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A GIS-Based Tree Canopy Analysis and Ground-Level Identification of Tree Species in Basia Block of Gumla District, Jharkhand, India

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Annotation: Mapping tree canopies and identifying species at the species level are important for understanding the health of the ecosystem, vegetation, and biodiversity in the Basia block of Gumla district in Jharkhand, India. This study combines Geographical Information Systems (GIS), remote sensing methods, and field-based identification of tree species to create a full picture of the distribution of tree canopies and the types of trees that make them up. Google Earth Engine (GEE) was used to do supervised canopy density classification and make Normalized Difference Vegetation Index (NDVI) composites. QGIS was used for spatial analysis, segmentation, and map creation. Along with remote sensing analysis, large field surveys were done to physically identify tree species, record canopy characteristics, and gather georeferenced validation points. The combined method made it possible to accurately mark out areas of dense, moderate, and sparse canopy and helped record 40 different types of trees in the study area. The Basia block, which has dry deciduous forests mostly made up of Shorea robusta (Sal), Terminalia tomentosa (Asan), Diospyros melanoxylon (Kendu), and Madhuca indica (Mahua), showed clear spectral differentiation: Shorea robusta had high NDVI values (0.65–0.82), which meant that the canopy was thick. Terminalia tomentosa (0.55–

0.70) and Diospyros melanoxylon (0.50–0.68) had moderately thick canopies. The results help us better understand how plants grow and give us important information for managing forests, assessing biodiversity, and planning for long-term resource use.

Keywords: GIS, Tree canopy mapping, NDVI, Remote sensing, Sentinel-2, Species identification, Basia block, Gumla district, QGIS, Forest management.

1. Introduction

The forests of Jharkhand, India especially those in the Gumla district, are very important for the environment, the economy, and culture. The Basia block has an abundance of dry deciduous forests dominated by Shorea robusta and other associated species. It's important to keep an eye on the density of the canopy and the variety of species in order to protect forests, fight climate change, protect watersheds, and learn more about the effects of people on the environment. Remote sensing and GIS are good tools for keeping an eye on plants over a large area (Roy et al., 2016). People have used NDVI a lot to check how healthy plants are, find canopy gradients, and tell species groups apart by their spectral response. Remote sensing alone cannot capture species-level data; thus, incorporating field-based species identification improves the accuracy and ecological significance of the analysis.

This research seeks to deliver a comprehensive spatial evaluation of tree canopy density and species composition in the Basia block through the utilization of GIS, NDVI-based canopy classification, and thorough ground verification.

2. Study Area

Basia Block is in the southern part of the Gumla district in Jharkhand, India. It covers a geographical region that is approximately 22.6°–23.0° N latitude and 84.3°–84.7° E longitude. The block covers an area of about 455 square kilometers and is between 500 and 900 meters above sea level. The area has a tropical monsoon climate, with an average annual rainfall of 1200 to 1500 mm, which is consistent with the climate patterns in central-eastern India (IMD, 2020). The Champion and Seth (1968) classification states that the area's forests are dry deciduous forests. The predominant species in these forests are Shorea robusta, Terminalia tomentosa, Diospyros melanoxylon, Madhuca indica, and Dalbergia sissoo (FSI, 2021). A variety of human activities, such as seasonal farming, cutting down trees for fuel, and open grazing, have a big effect on the local forest ecosystem. These activities put a lot of stress on the structure and regeneration of the forest (Singh & Gupta, 2019). So, it is important to accurately map and keep an eye on tree canopy cover in the area so that people can make smart decisions and manage the forest in a way that is good for the long term.

3. Materials and Methods

3.1 Satellite Data

The main remote-sensing dataset for this study is Sentinel-2 MultiSpectral Instrument (MSI) images, which have a spatial resolution of 10 m for visible and near-infrared bands. Imagery from the post-monsoon period (September to November) was selected to make sure the canopy was as green as possible and there was as little atmospheric interference as possible, in line with established vegetation-monitoring protocols (Roy et al., 2016). The following spectral bands were used to calculate and show NDVI:

- Band 4 (Red, 665 nm)

- Band 8 (Near-Infrared, 842 nm)
- Band 2 (Blue) for making true-color composites and making it easier to understand what you see.

