
TEMPORAL CHANGES OF URBAN GREEN AREAS ACROSS NEIGHBORHOODS IN MAKURDI METROPOLIS, BENUE STATE FROM 2000 TO 2024

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ABSTRACT

This study examined the temporal changes of urban green areas across neighborhoods in Makurdi Metropolis, Benue State, from 2000 to 2024. Using GIS and remote sensing techniques, land use and land cover changes were analysed to determine the extent, distribution, and transformation of green areas over time. The findings revealed a significant decline in urban green areas from 58.62% (25.837 km²) in 2000 to 48.04% (21.317 km²) in 2024, with a corresponding increase in non-green areas from 41.38% to 51.96%. Spatial analysis showed that high-density neighborhoods, including Wadata, Akpehe I, and High Level, experienced the most severe reduction in green cover, while planned and low-density areas such as New GRA and Welfare Quarters retained relatively higher proportions of green spaces. The study also found that urban green areas are characterized by low species diversity, with dominance of a few tree species such as *Mangifera indica* and *Terminalia mantaly*, indicating a largely utilitarian pattern of urban greening. Further analysis identified key drivers of green space decline, including urban expansion, infrastructure development, land conversion, and weak planning control mechanisms, reflecting the strong influence of anthropogenic activities on green area dynamics. The study concludes that urban green areas in Makurdi Metropolis have undergone substantial decline and spatial redistribution over the study period, emphasizing the need for sustainable urban planning, improved land-use regulation, and strategic urban greening interventions to ensure long-term environmental sustainability.

KEY WORDS: *Urban, Green Areas, Non-Green Areas, Neighbourhoods.*

1. INTRODUCTION

Urbanization has become one of the most dominant global processes shaping land use patterns, particularly in developing countries. It is characterized by rapid population growth, spatial expansion, and increased demand for infrastructure, which often occurs at the expense of natural ecosystems, including urban green areas (Dushkova & Ignatieva, 2020; Soliman, 2021). Urban green areas such as parks, urban forests, gardens, wetlands, and open spaces are critical components of urban environments, contributing to ecological balance, climate regulation, and improved quality of life. Globally, the expansion of urban areas has resulted in significant reductions in green spaces, as natural land cover is increasingly converted into built-up and impervious surfaces (Abebe & Megento, 2016; Odindi & Mbangara, 2015). Studies have shown that urban growth, particularly along city fringes, leads to the encroachment of residential and commercial developments into green areas, thereby altering land use patterns and degrading environmental quality (Yuan et al., 2015). This transformation is often driven by socio-economic pressures, population density, and weak urban planning frameworks (Gairola & Noresah, 2016).

Urban green areas play a crucial role in mitigating the adverse effects of urbanization. They help regulate urban temperatures, reduce the urban heat island effect, improve air quality, and enhance biodiversity (Bowler et al., 2010; Meili et al., 2021). Empirical evidence indicates that vegetation cover can significantly lower urban temperatures, with reductions ranging between 1°C and 5°C depending on the density and distribution of green spaces (De Abreu-Harbach et al., 2015; Sharmin, 2022). In addition, green areas contribute to human well-being by providing recreational spaces, promoting physical activity, and supporting mental health (Alexander & Gleeson, 2020; Marouli et al., 2020).

Despite these benefits, the depletion of urban green areas remains a major concern, particularly in Sub-Saharan Africa, where rapid and often unplanned urban growth has intensified pressure on available green spaces. Evidence suggests that green areas in many African cities occupy a very small proportion of total land area due to competing land uses and inadequate planning (Abebe & Megento, 2016). In Nigeria, this trend is evident in cities such as Lagos, where green spaces have declined drastically due to urban expansion and infrastructural development.

Makurdi Metropolis, the capital of Benue State, reflects similar urbanization dynamics. Over the past two decades, the city has experienced significant population growth, expansion of

residential neighborhoods, and increased commercial activities. These developments have contributed to the transformation of natural landscapes into built-up areas, thereby reducing the extent and quality of urban green areas. The replacement of vegetated surfaces with impervious materials has also contributed to rising temperatures, altered micro-climatic conditions, and environmental stress within the metropolis (Nor, 2013).

Understanding the temporal changes in urban green areas is essential for sustainable urban planning and environmental management. Spatio-temporal analysis enables the assessment of how green areas have changed over time, identifying patterns of loss, fragmentation, and distribution across different neighborhoods. Such analysis is particularly important in rapidly growing cities like Makurdi, where urban development pressures are high and environmental planning is still evolving.

However, despite the growing importance of urban green infrastructure, there is a noticeable gap in empirical studies focusing on the temporal dynamics of green areas in Makurdi Metropolis. Existing studies are limited and have largely focused on specific aspects such as urban heat island effects or residents' willingness to pay for parks (Ikyaagba et al., 2023; Samuel et al., 2021), without providing a comprehensive spatio-temporal assessment of green space changes.

Against this backdrop, this study seeks to analyze the temporal changes of urban green areas across neighborhoods in Makurdi Metropolis from 2000 to 2024. By examining patterns of change and their spatial distribution, the study aims to provide insights that can inform sustainable urban planning, environmental management, and policy interventions in the study area.

2 STUDY AREA

Makurdi, which doubles as the capital city of Benue State and the headquarters of Makurdi Local Government Area, is the largest urban areas in the State. It is located between latitudes 7° 20' and 8° 10' N, and Longitudes 8° 4' and 9° 40' E. It has a land area of about 800 km², and the city is traversed by the River Benue, which divides it into two: Makurdi North and South (Tyubee, 2004). It comprises the urban areas within Makurdi Local Government Area, including Mission, Clark/Market, Wadata/Ankpa, North Bank I and Wailomayo political divisions or council wards, as well as parts of Fiidi, Modern Market, Bar and North Bank II council wards. It is situated within a physiographic zone called the Benue trough with a mean elevation of 92 meters above sea level (Geographical Information System (GIS) Laboratory, Benue State University, Makurdi, 2023). Makurdi Town has a land area of about

810 square kilometers and situated in the Benue Valley on the banks of River Benue. Makurdi is a transit/nodal point (rail, road, and inland waterways) between the South-East and Northern parts of Nigeria (Nyagba, 1995).

Makurdi Metropolis is bounded by Gwer West Local Government Area to the west, Gwer East Local Government Area to the south, Guma to the North East and Doma to the North West. Politically, it falls within the Middle Belt region of Nigeria and has a radius of 16 kilometres from its centre. It is the capital of Benue State and headquarters of Makurdi Local Government Area (Shabu, Fate, & Ukula, 2021). It serves as a major link between the Northern and Southern parts of Nigeria. The Town has several drainage channels. These channels include river Benue, which bisects the town into South and north banks, and its tributaries including Urudu, Demekpe, Kereke and Mu and the smaller ones include Idye and Dyege (Shabu, Fate, & Ukula, 2021).

