

SPATIO-TEMPORAL ANALYSIS OF URBAN GROWTH PATTERN IN LOKOJA, KOGI STATE, NIGERIA

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Abstract

Urban growth, particularly in the developing world is continuing to be one of the crucial issues of global change in the 21st century affecting the physical dimensions of cities. The study examined the spatio-temporal pattern of urban growth in Lokoja town for a period of 19 years, using remote sensing data and Geographic Information System (GIS) techniques. Three different land cover maps derived from Landsat image of 2001, 2011, and 2020 were used to reveal the patterns and dynamics of urban growth in the study area. The result revealed that the city has been undergoing extensive urban growth processes. The growth has been from urban center to adjoining non-built-up areas mainly in the south west and in the north-western direction alongside major transportation corridors. The total built-up has grown from 1492.35 hectares in 2001 to 2890.85 hectares in 2011 and 5556.27 hectares in 2020 at a mean urban growth rate of 9.37%, and 10.24% from 2001-2011 and 2011-2020 respectively. The study was able to determine the present and future direction of growth of the town, with facts that the town is growing in the north-western and south-western direction with growth constraint in the north eastern part of the town, with same measure of physical development, in the next coming years, the town is expected to grow in a similitude direction as the present. The research recommends the development of more and well-articulated physical development plan. Authorities responsible for monitoring should encourage the use of remote sensing technique and GIS to monitor the growth of the city, there should be public enlightenment on the negative effects that slum areas have on their physical and social environment.

Key Words: *Spatio-temporal, Pattern; Urban, Growth, Lokoja, Nigeria*

Introduction

It was reported by United Nations (2010) that cities will be home to half of the world's 6.6 billion humans, by 2030 nearly 5 billion people are expected to be living in cities. Holding huge population, cities are definitely the hot spots of production, consumption, and waste generation. An urban area is spatial

concentration of people who are working in non-agricultural activities. The essential characteristic here is that urban means non-agricultural. Urban can also be defined as a fairly complex concept. Criteria used to define urban can include population size, space, density, and economic organization. Usually, however, urban is simply defined by some base line

size, such as 50, 000 people as in the case of United States (Federal Register, 2010). Any way this definition varies between regions and cities (Long 1998) while urban growth is a spatial and demographic process and refers to the increased importance of towns and cities as a result of concentration of population within a particular economy and society (Bhatta *et al.*, 2010).

Urban sprawl has resulted in unsustainable urban development patterns from social, environmental, and economic perspectives. A study conducted by Zhenfeng *et al.* (2021) in Morogoro urban municipality, Tanzania has been among the earliest examples of research in Africa that combine remote sensing with social media data to determine urban sprawl from 2011 to 2017. It is clear that city development holds the key to many of the challenges we face in our interactions with the environment. Most major urban areas around the world are expanding and signs of sprawling development are emerging. Cities are concentration centres of production, consumption that drive land change and a host of environmental problems (Grimm *et al.*, 2008). The combination of a larger and more mobile population with city growth has reduced the quality of life for important segments of the population. However, because the world population is growing, urbanization will unavoidably continue. It is thus important to understand the underlying mechanisms of city growth to mitigate the negative aspects of urbanization.

Lokoja has experienced series of political status change within the last 50 years; first as a provincial capital, then later Local Government headquarter and

now a state capital. Consequently, infrastructure and amenities are almost continuously under intense pressure, stress and in short supply. Erratic and unreliable power and water supply, long queues at public water point, long distance trekking in search of water, traffic congestion are among the many manifestations of infrastructure inadequacies. The city has been experiencing a large influx of population from its surrounding regions. This had led to rapid growth and expansion that had left profound changes on the landscape in terms of land use and land cover expansion without due consideration to interrelated factors such as transportation, employment, health and other liveable factors.

Many relevant research works have been carried out, for instance, Ade and Afolabi (2013) analyzed urban sprawl in Abuja, the federal capital territory using remote sensing and GIS techniques from 1987 to 2007. Their results show that built up area increased from 49.9km square in 1987 to 93.77km square in 1999 and further increased to 179.48km square in 2007. This growth extends not just inwards but outwards implying that satellite towns surrounding the city are being affected, posing a threat to the limited available resources in the city and resulting to high cost of living. However, despite the development of Lokoja to date researchers where not much concern to examine the expansion of the settlement. It is in view of this, that this study seeks to determine the spatial-temporal pattern of growth in Lokoja, so as to establish the future pattern of growth using simulation.

Materials and Methods

The Study Area

Figure 1 presents the study area (Lokoja), Kogi State, Nigeria.

