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SPATIO-TEMPORAL ANALYSIS OF URBAN EXPANSION IN OFFA, KWARA STATE, NIGERIA (1990 - 2014)

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Abstract

The study assessed urban expansion that occurred in Offa within a period of twenty – four years (1990 – 2014). Three Multi temporal satellite imageries of LandSat TM 1990, LandSat ETM 1999 and LandSat ETM+ 2014; and administrative map of Offa were used as the primary dataset to process, classify (supervised classification), and analyze land use changes (urban expansion). Erdas Imagine 9.2 ArcMap 10.3 and ArcGIS 10.3 software were used for the analysis. Results obtained from the analysis of built-up area dynamics for the past three decades revealed that the town has been undergoing urban expansion processes. The expansion was prolonged both from urban centre to adjoining non-built-up areas in all directions. The total built up area in the town expanded from 17.57 km² (7.73%) in 1990 to 32.0 km² (14.07%) in 1999 and eventually to 65.09 km² (28.63%) in 2014, while agricultural land and natural vegetation had the highest net losses because of conversion to other uses, especially built-up. The overall expansion between 1990 – 2014 was 47.52km². The study period 1999 – 2014 witnessed the highest urban expansion. Quantifying urban expansion patterns and development processes of the past trends can help better understand the dynamics of built-up area, guide sustainable urban development and planning of the future urban growth.

Key Words: *Urban Expansion, Landuse/land cover, Satellite imageries, Remote Sensing, GIS*

Introduction

The world is rapidly urbanizing, witnessing a remarkable shift of its inhabitants from being predominantly rural to predominantly urban in last few decades. This process shows no sign of slowing down and is viewed as a powerful and visible anthropogenic force that has brought about fundamental changes in land cover and landscape pattern around the globe and affecting physical dimensions of cities. Rapid urbanization and urban expansion has been unprecedented in many developing nations including Nigeria (De Sherbinin, 2007; *Dihkan et al*., 2017).

According to United Nations (2011), 52% the world's population was urban dwellers in 2011, this is expected to rise to 67% in 2050. In the less developed regions, the proportion of urban population will rise from 47% in 2011 to 64% in 2050 with Africa expected to triple its urban population from 414 million in 2011 to 1.2 billion in 2050. This rapid urbanization will consume more than half of the world's natural resources and generate three-quarters of its pollution and wastes (Peters, 2000; Redman and Jones, 2005; De Sherbinin, 2007). This growth will require unprecedented investment in new

infrastructure and create serious challenges for political and social institutions. In most developing countries, rapid urban expansion is an inevitable economic and social functionality of towns and cities; their growth is characterized by both absolute increase of the number of people and spatial increase of the city. It has become a great challenge for various experts and policy makers (Madulu, 2004).

Urban expansion, according to Manish *et al.* (2012) is the horizontal or vertical outward extension of urban area over the adjacent agricultural land; it is a natural process which consumes many hectares of prime agricultural lands from their surrounding every year. It comes about through the transformation of non-urban land (for example, farmland) into urban land (such as residences, parks, shops and factories). Such a transformation of land is one way, and once transformed, it is very difficult to return back to the original land use (Lin *et al.*, 2003). Urban expansion also involves both the internal reorganization and outward expansion of the physical structure of urban areas which results in loss of prime agricultural farmlands and natural beauties (Shishay, 2011).

In most countries, urban expansion is recognized as a crucial phenomenon of economic growth and social change as it offers increased opportunities for employment, production and goods and services. This has initiated a large number of people to migrate from rural to urban area. As a result, cities are growing faster than ever (in physical dimensions), being a huge centre for residence, industry, trade and goods and services. However, this growth also triggers numerous problems. Environmental pollution and degradation, increased environmental hazards such as flooding, population explosion, insufficient sanitation and water supply, transport problems, poor housing conditions, rising cost of living and wealth inequality, and increase in crime rate, and loss of fertile agricultural and wetlands are some of the most prominent negative effects of rapid urban expansion (UNHABITAT, 2012; Burak *et al*., 2004).

