Spatial assessment of Land use/Land cover in Informal Settlements of North-Central Nigeria

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Abstract

Informal settlements remain a major challenge for urban planning, administration, and sustainable development in North-Central Nigeria. The rapid expansion of settlements undermines resilience planning and adaptive management, as limited knowledge on spatial growth and land use/land cover (LULC) dynamics. The study evaluates spatial variations in informal settlements across selected states in North-Central Nigeria. Three states (Kogi, Benue, Plateau) and the Federal Capital Territory were purposively selected, focusing on capital cities where informal settlement growth drives urban expansion. Two informal areas were studied in each state while geospatial tools and GIS techniques were applied to assess LULC changes over the spatio-temporal periods: 2005 – 2024 (Kogi), 2004 –2024 (Benue), 2001–2024 (Plateau), and 2006–2024 (FCT) for which data were available. Findings reveal significant increases (more than 50%) in built-up development alongside a marked decline in vegetated land (3-25%), indicating rapid spatial transformation of informal communities. The study highlights the urgent need for viable regional land-use framework, community-based upgrading initiatives, green infrastructure and collaboration among planners and policy makers to ensure coherent and sustainable responses to the growth of informal settlements in North-Central Nigeria.

Keywords: *Informality, informal settlement, spatial form, growth and sustainable development.*

1 Introduction

Several scholars have advanced definitions of informal settlements (Wahab and Agbola, 2017; Abebe *et al*., 2019; Ijatuyi *et al*., 2020; Akirso, 2021 and Adegbemile, 2022) and often framed within the legal and institutional contexts in which such settlements emerge. Despite differences in emphasis, there is broad agreement on defining characteristics which include substandard housing, inadequate or absence of basic infrastructure, overcrowding, and generally poor environmental conditions (Ajala *et al*., 2025). UN-Habitat (2016) further examined informal settlements as residential areas occupied without legal authorization, typically unplanned, and marked by housing that fails to comply with established building and planning regulations.

A contemporary challenge associated with informal settlements is the growing influence of unregulated urbanisation and rapid population increase. Research indicates that multiple drivers contribute to their emergence and expansion, including insurgency, civil conflict, land tenure insecurity, high housing costs, migration and employment opportunities (Satterthwaite *et al*., 2018). Informal settlements accommodate millions of urban residents who sustain city economies, making them integral to urban growth processes (Olalekan *et al*., 2020; Sulyman and Ajala, 2021). Nevertheless, urban planners, engineers, policymakers, and other professionals recognized these settlements as highly complex in terms of development and management within urban contexts. Despite their prominence in global discourse, meaningful governmental interventions remain inadequate. For urban planners, a deeper understanding of the formation, evolution, and long-term impacts of informal settlements are essential to inform effective strategies for sustainable urban development.

The spatial variation of informal settlements has become increasingly relevant to urban planning and management, particularly in designing preventive strategies to address growth-related impacts. Earlier studies (Jinadu, 2004, 2008; Saliu *et al*., 2019; Achuenu *et al*., 2020 and Junaid *et al*., 2020) indicated the need for a stronger spatial perspective, particularly through land use and land cover (LULC) analysis across informal settlements, and comparative assessments using Geographic Information Systems (GIS). In rapid urbanising areas like the North-Central region of Nigeria (Oguche *et al*., 2019; Gwanshak *et al*., 2021; Ibrahim, 2022; Ukoje and Ibor, 2022 and Ajala *et al*., 2025), efficient urban

planning and management of informal settlements necessitates regular assessments of land use and cover distribution as well as continuously updated evidence-based data. In the light of this, this paper aimed to investigate the spatial variation of informal communities in the North Central region of Nigeria across years using Geographic Information Systems (GIS). The objectives of the study are to analyze the land use/land cover of the study area; examine the growth trend and pattern of developments of the selected informal settlements using three spatio-temporal periods and their implications for sustainable urban development. The study concentrates on urban areas with informal settlements in Abuja (Gwagwalada Area Council), Jos (Jos North Local Government Area), Makurdi (Makurdi Local Government Area), and Lokoja (Lokoja Local Government Area). The selection was due to the increasing number of informal settlements, which were influenced by a range of factors including locational choices, economic, transportation, land ownership and socioeconomic factors among others.

2.1 Literature review

Rapid urbanisation in many developing nations has heightened vulnerability to the growth of informal settlements (Aboulnaga *et al*., 2021; Deeyah *et al*., 2021 and Jelili *et al*., 2023). In Nigeria, nearly half of the population resides in urban areas, where settlements continue to expand despite inadequate infrastructure like electricity, transportation, potable water, and sanitation (Saliu *et al*., 2019). Evidence from Nigerian cities show that governments at various levels have struggled to harness the benefits of urbanisation to effectively address the proliferation of informal settlements. The inability to integrate urban growth with sustainable planning has hindered efforts to promote inclusive and resilient development (Olalekan *et al*., 2020).

The prevalence of informal settlements and the trajectory of their development in the West African region have further attracted the attention of researchers globally (UN-Habitat, 2016). Over a period of a decade, the level of urban growth has taken on numerous different shapes and experienced significant transformations. In light of this, governments across the nation face a significant common problem of urban growth in all of its forms. The main challenge of the development and urbanisation is related to the way in which cities are managed and how land is used, which eventually results in the formation of informal settlements (Wahab, 2017; Sulyman and Ajala, 2021). Researchers have presented several techniques in the literature to estimate the level of informal settlements (Saliu *et al* 2019; Junaid *et al*. 2020; Jerry *et al.,* 2021). In this study, however, the application of Geographic Information System was employed. This method is justified for tracking the expansion of informal settlements and examining changes in land use/cover.