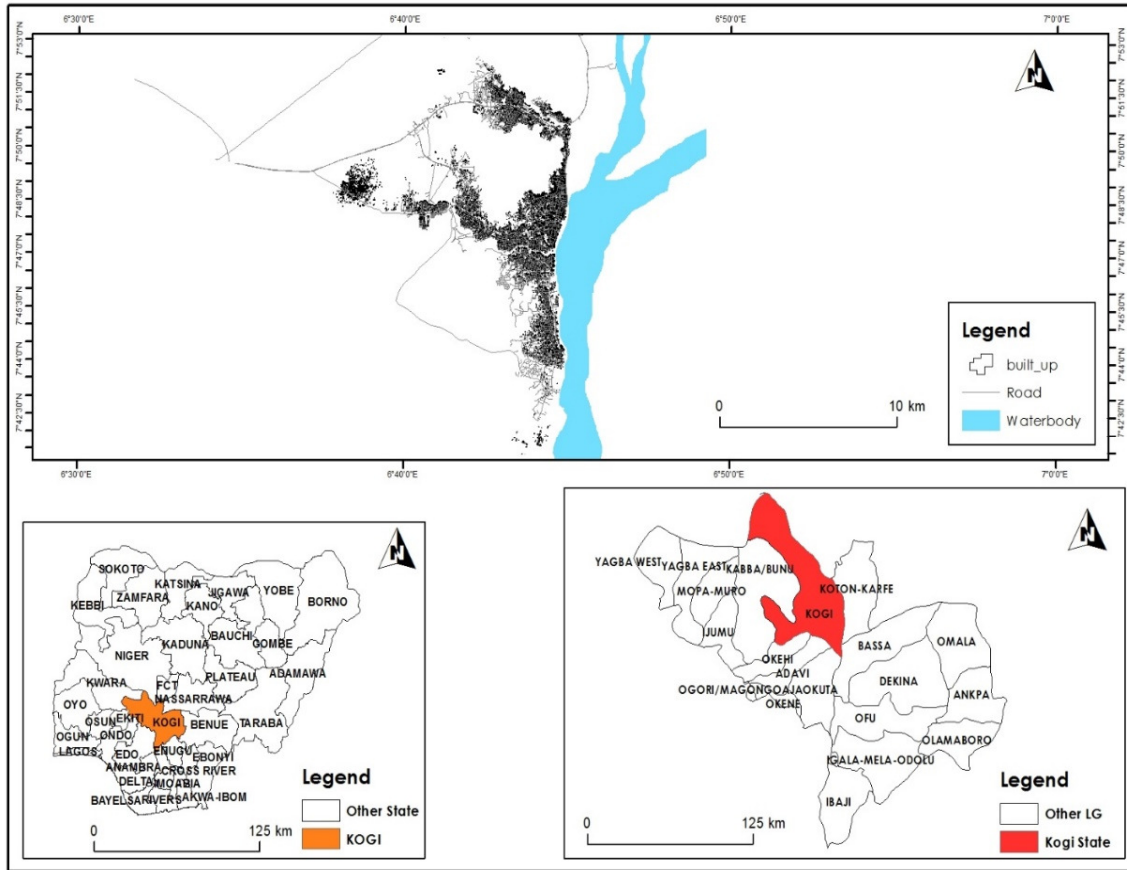


Fig. 1: Map showing study Area
Source: Extracted from Google earth

Methods of Data Collection

Landsat of Thematic Mapper (TM) and Enhanced Thematic Mapper plus (ETM+) of 2001, 2011, and 2020 was downloaded from USGS archives in a GeoTIFF format (Tagged Image File Format).

Methods of Data Analysis

Image processing was carried out using the Earth Resource Data Analysis Software (ERDAS) 15 to mosaic the data set which later be stacked into false color. Images preprocessed in other Erdas Imagine 15.0 was imported in the Arc GIS 10.7 software where the area of interest was extracted via the clipping process in

the Arc toolbox. The AOI raster and Vector feature of the Lokoja Town, was then re-projected to WGS 1984 Universal Transverse Mercator (UTM) Zone 32N. Maximum Likelihood Classification was carried out on ArcGIS to classify the landsat images into three classes and this was done by training samples for each class and assigning different colours, the system automatically uses the training samples across the landsat images to interpret the image result. Because of how conversant the researcher is to the study area, raster cleaning was done in order to edit the

raster in areas where there was mix up in colours. The data collected was presented through maps (Tunde-Ajayi and Adetola, 2020).

Calculation of Raster Count to

Determine Raster Area

Raster Count * Cell size (30by30)

Raster Count *900

Determination of growth rate was done using the formular = $(A2 - A1/A1 * 100)/N$

Where: A2 is the total coverage of the present year, A1 is the total coverage of

the previous years and N is the number of years.

