Distribution and Diversity of Nonwood Forest Product (NWFP) Species in Sal and Teak Landscapes: A Central Indian Perspective

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Research Article

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Abstract

The Mandla district of Madhya Pradesh is a transitional zone between tropical dry deciduous forest and tropical moist deciduous forest. For the quadrats, systematic random sampling and square quadrats 10 m*10 m in size were used in two territorial forest divisions and one wildlife-protected area. Software such as QGIS, MS Excel, and PAST was used for the study. *Tectona grandis* (Teak) and *Shorea robusta* (Sal) are the major tree species in the area of study and are associated with different species depending on climatic and edaphic factors. These forest types support many nonwood forest produce (NWFP) species, which support the livelihood of local communities. Species such as *Madhuca* sp., *Diospyros melanoxylon*, *Buchanania lanzan*, *Boswellia serrata*, and *Embelia basal* are the major NWFP species found here. The Shannon-Weinner diversity (H') index and Simpson (1-D) diversity index for Teak and Sal forests were highly diverse in both types of forests. In this study, we found that *Shorea* sp., one of the major NWFPs, presented the highest density. *Madhuca sp.* is one of the key NWFPs in both types of forests but is present primarily near the agricultural lands surrounding the villages. *Diospyros melanoxylon* was present at a very high frequency in Teak forest rather than in Sal forest. The IVI for both *Maduca* sp. and *Diospyros melanoxylon* was greater in the Teak forest than in the Sal forest, indicating a major socioecological role in both forest types.

Introduction

Nonwood forest products (NWFPs), often referred to as minor forest products (MFPs), encompass a wide range of plants, fungi, and animal-based products harvested from forests for various uses, excluding timber. These resources are vital for meeting essential household needs and providing food, medicinal items, fibers, and cultural products, thereby playing crucial roles in both commercial and sustainable livelihoods, particularly in developing regions (Shepperd et al. 2020; FAO 2018). The Food and Agriculture Organization (FAO) defines NWFPs as biological goods derived from forests, wooded lands, and trees outside forests, excluding wood, and highlights their significance in food security and subsistence (FAO 2007; ICFRE 2011). The importance of NWFPs was emphasized during the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992, where they were recognized as essential for environmentally sound and sustainable development (Singhal 2000). In India, the economic and cultural significance of NWFPs is profound, with approximately 3,000 such products integrated into the economy. In some regions, NWFPs contribute approximately 50% of total earnings from forest-related trade (ICFRE 2000). However, the increasing economic importance of NWFPs has led to intensified harvesting, raising concerns about the sustainability of these resources.

Madhya Pradesh was the first Indian state to nationalize key NWFPs in 1964, including tendu leaves (*Diospyros melanoxylon*), sal seeds (*Shorea robusta*), harra (*Terminalia chebula*), and gum, under the Madhya Pradesh Vanopaj Adhiniyam, 1969, as a measure to regulate and control the exploitation of these valuable forest products (Prasad 1999; Singhal 2000). With 30.72% of its geographical area covered by forests, Madhya Pradesh is home to diverse forest types, including tropical dry deciduous, moist deciduous, subtropical semievergreen, and tropical moist evergreen forests (FSI 2021). These

forests are predominantly classified into Teak, Sal, and miscellaneous forest formations, each supporting a unique set of plant species and playing a critical role in maintaining biodiversity (Roychoudhary et al. 2022; MFP Federation 2011).

A study in central India showed that greater positive skewness of biodiversity abundance in the plantation of teak species than in secondary forests (Saha, 2000). Teak and Sal forests, which are particularly rich in biodiversity, are vital to the ecological health of the region. The change in climate in central India will increase Teak forest and decrease Sal forest in future and temperature for Teak and precipitation for Sal was mainly influenced by climate variables (Patasaraiya et al, 2023). Sal forests, in particular, are known for their species richness and role in climax-level succession, which is influenced by favorable climatic conditions (Kumar & Saikia 2018). The natural Sal forest also have high diversity while agroforestry has proven that Sal forests beneficial for biodiversity (Shafiqe et al, 2024) while a greater threat of Sal dominating forest is illegal cutting, encroachment, illegal wildlife trading, and urbanization (Shrivastava et al, 2023). Studies conducted in other regions, such as the tropical moist deciduous Sal forests of Assam, have also highlighted the high species diversity within these ecosystems (Dutta & Devi 2013). Additionally, Sal dominant forests contribute significantly to the natural regeneration of rare species, aiding in the conservation of associated forest vegetation (Pandey & Shukla 2003).

