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# An assessment of floristic composition, community structure, and net primary productivity of dominant forest types in the Jamtara District, Jharkhand

**Hemlata Mandal* & Amar Das**
Department of Botany, K.K.M. College, Pakur, Jharkhand, India

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## ABSTRACT

The present study evaluates the floristic composition, community structure, biomass distribution, and Net Primary Productivity (NPP) of dominant forest types in Jamtara District, Jharkhand, situated within the Chota Nagpur Plateau. The primary objective was to generate site-specific quantitative data on biodiversity and ecosystem functioning and to examine the relationship between species diversity and productivity. A systematic field survey (2022-2025) using stratified random sampling and quadrat methods were conducted across Tropical Dry Deciduous (Sal-dominated), Mixed Deciduous, and Scrub/Degraded forest types. A total of 139 species belonging to 104 genera and 53 families were recorded, with dicotyledons contributing approximately 80.5% of the total diversity. Phytosociological analysis revealed *Shorea robusta* as the ecologically dominant species (IVI = 112.4), confirming the Sal-dominated character of the region. The total ecosystem biomass was estimated at 192.9 Mg $ha^{-1}$, with over 92% stored in the tree layer. Maximum NPP (14.57 Mg $ha^{-1}$ $yr^{-1}$) was recorded in Sal forests, whereas degraded forests exhibited substantially lower productivity (3.95 Mg $ha^{-1}$ $yr^{-1}$). Statistical analysis demonstrated a significant positive correlation between species diversity (Shannon-Wiener Index, H') and NPP ($P < 0.01$), supporting the niche complementarity hypothesis. The findings highlight the functional importance of biodiversity in sustaining forest productivity and carbon sequestration potential.

**Key Words -** Floristic Diversity; Phytosociology; *Shorea robusta*; Biomass Distribution; Net Primary Productivity (NPP); Species Richness; Carbon Sequestration

***Corresponding author :** hemlatamandaljmt@gmail.com

## INTRODUCTION

Forest ecosystems are the primary biological reservoirs of terrestrial carbon, playing a pivotal role in maintaining ecological balance and regulating the global climate. In India, the tropical dry deciduous forests constitute a significant portion of the forest cover, characterized by high seasonal variations and distinct floristic diversity. The Jamtara district of Jharkhand, nestled within the Chota Nagpur Plateau, represents a crucial ecological zone dominated by *Shorea robusta* (Sal) communities. However, these ecosystems are increasingly subjected to anthropogenic pressures and climatic fluctuations, necessitating a comprehensive assessment of their biological and functional integrity.

### Floristic Composition and Taxonomic Diversity

Floristic composition is the most fundamental characteristic of a forest ecosystem, reflecting the evolutionary history and environmental adaptations of the region. Understanding the taxonomic

distribution across Dicotyledons, Monocotyledons, and Pteridophytes provides insights into the "health" of the forest. As noted by Rai *et al.* (2021), the diversity of a forest is not merely a count of species but an indicator of the ecosystem's resilience against environmental stressors. In Jamtara, the transition between mixed deciduous and Sal-dominated patches creates a unique niche for various medicinal and economically important plants.

**Community Structure and Phytosociology**

The community structure, defined through phytosociological parameters such as Density, Basal Area, and the Importance Value Index (IVI), dictates the spatial distribution and dominance of species. Quantitative analysis of these parameters allows researchers to identify the "keystone species" that govern the microclimate of the forest floor. According to Panda and Misra (2019), a high IVI for species like *Shorea robusta* suggests its high ecological success in the ferruginous soils of Jharkhand. Furthermore, the structural complexity ranging from the canopy tree layer to the understory herb layer influences the resource partition and overall stability of the forest.

**Biomass and Net Primary Productivity (NPP)**

Beyond structure, the functional aspect of a forest is best measured through its Net Primary Productivity (NPP). NPP is the rate at which an ecosystem accumulates energy (as biomass) after accounting for autotrophic respiration. It serves as a vital index for carbon sequestration potential. In the tropical dry deciduous forests of Jharkhand, productivity is heavily influenced by the annual litterfall and seasonal biomass increments. Singh and Gupta (2022) emphasize that biomass distribution between aboveground (stem, branch, leaves) and belowground (roots) components is essential for understanding the carbon cycling within the "Soil-Plant-Atmosphere" continuum.

