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ASSOCIATED DRIVERS OF DEFORESTATION DYNAMIC IN OPARA FOREST RESERVE, OYO STATE, NIGERIA

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ABSTRACT

Forest ecosystems play a critical role in climate regulation, biodiversity conservation, and socioeconomic sustainability. However, rapid deforestation driven by anthropogenic activities threatens these benefits, particularly in tropical regions. Therefore, this study examines deforestation pattern and its associated drivers in Opara Forest Reserve, Nigeria. Multi-temporal Landsat imagery between 1984 and 2025 were obtained, and structured questionnaire were used to elicit information on the factors influencing forest cover changes. Maximum Likelihood Algorithm was used to classify forest cover dynamics into Land Use Land Cover (LULC). Logistic regression was used to evaluate deforestation drivers from 200 stakeholder surveys from forest edged communities. Three LULC were identified; forest, farmland and non-forest. About 56.3% net forest loss (1984–2025) were observed, with deforestation peaking at 2.7% annually (2013–2021). Forest cover declined from 71.3% (1984) to 27.1% (2021), while farmland and non-forest areas expanded significantly. The ecological impacts of this transformation align with threshold theory, demonstrating that forest degradation below 34% cover triggers disproportionate biodiversity loss and ecosystem service decline. Agricultural expansion (11.867 Odds Ratio), demand for timber (3.577 Odds Ratio), and lack of law enforcement (2.467 Odds Ratio) contribute significantly to deforestation in the Okpara Forest Reserve at $p < 0.05$). Notably, the study documents spatial variations in deforestation perceptions and solution preferences among local communities, highlighting the complex interplay between ecological thresholds and human dimensions of forest management. These findings contribute to both theoretical and applied dimensions of forest conservation. The empirical evidence of nonlinear deforestation trajectories advances our understanding of ecological thresholds in tropical forest systems.

***Keywords**: Conservation, Deforestation, Remote Sensing, Geographic Information System, Land-Use Change, Opara Forest Reserve, and Forest Governance.*

INTRODUCTION

The world’s forests provide a great service and benefits to our ecosystems. It provides foundations for life on earth through ecological functions by regulating the climate, water and soil resources, and also by serving as habitats for plants and animals (Sekercioglu, 2010; Alegbeleye *et al.*, 2025) Moreover, it also provides a variety of essential goods for domestic and export markets (Adla *et al.*, 2020). Similarly, forests area is used for recreation, tourism and other local opportunities (Zhiyanski *et al.*, 2021) According to Fasona *et al.* (2022), deforestation is the conversion of forest to another land use or the long-term reduction of the tree canopy cover below the minimum 10% threshold. Globally, annual deforestation amounts to about 13.7 million hectares and it has been widely recognized that curbing this forest loss is essential for both the maintenance of biodiversity and for cutting greenhouse gas emissions (FAO, 2005; GFW, 2023). The escalating rate of deforestation presents a critical environmental challenge worldwide, with Nigeria being significantly affected (Alo *et al.*, 2021; Alegbeleye *et al.*, 2024). Rapid population growth (2.8% annually) and accelerated urban expansion (4.5% annually) continue to drive land-use changes, threatening forest ecosystems across the country (Arowolo and Deng, 2018). In Oyo State, this crisis is driven by multiple pressures, including unsustainable grazing practices and wildfires, which have led to severe forest degradation (Akinyemi, 2018). These anthropogenic activities, as documented in Gambari Forest Reserve (Onilude *et al.* 2019), have resulted in substantial biodiversity loss and irreversible depletion of genetic resources. The conversion of forested lands to alternative uses has further exacerbated ecological imbalances, highlighting the urgent need for sustainable land management strategies (Akintunde-Alo *et al.*, 2024). Like some of the forest reserves in the country, Opara forest reserve has been in existence for over six decades but there is inadequate information on the land-use-land-cover dynamic, and the little available information are outdated. Therefore, to manage Opara forest reserve sustainably, there is a need for accurate information on the land-use-land-cover dynamic occurring in the reserve. This study aims to analyze deforestation patterns in Opara Forest Reserve by assessing decadal land-use changes, quantifying deforestation rates, and identifying key drivers of the deforestation dynamics to inform sustainable management strategies.

In conclusion, this study provides critical insights into deforestation patterns in Opara Forest Reserve, filling a crucial research gap through its comprehensive decadal analysis. By employing geospatial technologies to map land-use changes and quantify deforestation rates, the research offers an evidence-based foundation for sustainable forest management. The findings will enable policymakers and conservationists to develop targeted interventions that address the specific drivers of forest loss while preserving biodiversity.