Objective of the study

The assessment of diversity in Sal and teak-dominated forest realms is crucial for conserving forest ecosystems and the biodiversity associated with these species-dominated forests. In central India, Sal and teak forests cover extensive areas and are vital for the conservation and sustainable development of local communities dependent on these resources. This study addresses the research question "How NWFP tree species are distributed in major forest types in central India which are dominated by Sal and Teak forests?" To answer this question, the primary objectives of this research are;

1. To understand the diversity of NWFP tree species in major forest types in central India.
2. To assess the distribution of major NWFP tree species in central India.

Materials and methods

Materials and methods

Study area

The Central Indian highlands are climatically defined by two major forest types: 1. Tropical dry deciduous forest and 2. Tropical moist deciduous forest. Madhya Pradesh clearly distinguishes between these two forest types. In the northern and western parts of the state, which are fairly dry with less precipitation, Teak (*Tectona grandis*) is the dominant tree species, whereas the southern and eastern parts are dominated by Sal (*Shorea robusta*). Mandla is one of the tribal dominated districts of Madhya Pradesh,

residing between $22^0$30’ N – $23^0$15’ N and $79^0$45’ E – $80^0$30’ (Srinivas et al. 2019), with a forest cover of 48.79% (FSI,2021) of its total geographical area consisting of both major forest types of Central India. The district, with approximately half of its area under forest cover with both Teak- and Sal-dominated areas, is important for this study.

Sample distribution

The samples were taken from two territorial divisions and one protected area, i.e., 1. East Mandla forest division (EMFD), 2. West Mandla forest division (WMFD) and 3. Kanha tiger reserve (KTR). This district has 17 forest ranges consisting of 74 forest villages and many revenue villages. A total of 237 sampling plots were laid in the district and were separated into two major groups, i.e., Teak (160 sampling plots) and Sal (77 sampling plots) dominated forests. The data were collected via the quadrat method. Square quadrats of 10 m*10 m were used. The targeted areas were designated forests for the forest villages. A systematic random sampling method was used, and quadrats were laid every 500 m.

Parameters taken

For the analysis of the data, PAST software was used. Comparative analysis was performed for the two forest types and key NWFPs. The Shannon—Wiener index of diversity and Simpson’s index of dominance were calculated. To understand the relative importance of species, the importance value index (IVI) was calculated via frequency, density and abundance values.

Results

During this study, 93 species belonging to 35 families were found to be widely present in the Mandla district. A total of 23151 individuals, including trees, shrubs and seedlings, were counted for all the species. The samples were taken from teak (160)- and sal (77)-dominated forests, and 7070 and 4699 plants, respectively, were excluded. In the tropical dry deciduous Teak-dominated forest, 71 species were found, whereas 66 species were found in the tropical moist deciduous Sal-dominated forest. Sal forest in both Tendu & Mahua is rare, whereas Sal alone dominated the forest, with a relative density of 46.47. On the other hand, in Teak-dominated forests, Tendu and Mahua plants are relatively more common.

Figures 2 and 3 illustrate the relationships between the number of individuals and the number of quadrats for different NWFP species in Teak- and Sal-dominated forests. The curves for each species indicate how the species richness increases with increasing sampling effort. In both forest types, *Tectona grandis* and *Shorea robusta* presented a greater number of individuals than did *Diospyros melanoxylon* and *Madhuca* sp., suggesting that these species are more dominant or widely distributed within their respective forest types.

Figures 4 and 5 compare the three diversity indices between the moist deciduous Sal Forest (MDSF) and dry deciduous Teak Forest (DDTF). The indices measured are Simpson's diversity index (Simpson_1-D), the Shannon diversity index (Shannon_H), and evenness (Evenness_e^H/S). The bars represent the indices for the two forest types, with blue for MDSF and yellow for DDTF.

- **Simpson's diversity index (Simpson_1-D)**: This index shows slightly greater diversity in the DDTF (0.99) than in the MDSF (0.9824), indicating a more even distribution of species in the Teak forest.
- **Shannon Diversity Index (Shannon_H)**: The Shannon index is greater in the DDTF (4.835), suggesting greater species richness and diversity in the Teak forest than in the Sal (4.167) forest.
- **Evenness (Evenness_e^H/S)**: The evenness index is slightly greater in the MDSF (0.8377) than in the DDTF (0.7861), indicating a more uniform distribution of individuals among the species present in the Sal forest.

The comparative chart effectively highlights the differences in biodiversity between the two forest types, with the DDTF showing higher overall diversity but slightly lower evenness than the MDSF. These findings are crucial for understanding the ecological dynamics and management practices required for these forest ecosystems.