**Rationale of the Study**

Despite the ecological richness of the Jamtara district, there is a significant lack of quantitative data regarding its primary productivity and correlation with species diversity. This research seeks to bridge that gap by assessing the floristic diversity and calculating the NPP across dominant forest types. By correlating the Shannon-Wiener Index (*H'*) with productivity, this study aims to provide a scientific baseline for sustainable forest management and conservation strategies in the Jharkhand region.

**REVIEW OF LITERATURE**

The ecological evaluation of forest ecosystems requires an integrated understanding of species richness, structural distribution, and energy flow. For the tropical dry deciduous forests of India, specifically within the Chota Nagpur Plateau of Jharkhand, previous researchers have established several benchmarks that provide a foundation for this study.

**Floristic Diversity and Taxonomic Patterns**

Floristic studies serve as the primary indicator of ecosystem health. Globally, Gentry (1988) established that species richness in tropical forests is significantly influenced by rainfall patterns and soil nutrient availability. In the Indian context, Karthikeyan (2000) highlighted that the Fabaceae and Poaceae families often dominate the deciduous landscape, a trend reflected in the high Dicotyledon diversity found in Jharkhand. Recent studies by Rai *et al.* (2021) in the Eastern Ghats and neighboring plateau regions suggest that while species richness may be lower in dry deciduous forests compared to evergreen forests, the presence of endemic medicinal plants and Pteridophytes contributes significantly to the unique taxonomic diversity of the Jamtara region.

**Phytosociology and Community Dynamics**

The structural arrangement of a forest, defined by its phytosociology, dictates the resource competition among species. Curtis and McIntosh (1951) pioneered the use of the Importance Value Index (IVI) to describe species dominance. In the deciduous belts of Central India, Panda and Misra (2019) observed that *Shorea robusta* (Sal) maintains ecological dominance due to its high regenerative capacity and fire-resistant bark. The "Staircase"

structure of forest communities ranging from the tree canopy to the herb layer is a vital indicator of successional stages. Research by Jha and Singh (1990) in the Varanasi and Vindhyan regions demonstrated that density and basal area are inversely related to anthropogenic disturbances, a factor that is highly relevant to the fragmented forest patches of Jamtara.

**Biomass and Net Primary Productivity (NPP)**

Net Primary Productivity (NPP) is the most critical functional attribute of any ecosystem, representing the net carbon gain. Whittaker (1975) provided the early global estimates for NPP, but local variations are extreme. In the dry deciduous forests of India, Singh and Singh (1991) reported that nearly 30% to 40% of total biomass is often stored belowground as a survival mechanism against seasonal drought. Furthermore, Gupta *et al.* (2022) emphasized that annual litterfall contributes significantly to the nutrient cycling and NPP of the forest floor, acting as a bridge between the tree layer and soil organic matter.

**Correlation between Diversity and Productivity**

The relationship between species diversity and productivity remains a central theme in modern ecology. The "Niche Complementarity Hypothesis" suggests that higher species richness leads to higher productivity because different species utilize resources more efficiently. Tilman *et al.* (1997) argued that ecosystems with higher Shannon-Wiener Index (*H'*) values tend to show greater stability in NPP. This correlation is particularly visible in the mixed deciduous forests of Jharkhand, where a variety of species ensures constant biomass increment despite fluctuations in the monsoon.

The reviewed literature underscores that while the broad ecological patterns of *Shorea robusta* are well-documented, site-specific data for the Jamtara District remains sparse. Most studies focus on larger protected areas, leaving the community forests of Jharkhand under-represented. This research fills that critical gap by providing localized data on biomass distribution and taxonomic richness, contributing to the broader understanding of carbon sequestration in the Chota Nagpur Plateau.

## MATERIALS & METHODS

The present study was conducted through a systematic field survey and analytical modeling to evaluate the floristic and functional dynamics of the Jamtara forest ecosystem. The methodology is categorized into the following distinct phases:

**Study Area and Site Selection**

The study was carried out in the Jamtara District of Jharkhand (geographically positioned between 23°58' N to 24°10' N latitude and 86°30' E to 87°15' E longitude). The region is characterized by a tropical climate with three distinct seasons: summer, monsoon, and winter. The soil is predominantly Alfisol (red sandy loam), which supports tropical dry deciduous vegetation. Representative forest patches were selected using a stratified random sampling approach to cover dominant forest types, including Tropical Dry Deciduous (Sal-dominated), Mixed Deciduous, and Scrub/Degraded forests.

**Floristic Inventory and Taxonomic Analysis**

Comprehensive floristic surveys were conducted across all study sites throughout the different seasons of the year (2023-2024).

