

Urbanization Impacts on Plant Diversity in Otukpo, Benue State, Nigeria.

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Abstract: Urbanization plays a key role in driving environmental changes, significantly influencing plant diversity and ecosystem functioning, particularly in tropical cities. This research examines the impact of urbanization on plant diversity and ecosystem services in Otukpo, a fast-growing city in Benue State, Nigeria. Using Landsat imagery from 1990, 2010, and 2024, along with supervised classification (SVM) methods, the study analyzes land use/land cover (LULC) shifts over three decades to assess how urban expansion alters local vegetation. The findings highlight the urgent need to incorporate biodiversity conservation and green infrastructure in urban planning to reduce the negative consequences of urbanization. Furthermore, the research emphasizes the potential of remote sensing technologies to track long-term urbanization effects on ecosystems, providing a replicable approach for future investigations in tropical cities. The study also calls for further research to examine how climate change and invasive species influence plant diversity and to evaluate the role of urban green spaces in safeguarding biodiversity.

Keywords: Urbanization Impact, Plant Diversity, Otukpo, Nigeria

1. Introduction

Urbanization is one of the most transformative processes affecting landscapes and ecosystems worldwide, particularly in tropical regions where rapid population growth and urban expansion are prevalent. In recent decades, tropical cities in Africa and Asia have experienced unprecedented rates of urban growth, leading to significant changes in land use, biodiversity, and ecosystem services (Gonzalez-Tokman et al., 2024; Kowarik, 2018). In the Otukpo, urbanization is occurring at an accelerating pace due to both population growth and increasing infrastructural development. Plant diversity in urban areas often faces challenges such as habitat fragmentation, pollution, and competition from non-native species, which can alter ecosystem functions such as carbon storage, water regulation, and soil fertility (Agbaogun et al., 2024; Mohan & Kandya, 2015). In tropical cities, where rapid urbanization can lead to significant environmental transformations, GIS is used to track the distribution of plant species and their relationships with land-use changes.

2. Material and Method

Otukpo Local Government Area (LGA) is located in Benue State, Nigeria, at approximately 7.2644° N latitude and 8.1442° E longitude. It lies approximately 50 kilometers south of Makurdi, the state capital. The LGA is geographically located in a region characterized by a mix of both upland and lowland areas. The climate in Otukpo is tropical, with a distinct wet and dry season. (Abah, 2014). Otukpo borders other LGAs such as Ado, Okpokwu, and Buruku, providing it

with a strategic position for trade and interaction with neighboring communities. This study uses Landsat imagery to monitor land cover change over time. The selected periods are 1990: Landsat 5 (TM) with 30-meter resolution and seven spectral bands; 2010: Landsat 7 (ETM+), similar to Landsat 5 but with gaps due to Scan Line Corrector failure, addressed via interpolation; and 2024: Landsat 8 (OLI/TIRS), offering enhanced spectral bands for better atmospheric and vegetation analysis. Imagery was obtained from USGS Earth Explorer and pre-processed for high quality and cloud-free images. Two vegetation indices, NDVI and EVI, were calculated to assess vegetation health across the years: NDVI: Measures vegetation density, with higher values indicating healthier vegetation. EVI: Sensitive to canopy cover, useful for areas with dense vegetation and assessing vegetation health changes due to urbanization. These indices are calculated for vegetated classes (forests, agriculture, and wetlands) to track vegetation changes over time. The results focus on urbanization's spread into agricultural and forested areas and its effects on water bodies and wetlands.

3. Results

The analysis includes the results of population increase, land cover classification, vegetation indices (NDVI and EVI), change detection, and accuracy assessments for 1990, 2010, and 2024. This part interprets the patterns of land use change over time and explores how urbanization has influenced plant diversity and ecosystem services in these two cities. The population trend in Otukpo between 2006 and 2024 is presented in Table 1. The table reveals that Otukpo had a total population of 266,411 in 2006, which increased to 346,344 in 2016 and is projected to reach 410,283 in 2024. The percentage change in population between 2006 and 2016 and between 2016 and 2024 is also presented in the table. Otukpo's population increased by 30.0% between 2006 and 2016 and by 18.5% between 2016 and 2024, according to the results. The findings support the opinion of earlier researchers (Angel et al., 2005; Adeboyejo & Abolade, 2007) that the rate of population growth in both urban and rural areas is not proportional to the amount of land supply.

Table 1: Population Trend between 1996, 2006, 2014 and 2024 in Otukpo

Local Government	Population				Population change From 1996 to 2023		
	1996	2006	2016*	2024*	1996-2006	2006-2016	2016-2024
Otukpo	-	266,411	346,344	410,283	-	79,933 (30.0%)	63,939 (18.5%)

For Otukpo, the land cover classification highlights a more gradual urbanization compared to Makurdi, with less drastic changes in forest and agricultural land.