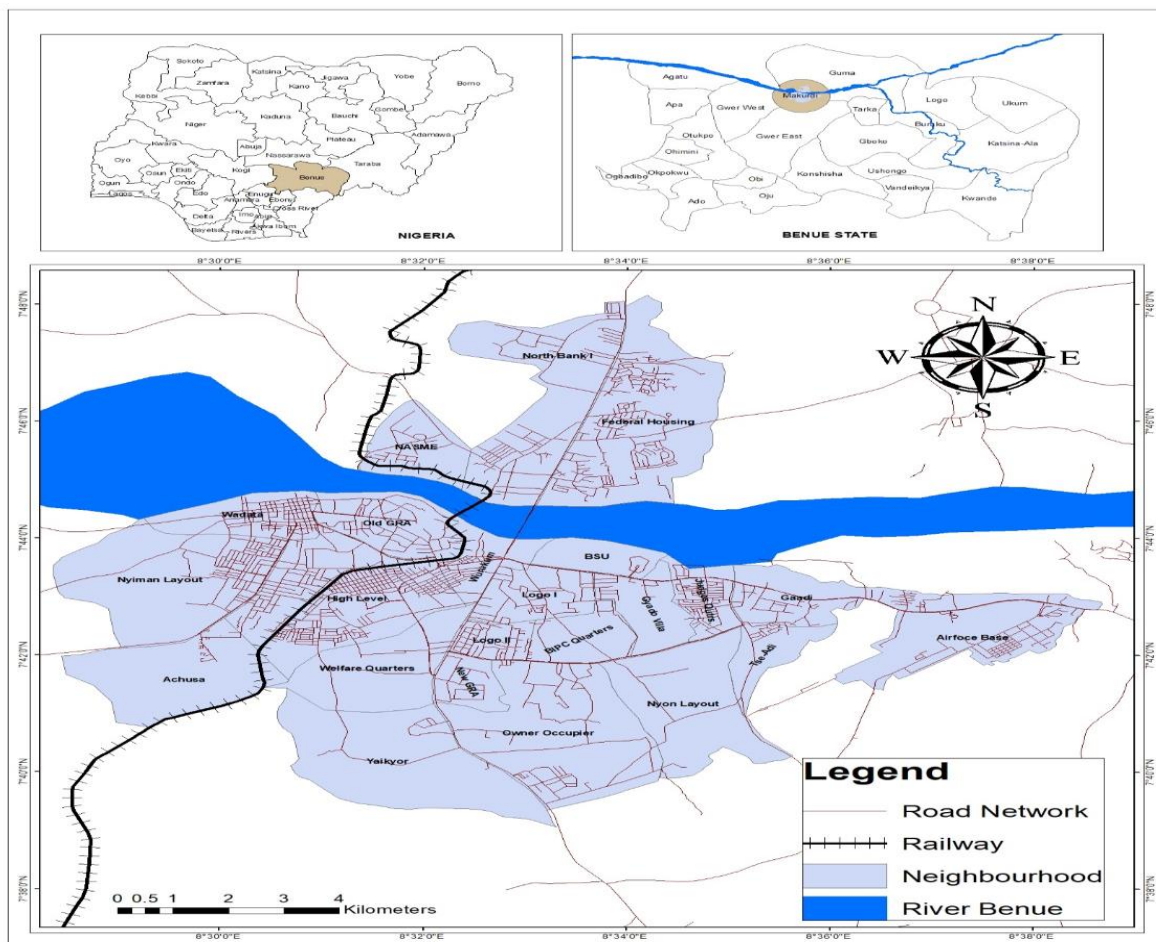


Figure 1: Makurdi Local Government Area showing Makurdi Metropolis.

Source: Geographical Information System (GIS) Laboratory, Benue State University, Makurdi (2023)

Makurdi Metropolis, located in the Benue Valley, experiences a tropical, seasonally wet and dry climate (Koppen's Aw), with distinct wet (April–October) and dry (November–March) seasons. The wet season brings rainfall ranging from 1000–2000 mm annually, peaking in August/September (221 mm on average). The town's climate is influenced by the South-West Monsoon (SWM) and North-East Monsoon (NEM), while the Intertropical Discontinuity (ITD) and local topography also affect rainfall patterns (Tyubee, 2004). The mean rainy season lasts 182 days, and temperatures vary between 26°C in December and 31°C in March/April. Humidity ranges from 43% in January to 81% in July/August, with high temperatures and humidity causing thermal stress during the dry season (Tyubee, 2005).

The geology of Makurdi Metropolis is dominated by sedimentary formations, primarily sandstone, which underlies most of the town and contributes to its fertile soils (Abaa, 2004). These well-drained soils support urban parks and green spaces, enhancing the town's aesthetic and ecological quality. However, urbanization has led to the loss of much of Makurdi's natural vegetation, replaced by fruit trees and ornamental plants, though parks still play a crucial role in preserving greenery and offering shaded, cooler spaces that mitigate the effects of urban heat islands and improve residents' well-being.

Makurdi Metropolis faces challenges with flooding due to its low-lying terrain and poor drainage systems, particularly in flood-prone areas like Wadata and Wurukum. The town is situated near the River Benue, which frequently overflows during the rainy season, exacerbating flooding risks. Urban parks integrated with green infrastructure can help manage stormwater, reduce flooding, and offer safe outdoor spaces for recreation and mental restoration (Udo1970).

Makurdi Metropolis population is projected to reach 666,087 by 2024, with urban growth driven by commerce, civil service, and small-scale agriculture (Lyam, 1995). The rapid population increase has resulted in urban congestion, highlighting the need for parks as accessible spaces for relaxation, social interaction, and stress relief. The diverse land uses in Makurdi, ranging from residential and commercial to recreational, further underscore the importance of urban parks in maintaining environmental quality and supporting the physical and emotional well-being of the growing population (Lyam, 1995).

3 MATERIALS AND METHODS

3.1 Research Design

The researcher employed a mixed design, Qualitative research design and Quantitative research design, using geospatial analysis and spatial statistics to assess the distribution of

urban green spaces in Makurdi town. Remotely sensing data from Landsat Satellite imagery of Operational Land Imager 9 (OLI) Oct (2024) were used. The Landsat imagery dataset was sourced from the Earth explorer platform from United States Geological Surveys (USGS) to determine the temporal changes of urban green areas in Makurdi Metropolis.

3.2 Data Needs

Table 1: Showing Data needs for Analysis.

Objectives	Data category	Variables	Description	Source	Data type
iSpatio-temporal pattern of urban green areas					
Temporal changes of urban green Areas across neighbourhoods					
	Historical Land Cover	Green area extent per year	Green space distribution over time	Satellite imagery	Raster
	Change Detection Data	Gain/loss of green areas	Quantifies increase or decrease	GIS analysis	Numeric

3.3 Data Source

1. Data on spatio-temporal pattern of green areas in Makurdi Metropolis was obtained through GIS and Remote sensing photographs 2000 – 2024.
2. Land Sat ETM (2000) of 30m spatial resolution
3. Land Sat ETM+ (2008) of 30m spatial resolution
4. Land sat-8 (2016) of 30m spatial resolution
5. Land sat-8 (2024) of 30m spatial resolution
6. Data on types of green areas in the study area was obtained through field survey.
7. Data on temporal changes of urban green areas was obtained through GIS and remote sensing data in Makurdi Metropolis.

