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A Geographical Analysis of Forest-Cover Changes and Deforestation in Northern Nandurbar District, Maharashtra: A Remote-Sensing and GIS-Based Study (1990–2024)

Dr. Raju Zavrao Yashod,

Abstract

This research paper examines forest-cover changes and deforestation in the northern part of Nandurbar District, Maharashtra, with particular reference to Akkalkuwa, Dhadgaon, Taloda, and Shahada Tehsils. The study uses Landsat 5 Thematic Mapper imagery from 15 December 1990 and Landsat 8 Operational Land Imager imagery from 12 December 2024, analyzed through the Normalized Difference Vegetation Index (NDVI) in QGIS. Secondary data from the India State of Forest Report, district records, and field observations are also used. The results indicate a decline in dense and moderate forest cover, an increase in sparse vegetation and bare land, and a reduction in average NDVI from 0.57 in 1990 to 0.42 in 2024. Forest cover declined in all four northern Tehsils between 2005 and 2017, with Dhadgaon recording the largest reduction. Population growth, agricultural expansion, fuel wood collection, grazing, infrastructure development, and weak enforcement of protection measures are identified as major causes of forest degradation. The paper recommends community-based conservation, afforestation with native species, strengthened protection of ecologically sensitive areas, and regular monitoring using remote sensing and GIS.

Keywords: *Forest cover; deforestation; NDVI; remote sensing; GIS; Nandurbar; Maharashtra.*

Introduction:

Forests are essential natural resources because they regulate water cycles, conserve soil, support biodiversity, store carbon, and provide fuel, fodder, and food, timber, and non-timber forest products. In tribal and hilly regions such as northern Nandurbar, forests are closely linked with local livelihoods, water availability, and cultural practices.

Globally, forests cover approximately 31 percent of the land area, but deforestation and forest degradation continue to reduce forest extent and quality. The Food and Agriculture Organization estimates that about 420 million hectares of forest were converted to other land uses between 1990 and 2020, although the annual rate of net forest loss has declined in recent decades.

Nandurbar District lies in the north-western part of Maharashtra and forms part of the Satpura hill region. Its Northern Tehsils—Akkalkuwa, Dhadgaon, Taloda, and Shahada—have historically supported substantial forest cover. However, increasing population, agricultural expansion, developmental projects, fuelwood collection, grazing, and other human activities have placed considerable pressure on forest resources.

The India State of Forest Report (ISFR) 2023 records Nandurbar District's forest cover as 1,128.17 sq. km, or 18.94 percent of its geographical area, with a reported decrease of 64.49 sq. km relative to the 2021 assessment. This confirms that forest loss remains a continuing concern in the district. Hence, the researcher has focused on the **geographical analysis of forest-cover changes and deforestation in Northern Nandurbar District, Maharashtra, and** a remote-sensing and GIS-

Objectives of the Study:

1. To analyse the spatial distribution of forest cover in northern Nandurbar District.
2. To measure changes in forest cover between 2005 and 2017 using government and empirical data.
3. To assess long-term forest-cover transformation from 1990 to 2024 using Landsat satellite imagery and NDVI in GIS.
4. To identify the major geographical, social, economic, and developmental causes of deforestation and forest degradation.
5. To examine the impact of forest loss on tribal communities, soil, water resources, and biodiversity.
6. To suggest practical measures for sustainable forest management and conservation.

Geographical Study Area:

Figure 1. Location map of the study area, northern Nandurbar District.

