African Journal of Social and Behavioural Sciences (AJSBS)
Volume 16, Number 6 (2026) ISSN: 2141-209X

GEOSPATIAL ANALYSIS OF URBAN DEVELOPMENT IN IJAGBO, IPEE AND OFFA TOWNS, KWARA STATE, NIGERIA

Surajudeen Ayobami Mohammed[1*] & Lukman Tanimowo Ishola[2]

[1]Department of Geography & Environmental Management, Ahmadu Bello University, Zaria, Kaduna State, Nigeria

[2]Department of Geoinformatics & GIS, African University of Science and Technology, Abuja, Nigeria

*oremipolucky12@gmail.com

ABSTRACT: Urban development in Ijagbo, Ipee and Offa, Kwara State are linked to socio-economic and political transformations in recent times. These transformations align with broader trends in post-socialist and rapidly urbanizing regions, where economic restructuring often precipitates the large-scale conversion of agricultural land into built-up areas, as well as the often-overlooked merging of urban centres in close proximity, as observed in the study area. This study analyzed the present spatial extent of urban development in Ijagbo, Ipee and Offa as a single entity with merging landscapes, taking urban growth into consideration. Multi-temporal satellite images of Landsat 7 and 8 were obtained from the United States Geological Survey and classified using the Maximum Likelihood Classifier (MLC) into five (5) LULC classes: cropland, built-up, vegetation, bareland and water bodies. The built-up area, which represents urban development, was extracted (mapped), and the 'Calculate Geometry Tool' was used to calculate the areas of the selected polygons (in km^2 and corresponding percentage) for static years across the study period to determine the spatial extent. The land use land cover classification of the study area revealed that physical urban development stood at 12.26% (34km^2) in 2000 and increased to 20.45% (56.73km^2) in 2010 and 28.72% (79.65km$^{2)}$ in 2020. The study provided an insight into the spatial extent of urban development in Ijagbo, Ipee and Offa, with a conscious probability of these overlapping urban centres developing into a single metropolis as found in other big cities across Nigeria in the near future. The integration of land use planning, strengthened environmental regulations and enforcement, sustainable urban development practices with real-time monitoring, and active stakeholder engagements are therefore recommended. These will foster a resilient and sustainable urban development in the study area.

INTRODUCTION

Urbanization is a global phenomenon that has been transforming the world's population geography for centuries. As people move from rural areas to cities, the dynamics of population distribution, density, and composition undergoes significant changes, a complex set of socio-economic, political, cultural, demographic and environmental development. This process has resulted in an increase in the proportion and density of population and resource consumption in towns and cities, making up urban settlements (Francis, 2023).

Urbanization remains a major driver reshaping global landscapes, often outpacing planning and regulatory capacities and causing serious environmental stress (Seto, Güneralp, & Hutyra, 2012; Chen et al., 2020). Conventional urban growth has prioritized built-up land expansion at the expense of green cover, resulting in habitat fragmentation, biodiversity loss, and degraded ecosystem services. In the last two decades, of all countries of the world, Africa and Asia have become overachieving continents by showing a rushed urbanization (UNDESA, 2024). In those continents, urban growth is characterized by the swift transformation of rural areas to urban centers as a result of unprecedented population growth, diversified economic activities, and advancements in modern construction techniques and equipment, especially in developing countries like Nigeria, where agricultural lands are being converted into residential, commercial and industrial layouts.(Mohammed, 2015; Alani, 2016). Such conversions, resulting in the creation of new urban centres, expansion of existing ones and various adjustments in natural landscapes, are physical products of urbanization which is a universal and dynamic phenomenon that continues to significantly increase built-up areas to accommodate the social and economic development of urban and semi urban centres (Sharma & Kumar, 2025). The improved changes are reflected by the quality of life and are perceived as urban development.

