

## Evaluation of Spatio-Temporal Dynamics of Urban Sprawl in Osogbo, Nigeria using Satellite Imagery & GIS Techniques

Aguda, A.S<sup>a</sup> and Adegboyega, S.A

<sup>a</sup> Department of Geography, Obafemi Awolowo University, Ile-Ife, Nigeria

<sup>b</sup> Department of Remote Sensing & Geoscience Information System, Federal University of Technology, Akure, Nigeria.

Accepted 02 September 2013, Available online 01 October 2013, (Sept/Oct 2013 issue)

### Abstract

*The sprawling nature of urban development on the fringe areas of big cities in developing countries particularly Nigeria has received much attention to the neglect of rapidly growing medium-sized cities despite the recent observation that African cities with less than 500, 000 inhabitants are absorbing two-third of all urban population growth. It has been argued that to understand the impact of new urbanization on the environment and people, these processes need to be examined in medium and small cities rather than restricting our inquiries to the large and mega-cities. This study assesses the trends and spatial patterns of urban sprawl in Osogbo between 1962 and 2011 with a view to generating base line geo-spatial information that may be used for effective and efficient urban planning and development policies.*

*The study employed Aerial Photos, Satellite Imageries and population Census data to achieve the purpose of the study. Digital image techniques were utilized in the processing of the images, statistical tools of GIS technologies, land use development index, land consumption rate index and land absorption coefficient index were used to analyze the data on temporal basis. Overlay operation was performed to integrate the urban land use to reveal the trends in the urban development over the study period. The emerging sprawling growth was further investigated by quantitatively mapping the metrics of manifestations using Erdas Imagine 9.1 and Arc GIS 9.3 Software. The results showed that urban sprawl in Osogbo was at a rate of 4.9Km<sup>2</sup> per annum, indicating that the city which was 3.95Km<sup>2</sup> in 1962 had increased to 241.79Km<sup>2</sup> by size in 2011. Also, the pattern of sprawling was linear, leapfrogged and scattered along the major transport arteries thus, reflecting a star-shaped pattern. The study therefore advocates integration of the on-going urban renewal programme in Osun State into a consciously evolved digital master plan and set up a task force to enforce compliance. This can be strengthened by institutionalizing the recently adopted Geographic Information System (GIS) to evaluate, monitor and manage land development in the peri-urban areas of the city.*

**Keywords:** *Urban sprawl, Medium-sized city, GIS, Satellite imageries, Digital image techniques, Land use planning, Geo-spatial information, Urban renewal.*

### 1. Introduction

The most striking feature of rapid urbanization process on the global scale is the increasing agglomeration of the world population, estimated at over 6.8 billion by (US Census Bureau, 2010), in or around the metropolitan areas and mega-cities including the urban fringes. UN-Habitat (2005) thus, projects that by the year 2025, 61% of the world population will be urban and 85% of urban development will occur at the urban hinterland widely referred to as peri-urban, suburbs, urban fringe, city edge, metropolitan shadow amongst others. The prevailing process of globalization is fuelling the rate of urbanization especially in many developing countries, particularly Africa where many countries are already moving towards having 40 to 50 percent of their population living in cities (Mabogunje, 2011). He stated

that Nigeria, for instance, is estimated as likely to reach this half way point by 2015. Yet, there is little indication that the standard of urban governance in the country is ready to absorb such large increase of persons without simply condemning many more of them to living in squalid, peri-urban settlements. This is corroborated by the assertion made by Aguda and Olayiwola (2011) that the most noticeable problems in many African countries are those that relate to economic, political and social challenges. The economic problem, according to them, relate to poverty and political problems which have to do with bad governance and corruption while the social problems is more of the rapid population increase especially within the major urban areas where more than half of the population live.

The increasing agglomeration of population in the urban areas with prevailing inadequate institutional