3.4 Instruments of Data Collection

The following instruments were used to collect data on spatio-temporal pattern of urban green areas, types of green areas, temporal changes, residents’ proximity and accessibility of urban green areas, factors affecting urban green areas with the use of the following instruments:

- 1 **Ground truthing;** Ground truthing was conducted to validate classified land cover data. GPS points of selected green areas will be collected to improve classification accuracy.

- 2 GIS and Remote sensing data:** The researcher also used GIS and Remote sensing data, this involved collecting information about the study area (Makurdi Metropolis) through aerial photographs.

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3.6 Study Population

The study population comprised of all neighbourhoods of Makurdi Metropolis having an estimated total population of 272,000 in 2024, distributed across 56 neighborhoods and residents in the selected neighbourhoods must have lived in the neighbourhoods for at least a minimum of eight years. This is to capitalize on genuine experience. Residents were included in the study population because the proximity and accessibility of green areas and factors affecting green areas are qualitative, context-specific and cannot be derived from remote sensing alone.

3.7 Data Analysis

The data analysis techniques for this study on temporal changes in green areas, a change detection technique was applied by comparing classified images from different years. This helps in determining areas where green spaces have increased or decreased. The rate of change was calculated, and a transition analysis was carried out to show how land has been converted from green areas to other uses such as built-up areas. These areas were mapped using GIS, and their sizes were calculated for each neighbourhood.

3 RESULTS AND DISCUSSION

4.1 Temporal Changes of Urban Green Areas in Makurdi Town

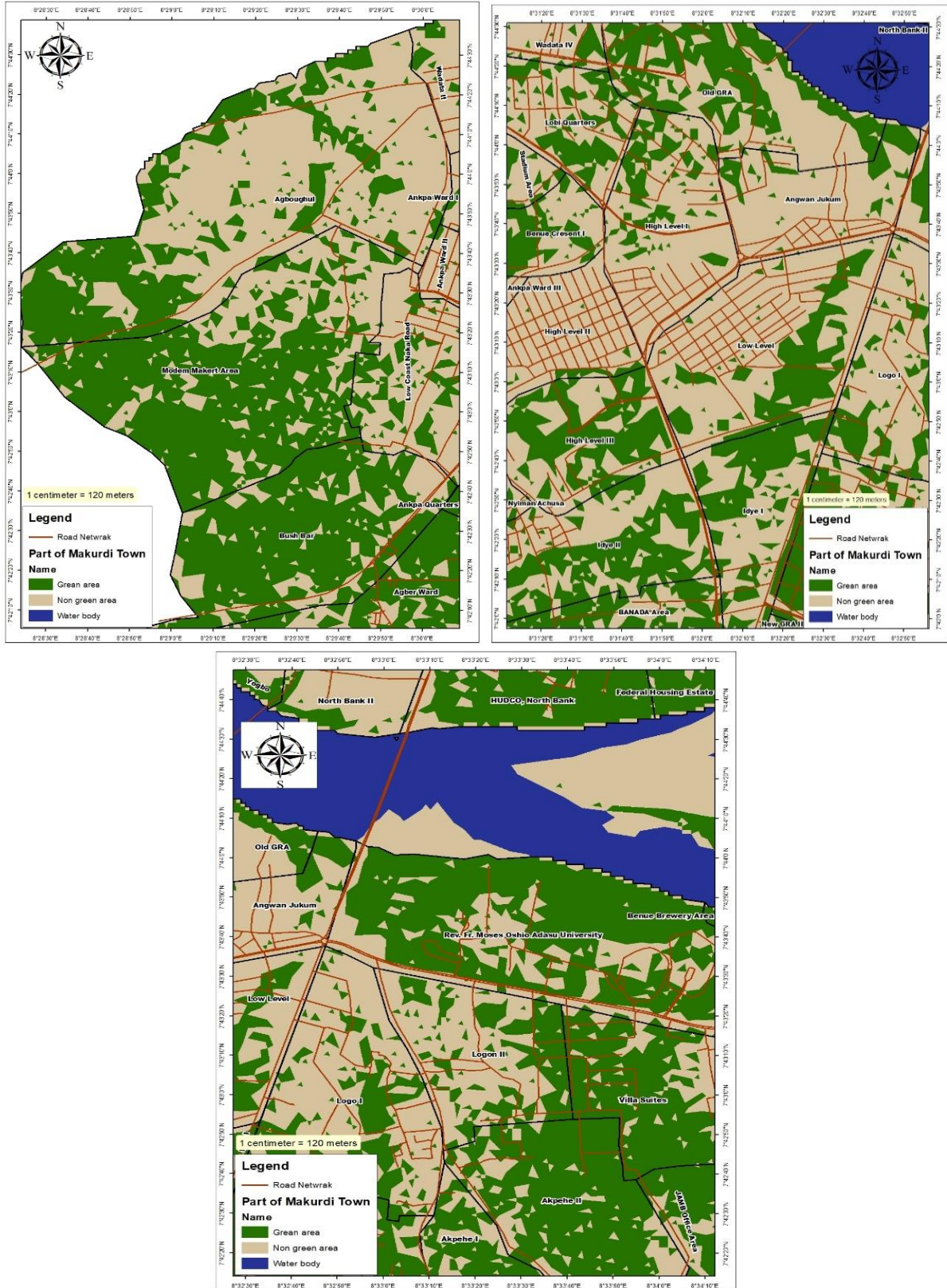
The study area, Makurdi town, was modelled using the NDVI values to generate the Urban Green Space for the study. To quantify the urban green space in the study area, the entire study area was balkanized into 56 neighbourhoods, constituting the Makurdi town, to determine the urban green space available in 2000, 2008, 2016, and 2024 per neighbourhood. A standard measure for neighbourhood size was used to arrive at the availability of urban green space per neighbourhood.