Urban development can be viewed as a process of positive changes (quantitative growth and qualitative progress) occurring in a given city (urban area), which takes into account the needs, preferences and hierarchy of values characteristic to this area and its community (Dorota & Danuta, 2016). Isomkwo and Dzum (2019) conceptualized urban development as the conscious or unconscious improvement in the circulatory and transportation, residential, commercial and economic functions of a settlement as a result of an increase in human population. It was further explained as the growth of a settlement into areas that were hitherto uninhabited in order to accommodate growth of human population. According to Ritchie et al. (2024), urban development is a science of managing and directing city growth with respects to the discipline of land utilization planning which explores a very wide range of aspects of the built and social environments. The conceptual models of urban development however often ignore the spatial dimension, which is crucial for understanding human quality of life, food and energy consumption, health, climate, and hunger vulnerabilities.

Urban development in Ijagbo, Ipee and Offa (IIO) like other parts of Kwara State, is experiencing a mix of growth and challenges. Small and isolated population centres are rapidly transforming into overlapping urban areas, without paying adequate attention to patterns, extent and suitability of the land. These, as observed in other parts of Nigeria, are major causes of land conflicts, poor environmental quality, extreme poverty and physical dereliction of infrastructure, amongst others (Dung-Gwom et al., 2008). These areas exemplified rapid urban development typical of emerging African cities, with prevalent conversion of agricultural land to built-up areas. This unregulated growth has caused habitat destruction, pollution, soil erosion, increased runoff, urban heat islands, and elevated greenhouse gas emissions, threatening environmental sustainability and human health (Ipadeola et al., 2018; Idrees et al., 2021). Integrating GI into urban planning offers a strategic pathway to mitigate these impacts by preserving and enhancing ecosystem functions within the urban fabric.

Accurate, timely LULC data underpins monitoring and sustainable policy-making (Gaur & Singh, 2023; Karimi & Sultana, 2024). Advances in satellite remote sensing and GIS enable robust multi-temporal change detection using platforms such as Landsat, MODIS, SAR, and CBERS. Analytical models, such as Markov chains, cellular automata, and hybrid CA-Markov, offer powerful frameworks to simulate urban growth and environmental impacts (Wu & Ma, 2019; Mostafa, Li, & Sadek, 2023; Mirzakhani, Behzadfar, & Azizi Habashi, 2025). Hybrid CA-Markov models improve prediction by integrating spatial and temporal dynamics, proving invaluable for scenario analysis and sustainable planning incorporating GI principles (Ait el Haj et al., 2023; Agyemang, Silva, & Fox, 2019).This study thus analyzes urban development in IIO from 2000 to 2020 using geospatial tools. The study focused on mapping LULC and calculating the spatial extent of urban development within the study years; these will provide insights into sustainable urban development for adequate planning and policymaking.

METHODOLOGY

Study Area

Ijagbo, Ipee and Offa are traditional and ancient Nigerian towns, which like other such towns in the country exists long before the advent of British colonial rule. There is no exact information on the age of the towns, but it is commonly believed that the original settlers were Yoruba from Ile–Ife, which is widely regarded as the main origin of the Yoruba people. Spatially, these towns are in very close proximity and overlapped in varying degrees such that it hard to physically delineate the boundaries. The three towns were part of what formed the old Oyun LGA before the creation of Offa LGA, with headquarters sited in Offa; however, these towns still maintained their continuous spatial overlapping without substantial boundary delineations till today, even though they have been further segregated for political governance.

The study area is located near the southern boundary of Kwara State in the Central Zone of Nigeria, approximately between Latitudes 8° 15′ N – 8°70′ N and Longitudes 4° 40′ E – 4°75′ E (Fig. 3.1), covering about 277.37km^2. It is bounded by, Ajase-Ipo, to the north, Ojoku, Igbonna, and Ikotun to the west, Igosun and to the east, Erin Ile to the south, and Ilemona to the south west. The National Population Census of 2006 put the population of the study area at 107,134 (NPC, 2006); this was projected to 201,129 in 2024 using the 3% growth rate of the Nigeria Population Commission. The town's morphology has changed over time to assume its present status and the accompanying socioeconomic and religious life styles problems as experienced in similar urban centres in Nigeria. The study area map is presented in Figure 1.