The Mandla district is the transitional zone from tropical dry deciduous forest to tropical moist deciduous forest, and the Mavai range of EMFD is the place where the shift from *Tectona grandis* to *Shorea robusta* can be seen. *Shorea robusta* is a key NWFP of the district, with a frequency of 92.21, as it is found only in a few places in the district. However, *Madhuca sp*. is one of the most important NFP types, with frequencies of only 18.18 and 18.13 in the Sal & Teak forests, respectively. *Diospyros melanoxylon* was more common (75.63) in teak forests than in Sal forests (37.66). This comparative chart highlights the significant differences in the distributions and ecological importance of these NWFP species between the two forest types. *Shorea robusta* is highly dominant in the MDSF but absent in the DDTF. In contrast, *Diospyros melanoxylon* was more common and denser in the Teak forest. *Madhuca* sp. was moderately present in both forests, with relatively consistent values across all the parameters.

The importance value index indicates the relative importance of a species in a community in a particular area. The aggregation of relative frequency, relative density, and relative abundance are used here. This figure illustrates the importance value (IV) index of three major NWFP species in two types of forests: dry deciduous tea forest (DDTF) and moist deciduous salt forest (MDSF). The y-axis represents the IV index, whereas the x-axis lists the species. *Diospyros melanoxylon* has a higher IVI (28.41) in the Teak forest than in the Sal forest, indicating its greater ecological significance in this forest type than in the Sal forest (11.10). The IVI for *Madhuca sp*. was relatively low in both forest types, with a slightly greater value (3.26) in the Teak forest than in the Sal forest (2.82), suggesting that it has a minor but comparable ecological role in both forest ecosystems. *Shorea robusta* is highly dominant in the MDSF forest, as indicated by its high (69.84) IV index, whereas it is absent in the DDTF. This highlights its critical ecological importance and prevalence in the ecosystem.

Table 1 shows the various species present in both forest types. In the Moist deciduous forest, the maximum number of plants found was *Shorea robusta* (2184), while the number of other species ranged from 378–100. However, in dry deciduous forests, the plants are more homogenously distributed. The numbers ranged from 1756 to 115, starting with *Anogeissus latifolia* as first and *Tectona gradis* ranks third (696) in the list.

Table 1
Species found in Sal and Teak dominated Forest

Tree species found highest in Sal forest			
Scientific Name	**Usage** **T = Timber NT = Non Timber**	**Parts used**	**NW usage**
Shorea robusta	T/NT	Timber/Seed	seed oil
Mallotus philippensis	NT	Fruit	Dye
Diospyros melanoxylon	T/NT	Timber/Leaf/Fruit	Leaf as Indian cigarette wrap/Fruit as food
Embelia basal	NT	Fruit	Medicines
Catunaregam spinose	NT	Bark/Fruit/Leaf	Medicine/Food
Phoenix sylvestris	NT	Leaves/Fruits	Handicraft/Food
Terminalia elliptica	T	Timber	
Syzgium cumini	T/NT	Timber/Fruit	Food
Terminalia chebula	T/NT	Timber/Fruit	Medicines
Tree species found highest in Teak forest			
Scientific Name	**Usage**	**Parts used**	**Non Wood usage**
Anogeissus latifolia	T	Timber	
Diospyros melanoxylon	T/NT	Timber/Leaf/Fruit	Leaf as Indian cigarette wrap/Fruit as food
Tectona grandis	T	Timber	-
Terminalia elliptica	T	Timber	
Langerstroemia parviflora	NT	Timber	
Carissa opaca	NT	Fruit	Food/Medicines
Miliusa tomentosa	NT	Fruit/Leaf	Leaf oil in medicines
Cassia fistula	NT	Bark/Fruit/Leaf/Flower	Medicine/Food
Butea monosperma	NT	Flower	Dye/Medicine
Flacourtia indica	NT	Fruit/Root	Medicine
Casearia graveolens	NT	Fruit/Leaf	Traditional fishing/Medicine

Tree species found highest in Sal forest			
Scientific Name	**Usage** **T = Timber NT = Non Timber**	**Parts used**	**NW usage**
Catunaregam spinose	T	Bark/Fruit/Leaf	Medicine/Food
Diospyros montana	T	Timber	