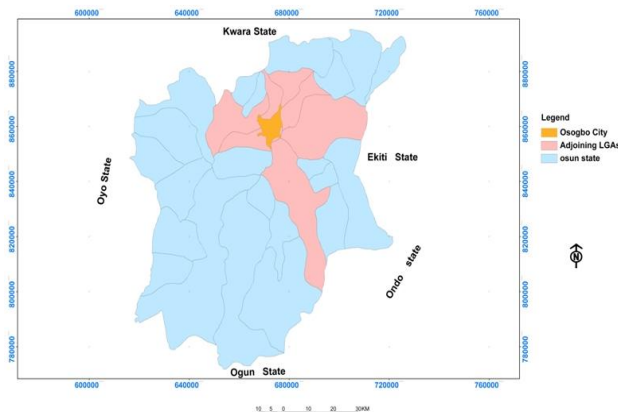
framework, in addition to the above stated problems, to a large extent tend to have triggered unguided and unsystematic urban expansion not only in the big cities but also in the fast growing medium-size cities, most especially around the urban fringe areas of these cities. Urban fringe denotes a dynamic area occasioned by spontaneous developments which is propelled by rapid urban population growth. Though there is no consensus definition of sprawl but it is defined as a “physical pattern of low-density expansion of urban areas, under market conditions, mainly into the surrounding agricultural areas” (European Environmental Agency, 2006). According to the same source, this results in a patchy, scattered, strung out, discontinuous and leapfrogged landscape. Mapping of these manifestations of sprawl becomes very important because a map of urban or built land is an adequate starting point in studying urbanization. A map provides the visual aspect from which studies on urban sprawl can begin in relation to urban growth. A Geographic Information System is useful for mapping the spatial distribution of urban areas. Mapping urban phenomena is a crucial part of quantifying urban sprawl. This is more effective when satellite imageries are used. The dynamic nature of sprawl is better captured by the use of satellite images due to its repetitive coverage of urban areas overtime. It is necessary to say urban growth is often confused with urban sprawl. However, there is a distinction between urban growth and urban sprawl. Cities often experience growth either physically, by population, or by a combination of both. Urban sprawl is much more complicated because it may or may not qualify as urban growth. How a city grows can create the appearance of sprawl. Such urban growth may appear as a low-density leapfrog pattern, a linear or strip development pattern along highways, or a tightly condensed pattern of new development around pre-existing built-up landscapes (Nechyba et al 2004). Without urban growth there would be no appearance of urban sprawl. Urban growth may have more of a planned appearance while the pattern of sprawl often appears awkward, uncontrolled, and haphazard. Usually sprawls take place in the urban fringe, at the edge of an urban area or along the highways. No doubt, Urban sprawl promotes the spread of urban land use into the rural-urban fringe and draws a larger number of people into the rural-urban interface.

Expectedly, several studies have addressed urban sprawl dynamics in the fringe areas of mega cities and big cities in developing countries particularly Nigeria (Okewole, 2002; Oyinloye, 2003; Adesina, 2007; Adegboyega, 2008; Olujinmi, 2009 and Mabogunje, 2011). The fast growing medium size and small cities are however, neglected despite the UN-HABITAT (2008) observation that African cities with less than 500,000 inhabitants are absorbing two-third of all urban population growth. It has been argued that to understand the impact of new urbanization on the environment and people, these processes need to be examined in these

cities rather than restricting our inquiries to the largest and frequently over-studied megacities (Redman and Jones, 2004).

In view of the above, this study assesses the trend, rate and spatial patterns of urban sprawl around Osogbo fringe areas to generate and provide geo-spatial information for the realization of the main objective of the National Urban Development Policy which is “to ensure that land is available for the purpose of controlled and orderly development in the urban areas” (Agbola, 2006). Thus, it is hoped that this study will reawaken and revitalize the interest the country has in the adoption of Agenda 21 of the sustainable development that stresses the importance of partnerships in improving social, economic and environmental quality in urban areas. This is a consequential strategy on the renewed focus on effective land use planning that include adequate environmental infrastructure, water, sanitation, drainage, transportation and solid waste management, in addition to a sound social infrastructure capable of alleviating hunger. This, in a way, provides the platform in form of information-base for pursuing and implementing the strategies of Millennium Development Goals of 2020 which include a good environment and sanitation.

**2. Study Area - Osogbo**



**Figure 1: Location of the Study Area**

Osogbo was founded in the late 18th century and originated as a traditional as well as cultural town see figure 1). The town is known for her very rich arts and cultural heritage (Adenaike, 1991; Awe and Albert, 1995). The establishment of a railway station is perhaps the most important single factor in the growth of the town. Apart from the railway, postal and telecommunication, NEPA regional station, road network and some small as well as large scale business exist. Osogbo thus became a major trading and distribution center for people within and outside its immediate environment. The emergence of Osogbo as a state capital coupled with other factors has led to the influx of people from other towns and villages, thus giving it the status of a twin city, that is, a traditional as well as a modern city. (Adenaike, 1991; Egunjobi, 1995).

