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EVALUATION OF FOREST DEGRADATION IN AGO OWU FOREST RESERVE, OSUN STATE, NIGERIA: REMOTE SENSING AND GIS APPROACH

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Abstract. Deforestation and forest degradation threaten biodiversity, climate regulation, and local livelihoods, particularly in tropical regions like Nigeria. This study evaluates the extent of deforestation and forest degradation in the Ago Owu Forest Reserve, Osun State, Nigeria, over 40 years (1984–2024) using remote sensing and Geographic Information System (GIS) techniques. This study aims to evaluate the trends of deforestation in Ago Owu Forest Reserve to mitigate the adverse effects of deforestation, to analyze Landsat satellite imagery from the years 1984, 2004, and 2024, using Land Use and Land Cover (LULC) classification and Normalized Difference Vegetation Index (NDVI). The results reveal a dramatic decline in forest cover, from 81.92% in 1984 to 11.26% in 2024. Simultaneously, built-up areas expanded from a negligible 0.056% in 1984 to 37.18% in 2024, highlighting significant human encroachment and urbanization into the forest reserve. The NDVI analysis reveals the degeneration of the forest NDVI from 0.7 to 0.2, indicating a reduction in forest density due to deforestation, urbanization, and logging activities. The findings provide critical insights into the need for effective and efficient deforestation policies to balance ecological preservation.

Keywords: deforestation, forest degradation, NDVI, LULC, vegetation, urbanization.

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1. Introduction

Forests are vital ecosystems that provide a myriad of ecological, economic, and social benefits. They play a crucial role in maintaining global biodiversity, regulating climate, and supporting the livelihoods of millions of people (Goetz et al., 2015). Forests act as carbon sinks, absorbing large amounts of carbon dioxide, which helps mitigate climate change. They also play a critical role in water regulation, soil conservation, and the preservation of wildlife habitats (Enuoh & Ogogo, 2018).

In many parts of the world, forests are under increasing pressure from human activities. Deforestation and forest degradation have emerged as significant global environmental challenges, contributing to biodiversity loss, disruption of water cycles, soil erosion, and increased greenhouse gas emissions (Gashaw et al., 2014; Grecchi et al., 2017; Mensah et al., 2015; Reddy et al., 2016a; Miettinen et al. 2014). These processes are often driven by agricultural expansion, logging, infrastructure development, and other land use changes, particularly pronounced in developing countries like Nigeria (Asifat & Orimoogunje, 2020; Fabiyi, 2011; Enuoh & Ogogo, 2018).

Nigeria, once home to vast tropical rainforests, has experienced a significant reduction in forest cover over the past few decades (Fabiyi, 2011). The country's forest resources have been exploited for timber, fuelwood, and agricultural land, leading to extensive deforestation and forest degradation (Asifat & Orimoogunje, 2020). The rate of forest loss in Nigeria is among the highest in the world, with serious implications for the environment and local communities that depend on forest resources for their livelihoods (Enuoh & Ogogo, 2018; Asifat & Orimoogunje, 2020).

The Ago Owu Forest Reserve in Nigeria, established to protect its rich biodiversity, has experienced significant changes in its forest cover due to illegal logging, agricultural encroachment, and other anthropogenic activities (Asifat & Orimoogunje, 2020; Aderele et al., 2020; Falana et al., 2022). These activities have reduced the extent of forested areas and led to the degradation of remaining forests, affecting their ecological integrity and ability to provide essential ecosystem services. Environmentalists and policymakers are concerned about the continuous loss of forest cover and degradation of remaining areas.

Understanding the dynamics of deforestation and forest degradation in Ago Owu Forest Reserve is crucial for developing effective conservation strategies. Remote sensing and Geographic Information System (GIS) technologies offer powerful tools for monitoring and assessing changes in forest cover over time. These technologies enable researchers to analyze large areas efficiently, providing accurate and up-to-date information on the extent of deforestation and degradation.

Several researchers have conducted studies on forest degradation in various regions like Cross River, Nigeria (Enuoh & Ogogo, 2018); Dera District, Ethiopia (Gashaw et al., 2014); northern Mato Grosso (Grecchi et al., 2017); Ghana (Mensah et al., 2015); western Himalaya, Pakistan (Qamer et al., 2016); Andaman and Nicobar Islands (Reddy et al., 2016b); Brazilian Amazon (Shimabukuro et al., 2019).

