

THE ENCROACHMENT OF URBANIZATION ON AGRICULTURAL LAND: A SPATIAL AND TEMPORAL ANALYSIS OF FARMLAND USE CHANGE IN LOKOJA (1992 TO 2032)

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Abstract

Rapid urban expansion in Nigerian cities has placed sustained pressure on peri-urban agricultural land, with significant implications for food security, rural livelihoods, and environmental stability. This study examines the spatial and temporal dynamics of farmland use change in Lokoja, the capital of Kogi State, over the period from 1992 to 2022, and projects the trajectory of change to 2032. A mixed-methods design was adopted, integrating remote sensing and geographic information system techniques with a structured household survey administered to a sample of three hundred and sixty respondents drawn from eight peri-urban nodes, namely Zango, Sarkin-noma, Adankolo, Lokongoma, Gadumo, Natako, Ganaja, and Felele. Multi-temporal Landsat imagery was classified to derive land use and land cover maps, and a post-classification comparison was used to quantify transitions between classes. The results reveal that the built-up area expanded from approximately fifteen per cent of the land surface in 1992 to thirty-five per cent in 2022, while farmland contracted from thirty-seven per cent to twenty-seven per cent over the same period. Post-classification analysis indicates that around seventy-four square kilometres of land originally under cultivation in 1992 had been converted to built-up use by 2022, representing the single largest land transition observed. Compound annual growth rate projections suggest that, if prevailing trends persist, built-up land could approach forty-six per cent of the land surface by 2032 while farmland declines further toward twenty-four per cent. The survey identifies population growth, housing demand, and commercial development as the principal drivers of conversion. The study concludes that the unregulated encroachment of urbanization on farmland constitutes a substantial threat to local food systems and recommends the integration of agricultural land protection into the urban planning framework of Lokoja.

Keywords: urbanization; farmland use change; remote sensing; geographic information system; food security; Lokoja; land use and land cover; peri-urban

1. Introduction

Urbanization is among the most consequential processes shaping the contemporary world, and nowhere is its pace more pronounced than in the rapidly growing cities of sub-Saharan Africa. The expansion of urban settlements brings undeniable economic and social benefits, yet it also generates intense competition for land at the urban fringe, where agricultural holdings, natural vegetation, and emerging built-up areas meet. In this peri-urban zone, farmland is frequently the first casualty of expansion, converted to residential, commercial, and infrastructural use through a process that is often unplanned and irreversible. Understanding the spatial and temporal dimensions of this conversion is essential for safeguarding food security and managing urban growth in a sustainable manner.

Lokoja, the capital of Kogi State in north-central Nigeria, exemplifies these dynamics. Since attaining capital status, the city has experienced sustained population growth and physical expansion, driven by administrative functions, commercial activity, and its strategic location at the confluence of the Niger and Benue rivers. This growth has placed considerable pressure on the agricultural land that historically sustained the local population, raising urgent questions about the long-term viability of farming in the peri-urban zone. Despite the visible transformation of the landscape, systematic quantitative evidence on the rate, magnitude, and direction of farmland conversion in Lokoja remains limited.

The application of remote sensing and geographic information system techniques has greatly enhanced the capacity of researchers to monitor land use and land cover change over time. Satellite imagery provides a consistent and repeatable record of the land surface, enabling the detection and quantification of change across multiple decades (Lambin and Meyfroidt, 2011). When combined with field data and socio-economic survey information, these techniques offer a powerful means of understanding both the patterns of change and the human drivers that produce them. This study harnesses such an integrated approach to examine farmland use change in Lokoja.

The central aim of this study is to analyse the spatial and temporal dynamics of farmland use change in Lokoja over the period from 1992 to 2022 and to project the likely trajectory of change to 2032. The specific objectives are to quantify the changes in land use and land cover across the study period, to determine the magnitude and direction of farmland conversion through post-classification analysis, to identify the principal drivers of conversion through a household survey, and to project future land use scenarios using compound annual growth rate analysis. By addressing these objectives, the study contributes empirical evidence to the wider debate on urban encroachment and agricultural sustainability in Nigerian cities.