Discussion

The study conducted in the forests of Mandla district, Madhya Pradesh, offers significant insights into the distribution and diversity of nonwood forest products (NWFPs) within two distinct forest types, the Tropical Dry Deciduous Teak Forest (DDTF) and the Tropical Moist Deciduous Sal Forest (MDSF). The findings reveal significant differences in species composition and ecological roles between these forest types, which has implications for both forest management and local livelihoods. While both forest types harbor a rich diversity of species, the composition and distribution patterns of these species vary considerably between the two forest types. *Madhuca sp*., a key NWFP species present in Central India, presented very low values for all the diversity indices in both forest types. Most of the Mahua trees are near villages or surrounding agricultural lands, while these sampling plots are taken into the forest only. Additionally, the species compositions differ in both forest types, and *Diospyros melanoxylon* is primarily found in dry Teak forest. This study emphasizes the ecological significance of various NWFP species in these forests. For example, *Shorea robusta* in Sal forests and *Diospyros melanoxylon* in Teak forests have high importance value indices (IVIs), reflecting their crucial roles in their respective ecosystems. The data indicate a clear divergence in the species composition between DDTF and MDSF. *Shorea robusta* dominates the MDSF, with a notably high importance value index (IVI) of 69.84, emphasizing its ecological dominance and critical role in maintaining the structure and function of these forests. In contrast, *Shorea robusta* is absent in the DDTF, highlighting the species-specific environmental preferences and the distinct ecological niches that these forest types provide. Additionally, species such as *Madhuca sp*., despite their relatively low frequency in forest interiors, play a vital role in the livelihoods of local communities because of their economic value.

Conclusion

This study revealed that in the tropical moist deciduous forests of Central India, *Shorea robusta* (Sal) is the most dominant species across all ecological aspects. In contrast, tropical dry deciduous forests, although characterized by the presence of *Tectona grandis* (Teak), are more frequently represented by *Anogeissus latifolia* and *Diospyros melanoxylon*. Both forest types exhibit high biodiversity, but the species in the Teak forests are more evenly distributed. Additionally, the species composition varies between the two forest types, particularly concerning nonwood forest product (NWFP) species. This

study provides critical insights into the distribution and diversity of NWFP species in Central India's Sal- and Teak-dominated forests. The findings underscore the ecological and economic significance of these species and highlight the need for targeted conservation and management strategies that consider the unique characteristics of each forest type. Such strategies are essential for conserving biodiversity and promoting the sustainable livelihoods of forest-dependent communities. This research emphasized that both Teak and Sal forests in Mandla District are rich in biodiversity, each with unique species compositions and distribution patterns. The Teak forests presented greater overall species diversity and richness, whereas the Sal forests presented greater evenness in species distribution. Given the ecological importance of species such as *Shorea robusta* and *Diospyros melanoxylon*, as well as the economic significance of *Madhuca* sp., this study advocates for a differentiated management approach that considers the unique species composition of each forest type.

Declarations

Author Contribution

P.B. has done field data collection, analysis and result writing. A.P.U. has supervised the conceptualization of the study, helped in field arrangements for data collection and has written discussion section of the paper. Both P.B. and A.P.U. jointly wrote the introduction and conclusion.