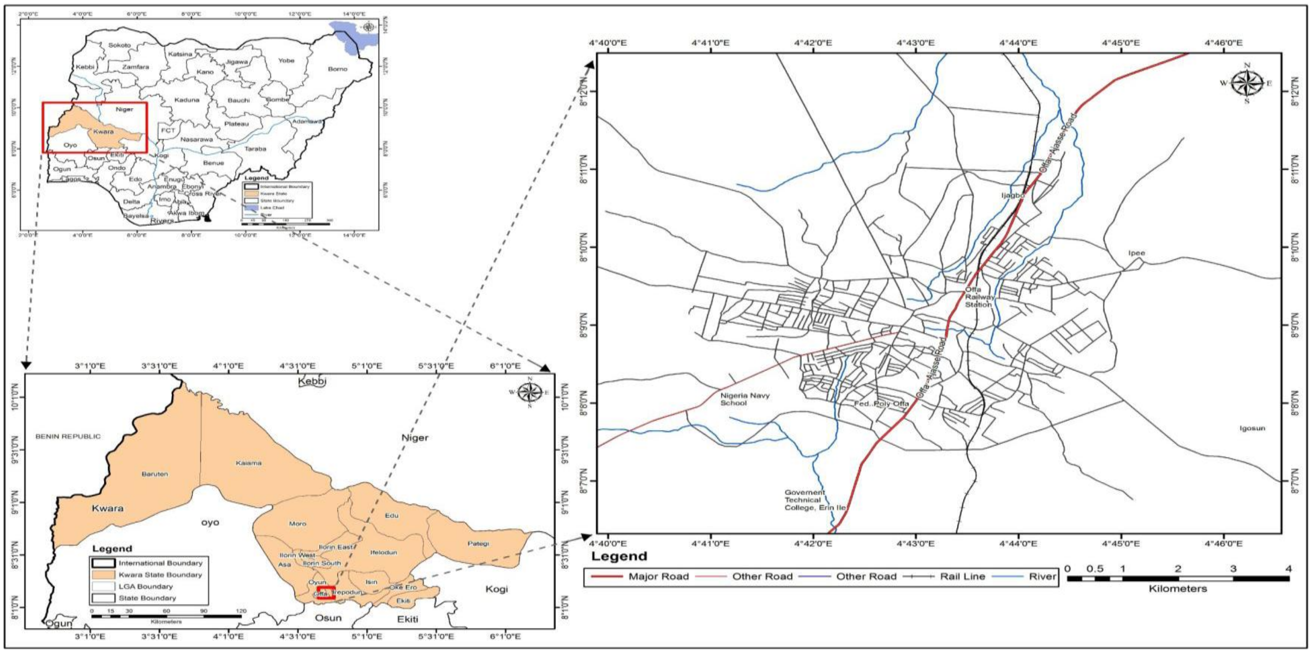


Figure 1: Ijagbo, Ipee and Offa

Source: Modified Kwara State Administrative Map

Three satellite images were acquired from United States Geological Survey (USGS) to analyze urban development dynamics at various intervals: Landsat Thematic Mapper (TM) for 1990, Landsat Enhanced Thematic Mapper Plus (ETM+) for 1999 and 2010; and Landsat 8 Operational Land Imager of 2020 with a spatial resolution of 30 meters. The satellite datasets used and their attributes are presented in Table 1.

Table 1: Data Types, Sources and Purposes

S/N	Types of Data	Sources	Purpose
1	Landsat – 7(ETM+)	United State Geological Survey (USGS).	LULC (2000)
2	Landsat – 7 (ETM+)	United State Geological Survey (USGS).	LULC (2010)
3	Land – 8 (OLI)	United State Geological Survey (USGS).	LULC (2020)
4	Administrative map of Kwara State.	Kwara State Ministry of Land and Survey	Base map.

Source: Author's analysis, 2025

Data Processing

Image Preprocessing

To ensure the reliability and comparability of the satellite data, various preprocessing steps were undertaken, such as radiometric correction (to rectify sensor noise and atmospheric interferences (Jin, Ahn, Seo, & Choi, 2020), Geometric correction, which involve geo-referencing all images to the Universal Transverse Mercator (UTM) projection, Zone 31N, using the WGS 84 datum. Additionally, sub-setting and cloud masking (clipping images to the study area boundary) and identifying cloud pixels excluded from the analysis through thresholding and manual editing (Jensen, 2015; Kollert et al., 2021).