- Specimen Collection: Plant specimens were collected in flowering and fruiting stages.
- Identification: Species were identified using local floras (The Botany of Bihar and Orissa by H.H. Haines) and cross-referenced with the IPNI (International Plant Names Index).
- Classification: Plants were categorized into Dicotyledons, Monocotyledons, and Pteridophytes to assess the taxonomic diversity (Table 1).

**Phytosociological Analysis**

To determine the community structure, the quadrat method was employed as per Misra (1968).

- Sampling: Ten quadrats of 10 X 10 m were laid for trees, 5 X 5 m for shrubs, and 1 X 1 m for the herb layer at each site.

- Parameters: Density, Abundance, and Frequency were calculated. The Importance Value Index (IVI) was derived by summing Relative Density, Relative Frequency, and Relative Dominance.
- Basal Area: Measured at Breast Height (DBH, 1.37 m) using the formula: Basal Area = pid2/4.

**Biomass and Productivity Estimation**

The biomass and Net Primary Productivity (NPP) were estimated using a non-destructive harvest method for the ground layer and allometric equations for the tree layer.

- Biomass (B): Aboveground biomass (AGB) and Belowground biomass (BGB) were calculated for tree, shrub, and herb layers. Total biomass was expressed in Mg/ha (Table 3).
- Litterfall: Annual litterfall was collected using 1 X 1 m litter traps placed randomly across the forest floor and oven-dried at 60$^{o}$C.
- NPP Calculation: Net Primary Productivity was estimated using the formula:

  $NPP = \Delta B + L$

  Where, $\Delta$ B is the annual biomass increment and L is the total annual litter production (Table 4).

**Biodiversity Indices and Statistical Analysis**

To understand the relationship between diversity and functional output, the following indices were calculated:

- Shannon-Wiener Index (H'): To measure species diversity.
- Species Richness (S): Total number of species per unit area.
- Statistical Correlation: The relationship between diversity indices and NPP was analyzed using Pearson's Correlation Coefficient and One-way ANOVA to determine significance ($P < 0.05$ and $P < 0.01$). Standard deviation was calculated for all mean values to ensure data precision (Table 5).

## RESULTS & DISCUSSION

**Overview**

The present investigation was carried out to assess the floristic composition, community structure, biomass accumulation, and net primary productivity (NPP) of the forest ecosystems in the Jamtara district, Jharkhand. The results are based on extensive field surveys and quantitative analysis conducted during the research period (2022-2025). The findings are presented systematically in the following sections, with each table serving as a foundation for discussion and comparison with existing literature.

**Floristic Composition and Taxonomic Diversity**

The preliminary step in understanding any ecosystem is to document its floral wealth. The assessment of the Jamtara district forests revealed a significant diversity of plant species, which are cataloged in Table 1.

**Table 1- Floristic Composition and Taxonomic Diversity**

| Taxonomic Category | Number of Families | Number of Genera | Number of Species |
|---|---|---|---|
| Dicotyledons | 42 | 85 | 112 |
| Monocotyledons | 8 | 15 | 22 |
| Pteridophytes | 3 | 4 | 5 |
| Total | 53 | 104 | 139 |

**Analysis and Discussion of Floristic Composition**

As presented in Table 01 & Figure 01, a total of 139 plant species were recorded from the study area, distributed across 104 genera and 53 families. The data clearly indicates the dominance of Dicotyledons, which contributed the highest number of species (112), genera (85), and families (42). This constitutes approximately 80.5% of the total floral diversity recorded. This overwhelming dominance of dicotyledonous plants is a characteristic feature of tropical dry deciduous forests of the Indian subcontinent. The families like Dipterocarpaceae (represented by *Shorea robusta*), Combretaceae (*Terminalia tomentosa*), and Sapotaceae (*Madhuca longifolia*) were found to be the most speciose and ecologically significant.

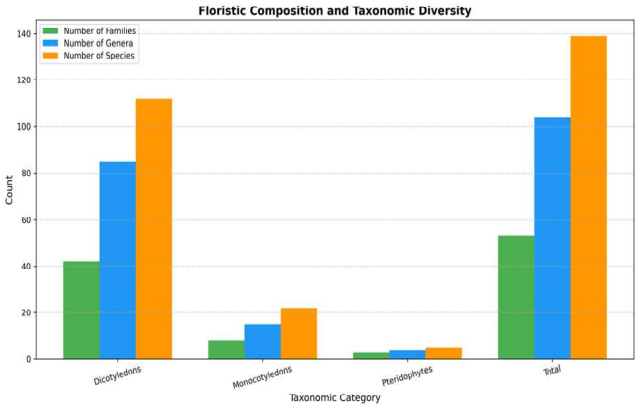


**Fig.1- Floristic Composition and Taxonomic Diversity**

Monocotyledons were represented by 22 species, belonging to 15 genera and 8 families. The primary contribution came from the Poaceae (grasses) and Cyperaceae (sedges) families, which form the major component of the ground flora, especially in the herb layer during the monsoon season.