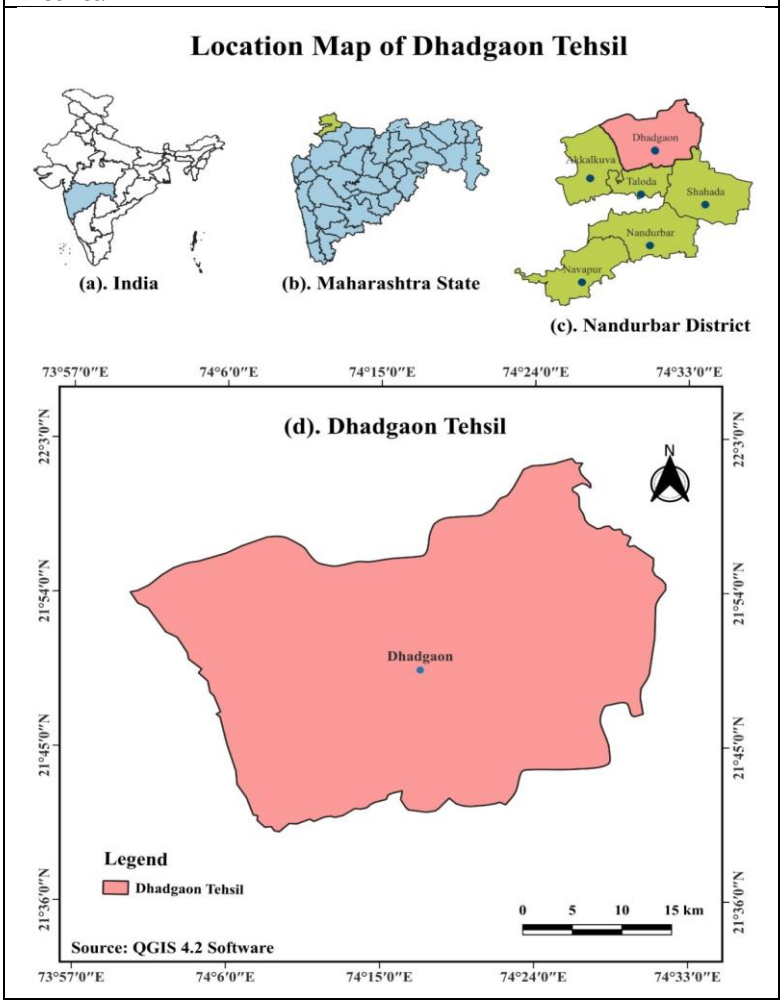


Figure no. 1 shows the study area covers the northern part of Nandurbar District, Maharashtra, mainly including Akkalkuwa, Dhadgaon, Taloda, and Shahada Tehsils. The region lies within the Satpura hill belt and is characterized by rugged terrain, heterogeneous land use, tribal settlements, agricultural land, and forested areas. Dhadgaon Tehsil is a distinct geographical unit with a mountainous setting and a predominantly tribal population.

The northern part of the district receives seasonal rainfall and supports deciduous vegetation. Forest areas provide important ecological services, including soil conservation, groundwater recharge, wildlife habitat, and the supply of fuelwood and minor forest produce to local communities.

Research Methodology

This study adopts an empirical and descriptive research design, combining quantitative remote sensing, secondary data analysis, field observation, and household survey information. Satellite images were processed in QGIS 3.34 to calculate the Normalized Difference Vegetation Index (NDVI).

NDVI is calculated using the following formula:

NDVI = (NIR − RED) / (NIR + RED)

where NIR represents near-infrared reflectance and RED represents red-band reflectance. Higher NDVI values generally indicate denser and healthier vegetation, whereas lower values indicate bare land, water bodies, or sparse vegetation.

Data Sources

- Landsat 5 Thematic Mapper imagery dated 15 December 1990, with 30 m spatial resolution.
- Landsat 8 Operational Land Imager imagery dated 12 December 2024, with 30 m spatial resolution.
- India State of Forest Report data published by the Forest Survey of India.
- District and Tehsil administrative records of Nandurbar District.
- Survey of India topographical sheets.
- Field survey, GPS-based location recording, and observation of land use and forest condition.
- Published research literature and government reports.

Table 1. Details of satellite imagery used in the study

Sr. No.	Satellite/Sensor	Path/Row	Date of Image	Spatial Resolution

1	Landsat 5 Thematic Mapper (TM)	147/045	15 December 1990	30 m
2	Landsat 8 Operational Land Imager (OLI)	147/045	12 December 2024	30 m
Source: U.S. Geological Survey.				

NDVI Classification:

Table 2. NDVI classification used for vegetation and forest-cover analysis.