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Figures

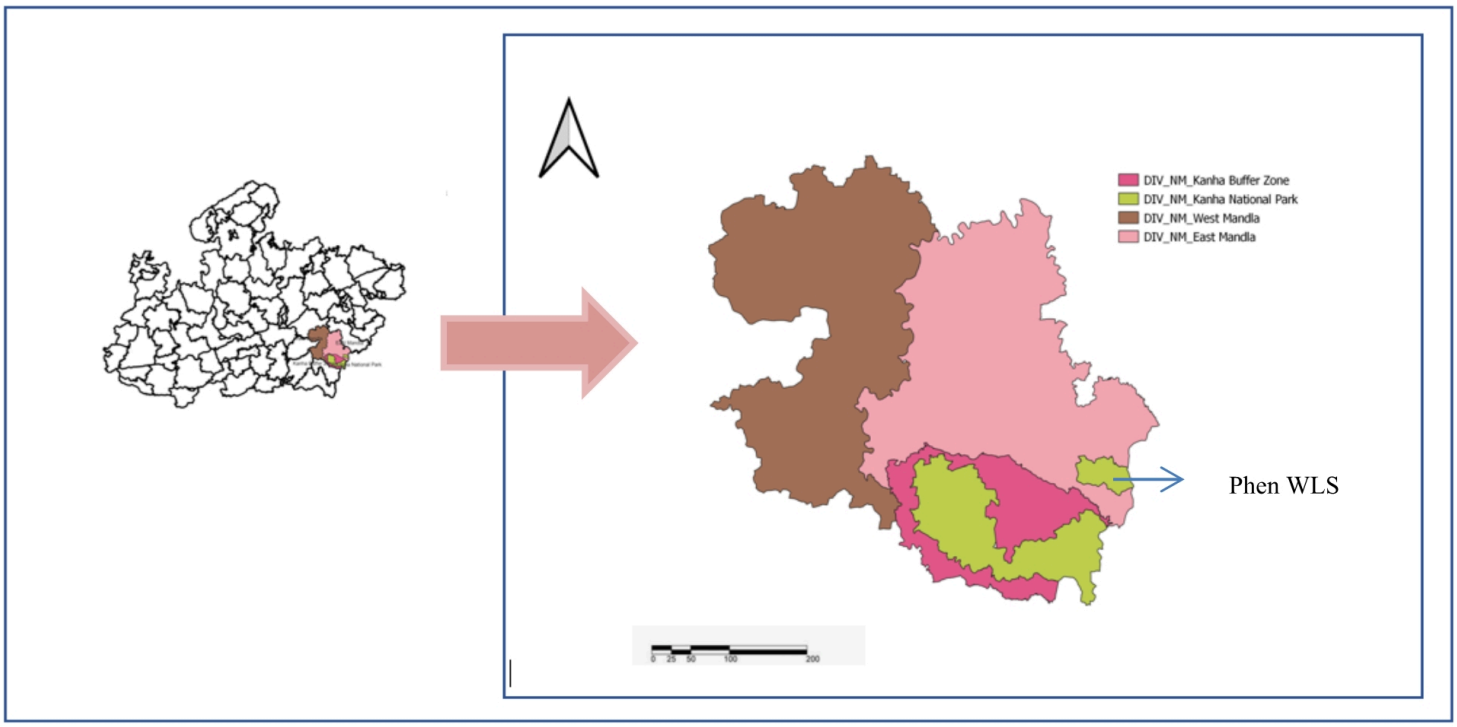

Figure 1

Forest Divisional Map of Mandla district, Madhya Pradesh, India

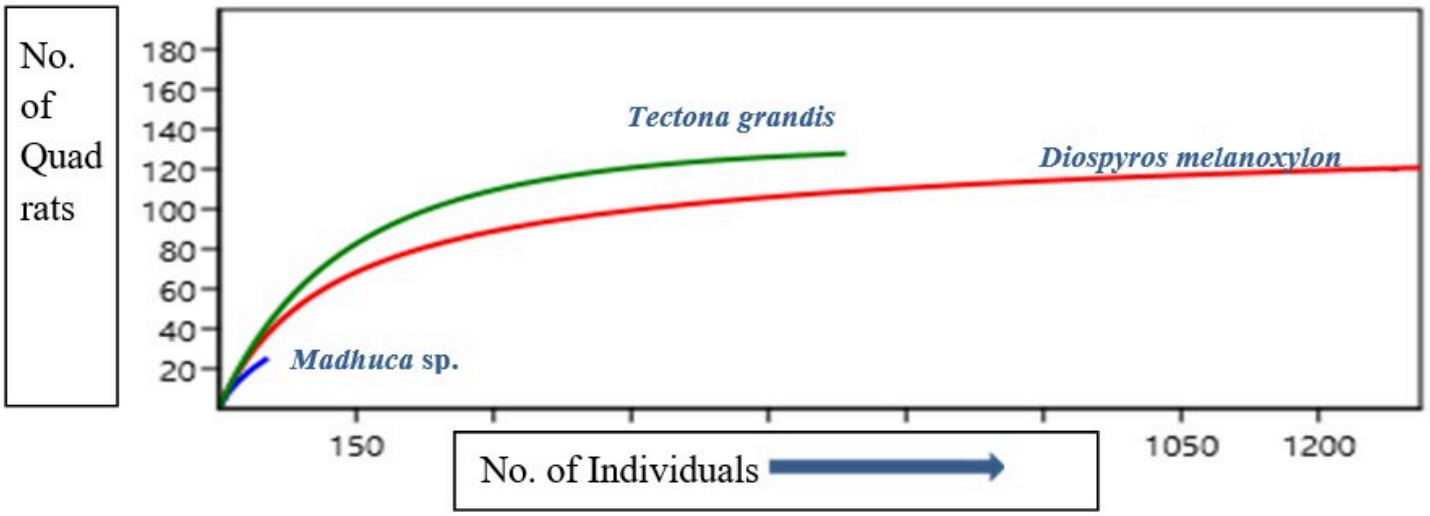

Figure 2