Asifat and Orimoogunje (2020) studied forest cover change and species distribution in Ago-Owu Forest Reserve from 1986 to 2016. They used GPS to survey plots and classified them into woody tree families. ArcGIS software version 10.1 was used. Results showed a decline in un-disturbed forest land from 234.98 km^2 in 1986 to 233.66 km^2 in 1996 and a rise in disturbed land area from 42.16 km^2 in 1996 to 44.69 km^2 in 2006. The built-up increased from 17.16 km^2 in 1986 to 96.32 km^2 in 2016. Natural and anthropogenic processes, such as farming, industrial softwood demand, and settlement expansions, were found to be responsible for these changes. However, there is a lack of updated data on the rate and extent of deforestation and degradation in the reserve. This study looks forward to filling this gap by using remote sensing and GIS techniques to evaluate and monitor changes in forest cover over time from 1986 to 2024.

In this study, remote sensing and GIS techniques were utilized to evaluate the extent of deforestation and forest degradation in Ago Owu Forest Reserve. By analyzing satellite imagery over a specific period, the study aims to quantify the changes in forest cover, identify the drivers behind these changes, and assess the impacts on the ecosystem. The findings will provide valuable insights into the current state of the forest reserve and contribute to developing sustainable management practices aimed at conserving this important natural resource.

This research is particularly timely given the increasing global focus on climate change mitigation and biodiversity conservation. As Nigeria works towards achieving its environmental goals under international agreements such as the Paris Agreement and the Convention on Biological Diversity, understanding the factors driving deforestation and forest degradation in key areas like Ago Owu Forest Reserve is essential. The results of this study will not only contribute to the scientific understanding of forest dynamics in Nigeria but also will inform policy decisions and conservation efforts aimed at preserving the country's remaining forest resources.

2. Material and method

2.1. Study area

Ago Owu Forest Reserve is located in Osun State, southwestern Nigeria between the approximated latitude of 7°40′N and 7°50′N and longitude of 4°30′E and 4°40′E, as shown in Figure 1. The reserve encompasses diverse tropical forest ecosystems typical of the region, including moist, dry forests, and associated savannah and transitional zones (Asifat & Orimoogunje, 2020).

Ago Owu Forest Reserve is renowned for its rich biodiversity, housing numerous species of flora and fauna endemic to the region (Falana et al., 2022). The forest provides essential ecosystem services such as carbon sequestration, water regulation, and habitat for wildlife (Aderele et al., 2020). The reserve is home to indigenous communities whose livelihoods depend on the forest resources. It holds cultural significance for local communities, with traditional practices and beliefs often intertwined with forest conservation efforts (Eneji et al., 2019).