Class	NDVI Range	Interpretation
Water bodies	Below 0	Rivers, ponds, reservoirs, and other water features
Bare land	0 to 0.25	Bare soil, rock, settlements, and sparsely vegetated land
Sparse forest/vegetation	0.25 to 0.35	Sparse vegetation, degraded forest, and open scrub
Moderate forest	0.35 to 0.50	Moderately dense vegetation and mixed forest
Dense forest	Above 0.50	Dense vegetation and relatively healthy forest cover

Results and Discussion:

Forest-Cover Change, 2005–2017

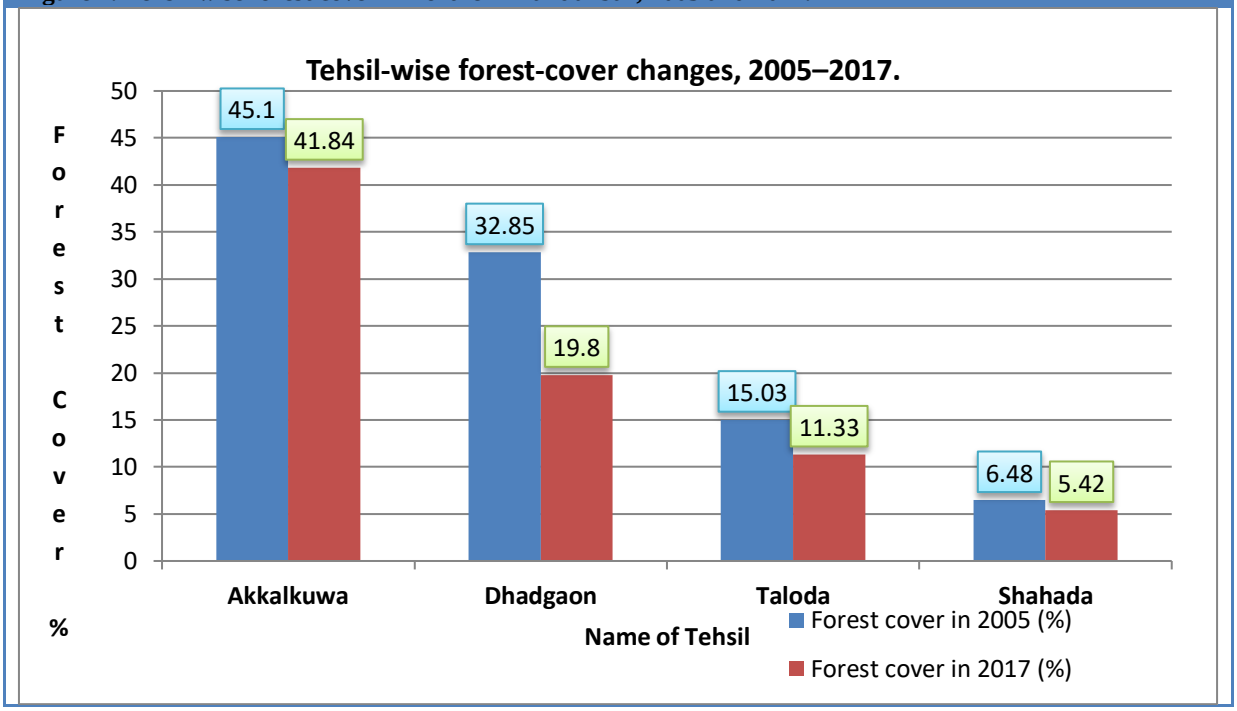
The study finds that forest cover declined in all four northern Tehsils between 2005 and 2017. The overall average forest cover fell from 24.87 per cent to 19.60 per cent, representing a reduction of 5.27 percentage points.

The table no. 3 and figure No. 2 has shows that Dhadgaon Tehsil has experienced the largest decline, from 32.85 per cent to 19.80 per cent, a fall of 13.05 percentage points. This indicates that forest degradation was particularly severe in the hilly and tribal-dominated parts of the study area. Akkalkuwa retained the highest forest cover, although it also recorded a decline of 3.26 percentage points.

Table 3. Tehsil-wise forest-cover changes**, 2005–2017.**

Tehsil	Forest cover in 2005 (%)	Forest cover in 2017 (%)	Change ((% points)
Akkalkuwa	45.10	41.84	−3.26
Dhadgaon	32.85	19.80	−13.05
Taloda	15.03	11.33	−3.70
Shahada	6.48	5.42	−1.06

Figure 2. Tehsil-wise forest cover in northern Nandurbar, 2005 and 2017.



