

Original Article

Biodiversity Assessment and Calorific Value of Forest Crops in the Nagpur Forest Division.

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Abstract

Teak (*Tectona grandis*) is a globally prized, prosperous hardwood timber, naturally found across South and Southeast Asia, including a large natural distribution in India. To compensate for the decline of natural forests, India established its first teak plantation in Kerala in 1842, a practice that has become common nationwide, particularly in states such as Madhya Pradesh, Maharashtra, Karnataka, Tamil Nadu, and Kerala. Indian teak wood's key characteristics include a natural golden-brown color, a distinctive leather-like smell from its natural oils, high density and hardness, and impressive durability. It's highly resistant to moisture, warping, cracking, and termite infestations, making it excellent for outdoor use and furniture. Teak also has a straight, visually appealing grain pattern and can be easily polished. Teak wood has a higher calorific value than many common wood species. Its high oil and extractive content primarily influence its energy content. With the growing importance of forest biomass as a source of clean, renewable energy, this study aims to evaluate the net calorific values of wood from key tree species in the Nagpur forest division. The selection of species for analysis is based on forest inventories, which highlight the prevalence of commercially important *Tectona grandis* (teak), as well as other significant species.

Keywords: Teak, Hardwood timber, Plantations, Forest biomass, Calorific value.

Introduction

India's megadiverse status, encompassing 8% of global biodiversity, is reflected in its vast area of 328.73 million ha, making it the seventh largest country. About one-fifth of India's geographical area is covered with forests, and approximately 45,000 plant species exist in India. The commercially important tree *Tectona grandis* (Teak) is classified within the Lamiaceae family and is a major species used in tree plantations, which is naturally distributed in India. (K.Palanisami et.al (2009). India possesses the world's most extensive collection of teak genetic resources. In India, *Tectona grandis* forests are widely distributed in Maharashtra, Madhya Pradesh, Tamil Nadu, and Karnataka. Kerala, Uttar Pradesh, Gujarat, Orissa, and Rajasthan. (India State Forest Report 2023)

The calorific value measures the energy from burning one unit of a fuel, but this value decreases with wood's moisture content, as energy is lost to evaporating water. For teak wood, its calorific value is important for determining its potential as a biofuel, with the energy released upon combustion being influenced by the wood's internal chemical makeup and external factors like its growing conditions.