Land Use/Land Cover Classification

Maximum likelihood classifier (MLC) is one of the most commonly used classification methods for supervised classification of Landsat images (Phiri & Morgenroth, 2017). Maximum Likelihood Classifier (MLC) was used for classifying the satellite images to identify land use and land cover (LULC) classes in the study area. Training sites were established within the imagery by delineating polygons and saved as signature files which were eventually used in supervised image classification process to generate the LULC map for the study area. The study area was categorized into five distinct classes (Bare surfaces, Cropland, Built-up land, Vegetation, and Water body) based on texture, tone, and color, with each class assigned to pixels during image classification. The classification scheme was adapted from previous studies in Sub-Saharan Africa (Sumari et al., 2020; Govender, Dube, & Shoko, 2022). Image classification was computed using ERDAS IMAGINE 2015 software.

Table 2: Land use/Land cover Classification Scheme

Landuse /Land Cover Categories	Description
Cropland	Lands covered with temporary crops followed by harvest period, Crop fields and pastures
Built–up land	Land covered by buildings and other man-made structures. Residential, commercial services, industrial area, mixed urban or built-up lands
Vegetation	Land covered with natural vegetation (any plant species)
Bare land	Lands with exposed soil, sand or rocks, strip mines, quarries and gravel pits and has no vegetated cover during any time of the year.
Water Body	Rivers, lakes, streams, reservoirs

Source: Modified from Jensen, 2015

The classified image was reclassified into built-up class (assigned a value of 1) and non-built-up classes (assigned a value of 0). The non-urban areas of the study area were masked out using a vector polygon, and only the built-up lands within the urban areas were left as urban built-up lands. The 'Calculate Geometry Tool' was used to calculate the areas of the selected polygons (in km^2 and corresponding percentage) for each static year across the study period to determine the built–up area (urban development)

Accuracy Assessment

The aim of accuracy assessment is to quantitatively assess how effectively the pixels were sampled into the correct land cover classes. Accuracy assessment was conducted using a confusion matrix and the kappa coefficient, with independent validation points. The overall accuracy (OA) measures the proportion of correctly classified pixels, while the kappa coefficient (K) adjusts for chance agreement, ranging from -1 to 1. A kappa value above 0.85 indicates almost perfect agreement and is considered acceptable for further analysis (Owoeye & Ibitoye, 2016; Congalton & Green, 2019; Dettori & Norvell, 2020). This rigorous assessment ensures high reliability and validity in the LULC classification results, supporting robust change detection and modeling.

$$\text{Overall Accuracy (OA)} = \frac{[(Pc)+(Nc)}{(Pc)+(Fp)+(Nc)+(Fn)]} \times 100 \quad \text{.............................. eqn. (1)}$$

$$\text{Kappa coefficient (K)} = \frac{OA-P(e)}{1-P(e)} \quad \text{.............................. eqn. (2)}$$

Where OA denotes overall accuracy and the percentage of correctly classified cases. Pc is the proportion of correctly identified positive cases. Nc denotes the number of correctly classified negative cases. Fp denotes the number of incorrectly classified negative cases as positive. Fn is the number of positive cases that were incorrectly classified as negative. P (e) is defined as the expected ratio by chance (i.e., the proportion of the sum of marginal probabilities multiplied by the class to the total class entries).

RESULTS AND DISCUSSION

The classification generated satellite image maps, the amount and extent of land cover-use classes, as well as accuracy assessment error matrices. The classified LULC maps for the study area for the years 2000, 2010, and 2020 revealed considerable spatial and quantitative changes (Table 3; Figure 2). Over the past 20 years, built-up areas expanded remarkably, primarily at the expense of vegetation and cropland.