Results and Discussion

Growth Pattern of Lokoja 2001 - 2020

Figure 2 below showed that the total built up area in the year 2001 was approximately 1492.35ha. The pattern of development within the area from the image below depicts a leapfrog pattern. The image depicted shows that settlements are quite distant from each other and thus follow the leapfrog form of growth.

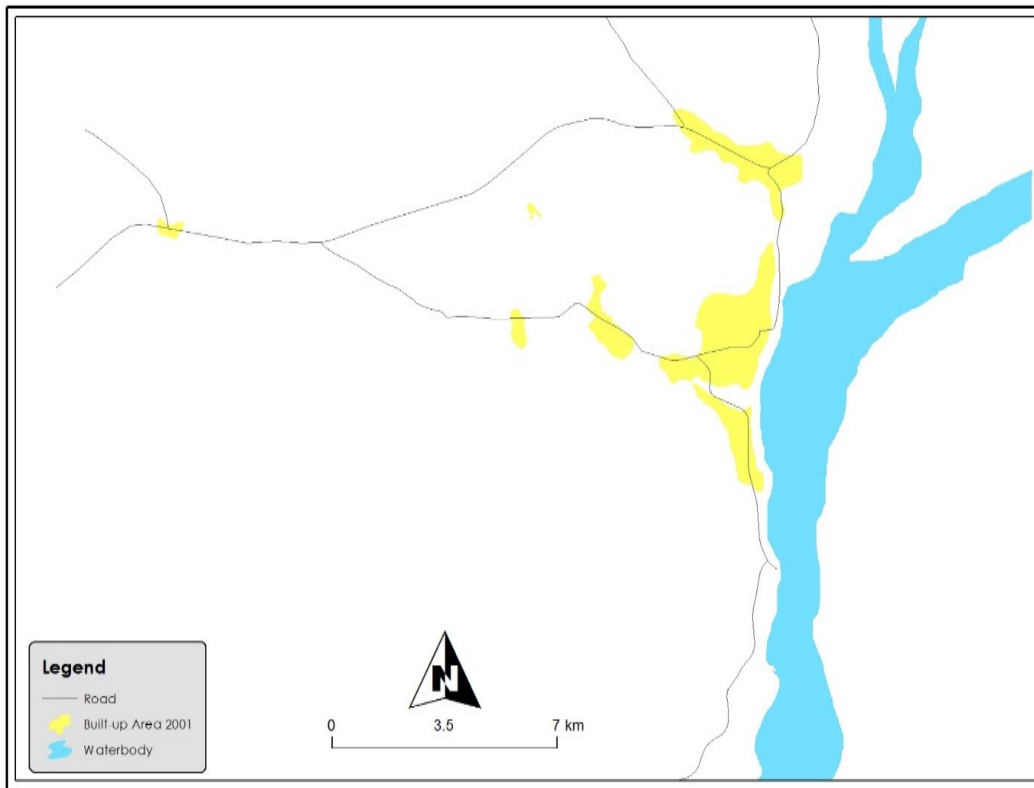


Fig. 2: Map showing growth pattern of Lokoja town as at the year 2001

Figure 3 showed that the built-up area in 2011 was approximately 2890.85ha. The pattern depicted that infilling and urban expansion has taken place within ten years with great magnitude. The

pattern can be said to be both a leapfrog pattern and nucleated pattern. From the year 2001 and 2011, new development has taken place between vacant lands of areas that already have been developed.