Based on the 1952 census data, the population of the town was estimated at 122,728, eleven years later, in 1963, the figure increased to 152,424 while twenty-eight years later, in 1991, the census estimate of the population was 189,733 ( a highly controversial figure), according to the National Bureau of Statistics, the adjusted figure was put at 250,951. According to the 2006 population census estimate, the population figure of the town was put at 287,156. Conservative estimates of the population in 2006 and 2011 were 381,405 and 438,516 respectively. The phenomenal growth in the population overtime is related to the introduction of modern technology and administration as Osogbo became a growth centre that pulled population from its neighbouring settlements through its centripetal forces of railway station, Steel rolling mill, Machine tool industries and commercial activities. Road transport allowed dispersal of development in all direction from the traditional core. As the population keeps increasing, further development in housing and other related services occurs. Osogbo has over the years become a capital with several core areas.

The forces of demand and supply stimulated upward increases in land values as well as house rents that culminate in competition for available space. In the process, land values, house rents and other factors forced the urban dwellers to the periphery where centripetal forces like cheap land, accessibility to major roads and abundant land are available. The emerging urban development has engulfed the land use type regarded as “Oko Odun” (Annual crop lands) by (Osunade, 1989) or Oko Etile (Ojo, 1966) and continued to encroach “Oko Egan”, that is, the high forest that supports the growth of tree crops. This inefficient land use has paved way to undesired and unsustainable urban pattern of development around the fringe areas of Osogbo.

**3. Materials and Methods**

The study utilized Aerial Photos, Satellite Imageries and Population Census data for accomplishing the objectives of this study. The details of the data were shown in Table1

*3.1 Methods of Data Processing*

The acquired data were extracted from the remotely sensed data in table 1 using digital image processing techniques which include image enhancement and filtering to improve the pictorial quality of the images. The Aerial Photos were scanned, mosaicked and used as base image for the study. The images available for the study were loaded and imported from ILWIS to the Erdas Imagine environment. The Area of Interest (AOI) was selected and saved for each of the images (Table 2).

**Table 1:** Details of Aerial Photos, Satellite images and Population Census Data used

S/N	Aerial Photo/Image s/Population data	Year	Scale/Resolu tion	Sources
1	Aerial Photo of Osogbo	December, 1962	2.819444444	Federal Ministry of Works, Lagos
2	Landsat MSS	November, 1972	60m x72m	http: glcf.umiacs.umd.edu accessed on June 18, 2009
	Landsat TM	December, 1986	30m x30m	Regional Centre for Training in Aerospace Survey O.A.U. Ile-Ife.
4	SPOT -XS	November, 1995	20m x20m	Archive of Mr. Kola Adekola, Idi- osan, Ibadan
5	Landsat ETM+	December, 2002	28.5m x 28.5m	Regional Centre for Training in Aerospace Survey O.A.U. Ile-Ife.
6	Nigeria Sat-1	November, 2003	32m x 32m	Dept of Urban and Regional Planning, Osun State University, Osogbo
7	SPOT-5	December, 2007	5m x 5m	Department of Geography, O.AU. Ile-Ife.
8	Google Earth Image	February, 2011	15m x 15m	Google Earth website accessed on August 12, 2010
9	Population Census Data	1962 update	-	Nigeria Population Commission, Osogbo.

Source: Author’s Acquired Data, 2011

**Table 2:** Sub images of the Study Area

Imageries	No of Rows	No of Columns
Aerial Photo 1962	8641	8641
LandSat MSS 1972	727	800
Landsat TM 1986	1403	1404
SPOT-XS 1995	7327	7757
Landsat ETM+ 2002	1263	1366
NigSat_1 2003	7327	7757
SPOT5 2007	7119	7858
Google Earth Image 2011	493	864

Source: Author’s Image Analysis, 2011.

Global Positioning System (GPS), Garmin map 76, was employed to take the coordinates of some well distributed ground control points over the imaged area obtained during reconnaissance survey (Table 3). These points were used to georeference the images (Table 4). The georeferenced images were resampled to ensure that all the images under use have equal pixel size to facilitate data integration. Supervised classification, the adjudged most appropriate image classification method for multispectral images (ITC-ILWIS, 2001); was adopted to obtain the land use and land cover layers. This is

supported with ground truthing. To this end, confusion matrix operation was performed to identify the nature of the classification errors (errors of omission or exclusion; errors of commission or inclusion), as well as their quantities. The GIS Softwares utilized include ILWIS 3.6, ERDAS IMAGINE 9.1 and ARCGIS 9.2 Versions.