Table 3: Land use/Land cover Classification Statistics (2000 – 2020)

LULC Classes	2000 Area (Sq Km)	%	2010 Area (Sq Km)	%	2020 Area (Sq Km)	%
Built -up	34.00	12.26	56.73	20.45	79.65	28.72
Cropland	76.10	27.44	60.11	21.67	47.13	16.98
Vegetation	102.08	36.80	90.10	32.48	60.52	21.82
Bare surface	63.02	22.72	68.33	24.63	88.11	31.77
Water Body	2.17	0.78	2.10	0.77	1.96	0.71
Total	**277.37**	**100**	**277.37**	**100**	**277.37**	**100**

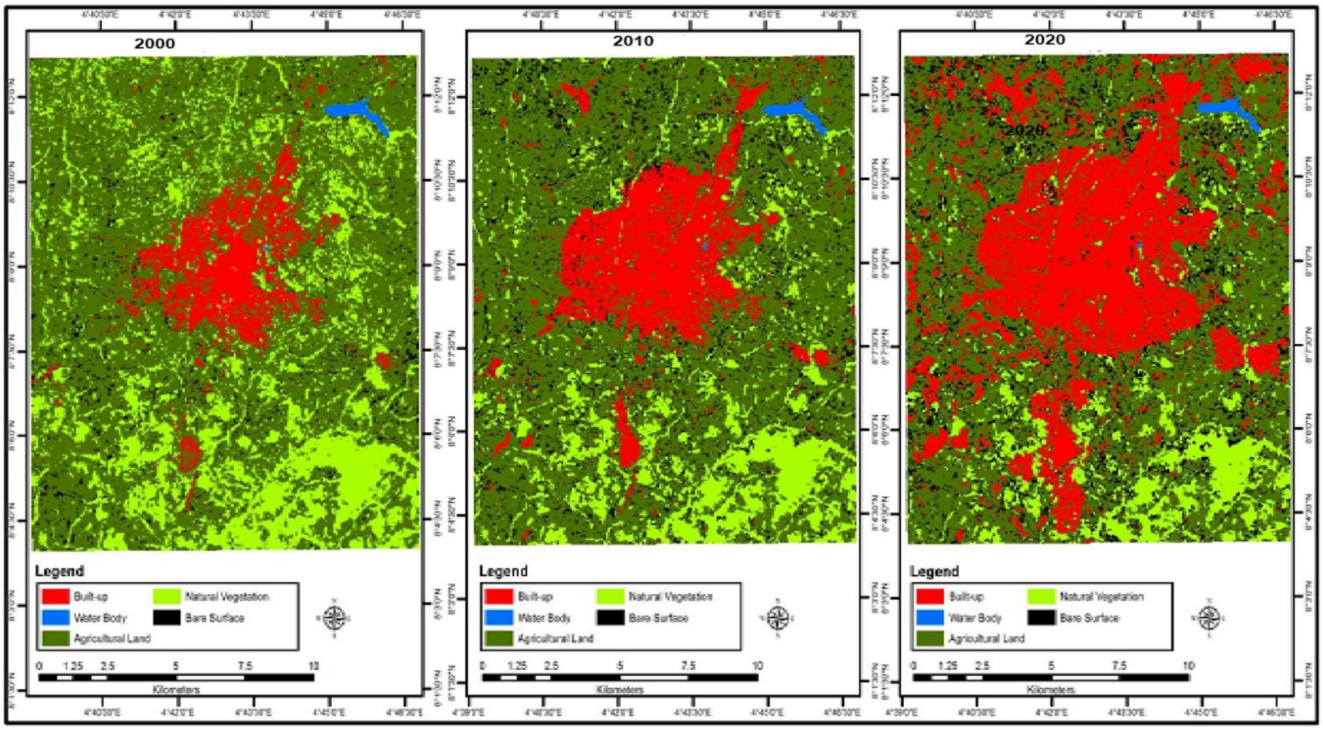
Source: Author's Analysis, 2025

As shown in Table 3, Built-up occupied area, which occupied a small 12.26% of the study area in 2000, significantly increased to 20.45%, which is almost double the initial size in 2010. The same level of increment was also noticed between 2010 and 2020 (20.45% - 28.72); cumulatively, this represented a remarkable growth of over 16% net growth over the study period. This rapid development highlighted the continuous accelerated urban development of the study area, and can be attributed to the siting of federal and military institutions, in addition to industrial, transportation, commercial, and physical development of the area, locating and upgrading of new and existing social amenities, and the accompanying rise in socioeconomic indices. Influx of people, mainly due to employment and educational opportunities, also contributes substantially to population growth and sets off the process of urban development (Mohammed, 2021)