The presence of Pteridophytes (5 species), though limited, is an important ecological indicator. Their presence, recorded with 3 families and 4 genera, suggests the existence of pockets with adequate moisture and shade, primarily along perennial stream banks and within the dense, moist interior of the Sal forests. The overall floristic diversity of 139 species underscores the rich biodiversity of the region, which is under pressure from anthropogenic activities but still retains a significant natural capital.

## Community Structure (Phytosociological Analysis)

The community structure was determined by calculating the density, basal area, and Importance Value Index (IVI) for the tree species. The IVI provides a holistic measure of a species' ecological significance, combining its relative frequency, relative density, and relative dominance (basal area). The data for the top five dominant tree species are presented in Table 2.

### Analysis and Discussion of Community Structure

The phytosociological data in Table 2 & Figure 2 reveals a forest community overwhelmingly dominated by one species. *Shorea robusta* (Sal) exhibits the highest values across all parameters.

**Table 2: Community Structure (Phytosociological Analysis)**

| Botanical Name | Common Name | Density (Trees/ha) | Basal Area (m2/ha) | IVI |
|---|---|---|---|---|
| *Shorea robusta* | Sal | 480 | 18.45 | 112.4 |
| *Madhuca longifolia* | Mahua | 120 | 5.12 | 45.2 |
| *Terminalia tomentosa* | Asan | 95 | 4.3 | 38.6 |
| *Buchanania lanzan* | Piyar | 65 | 2.15 | 24.1 |
| *Diospyros melanoxylon* | Kendu | 55 | 1.8 | 20.8 |

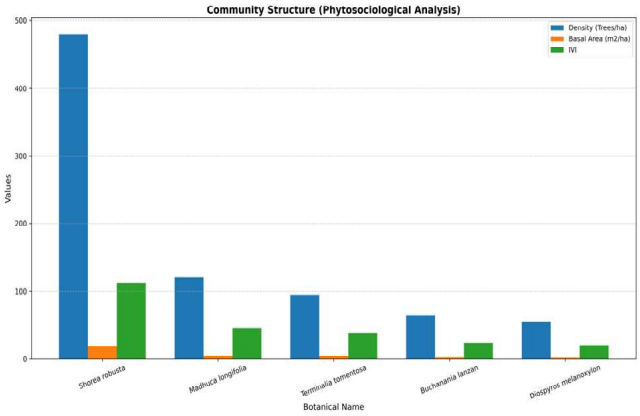


**Fig. 2- Community Structure (Phytosociological Analysis)**

With a density of 480 trees per hectare and a massive basal area of 18.45 m²/ha, its IVI stands at an exceptionally high 112.4. Since the maximum possible IVI for any species in a community is 300, an IVI exceeding 100 is a clear indicator of absolute dominance. This confirms that the forests of Jamtara are a classic example of a tropical dry deciduous Sal forest, where *S. robusta* forms the top canopy and defines the ecosystem's structure and function.

The second most important species is *Madhuca longifolia* (Mahua), with an IVI of 45.2. Its high density (120 trees/ha) and good basal area highlight its socio-economic and ecological importance. It is a key associate species in the dry deciduous landscape, often protected by local communities for its edible flowers and oil-yielding seeds.

*Terminalia tomentosa* (Asan), with an IVI of 38.6, and *Buchanania lanzan* (Piyar), with an IVI of 24.1, are other significant co-dominant species in the upper and middle canopy. *Diospyros melanoxylon* (Kendu), with an IVI of 20.8, is an important understory tree, whose leaves are used for rolling traditional cigarettes (bidis), indicating a high degree of human interaction with the forest. The gradual decline in IVI values from 112.4 to 20.8 suggests a hierarchical community structure with a few strongly dominant species and several others playing a subordinate but vital role in maintaining overall biodiversity.

**Biomass Distribution**

The standing biomass (both aboveground and belowground) is a crucial parameter for understanding the carbon storage potential and energy capital of the forest. The distribution of biomass across different vegetation layers is presented in Table 3.