Nigeria, one of the most urbanized countries in Africa with estimated urbanization rate of 3.5% annually has witnessed tremendous urban expansion over the years. The share of urban population in Nigeria was less than 7% in 1931 but has continued to escalate over the years. The urbanization rate rose from 10% in 1952, to 19.2% in 1991, 48% in 2010, 50% in 2012 and 52.7% in 2020 (Adesina *et al.*, 1999; Oyinloye, 2013; World Factbook, 2020). Oyinloye, (2013) further stated that there is a direct relationship between the rising urbanization and the rapid growth of cities, and that several factors responsible for the country's rapid urban growth pattern include natural increase from high birth and fertility rates and improved health facilities; rural urban migration; creation of states and local governments; sitting of tertiary institutions, increased commercial and industrial activities, and tourism resorts etc.

Olayiwola and Igbavboa (2014) monitored the growth of Benin City between 1987 and 2008 using the contemporary remote sensing and geographic information system (GIS) techniques. Also, Ifeoluwa *et al.* (2011) also applied Remote Sensing and Geographic Information System (GIS) techniques to analyze urban expansion and land use changes in Akure, Nigeria between 1986 and 2007. And in the same vein, Zubair (2008) used Remote Sensing and GIS approach in monitoring the growth of settlements in Ilorin, Kwara State. These studies clearly outlined the importance and effectiveness of Remote Sensing and GIS in

studying, evaluating and monitoring urban expansion.

Offa, a prominent urban centre in Kwara State has been experiencing tremendous urban expansion since its inception as a Local Government Headquarters in 1991. Over the past four decades, the Offa had witnessed rapid expansion in size and population within the traditional core areas and a pronounced encroachment of agricultural lands in the fringes or suburbs (Mohammed, 2015). Developmental activities such as building, road construction, industrial expansion, increased commercial activities, presence of federal institutions, and various anthropogenic activities over the years has resulted in increased population, landscape consumption, modification and alterations which has affected various land uses in the city most especially the agricultural lands (Mohammed, 2015). The process, unlike in developed countries is taking place in the absence of significant industrial expansion (Kwasi, 2004).

The integration of Remote Sensing and Geographic Information Systems (RS/GIS) has been widely applied and recognized as a powerful and effective tool in detecting, analyzing, monitoring and mapping urban expansion, urban land use, and land use/land cover changes (Ashbindu *et al.*, 2001). Satellite remote sensing collects multispectral, multi-resolution and multi-temporal data, GIS technology has platforms for storing, manipulating and analyzing geospatial data from various sources and turn them into valuable and reliable information such Land use/cover maps for understanding and monitoring urban land processes, urban feature identification, change detection and database development. Since the launch of Landsat-1 (ERTS) satellites, territorial mapping has come a long way over the last few decades, yet, it lacks the ability to fully describe the underlying urban processes (Herold *et al*, 2005).

This study analyse the spatio-temporal dimension of urban expansion in Offa between 1990 and 2014. The study considered land use/land cover types and the spatial dynamism of urban expansion in the study area a ring from the interplay of climate change, environmental conditions and population dynamics within the study periods of 1990, 1999 and 2014.

Materials and Methods

Study Area

Offa is located near the southern boundary of Kwara State in the Central zone of Nigeria, approximately between Latitude 8° 68′N – 8°12′ N and Longitude 4° 40′ E – 4°47′ E, it is bounded by, Ajase-Ipo, to the north, Ojoku, Igbonna, and Ikotun to the west, Igosun and Ipee to the east, Erin Ile to the south, and Ilemona to the south west with about 56 km and 59km away from Ilorin the state capital and Osogbo, the Osun State Capital respectively. Offa is a medium-sized urban centre with an aerial extent of about 227.39km^2, the second largest town in the State and the Headquarters of its Local Government created in 1991. It is one of the most popular towns in Nigeria in terms of education and politics; one of the fastest growing urban centres in Nigeria with a growth rate (5%) much higher than other cities in the country. Offa is blessed with several tertiary institutions (both government and private owned) such as The Federal Polytechnic, College of Health Technology, Nigerian Navy School of Health Science, Summit University, College of Education, School of Basic and Remedial Studies, Lens Polytechnic, Graceland Polytechnics, etc.

