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ORIGINAL RESEARCH ARTICLE

Analyzing the Spatio-Temporal Dynamics and Socio-Economic Impacts of Deforestation in Yola South Local Government Area, Adamawa State, Nigeria (2004-2024)

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ABSTRACT

Deforestation is a serious threat to both ecosystems and the livelihoods of people in West Africa. This study provides a closer examination of the patterns, causes, and socio-economic impact of deforestation in the Yola South Local Government Area (LGA), a key region in Adamawa State, Nigeria. To address this issue, we used a mixed-methods approach that combined Geographic Information Systems (GIS) and remote sensing with socio-economic surveys. We analyzed Landsat satellite images from 2004, 2014, and 2024 to track changes in land use and land cover (LULC), We also distributed a structured questionnaire to 300 randomly chosen households and conducted key informant interviews to gather insights on local perceptions, impacts, and driving factors. Our GIS analysis indicates a 62% drop in forest cover, shrinking from 37,895.31 hectares in 2004 to 14,389.92 hectares by 2024. Meanwhile, agricultural land expanded by 167%. The survey revealed that a significant 88% of residents are aware of deforestation, with agricultural expansion (40%), firewood collection (22%), and logging (16%) identified as the main culprits. The socio-economic impacts are concerning reduction in crop yield (28%), soil erosion (22%), and rising firewood costs (18%) reported. Notably, 74% of respondents felt that their livelihoods were negatively affected, and 66% connected deforestation to increased poverty in the community. This study highlights a critical and worsening deforestation crisis in Yola South LGA, primarily driven by agricultural growth and energy demands. The consequences include severe environmental degradation and socio-economic challenges. We strongly recommend urgent, integrated actions, such as promoting sustainable farming practices, offering alternative energy solutions, enforcing environmental regulations, and launching large-scale community-based reforestation initiatives.

Introduction

Deforestation, defined as the large-scale clearing of forests without adequate regeneration or replanting, represents one of the most pressing global environmental challenges of the twenty-first century (FAO, 2020). It significantly undermines biodiversity, contributes to greenhouse gas emissions, and disrupts climate regulation processes (IPCC, 2022; Foley et al., 2005). Forest ecosystems provide essential services including carbon sequestration, soil protection, hydrological regulation, and livelihood support for millions of people worldwide (Millennium Ecosystem Assessment, 2005).

In Africa, where a substantial proportion of the population depends directly on land-based resources for subsistence and income generation, forest loss threatens employment, food security, and ecosystem stability (Damte et al., 2017; FAO, 2020). West Africa, in particular, has experienced some of the highest rates of forest cover decline globally, driven largely by agricultural expansion, fuelwood extraction, and rapid population growth (Curtis et al., 2018; Hansen et al., 2013). These processes are frequently associated with secondary environmental consequences such as soil erosion, declining water quality, watershed degradation, and biodiversity loss (Achard et al., 2014; Foley et al., 2005).

In Nigeria, deforestation remains a critical environmental concern despite increasing awareness and policy responses. Nigeria has recorded one of the highest deforestation rates in sub-Saharan Africa, largely attributable to agricultural expansion, urbanization, and dependence on biomass energy (FAO, 2020; Hansen et al., 2013). Forest degradation in the country has heightened vulnerability to climate variability, reduced ecosystem resilience, and placed millions of people at socio-economic risk (IPCC, 2022). Understanding the local dynamics and drivers of forest loss is therefore essential for designing context-specific mitigation strategies. This study focuses on Yola South Local Government Area (LGA) in Adamawa State, North-Eastern Nigeria. The area, characterized by a rapidly expanding urban core surrounded by rural agricultural communities, provides a valuable setting for examining the interaction between urban growth, agricultural pressure, and environmental sustainability.

The goal of this research is to thoroughly investigate deforestation and its effects on the socio-economic activities of the residents in Yola South LGA. The specific objectives include:

1. Analyzing land use and land cover changes from 2004 to 2024.
2. Assessing how deforestation impacts human livelihoods.
3. Identifying the key drivers of deforestation.
4. Exploring local opinions on how to reduce deforestation efforts.