Vegetation with the highest coverage (36.80%) in 2000 also witnessed a decreasing trend throughout the study period; from 36.80% in 2000 to 32.48% and 21.82% in 2010 and 2020, respectively. Logically, as built-up areas increase, vegetation decreases, as does cropland. It is a chain reaction; as population grows, more surrounding land, which is basically agricultural land, is absorbed for urban land uses such as the construction of buildings and roads; farmers tend to open up new forest land for agricultural activities (encroachment for agricultural and urban land uses), as well as the accompanying population pressure on forest resources and biodiversity.

Cropland had 27.44% coverage of the study area in 2000; this is not surprising as farming is one of the major occupations in the study area. It decreased significantly throughout the study period, to 21.67% in 2010 and 16.98% in 2020. This was mainly due to the rapid physical development (such as the construction of roads, buildings, etc) and urban expansion, which tend to absorb more farmland to accommodate the growing population at the cost of agricultural land.

Bare Surface rose significantly throughout the study period; 22.72% in 2000, 24.63% in 2010 and a significant 31.77% in 2020. This could also be attributed to the fact that the process of cultivation involves the clearing of natural vegetation; abandonment of farmlands (and agricultural activities) for white-collar jobs; and the huge financial benefits attached to selling land for urban land use rather than agricultural purposes. Water body is the smallest of all the classes throughout the study years and equally reduced within the same period. Population growth is the major culprit, but the low change rate could be due to the presence of boreholes and water wells in almost all households in the study area, which effectively reduce the growing population's pressure on water bodies.



The result corroborates the findings of Ajala et al. (2023), which revealed the periodic percentage increase of cropland and built–up areas in Kwara State over the past 30 years. Alani (2016) also reported vegetation (natural forest) as the dominant class in the study area, having lost over 30% of its coverage to agricultural activities, lumbering and built–up expansion over the past 40 years. The low proportion of water bodies in spatial extent is also in accordance with the study of Elijah and David (2022). Figure 2 presents the spatial pattern of the LULC dynamics of the study area between 2000 and 2020.

Figure 2: Land use / Land cover Classes of the study area (2020)

Source: Author's Analysis, 2025

Urban development in the study area can be attributed to political presence (creation of LGAs and headquarters), establishment of tertiary institutions, increased industrial and commercial activities, expansion of cities and villages, construction of roads and buildings, and the accompanying rise in socioeconomic indices. Influx of people (mainly due to education and employment opportunities) also contributes substantially to population growth and sets off the process of urban development. Though the study area is still largely dominated by agricultural activities, urban development is noticeably on the increase as reported by Alani (2016) and Mohammed (2021).

Assessment of Classification Accuracy

The land cover-use maps generated from principal components (Figure 2) had an overall map accuracy of 85.83%. This was acceptable for the subsequent change detection and analysis. The user's accuracy of individual classes ranged from 66.66% to 90.20%, while the producer's accuracy ranged from 66.671% to 97.78% (Table 5).

Table 4: Error matrix of the land use land cover analysis

Land use	**Built–up**	**Water body**	**Crop land**	**Vegetation**	**Bare land**	**Total (user)**
Built – up	44	0	4	1	1	50
Water body	0	4	1	1	0	6
Cropland	0	1	106	16	1	124
Vegetation	0	1	4	46	0	51
Bare land	1	0	2	0	6	9
Total (producer)	**45**	**6**	**117**	**64**	**8**	**240**

Table 5: Accuracy totals

S/NO	**LULC**	**Reference Totals**	**Classified Totals**	**Correct Pixels**	**Producer's Accuracy**	**User's Accuracy**
	Built - up	45	50	44	97.78	88.00
	Water body	6	6	4	66.67	66.70
	Crop land	117	124	106	90.60	85.48
	Vegetation	64	51	46	71.87	90.20
	Bare land	8	9	6	75.00	66.66
	Totals	240	240	206		

Overall accuracy = 85.83

Kappa coefficient = 0.811

The overall total accuracy and kappa coefficients were above 85% and 0.811, as shown in Table 5. These demonstrate a dependable and accurate image classification for analyzing land use/land cover change. The value of the kappa coefficient 0.811 indicates that there is a strong agreement between the reference map and the classified map. In accuracy assessment, Khat >0.80 represent strong agreement and good accuracy. 0.40-0.80 is middle, <0.40 is poor (Gao, 2009).

