A., 2001, An evaluation of the effect of ANR programmes on regeneration and soil nutrient status of Teak, Sal and mixed forest area of Madhya Pradesh. My Forest. 37(1), 399-416.
- Chandra K.K., Bhardwaj A.K., Singh A, Rajesh Kumar, 2021, Impact of drought on tropical forests and plant mechanisms to mitigate drought stress. Tropical Dry Forests: Emerging Features and Ecological Perspectives. (Eds. Chaturvedi RK, Singh R., Bhadouria R.) Nova Science Publisher, New York, USA. ISBN. 978-1-53619-543-9 (ebook) pg. 367-383.
- Chandra, K.K., Bhardwaj A.K., 2015, Incidence of Forest Fire in India and Its Effect on Terrestrial Ecosystem Dynamics, Nutrient and Microbial. International Journal of Agriculture and Forestry, 5(2): 69-78.
- Chaubey O.P., Sharma A., Krishnamurthy G., 2015, Plant Diversity, Edaphic Status and Population Structure in Different Forest Types of Madhya Pradesh and Chhattisgarh States in India. International Journal of Bio-Science and Bio-Technology, 7(2).
- Chazdon R. L., Lindenmayer D., Guariguata M.R., Crouzeilles R., Benayas J.M.R., Chaverro E.L., 2020, Fostering natural forest regeneration on former agricultural land through economic and policy interventions, Environ. Res. Lett. 15, 099501.
- Chetan H. C., Nagaraja B. C., 2020, Vegetation dynamics and its dispersal syndrome across size class of tropical montane (Shola) forest, Kundremukh, Western Ghats, India. International Journal of Ecology and Development Vol.35(1)
- Cornwell, W.K., Grubb P.J., 2003, Regional and local patterns in plant species richness with respect to resource availability. Oikos, 100, 417–428.
- Dibaba A., Soromessa T., Warkineh B., 2021, Plant community analysis along environmental gradients in moist afro-montane forest of Gerba Dima, south-western Ethiopia. BMC Ecol. Evol., 22, 1–17.
- FAO. Forest Resources Assessment Working Paper 177, Assessing forest degradation towards the development of globally applicable guidelines. Rome, Italy. 2011;109.
- Fayiah M., Singh S., Mengesha Z., Chen B., 2018, Regeneration status and species diversity of a mix dry deciduous forest: a case of Barah forest, Jabalpur, Madhya Pradesh, India. Indian J Trop Biodiv 26(1), 17-29.
- Fayiah M., Singh S., Mengesha Z., Chen B., 2018, Regeneration status and species diversity of a mix dry deciduous forest: a case of barah forest, jabalpur, madhya pradesh, india, indian journal of Tropical Biodiversity.
- Feroz S. M., Enamul Kabir M. and Hagihara A., 2015, Species composition, diversity and stratification in subtropical evergreen broadleaf forests along a latitudinal thermal gradient in the Ryukyu Archipelago, Japan Global Ecology and Conservation 4, 63–72.
- Gandhi D., Sundarapandian S., 2014, Inventory of trees in tropical dry deciduous forests of Tiruvannamalai district, Tamil Nadu, India. Biodiversitas Journal of Biological Diversity, 15(2).
- Hawkins, B.A.; Field, R.; Cornell, H.V.; Currie, D.J.; Guégan, J.-F.; Kaufman, D.M.; Kerr, J.T.; Mittelbach, G.G.; Oberdorff, T.; O'Brien, E.M.; et al. Energy, water, and broad-scale geographic patterns of species richness. Ecology 2003, 84, 3105–3117.

- Hawthorne W.D., Marshall C.A., Juam M.A., Agyeman V.K., 2011, The impact of logging damage on tropical rainforest, their recovery and regeneration. *An Annotated Bibliography*, 47-121.
- Holl K.D., Aide T.M., 2011, When and where to actively restore ecosystems? *Forest Ecol. Manage.* 261, 1558–63.
- Holl K.D., Reid J.L., Oviedo-Brenes F., Kulikowski A.J., Zahawi R.A., 2018, Rules of thumb for predicting tropical forest recovery *Appl. Veg. Sci.* 21 669–77.
- Hossain M.A., Hossain M.K., Salam M.A., Rahman S., 2013, composition and diversity of tree species in dudhpukuria-dhopachori wildlife sanctuary of chittagong (south) forest division, Bangladesh, *research journal of pharmaceutical, biological and chemical sciences* 4(2) 1447
- Hossain M.A., Hossain M.K., Salam A.M., Rahman S., 2014, *Journal of Pharmaceutical, Biological and Chemical Sciences Composition and Diversity of Tree Species in Dudhpukuria-Dhopachori Wildlife Sanctuary of Chittagong (South) Forest Division, Bangladesh* 4(2).
- Houghton R., Byers B., Nassikas A.A., 2015, A role for tropical forests in stabilizing atmospheric CO₂ *Nat. Clim. Change* 5, 1022–3.
- Kanagaraj S., Selvaraj M., Kangabam R.D., Munisamy G., 2017, Assessment of tree species diversity and its distribution pattern in Pachamalai Reserve Forest, Tamil Nadu, *Journal of Sustainable Forestry*, 36(1), 32–46.
- Kanagaraj S., Selvaraj M., Kangabam R.D., Munisamy G., 2017, Assessment of tree species diversity and its distribution pattern in Pachamalai Reserve Forest, Tamil Nadu, *Journal of Sustainable Forestry*, 36(1).