This research aims to provide valuable, evidence-based insights that can guide policymakers, environmental organizations, and local communities in crafting effective conservation and sustainable land management strategies.

Research Design

A mixed-methods approach was employed, blending quantitative spatial analysis with both qualitative and quantitative socio-economic surveys. This convergent parallel design allowed us to gain a well-rounded understanding by combining satellite data with insights from the community.

Data Collection and Analysis

Spatial Data: Satellite imagery from the Landsat series was used for this study, including Landsat 5 Thematic Mapper (TM)

for 2004, Landsat 8 Operational Land Imager (OLI) for 2014, and Landsat 8 and Landsat 9 OLI/TIRS (OLI/TIRS for Landsat 8 and OLI-2/TIRS-2 for Landsat 9) for 2024. The images were pre-processed in QGIS using standard radiometric and geometric correction procedures to improve data quality and spatial alignment. Supervised classification techniques were then applied to categorize land use and land cover into five classes: forest, agricultural land, built-up area, bare surface, and water bodies. A post-classification comparison approach was subsequently employed to assess land use and land cover changes over the study period.

Spatial Data

Satellite imagery from the Landsat series was utilized for this study due to its long-term temporal consistency and suitability for land use and land cover (LULC) monitoring (Wulder et al., 2019). Specifically, Landsat 5 Thematic Mapper (TM) imagery was used for 2004, Landsat 8 Operational Land Imager (OLI) for 2014, and Landsat 8 and Landsat 9 OLI/TIRS (OLI-2/TIRS-2 for Landsat 9) for 2024. The Landsat program provides moderate-resolution (30 m) multispectral data that have been widely applied in environmental change detection studies globally (Roy et al., 2014; Wulder et al., 2019).

The images were pre-processed in QGIS following standard radiometric and geometric correction procedures to enhance spectral consistency and spatial alignment. Radiometric correction is essential for minimizing atmospheric and sensor-related distortions, while geometric correction ensures proper spatial registration across multi-temporal datasets (Jensen, 2015; Mather & Koch, 2011).

Supervised classification techniques were subsequently applied to categorize land use and land cover into five classes: forest, agricultural land, built-up area, bare surface, and water bodies. Supervised classification methods, particularly maximum likelihood algorithms, remain widely used in LULC mapping due to their robustness in handling multispectral data (Jensen, 2015; Lillesand, Kiefer, & Chipman, 2015).

A post-classification comparison approach was employed to detect and quantify land use and land cover changes over the study period. This method is considered one of the most reliable techniques for multi-temporal change detection because it minimizes the influence of atmospheric and sensor differences between dates and provides detailed "from–to" change information (Singh, 1989; Lu et al., 2004).

Socio-Economic Data

A multi-stage sampling technique was adopted to ensure representativeness across the study area. Multi-stage sampling is widely used in socio-economic and community-based studies where populations are geographically dispersed and administratively structured (Cochran, 1977; Kothari, 2004). Yola South LGA was purposively selected due to its documented exposure to rapid land use change and urban expansion. The LGA was subsequently stratified into four administrative wards to enhance spatial representation. From each ward, households were selected using simple random sampling procedures to minimize selection bias (Creswell, 2014). A total of 300 respondents participated in the structured questionnaire survey. In addition to the household survey, ten (10) key informant interviews were conducted to obtain qualitative insights and triangulate quantitative findings. The integration of questionnaire surveys and key informant interviews strengthens internal validity and improves contextual interpretation of socio-economic dynamics (Creswell & Plano Clark, 2018).

The collected data were analyzed using descriptive statistics, including frequencies and percentages, to summarize socio-economic characteristics and perception patterns. Inferential statistical analysis was conducted using the Chi-square (χ^2) test to examine associations between categorical variables. The Chi-square test is appropriate for testing independence between nominal variables in survey-based research (Field, 2018; McHugh, 2013). Statistical analyses were performed using Microsoft Excel for preliminary tabulation and IBM SPSS for advanced statistical computation.

Results and Discussion

Spatio-Temporal Land Use/Land Cover Changes

The LULC analysis revealed profound transformations over the 30-year period (2004-2024), as summarized in Table 1 and visualized in Figures 1-3.