Conversely, Jinadu (2004) used Landsat satellite imagery to study the trend of urban growth in FCT, Abuja, from 1987 to 2001 and the rate of physical development from 4.489 to 89.265 km^2. Also, Jinadu (2008) discovered that the settlements in the FCT were clustered together in space after analyzing the spatial pattern of Abuja communities using vector-based GIS data. Similarly, Ishaya *et al* (2008) conducted a study on the application of Remote sensing and GIS in urban expansion and loss of vegetation cover in Kaduna town, North-central, Nigeria. Based on the study, the built-up areas increased yearly between 1990 and 2000, but the vegetation cover decreased significantly. It was also noted that the amount of bare land expanded. Saliu *et al* (2019) analyzed the effects of floods along the Benue River on land usage and land cover using satellite imageries from 2002, 2012, and 2014. In 2002, 2012, and 2014, floods damaged 53% of vegetation and 38% of farmland, making cropland the most severely impacted area. Crop output, fisheries, livestock, and agro-processing were all impacted by the floods.

However, Junaid *et al*. (2020) used satellite imagery across spatiotemporal periods (2002-2017) to examine the problem of urban sprawl with reference to Nyanyan–Mararaba–Masaka road corridor along the Abuja–Keffi highway in North Central, Nigeria. The analysis showed that between 2007 and 2012, growth reached 15.3%, but between 2012 and 2017, it decreased to 2%. Achuenu *et al.* (2020) assessed the effects of succession and invasion on land use and land cover changes in Dadin Kowa, Jos from 1962-2016, using aerial photographs and satellite imagery processed with various techniques. The findings indicate a gradual rise in built-up areas, forests, and water bodies, which encroached upon agricultural land use and resulted in a significant reduction in agricultural land by 2016.

Jerry *et al*. (2021) examined the changes in land cover patterns in the western part of Lagos State, due to rapid urbanisation. As a result of urban development's domina-

tion and landscape fragmentation, the results revealed a marked decline in ecological assets and an increase in built-up areas. The submission of all these studies suggests that the human activity caused changes in both built -up and non-built-up land while human populations and the use of land turned most of the naturally occurring environment into manmade environment. The goal is to meet the urgent needs of humanity from natural resources.

3.1 The study area

The study area is located in the North Central region of Nigeria in which three states (Plateau, Kogi, and Benue State) and FCT were chosen for the study. These are presented in Figures 3.1 and 3.2. It concentrated on areas with informal settlements in Lokoja, Jos North, Makurdi, and Abuja (Gwagwalada Area Council). These cities were selected for the study because they are the fastest urbanising cities (Oguche *et al*., 2019; Gwanshak *et al*., 2021; Ibrahim, 2022; Ukoje and Ibor, 2022); their urban core is motivated by innumerable activities and proliferation of informal settlement (slums, shantytowns, and squatter colonies. The selected informal settlements in North-central Nigeria are presented in the Table 3.1

4.1 Research methodology

The study employed a combination of primary and secondary data sources via physical observations, geospatial techniques, as well as the coordinates of informal settlements locations. Geographic Information System (GIS) and Google Earth are the geospatial tools used. It involved utilizing three spatio-temporal periods to ascertain the level and pattern of informal settlement growth within the study area. The spatio-temporal periods that were available and taken into account for this study are presented in Table 3.1.

However, the imageries were obtained by importing the shape files of every selected informal settlement in North-Central Nigeria at a resolution of 15 meters, and then zooming in to the required viewable level using the Google Earth Pro software. Through the use of the Select Time slider, the year variations were acquired and suitably saved to carry out further GIS analysis. The geographic information system program (ArcGIS 10.8 version) was utilized for the spatial analysis. The program was chosen because it has the built-in competence and approach needed to accomplish the essential tasks and generate the final map. Conversely, the ArcGIS (10.8) was used to carry out task such as the importation, overlay, processing and editing of imageries; image classification, map embroidery and map exportation. The study adopted five classes of Land use/Land cover (LULC) classification. These classes include Built-up area, Bare ground, Vegetation, Water body and Marshy area (as shown in Table 4.1). The imageries were analyzed using the supervised Classification method.

Table 3.1: The selected informal settlements in North-central region

State	City	Selected informal Settlements	Spatio-temporal period
FCT	Abuja	Zuba and Tunga-maje	2006, 2016 and 2024
Benue	Markurdi	Gaadi and Fiidi	2004, 2014 and 2024
Plateau	Jos	Utan and Jenta-adamu	2001, 2011 and 2024
Kogi	Lokoja	Adankolo and Lokongoma	2005, 2015 and 2024