METHODOLOGY

Study Area

The study was carried out in Opara forest reserve of Oyo state. The reserve is situated within three local government areas of the state: Saki, Atisibo, and Iwajowa. Opara Forest Reserve occupies the western region of Oyo State, geographically positioned between latitude 7°52'26.40"N to 8°43'19.20"N, and longitudes 3° 9'3.60"E to 3° 3'46.80"E (Figure 1). Opara forest reserve is about 246,640 hectares (ha) and it is the largest of all forest reserve in the state accounting for about 72.6% of the entire forest reserve in the state (Alo, 2017). The neighboring community includes the Wasimi, Ijio, Ago ofiki amd Idi Araba. The study area exhibits a tropical savanna climate with marked wet and dry seasons. Rainfall is strongly seasonal, beginning in mid-March and lasting through October, with peak precipitation occurring between April and July. A short dry spell typically interrupts the rains in August, followed by a prolonged dry season from November to March. Mean annual temperatures remain consistently high around 27^{o}C throughout the year (Husing *et al.*, 2019). The vegetation consists of wooded savanna, a transitional zone between forest and grassland ecosystems. This derived savanna landscape features a mosaic of fire-resistant trees interspersed with woodland patches and tall grasses, characteristic of Nigeria's forest-savanna ecotone. The vegetation structure reflects adaptation to seasonal drought and periodic wildfires, which shape species composition and distribution patterns in the area (Olajuyigbe *et al.*, 2023). The study area lies within the Precambrian Basement Complex of southwestern Nigeria, characterized by migmatites, biotite garnet-schists, and quartzites as the predominant rock types (Elueze, 1981; Rahaman, 1988). These crystalline igneous and metamorphic rocks are typically impermeable, with limited primary porosity and permeability. However, secondary aquifers develop through weathering and fracturing processes, creating viable groundwater storage and transmission zones. (Husing *et al.*, 2019).

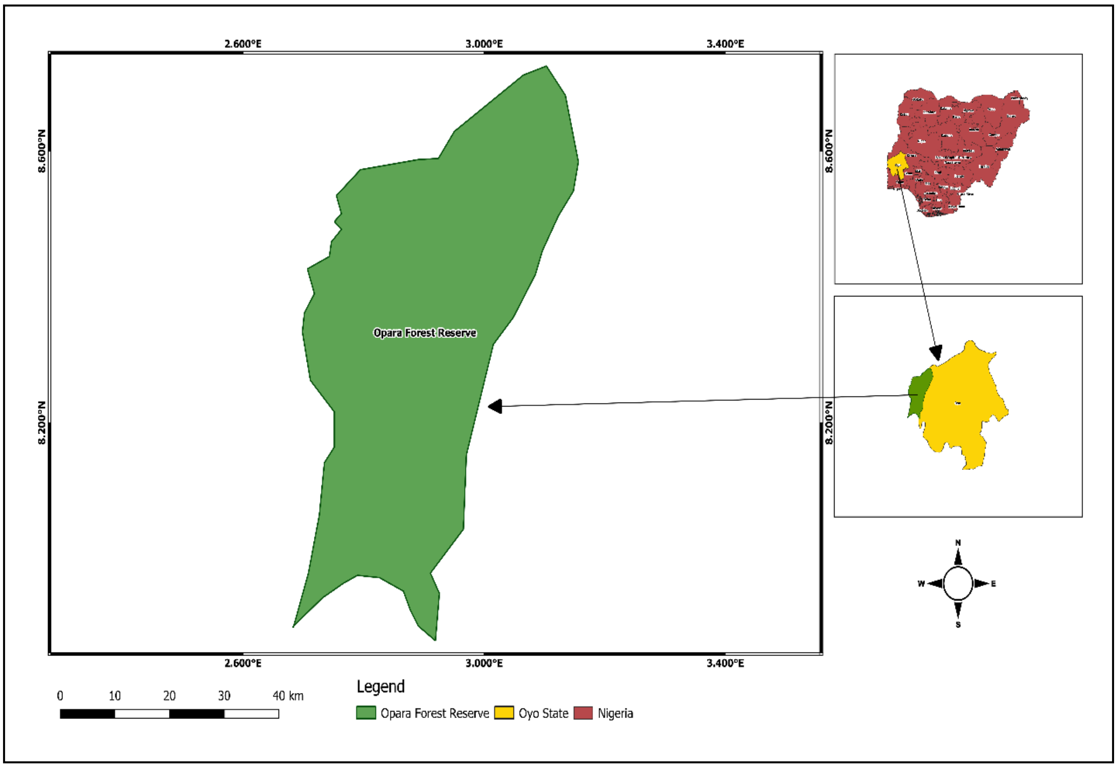

Figure 1: Map Of Opara Forest Reserve.