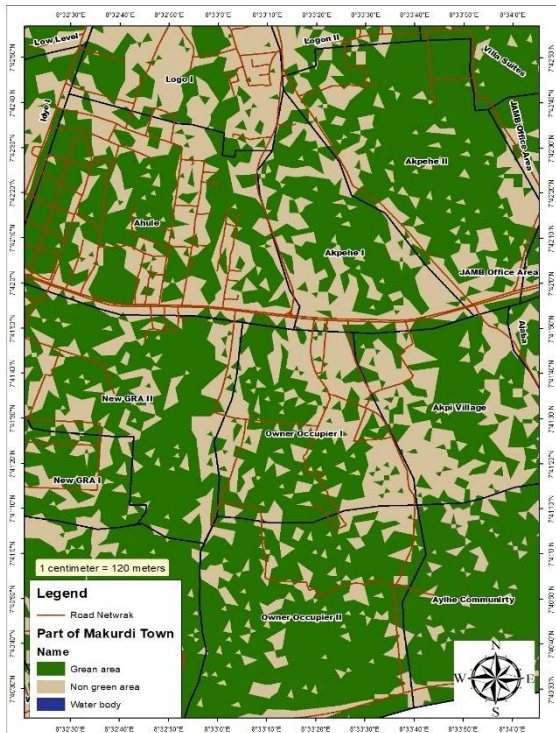
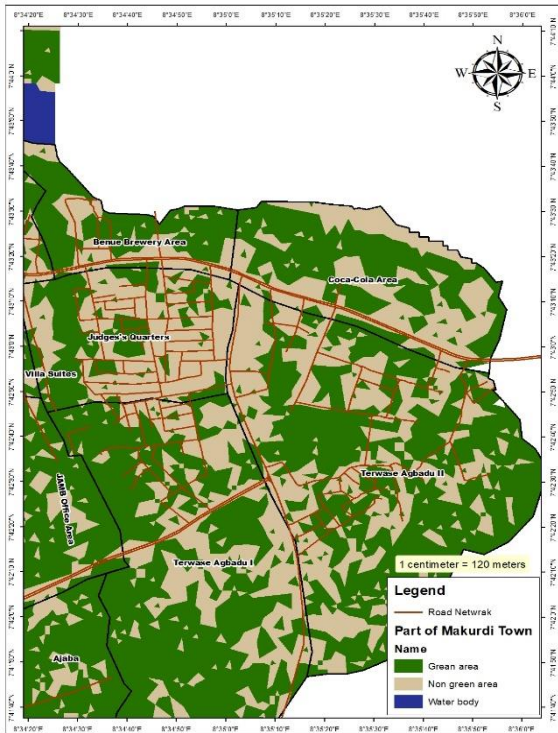
The findings indicate a consistent decline in green area across all neighbourhoods between 2000 and 2024, confirming a widespread pattern of urban expansion at the expense of vegetation. In 2000, many neighbourhoods recorded relatively high green area proportions, often above 60%, for example, Sule Settlement (74.74%), Low-cost North Bank (82.22%), Federal Housing (99.06%), and Welfare Quarters (81.39%). However, by 2024, these values had significantly reduced, with Sule Settlement dropping to 61.28%, Low-cost North Bank to 67.41%, Federal Housing to 81.13%, and Welfare Quarters to 66.70%. This reflects a clear downward trajectory in green cover over time.

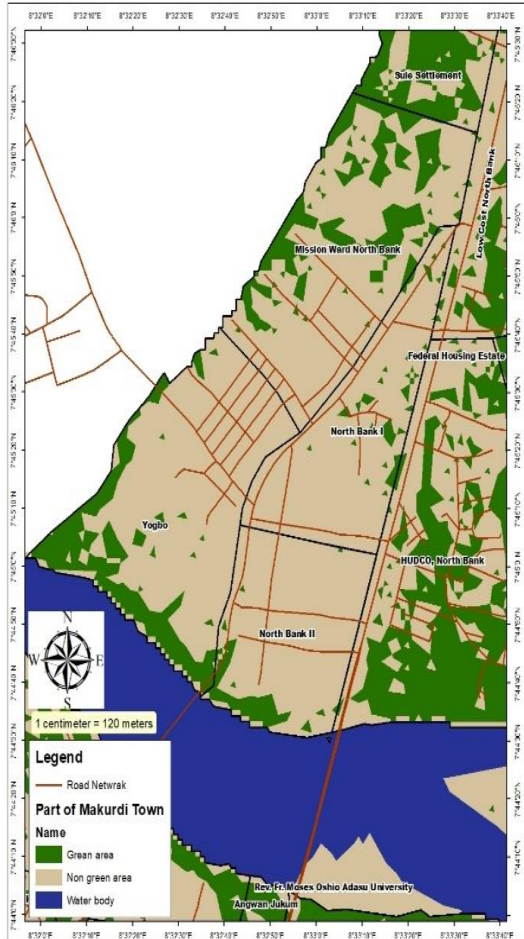
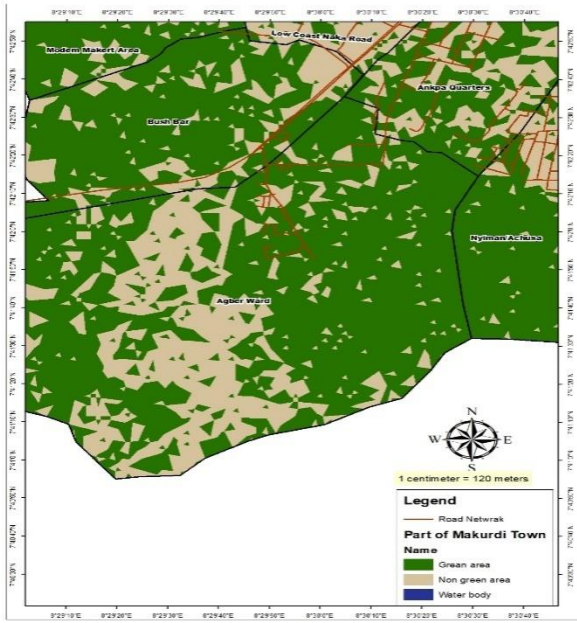
Moderately green neighbourhoods such as Old GRA (59.85% to 49.08%), Kanshio (78.62% to 64.45%), and New GRA II (63.42% to 52.07%) also show substantial percentage declines, indicating that even planned or less densely built areas are experiencing vegetation loss. Similarly, low-green areas such as North Bank I (6.22% to 5.09%) and High Level II (4.63% to 3.79%) exhibit minor reductions, largely because they were already highly urbanized at the time of the study period.

In contrast, some areas retained relatively high green proportions despite decline, such as Ajaba (97.87% to 80.11%), Ayihe Community (100% to 82.77%), and Owner Occupier II (96.36% to 78.90%), suggesting that peri-urban or less densely developed zones still maintain significant vegetation cover, although under increasing pressure. Meanwhile, Wadata III remained at 0% green area throughout the study period, indicating a completely built-up environment with no vegetation presence.