Source: Authors' fieldwork, 2025

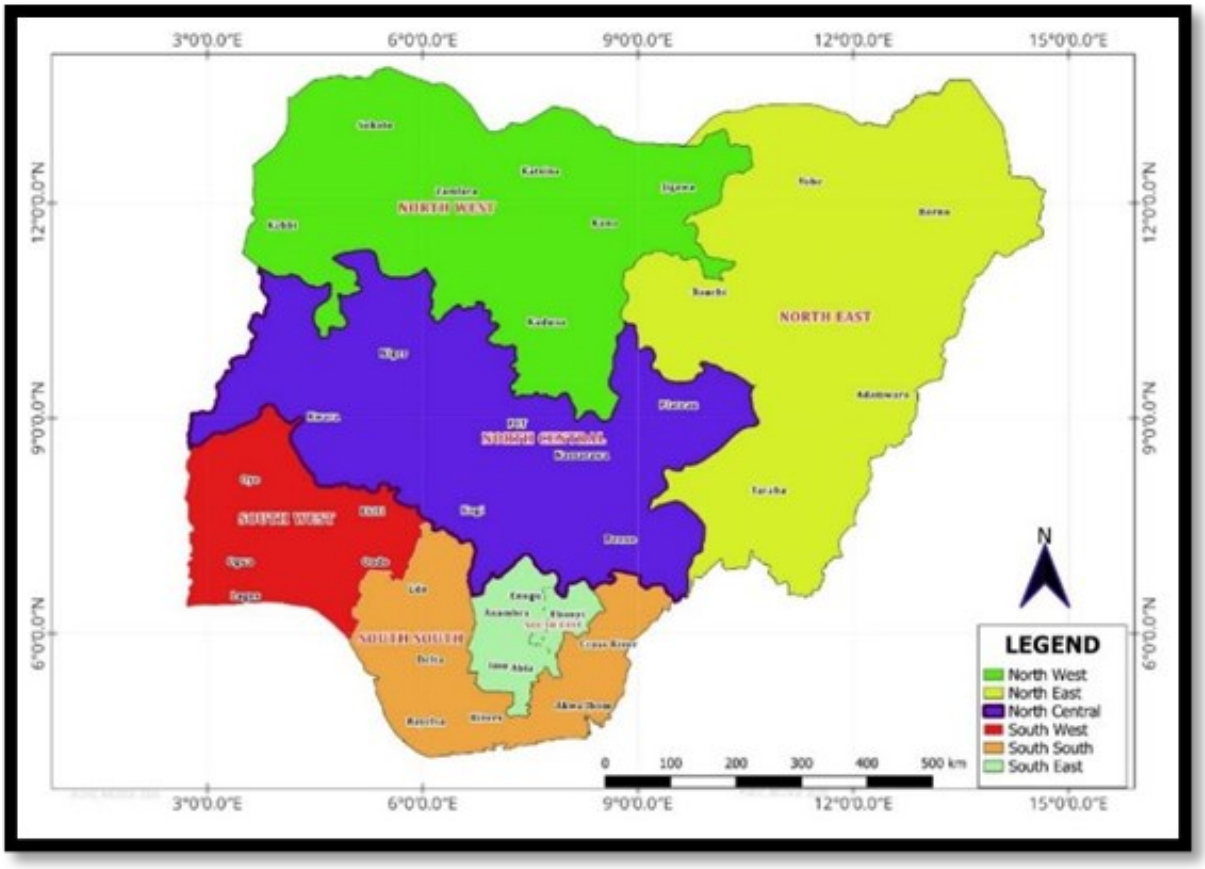

Figure 3.1: North-central in the context of Nigeria
Source: POFIC Bridge Production, Birnin-Kebbi, 2024 and Author's compilation, 2025

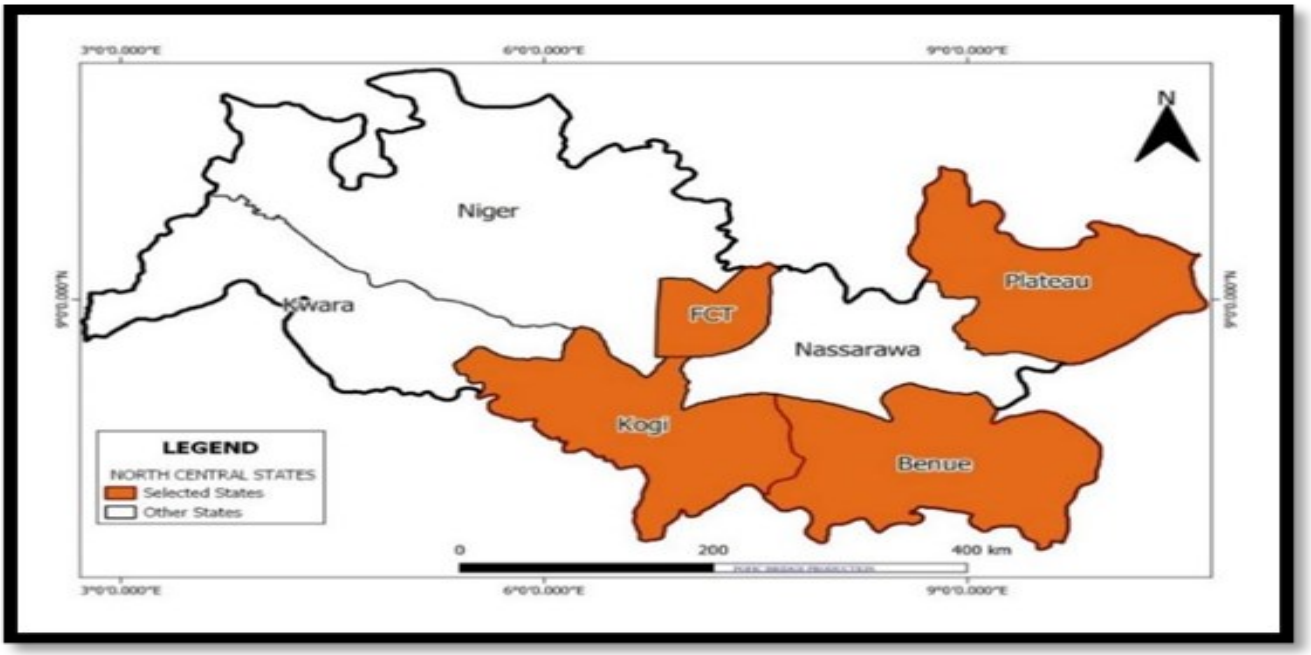

Figure 3.2: Selected States in the context of North-central, Nigeria
Source: POFIC Bridge Production, Birnin-Kebbi, 2024 and Author's compilation, 2025

Table 4.1: Land use/Land cover classification for the study

S/N	Classification	Description
1	Built-up Area	Residential, Commercial, institutional, industrial land use and transportation infra-structures
2	Bare ground	Open Spaces, rocks, hills, open field and play ground
3	Vegetation	Crop land, Plantations, horticultural zones, trees, shrubs, herbs, gardens, grass-lands, and green areas.
4	Water body	Rivers, lake and stream
5	Marshy Area	Wetland, swampy land, muddy land/waterlogged land

Source: Authors' fieldwork, 2025

5.1 Result and Discussions

The analysis in Table 5.1 shows the statistics of LULC distribution of informal settlements from 2005-2024 in Kogi state.