Data Collection

Both primary and secondary data were used for this study. The primary data was collected using structured questionnaires targeting key stakeholders in two forest-adjacent communities (Ijio and Saki West), which were purposively selected due to their proximity to the forest reserve. The study engaged three main stakeholder groups: local settlers, charcoal producers, and forest officers. A random sampling approach was used to select 200 settlers, while a systematic 50% sampling method was applied to charcoal producers, resulting in 75 participants from a registered pool of 150. Additionally, two forest officers were purposively interviewed to obtain institutional perspectives. The questionnaires were designed to assess deforestation drivers, land-use practices, and conservation attitudes. The satellite imageries comprising Landsat 5 (Thematic Mapper), Landsat 7 (Enhanced Thematic Mapper) Landsat 8 and 9 (Operational Land Imager) for the years 1984 to 2025 was downloaded from the United State of Geological Survey (USGS) website. The imageries downloaded was used for Land Use Land Cover (LULC) mapping for the years 1984, 1990, 2013, 2011, 2021 and 2025. The boundary data for the map of study area was produced using Google Earth pro. Data were collected for the key benchmark locations, including major roads, junctions, rivers, and hills around the reserve from the satellite imagery. Secondary data which contains information on neighboring communities, their activities, and a sketch map of Opara Forest Reserve was obtained from the Oyo State Department of Forestry.

Data Analysis

Image Pre-processing

The downloaded imageries were processed in the ArcGIS and QGIS interface. Principal component Analysis was used for the bands selection and modification of the pixel value of the images. This was done to improve interpretability of the images and extract information from data which may not readily visible in raw form.

Image Classification

In this study, image classification was performed using the Maximum Likelihood Classifier (MLC). Image classification involves assigning each pixel to a specific spectral class based on its spectral characteristics, utilizing predefined training datasets derived from the available spectral information. A modified version of the Anderson (1976) scheme of land use /land cover classification were adopted as was done by Alo *et al.,* (2020) and Agbor *et al.*, (2021) for the image classification (Table 1).

Table 1: Land Use Land Cover Description

LUC Categories	**Description**
Forest area	They include: evergreen, deciduous and wetland forest vegetation.
Farmland/grassland	This includes sown pasture and rangeland.
Non-Forest area	They include bare land, which are land area not under agriculture uses during the study; and settlements which are the residential areas, road and network.

Source: *Monica Cavinaw Geography, (2007)*

Accuracy Assessment

The accuracy of the land use/land cover classification was evaluated using an error matrix approach. Reference data collected from high-resolution imagery were compared with the classified map at randomly selected sample points. The error matrix was generated by cross-tabulating the classified map categories (rows) against the reference data (columns). From this matrix, key accuracy metrics including overall accuracy, producer's accuracy, user's accuracy, and Kappa coefficient were computed to quantitatively assess the classification performance and identify sources of error in the LULC mapping.

Land Cover Change Analysis

To determine the rate of changes over the years assessed for the study area, change detention examination was carried out. The Absolute change, percentage change for each year, and the average rate of change between the years were all calculated using the formula below

$$Absolute\ Change\ (\%) = A_{final} - A_{initial} \tag{1}$$

$$Percentage\ Change\ (\%) = \left(\frac{A_{final} - A_{initial}}{A_{initial}}\right) X100 \tag{2}$$

$$Average\ Rate\ of\ Change\ (\%/year) = \frac{Percent\ Change}{\Delta T} \tag{3}$$

Where:

$A_{initial}$= Area at start time
A_{final}= Area at end time
ΔT= Time interval (in years)

Factors Influencing the Rate of Deforestation

The responses from structured questionnaire were analyzed using both descriptive and inferential statistics. Logit regression analysis was used to quantify the impacts of various activities affecting deforestation in the study area.

$$\log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k + \epsilon \tag{4}$$

Where:

p=probability of deforestation occurrence

β_0=*intercept term,*
$\beta_{1..k}$=*Coefficients of predictor variables* $X_{1..k}$ *(e.g., distance to settlements, charcoal production intensity)*
ϵ=*Error term*

RESULTS

Land Use Land Cover Dynamic of Opara Forest Reserve

As shown in Table 2, the forest area was 156,915.50 hectares (71.30% of total area) in 1984. By 1990, it decreased to 137,316.20 hectares (62.40%). In 2000, forest cover further declined to 93,440.25 hectares (42.46%). The downward trend continued to 75,740.22 hectares (34.42%) in 2013 and reached its lowest point at 59,523.57 hectares (27.05%) in 2021. A slight recovery is projected to 68,513.08 hectares (31.13%) by 2025. Farmland and grassland initially expanded from 41,288.76 hectares (18.76%) in 1984 to 47,517.57 hectares (21.59%) in 1990. The expansion continued to 77,960.70 hectares (35.43%) in 2000 and peaked at 87,176.70 hectares (39.60%) in 2013. After 2013, farmland decreased to 75,002.49 hectares (34.08%) in 2021 and is projected to decline further to 24,692.52 hectares (11.22%) by 2025. Non-forest areas increased steadily from 21,848.40 hectares (9.93%) in 1984 to 35,218.89 hectares (16.01%) in 1990. The growth continued to 48,651.66 hectares (22.11%) in 2000, 57,135.69 hectares (25.69%) in 2013, and 85,526.55 hectares (38.87%) in 2021. By 2025, non-forest areas are projected to reach 126,847.00 hectares (57.64%).