Overall, the synthesized pattern shows that green area percentages have decreased across all categories high, medium, and low green neighborhoods between 2000 and 2024, with reductions typically ranging between 5% and over 20%. This uniform decline highlights the dominant influence of urbanization, resulting in the progressive replacement of green spaces with built-up land uses. The trend underscores a growing risk to urban environmental







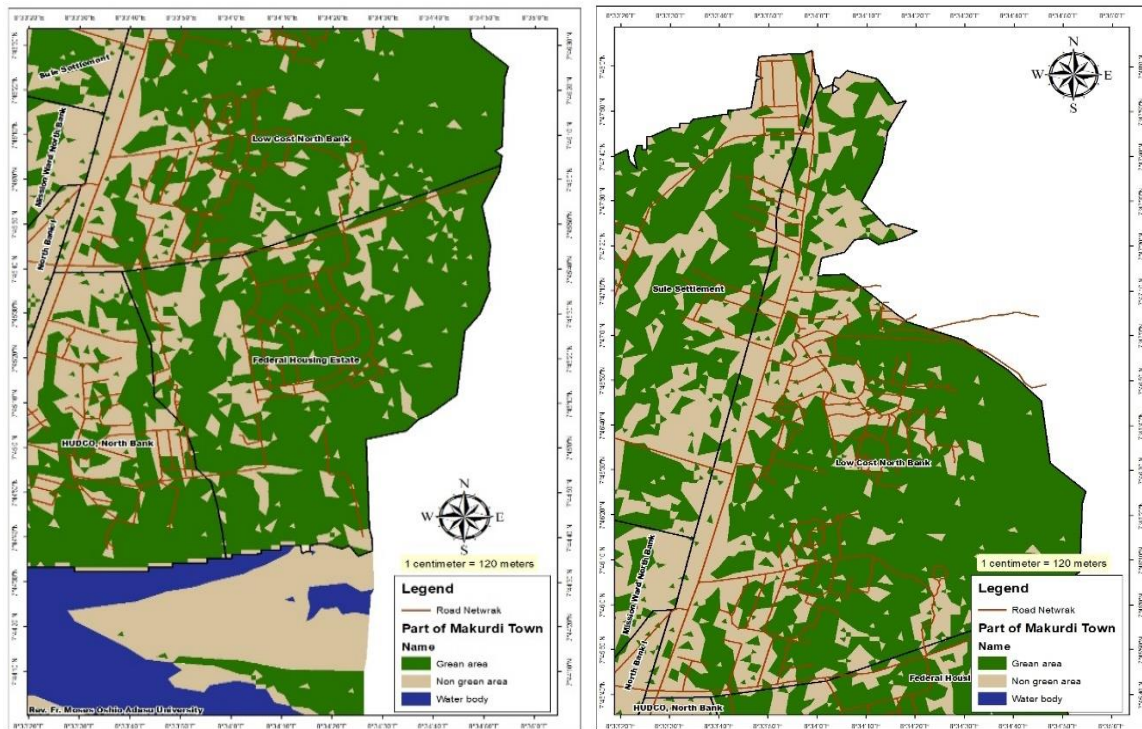


Figure 2-14: Spatio-temporal variation of Green Areas in Makurdi Town (2000- 2024)

The findings of this study are consistent with a growing body of empirical literature in Nigeria and other developing countries, which report declining urban spaces due to rapid urban expansion. For instance, Oyinloye and Kufoniyi (2019), in their study of Akure, observed a steady decrease in vegetation cover alongside a significant increase in built-up areas between 2000 and 2015. Similarly, Arowolo and Deng (2018) reported that major Nigerian cities, including Abuja and Lagos, have experienced substantial loss of green areas as a result of urbanisation and population pressure. These studies align closely with the current findings in Makurdi, where green areas declined from 58.62% in 2000 to 48.04% in 2024, while non-green areas increased correspondingly. The consistency of these patterns suggests that the observed changes in Makurdi are part of a broader national trend of vegetation loss driven by unregulated urban growth and infrastructural development.

More specifically, studies conducted within the Middle Belt region further reinforce the patterns identified in this study. For example, Agbor et al. (2019), in their analysis of land use dynamics in the Lower Benue Basin, found that built-up areas expanded significantly at the expense of vegetation cover, largely due to agricultural expansion and urban sprawl. In a related study, Aho et al. (2019) also documented increasing anthropogenic pressure on land resources in Benue State, leading to progressive degradation of natural vegetation. These findings are in strong agreement with the spatial patterns observed in Makurdi, particularly in

neighbourhoods such as High Level 1, North Bank, and Wadata 1, where rapid conversion of green areas to built-up land was evident. The dramatic decline in green cover in these areas mirrors the broader regional trend of land transformation driven by both formal and informal urban development processes. At the intra-urban scale, the spatial disparities identified in this study are also supported by empirical evidence from other Nigerian cities. For instance, Olalekan et al. (2021) found that urban green spaces in Ibadan are unevenly distributed, with high-income and planned neighbourhoods maintaining more vegetation cover compared to densely populated and informal settlements. This pattern is clearly reflected in Makurdi, where areas such as New GRA, Welfare Quarters, and Ayihe community retained relatively high green coverage, while Akpehe 1, Wadata 1, and Logo I recorded persistently low levels. Similarly, Adegun et al. (2021) reported that ineffective planning control and weak enforcement of land-use regulations contribute significantly to the loss of green infrastructure in rapidly growing Nigerian cities.

Beyond Nigeria, comparable trends have been documented in other developing regions, reinforcing the global relevance of the findings. For example, Hassan et al. (2020) in a study of urban expansion in Sub-Saharan Africa reported that most cities are experiencing a transition from vegetation-dominated landscapes to built-up environments, with significant environmental consequences. Similarly, Li et al. (2018) observed that rapid urbanisation in Asian cities has led to fragmentation and reduction of urban green spaces, thereby exacerbating urban heat island effects and environmental degradation. The sharp decline in green areas observed in Makurdi between 2016 and 2024, and the near reversal of green to non-green dominance, is therefore not an isolated phenomenon but part of a wider global pattern. However, the situation in Makurdi appears particularly critical due to the speed of recent changes and the apparent lack of effective mitigation strategies, underscoring the urgency for proactive urban planning interventions. Detail information on temporal changes for each neighbourhood is stated as follows;

1. Sule Settlement

Sule Settlement has a total area of 5.001 km². In 2000, the green area was 3.738 km² (74.74%), while the non-green area was 1.263 km² (25.26%). By 2024, the green area declined to 3.065 km² (61.28%), while the non-green area increased to 1.936 km² (38.72%). This indicates a clear decrease in green area and corresponding increase in built-up (non-green) surfaces.

2. Low-cost North Bank

Low-cost North Bank covers a total of 5.915 km². In 2000, green area stood at 4.865 km² (82.22%), with non-green area at 1.050 km² (17.78%). By 2024, green area reduced to 3.987 km² (67.41%), while non-green area rose to 1.928 km² (32.59%). This reflects a significant decline in vegetation and expansion of built-up areas.

3. Mission Ward North Bank

Mission Ward NB has a total area of 1.480 km². In 2000, green area was 0.435 km² (29.45%), while non-green area was 1.045 km² (70.55%). By 2024, green area decreased to 0.357 km² (24.13%), and non-green area increased to 1.123 km² (75.87%). This shows a steady reduction in green cover.

4. Yogbo

Yogbo has a total area of 1.539 km². In 2000, green area was 0.376 km² (24.39%), and non-green area was 1.163 km² (75.61%). By 2024, green area declined to 0.308 km² (20.00%), while non-green area increased to 1.231 km² (80.00%), indicating a consistent decline in green space.