Species area curve of major NWFPs in Teak dominated forest

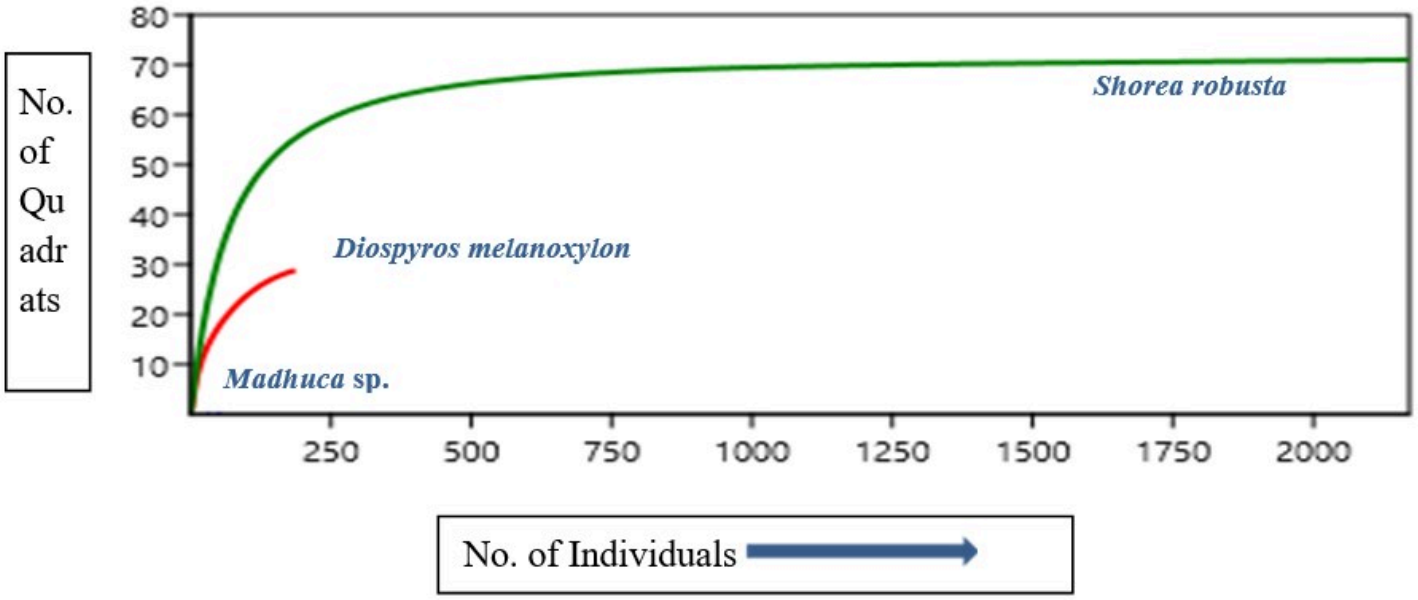

Figure 3

Species area curve of major NWFPs Sal dominated forest

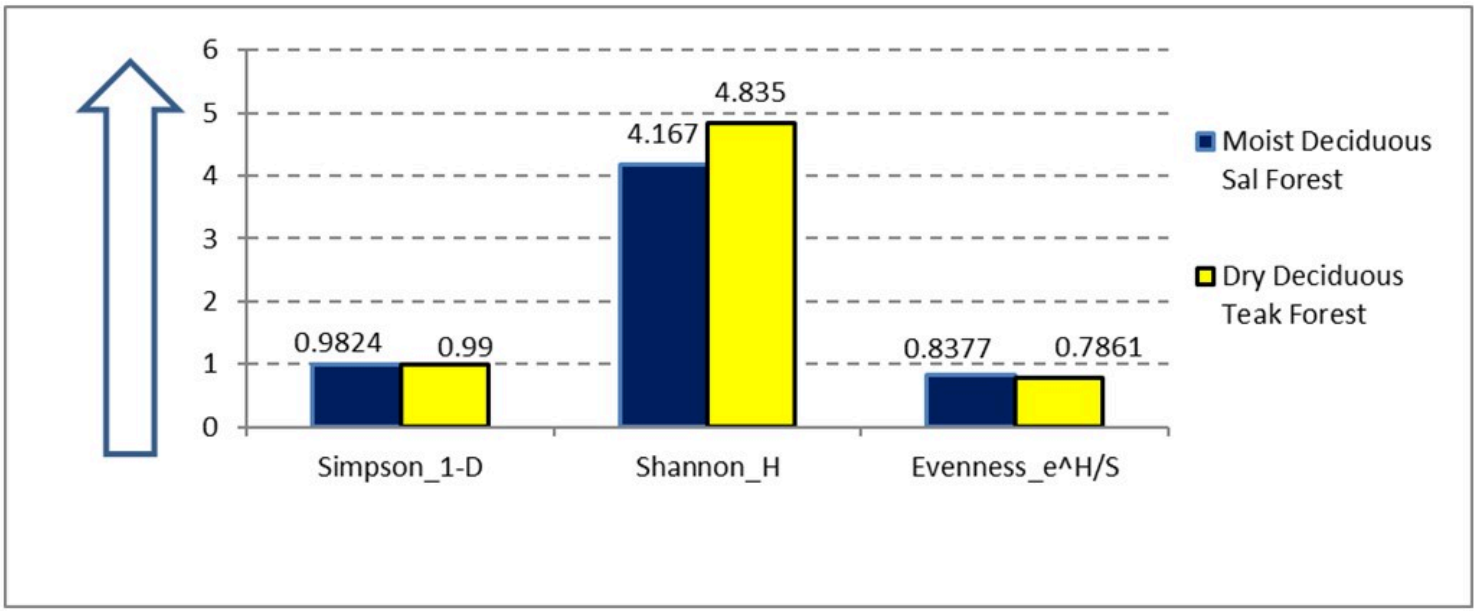

Figure 4