1) Adankolo area: The analysis of Adankolo informal settlement in Table 5.1 shows a total land area of 276.38 hectares, with notable land use/land cover (LULC) changes between 2005 and 2024. Built-up areas expanded significantly in 2005 and 2024, reflecting rapid urban growth, but experienced a slight decline in 2015. The reduction is plausibly linked to the 2015 flood event, which enlarged the water body, destroyed housing, and reduced bare ground. Vegetation and bare land also recorded substantial decreases in 2005 and 2024, examine the pressure of urban expansion. The classified LULC maps for Adankolo across the study period (2005–2024) are indicated in Figures 5.1–5.3, for spatial transformations

2) Lokongoma area: Table 5.1 indicates that the Lokongoma informal settlement covers a total land area of 230 hectares. Land use/land cover (LULC) analysis between 2005 and 2024 shows a steady increase in built-up areas accompanied by a decline in vegetation. Bare ground and marshy land expanded between 2005 and 2015 but contracted by 2024, reflecting shifts in settlement dynamics and environmental conditions over time. The classified LULC maps for Lokongoma across the three study years (2005, 2015, and 2024) as presented in Figures 5.4–5.6, illustrating the spatial transformations

Table 5.1 Land use/land cover of informal settlements area in Kogi State

Informal settlements	Landuse/cover	2005		2015		2024	
		Area (Ha)	(%)	Area (Ha)	(%)	Area (Ha)	(%)
Adankolo	Water body	106.97	38.7	109.66	39.68	105.08	38.02
	Vegetation	3.50	1.20	12.00	4.34	3.28	1.19
	Bare Ground	2.30	0.80	-	-	1.49	0.54
	Built-up area	163.61	59.30	154.72	55.98	166.53	60.25
	Total	**276.38**	**100**	**276.38**	**100**	**276.38**	**100**
Lokongoma	Marshy Area	23.0	10.0	27.6	12.0	16.1	7.0
	Vegetation	115.0	50.0	50.6	22.0	6.9	3.0
	Bare Ground	11.5	5.0	13.8	6.0	4.6	2.0
	Built-up area	80.5	35.0	138	60.0	202.4	88.0
	Total	**230.0**	**100**	**230.0**	**100**	**230.0**	**100**

Source: Authors' fieldwork, 2025

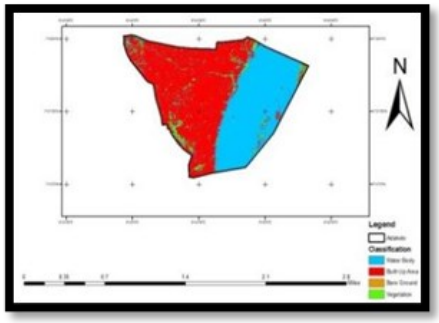

Figure 5.1: Adankolo (2005)

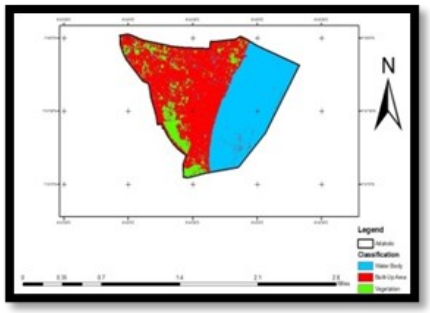

Figure 5.2: Adankolo (2015)

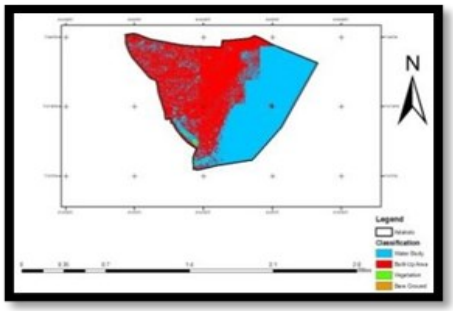

Figure 5.3: Adankolo (2024)
Source: Authors'

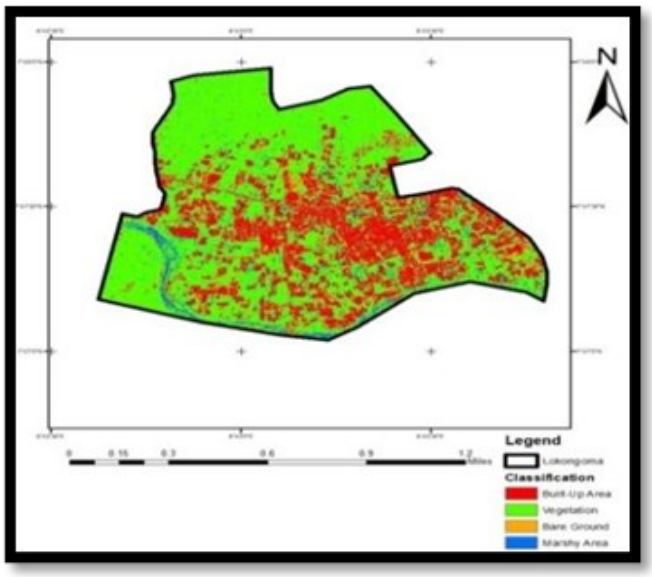

Figure 5.4: LULC of Lokongoma, (2005)