Forest-Cover Class Change, 1990–2024:

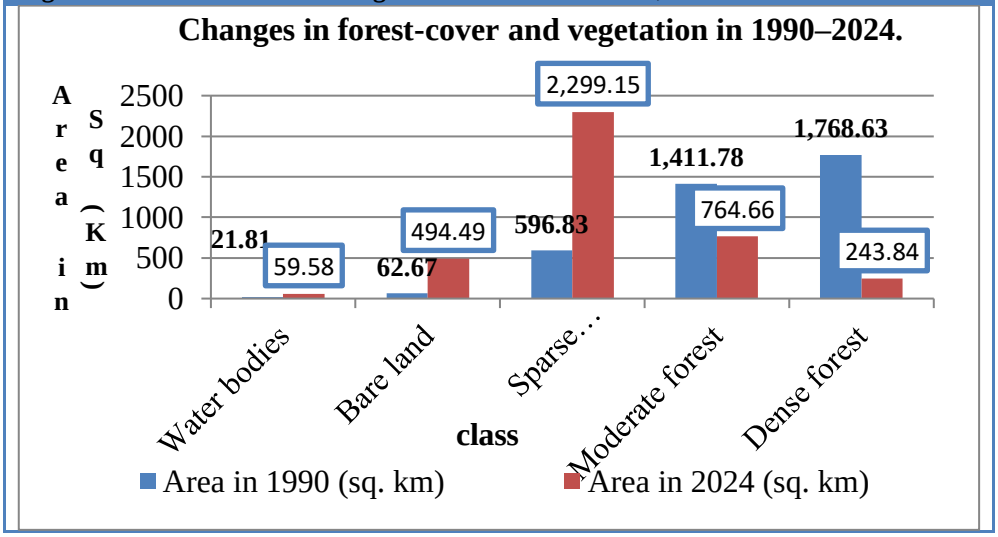
Table 4. Changes in forest-cover and vegetation classes, 1990–2024.

Forest/vegetation class	Area in 1990 (sq. km)	Area in 2024 (sq. km)	Change (sq. km)	Trend
Water bodies	21.81	59.58	+37.77	Increase
Bare land	62.67	494.49	+431.82	Increase

Sparse forest/vegetation	596.83	2,299.15	+1,702.33	Increase
Moderate forest	1,411.78	764.66	−647.12	Decrease
Dense forest	1,768.63	243.84	−1,524.79	Decrease

The Table 4 has shows to The NDVI-based analysis shows a major transformation in vegetation classes between 1990 and 2024. Dense forest declined sharply, while sparse vegetation and bare land increased substantially. These changes suggest both deforestation and progressive forest degradation.

Figure 3. Forest-cover class change in northern Nandurbar, 1990–2024.



The Figure 3 has shows the increase in sparse vegetation does not necessarily represent an improvement in forest quality. In many areas, dense or moderate forest may have been converted into sparse vegetation because of cutting, grazing, fire, soil erosion, or agricultural expansion. Therefore, the increase in sparse vegetation should be interpreted as evidence of forest degradation rather than forest recovery.

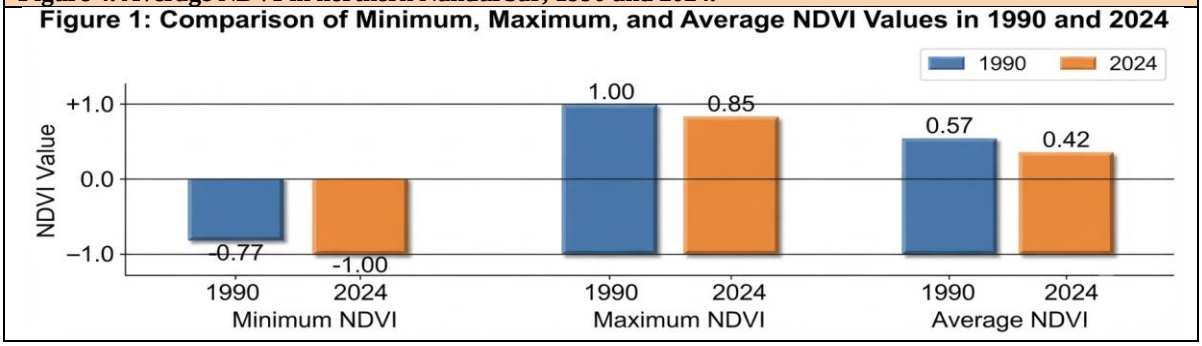
NDVI Change:

Table 5. Minimum, maximum, and average NDVI values, 1990 and 2024.