- Kumar R., Darro H.C., Bhardwaj A.K., Chandra K.K., 2021, Forest Fire and its Influence on Environmental conditions: A review. *Bull. Env. Pharmacol. Life Sci.*, Vol 10 (12), 258-267.
- Latt, M.M., Park B.B., 2022, Tree Species Composition and Forest Community Types along Environmental Gradients in Htamanthi Wildlife Sanctuary, Myanmar: Implications for Action Prioritization in Conservation. *Plants*, 11(16), 2180.
- Lawal A, Adekunle V.A., 2013, A silvicultural approach to volume yield, biodiversity and soil fertility restoration of degraded natural forest in South-West Nigeria. *International Journal of Biodiversity Science, Ecosystem Services & Management*, 9(3) 201-14.
- Locatelli B., Catterall C.P., Imbach P., Kumar C., Lasco R., Marín-Spiotta E., Mercer B., Powers J.S., Schwartz N., Uriarte M., 2015, Tropical reforestation and climate change: beyond carbon *Restor. Ecol.* 23, 337–43
- Manohar A., 2015, A Study on the Floristic Compositions of Hudguru Reserve Forest, Kodagu District, Karnataka, India
- Mohan A., HariKrishna J., 2019, *Cleistanthus collinus* Poisoning. *Indian J Crit Care Med* 23(4), 256–259.
- Nepali, B.R., Skartveit, J., Baniya, C.B., 2021, Impacts of slope aspects on altitudinal species richness and species composition of Narapani-Masina Landscape, Arghakhanchi, West Nepal. *J. Asia-Pac. Biodivers*, 14, 415–424.
- Nur A., Nandi R., Jashimuddin M., Hossain M.A., 2016, Tree Species Composition and Regeneration Status of Shitalpur Forest Beat under Chittagong North Forest Division, Bangladesh. *Advances in Ecology*, vol. 2016, 1- 7.
- Olawayin O.T., Akinbowale A.S., Olugbadieye O.G., Adesuyi F.E., 2020, diversity and volume assessment of tree species in the tropical forest at obanla, akure, nigeria, *asian journal of research in agriculture and forestry*, 5(4): 11-19.

- Onyekwelu J.C., Adekunle V.A., Adeduntan S.A., 2005, Does tropical rainforest ecosystem possess the ability to recover from severe degradation. In Sustainable forest management in Nigeria: lessons and prospects. Proceeding of the 30th Annual Conference of Forestry Association of Nigeria, Kaduna, Nigeria. 145-163.
- Pradhan R., Ghos P, Rana SS, Shashi Kumar C. 2015. *Shorea Robusta* (Dipterocarpaceae) Seed and Its Oil as Food. International Journal of Food Sciences and Nutrition 4(4), 228-233.
- Rahman I.U., Afzal A., Iqbal Z., Bussmann, R.W., Alsamadany H., Calixto E.S., Shah G.M., Kausar R., Shah M., Ali N., 2020, Ecological gradients hosting plant communities in Himalayan subalpine pastures: Application of multivariate approaches to identify indicator species. Ecol. Inform., 60, 101162.
- Sathish B.N., Viswanath S., Kushalappa C.G., Jagadish M.R., Ganeshaiah K.N., 2013, Comparative assessment of floristic structure, diversity and regeneration status of tropical rain forests of Western Ghats of Karnataka, India. Journal of Applied & Natural Science, 5, 157–164.
- Singh, D., Varma, S., & Jayakumar, S., 2016, Tree inventory along the altitudinal gradients in Singara Range, Western Ghats, India. Proceedings of the International Academy of Ecology and Environmental Sciences, 6(4), 97–109.
- Supriya Devi L., Yadava P.S., 2006, Floristic diversity assessment and vegetation analysis of tropical semi evergreen forest of Manipur, north east India, Tropical Ecology 47(1), 89-98.
- Tamilselvan B., Sekar T. and Anbarashan M., 2021, Tree Diversity, Stand Structure and Community Composition of Tropical Forest in Eastern Ghats of Tamil Nadu, India, Indian Forester, 147(5), 481-489.
- Tapwal A, Kumar R, Borah D., 2015, Effect of mycorrhizal inoculations on the growth of *Shorea robusta* seedlings. Nusantara Bioscience, 7(1), 1-5.
- Uddin M., Chowdhury F.I., Hossain M.L., 2020, assessment of tree species diversity, composition and structure of medha kachhapi national park, cox's bazar, bangladesh, asian journal of forestry volume 4(1), 15-21.
- Vera De Cauwer, Coert J. Geldenhuys, Raf Aerts, Miya Kabajani and Bart Muys, 2016, Patterns of forest composition and their long term environmental drivers in the tropical dry forest transition zone of southern Africa, De Cauwer et al. Forest Ecosystems, 3(23).
- Yam, G., Tripathi, O.P., 2016, Tree diversity and community characteristics in Talle Wildlife Sanctuary, Arunachal Pradesh, Eastern Himalaya, India. J. Asia-Pac. Biodivers., 9(2), 160–165.
- Yangchenla Bhutia, Ravikanth Gudasalamani, Rengaiyan Ganesan and Somidh Saha, 2019, Assessing Forest Structure and Composition along the Altitudinal Gradient in the State of Sikkim, Eastern Himalayas, India, Forests, 10, 633.
- Zakaria M, Rajpar MN, Ozdemir I, Rosli Z., 2016, Fauna diversity in tropical rainforest: threats from land-use change. Tropical Forests-The Challenges of Maintaining Ecosystem Services while Managing the Landscape 11-49.