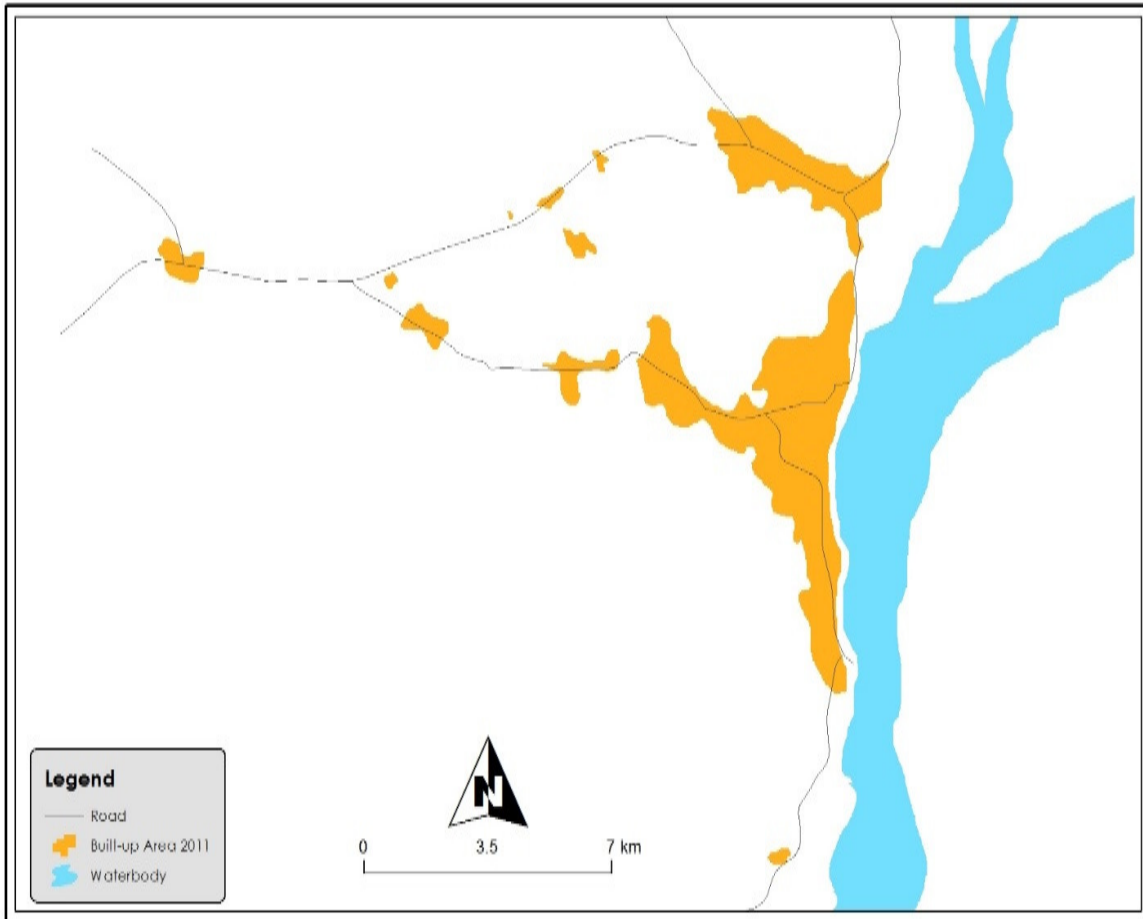


Fig. 3: Map showing growth pattern of Lokoja as at the year 2011

Figure 4 below showed that the built-up area in year 2020 increased to approximately 5556.27ha. The pattern depicted from the figure varies from

leapfrog, nucleated and continuous development along major roads and this is due to development of new areas brought about by the opening of roads.