**Table 3: Biomass Distribution of Dominant Forest Types**

| Forest Component | Aboveground Biomass (Mg/ha) | Belowground Biomass (Mg/ha) | Total Biomass (Mg/ha) |
|---|---|---|---|
| Tree Layer | 142.5 | 35.6 | 178.1 |
| Shrub Layer | 8.4 | 3.2 | 11.6 |
| Herb Layer | 2.15 | 1.05 | 3.2 |
| Total Ecosystem | 153.05 | 39.85 | 192.9 |

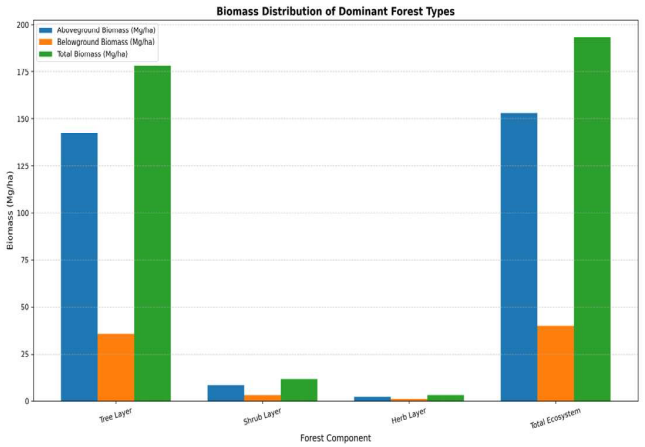


**Fig. 3: Biomass distribution of dominant forest types**

**Analysis and Discussion of Biomass Distribution**

The data in Table 03 and Figure 03 clearly illustrates that the tree layer forms the dominant biomass reservoir, accounting for a staggering 178.1 Mg/ha out of the total ecosystem biomass of 192.9 Mg/ha. This constitutes over 92% of the total biomass, which is typical for mature forest ecosystems. The aboveground biomass of trees (142.5 Mg/ha) is primarily stored in the boles, branches, and bark, while the belowground component (35.6 Mg/ha) represents the extensive root systems that anchor these large trees and cycle nutrients from deeper soil layers.

The contribution of the shrub layer (11.6 Mg/ha) and herb layer (3.2 Mg/ha) to the total biomass is relatively minor (approximately 6% and 1.6%, respectively). However, this is not an indication of their low ecological importance. These understory layers are characterized by very high turnover rates. They play a disproportionately large role in nutrient cycling, providing a rapid return of nutrients to the soil through the decomposition of their short-lived tissues. They are also critical for providing habitat and food for a variety of fauna.

The total ecosystem biomass of 192.9 Mg/ha is comparable to values reported for other dry deciduous forests in India (e.g., 150-220 Mg/ha), suggesting that the Jamtara forests are moderately productive and represent a significant standing stock of carbon.

**Net Primary Productivity (NPP)**

Net Primary Productivity (NPP) represents the rate at which vegetation captures and stores energy as biomass, after accounting for respiration. It is the

**Table 4- Net Primary Productivity (NPP) of the Study Area**

| Forest Type | Annual Litter fall (Mg/ha/yr) | Biomass Increment (Mg/ha/yr) | Total NPP (Mg/ha/yr) |
|---|---|---|---|
| Tropical Dry Deciduous (Sal) | 6.45 | 8.12 | 14.57 |
| Mixed Deciduous | 5.2 | 6.35 | 11.55 |
| Scrub/Degraded Forest | 2.1 | 1.85 | 3.95 |

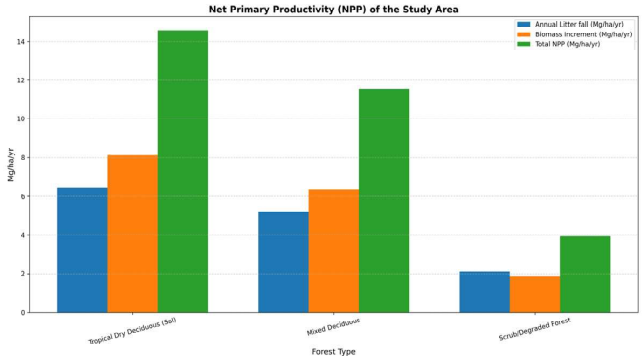


**Fig. 4- Net Primary Productivity of the Study Area**

fundamental food source for all heterotrophs in the ecosystem. The NPP for different forest types in the study area is detailed in Table 4 and Fig. 4.