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Study Area

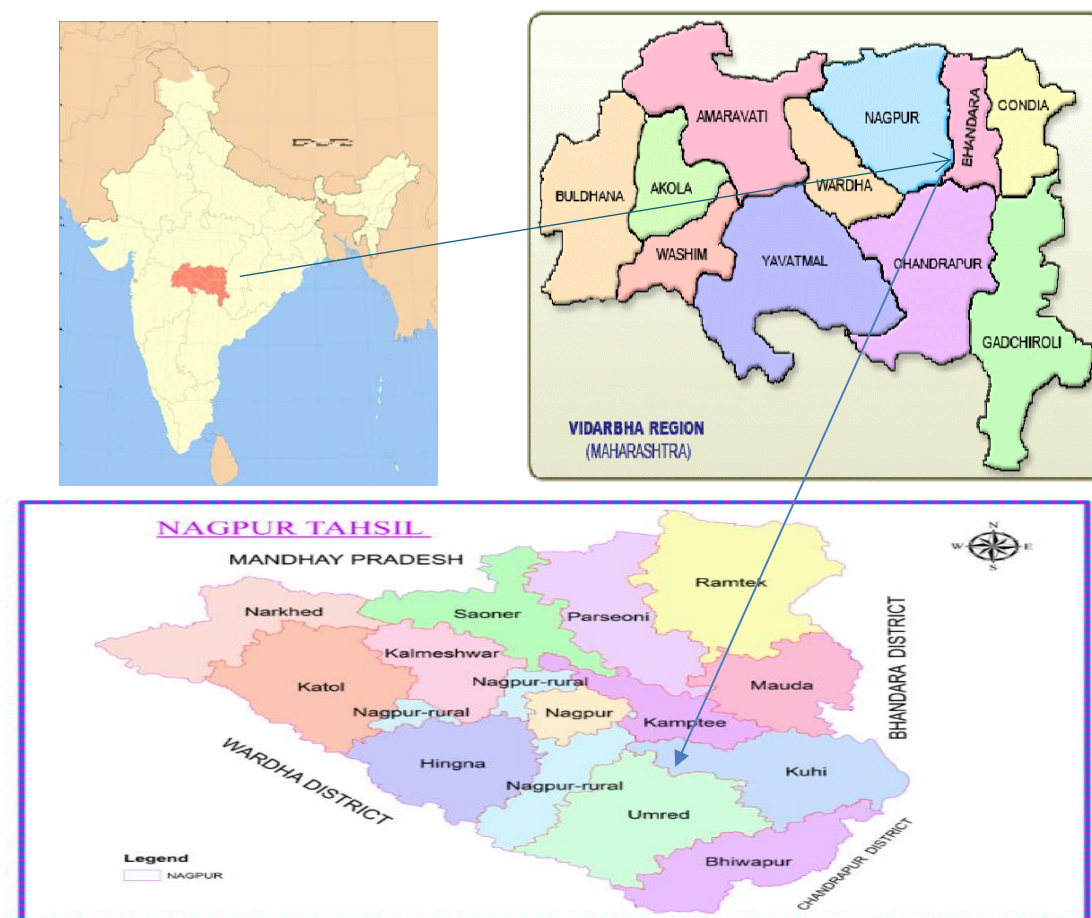


Figure 1: Map of the study area.

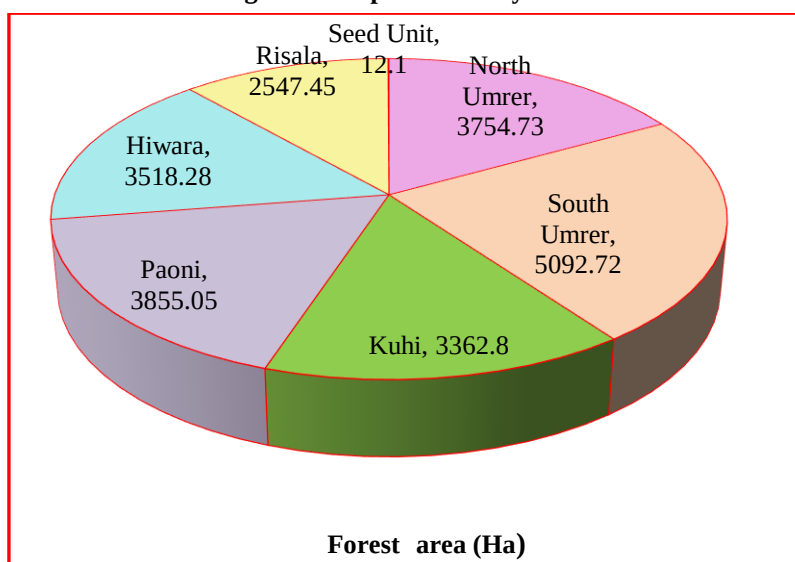


Figure 2: Range-wise distribution of Nagpur Forest Division.

The present study is based on the forest area of Nagpur division. The forest areas occur in compact blocks as well as in scattered patches within the civil territory of Nagpur District of the State of Maharashtra. The area lies between the parallels of 20° 35" and 21° 44" N and 44" N and the longitudes of 78° 15" and 79° 40" E.

Configuration of the ground

Nagpur Forest division lies at the southern fringe of the Satpura Range. The greater part is undulating, plain, and is traversed by low hill ranges. It is hilly in the north-east and has an average elevation of about 300 m above mean sea level. Altitude varies from 204.04 m. to 615 m. The Division is well-drained and falls within the catchments of the Wardha and Wainganga rivers. There are ancient crystalline rocks mainly consisting of gneiss and granulite lying in the North and East portions. The Deccan Trap volcanic flow lies in the western and southern part of the division. In addition, many sedimentary rock formations, including some coal-bearing beds, are also found. The soils in the division can be broadly divided into the following six classes:

(1) Black soil, (2) Morand, (3) Khardi, (4) Bardi, (5) Kachhar, and (6) Wardi.

1. Climatic parameters:

The climate is characterised by a hot summer, well-distributed rainfall, and dryness except in the rainy season. The cold season is from December to February and is followed by the hot season from March to May. The southwest monsoon season is from June to September, while the period from October to November constitutes the post-monsoon season. The average annual rainfall is 1101.4 mm. The average annual temperature in the district is 27 °C. (*Nagpur District Gazetteer 24-25*)

Materials and Methods

1. Biodiversity Assessment

The method of systematic line plot sampling is used for biodiversity assessment. A total of 367 sample plots, each measuring 31.62m x 31.62m (or 0.1 ha), were established at the intersections of a 750m x 750m grid. Trees within these plots were counted, and their girth was measured in uniform classes of 15cm. Using the enumeration data, species-specific girth and density distribution were calculated. A biodiversity assessment, including species density, frequency, basal area, dominance, and the Importance Value Index (IVI), were calculated for all tree species. The biodiversity assessment identified the major tree species within the division. These findings guided the selection of specific species, including *Tectona grandis*, for further calculations of calorific values.