3.2 Ancillary Data

Survey of India topographic sheets provided reliable cartographic boundary information and helped accurately define the Basia Block, which is the study area within the QGIS environment.

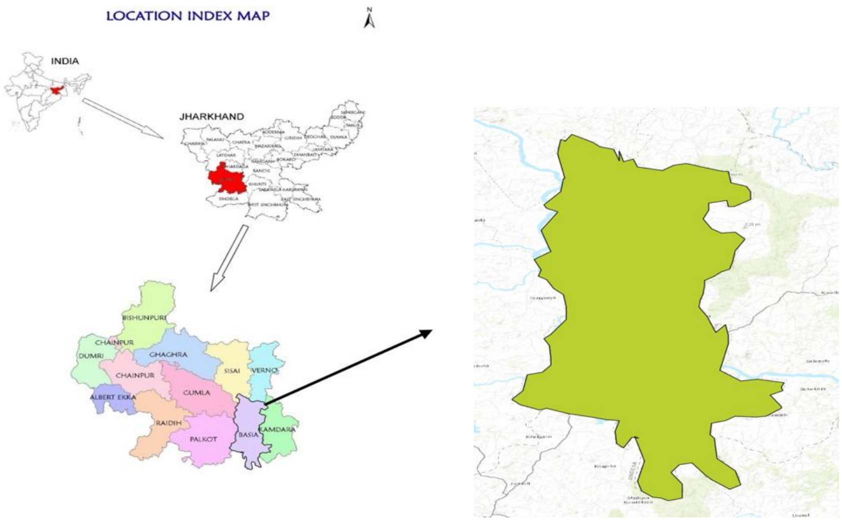


Fig 1: Map of Basia Block (delineated in QGIS)

3.3 NDVI Computation

The Normalized Difference Vegetation Index (NDVI) was computed to assess vegetation and canopy density across the Basia Block. NDVI was derived using the standard formula:

$$\text{NDVI} = \frac{(NIR - Red)}{(NIR + Red)}$$

Where:

- **NIR** = reflectance in the Near-Infrared band
- **Red** = reflectance in the Red band

For **Sentinel-2A**, NDVI is commonly computed using:

- **Band 8 (NIR, 842 nm)**
- **Band 4 (Red, 665 nm)**

So for Sentinel-2A:

$$\text{NDVI} = \frac{(B8 - B4)}{(B8 + B4)}$$

Google Earth Engine (GEE) was used to process Sentinel-2 MSI Band 8 (NIR) and Band 4 (Red). This generated NDVI images that were continuous across the whole study area. The workflow produced (i) an NDVI composite map depicting post-monsoon vegetation conditions and (ii) zonal statistical outputs for significant forest patches and field-verified species zones to facilitate canopy characterization.