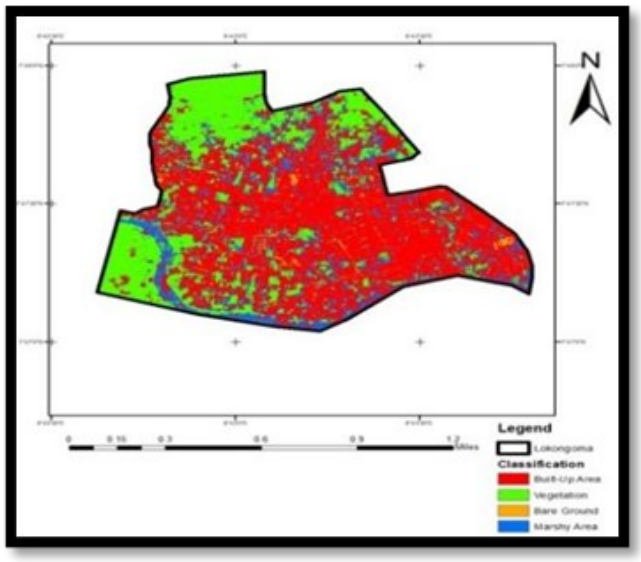

Figure 5.5: LULC of Lokongoma, (2005)
Source: Authors' field Survey, 2025

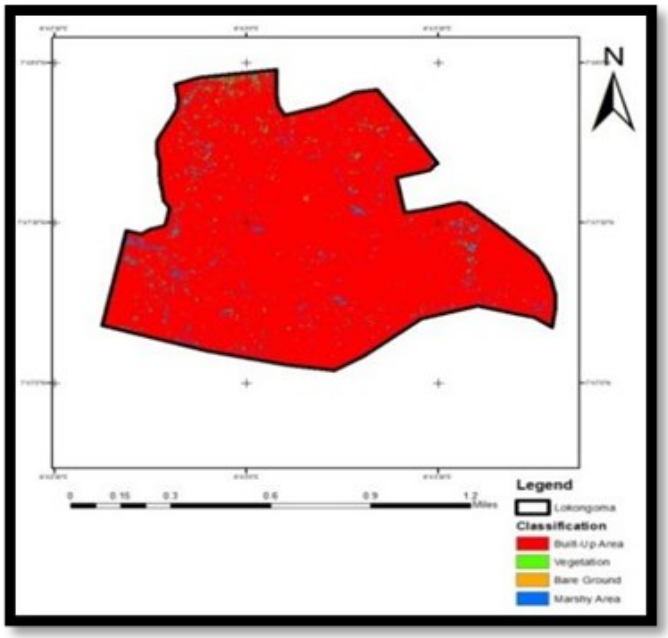

Figure 5.6: LULC of Lokongoma, (2024).
Source: Authors' field survey, 2025

Table 5.2 shows the LULC distribution of informal settlements from 2004-2024 in Benue state.

i) Gaadi Area: Table 5.2 shows the result of LULC in Gaadi area at the spatio-temporal period of (2004-2014-2025) with a total land area of 58.5hectares. The result reveals that in 2004, the Bare ground recorded the highest class with 38.61 hectares (66%) while in 2014, the built-up area was the major land use class with 38.02 hectares (65%) of the total area. In 2025, the result shows that the built-up was still the predominant land use with 40.95 hectares (70%) of the total area.

The classified land use/land cover maps of Gaadi area at the stated periods were illustrated in Figures (5.7 to 5.9) respectively. The statistics of LULC (2004-2014-2024) in Gaadi area generally implies that the built-up area has significantly increased from 12% in 2004 to 70% in 2024. It indicate a notable decline in the area covered by bare ground between 2004 (60%) and 2014 (5%), whereas vegetative land showed a relative expansion between 2004 (22%) and 2014 (30%), but experienced a decline in 2024

Table 5.2: Land use/land cover of informal settlements area in Benue state

Informal settlements	Landuse/cover	2004		2014		2024	
		Area (Ha)	(%)	Area (Ha)	(%)	Area (Ha)	(%)
Gaadi	Vegetation	12.87	22	17.55	30	11.7	20
	Bare Ground	38.61	66	2.93	5	5.85	10
	Built-up area	7.02	12	38.61	65	40.95	70
	Total	**58.5**	**100**	**58.5**	**100**	**58.5**	**100**
Fiidi	Marshy Area	8.8	8	16.5	15	6.2	5.64
	Vegetation	73.7	67	20.9	19	27.5	25
	Bare Ground	22.0	20	11	10	19.45	17.68
	Built-up area	5.5	5	61.6	56	56.85	51.68
	Total	**110**	**100**	**110**	**100**	**110**	**100**

Source: Authors' field survey, (2025)

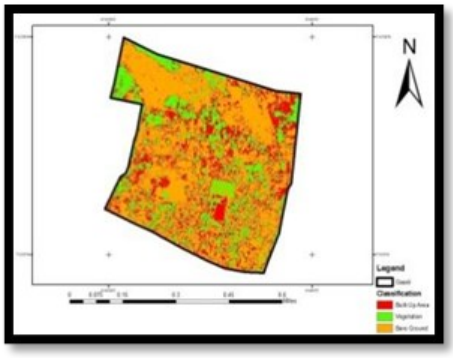

Figure 5.7: Gaadi (2004)

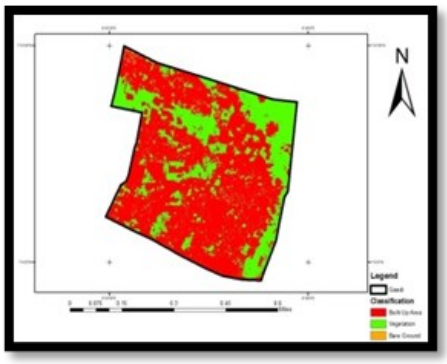

Figure 5.8: Gaadi (2014).

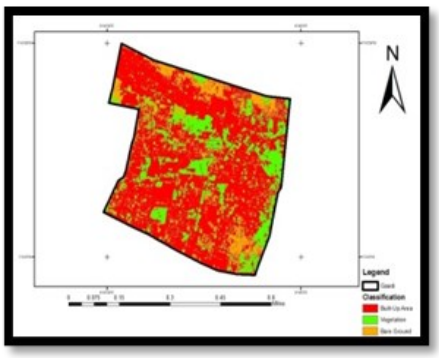

Figure 5.9: Gaadi (2024).

Source: Authors' field survey, 2025

ii) Fiidi Area: The result of LULC (2004-2014-2024) in Fiidi area is presented in Table 5.2 with a total land area of 110 hectares. The derived result in 2004 revealed that the vegetation land occupied the highest class with 73.7 hectares (67%). In 2014, the built-up area is the predominant land use category which accounted for 61.6 hectares (56%) of the total area. In 2024, the built-up land is still the highest class with 56.85 hectares (51.68%). Therefore, the categorized land use/land cover maps of the specific periods in Fiidi area are presented in Figures5.10 – 5.12 respectively. The LULC result for the years 2004–2014–2024, however, signifies that the built-up area expanded by 56.1 hectares between 2004 and 2014 and slightly decreased by 4.75 hectares between 2014 and 2024. As such, the size of vegetation decreased between 2004 and 2024, while the extent of bare ground decreased between 2004 and 2014 but increased in 2024. The size of marshland increased by 7.7 hectares between 2004 and 2014, but it declined in 2024.