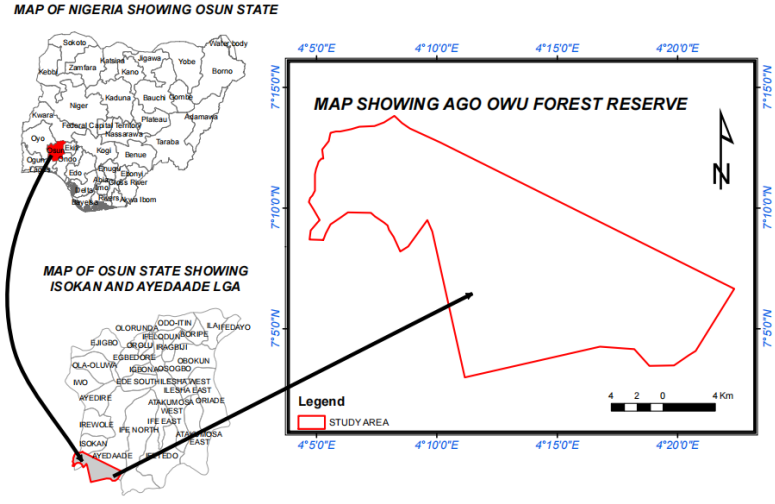

Figure 1. Map of the study area

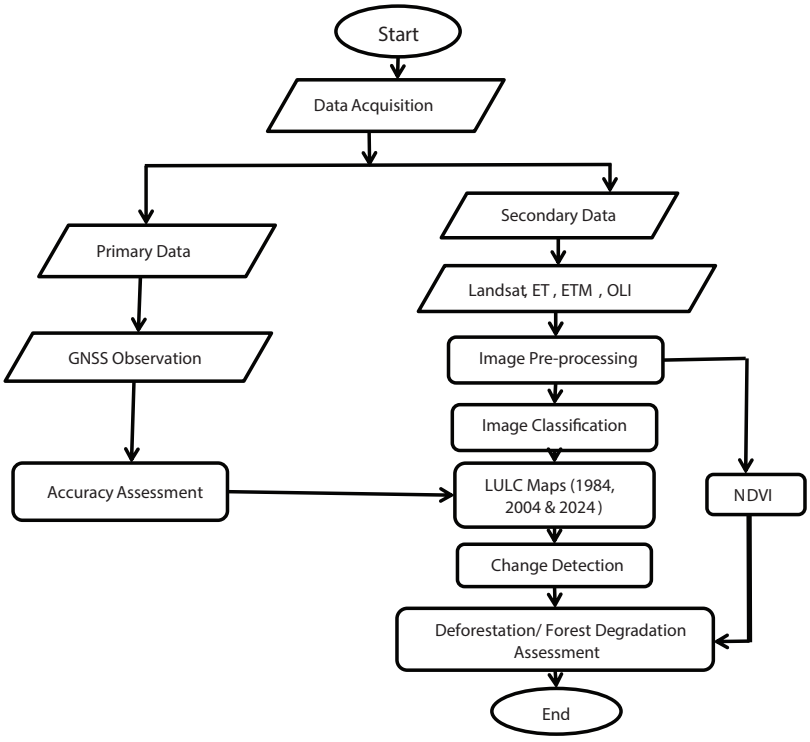

Figure 2. Flowchart of the study

2.2. Method

This research focuses on assessing deforestation and forest degradation of Ago Owu Forest Reserve, Osun State, using remote sensing and GIS techniques. As shown in Figure 2, the study assessed the variations in the Land cover pattern of the study area over four decades (1984, 2004 and 2024) using Landsat satellite datasets (Landsat 4, Landsat 7 & Landsat 8) and ArcGIS software. The accuracy of the classified land cover map was examined by comparing the processed Land cover with the ground information to determine the level of accuracy of the classified image. The study employed change detection methods to analyze LULC changes between 1984, 2004, and 2024. Additionally, the study examined the health of the vegetation and forest within the study area using the Normalized Difference Vegetation Index (NDVI).

2.3. Data collection

The successful execution of this study relies on the utilization of various relevant datasets, along with their respective sources. Both primary and secondary data were used in this study. The primary data used in this study include the ground coordinates obtained through GNSS observations. The secondary data used in this study include Landsat 4 satellite imagery with a spatial resolution of 30.0 meters, Landsat 7 ETM+ (Enhanced Thematic Mapper Plus) satellite imagery with a spatial resolution of 30.0 meters, Landsat 8 OLI (Operational Land Imager) satellite imagery with a spatial resolution of 30.0 meters. Table 1 shows the data collected and its attributes.

2.4. Data processing

2.4.1. Image processing

Identification of bands was made possible through the metadata of the downloaded Landsat imageries for 1984, 2004, and 2024. False color composite imageries were utilized. This study involves the use of Landsat 4, 7, and 8 OLI/TIRS with bands 5, 4, and 3. The first step involved opening ArcMap and activating the necessary toolbox ex-

Table 1. Data and their attributes

S/N	Data type	Data source	Resolution	Year	Uses
1	Landsat 4 TM (Thematic Mapper) satellite imagery with a spatial resolution of 30.0 meters.	U.S. Geological Surveys (U.S.G.S).	30m	1984	LULC 1984
2	Landsat 7 ETM+ (Enhanced Thematic Mapper Plus) satellite imagery with a spatial resolution of 30.0 meters.	U.S. Geological Surveys (U.S.G.S).	30m	2004	LULC 2004
3	Landsat 8 OLI (Operational Land Imager) satellite imagery with a spatial resolution of 30.0 meters.	U.S. Geological Surveys (U.S.G.S).	30m	2024	LULC 2024
4	Ground coordinate	GNSS Observation	2024	Accuracy Assessment	

tensions. The folder containing the Landsat imageries for Ago Owu forest was selected, along with the "add data" icon, and all the bands were picked and uploaded appropriately for Landsat 8 using bands 5, 4, 3.

The identified bands were combined to form a composite map in the ArcMap environment. The boundary of the study area was clipped out from the whole Landsat Image with the location shape.

2.4.2. Image classification

Image classification is sorting pixels into finite numbers of individual classes or categories of data based on the data file value. It is the categorization of all pixels in a digital image into one of several land cover classes or themes. The maximum likelihood classifier, a method of supervised classification was used to classify land cover types of the study area. The area was classified into three (3) different land cover classes: built-up area, forest, and light vegetation.

Supervised image classification in ArcMap involves activating the image classification toolbar, selecting training sites, and generating a spectral signature file. The Ago Owu forest reserve shape file was used to select training samples for various vegetation classes. The spectral signature file was generated using the toolbar. The maximum likelihood technique was applied to obtain a land use and cover map for 1984, 2004, and 2024. The area of each class was computed using the field calculator button, using Eq. (1). The process ensures accurate classification of vegetation in different shades of green.

Area of each Class = Total Number of Pixel per Class × Total Resolution of imageries. (1)

2.4.3. Change detection methods to analyse LULC changes between 1984, 2004, and 2024

The changes that occurred in the study area over time (From 1984 to 2024) were identified and analyzed. Landsat datasets acquired at different time periods (1984, 2004, and 2024) were compared to detect changes in land use or land cover classes.