Accuracy Assessment

Table 3 presents classification accuracy metrics for three land use/land cover (LULC) classes (Forest, Farmland/Grassland, and Non-Forest) across the years 1984, 1990, 2000, 2013, 2021, and 2025. The Forest class showed an initial increase in Producer's Accuracy (PA) from 83.1%

Table 2: Land Use Land Cover Classification Area.

Classification	1984		1990		2000		2013		2021		2025	
	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
Forest	156915.50	71.30	137316.20	62.40	93440.25	42.46	75740.22	34.42	59523.57	27.05	68513.08	31.13
Farmland/ grassland	41288.76	18.76	47517.57	21.59	77960.70	35.43	87176.70	39.60	75002.49	34.08	24692.52	11.22
Non-forest	21848.40	9.93	35218.89	16.01	48651.66	22.11	57135.69	25.69	85526.55	38.87	126847.0	57.64
Total	**220052.6**	**100**	**220052.6**	**100**	**220052.6**	**100**	**220052.6**	**100**	**220052.6**	**100**	**220052.6**	**100**

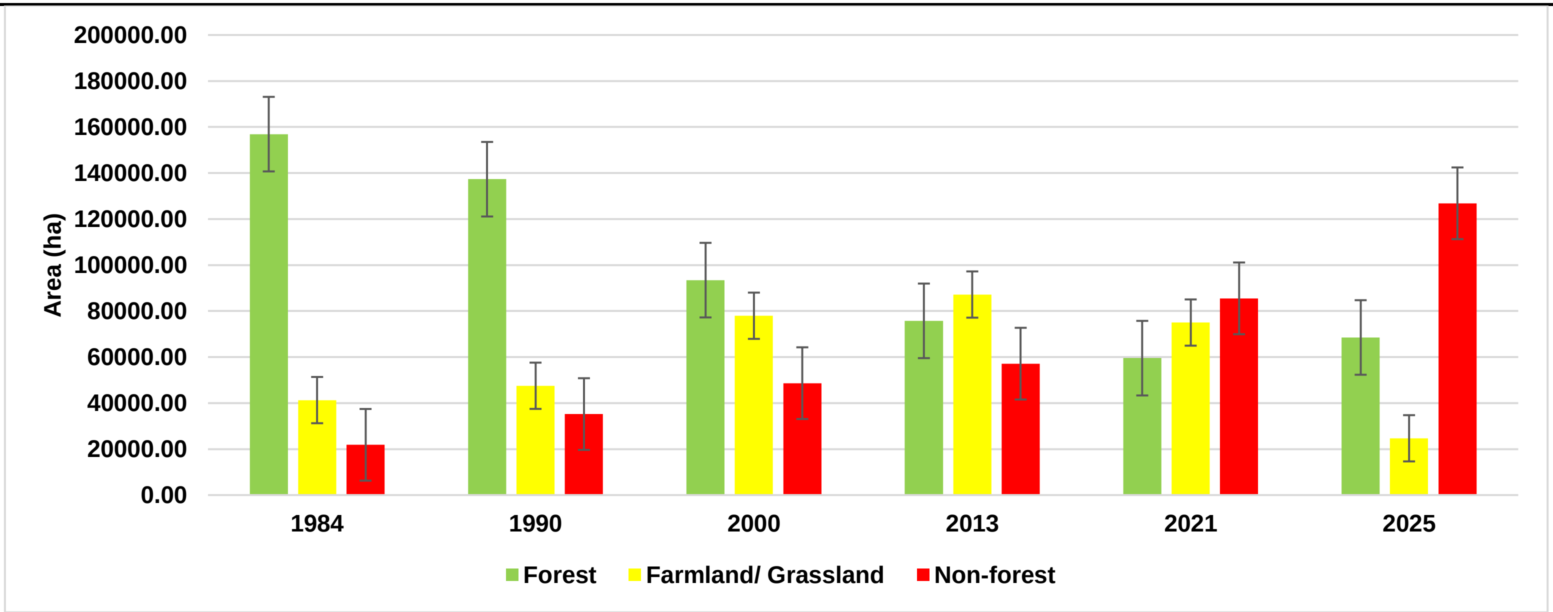

Figure 2: Distributions of Land Use Land Cover in Opara Forest Reserve

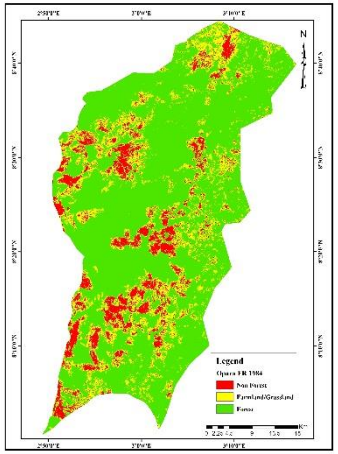

Figure 3: 1984 Opara LULC

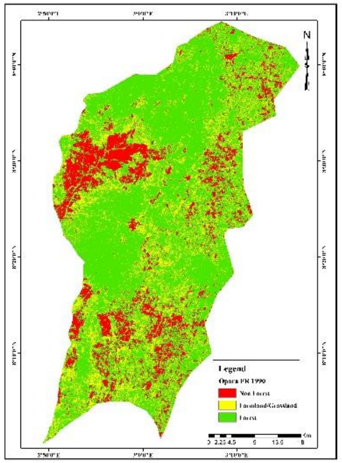

Figure 4: 1990 Opara LULC

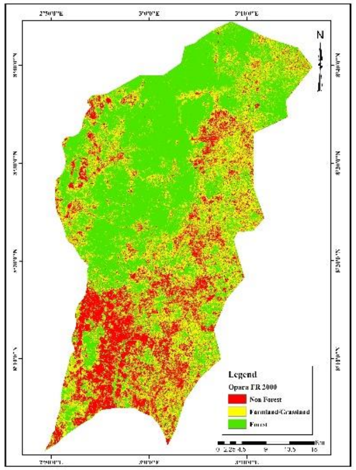

Figure 5: 2000 Opara LULC

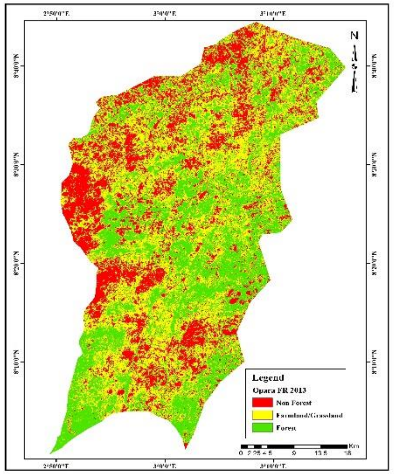

Figure 6: 2013 Opara LULC

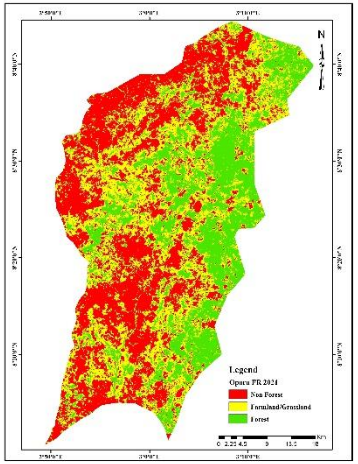