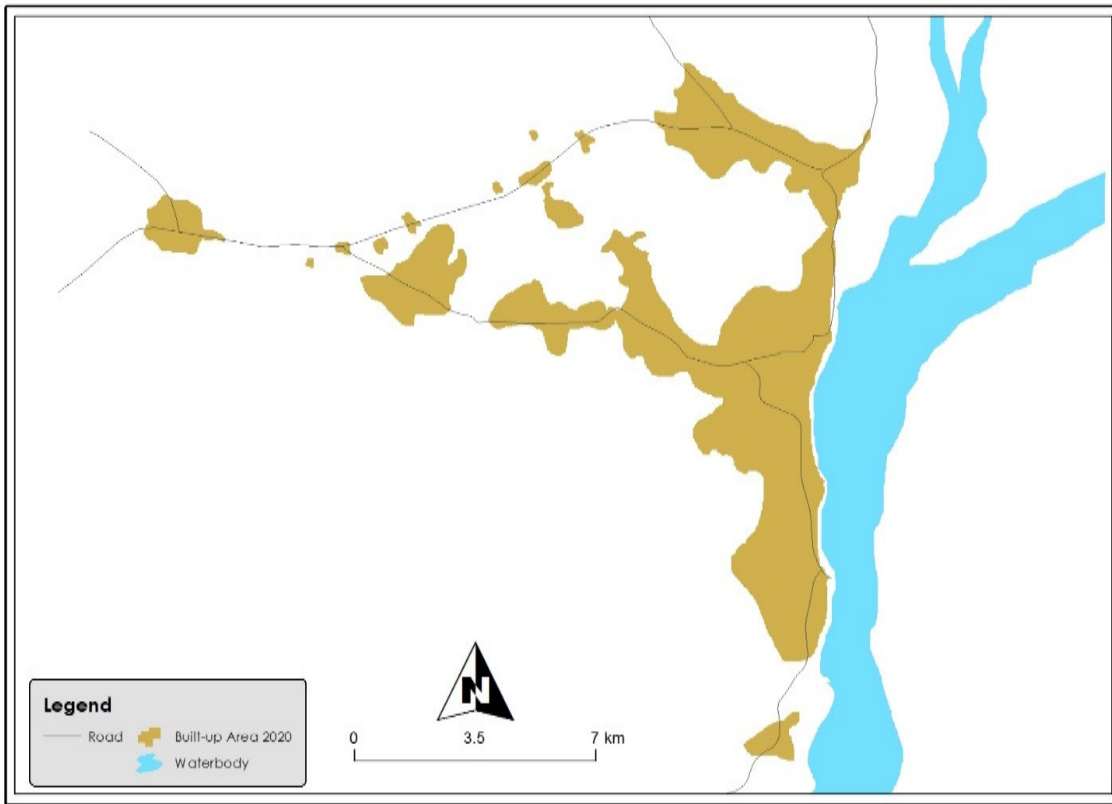


Fig. 4: Map showing growth pattern of Lokoja as at the year 2020

The built-up area in Lokoja gained more land areas with time. The pattern of urban growth was derived from the four imageries of the study area, overlay analysis from the results of figure 8 below and visual interpretation was carried out in determining the patterns of the growth. On the bases of the results obtained from the analysis, two patterns of urban sprawl namely; cluster, and leapfrog were found which varied from different study periods (2001, 2011 and 2020). Though, all of the study periods witnessed cluster pattern of growth in certain areas. It was found that in 2001, the pattern of the growth was quite that of a leapfrog while 2011 and 2020 witnessed both cluster and leapfrog pattern of urban growth as show in figure 2, 3 and 4 respectively. These results correspond with that of Umar and Kumar

(2014) in Kano metropolis who discovered the expansion of the metropolis throughout the study period. Findings from this study correspond with that of Cyril, Mwanret and Emmanuel (2019) in Kaduna South LGA, Kaduna State from 1987 to 2016, which revealed built-up land to has been increased from 26.71% (1987) to 59.41% (2016). This result is in line with that of Ayenikafo and Wang (2021) in Benin, Nigeria from 2000 to 2020 who observed increase in build-up are by about 3.22%, 2.01%, and 1.57%, in Bante, Glazoué, and Ouèssè, respectively.

Based on the nature of the pattern of growth in the study area, it was also found out that there was an uncontrolled uneven growth of urban area into the surrounding study area forming poorly planned patterns of development. The direction of

expansion has been observed to tend towards the Okene-Kabba road and the Lokoja-Ajaokuta roads in an undefined pattern. Land adjacent to these roads is developed but those without direct access remain in the rural uses/covers.

Spatial Extent of Growth 2001 - 2020

The spatial extent of urban growth has been progressively increasing throughout

the study period as shown on table 1. The year 2001 which represents the base year of this study had the least extent of buildup land which constituted 1492.35 hectares (1.65%) (Figure 5), This was preceded by the years 2011 (10 years later) where the extent of urbanization rapidly increased to 2890.85 hectares (3.14%) (Figure 6).

Table 1: showing the spatial extent of growth in the year 2001, 2011, and 2020

CLASS	YEAR					
	2001		2011		2020	
	Area (Ha)	%	Area (Ha)	%	Area (Ha)	%
Built-up	1492.35	1.65	2890.85	3.14	5556.27	6.04
Water body	7590.15	8.25	7655.23	8.32	7600.21	8.26
Unbuilt	90,547.55	90.10	89,149.05	88.54	86,483.63	85.7
TOTAL	92,039.9		92,039.9		92039.9	