2.4.4. Vegetation and forest health within Ago Owu Forest Reserve

The Vegetation and forest health within Ago Owu Forest Reserve in 1984, 2004, and 2024 were determined using the Normalized Difference Vegetation Index (NDVI). NDVI uses Red and Near-Infrared bands of Landsat images to determine the state of health of vegetative properties within the area. Hence, it is calculated in ArcGIS 10.8 environment using the expression shown in Eq. (2).

$$NDVI = \frac{NIR - R}{NIR + R}, \quad (2)$$

where: *NIR* is the Near Infrared band of the Landsat series (Band 5 for Landsat 8 and Band 4 for Landsat 7); *R* is the Red Band (Band 4 for Landsat 8 and Band 3 for Landsat 7).

3. Result and discussion

3.1. Land cover pattern of Ago Owu Forest Reserve 1984, 2004 & 2024

Table 2 presents the area covered by the various land-use classes in 1984, 2004, and 2024. In 1984, Ago Owu Forest Reserve encompassed a total area of 305.412 square kilometers, predominantly covered by dense forest occupying 81.92% of the landscape, equivalent to 250.19 square kilometers. Light vegetation, including crops, grasslands, and shrubs, accounted for 18.02% of the area, totaling 55.04 square kilometers, while urban or built-up areas covered 0.056% of the reserve, covering 0.17 square kilometers.

In 2004, there was an increase in Urban or built-up areas, covering 11.07% of the total area, equivalent to 33.81 square kilometers. Conversely, the forest is 18.08%, occupying 55.22 square kilometers, and Light vegetation, categorized as crops, grass, or scrub, covers 70.85% of the reserve's area, totaling 216.38 square kilometers. In 2024, Urban or built-up areas covered 37.18% of the total area, amounting to 113.55 square kilometers. Forest covered 11.26%, occupying 34.39 square kilometers. Light vegetation (crops, grass, and scrub) covered 51.56% of the area, totaling 157.47 square kilometers.

Table 2. Area covered by the various land use classes within the area

Class	% (1984)	Area in Sq. Km (1984)	% (2004)	Area in Sq. Km (2004)	% (2024)	Area in Sq. Km (2024)
Built-up	0.056	0.17	11.07	33.81	37.18	113.55
Forest	81.92	250.19	18.08	55.22	11.26	34.39
Light forest	18.02	55.04	70.85	216.38	51.56	157.47
Total	100	305.412	100	305.412	100	305.412

The 1984 LULC map of Ago Owu Forest Reserve shown in Figure 3 shows that the majority of the reserve was covered by dense forest, with dark green areas representing intact areas and light vegetation patches indicating less dense forest cover. Few built-up areas were visible, suggesting minimal human activities. By 2004, the dark green region decreased, indicating a significant loss of dense forest cover as shown in the 2004 LULC map in Figure 4. The light green areas expanded significantly, indicating an increase in sparse vegetation, likely due to deforestation or forest degradation. The conversion of dense forest to light vegetation is a clear sign of degradation, where the forest's ecological function is diminished. The presence of red patches, representing built-up areas, increased significantly by 2004, indicating a rise in human activities such as settlements, agriculture, or logging operations, which are major contributors to deforestation and forest degradation.

In Figure 5, the 2024 LULC map shows that forest cover in the forest has decreased significantly, with the remaining areas becoming more fragmented and isolated. This indicates ongoing deforestation over the past 20 years,

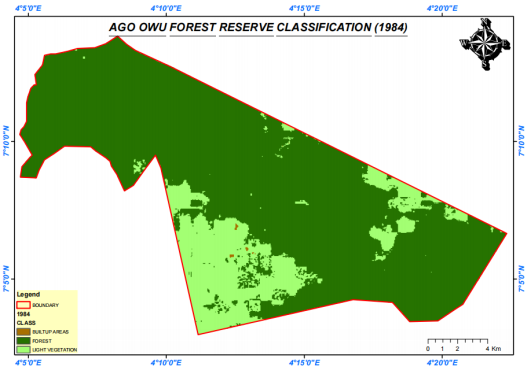

Figure 3. LULC map of the study area for 1984

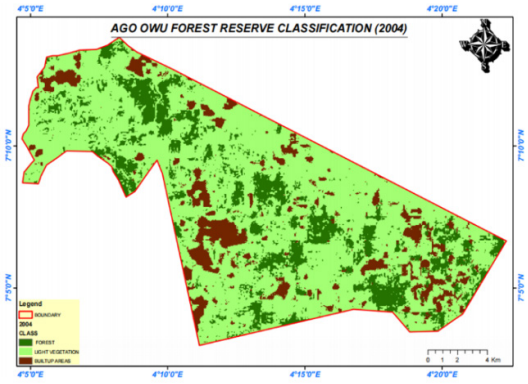

Figure 4. LULC map of the study area for 2004

reducing biodiversity and ecosystem service capabilities. The fragmentation also makes it difficult for wildlife to move between habitats, potentially leading to a decline in species diversity. Light green areas have expanded significantly, indicating ongoing forest degradation due to logging, agricultural expansion, or other land use. This degradation is typically the result of human activities such as selective logging or slash-and-burn agriculture. Without conservation efforts, these areas may become more susceptible to complete deforestation. Built-up areas, which have increased substantially since 2004, are more widespread, especially along the edges of the reserve and