2. Literature Review

The conversion of agricultural land to urban use is a globally significant phenomenon that has attracted considerable scholarly attention. Lambin and Meyfroidt (2011) argue that global land use change is accelerating under the combined pressure of population growth, economic development, and urbanization, with peri-urban agricultural land particularly vulnerable to conversion. In the

African context, Cobbinah and Amoako (2018) document how the rapid and frequently unplanned growth of cities has consumed vast areas of farmland, undermining local food production and exposing urban populations to heightened food insecurity.

Studies employing remote sensing in Nigerian cities consistently reveal substantial losses of agricultural land to built-up expansion. Enaruvbe and Atedhor (2015) used satellite imagery to demonstrate marked farmland decline in parts of southern Nigeria, attributing the change to population pressure and weak land use planning. Similar findings have been reported across other rapidly urbanizing settlements, where the absence of effective land management institutions has allowed market-driven conversion to proceed largely unchecked (Mosammam et al., 2017). The convergence of these studies underscores the value of a spatial and temporal approach to understanding farmland dynamics.

The conceptual framework adopted in this study draws on the land change science tradition, which situates observed patterns of land conversion within a broader system of driving forces and consequences. Shishay, Messay, and Solomon (2021) provide a useful synthesis in which biophysical, demographic, economic, and institutional factors interact to produce land use change, which in turn generates feedbacks affecting livelihoods, food systems, and the environment. This framework, illustrated in Figure 1, informs the interpretation of the empirical findings presented in the subsequent sections.

Figure 1 presents the conceptual framework that guides the analysis. It locates farmland use change at the intersection of driving forces and consequences, with demographic, economic, and institutional pressures generating urban expansion that displaces agricultural land, which in turn produces food security, livelihood, and ecological consequences.

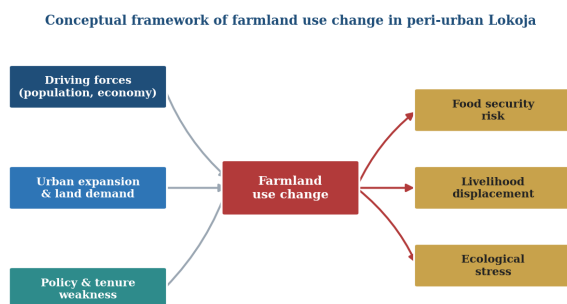


Figure 1: Conceptual framework of farmland use change in peri-urban Lokoja, adapted from the land change science tradition.

Source: Authors' adaptation after Shishay, Messay, and Solomon (2021).

3. Materials and Methods

3.1 Study Area

Lokoja lies at approximately latitude 7 degrees 48 minutes north and longitude 6 degrees 44 minutes east, at the confluence of the Niger and Benue rivers in north-central Nigeria. The city experiences a tropical wet and dry climate, with a mean annual rainfall of approximately 1,150 millimetres and temperatures ranging between 24 and 34 degrees Celsius. Its strategic location, administrative status, and growing commercial importance have

driven sustained urban expansion across the surrounding peri-urban zone. Eight peri-urban nodes were selected for detailed study, namely Zango, Sarkin-noma, Adankolo, Lokongoma, Gadumo, Natako, Ganaja, and Felele, chosen to represent the principal directions of urban growth.

3.2 Data and Sampling

The study adopted a mixed-methods design integrating remote sensing, geographic information system analysis, and a structured household survey. Multi-temporal Landsat imagery for the years 1992, 2002, 2012, and 2022 was acquired and processed to derive land use and land cover maps. The household survey was administered to a sample drawn from the eight peri-urban nodes, with the sample size determined using the Taro Yamane formula expressed in Equation 1.

$$n = N / [1 + N(e)^2] \quad (1)$$

In Equation 1, n denotes the required sample size, N denotes the total population of the study area, and e denotes the margin of error, taken as 0.05. Applying the formula to the estimated household population of the eight nodes produced a sample size of three hundred and sixty respondents, allocated proportionally across the nodes. Structured questionnaires were administered to capture perceptions of the drivers, patterns, and effects of farmland conversion.