Figure 3: Representative forest area for biodiversity assessment.

2. Calorific Value Determination:

The wood samples collected are ground finely and then converted into pellets with the help of a pellet-making machine. To determine the calorific value of wood with a bomb calorimeter, a precisely weighed wood pellet sample is placed in a crucible inside the sealed bomb, which is then filled with pure oxygen under high pressure. The

bomb is submerged in a known mass of water in a copper calorimeter equipped with a stirrer and thermometer. A fine fuse wire, ignited electrically, burns the wood sample, releasing heat. This heat raises the surrounding water's temperature, which is measured. The temperature change, along with the known mass of the wood sample and the calorimeter's specific heat capacity, allows for the calculation of the wood's calorific value. The calorific value is calculated using the formula: $\text{Calorific Value (CV)} = (m_{\text{water}} \times C_{\text{water}} \times \Delta T - w_{\text{wire}} \times q_{\text{wire}}) / m_{\text{sample}}$

Where:

m_{water}: Mass of water.

C_{water}: Specific heat capacity of water.

ΔT: Temperature change (T_f - T_i).

w_{wire}: Mass of the fuse wire.

q_{wire}: Calorific value of the fuse wire (known).

m_{sample}: Mass of the wood sample.



Figure 4: Pellets prepared from a fine wood sample.



Figure 5: Determination of calorific value by using a bomb calorimeter

Results and discussion

It was found that the forests of the Nagpur Forest Project division belong to the Subgroup 5A – Southern Tropical Dry Deciduous Forests as per the revised classification of 'Champion and Seth'. The site quality of the Forests varies from II/III to IV, with crown density varying from 0.2 to 0.8.

- Floristics Composition:** - The area of this division is rich in flora. The floristic composition of the area is as follows.

Number of Trees Per Ha.												
Sr. No.	Species	Girth-wise Classification of Trees in cm.										
		15-30	31-45	46-60	61-75	76-90	91-105	106-120	121-135	135-150	Above 150	Total
Basal Area Factor in sq m.		0.0042	0.0115	0.0224	0.0368	0.0549	0.0765	0.1017	0.1314	0.1628	0.2102	
1	<i>Tectona grandis</i>	41.44	29.03	20.63	13.79	8.56	4.36	2.15	0.65	0	0	120.61
2	<i>Terminalia tomentosa</i>	8.47	5.9	5.66	3.74	2	1.46	0.35	0.36	0.16	0	28.10
3	<i>Tamarindus arjuna</i>	0.03	0	0.1	0.02	0	0	0.03	0	0.11	0	0.29
4	<i>Pterocarpus marsupium</i>	0.2	0.06	0.37	0.32	0.13	0.12	0.02	0.06	0.05	0	1.33
5	<i>Chloroxylon swietenia.</i>	12.13	7.09	3.42	1.67	1	0.49	0.11	0	0	0.05	25.96
6	<i>Aegle marmelos</i>	2.45	1.17	1.21	1.28	0.82	0.21	0.22	0	0.02	0.02	7.40
7	<i>Hardwickia binata</i>	1.17	1.86	0.95	0.05	0.05	0	0.02	0	0	0	4.10
8	<i>Terminalia bellerica</i>	0.33	0.3	0.21	0.27	0.38	0.22	0.06	0	0	0	1.77
9	<i>Buchanania lanzan</i>	7.92	2.78	1.08	0.44	0.33	0.11	0.11	0.05	0	0	12.82
10	<i>Albizzia odoratissima</i>	0.03	0.13	0.03	0.03	0.08	0	0	0.02	0	0	0.32
11	<i>Anogeissus latifolia</i>	3.1	2	1.49	0.93	0.54	0.93	0.46	0.28	0	0	9.73
12	<i>Grewia tiliaefolia</i>	0.27	0.44	0.23	0.11	0	0	0	0	0	0	1.05
13	<i>Cleistanthus collinus</i>	3.89	2.01	1.61	0.34	0.16	0.06	0	0	0	0	8.07
14	<i>Cochlospermum religiosum</i>	3.38	2.05	0.91	0.2	0.06	0	0	0	0	0	6.60
15	<i>Adina cordifolia</i>	0.14	0.03	0.02	0	0.02	0	0	0	0	0	0.21
16	<i>Acacia catechu</i>	3.22	3.11	3.62	1.07	0.33	0.02	0	0	0	0	11.37
17	<i>Schleichera oleosa</i>	0.36	0.32	0.12	0.08	0.05	0	0.02	0	0	0	0.95
18	<i>Mitragyna parviflora</i>	0.06	0.17	0.14	0.34	0.11	0.12	0	0	0	0.02	0.96
19	<i>Miliusa velutina</i>	3.54	2.29	1.17	0.57	0.14	0.03	0.02	0	0	0	7.76
20	<i>Holarrhena antidysenterica</i>	3.22	0.57	0.27	0.06	0.05	0.26	0.2	0	0	0	4.63
21	<i>Lagerstroemia parviflora</i>	10.53	2.75	1.06	0.33	0.14	0.14	0	0	0	0	14.95
22	<i>Lannea coromandelica</i>	0.83	1.66	1.22	1.59	0.63	0.8	0.4	0.11	0.16	0.06	7.46
23	<i>Madhuca indica</i>	1.59	1.32	0.8	0.9	0.51	0.33	0.45	0.17	0.13	0.35	6.55
24	<i>Butea monosperma</i>	6.44	5.63	3.63	1.44	0.76	0.14	0.14	0.05	0	0	18.23
25	<i>Soyimida febrifuga</i>	0.65	0.67	0.44	0.32	0.62	0.44	0.5	0.14	0.11	0	3.89
26	<i>Boswellia serrata</i>	0.29	0.34	0.16	0.09	0.06	0.11	0.24	0.05	0.02	0	1.36
27	<i>Bombax ceiba</i>	0	0.02	0	0.06	0	0	0	0	0	0	0.08
28	<i>Dalbergia latifolia</i>	0.07	0	0.05	0	0	0	0	0	0	0	0.12
29	<i>Ougennia oogenesis</i>	0.03	0.03	0.02	0	0	0	0	0	0	0	0.08
30	<i>Diospyros melanoxylon</i>	14.87	2.68	1.12	0.75	0.45	0.33	0.15	0.05	0	0	20.40
31	Other	39.28	18.73	9.27	5.31	2.41	1.85	1.04	0.39	0.43	1.05	79.76
	Total	169.93	95.14	61.01	36.1	20.39	12.53	6.69	2.38	1.19	1.55	406.91
Basal Area in Sq.m. per ha.		0.71	1.09	1.37	1.33	1.12	0.96	0.68	0.31	0.19	0.32	8.09