Year	Minimum NDVI	Maximum NDVI	Average NDVI
1990	−0.77	1.00	0.57
2024	−1.00	0.85	0.42

The Table 5 has shows the average NDVI declined from 0.57 in 1990 to 0.42 in 2024. This reduction indicates a decline in overall vegetation density and vigour across the study area. Although seasonal differences between the two image dates may influence the result, the long-term decline is consistent with the observed increase in sparse vegetation and bare land.

Figure 4. Average NDVI in northern Nandurbar, 1990 and 2024.



Forest Degradation Rate:

Table 6. Estimated forest-cover change and annual degradation rate, 1990–2024.

Study area	Geographical area (sq. km)	Forest-cover area in 1990 (sq. km)	Forest-cover area in 2024 (sq. km)	Total change (sq. km)	Average annual change (sq. km)	Average annual rate (%)
Northern Nandurbar	3,861.72	3,777.24	3,307.65	−469.59	−13.81	−0.37

The Table 6 has shows the estimated forest-cover area declined from 3,777.24 sq. km in 1990 to 3,307.65 sq. km in 2024. This represents a reduction of 469.59 sq. km over 34 years. The average annual reduction is approximately 13.81 sq. km, or about 0.37 per cent per year.

Causes of Deforestation and Degradation:

1) Expansion of cultivated land, especially in and around forest fringes.

2) Population growth and increasing demand for fuelwood, fodder, timber, and construction material.
3) Uncontrolled grazing by livestock.
4) Forest fires, particularly during the dry season.
5) Road construction, mining-related activity, and other infrastructure development.
6) Soil erosion and land degradation on steep slopes.
7) Weak enforcement of forest-protection regulations.
8) Limited participation of local communities in forest protection and management.

Impacts of Forest Loss:

Forest loss affects both the environment and local livelihoods. Reduced tree cover increases soil erosion, lowers groundwater recharge, and intensifies the risk of drought and water scarcity. The loss of forest habitat also threatens wildlife, medicinal plants, and biodiversity.

For tribal communities, deforestation reduces access to fuelwood, fodder, food, and minor forest produce. It can also increase the time and labour required to collect forest resources, particularly for women. In the long term, forest degradation may worsen rural poverty and increase vulnerability to climate-related hazards.

Recommendations:

1) Promote afforestation and reforestation using native and locally suitable species.
2) Strengthen protection of dense forest areas, wildlife habitats, and ecologically sensitive slopes.
3) Encourage community-based forest management through Joint Forest Management committees and tribal institutions.
4) Provide alternative cooking fuel, improved stoves, and energy-efficient technologies to reduce dependence on fuelwood.
5) Control grazing through rotational grazing, fodder development, and awareness programmes.
6) Regularly monitor forest cover using satellite imagery, NDVI, GIS, and field verification.
7) Integrate forest conservation with watershed development, soil-conservation measures, and sustainable agriculture.
8) Strengthen enforcement against illegal cutting, encroachment, and unauthorized land conversion.

Limitations of the Study

The study relies on NDVI-based classification, which may be affected by seasonal variation, atmospheric conditions, cloud cover, and differences between Landsat sensors. Field validation and accuracy assessment are necessary to confirm the reliability of the classified forest-cover categories. In addition, the causes of forest change are influenced by multiple social, economic, and institutional factors that cannot be fully measured through satellite data alone.

Conclusion :

The study shows that northern Nandurbar District has experienced significant forest-cover change and degradation between 1990 and 2024. The decline in dense and moderate forest, the expansion of sparse vegetation and bare land, and the fall in average NDVI indicate increasing pressure on forest resources. Dhadgaon recorded the most severe decline in forest cover between 2005 and 2017.

Sustainable forest management requires a combination of scientific monitoring, community participation, afforestation, protection of sensitive areas, and alternative livelihood and energy options. Remote sensing and GIS can provide valuable support for regular forest monitoring and evidence-based conservation planning.

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Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of thesis paper

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