Figure 7: 2021 Opara LULC

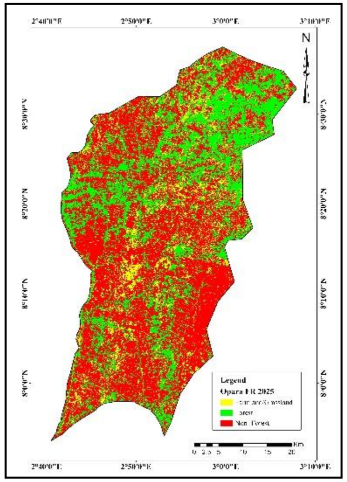

Figure 8: 2025 Opara LULC

in 1984 to a peak of 88.7% in 2013 before declining to 85.4% in 2025, while User's Accuracy (UA) followed a similar trend, rising from 87.9% to 92.6% and then dropping to 90.2%. Farmland/Grassland PA improved from 78.6% in 1984 to 85.9% in 2013 before decreasing to 82.7% in 2025, with UA peaking at 84.6% in 2013 and later falling to 79.9%.

Non-Forest maintained high accuracy, with PA increasing from 90.8% to 94.8% before a slight decline to 92.9%, while UA followed a comparable pattern. Overall accuracy rose from 85.2% in 1984 to 89.4% in 2013 before decreasing to 87.9% in 2025, with the Kappa Coefficient reflecting similar trends, peaking at 0.85 in 2013 and then slightly dropping to 0.82.

Table 3: Accuracy Assessment

LULC Class	**Accuracy Metric**	**1984**	**1990**	**2000**	**2013**	**2021**	**2025**
Forest	PA **(%)**	83.1	84.8	86.9	88.7	86.3	85.4
	UA **(%)**	87.9	89.5	90.8	92.6	91.1	90.2
Farmland/ Grassland	PA **(%)**	78.6	81.5	83.7	85.9	80.8	82.7
	UA **(%)**	75.9	78.8	81.5	84.6	80.8	79.9
Non- Forest	PA **(%)**	90.8	91.7	93.5	94.8	93.5	92.9
	UA **(%)**	88.6	90.4	92.7	93.9	91.8	91.5
	Overall Accuracy (%)	85.2	86.7	88.1	89.4	88.6	87.9
	Kappa Coefficient	0.78	0.81	0.83	0.85	0.83	0.82