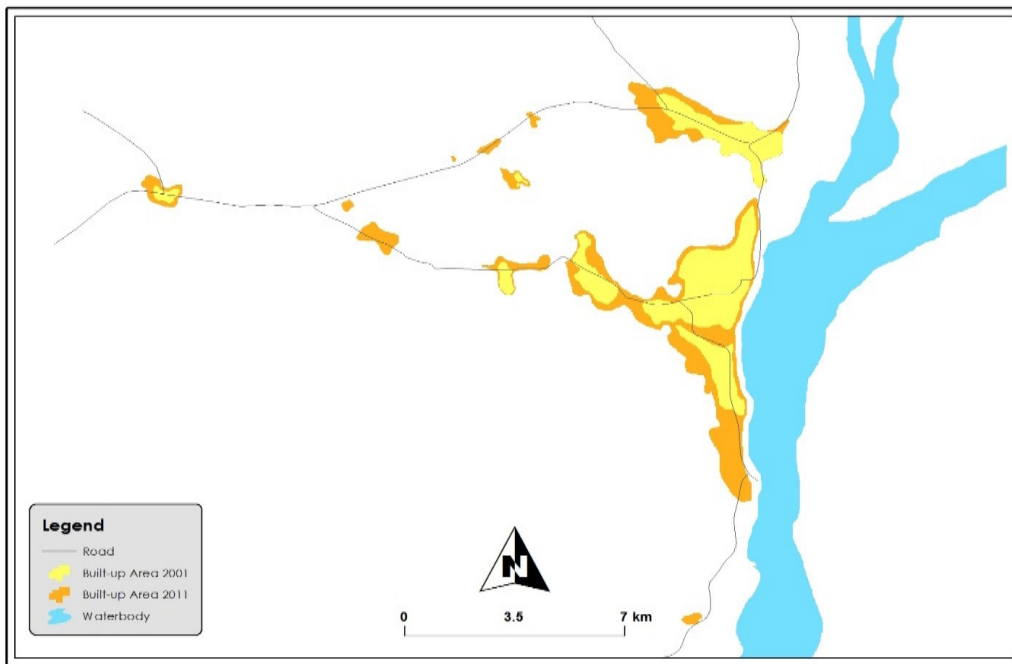


Fig. 5: Map showing spatial extent of built-up from the year 2001-2011

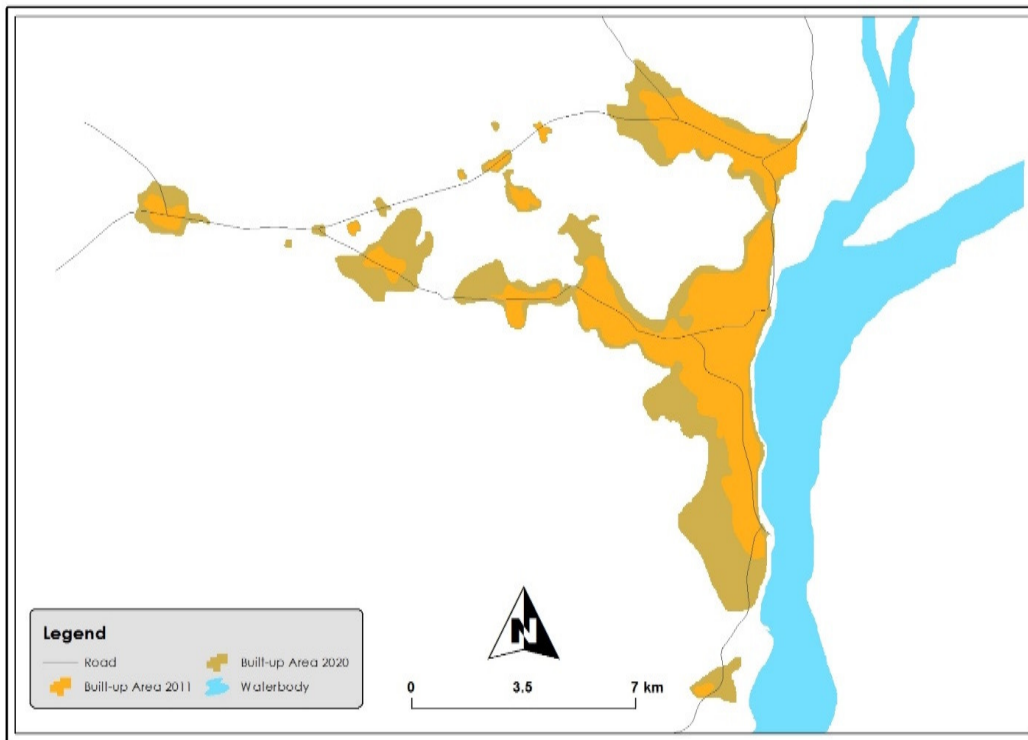


Fig. 6: Map showing spatial extent of built-up from the year 2011-2020

This rapid increase in built-up could however be accounted for by the increase in the construction of government office for its ministries and parastatals, housing facilities for staff as well as the influx of the rural population coming to seek for a greener pasture in the urban area. More

urban expansion resulting from continuous dividends of democracy which increased administrative and commercial activities, residential development all resulted in an increase in the extent of urban area to 5556.27 hectares (6.04%) in the year 2020 as shown in Figure 7.