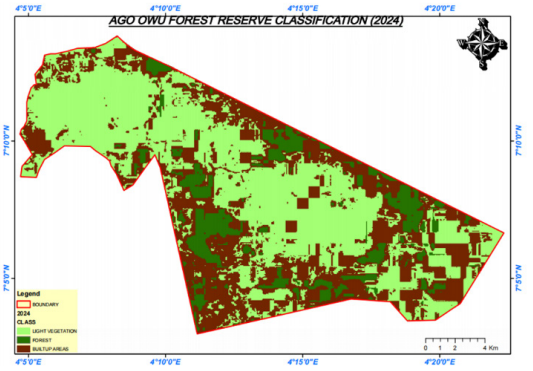

Figure 5. LULC map of the study area for 2024

within previously forested zones. This encroachment not only reduces forest cover but also exacerbates the fragmentation of remaining forest areas, further driving deforestation and degradation.

3.2. Accuracy assessment

Accuracy assessment of the classified land use/land cover maps of the study dates was carried out using user accuracy, producer accuracy, overall accuracy, and Kappa coefficient of 1984, 2004, and 2024 shown in Tables 3–6. From Table 3, it is discovered that 1984 shows the lowest classification accuracy with an overall accuracy of 85.71% and a Kappa coefficient of 0.525, indicating moderate agreement between the classified map and the referenced data. By 2004, the classification significantly improved with an overall accuracy of 96.55% and a Kappa coefficient of 0.948, indicating near-perfect agreement. In 2024, the accuracy remains high with an overall accuracy of 93.10% and Kappa of 0.896, confirming that the classification is still reliable, though slightly lower than in 2004.

3.3. Change detention method

The change detection for Ago Owu Forest Reserve from 1984 to 2024 presented in Table 3 illustrates profound shifts in land cover dynamics. Beginning in 1984, the re-

Table 3. Accuracy assessment of Land cover for year 1984

1984 Accuracy	Forest	Built-up areas	Light vegetation	Total	Commission error (%)	User's accuracy (%)
Forest	7	0	1	8	12.50%	87.50%
Built-up areas	1	8	1	10	10.00%	80.00%
Light vegetation	1	0	9	10	10.00%	90.00%
Total	9	8	11	28		
Commission error (%)	11.11%	0.00%	9.09%			
Producer's accuracy (%)	77.78%	100.00%	81.82%			
Overall classification accuracy	85.71%					
Kappa coefficient = P(a) – P(R) / 1 – P(R)						
P(a)		0.86				
P(R)		0.334183673				

Table 4. Accuracy assessment of Land cover for year 2004

2004 accuracy	Forest	Built-up areas	Light vegetation	Total	Commission error (%)	User's accuracy (%)
Forest	9	0	1	10	10.00%	87.50%
Built-up areas	0	8	0	10	0.00%	80.00%
Light vegetation	0	0	9	9	0.00%	90.00%
Total	9	8	10	29		
Commission error (%)	0.00%	0.00%	0.00%			
Producer's accuracy (%)	100.00%	100.00%	90.00%			
Overall classification accuracy	96.55%					
Kappa coefficient = p(a) – p(r) / 1 – p(r)	94.83%					
P(a)		0.97				
P(R)		0.33293698				

Table 5. Accuracy assessment of Land cover for year 2024

2024 accuracy	Forest	Built-up areas	Light vegetation	Total	Commission error (%)	User's accuracy (%)
Forest	10	0	0	10	0.00%	100.00%
Built-up areas	0	8	1	9	11.11%	88.89%
Light vegetation	1	0	9	9	10.00%	90.00%
Total	11	8	10	29		
Commission error (%)	9.09%	0.00%	10.00%			
Producer's accuracy (%)	90.91%	100.00%	90.00%			
Overall classification accuracy	93.10%					
Kappa coefficient = P(a) – P(R) / 1 – P(R)	89.64%					
P(a)		0.93				
P(R)		0.335315101				

serve was predominantly covered by dense forest, constituting 81.92% of the area, with minimal urban development and lighter vegetation types. By 2004, urbanization accelerated, expanding built-up areas to 11.07% of the reserve while forest cover decreased sharply to 18.08%. Lighter vegetation types, notably light forest, surged to 70.85%, indicative of significant land use changes. By 2024, urban areas continued to expand rapidly, covering 37.18% of the reserve, further diminishing forest cover to 11.26%. The light forests also decreased, signaling ongoing environmental changes. These trends highlight increasing pressures from urban expansion and their detrimental effects on forest ecosystems.