3.3 Analytical Techniques

Land use and land cover classes were derived through supervised classification of the satellite imagery, and the accuracy of the classification was assessed using ground control points. Change detection was performed through post-classification comparison, in which independently classified maps from successive dates were overlaid to quantify transitions between classes. The mean score of survey responses was computed using Equation 2 to summarise perceptions across the Likert-scaled items.

$$X_{\bar{}} = (\sum f x) / n \quad (2)$$

In Equation 2, $X_{\bar{}}$ denotes the mean response score, f denotes the frequency of responses in each category, x denotes the category weight, and n denotes the total number of respondents. A criterion mean of 2.50 was adopted, such that items with mean scores at or above this threshold were regarded as agreed drivers or effects. The relationship between urban growth and farmland decline was further examined using the simple linear regression model expressed in Equation 3.

$$Y = a + bX + e \quad (3)$$

In Equation 3, Y denotes the dependent variable, in this case the extent of farmland, X denotes the independent variable representing the extent of built-up area, a denotes the intercept, b denotes the regression coefficient, and e denotes the error term. To project future land use, the compound annual growth rate of each land class was computed using Equation 4.

$$CAGR = (V_{\text{end}} / V_{\text{start}})^{(1/n)} - 1 \quad (4)$$

In Equation 4, V_{end} denotes the value of the land class at the end of the observation period, V_{start} denotes the value at the beginning, and n denotes the number of years in the interval. The projected future value of each class was then estimated using the growth model expressed in Equation 5.

$$FV = PV \times (1 + CAGR)^t \quad (5)$$

In Equation 5, FV denotes the projected future value of the land class, PV denotes the present value at the base year, $CAGR$ denotes the compound annual growth rate derived from Equation 4, and t denotes the number of years projected forward. Applying this model to the observed trends enabled the projection of land use composition to the year 2032.

4. Results and Discussion

4.1 Land Use and Land Cover Change

The supervised classification of the multi-temporal imagery revealed a consistent and substantial transformation of the land surface across the study period. Table 1 summarises the proportional composition of the principal land classes for the years 1992, 2002, 2012, and 2022.

Table 1. Land use and land cover composition of Lokoja, 1992 to 2022 (per cent of land area)

Land class	1992	2002	2012	2022	Net change
Built-up	15	21	28	35	+20
Farmland	37	34	30	27	-10
Vegetation	30	27	24	22	-8
Bare soil	12	13	13	12	0
Water body	6	5	5	4	-2

Source: Authors' analysis of Landsat imagery, 2024.

The data in Table 1 demonstrate that the built-up class expanded steadily from fifteen per cent of the land surface in 1992 to thirty-five per cent in 2022, a net gain of twenty percentage points. Over the same interval, farmland contracted from thirty-seven per cent to twenty-seven per cent, while vegetation declined from thirty per cent to twenty-two per cent. The persistence of the bare soil class and the modest contraction of the water body class indicate that the dominant transition was from agricultural and vegetated land toward built-up use. Figure 2 displays the full compositional change across the four observation dates.

Figure 2 presents the proportional composition of the five land classes at each observation date. The progressive enlargement of the built-up band and the corresponding contraction of the farmland and vegetation bands convey the scale and direction of the transformation across the three decades.

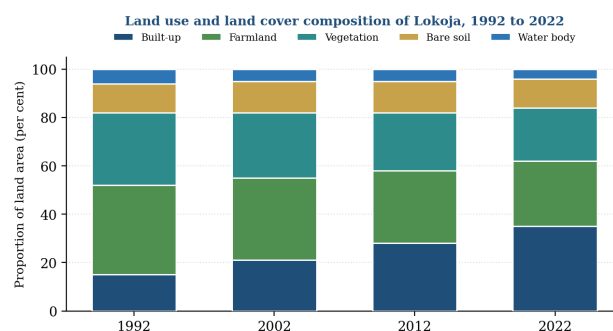


Figure 2: Land use and land cover composition of Lokoja across the four observation dates, 1992 to 2022.

Source: Authors' analysis of Landsat imagery, 2024.

The divergence between built-up expansion and farmland decline is shown most clearly in Figure 3, which traces the two dominant

classes across the study period. The two trajectories cross between 2002 and 2012, marking the point at which the built-up area overtook farmland as a proportion of the land surface.

Figure 3 isolates the built-up and farmland trajectories to highlight their divergence. The crossing of the two lines between the 2002 and 2012 dates represents a structural threshold in the land economy of the city, after which the built-up footprint became the dominant land class.