Comparative chart of diversity indices of Sal and Teak dominated forests

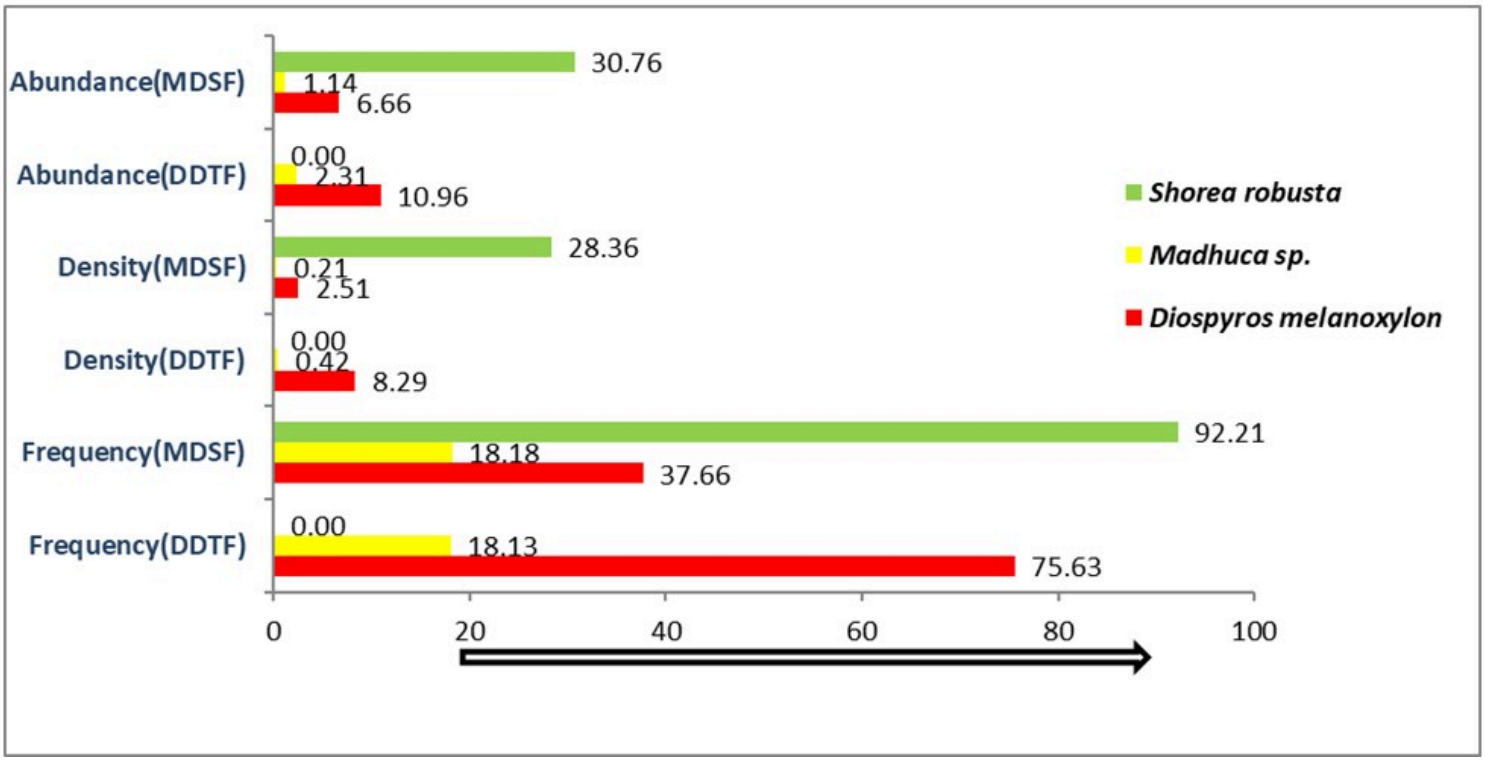

Figure 5

Comparative chart of Frequency, Density and Abundance of major NWFPs in Sal & Teak forest of Central India