The chart in Figure 6 clearly shows a trend of significant deforestation in the Ago Owu Forest Reserve, with forest cover decreasing from 81.92% in 1984 to 11.26% in 2024. This trend is likely driven by human activities such as logging, agriculture, and urban expansion. The increase in light vegetation areas from 18.02% in 1984 to 70.85% in 2004, followed by a slight decrease to 51.56% in 2024, indicates ongoing forest degradation. While some areas may have experienced slight recovery, the overall picture points to a severely degraded forest ecosystem. The growth in built-up areas from 0.056% in 1984 to 37.18% in 2024 highlights the significant impact of human encroachment. The rapid expansion of settlements or agricultural areas within the reserve is a primary cause of deforestation and forest degradation.

Table 6. Change Detection between 1984, 2004 & 2024

Class	% (1984)	Area in SQ. KM (1984)	% (2004)	Area in SQ. KM (2004)	Change 1 (2004–1984)	% (2024)	Area in SQ. KM (2024)	Change 2 (2024–2004)
Built-up	0.056	0.17	11.07	33.81	33.64	37.18	113.55	79.74
Forest	81.92	250.19	18.08	55.22	–194.97	11.26	34.39	–20.83
Light vegetation	18.02	55.04	70.85	216.38	161.34	51.56	157.47	-58.91
Total	100	305.412	100	305.412	0	100	305.412	0

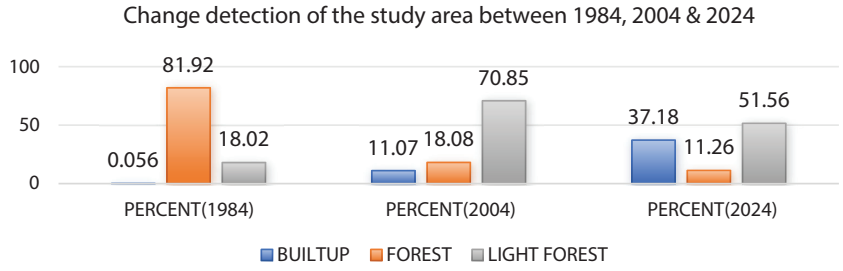

Figure 6. Change in Land cover of Ago Owu Forest Reserve 1984, 2004 & 2024

3.4. Result on vegetation/forest health within Ago Owu Forest Reserve

NDVI (Normalized Difference Vegetation Index) is a numerical indicator used in remote sensing to assess whether the observed target contains live green vegetation or not. NDVI values range from –1 to 1. Higher values indicate healthier, denser vegetation, while lower values can indicate sparse vegetation or non-vegetative surfaces.

Figures 7–9 show the NDVI map for 1984, 2004, and 2024 respectively. The green areas represent regions with dense and healthy vegetation. The red and brown areas indicate regions with lower NDVI values, suggesting sparse vegetation or degraded areas. These could be areas where the forest was either less dense or had already undergone some level of degradation due to natural factors or human activities like logging or agriculture.