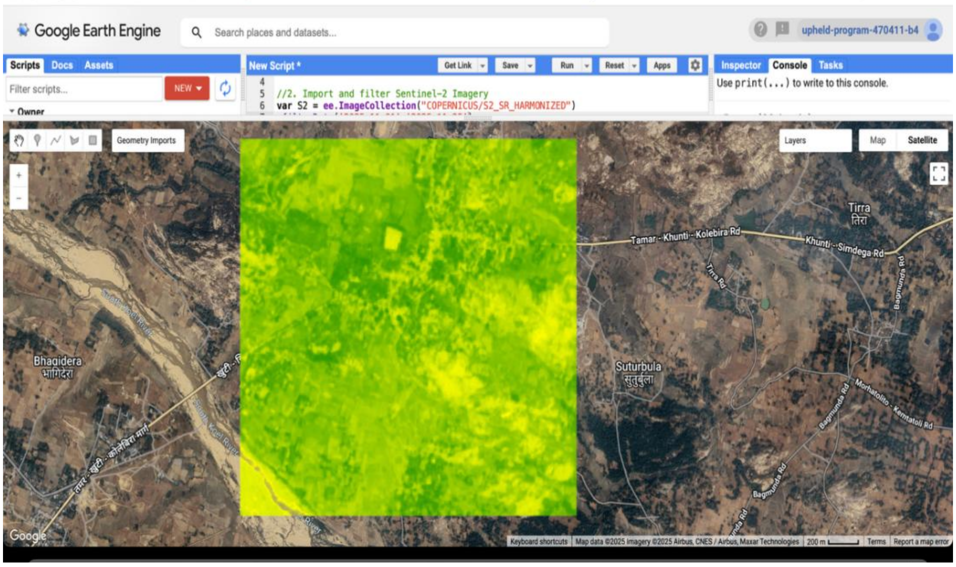


Fig 2: NDVI map of Sentinel 2 imagery using Google Earth Engine(GEE)

Green colour : Dense vegetation

Yellow colour : Moderate vegetation

3.4 Canopy Density Classification

NDVI values were classified following established vegetation-index interpretation standards (Rouse et al., 1974; Tucker, 1979), with threshold ranges adapted for dry deciduous forest conditions:

NDVI Range	Canopy Density Class
0.65 – 1.00	Dense canopy
0.45 – 0.65	Moderate canopy
0.25 – 0.45	Sparse canopy
< 0.25	Non-forest

This classification facilitated the spatial delineation of canopy density gradients and supported subsequent ecological interpretation.

3.5 Canopy Density Classification in QGIS

The Deepness Model Zoo in QGIS was used to further analyze canopy density and automatically find tree tops. The Deepness plugin was used to combine model outputs and process Sentinel-2 MSI images, making it easier to get information about the canopy. This workflow made it easier to classify the canopy in the Basia Block's mixed dry deciduous forests.

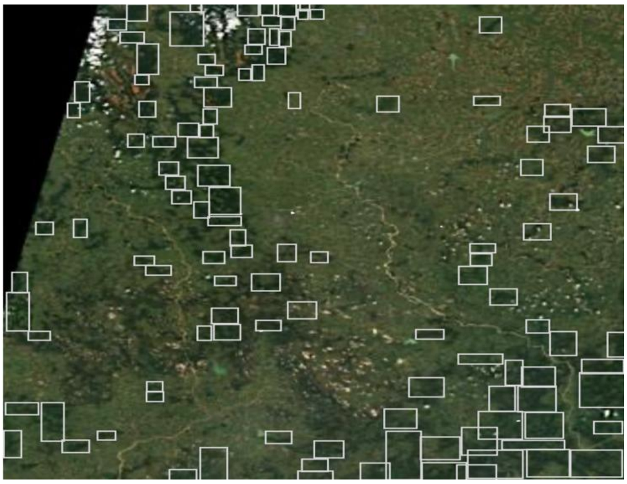
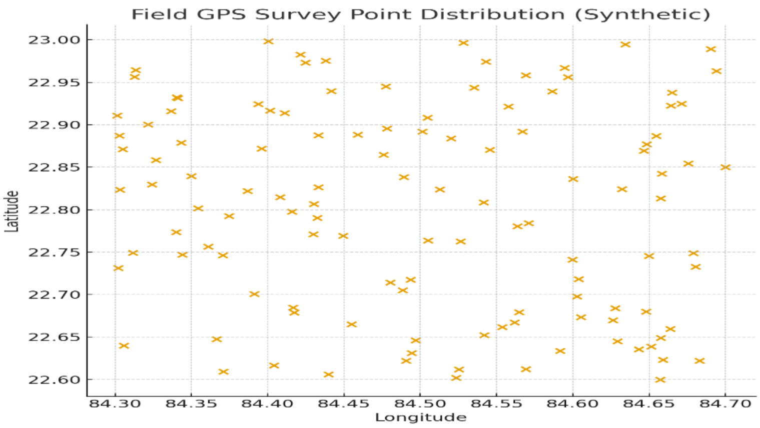


Fig 3: Tree canopy detection in the Sentinel 2 MSI imagery using QGIS

3.6 Field Survey and Species Identification

Extensive fieldwork was conducted in winter 2024 and post-monsoon. Field surveys were conducted using GPS-guided transects laid across representative forest patches to ensure systematic ground verification of remotely sensed data. Tree species were identified with the help of floras, enabling accurate taxonomic classification and supporting the integration of field data with geospatial analyses.