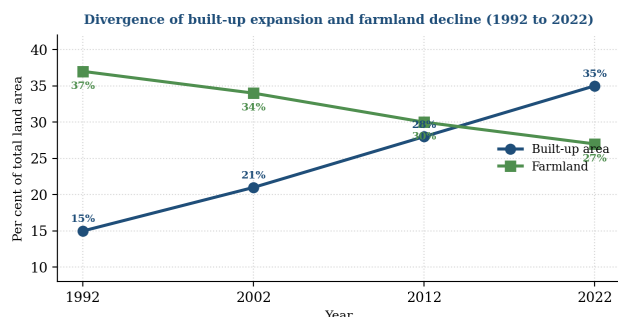


Figure 3: Divergence of built-up expansion and farmland decline in Lokoja, 1992 to 2022.

Source: Authors' analysis of Landsat imagery, 2024.

4.2 Post-Classification Transition Analysis

The post-classification comparison quantified the specific transitions underlying the aggregate change. Of the land classified as farmland in 1992, the analysis indicates that approximately seventy-four square kilometres had been converted to built-up use by 2022, equivalent to roughly eighty per cent of the farmland present at the start of the period. Smaller proportions transitioned to bare soil and vegetation, while only a modest share remained under cultivation. Figure 4 presents the destination of the 1992 farmland by class.

Figure 4 disaggregates the fate of the land that was under cultivation in 1992. The overwhelming share converted to built-up use confirms that urban expansion, rather than ecological succession or fallowing, was the principal mechanism of farmland loss.

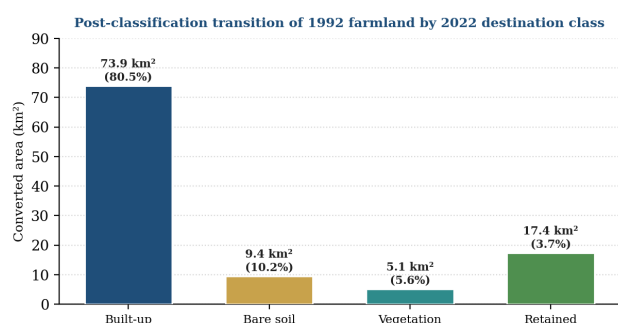


Figure 4: Post-classification transition of 1992 farmland by destination class in 2022.

Source: Authors' analysis of Landsat imagery, 2024.

This finding is consistent with the wider literature on peri-urban land conversion in Nigerian cities, which identifies the direct substitution of farmland by residential and commercial development as the dominant transition pathway (Enaruvbe and Atedhor, 2015). The magnitude of the conversion observed in Lokoja, exceeding eighty per cent of the original farmland,

underscores the intensity of the pressure exerted by urban growth on the agricultural land base. The simple linear regression of farmland extent on built-up extent, specified in Equation 3, returned a strong negative coefficient, confirming the inverse relationship between the two classes across the study period.

4.3 Drivers of Farmland Conversion

The household survey of three hundred and sixty respondents identified the principal drivers of farmland conversion as perceived by the peri-urban population. Table 2 reports the mean response scores for the leading drivers, computed using Equation 2.

Table 2. Perceived drivers of farmland conversion (N = 360)

Driver	Mean	SD	Remark
Population growth	3.62	0.71	Agreed
Housing demand	3.55	0.74	Agreed
Commercial development	3.41	0.79	Agreed
Land speculation	3.28	0.82	Agreed
Infrastructure expansion	3.20	0.85	Agreed
Weak land policy	3.07	0.88	Agreed
Proximity to city centre	2.94	0.90	Agreed

Criterion mean = 2.50. Source: Authors' field survey, 2024.

All seven drivers returned mean scores above the criterion value of 2.50, indicating broad agreement among respondents on their relevance. Population growth and housing demand emerged as the most strongly endorsed drivers, reflecting the demographic and residential pressures that accompany the city's expansion. Figure 5 displays the ranked drivers, while the persistence of land speculation and weak land policy among the agreed drivers points to the institutional dimension of the problem. These perceptions align with the conceptual framework presented in Figure 1, in which demographic, economic, and institutional forces jointly produce land conversion.

Figure 5 ranks the perceived drivers of conversion by their mean response score. The prominence of population growth, housing demand, and commercial development confirms that the conversion is driven primarily by the residential and economic demands of a growing urban population, while the appearance of weak land policy among the agreed drivers signals the institutional space available for intervention.