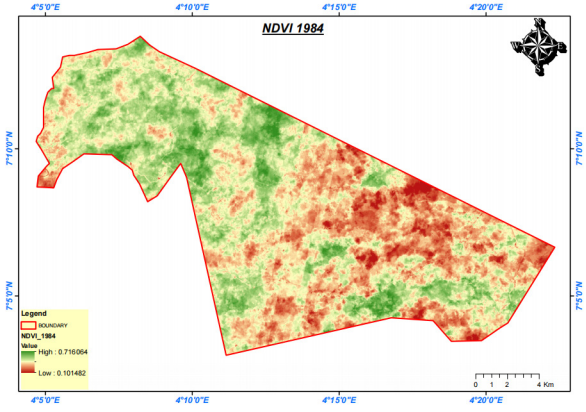

Figure 7. NDVI map of the study area for 1984

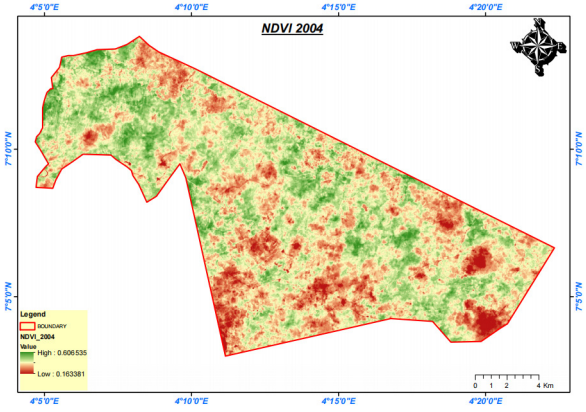

Figure 8. NDVI map of the study area for 2004

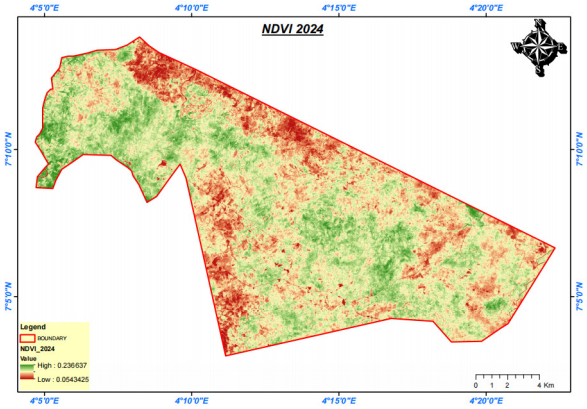

Figure 9. NDVI map of the study area for 2024

In 1984, the highest NDVI recorded was 0.7. The NDVI indicated dense and healthy vegetation/forest within the reserve The high NDVI values (closer to +1) suggest that these parts of the forest were well-preserved and had a thick canopy cover, indicating a relatively intact forest ecosystem in 1984. However, by 2004, the NDVI had decreased to 0.6, suggesting a significant reduction in vegetation/forest health indicating a reduction in forest density due to factors such as deforestation for agricultural expansion, urbanization, and logging activities. This trend worsened by 2024, with the NDVI plummeting to 0.2, indicating less biomass production and a less healthy or less dense forest indicative of ongoing deforestation and continued forest degradation in the reserve.

4. Conclusions

The research evaluates deforestation and forest degradation in Ago Owu Forest Reserve, Osun State, using remote sensing and GIS techniques. It assesses land cover patterns over four decades at an epoch of 20 years (1984, 2004 & 2024) using Landsat satellite datasets (Landsat 4, Landsat 7 & Landsat 8) and ArcGIS software. Accuracy is assessed by comparing processed land cover maps with ground conditions. Change detection methods are used to analyze LULC changes between 1984, 2004, and 2024. Vegetation and forest health are assessed using the Normalized Difference Vegetation Index (NDVI).

The land cover changes observed in Ago Owu Forest Reserve from 1984 to 2024 reveal a significant

transformation in its landscape composition, reflecting ongoing processes of urban expansion, deforestation, and alterations in vegetation types. In 1984, the reserve was predominantly covered by dense forest, constituting 81.92% of its total area. Light vegetation and urban areas made up 18.02% and 0.056%, respectively. This initial snapshot illustrates a largely intact forest ecosystem with minimal urban encroachment.

By 2004, there was a notable increase in urban or built-up areas, expanding to cover 11.07% of the reserve. Concurrently, forest cover decreased to 18.08%, while light vegetation increased to 70.85%. This period marks a significant shift driven by urbanization and an increase in light vegetation (crops, grass, or scrub) leading to the reduction of forested areas. In 2024, Light vegetation remained predominant, and urban or built-up areas further expanded to cover 37.18% of the reserve, demonstrating a rapid pace of urban development. Forest cover significantly declined to 11.26%, indicating continued deforestation pressures.

The downward trend in NDVI values from 1984 to 2024 highlights a concerning trajectory of deforestation and forest degradation within Ago Owu Forest Reserve. The initial high NDVI values in 1984 reflected a healthy and densely vegetated landscape, predominantly covered by dense vegetation (forest). However, rapid urban expansion and deforestation over the decades have led to a sharp decline in forest cover and vegetation health, as evidenced by the decreasing NDVI values. These findings underscore the urgent need for effective conservation measures and sustainable land management practices to mitigate further degradation.

This research will enhance the government of Osun state in its plans to improve forest monitoring systems, detect deforestation, and improve decision-making for forest protection and conservation.

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Author contributions

Paul T. Elufisan and Kolawole S. Ilesanmi conceived the study and were responsible for the design and development of the data analysis. Peter T. Adetoro and Paul T. Elufisan were responsible for data collection and analysis. Paul T. Elufisan was responsible for data interpretation and write-up. Kolawole S. Ilesanmi was responsible for corrections and proofreading.

Disclosure statement

No competing financial, professional, or personal interests on this study.