Table 1: Land Use/Land Cover Change in Yola South LGA (2004-2024)

LULC Class	2004 (Ha)	2014 (Ha)	2024 (Ha)	Change (2004-2024)	% Change
Forest Cover	37,895.31	21,394.26	14,389.92	-23,505.39	-62.0%
Agric. Land	21,289.77	49,617.90	56,828.70	+35,538.93	+167.0%
Built-up Area	10,269.54	14,241.69	15,128.01	+4,858.47	+47.3%
Bare Surface	19,433.97	26,481.60	29,357.55	+9,923.58	+51.1%
Water Bodies	28,802.43	9,614.79	7,418.70	-21,383.73	-74.2%

1. Forest Cover: Experienced a drastic and consistent decline, losing over 23,500 hectares (62% of its 2004 cover).
2. Agricultural Land: Showed the most aggressive expansion, increasing by 167%, directly replacing forested areas.
3. Water Bodies: Diminished alarmingly by 74.2%, indicating potential hydrological changes linked to watershed disturbance. (Figures 1, 2, and 3 describe the original document: LULC maps for 2004, 2014, and 2024)

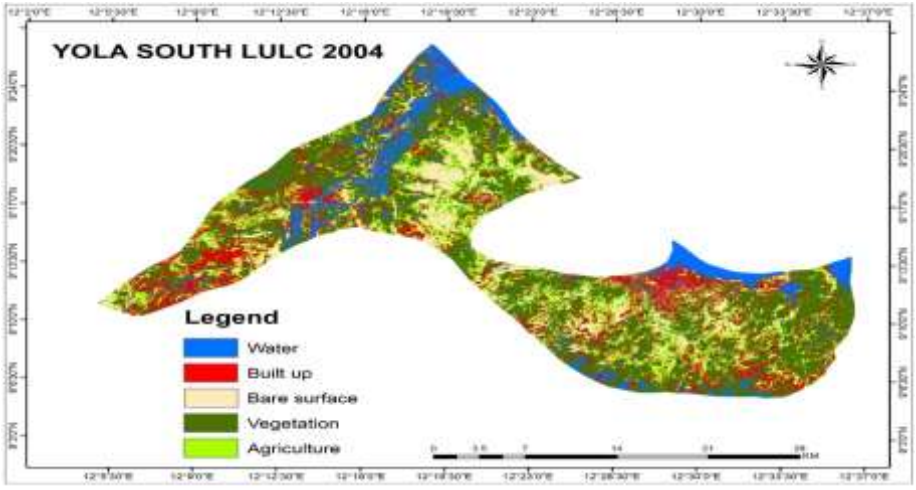

Figure 1: LULC Yola South, 2004

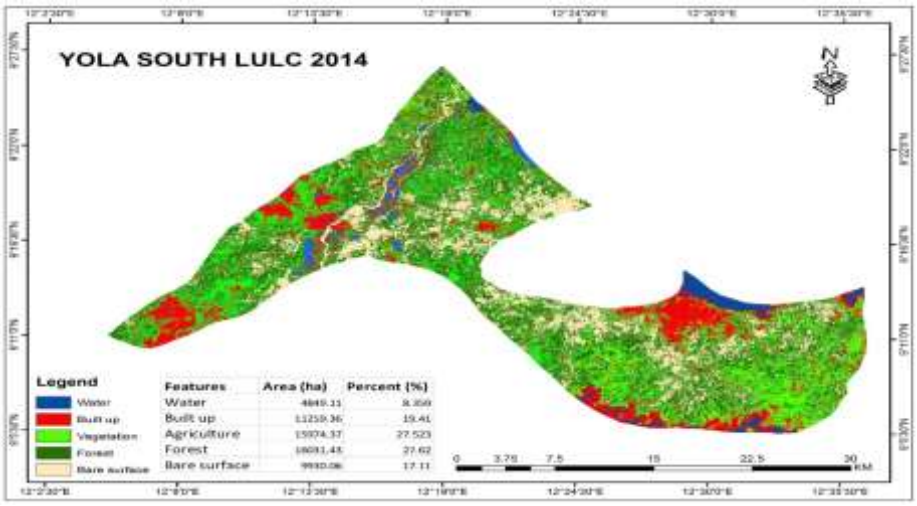

Figure 2: LULC Yola South, 2014

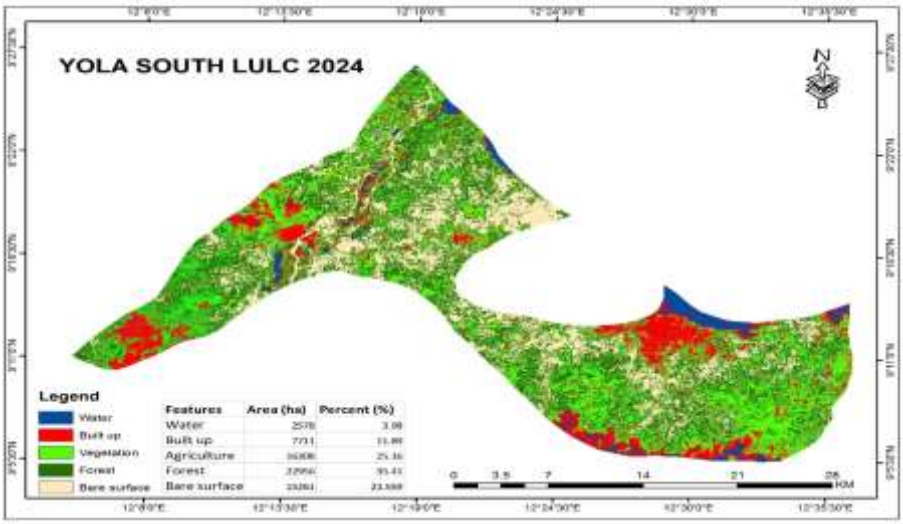

Figure 3: LULC Yola South, 2024

Accuracy Assessment of the Classification

The accuracy assessment of the classified LULC maps for Yola South LGA shows a progressive improvement over the past two decades. In 2004, the map achieved an overall accuracy of approximately 72% with a Kappa coefficient of 0.62. By 2014, the overall accuracy increased to around 