Land Cover Change Analysis (1984-2025) in Opara Forest Reserve

The study revealed significant fluctuations in forest cover over the 41-year period (Table 4). From 1984-1990, forests decreased by 19,599 hectares (-12.5%), averaging -2.1% annual loss. The period 1990-2000 showed an unexpected gain of 43,876 hectares (32.0%), with +3.2% annual growth. However, 2000-2013 resumed losses (-17,700 ha, -18.9%, -1.5%/year), which continued through 2013-2021 (-16,217 ha, -21.4%, -2.7%/year). The most recent period (2021-2025) showed partial recovery (+8,990 ha, +15.1%, +3.8%/year). The net change from 1984-2025 was -88,402 hectares (-56.3%), averaging -1.4% annually. Farmland/Grassland initially expanded (1984-1990: +6,229 ha, +15.1%, +2.5%/year), then sharply declined (1990-2000: -30,443 ha, -64.1%, -6.4%/year). Moderate decreases continued (2000-2013: -9,216 ha, -11.8%, -0.9%/year) before rebounding (2013-2021: +12,174 ha, +14.0%, +1.7%/year). The 2021-2025 period showed dramatic expansion (+50,310 ha, +67.1%, +16.8%/year).

Table 4: Rate of Deforestation in Opara Forest Reserve

LULC Class	**1984-1990**		**1990-2000**		**2000-2013**		**2013-2021**		**2021-2025**		**1984-2025**	
	Absolute change	Percent change (%)	Absolute change	Percent change (%)	Absolute change	Percent change (%)	Absolute change	Percent change (%)	Absolute change	Percent change (%)	Absolute change	Percent change (%)
Forest	-19599.30	-12.49	43875.95	31.95	17700.03	18.94	16216.65	21.41	-8989.51	-15.10	-88402.42	-56.34
Farmland/ Grassland	6228.81	15.09	-30443.13	-64.07	-9216.00	-11.82	12174.21	13.96	50309.97	67.08	-16596.24	-40.20
Non-forest	13370.49	61.20	-13432.77	-38.14	-8484.03	-17.44	-28390.86	-49.69	-41320.45	-48.31	104998.60	480.58
Total	0.00	63.79	0.00	-70.26	0.00	-10.32	0.00	-14.31	0.00	3.66	0.00	384.04

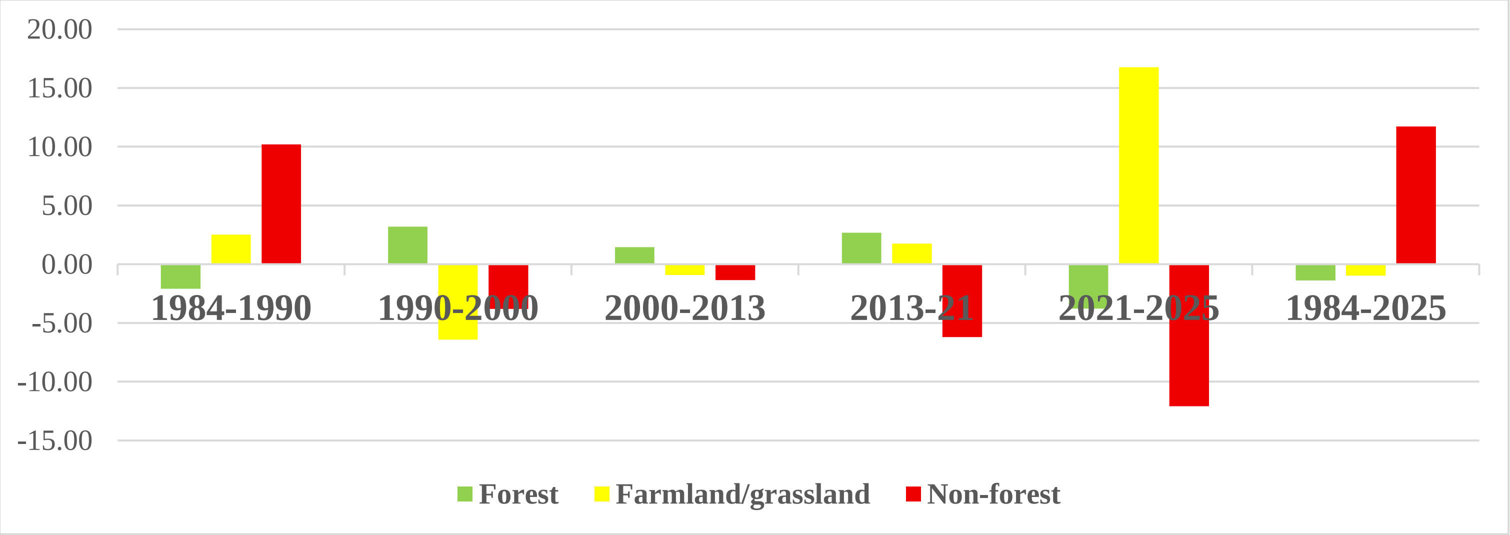

Figure 9: Average rate of Change per year

Overall, 1984-2025 change was -16,596 ha (-40.2%), averaging -1.0% annually. Non-Forest Area showed the most volatility. Rapid early growth (1984-1990: +13,370 ha, +61.2%, +10.2%/year) was followed by decline (1990-2000: -13,433 ha, -38.1%, -3.8%/year). Moderate decreases continued (2000-2013: -8,484 ha, -17.4%, -1.3%/year) before substantial expansion (2013-2021: +28,391 ha, +49.7%, +6.2%/year).