References

Aderele, M. O., Bola, T. S., & Oke, D. O. (2020). Land use/land cover changes of Ago-Owu Forest Reserve, Osun State, Nigeria using remote sensing techniques. *Open Journal of Forestry*, *10*(4), 401–411. https://doi.org/10.4236/ojf.2020.104025

Asifat, J. T., & Orimoogunje, O. O. I. (2020). Forest cover change and species distribution in Ago-Owu Forest Reserve, Osun State, South-Western, Nigeria. *Tropical Plant Research*, *7*(2), 357–365. https://doi.org/10.22271/tpr.2020.v7.i2.041

Eneji, C. V. O., Ogundu, C. N., & Ojelade, I. A. (2019). Indigenous cultural practices and natural resources conservation in Owerri, Imo State, Nigeria. *Advances in Social Sciences Research Journal*, *6*(9), 382–392. https://doi.org/10.14738/assrj.68.6381

Enuoh, O. O., & Ogogo, A. U. (2018). Assessing tropical deforestation and biodiversity loss in the Cross-River Rainforest of Nigeria. *Open Journal of Forestry*, *8*(3), Article 86263. https://doi.org/10.4236/ojf.2018.83025

Fabiyi, O. (2011). Change ACTORS' analysis and vegetation loss from remote sensing data in parts of the Niger Delta region. *Journal of Ecology and the Natural Environment, 3*(12), 381–391.

Falana, A. R., Ademigbuji, A. T., Odeyale, O. C., Ibode, T. R., Ojo-Fakuade, F. F., Bamigboye, T. O., & Aigbokhan, O. J. (2022). Assessment of agroforestry practices in Ago-Owu Forest Reserve, Ayedaade local government area, Osun State, South-Western Nigeria. *Journal of Applied Sciences and Environmental Management*, *26*(10), 1621–1627. https://doi.org/10.4314/jasem.v26i10.1

Gashaw, T., Bantider, A., & Mahari, A. (2014). Evaluations of land use/land cover changes and land degradation in Dera District, Ethiopia: GIS and remote sensing-based analysis. *International Journal of Scientific Research in Environmental Sciences*, *2*(6), 199–208.

Goetz, S. J., Hansen, M., Houghton, R. A., Walker, W., Laporte, N., & Busch, J. (2015). Measurement and monitoring needs, capabilities and potential for addressing reduced emissions from deforestation and forest degradation under REDD+. *Environmental Research Letters*, *10*, Article 123001. https://doi.org/10.1088/1748-9326/10/12/123001

Grecchi, R. C., Beuchle, R., Shimabukuro, Y. E., Aragão, L. E., Arai, E., Simonetti, D., & Achard, F. (2017). An integrated remote sensing and GIS approach for monitoring areas affected by selective logging: A case study in Northern Mato Grosso, Brazilian Amazon. *International Journal of Applied Earth Observation and Geoinformation*, *61*, 70–80. https://doi.org/10.1016/j.jag.2017.05.001

Mensah, F., Adanu, S. K., & Adanu, D. K. (2015). Remote sensing and GIS based assessment of land degradation and implications for Ghana's ecological zones. *Environmental Practice*, *17*(1), 3–15. https://doi.org/10.1017/S1466046614000465

Miettinen, J., Stibig, H.-J., & Achard, F. (2014). Remote sensing of forest degradation in Southeast Asia – aiming for a regional view through 5–30 m satellite data. *Global Ecology and Conservation*, *2*, 24–36. https://doi.org/10.1016/j.gecco.2014.07.007

Qamer, F. M., Shehzad, K., Abbas, S., Murthy, M. S. R., Xi, C., Gilani, H., & Bajracharya, B. (2016). Mapping deforestation and

forest degradation patterns in Western Himalaya, Pakistan. *Remote Sensing*, *8*(5), Article 385. https://doi.org/10.3390/rs8050385

Reddy, C. S., Manaswini, G., Satish, K. V., Singh, S., Jha, C. S., & Dadhwal, V. K. (2016a). Conservation priorities of forest ecosystems: Evaluation of deforestation and degradation hotspots using geospatial techniques. *Ecological Engineering*, *91*, 333–342. https://doi.org/10.1016/j.ecoleng.2016.03.007

Reddy, C. S., Satish, K. V., Pasha, S. V., Jha, C. S., & Dadhwal, V. K. (2016b). Assessment and monitoring of deforestation and land-use changes (1976–2014) In Andaman and Nicobar Islands, India using remote sensing and GIS. *Current Science*, *111*(9), 1492–1499. https://doi.org/10.18520/cs/v111/i9/1492-1499

Shimabukuro, Y. E., Arai, E., Duarte, V., Jorge, A., Santos, E. G. D., Gasparini, K. A. C., & Dutra, A. C. (2019). Monitoring deforestation and forest degradation using multi-temporal fraction images derived from Landsat sensor data in the Brazilian Amazon. *International Journal of Remote Sensing*, *40*(14), 5475–5496. https://doi.org/10.1080/01431161.2019.1579943