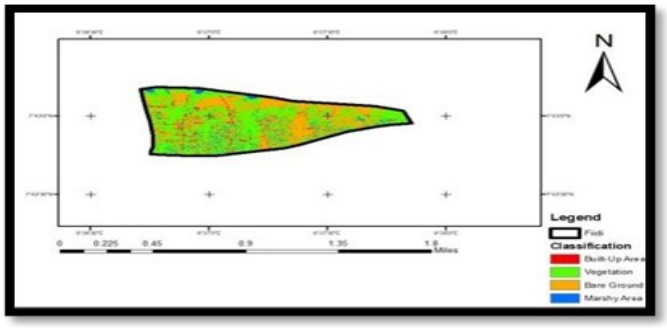

Figure 5.10: LULC of Fiidi (2004)

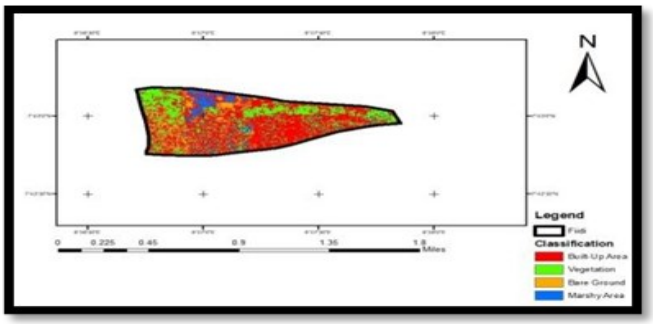

Figure 5.11: LULC of Fiidi (2014)

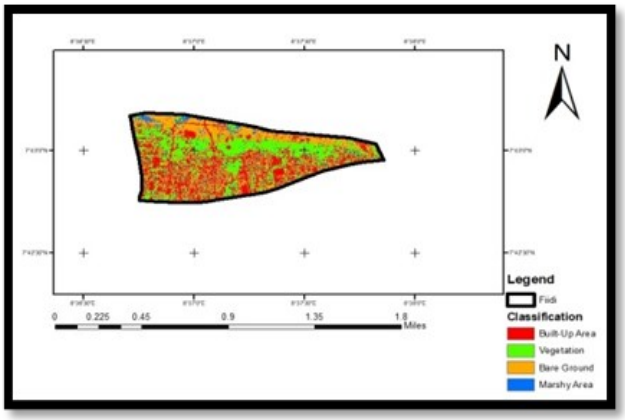

Figure 5.12: Classified land use/land cover map of Fiidi area, (2024).
Source: Authors' field survey, 2025.

i) Jenta-Adamu area: The result in Table 5.3 shows that Jenta-Adamu settlement has a total land area of 177 hectares. The derived result reveals that the built-up area in 2001 occupied the main landuse class with 115.05 hectares (65%). In 2011, the major land use category is built-up land which accounted for 127.44 hectares (72%) of the total area. In 2024, the built-up area is still the dominant use with 164.61 hectares (93%) of the total area indicating rapid spatial transformation of informal communities. This implies that the built-up area has experienced a magnitude rise from 115.05 hectares in 2001 to 164.61 hectares in 2024 while there is a significant decline of Bare ground from 2001 (61.95 hectares) to 2024 (8.85 hectares). Likewise, there is a reduction of vegetation area from 2011 (14.16 hectares) to 2024 (3.54 hectares). Therefore, the classified land use/land cover map of Jenta-Adumu area at the specified periods is presented in Figure 5.13 to 5.15

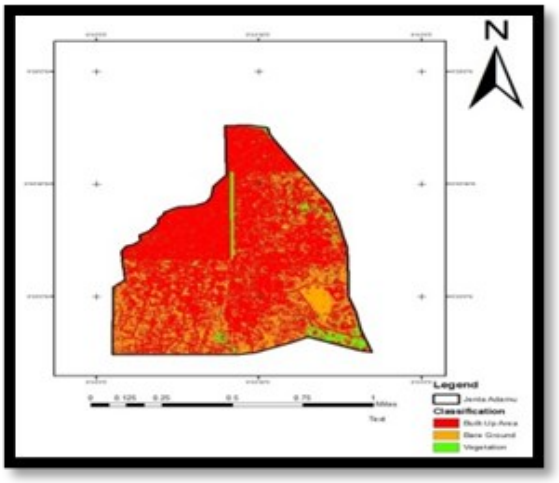

Figure 5.13: LULC of Jenta-Adamu (2001)

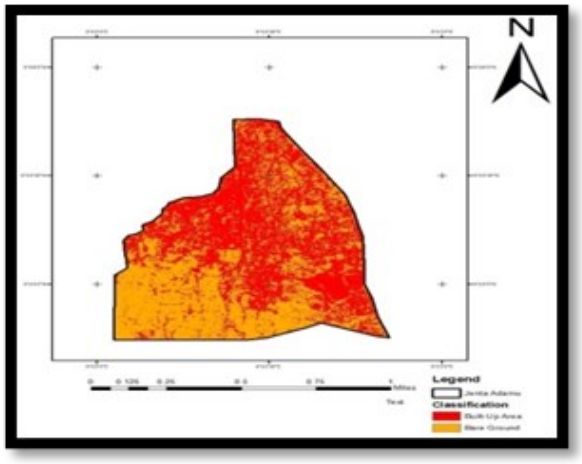

Figure 5.14: Jenta-Adamu (2011).
Source: Authors' field survey, 2025

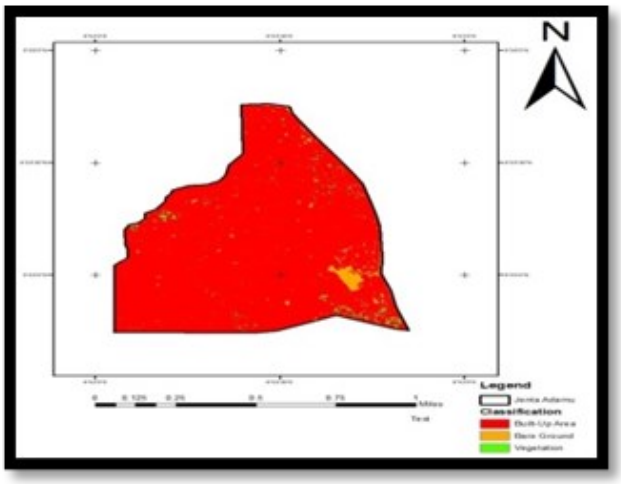

Figure 5.15: LULC of Jenta-Adamu area, (2024)
Source: Authors' field survey, 2025.