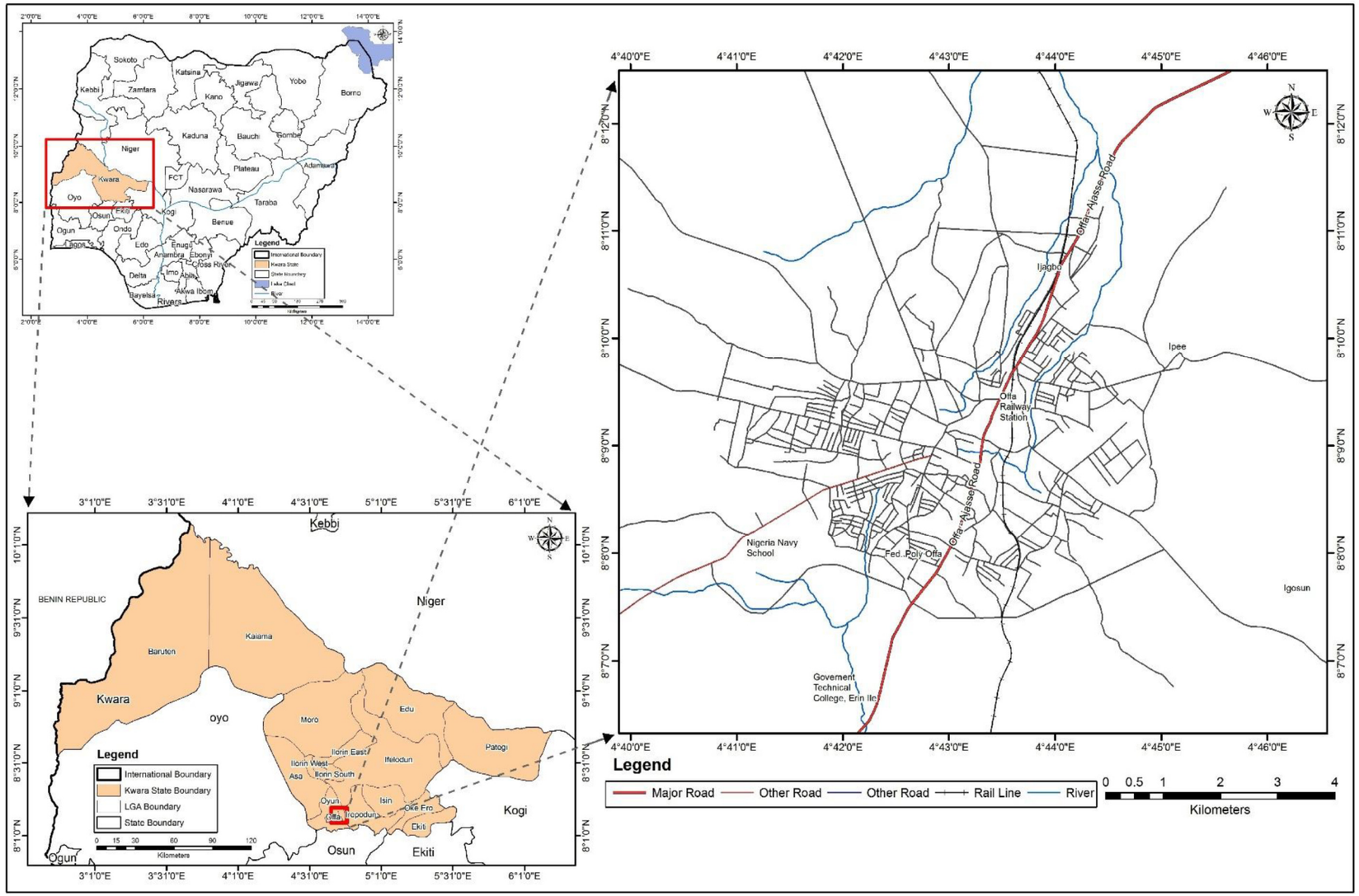


Fig. 1: Offa, Kwara State

Data Collection and Analysis

Remotely sensed data (maps and satellite imageries) were the major datasets used for this study. These were combined with ground truthing and reconnaissance survey. Administrative map of Offa was sourced from Kwara State Ministry of Land and Survey; and the Satellite Imageries were sourced from the National Centre for Remote Sensing, Jos. These includes, LandSat TM (Thematic Mapper) of 27th November, 1990 with a spatial resolution of 30 metres, LandSat ETM (Enhanced Thematic Mapper) of 27th October, 1999 with a spatial resolution of 30 meters and LandSat ETM+ (Enhanced Thematic Mapper Plus) of 27th October 2014 with a spatial resolution of 30 meters. These images were subjected to various processes to ensure accurate qualitative extraction, interpretation and change detection. The administrative map was digitized to create a base map of the study area, while the satellite imageries were subjected to change detection analysis. Literatures used were derived from relevant dissertations, conference papers, journal articles, and textbooks, amongst other secondary data.

The 'Extraction Tool' in ArcMap (10.3) was used to extract the study area from satellite imageries. The land use land cover maps of the study area were produced using supervised classification techniques in Erdas Imagine (9.2) and ArcGIS (10.3) by extracting land use land cover features using maximum likelihood supervised techniques. The raster files, generated in Erdas Imagine 9.2 were then converted into shape file (shp) and transferred to ArcGIS for area calculations and change detection analysis. Jensen (2005) land use / land cover classification scheme was used to classify the various land use/land cover types within the study area. Five land use types/category were identified; built-up land, natural vegetation, agricultural land, water body and bare surfaces. A statistical table was generated to show the areal extent (in km²) and percentage of different land use type in the area for each study year (1990, 1999, and 2017) for easy comparison.

One of the prerequisites for understanding land use changes is a successful land change detection modeller (LCM). For this study, change detection analysis was carried out on Landsat images of different years (i.e. 1990, 1999 and 2014) to analyse the pattern and trend of change in the study area. The built-up, bare ground, water body, natural vegetation and agricultural land of the three study years were used and compared from the classified images so that the dynamic changes and the characteristics of environmental changes could be recognized.

Results and Discussion