74%, with a Kappa of 0.65. The most recent assessment for 2024 indicates an overall accuracy of 76% and a Kappa coefficient of 0.66, reflecting substantial agreement between the classified maps and reference data across all three periods (Table 2).

Table 2: Confusion Matrix and Accuracy Assessment of LULC Classification (2004–2024)

Year	Overall Accuracy	Kappa
2004	~72%	~0.62
2014	~74%	~0.65
2024	76%	0.66

Awareness, Drivers, and Perceived Impacts of Deforestation

1. Awareness and Understanding: A striking 88% of respondents were aware of deforestation happening in their area. Most of them (58%) simply defined it as "cutting down trees," while 27% connected it to "clearing forests for farming."
2. Perceived Drivers: The main drivers identified were agricultural expansion, with 40% of respondents pointing to it. This was followed by firewood collection (22%), logging (16%), and construction activities (11%). Local residents were viewed as the key players (55%), and government projects (21%) and logging companies (19%) were also seen as contributors.
3. Socio-Economic Impacts: A significant 74% of respondents felt that deforestation had a negative impact on their livelihoods. The primary economic issues mentioned included reduced crop yields (28%), soil erosion (22%), and higher firewood costs (18%). Additionally, 66% believed that deforestation leads to increased poverty and hardship in their community.