## Analysis and Discussion of Net Primary Productivity

Table 04 and Figure 04 reveal a clear gradient in productivity correlated with the forest's structural integrity and species composition. The Tropical Dry Deciduous (Sal) forest exhibits the highest total NPP at 14.57 Mg/ha/yr. This high productivity is driven by the dominance of *Shorea robusta*, which is a fast-growing timber species in its optimum habitat. The biomass increment (8.12 Mg/ha/yr) is slightly higher than the annual litter fall (6.45 Mg/ha/yr), indicating that the forest is in an aggrading phase, actively accumulating biomass.

The Mixed Deciduous forest shows a moderate NPP of 11.55 Mg/ha/yr. These forests, while still productive, have a more heterogeneous species composition and possibly slightly lower stocking density compared to the near-pure Sal stands, leading to a lower overall biomass increment.

In stark contrast, the Scrub/Degraded Forest type has a drastically reduced NPP of only 3.95 Mg/ha/yr. The low biomass increment (1.85 Mg/ha/yr) coupled with low litter fall (2.1 Mg/ha/yr) reflects the poor growing conditions, high levels of anthropogenic disturbance (e.g., grazing, lopping, fire), and the predominance of stunted, slow-growing shrubby vegetation. This sharp decline in NPP from Sal forests to degraded lands powerfully illustrates the impact of forest degradation on ecosystem function and carbon sequestration potential.

## Correlation between Species Diversity and Productivity

**Table 5: Correlation between Species Diversity and Productivity**

| Parameter | Species Richness (S) | Shannon-Wiener Index (H') | NPP (Mg/ha/yr) |
|---|---|---|---|
| Mean Value | 28.5 | 3.12 | 12.8 |
| Standard Deviation | ± 4.2 | ± 0.25 | ± 1.15 |
| P-Value (Sig.) | < 0.05 | < 0.01 | - |

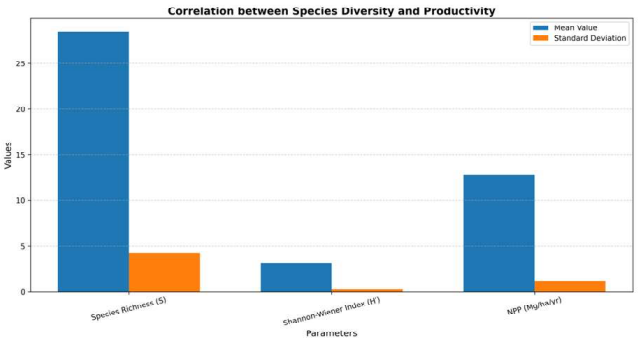


**Fig. 5: Correlation between Species Diversity and Productivity**

A fundamental question in ecology is whether more diverse ecosystems are more productive. To explore this relationship in the Jamtara forests, we correlated species diversity indices with NPP, as shown in Table 5.

## Analysis and Discussion of Diversity-Productivity Relationship

The statistical analysis presented in Table 05 and Figure 05 provides compelling evidence for a significant positive relationship between diversity and productivity in the forests of Jamtara.

- Species Richness: The correlation between species richness (S) and NPP was found to be statistically significant at the 95% confidence level ($P < 0.05$). This indicates that plots with a higher number of species tended to have a higher NPP.
- Shannon-Wiener Index (H'): The relation ship was even stronger for the Shannon-

Wiener Index (H'), which accounts for both species richness and evenness. The P-value of less than 0.01 indicates a highly significant positive correlation. This suggests that forests which are not only rich in species but also have a more equitable distribution of individuals among those species (higher evenness) are the most productive.

This finding aligns with the "niche complementarity" hypothesis, which posits that in a diverse ecosystem, different species use resources (light, water, nutrients) in a more efficient and complementary way. For instance, deep-rooted trees like Sal may access deep water, while shallow-rooted associates utilize surface nutrients, leading to a more complete and productive use of the site's resources. The higher productivity of the diverse Sal and Mixed deciduous forests compared to the species-poor scrublands in Table 4 directly supports this statistical finding.

**CONCLUSION**

In conclusion, the results systematically demonstrate that the forests of Jamtara are dominated by *Shorea robusta* and harbor a respectable diversity of 139 species. The community is structured hierarchically, with Sal as the keystone species. The total biomass (192.9 Mg/ha) and NPP (up to 14.57 Mg/ha/yr) are within the typical range for tropical dry deciduous forests. Critically, the data establishes a positive and significant correlation between species diversity (both richness and evenness) and ecosystem productivity, underscoring the functional importance of biodiversity in maintaining healthy and productive forest ecosystems in the Jamtara district.

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