The 2021-2025 period showed contraction (-41,320 ha, -48.3%, -12.1%/year). Net 1984-2025 change was +104,999 ha (+480.6%), averaging +11.7% annual growth.

Perceived Factors Influencing Deforestation in Opara Forest Reserve

The survey of 200 respondents revealed strong consensus on key deforestation drivers in Opara Forest Reserve. Agricultural activities were identified by 97% of respondents as responsible for forest loss, while only 3% disagreed. Timber demand was recognized by 95.5% as a contributing factor, with 4.5% rejecting this view. Lack of law enforcement was cited by 73.5% as responsible for deforestation, compared to 26.5% who did not consider it a factor. Population growth showed more divided opinions, with 44.5% believing it contributes to deforestation and 55.5% disagreeing. Logistic regression analysis quantified these relationships (Table 5). Agricultural activities (11.867 Odds Ratio), Demand for Timber (3.577 Odds Ratio), and Lack of Law Enforcement (2.467 Odds Ratio) contribute significantly to deforestation in the Okpara Forest Reserve

Table 5: Logistics binary nature of perceived factors responsible for deforestation

Influence factors	Coefficient	Odd Ratio
Demand for Timber (DT)	0.549	3.577*
Population Growth (PG)	0.474	1.398
Lack of Law Enforcement (LLE)	0.383	2.467*
Agricultural Activities (AA)	0.920	11.867*

- = values that are significant with Odd Ration > 2 at p<0.05 level of significant.

Location-Dependent Variation in Deforestation Attitudes and Proposed Solutions

The chi-square analysis revealed significant relationships between respondents' geographic location within the study area and several key deforestation-related factors (Table 6). Regarding perceptions of deforestation, we found no significant association with location and duration of residence ($\chi^2 = 1.821$, $p = 0.402$). However, strong location-dependent patterns emerged for both perceived deforestation frequency ($\chi^2 = 9.776$, $p = 0.021$) and environmental impact assessment ($\chi^2 = 10.351$, $p = 0.001$). Analysis of proposed solutions showed more complex patterns. Location demonstrated no significant association with support for community participation initiatives ($\chi^2 = 1.846$, $p = 0.174$) or agroforestry systems ($\chi^2 = 3.701$, $p = 0.054$). Notably, we observed perfect association between location and preference for afforestation/reforestation programs ($\chi^2 = 0.000$, $p = 1.000$). Significant location-based differences emerged for awareness campaigns ($\chi^2 = 9.898$, $p = 0.002$) and alternative livelihood provision ($\chi^2 = 10.143$, $p = 0.001$).

Table 6: Relationships between respondents' location and deforestation perceptions/solutions

Category	Variable	χ^2	p-value
Perceptions			
	Duration of residence	1.821	0.402^{NS}
	Perceived deforestation frequency	9.776	0.021^{8}
	Environmental impact assessment	10.351	0.001^{8}
Solutions			
	Community participation	1.846	0.174^{NS}
	Agroforestry systems	3.701	0.054^{NS}
	Afforestation/reforestation programs	0.000	1.000*
	Awareness campaigns	9.898	0.002*
	Alternative livelihood provision	10.143	0.001*

Note: NS = Not significant ($p > 0.05$), * = Significant at $p < 0.05$

DISCUSSION

Land Cover Dynamics in Opara Forest Reserve (1984 -2025)

The forest cover decline in Opara Forest Reserve shows a complex conservation challenge that reflects both regional deforestation patterns and unique local dynamics. The reserve's 1.2% annual forest loss between 1984-2025 does not exceeds Nigeria's national average of about 3.5% (FAO, 2005; GFW, 2023). However, this aligns with broader West African deforestation trends documented by Sandker (2017), but the accelerated conversion timeline indicates Opara may be experiencing compounded pressures from multiple drivers simultaneously. This change matches observations by Fasona *et al.* (2022) in nearby reserves, where inadequate enforcement and population growth intensified deforestation pressures. The ecological impacts reflect Rudel's threshold theory, where forest cover reduction below critical levels trigger disproportionate biodiversity loss, a pattern which is now evident in Opara's fragmented landscape (Rudel, 2021). The observed land use changes follow a typical trend that challenges traditional forest transition models. As documented by Fasona (2022) in Nigeria's southwestern forests, agricultural expansion initially served as the primary driver of forest loss, consistent with our findings of substantial early-stage farmland conversion. However, the subsequent shift toward non-forest land uses mirrors the "urban transition" phenomenon described by Geldmann *et al.* (2014) in their global analysis of protected areas under urban pressure. The current estimate of 57.64% non-forest cover in 2025 raises particular concern, as the estimates approaches a critical ecological threshold identified in similar tropical forest systems (Rudel, 2021).