Table 1: The floristic composition of the Nagpur Forest division

2. Biodiversity Assessment: -

A biodiversity assessment was conducted in a forest division using data from 367 sample plots, covering 0.18% of the total area. This involved enumerating individual trees and measuring their Diameter at Breast Height (DBH), Relative Density, Frequency and Basal Area to calculate several key attributes including the Important Value Index (IVI).

Sr. No.	Species	No. of trees per ha.	Relative Density	Relative Frequency	Relative Basal Area	IVI
1	<i>Tectona grandis</i>	120.6	29.64	10.13	32.01	71.78
2	<i>Terminalia tomentosa</i>	28.11	6.90	6.09	8.65	21.65
3	<i>Tamarindus arjuna</i>	0.29	0.07	0.34	0.25	0.66
4	<i>Pterocarpus marsupium</i>	1.33	0.33	1.43	0.74	2.50
5	<i>Chloroxylon swietenia.</i>	25.95	6.38	7.69	4.70	18.77
6	<i>Aegle marmelos</i>	7.38	1.82	1.43	2.35	5.60
7	<i>Hardwickia binata</i>	4.09	1.00	1.09	0.62	2.71
8	<i>Terminalia bellerica</i>	1.78	0.44	0.67	0.74	1.85
9	<i>Buchanania lanzan</i>	12.81	3.15	2.35	1.85	7.35
10	<i>Albizia odoratissima</i>	0.31	0.08	0.38	0.12	0.58
11	<i>Anogeissus latifolia</i>	9.73	2.39	7.90	3.58	13.87
12	<i>Grewia tiliaefolia</i>	1.05	0.26	0.97	0.25	1.47
13	<i>Cleistanthus collinus</i>	8.07	1.98	4.54	1.24	7.76
14	<i>Cochlospermum religiosum</i>	6.61	1.62	0.88	0.87	3.37
15	<i>Adina cordifolia</i>	0.2	0.05	0.29	0.03	0.38
16	<i>Acacia catechu</i>	11.37	2.79	4.45	2.35	9.59
17	<i>Mitragyna parviflora</i>	0.95	0.23	0.59	0.25	1.07
18	<i>Miliusa velutina</i>	0.96	0.23	0.55	0.49	1.28
19	<i>Holarrhena antidysenterica</i>	7.76	1.91	4.08	1.24	7.22
20	<i>Buchanania lanzan</i>	4.62	1.14	2.06	0.87	4.06
21	<i>Lagerstroemia parviflora</i>	14.95	3.68	6.30	1.61	11.59
22	<i>Lannea coromandelica</i>	7.47	1.83	2.10	0.37	4.31
23	<i>Madhuca indica</i>	6.54	1.61	2.61	3.58	7.80
24	<i>Butea monosperma</i>	18.23	4.48	3.87	3.71	12.05
25	<i>Soymida febrifuga</i>	3.88	0.96	2.06	2.35	5.36
26	<i>Boswellia serrata</i>	1.37	0.33	0.50	0.74	1.58
27	<i>Bombax ceiba</i>	0.08	0.02	0.25	0.03	0.30
28	<i>Dalbergia latifolia</i>	0.12	0.03	0.13	0.02	0.17
29	<i>Ougennia oogenesis</i>	0.08	0.02	0.08	0.01	0.12
30	<i>Diospyros melanoxylon</i>	20.39	5.02	8.78	2.72	16.52
31	Other	79.75	19.60	15.42	18.54	53.56
	Total	406.82				