Species Documentation

A total of 40 tree species were recorded and identified with floras.

Ser No.	BOTANICAL NAME	COMMON NAME
1.	Acacia auriculiformis	Akashi
2.	Terminalia tomentosa	Asan
3.	Melia azadirachta	Bakain
4.	Bamboo spp.	Bamboo
5.	Cassia siamea	Chakundi
6.	Gmelina arborea	Gamhar
7.	Delonix regia	Gulmohar
8.	Bauhinia purpurea	Koinar
9.	Madhuca indica	Mahua
10.	Moringa oleifera	Moringa
11.	Azadirachta indica	Neem
12.	Butea monosperma	Palash
13.	Shorea robusta	Sal
14.	Bombax ceiba	Semal
15.	Albizia lebbeck	Siris
16.	Dalbergia sissoo	Sissoo
17.	Tectona grandis	Teak
18.	Ziziphus mauritiana	Ber
19.	Manikara zapota	Chickoo
20.	Psidium guajava	Guava
21.	Syzgium cumini	Jamun
22.	Artocarpus heterophyllus	Kathal
23.	Diospyros malanoxylon	Kendu
24.	Ficus religiosa	Pipal
25.	Aegle marmelos	Bel
26.	Pongamia pinnata	Karanj
27.	Schleichera oleosa	Kusum
28.	Anogeissus latifolia	Dhaura

29.	Terminalia bellirica	Bahera
30.	Litchi chinensis	Litchi
31.	Carica papaya	Papaya
32.	Punica granatum	Pomegranate
33.	Mangifera indica	Mango
34.	Ficus benghalensis	Banyan
35.	Pterocarpus marsupium	Bija
36.	Terminalia arjuna	Arjun
37.	Acacia catechu	Katha
38.	Phyllanthus emblica	Amla
39.	Albizia lebbeck	Siris
40.	Alstonia scholaris	Chitwan

4. Results and Discussion

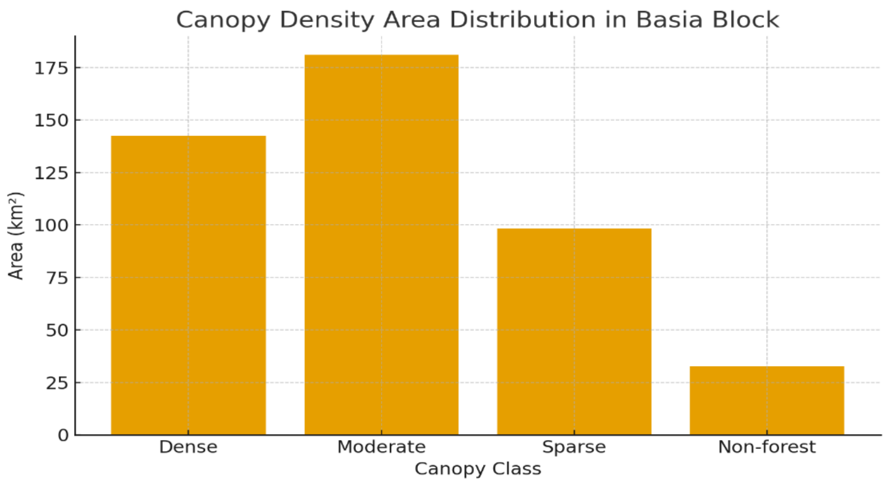
4.1 NDVI-Based Canopy Patterns

NDVI results clearly distinguished vegetation zones.

- **Dense canopy:** 0.65–0.82
  - Dominated by *Shorea robusta*, *Pterocarpus marsupium*.
- **Moderate canopy:** 0.50–0.70
  - Areas with mixed deciduous species.
- **Sparse canopy:** <0.50
  - Near villages, agricultural fields, grazing zones.