Urban development statistics (2000 – 2020)

The extent of urban development was captured for each of the static years across the study period and presented in Table 6.

Table 6: Extent of Urban Development

EXTENT OF URBAN DEVELOPMENT												
	2000		**2010**		**2020**		**2000 – 2010**		**2010 - 2020**		**2000 - 2020**	
Land use	Km^2	%	Km^2	%	Km^2	%	Km^2	%	Km^2	%	Km^2	%
Built-up	34.00	12.26	56.73	20.45	79.65	28.72	22.73	8.18	22.92	8.26	45.65	16.44

Source: Author's Analysis, 2025

Table 6 revealed the extent of urban development in the study area between 2000 and 2020. It is evident from above that urban built-up areas witnessed a significant change over the study period compared to other land uses; it increased by 45.65 km² (16.44%) between 2000 and 2020. This significant growth could be associated with increased socioeconomic activities, influx of population for educational and economic opportunities, amongst others. Olabode (2019) also listed political presence as well as improved public facilities and accessibility as pull factors for urban development. This result corresponds with the findings of Oyinloye (2013) and Mohammed (2015), which revealed that there is a direct relationship between rapid urban growth and factors such as creation of states and local governments; and siting of universities, polytechnics, colleges of education, commercial centres, industrial centres, tourism resorts and population influx in Nigeria. Also, Francis et al. (2013) argued that urban growth is the outcome of the social, economic and political developments, which in turn lead to urban

development expansion and growth of urban centres. We can deduce that urban development in the study area is the consequence of either few or all of political, commercial, industrial, social, physical development, improved socioeconomic indices and population influx. Figure 3 shows the gradual rise of urban development within the static years in the study area.