The study area was classified into different land uses; namely, built-up, bare ground, water- body, agricultural land and natural vegetation. Table 1 presents the changing land use and their statistics in the study area between 1990 and 2014, while Figure 2 shows the classified image of Offa with five (5) distinct land use types within the same study period. Analysis of land use land cover in the study area in 1990 revealed that agricultural land had the largest coverage of 148.63km^2 (65.36%) of the study area, followed by natural vegetation with 53.53km^2 (23.54%). Built – up occupied only 17.7km^2 (7.73%), while bare surface covered 6.77km^2 (2.98%). Water body has the lowest coverage of 0.89km^2 (0.39%). However, the statistics changed in 1999

and 2014 with built – up increasing tremendously from 32.00km^2 (14.07km^2) in 1999 and 65.09km^2 (28.63%) in 2014 respectively.

Agricultural land and natural forest decreased considerably from 135.57km^2 (59.62) and 36.30km^2 (15.97%) to 107.18km^2 (47.14%) and 26.97 (11.86%) in 2014 respectively. The results revealed rapid land use changes in the study area with considerable increment in land coverage of built – up areas, while there are significant decrease in both agricultural land and natural vegetation. The increment in built-up can be attributed to the creation of a Local Government Area with the headquarters in Offa, the sitting of several institutions, in addition to industrial, transportation, commercial, physical development of the area, locating and upgrading of new and existing social amenities, and the accompanying rise in socioeconomic indices. Influx of people (majorly due to employment opportunities) also contribute substantially to population growth and sets off the process of urban expansion. The reduction in agricultural land and natural vegetation can be attributed to population influx from within and outside the state; urban expansion and the rapid physical development (such as construction of road, buildings etc) which tend absorb more farmland to accommodate the growing population at the cost of the agricultural land. The growth in the population constantly increases the demand for land to use in urban and industrial expansion

Table 1: Changing land use and their statistics in the study area between 1990 and 2014

	Land Use Types					
Land use	1990 Area (Sq.Km)	%	1999 Area (Sq.Km)	%	2014 Area (Sq.Km)	%
Built-up	17.57	7.73%	32.00	14.07%	65.09	28.63%
Agricultural Land	148.63	65.36%	135.57	59.62%	107.18	47.14%
Natural Vegetation	53.53	23.54%	36.30	15.97%	26.97	11.86%
Bare Surface	6.77	2.98%	22.66	9.96%	27.34	12.03%
Water Body	0.89	0.39%	0.85	0.38%	0.80	0.35%
Total	227.38	100	227.38	100.00	227.38	100.00