5. Federal Housing

Federal Housing has a total area of 3.510 km². In 2000, green area was 3.477 km² (99.06%), with non-green area at 0.033 km² (0.94%). By 2024, green area reduced to 2.840 km² (81.13%), while non-green area increased to 0.662 km² (18.87%). Despite remaining highly green, there is a notable decline in vegetation.

6. HUDCO Quarters NB

HUDCO Quarters NB covers 2.181 km². In 2000, green area was 1.433 km² (65.72%), and non-green area was 0.748 km² (34.24%). By 2024, green area dropped to 1.174 km² (53.83%), while non-green area rose to 1.007 km² (46.17%), indicating a moderate decline.

7. North Bank I

North Bank I has a total area of 0.945 km². In 2000, green area was 0.058 km² (6.22%), while non-green area was 0.887 km² (93.78%). By 2024, green area slightly declined to 0.048 km² (5.09%), and non-green area increased to 0.897 km² (94.91%), showing a minimal but consistent decline.

8. North Bank II

North Bank II covers 0.891 km². In 2000, green area was 0.089 km² (10.07%), and non-green area was 0.802 km² (89.93%). By 2024, green area reduced to 0.073 km² (8.23%), while non-green area increased to 0.818 km² (91.77%), indicating a gradual decline.

9. Agboughul

Agboughul has a total area of 3.848 km². In 2000, green area was 1.676 km² (43.56%), while non-green area was 2.172 km² (56.44%). By 2024, green area declined to 1.372 km² (35.65%), and non-green area increased to 2.476 km² (64.35%), showing a moderate reduction in green space.

10. Akpehe I

Akpehe I has a total area of 1.045 km². In 2000, green area was 0.736 km² (70.43%), and non-green area was 0.309 km² (29.57%). By 2024, green area decreased to 0.603 km² (57.71%), while non-green area increased to 0.442 km² (42.29%), indicating a noticeable decline.

11. Wadata II

Wadata II has a total area of 0.950 km². In 2000, green area was 0.101 km² (10.62%), while non-green area was 0.848 km² (89.38%). By 2024, green area reduced to 0.083 km² (8.70%), and non-green area increased to 0.867 km² (91.30%), showing a slight decline.

12. Wadata III

Wadata III has a total area of 0.841 km². Both in 2000 and 2024, green area remained 0.000 km² (0%), while non-green area remained 0.841 km² (100%), indicating a fully built-up area with no change.

13. Wadata IV

Wadata IV covers 1.114 km². In 2000, green area was 0.292 km² (26.24%), while non-green area was 0.822 km² (73.76%). By 2024, green area declined to 0.239 km² (21.50%), and non-green area increased to 0.875 km² (78.50%), indicating a gradual decline.

14. Old GRA

Old GRA has a total area of 1.834 km². In 2000, green area was 1.098 km² (59.85%), and non-green area was 0.736 km² (40.15%). By 2024, green area decreased to 0.900 km²

(49.08%), while non-green area increased to 0.934 km² (50.92%), showing a significant reduction.

15. Angwan Jukum

Angwan Jukum has a total area of 1.021 km². In 2000, green area was 0.231 km² (22.63%), while non-green area was 0.790 km² (77.37%). By 2024, green area declined to 0.189 km² (18.53%), and non-green area increased to 0.832 km² (81.47%). This indicates a steady decrease in green cover.

16. Rev. Fr. Moses OrshioAdasu University Makurdi (MOAUM)

This neighborhood has a total area of 2.808 km². In 2000, green area was 0.580 km² (20.66%), with non-green area at 2.228 km² (79.34%). By 2024, green area reduced to 0.475 km² (16.92%), while non-green area increased to 2.333 km² (83.08%), indicating a consistent decline.

17. Logo I

Logo I has a total area of 1.662 km². In 2000, green area was 0.517 km² (31.13%), and non-green area was 1.145 km² (68.87%). By 2024, green area decreased to 0.424 km² (25.49%), while non-green area increased to 1.238 km² (74.51%), showing a moderate decline.

18. Logo II

Logo II covers 1.153 km². In 2000, green area was 0.517 km² (~31.13%), while non-green area was ~0.636 km² (~68.87%). By 2024, green area reduced to 0.428 km² (37.08%), and non-green area is 0.725 km² (62.92%). Despite slight inconsistencies in percentages, the area values confirm a decline in green cover.

19. Benue Brewery

Benue Brewery has a total area of 0.664 km². In 2000, green area was 0.398 km² (59.88%), and non-green area was 0.266 km² (40.12%). By 2024, green area declined to 0.326 km² (49.03%), while non-green area increased to 0.338 km² (50.97%), indicating a clear reduction.

20. Coca-Cola Area

Coca-Cola Area has a total area of 1.235 km². In 2000, green area was 0.724 km² (58.62%), and non-green area was 0.511 km² (41.38%). By 2024, green area reduced to 0.593 km²

(40.00%), while non-green area increased to 0.642 km² (52.00%), showing a substantial decline.

21. Judges Quarters

Judges Quarters covers 1.108 km². In 2000, green area was 0.650 km² (58.62%), and non-green area was 0.458 km² (41.38%). By 2024, green area declined to 0.532 km² (48.00%), while non-green area increased to 0.576 km² (52.00%), indicating a notable decrease.

22. Terwase Agbadu I

This area has a total of 2.893 km². In 2000, green area was 1.033 km² (35.71%), while non-green area was 1.860 km² (64.29%). By 2024, green area decreased to 0.846 km² (26.25%), and non-green area increased to 2.047 km² (70.75%), showing a clear decline.

23. TerwaseA gbadu II

Terwase Agbadu II covers 3.095 km². In 2000, green area was 0.519 km² (16.78%), and non-green area was 2.576 km² (83.22%). By 2024, green area reduced to 0.425 km² (13.74%), while non-green area increased to 2.670 km² (86.26%), indicating a gradual decline.

24. JAMB Office Area

This area has a total of 1.280 km². In 2000, green area was 1.280 km² (100%), with no non-green area. By 2024, green area slightly declined to 1.251 km² (97.76%), while non-green area increased to 0.029 km² (2.24%), but it remains almost entirely green.

25. Akpehe II

Akpehe II has a total area of 1.710 km². In 2000, green area was 0.692 km² (40.43%), and non-green area was 1.018 km² (59.57%). By 2024, green area decreased to 0.566 km² (33.11%), while non-green area increased to 1.144 km² (66.89%), indicating a moderate decline.

26. Villa Suites

Villa Suites covers 1.207 km². In 2000, green area was 1.142 km² (94.54%), and non-green area was 0.065 km² (5.42%). By 2024, green area declined to 0.935 km² (77.48%), while non-green area increased to 0.272 km² (22.52%), showing a significant reduction.