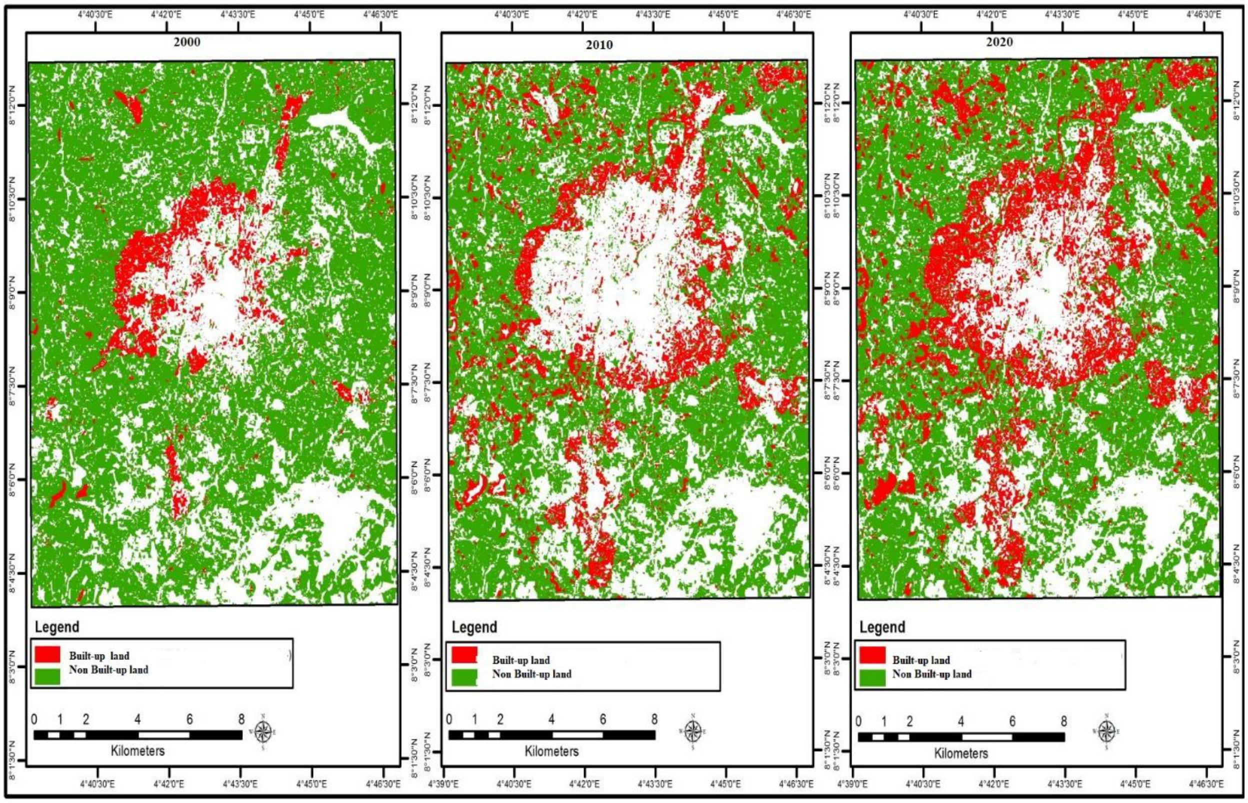


Figure 3: Extent of urban development (2000 – 2020)

These trends of urban development were in linear (along major roads) and leapfrogging patterns, especially in Offa. This creates peri-urban development; a form of urban development where agricultural and forested lands are constantly being fragmented by residential and road constructions according to corresponding potentials for human impacts. Similarly, the conversions of housing accommodations to corporate offices and commercial plazas in the study area are attributed to rapid population increase and urbanization, which forces people out of the metropolis to build their houses and settle at the fringe, coupled with the fact that land prices and house rent seem to be cheaper when compared to the city centre. These urban functions have, to a certain extent, stimulated high population growth that seemed to have culminated in increasing demand for residential and office buildings, commercial outlets, recreation centres and necessary social facilities, thus further increasing urban expansion and development in recent years. This finding is in agreement with the work of Oyeniyi et al. (2025), which revealed that developmental projects are catalysts for urban development in various forms, by fueling demand for housing for residence and infrastructural needs for investments depending on the accessibility within the urban framework. Mohammed (2021) also observed an unprecedented increase in the built-up area characterized by building conversions along the major roads in Offa, mostly from residential to various commercial uses like offices, filling stations, hotels, and banks, among others. These 'internal restructuring ' lead to significant changes in urban land use patterns that stimulate urban development.

Conclusion

This study analyzed the urban development in the study area. Landsat images of the study area were classified into various land cover and land use using the Maximum Likelihood Classifier (MLC). The extent of urban development was mapped, and the 'Calculate Geometry Tool' was used to calculate the areas of the selected polygons (in km^2 and corresponding percentage) in each static year across the study period.

The study concluded that Built–up and bare surfaces recorded the major gains within the study period, with 16.44% and 11.05% respectively. These could be due to high demand in residential and office accommodations alongside various socioeconomic activities resulting from population influx for employment and educational opportunities. Coincidentally, this period witnessed the establishment of numerous tertiary institutions in the study area. Cropland and vegetation expectedly recorded significant decreases, about 11% and 15% respectively, within the same period. These LULC classes are usually the most susceptible to urban expansion.

The study provided an insight into the spatial extent of urban development in Ijagbo, Ipee and Offa with a conscious probability of these overlapping urban centres developing into a single metropolis as found in other big cities across Nigeria in the near future. Therefore, integration of land use planning, strengthened environmental regulation enforcement, sustainable urban development practices with real-time geospatial monitoring, and active stakeholder engagements will foster a resilient and sustainable urban development in the study area. It is therefore recommended that the Kwara State Ministry of Housing and Urban Development should re-examine the implementation policy of the master plan of the study area using the GIS-Based Urban Growth Monitoring Tools for the huge potential of urban development discovered therein. The unoccupied portion of the study area should be labeled accordingly for befitting activities, and the agency should also ensure effective adherence to the updated master plan.

Limitations

Limitations to this study include inadequate geospatial datasets and incomplete cadastral maps (land parcel records), resulting in probable systematic commission and omission errors from the classifier as it incorrectly commits pixels of the class being sought to other classes.

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