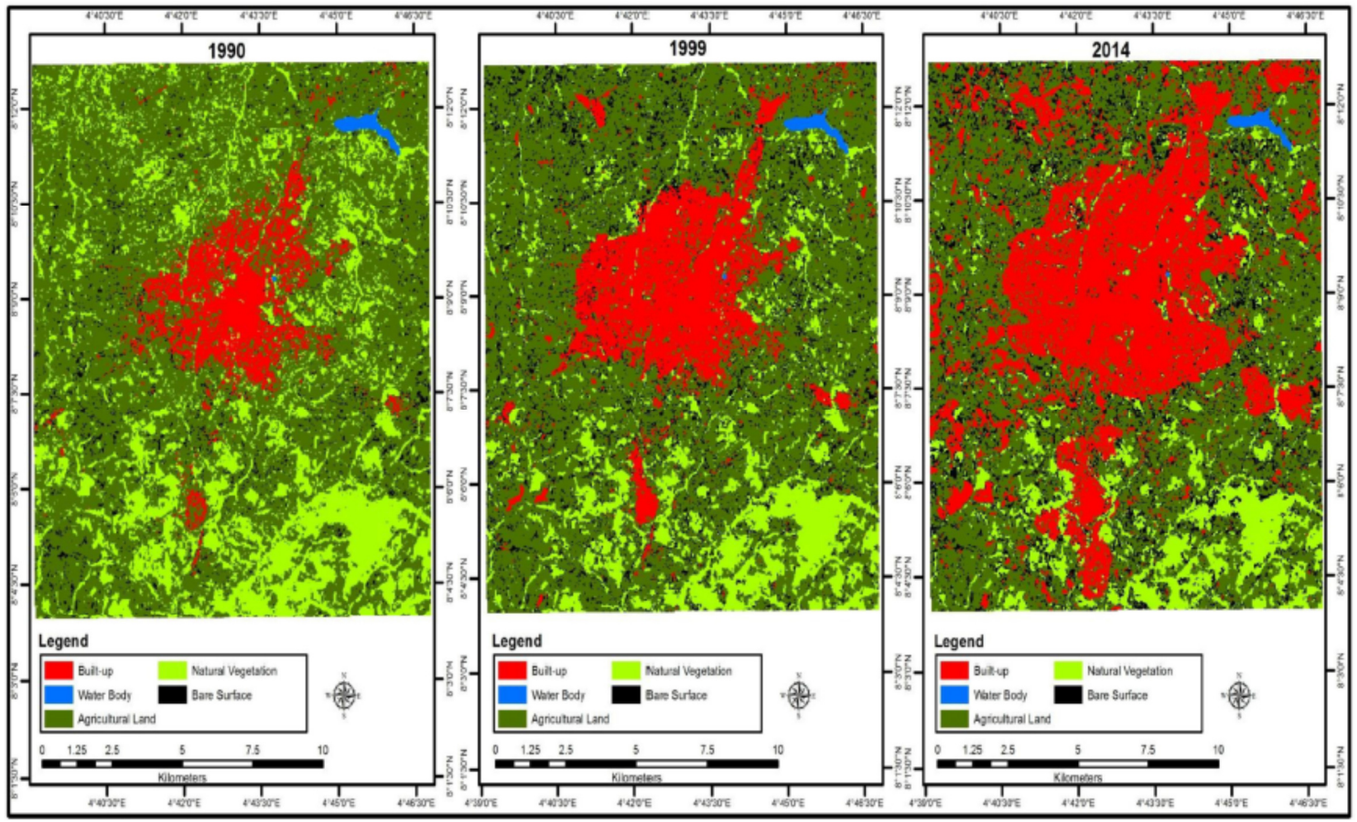


Fig. 2: Land use/Land cover maps Offa; 1990, 1999 and 2014

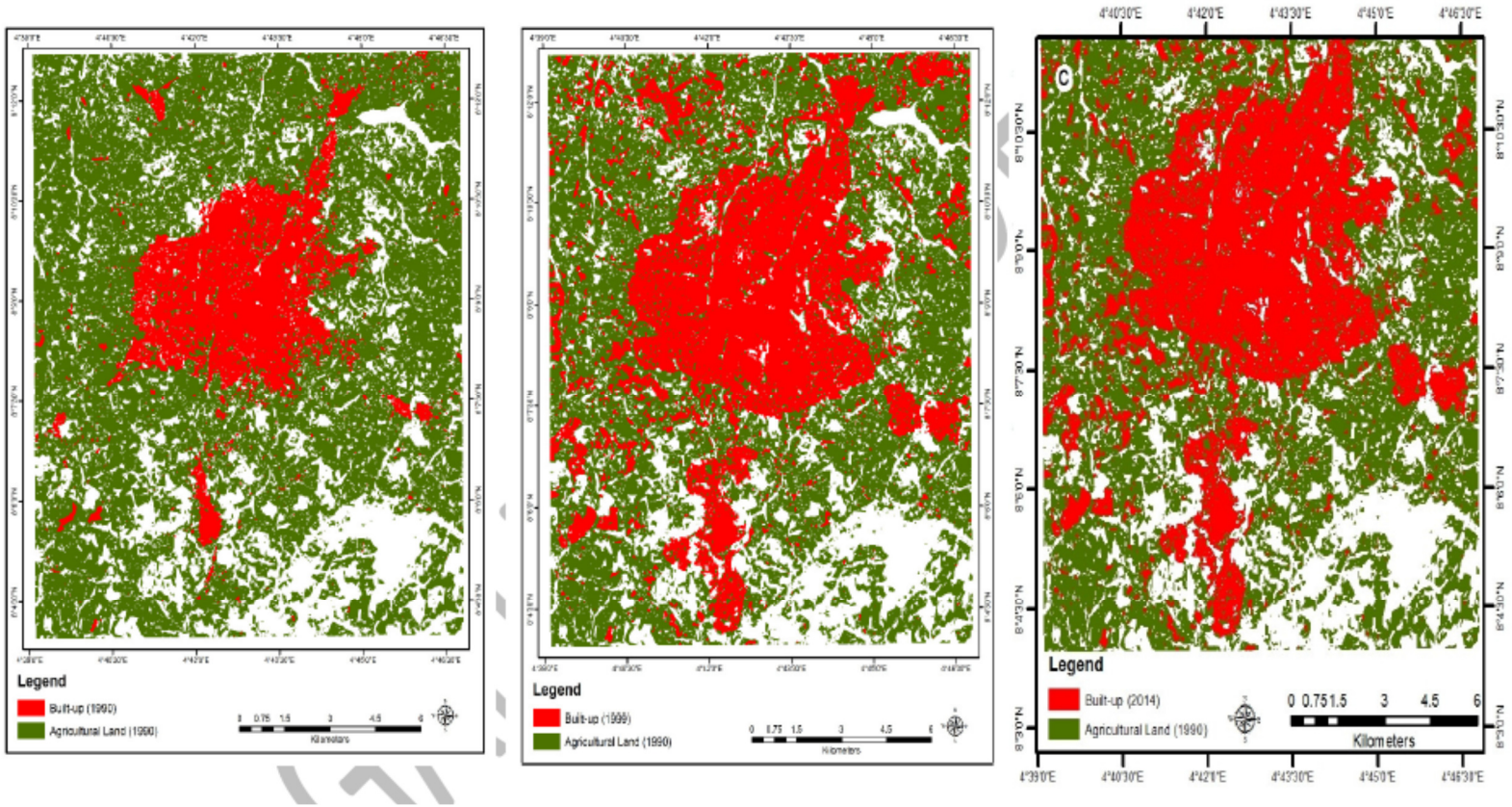
Spatial Dynamism of Urban Expansion

Having classified all imageries of 1990, 1999 and 2014 built-up area of the town, the three thematic layers were then overlaid on each other to reveal extent of urban expansion between 1990 and 2014 in the study area. The result shows a significant increment in the spatial urban expansion of the study area. The extent of urban growth in the study area is presented in kilometre square and percentage as shown in the tables 2 below.