27. Ahule

Ahule has a total area of 1.960 km². In 2000, green area was 1.762 km² (89.90%), and non-green area was 0.198 km² (10.10%). By 2024, green area reduced to 1.442 km² (73.57%), while non-green area increased to 0.518 km² (26.43%), indicating a strong decline.

28. Ajaba

Ajaba covers 1.880 km². In 2000, green area was 1.840 km² (97.87%), and non-green area was 0.040 km² (2.13%). By 2024, green area declined to 1.506 km² (80.11%), while non-green area increased to 0.374 km² (19.89%), showing a substantial decrease.

29. Ayihe Community

Ayihe Community has a total area of 1.819 km². In 2000, green area was 1.819 km² (100%), with no non-green area. By 2024, green area reduced to 1.506 km² (82.77%), while non-green area increased to 0.313 km² (17.23%), indicating a clear decline.

30. Owner Occupier II

This neighborhood covers 1.933 km². In 2000, green area was 1.863 km² (96.36%), and non-green area was 0.070 km² (3.64%). By 2024, green area declined to 1.523 km² (78.90%), while non-green area increased to 0.408 km² (21.10%), showing a significant loss.

31. Kanshio

Kanshio has a total area of 2.139 km². In 2000, green area was 1.682 km² (78.62%), and non-green area was 0.457 km² (21.38%). By 2024, green area decreased to 1.378 km² (64.45%), while non-green area increased to 0.761 km² (35.55%), indicating a moderate decline.

32. Welfare Quarters

Welfare Quarters covers 7.452 km². In 2000, green area was 6.067 km² (81.39%), and non-green area was 1.385 km² (18.61%). By 2024, green area reduced to 4.970 km² (66.70%), while non-green area increased to 2.482 km² (33.30%), indicating a large-scale decline.

33. Ifan

Ifan has a total area of 1.929 km². In 2000, green area was 1.504 km² (77.93%), and non-green area was 0.425 km² (22.07%). By 2024, green area declined to 1.232 km² (63.88%), while non-green area increased to 0.697 km² (36.12%), showing a steady decrease.

34. BNARDA Area

BNARDA Area covers 1.391 km². In 2000, green area was 1.143 km² (82.04%), and non-green area was 0.248 km² (17.96%). By 2024, green area reduced to 0.936 km² (67.26%), while non-green area increased to 0.455 km² (32.74%), indicating a notable decline.

35. New GRA II

New GRA II has a total area of 1.694 km². In 2000, green area was 1.077 km² (63.42%), and non-green area was 0.617 km² (36.58%). By 2024, green area decreased to 0.882 km² (52.07%), while non-green area increased to 0.812 km² (47.93%), showing a steady decline.

36. Akpi Village

Akpi Village covers 1.216 km². In 2000, green area was 0.783 km² (64.15%), and non-green area was 0.433 km² (35.85%). By 2024, green area declined to 0.642 km² (52.79%), while non-green area increased to 0.574 km² (47.21%), indicating a moderate decrease.

37. Owner Occupier I

This area has a total of 1.258 km². In 2000, green area was 1.060 km² (84.18%), and non-green area was 0.198 km² (15.82%). By 2024, green area reduced to 0.868 km² (69.03%), while non-green area increased to 0.390 km² (30.97%), showing a clear decline.

38. Modern Market Area

Modern Market Area covers 2.954 km². In 2000, green area was 2.758 km² (93.36%), and non-green area was 0.196 km² (6.64%). By 2024, green area declined to 2.259 km² (76.45%), while non-green area increased to 0.695 km² (23.55%), indicating a significant reduction.

39. Bush Bar

Bush Bar has a total area of 1.983 km². In 2000, green area was 1.679 km² (84.61%), and non-green area was 0.304 km² (15.39%). By 2024, green area decreased to 1.375 km² (69.35%), while non-green area increased to 0.608 km² (30.65%), showing a steady decline.

40. Agber Ward

Agber Ward covers 5.983 km². In 2000, green area was 4.023 km² (67.23%), and non-green area was 1.960 km² (32.77%). By 2024, green area declined to 3.294 km² (55.05%), while non-green area increased to 2.689 km² (44.95%), indicating a moderate decrease.

41. Ankpa Quarters

Ankpa Quarters has a total area of 1.608 km². In 2000 green area was 0.895 km² (55.63) and non-green space was 0.713km² (44.37). By 2014, green space declined to 0.733 km² (45.55) while non-green area increased to 0.875km² (54.45). This indicates a moderate decrease.

42. Idye I

Idye I has a total area of 1.185 km². In 2000, green area was 0.900 km² (75.24%), while non-green area was 0.285 km² (24.14%). By 2024, green area declined to 0.737 km² (62.20%), and non-green area increased to 0.448 km² (37.80%). This indicates a steady decrease in green cover.

43. Idye II

Idye II has a total area of 1.532 km². In 2000, green area was 0.947 km² (61.71%), while non-green area was 0.585 km² (38.29%). By 2024, green area reduced to 0.776 km² (50.64%), and non-green area increased to 0.756 km² (49.36%), showing a moderate decline.

44. High Level III

High Level III covers 1.118 km². In 2000, green area was 0.354 km² (31.66%), and non-green area was 0.764 km² (68.34%). By 2024, green area decreased to 0.290 km² (25.95%), while non-green area increased to 0.828 km² (74.05%), indicating a gradual reduction.

45. Low Level

Low Level has a total area of 1.902 km². In 2000, green area was 1.090 km² (57.24%), while non-green area was 0.812 km² (42.76%). By 2024, green area declined to 0.892 km² (46.90%), and non-green area increased to 1.010 km² (53.10%), showing a moderate decrease.

46. Nyiman/ Achusa

Nyiman/ Achusa covers 2.811 km². In 2000, green area was 1.119 km² (39.78%), and non-green area was 1.692 km² (60.22%). By 2024, green area reduced to 0.916 km² (32.60%), while non-green area increased to 1.895 km² (67.40%), indicating a steady decline.

47. Lobi Quarters

Quarters has a total area of 0.982 km². In 2000, green area was 0.237 km² (24.23%), and non-green area was 0.745 km² (75.77%). By 2024, green area decreased to 0.195 km² (19.83%), while non-green area increased to 0.787 km² (80.17%), showing a slight decline.

48. High Level I

High Level I cover 1.353 km². In 2000, green area was 0.417 km² (30.82%), and non-green area was 0.936 km² (69.18%). By 2024, green area declined to 0.342 km² (25.24%), while non-green area increased to 1.011 km² (~74.76%), indicating a gradual reduction.

49. High Level II

High Level II has a total area of 0.943 km². In 2000, green area was 0.044 km² (4.63%), while non-green area was 0.899 km² (95.37%). By 2024, green area slightly declined to 0.036 km² (3.79%), and non-green area increased to 0.907 km² (96.21%), showing a minimal but persistent decline.