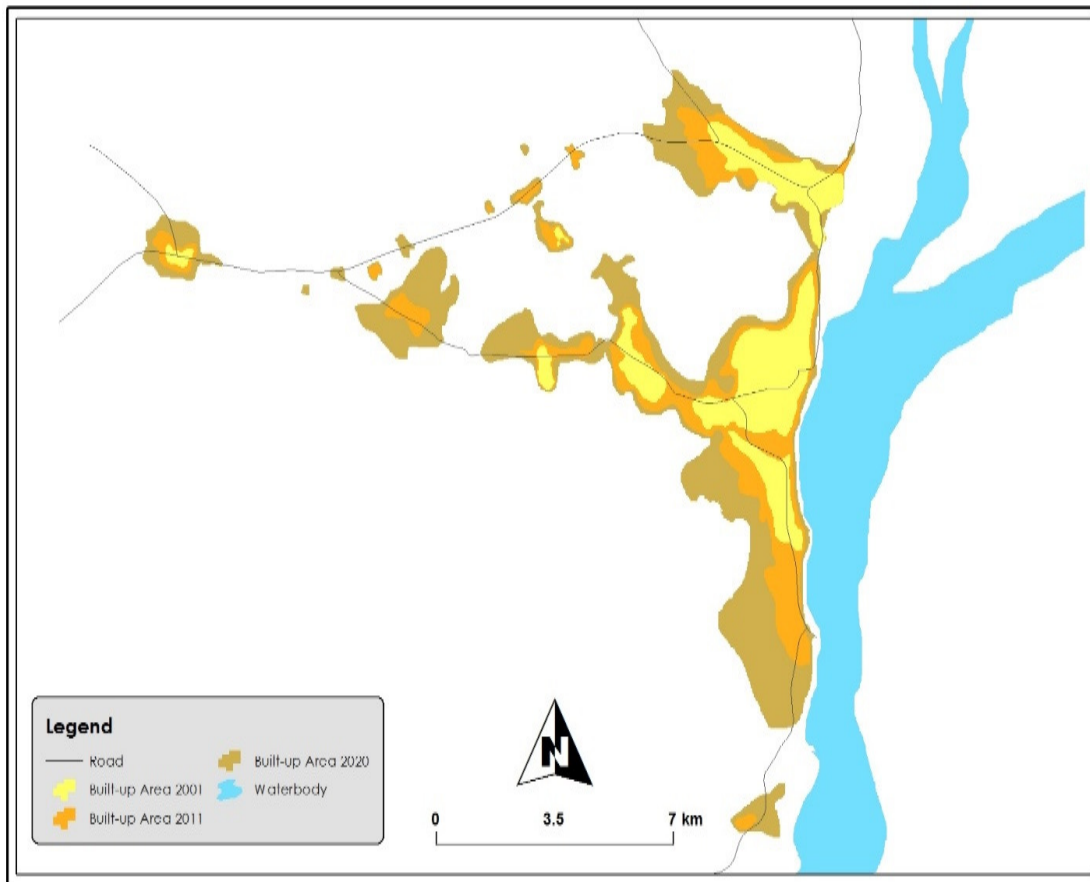


Fig. 7: Map showing spatial extent of built-up from the year 2001-2020

The results also support Sati and Danwalis (2020) in Kaduna North Local Government Area between 1993 and 2007 who stated that in most Nigerian cities there is remarkable increase in residential, commercial, communication, recreational, and institutional land use types. The findings correspond with that of Muhammad and Auwal (2023) in Kaduna Metropolis from 1986 to 2020 which revealed the built-up areas increased from 72.47 km² to 239.88 km².

Rate of Change in the Growth 2001 – 2020

Table 2 showed that, the area experience growth rate of buildup by 9.37% from 2001 to 2011 and 10.24% from 2011 to 2020. This indicated a tremendous increase in growth rate of the study area, which is due to the fact that Lokoja had already served as the capital of Kogi State for about 25 years, attracting people to the city in search of jobs and other activities as a result of its administrative function. This result is in line with that of Adzandeh *et al.* (2014) which shows a tremendous growth rate of Kano Metropolis by 10.77% from 1988 to 2000 and 24.72% from 2000 to 2005.

Table 2: Percentage of urban growth rate in Lokoja Town

Year	Periods	Built-up areas (hectares)	Mean urban growth rate (%)
2001	2001	1492.35	Base year
2011	2001-2011	2890.85	9.37
2020	2011-2020	5556.27	10.24

Present and Future Direction of Growth in Lokoja

Figure 8 presents the recent developments in Lokoja town have continue to spread in ‘Outlying’ pattern which terminates at the north-eastern direction of the town, along Adankolo. As observed from the field survey and from the result of the image interpretation, development continues to occupy the open spaces between Lokongoma and Zango, and to Felele respectively as shown in Figure 8. This will lead to the further

expansion of the towns in the same direction. And there are no natural constraints relating to topography that may impose limitations in the expansion of the town in the north-west and south-west directions in the future. An important thing to note is that Lokoja town’s growth is restricted to the north-eastern and south-eastern direction and this is because of the presence of the water. The roads and the topography of the study area seem to be accountable for the growth direction.