ii) Utan area: The same Table 5.3 presents the LULC of Utan area at a period of 2001, 2011 and 2024 with a total land area of 495 hectares. The derived results showed that the dominant landuse category in 2001and 2024 is built-up area with 321.75 hectares (65%) and 346.5 hectares (70%) respectively. This implies that the built-up area decreased by 49.5 hectares between 2011 and 2024 and increased by 74.25 hectares between 2001 and 2011. Thus, the classified land use/land cover map of Utan area at the examined periods is presented in Figures 5.16 to 5.18.

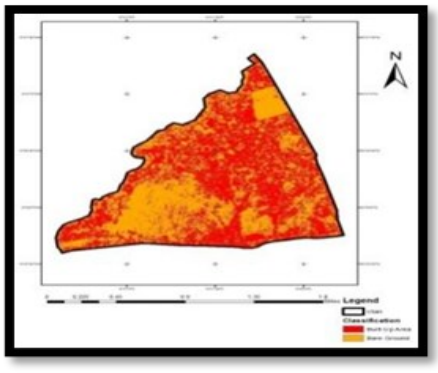

Figure 5.16: Utan (2001)

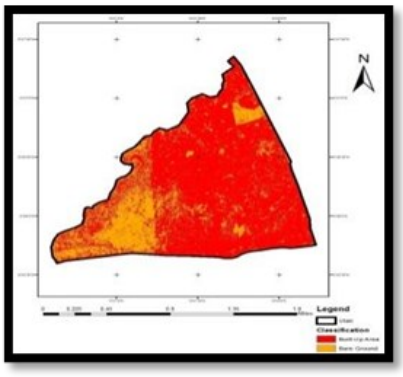

Figure 5.17: Utan (2011)

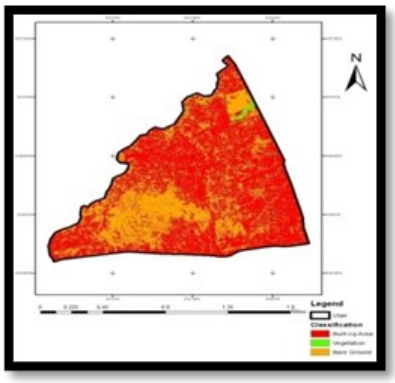

Figure 5.17: Utan (2024)
Source: Authors' field survey, 2025.

Table 5.4: Land use/land cover of informal settlements area in FCT

Informal settlements	Landuse/cover	2006		2016		2024	
		Area (Ha)	(%)	Area (Ha)	(%)	Area (Ha)	(%)
Zuba	Vegetation	19.2	10	3.84	2	5.76	3
	Bare Ground	9.6	5	28.8	15	19.2	10
	Built-up area	163.2	85	159.36	83	167.04	87
	Total	**192**	**100**	**192**	**100**	**192**	**100**
Tungan-maje	Vegetation	1051.56	69	76.2	5	45.72	3
	Bare Ground	15.4	1	1066.8	70	944.88	62
	Built-up area	457.2	30	381	25	533.4	35
	Total	**1524**	**100**	**1524**	**100**	**1524**	**100**

Source: Authors' field survey, 2025

(i) Zuba: Table 5.4 shows the statistics of LULC at Zuba informal settlement with a total land area of 192 hectares. The obtained result reveals that the built-up land is the highest land use class in 2005 and 2016 with 163.2 hectares (85%) and 159.36 hectares (83%) respectively. Likewise, the LULC in 2024 shows that the built-up area is still the predominant land use class which accounted for 167.04 hectares (87%) of the total area. The categorized maps for Zuba are presented in Figures 5.19-5.21. This infers that the built-up land increases between 2006 and 2024 (18years) with 3.84 hectares. Also, the vegetation declined between 2006 and 2024 by 13.44 hectares while the Bare ground witnessed a significant increase between 2006 and 2024.

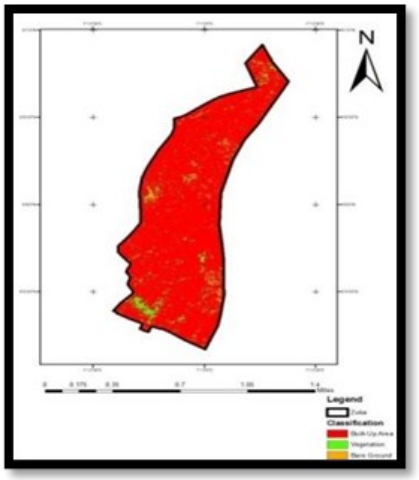

Figure 5.19: Zuba, (2006)

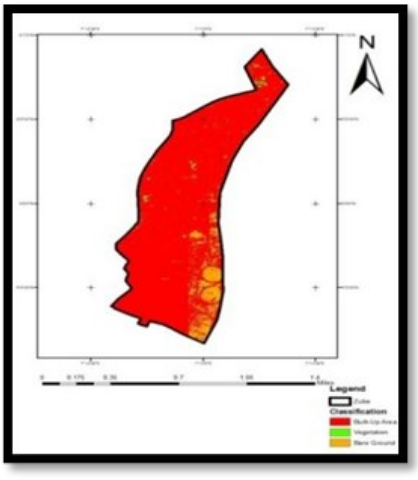

Figure 5.20: Zuba, (2016)

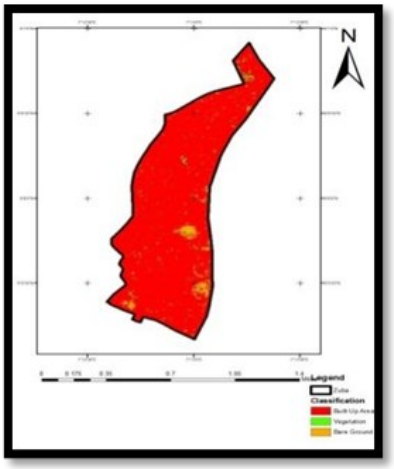

Figure 5.21: Zuba (2024)