Observed Environmental Changes: Residents reported several significant environmental changes, such as unpredictable rainfall (27%), loss of forest animals (24%), decreased soil fertility (23%), and rising temperatures (16%).The Chi-square analysis of the survey of the socio-Economic Impact from Yola South LGA showed that 66% of respondents believe deforestation contributes to rising poverty, while 34% do not. When tested against an equal expected distribution (50%–50%), this association was statistically significant ($\chi^2 = 10.24$, $df = 1$, $p < 0.05$), indicating that a substantially larger proportion of the community perceives a link between forest loss and socio-economic hardship. Similar patterns have been reported in other settings where survey respondents' perceptions of environmental change were statistically examined: for example, in a study around the Olokemeji Forest Reserve in Ogun State, Nigeria, socio-economic characteristics including gender and education showed significant associations with perceptions of deforestation impacts, as revealed by chi-square analysis (Olawuyi et al., 2025). In the Western region of Kogi State, researchers found significant relationships between people's socio-demographic traits and how they perceived deforestation's effects on economic activities using inferential statistics including chi-square tests (Awe et al., 2024). These comparable findings support the interpretation that local perceptions of the environmental–livelihood nexus are both strong and statistically meaningful, reflecting real concerns among rural populations about how forest degradation affects poverty and well-being.

Community Perspectives on Mitigation

Respondents proposed various solutions to tackle deforestation. The most popular suggestions included using alternative energy sources (29%, like LPG and solar), implementing afforestation and reforestation programs (24%), and promoting environmental education (18%). There was a strong demand for the government to enforce environmental laws (34%) and provide alternative energy resources (23%). Interestingly, while 43% of respondents mentioned some local forest protection efforts, 57% reported seeing none, highlighting the need for better coordinated action.

The findings reveal a concerning trend in Yola South LGA, showcasing a landscape that's rapidly deteriorating. A staggering 62% loss of forest cover over the past twenty years is

alarming and reflects the wider deforestation issues seen across West Africa. The main culprit here is agricultural expansion, which has surged by 167%, highlighting the intense pressure from a growing population that relies heavily on subsistence farming. This shift from forest to farmland is a textbook example of land change theory, where socio-economic needs directly impact land use.

The results from the socio-economic survey back up the spatial data, showing that the local population is acutely aware of these changes and their detrimental effects. The reported consequences of decreased crop yields, soil erosion, and a decline in biodiversity are well-known outcomes of deforestation. Notably, 66% of respondents connect deforestation to rising poverty levels, highlighted the critical cycle between environmental degradation and socio-economic instability. As natural resources dwindle, the livelihoods of those who depend on them become increasingly fragile.

The significant drop in water bodies, at 74.2%, is particularly alarming and deserves urgent attention. Deforestation in watershed areas hampers water infiltration, boosts runoff and erosion, and can lead to rivers and streams becoming silted and drying up. This has serious repercussions for irrigation, drinking water supplies, and aquatic ecosystems.

The community's proposed solutions are practical and align well with established conservation methods. Their focus on alternative energy tackles a fundamental issue of dependency on fuelwood, while their calls for afforestation and stricter law enforcement indicate a desire for both restoration and regulation. However, there's a noticeable gap between the local efforts (43%) and the perceived lack of action (57%), indicating that while community initiatives exist, and they aren't widespread or adequately supported. This presents a valuable opportunity for the government and NGOs to enhance and expand these grassroots efforts.

Conclusion

This study clearly indicates that Yola South LGA is facing a serious environmental crisis, primarily due to rapid deforestation driven by agricultural growth and energy demands. This situation has led to a multitude of negative effects, for example, land degradation, loss of biodiversity, disruption of water systems, and significant socio-economic challenges for a community that relies heavily on the land for livelihoods.

Immediate and coordinated action is essential. Based on our findings, we suggest the following:

1. Promote Sustainable Agricultural Practices: Encourage methods like agroforestry and conservation agriculture to increase productivity on existing farmland while minimizing forest encroachment.
2. Provide Affordable Alternative Energy: Implement government-subsidized LPG and clean cooking stoves to significantly reduce the use of fuelwood.
3. Strengthen Governance and Enforcement: It's vital to rigorously enforce forestry laws and create a community-based forest management system that involves local participation.
4. Launch Large-Scale Reforestation Programs: Initiate government-led and community-driven tree planting campaigns that focus on native species to help restore degraded lands and protect waterways.
5. Enhance Environmental Education: Integrate environmental education into school programs and local awareness initiatives to cultivate a culture of conservation.

By implementing these evidence-based recommendations, stakeholders can help reverse the trend of deforestation, ensuring both ecological health and socio-economic stability in Yola South LGA.

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