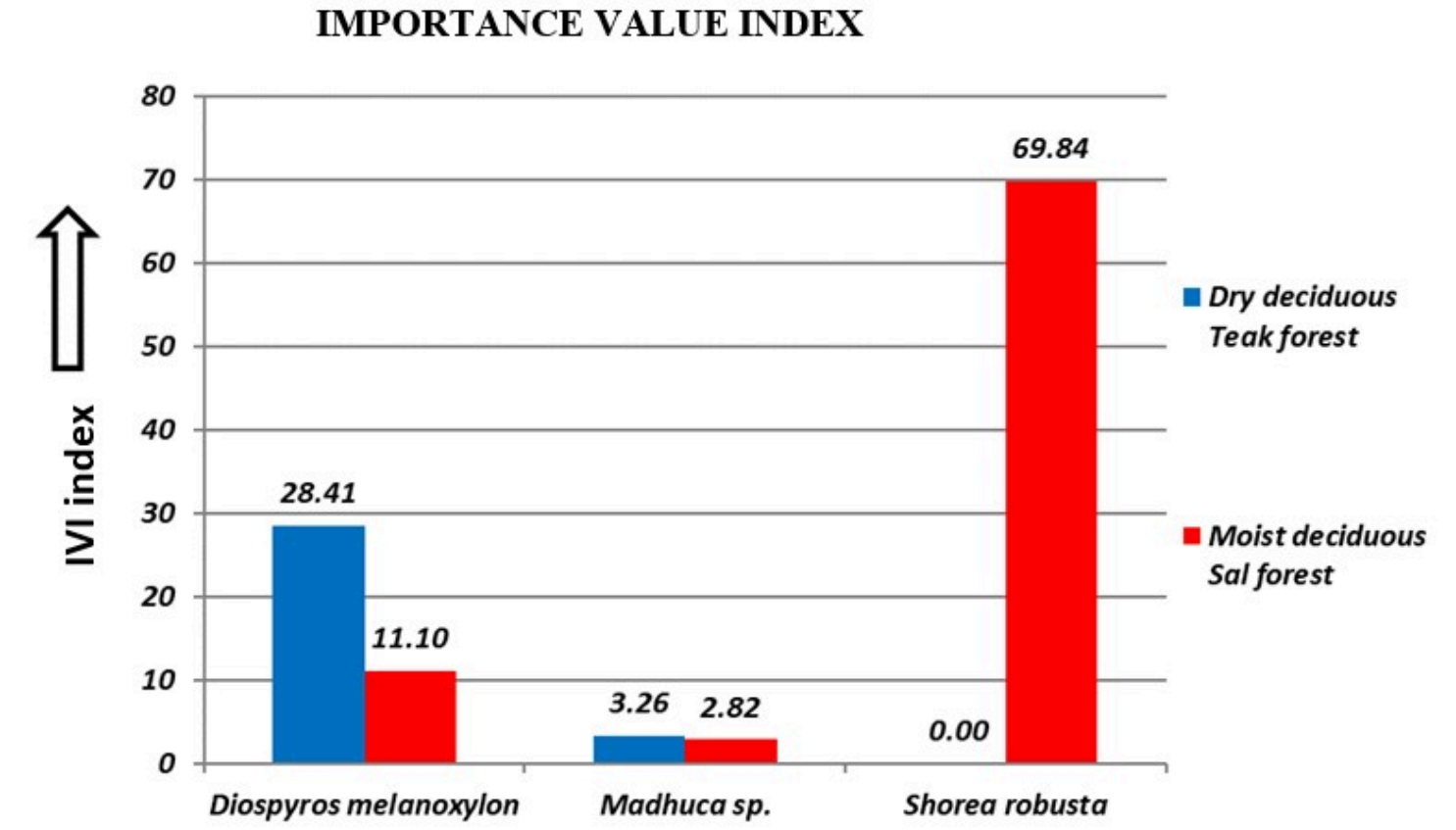

Figure 6

Comparative Importance value index of major NWFPs in Sal and Teak forest