Table 2: Land Cover Class Distribution for Otukpo (1990, 2010, 2024)

Land Cover Category	1990		2010		2024	
	Area (km ²)	Area (%)	Area (km ²)	Area (%)	Area (km ²)	Area (%)
Built-up Area	86.80	6.52	132.83	9.97	215.63	16.19
Forest Area	637.01	47.84	449.46	33.75	349.43	26.24
Crop Land	287.82	21.61	276.31	20.75	240.89	18.09
Water Body	111.92	8.40	138.35	10.39	237.06	17.80
Wetland	208.09	15.63	334.70	25.13	288.61	21.67
Total	1331.64	100.00	1331.64	100.00	1331.62	100.00

In Otukpo, urban expansion has been less measured compared to Makurdi, with urban land increasing by 9.97% from 1990 to 2010 and by 16.19% from 2010 to 2024. Despite this gradual urbanization, forest cover has still decreased substantially, from 29.44% in 1990 to 22.26% in 2024, indicating ongoing loss of natural vegetation. Crop land has remained relatively stable, with only a slight reduction by 12.82% between 2010 and 2024, although its share in land use has been gradually replaced by urbanization. The increase in water body areas from 8.40% in 1990 to 17.80% in 2024 may be attributed to natural changes in river flow patterns or the formation of new water bodies. Additionally, the increase in wetland from 15.63% in 1990 to 21.67% in 2024 is due to natural factors like flooding, sediment deposition, and climate change, as well as human activities such as restoration and water management. Alterations in water flow and land subsidence also played a role in their expansion See Table 1 and 2 and Figures 2 and 3

3.1 Vegetation Indices Analysis

Vegetation indices, such as Normalized Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI), were calculated for each year to assess vegetation health and density. These indices help monitor changes in plant vitality and ecosystem functioning over time.

Table 3: NDVI Trends for Otukpo (1990, 2010, 2024)

Year	Mean NDVI	Area with High NDVI (≥ 0.5) (%)	Area with Low NDVI (< 0.3) (%)
1990	0.70	75%	2%
2010	0.58	50%	10%
2024	0.45	40%	15%

Although NDVI values in Otukpo show a decline, the decrease is less pronounced than in Makurdi, with the mean NDVI dropping from 0.70 in 1990 to 0.45 in 2024. The proportion of high NDVI areas (indicating healthy vegetation) fell from 75% in 1990 to 40% in 2024, signaling that urbanization is also affecting vegetation quality in Otukpo, but the impact has been more moderate (see Table 3). In Otukpo, as urban areas expand, natural vegetation, including forests and open spaces, is increasingly encroached upon by agricultural activities and urban infrastructure. This encroachment has led to a noticeable loss of native plant species, especially in areas where construction and farming have disrupted natural ecosystems. In conclusion, urbanization in Otukpo has led to the loss of native plant species, the spread of invasive species, shifts in vegetation composition, and the fragmentation of natural habitats.

Scientific novelty/contribution of knowledge

This research provides valuable insights into the impacts of urbanization on plant diversity and ecosystem functioning in Makurdi and Otukpo, Benue State, Nigeria, addressing a gap in tropical urban ecology studies. It highlights how urbanization leads to the decline of native plant species and the rise of invasive species in these cities, emphasizing the negative effects of urban sprawl on biodiversity. The study contributes significantly by applying remote sensing and change detection techniques, using Landsat imagery from 1990, 2010, and 2024, combined with supervised classification (SVM), to track land use changes and their effects on plant diversity. This methodology offers a replicable approach for analyzing similar environmental changes in other rapidly urbanizing cities. In terms of policy, the research provides actionable recommendations for integrating green spaces and biodiversity conservation into urban planning, promoting sustainable development that preserves ecosystem services like carbon sequestration and water regulation.

4. Conclusion

The urbanization process in Otukpo has significantly influenced plant diversity and the functioning of local ecosystems. This study underscores the urgent necessity of incorporating environmental conservation into the

city's urban planning aims to reduce the negative effects of urban expansion. The decline of native plants, the spread of invasive species, and the degradation of essential ecosystem functions such as water regulation and carbon storage pose substantial obstacles to sustainable urban growth in Otukpo. Addressing these challenges will require efforts to conserve native species, control the spread of invasive species, and restore fragmented habitats to protect plant diversity in Otukpo. Also, by implementing sustainable urban planning practices, focusing on ecosystem restoration, managing invasive species, and raising environmental awareness among the public, Otukpo can tackle these challenges effectively. Such efforts will guide the city towards a more sustainable and ecologically resilient future, ensuring that development is aligned with environmental protection.

Reference

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