Table 2: Ecological parameters of the species of the Nagpur Forest division

The results show that the frequency of all main species is high, with *Tectona grandis* having the highest frequency of 10.13, followed by *Diospyros melanoxylon*. The lowest frequency is 0.08 of *Ougennia oogenesis*, followed by *Dalbergia latifolia*. The maximum basal area is occupied by *Tectona grandis* in all the forest. When judged from the important value index again, *Tectona grandis* has the maximum value of 71.78, whereas *Ougennia oogenesis* has the minimum value of 0.12.

3. Calorific Value determination

Based on enumeration data and biodiversity assessment, species-wise calorific value was calculated using a bomb calorimeter, and is found as under:

Sr. No.	Species Name	Calorific value MJ/kg
1	<i>Tectona grandis</i>	20.2
2	<i>Terminalia tomentosa</i>	18.6
3	<i>Terminalia arjuna</i>	5.03
4	<i>Pterocarpus marsupium</i>	19.7
5	<i>Chloroxylon swietenia.</i>	21.51
6	<i>Aegle marmelos</i>	20.4
7	<i>Hardwickia binata</i>	20.5
8	<i>Terminalia bellerica</i>	20.9
9	<i>Buchanania lanzan</i>	25.3
10	<i>Albizia odoratissima</i>	18.15
11	<i>Anogeissus latifolia</i>	16.6
12	<i>Grewia tiliifolia</i>	16.0
13	<i>Cleistanthus collinus</i>	19.1
14	<i>Cochlospermum religiosum</i>	17
15	<i>Adina cordifolia</i>	20.24
16	<i>Acacia catechu</i>	22
17	<i>Mitragyna parviflora</i>	15
18	<i>Miliusa velutina</i>	10
19	<i>Holarrhena antidysenterica</i>	14
20	<i>Buchanania lanzan</i>	27.2
21	<i>Lagerstroemia parviflora</i>	18
22	<i>Lannea coromandelica</i>	18.3
23	<i>Madhuca indica</i>	15
24	<i>Butea monosperma</i>	20.4
25	<i>Soymida febrifuga</i>	18
26	<i>Boswellia serrata</i>	18.2
27	<i>Bombax ceiba</i>	20
28	<i>Dalbergia latifolia</i>	21
29	<i>Ougennia oogeinensis</i>	20.5
30	<i>Diospyros melanoxylon</i>	20.1

Table 3: Calorific values of the species of the Nagpur Forest division.

The results show that the *Tectona grandis* having the highest frequency in the forest area of the Nagpur division having calorific value of 20.2 MJ/Kg, *Buchanania lanzan* having highest calorific value that is 27.2 and overall range of calorific values of different species is 5.02 to 27.2. The high calorific value of wood pellets signifies greater energy efficiency, higher heat output, and cost-effectiveness compared to lower-grade alternatives and traditional fuels. A high calorific value means that more heat is generated per unit of fuel burned. The high calorific value of teak wood signifies a superior energy output, making it a highly efficient and cost-effective biofuel, like other biofuel species.

Conclusion

This study concludes that the area of Nagpur Forest division is rich with floral biodiversity. Biodiversity assessments and calorific values provide a powerful and nuanced understanding of an ecosystem's health, its potential for biomass and energy production, and its capacity to sustain different species, including humans. By themselves, the two metrics offer valuable but limited information; together, they reveal insights into ecological dynamics, resource allocation, and resilience.

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Conflict of interest

None

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