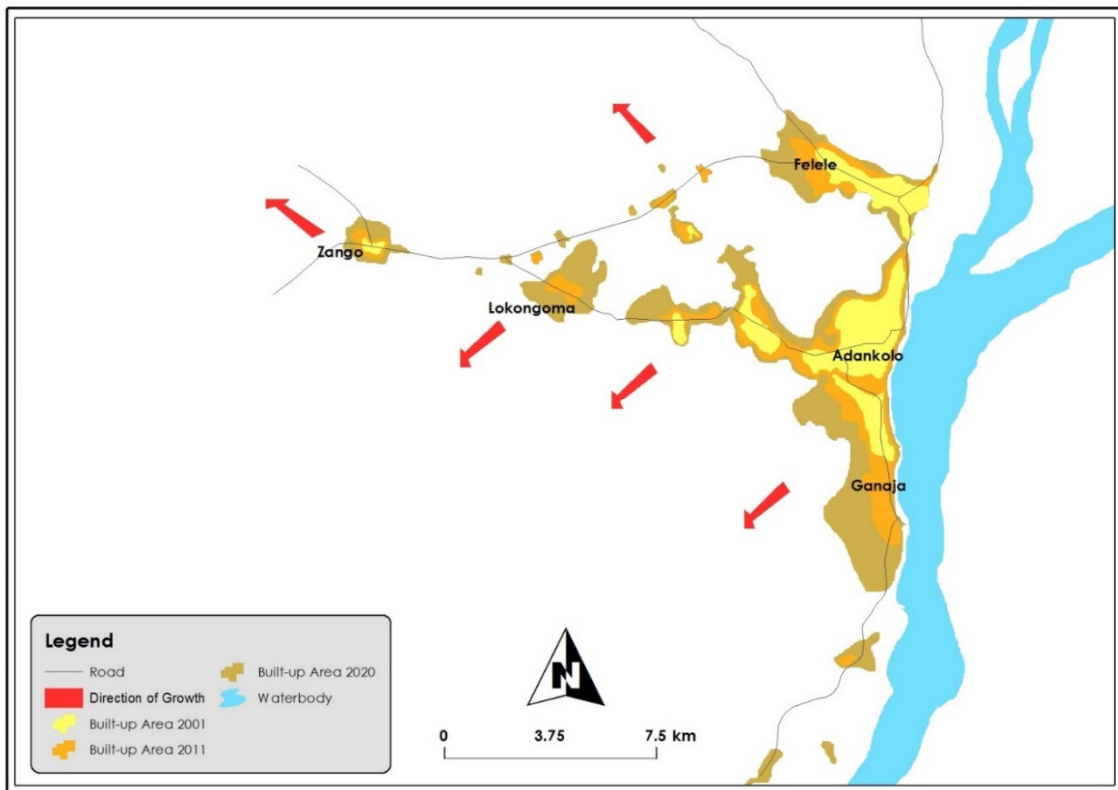


Fig. 8: Map showing the direction of growth of Lokoja Town

Conclusion

In conclusion, the study presents the power of remote sensing and GIS in performing studies that deals with urban expansion. The results show that the Lokoja is growing at a rapid rate in the north, south and western direction majorly along the transportation routes. The growth pattern is largely influenced by factors such as siting of educational institutions, the presence of government buildings, and economic growth of the city through industrial establishments. These institutions and industries provide employment opportunities needed by urban dwellers and they equally attract job-seekers mainly from the rural areas and other urban centers into the city. Topography and transportation route significantly influence the direction and pattern of urban growth in the city because they are the main stimulant for the establishment of the industrial, commercial, and educational institutions.

Therefore, it is advised that the authorities responsible for the physical planning of Lokoja town such as Kogi State urban planning and development board are respected to be pro-active in their activities, rather than reactive that is preparing a very well-articulated physical development plan and layouts that will guide the development and growth of the town before any development take place lot allowing development to take place before they intervene. Also, authorities responsible for monitoring physical development should encourage the use of Geographic information system and remote sensing technique to monitor growth of the city. Finally, the public in Lokoja town should be enlightened on. The adverse effect that slums is likely implications on their physical and social

environment, even to their personal and health. Preservation of the natural vegetation and agricultural land measures should be taken in order to protect the natural vegetation cover in Lokoja town such as designation some area as reserved area and to try as much as possible to preserve the agricultural land for the future of food security.

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