50. Low-Cost Naka Road

Low-Cost Naka Road covers 1.415 km². In 2000, green area was 0.376 km² (26.73%), and non-green area was 1.039 km² (73.27%). By 2024, green area reduced to 0.308 km² (21.75%), while non-green area increased to 1.107 km² (78.25%), indicating a steady decrease.

51. Ankpa Ward I

Ankpa Ward I has a total area of 0.928 km². In 2000, green area was 0.345 km² (37.20%), while non-green area was 0.583 km² (62.80%). By 2024, green area declined to 0.283 km² (30.52%), and non-green area increased to 0.645 km² (69.48%), showing a moderate decline.

52. Ankpa Ward II

Ankpa Ward II covers 0.552 km². In 2000, green area was 0.108 km² (19.94%), and non-green area was 0.444 km² (80.06%). By 2024, green area decreased to 0.089 km² (16.18%), while non-green area increased to 0.463 km² (83.82%), indicating a gradual reduction.

53. Ankpa Ward III

Ankpa Ward III has a total area of 0.794 km². In 2000, green area was 0.048 km² (5.98%), while non-green area was 0.746 km² (94.02%). By 2024, green area declined to 0.039 km² (4.89%), and non-green area increased to 0.755 km² (95.11%), showing a slight decrease.

54. Stadium Area

Stadium Area covers 0.587 km². In 2000, green area was 0.371 km² (63.18%), and non-green area was 0.216 km² (36.82%). By 2024, green area reduced to 0.304 km² (51.79%), while non-green area increased to 0.283 km² (48.21%), indicating a clear decline.

55. New GRA I

New GRA I have a total area of 0.661 km². In 2000, green area was 0.415 km² (62.81%), and non-green area was 0.246 km² (37.19%). By 2024, green area declined to 0.340 km² (51.49%), while non-green area increased to 0.321 km² (48.51%), showing a moderate decrease.

56. Benue Crescent I

Benue Crescent I cover 1.215 km². In 2000, green area was 0.494 km² (40.65%), and non-green area was 0.721 km² (59.35%). By 2024, green area decreased to 0.405 km² (33.31%), while non-green area increased to 0.810 km² (66.69%), indicating a steady decline.

4.5.1 A Generic Temporal Variation of Green Areas in Makurdi Town

The result of temporal variations of green areas in Makurdi Town is presented in Table 9 and Figure 2-14

Table 1: Temporal Variation in Green Areas in Makurdi. (2000-2024)

Year/ Greening Status	2024		2016		2008		2000	
	Area in Km ²	%	Area in Km ²	%	Area in Km ²	%	Area in Km ²	%
Non-Green Areas	23.056	51.96	19.580	44.85	18.993	43.64	18.236	41.38
Green Areas	21.317	48.04	24.087	55.15	24.534	56.36	25.837	58.62
Total	44.374	100.00	43.677	100.00	43.527	100.00	44.073	100.00

The results presented in Table 1 and Figure 2 reveal a clear and progressive temporal shift in the composition of land use in Makurdi between 2000 and 2024, characterised by a steady decline in green areas and a corresponding expansion of non-green areas. In 2000, green areas dominated the urban landscape, accounting for 58.62% (25.837 Km²) of the total land area, while non-green areas constituted only 41.38%. This indicates that, at the beginning of

the study period, Makurdi still retained a relatively high level of vegetation cover and open spaces. However, by 2008 and 2016, green areas had declined to 56.36% and 55.15% respectively, reflecting gradual but continuous encroachment of built-up developments into previously vegetated lands.

The most significant change occurred between 2016 and 2024, where green areas dropped sharply to 48.04% (21.317 Km²), falling below the proportion of non-green areas for the first time in the study period. Correspondingly, non-green areas increased consistently from 41.38% in 2000 to 51.96% (23.056 Km²) in 2024. This steady increase in non-green surfaces, such as residential buildings, roads, and commercial infrastructure, strongly suggests intensified urban expansion, likely driven by rapid population growth, increased housing demand, and infrastructural development. The acceleration of this trend in the most recent period indicates that urban growth has become more rapid and possibly less controlled.

5 SUMMARY OF FINDINGS

The study revealed significant temporal changes in urban green areas across neighborhoods in Makurdi Metropolis between 2000 and 2024. Findings show a consistent decline in green cover from 58.62% in 2000 to 48.04% in 2024, accompanied by a corresponding increase in built-up and non-green areas. This trend reflects the impact of rapid urbanization, which has been widely associated with vegetation loss in urban environments. Spatially, green space distribution varies across neighborhoods, with planned and low-density areas such as New GRA and Welfare Quarters maintaining relatively high green coverage, while high-density neighborhoods like Wadata, High Level, and Akpehe experienced severe decline. This uneven pattern highlights the influence of urban planning and socio-economic conditions on green space retention.

The study also found that urban greening is dominated by a few tree species, particularly *Mangifera indica* and *Terminalia mantaly*, indicating low biodiversity and a largely utilitarian approach to urban greening. This limited diversity increases vulnerability to environmental stress and reduces ecosystem resilience.

Furthermore, the analysis identified multiple drivers of green space decline, including urban expansion, informal settlements, livelihood dependence, commercial activities, infrastructure development, and weak governance structures. These factors collectively demonstrate that green space loss is a multidimensional issue shaped by both human activities and institutional limitations (Yuan et al., 2015).

6 CONCLUSION

The study concludes that urban green areas in Makurdi Metropolis have undergone substantial decline over the 24-year period (2000–2024) due to increasing urbanization and land-use conversion. The loss is more pronounced in densely populated and unplanned neighborhoods, while planned areas show relatively better preservation of green spaces. Additionally, the dominance of few tree species reflects low ecological diversity, which may undermine the long-term sustainability of urban green infrastructure. The findings further confirm that green space decline is driven by interrelated socio-economic, environmental, and institutional factors, requiring integrated and strategic urban management approaches.

The study establishes that without effective planning and policy intervention, the continued loss of urban green areas may exacerbate environmental degradation, reduce urban resilience, and negatively affect the quality of life in Makurdi Metropolis.

7 RECOMMENDATIONS

Based on the findings, the study recommends that:

- 1 Urban planning authorities should strengthen land-use regulations to protect existing green areas
- 2 Government and stakeholders should promote urban greening initiatives with increased species diversity
- 3 Environmental awareness programs should be enhanced to encourage community participation
- 4 Policies should support sustainable land use and controlled urban expansion
- 5 Development of parks and recreational green spaces should be prioritized to balance urban growth

8 Contribution to Knowledge

- 1 This study contributes to knowledge by providing empirical evidence on the temporal dynamics of urban green areas in Makurdi Metropolis from 2000 to 2024. It highlights the spatial variations across neighborhoods, identifies dominant vegetation patterns, and explains the key drivers of green space decline.
- 2 Importantly, the study adds to existing literature on urban environmental change in developing cities by demonstrating how urbanization influences green space distribution

and sustainability, thereby offering a basis for evidence-based planning and policy formulation in Nigeria and similar urban contexts.

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