The limited ecological value of recent forest regrowth observed in Opara corresponds with Amani's (2022) extensive research on tropical forest recovery trajectories, which established that secondary regrowth typically supports significantly reduced biodiversity compared to primary forests. This pattern has been similarly documented in comparable Nigerian reserves by Ademoh *et al.* (2017). They suggest a regional challenge in achieving meaningful forest restoration. These collective findings support Sarfo *et al.*'s (2024) call for adaptive management approaches that specifically address the converging pressures of agricultural expansion and urban development in West Africa’s Forest reserves.

The study ultimately confirms the emergence of what Das (2024) term a "new threat paradigm" for forest conservation in the region, where traditional and emerging pressures interact to create compounded challenges. This underscores the need for conservation strategies that simultaneously address historical deforestation drivers while preparing for rapidly evolving land use changes at forest frontiers. The Opara case study provides critical empirical support for rethinking protected area management in Nigeria's changing ecological and socioeconomic landscape.

Perceived Factors and Spatial Patterns in Deforestation Drivers in Opara Forest Reserve

The stronger community consensus around agricultural expansion and timber extraction as primary deforestation drivers in Opara Forest Reserve aligns with established scientific literature. These are the major factors contributing significantly to deforestation in Okpara forst reserve. This finding corroborates Branthomme *et al.*'s (2021) global assessment that identified small-scale agriculture as the dominant driver of 80% of African deforestation, while supporting Asamoah *et al.*'s (2023) work in Ghanaian forests that documented how commercial logging compounds subsistence farming pressures. Similarly, Alegbeleye and Alo (2020) reported that agricultural activities and lack of law enforcement in the forest ecosystem significantly contributed to the factor responsible for spatio-temporal changes in urban green space in Ado Ekit metropolis. The observed spatial variation in threat perception echoes Hasanzadeh's (2011) demonstration of how place-based environmental experiences shape risk assessment more profoundly than duration of exposure.

The community's divided perspectives on law enforcement effectiveness reflect a pattern documented by Keane (2008) in Nigerian community forests, where visible enforcement activities often fail to positively correlate with conservation outcomes. Similarly, the lack of consensus about population growth impacts mirrors Sydenstricker-Neto's (2012) critique of simplistic population-deforestation narratives, emphasizing instead the mediating role of institutions and markets. These nuanced results validate Lim *et al.*'s (2017) framework that distinguishes between proximate causes and underlying drivers of forest loss.

The geographic variation in solution preferences provides empirical support for McGinnis's (2016) polycentric governance theory. The perfect location-dependence of afforestation support substantiates Rakotonarivo *et al.*'s (2023) findings about how land tenure systems shape restoration willingness. Meanwhile, the spatial variability in enthusiasm for awareness campaigns and alternative livelihoods reinforces Yankson's (2024) documentation of micro-geographies of resource dependence in African forests. These patterns collectively demonstrate what Kull *et al.* (2024) identified as the critical need to adapt global conservation frameworks to local contexts during forest transitions.

The study's most significant contribution lies in bridging the gap between Kaur's (2025) work on universal deforestation drivers and Ostrom's emphasis on institutional specificity. By mapping how spatially consistent threats generate location-dependent responses, the research offers a template for developing what Bürgi *et al.* (2017) term "embedded" conservation strategies - approaches that combine landscape-scale coordination with community-level adaptation. This dual focus proves particularly relevant for West Africa’s Forest reserves, where Mendizabal *et al.*'s (2018) observed urban transition dynamics are creating new conservation challenges that demand innovative governance solutions.

Conclusion

The deforestation crisis in Opara Forest Reserve exemplifies the complex interplay of ecological degradation and socioeconomic pressures facing Nigeria's protected forests. This study reveals that the reserve's accelerated forest loss (driven by agricultural expansion, timber extraction, and urban encroachment) reflects both localized governance failures and broader regional trends documented across West Africa. Critically, the research demonstrates how universal deforestation drivers manifest through place-specific dynamics, with community perceptions and response capacities varying markedly across the reserve's geography. These findings demand an integrated conservation strategy that simultaneously addresses immediate land-use pressures and underlying institutional gaps. Building on Ostrom's principles of polycentric governance, effective management must combine landscape-scale protection frameworks with micro-level adaptations to local ecological and social contexts. This requires prioritizing three key interventions: (1) strengthening enforcement against illegal logging while promoting sustainable agroforestry practices; (2) implementing spatially targeted restoration programs that reconnect fragmented habitats, and (3) developing collaborative land-use planning with adjacent urban centers to curb encroachment.

The path forward hinges on recognizing Opara's transformation from a forest-dominated ecosystem to a multifunctional landscape where conservation competes with competing land demands. By adopting adaptive governance models that balance ecological thresholds with community livelihoods, and leveraging both scientific monitoring, and traditional knowledge, stakeholders can work to reverse degradation trends while accommodating legitimate development needs. The reserve's precarious state offers a pivotal opportunity to test innovative approaches that could inform forest management across Nigeria's rapidly changing ecological frontiers.

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