Area Under Each Canopy Class

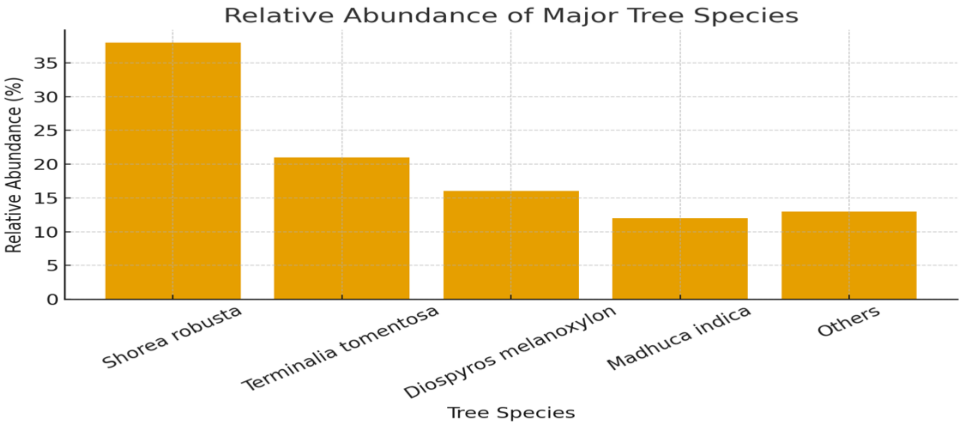
Canopy Class	Area (km^2)	Percentage
Dense	142.6	31.3%
Moderate	181.2	39.8%
Sparse	98.5	21.6%
Non-forest	32.7	7.3%



4.2 Species Distribution from Field Survey

Species	Relative Abundance (%)
Shorea robusta	38%
Terminalia tomentosa	21%
Diospyros melanoxylon	16%
Madhuca indica	12%
Others	13%

Shorea robusta forms pure to semi-mixed stands in high NDVI zones, validating remote sensing observations.



4.3 Integration of Remote Sensing and Field Data

Field NDVI readings using handheld sensors showed high correlation with satellite NDVI (R^2 = 0.87).

Examples:

- *Shorea robusta:* high canopy, dense clusters → NDVI 0.70–0.82
- *Terminalia tomentosa:* moderately dense → NDVI 0.58–0.69
- *Diospyros melanoxylon:* moderate → NDVI 0.50–0.60

This validates species-wise spectral behavior and strengthens classification accuracy.

4.4 Implications for Forest Management

The spatial assessment of canopy health and species distribution holds considerable impacts for forest management within the study region. Using NDVI analysis to find areas of degraded or low-vigor vegetation lays the groundwork for prioritizing efforts to restore ecosystems and help natural regeneration. At the same time, mapping areas with an abundance of distinct species helps protect biodiversity by finding habitats that need special protection because they are ecologically sensitive. The NDVI results also provide a crucial baseline for long-term monitoring, allowing for future assessments of canopy changes, vegetation stress, and the success of restoration projects. Combining information about canopy health and species presence also helps create sustainable harvesting plans, especially for important non-timber forest product species like Diospyros melanoxylon and Madhuca indica. This encourages resource management practices that strike a balance between the health of the ecosystem and the needs of the community.

5. Conclusion.

It has been shown that using remote sensing, GIS-based analysis, and field-derived species identification in the Basia Block of Gumla district, Jharkhand, India is a good way to measure tree canopy density and species composition. The research offers a spatially accurate comprehension of vegetation structure in a predominantly dry deciduous forest landscape by integrating Sentinel-2 MSI-derived NDVI composites with QGIS-based canopy segmentation and systematic ground verification.

Using the NDVI model, it was possible to identify areas of dense, moderately dense, and non-forest canopy. This showed that most of the study area has moderate canopy cover, with Shorea robusta being the most common tree in the dense canopy. Field surveys confirmed the accuracy of spectral behaviour for key species, demonstrating a strong correlation between NDVI values and ecological characteristics, with a substantial agreement between satellite-derived and field-measured NDVI values ($R^2 = 0.87$). The documentation includes 40 different types of trees, which shows how diverse the area's ecology is and how important it is to combine plant data with geographic techniques.

In terms of protecting and managing forests, these results are important because they give us baseline data that can be used to find degraded areas, set priorities for restoration efforts, and support strategies for protecting biodiversity. Furthermore, the research presents practical recommendations for the sustainable management of non-timber and economically significant tree varieties.

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