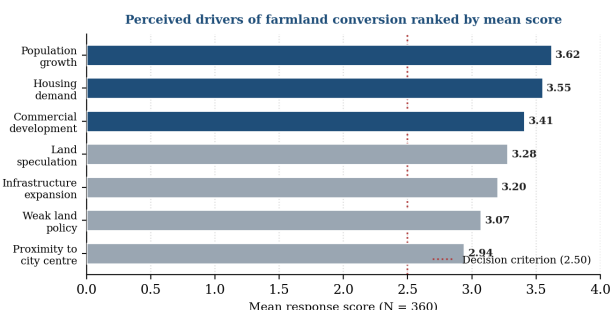


Figure 5: Perceived drivers of farmland conversion in Lokoja, ranked by mean response score.

Source: Authors' field survey, 2024.

4.4 Projection to 2032

Applying the compound annual growth rate model specified in Equations 4 and 5 to the observed trends produced projections of land use composition for the year 2032. The projection suggests

that, should prevailing trends persist, the built-up class could approach forty-six per cent of the land surface by 2032, while farmland declines further toward twenty-four per cent. Figure 6 presents the observed and projected trajectories of the two dominant classes.

Figure 6 extends the observed trajectories to 2032 using the compound annual growth rate model. The projected continuation of built-up expansion and farmland contraction indicates that, in the absence of intervention, the agricultural land base of the city will be further eroded within the coming decade.

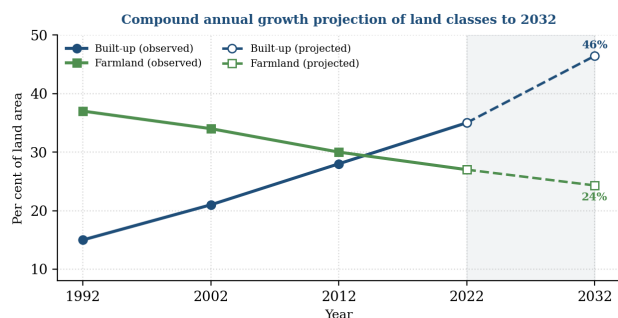


Figure 6: Compound annual growth rate projection of built-up and farmland classes to 2032.

Source: Authors' analysis and projection, 2024.

The projection carries significant implications for food security and livelihoods in Lokoja. The continued contraction of farmland threatens the capacity of the peri-urban zone to contribute to local food production, increasing dependence on food imported from more distant rural areas and exposing the urban population to price volatility and supply disruption. The displacement of farming households from their land also carries social costs, undermining livelihoods and eroding the agricultural knowledge embedded in these communities. These findings reinforce the conclusion that the unregulated encroachment of urbanization on farmland constitutes a substantial threat to the sustainability of the city.

5. Conclusion and Recommendations

This study has examined the spatial and temporal dynamics of farmland use change in Lokoja over the period from 1992 to 2022 and projected the trajectory of change to 2032. The integration of remote sensing, geographic information system analysis, and household survey data has revealed a consistent and substantial transformation of the land surface, characterised by the expansion of built-up land from fifteen to thirty-five per cent and the contraction of farmland from thirty-seven to twenty-seven per cent. Post-classification analysis confirmed that the conversion of farmland to built-up use was the dominant transition, accounting for the loss of approximately seventy-four square kilometres of agricultural land. The household survey identified population growth, housing demand, and commercial development as the principal drivers, while the compound annual growth rate projection indicated that the agricultural land base will be further eroded by 2032 in the absence of intervention.

On the basis of these findings, the study recommends the integration of agricultural land protection into the urban planning framework of Lokoja, including the designation of protected agricultural zones at the urban fringe and the enforcement of land use regulations that restrict the conversion of prime farmland. The

strengthening of land administration institutions is essential to curb speculative conversion and to ensure that urban growth proceeds in an orderly and sustainable manner. The promotion of compact urban development and the intensification of agriculture on retained farmland could further mitigate the loss of agricultural capacity. Finally, the establishment of a periodic land use monitoring system, drawing on the remote sensing methods employed in this study, would provide planners with the evidence required to manage the competing demands of urban growth and agricultural sustainability.

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