Source: Authors' field survey, 2025

ii) Tungan-maje area: The Table 5.4 reveals the LULC (2006-2016-2024) in Tungan-maje settlement with a total land area of 1524 hectares. The result shows that in 2006, vegetation is the predominant land use category at this period and their occupation was probably farming and other primary activities. While in 2016 and 2024, the Bare ground is the dominant class which covered 944.88 hectares (62%) and 944.88 hectares (62%) respectively. Generally, the LULC distribution between 2006 and 2024 infers that there is a relative increase of built-up area in Tungan-maje which covered 457.2 hectares (30%) in 2006 to 533.4 hectares (35%) in 2024 respectively. The vegetation land declined from 1051.56 hectares (69%) in 2006 to 45.72 hectares (3%) in 2024. Hence, the classified LULC maps for Tungan-maje area according to the specified period are presented in Figures 5.22 to5.24.

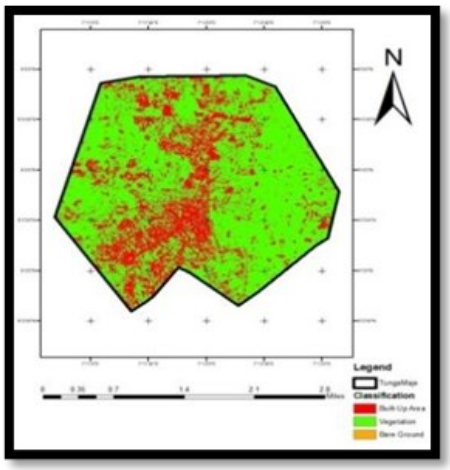

Figure 5.22: Tungan-maje (2006)

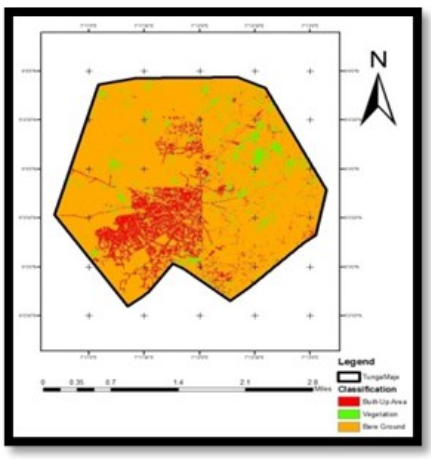

Figure 5.23: Tungan-maje (2016)

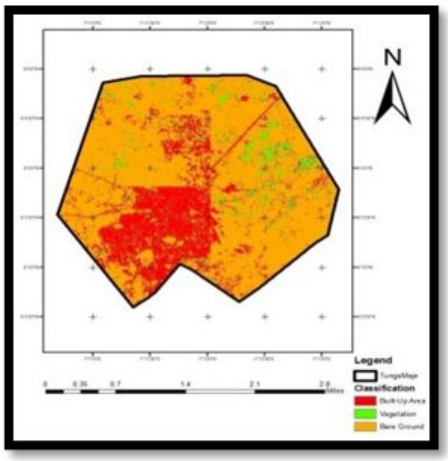

Figure 5.24: Tunga-maje (2024)

Source: Authors' field survey, 2025

The spatial analysis of informal settlements in North-Central Nigeria reveals a recurring trend of rapid expansion in built-up areas while declines in vegetation and bare land. These land-use transformations have several implications for sustainable development such as:

i. **Environmental Vulnerability**: The loss of vegetation reduces ecological resilience and heightens exposure to hazards such as flooding, erosion, and urban heat. Settlements like Adankolo and Tungan-maje exemplify how unchecked growth into natural areas undermines environmental sustainability.

ii. **Unstable Land-Use Dynamics**: Variations in bare ground and marshy land, as observed in Lokongoma and Fiidi, reflect unstable land-use practices that can complicate long-term planning and weaken adaptive capacity to climate change.

iii. **Urban Growth Pressures**: The predominance of built-up land in Gaadi, Jenta-Adamu, and Zuba highlights the intensity of population growth and housing demand. Without regulation, this trajectory fragments urban landscapes and strains infrastructure provision.

iv. **Loss of Agricultural and Ecological Land**: In areas such as Tungan-maje, the sharp decline in vegetation from 69% in 2006 to 3% in 2024 signifies displacement of farming and ecological functions which can threatening food security and biodiversity.

6.1 Conclusion and recommendations

The study analyzed the spatial variation of informal settlements and their implications for sustainable development in North-central Nigeria. It established the expansion and development of informal areas in selected cities using GIS at the spatio-temporal periods of 2005-2024 (Kogi state), 2004-2024 (Benue state), 2001-2024 (Plateau state) and 2006-2024 (FCT) respectively. The results reveal a rapid increase in built-up development across most informal communities, accompanied by a marked decline in vegetation cover. The study concluded that the land consumption within informal settlements is steadily rising, reinforcing the urgency for sustainable approaches to their development and management. However, to effectively manage the growth of informal settlements and promote sustainable urban development, the following practical measures are suggested:

i. Regional land-use frameworks should be established to regulate expansion and balance housing demand with ecological preservation.

ii. Community-Based upgrading initiatives must be prioritized to enhance housing quality, tenure security, and access to basic services, while ensuring resident participation in planning.

iii. Incorporating green infrastructure such as flood buffers, tree cover, and open spaces to strengthen resilience against climate hazards.

iv. Disaster-risk reduction should be embedded into settlement planning through hazard mapping, enforcement of building standards, and strengthening preparedness systems.

v. Adoption of Continuous Geographic Information System-based monitoring of land use/land cover dynamics to track and provide timely evidence for adaptive management.

Coordinated collaboration among planners, engineers, policymakers, and civil society to ensure coherent and sustainable responses to settlement growth.

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