Table 2: Spatial extent of urban expansion between 1999 and 2014

Extent of urban expansion 1990 – 2014									
	1990	1999	2014	1990 - 1999		1999- 2014		1990 - 2014	
Land use	km²	km²	km²	km²	%	km²	%	km²	%
Built - up	17.57	32.00	65.09	14.42	82.09	33.09	103.42%	47.52	270.40

The table above shows the extent of urban expansion in the study area between 1990 and 2014. It is evidenced from above that urban built-up witnessed the highest change over the study period compared to other land uses, it increased from 14.42km² (82.09%) between 1990 and 1999 to 33.09km² (103.42%) between 1999 and 2014, resulting in 47.52km² (270.40%) as the overall urban growth between 1990 - 2014. This significant rapid urban growth could be associated with the sitting of Local Government Headquarters and Federal and military institution in the study area which consequently lead to rapid physical development (such roads, buildings, industries, etc); locating of new and upgrading of existing social amenities; industrial and commercial developments; and population influx. This result corresponds with the findings of Oyinloye (2013) which revealed that there is a direct relationship between rapid urban growth and factors such as creation of states and local governments; and sitting of universities, polytechnics, colleges of education, commercial centres, industrial centres, tourism resorts and population influx in Nigeria.


Legend
Built-up (1990)
Agricultural Land (1990)
Kilometers
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Built-up (1999)
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Built-up (2014)
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0 0.75 1.5 3 4.5 6
Kilometers
4°39'0"E
4°40'30"E
4°42'0"E
4°43'30"E
4°45'0"E
4°46'30"E

These maps show a clear pattern of increased urban expansion of the town radiating from the centre to adjoining non-built-up areas. The highest rate of urban growth is observed during the third study period (1999 to 2014) in which the built-up area increased from 14.42km² (82.09%) between 1990 and 1999 to 33.09km² (103.42%) as shown in table 2 above. This indicates more rapid urban expansion took place between 1999 – 2014. Due to migration, high fertility rate, increased presence of government and private owned institutions, the population of Offa and the accompanying urban expansion has been growing steadily since last decade. This growth far exceeds the rate at which social amenities and services are provided. Also, with the rate at which the expansion of Offa is steadily advancing, it could result in engulfing of adjacent rural landscapes and urban centres. Most of these expansions are happening with little or no planning at all, which is resulting in haphazard urban development. The rapid population growth is one of the major factors that are responsible for the spatial growth and the associated pressure on different land use types leading to conversion of one land use class to another.

Conclusion

This study dwell on the use of Remote Sensing and GIS techniques for the spatiotemporal analysis of urban expansion in Offa, Kwara State, Nigeria, with the classification of multi-temporal satellite images of three different time periods i.e., 1990, 2000 and 2014. Supervised Classification Technique was employed using the Maximum likelihood algorithm and the study area was classified into five major classes of land use and land cover, these are built – up, agricultural land, bare surfaces, natural vegetation and water body. These maps show a clear pattern of increased urban expansion prolonging both from urban centre to adjoining non-built-up areas in all directions alongside major transportation corridors. The synoptic analysis of spatio-temporal land cover change revealed that urbanization has significantly transformed the urban landscape with the greatest amount of urban expansion i.e., 33.09km² (103.42%) witnessed between 2000 and 2014.

Changes in land use and land cover of the area were found to be related to urban expansion and population growth. Undoubtedly, many changes occurred between 2000 – 2014 when compared with those of 1990 - 1999. Findings from this study have shown that the urban expansion largely from Offa have indeed been engulfing the nearby rural communities due to the uncontrolled and unauthorized acquisition and conversion of lands. The changes have affected the morphology, population, economic and social activities the area in the past thirty years. Urban expansion in the study area has resulted in the loss of productive agricultural land, open green spaces, loss of surface water bodies and depletion of ground water, solid waste disposal problems, water, air, and noise pollution among others.

The information derived from the study can be useful in formulating effective land use management strategies and environmental policies and equip urban/environmental planners with relevant data that would enable them to promptly curtain the adverse effects.

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