**Table 3:** Ground Control Points obtained during Reconnaissance Survey

S/N	Ground Control Points	UTM (X)	UTM (Y)	Elevation
1	State Secretariat	860508.59	1329632.7	346m
2	Osun Bridge at old Governor's Office	865883.78	1333081.7	302m
3	Railway Crossing at Ola-Iya Junction	866037.86	1333193.3	306m
4	Ring Road Junction along Ilobu road	867955.55	1333108.6	318m
5	PHC Headquarter	869676.46	1336857.5	350m
6	Osogbo L.G.A. Secretariat	865954.27	1336826	350m
7	UNIOSUN Main campus	864003.94	1325881.3	348m
8	Fountain University	862328.14	1333288.2	333m
9	Kelebe	864153.05	1338852.6	354m
10	Steel Rolling Mill	873495.71	1340273.2	374m
11	Egbeda Village	868229.06	1345989.3	369m
12	Ota-Efun	871572.68	1338523.5	364m
13	Kobo	871796.67	1338661.3	373m
14	Dagbolu Osogbo	873634.59	1340363.4	374m
15	Dagbolu Ikirun	875407.23	1340412.7	387m
16	Oja Oluode	877146.37	1338626.8	389m
17	Oba Oke	879226.48	1336702.6	360m
18	Oba Ile	880944.05	1336644.1	355m
19	Igbokiti	876887.33	1335746.1	348m
20	Okinni	873714.8	1331496.6	332m

Source: Author's Fieldwork 2011

**Table 4:** Result of Georeferencing

Study Area	Images	Ground Control Points	Accuracy (pixel size)
Osogbo	Aerial Photo 1962	18	0.506
	LandSat MSS 1972	20	0.646
	Landsat TM 1986	20	0.5806
	SPOT-XS 1995	18	0.546
	Landsat ETM+ 2002	20	0.5326
	Nigeria Sat-1 2003	25	0.515
	SPOTS 2007	20	0.6205
	Google Earth Image 2011	20	0.663

Source: Author's Image Geometric Correction, 2011

3.2 Data Analysis

The georeferenced scanned Aerial Photos was displayed in ERDAS Imagine environment where the urban built-up area and other land use/land cover types were captured

as polygons, roads and rivers as linear and rural settlements as point features to serve as base year data for the study. The settlement layers were extracted. Based on this, analysis of the dynamism of land use, the extent and rate of urban expansion were quantitatively compared (Ma, et al., 2010; Adegboyega, 2012) using the formula:

$LUDI = \frac{U_b - U_a}{U_a T} * 100$ , Where LUDI is the annual rate of change,  $U_a$  and  $U_b$  represent extent of urban expansion at time a and b respectively. T is the length of time in year from time a to time b.

In addition, the study determined the following Population Growth Rate (PGR), Land Consumption Rate (LCR), Land Absorption Coefficient (LAC) and Percentage Agricultural Loss of the study area over the study period.

Population Growth Rate

$$100 \left[ \left( \frac{P_n}{P_0} \right)^{\frac{1}{n}} - 1 \right]$$

Where  $P_n$  represents the current population  $P_0$  represents the previous population n represents the number of years.

$B_n = B_0 (1 + r/100)^n$  Where  $B_n$  represents future built-up area,  $B_0$  represents current built-up area, r represents rate of urban expansion.

$P_n = P_0 \{1+r/100\}^n$  where  $P_n$  represents future population,  $P_0$  represents current population, r represents population growth rate

Land Consumption Rate

$$\frac{\text{Areal extent of a settlement}}{\text{Total Population}}$$

Land Absorption Rate

$$\frac{\text{Areal extent in T2} - \text{Areal Extent in T1}}{\text{Population in T2} - \text{Population in T1}}$$

L.C.R = A measure of compactness which indicates a progressive spatial expansion of a city.

L.A.C = A measure of change in consumption of new urban land by each unit increase in urban population (Yeates and Garner, 1976).

Percentage Agricultural Loss

$$\frac{X_2 - X_1}{X_1} * 100$$

Where  $X_1$  represents total built-up area for the previous year;  $X_2$  represents the total built-up area for the current year.

Further, the urban land uses were reclassified into manifestations of urban sprawl. These are urban main core, urban fringe, urban scatter, urban secondary core

and ribbon development. Its attributes were generated from the built-up area which includes urbanized area, urbanized open space, buildable, urban footprint and peripheral open space, Angel and Civco (2007) adopted this reclassification of urban land uses for Bangkok and Minneapolis.

ERDAS IMAGINE statistical tool was used to quantify the thematic layers. These data were combined with population census data to compute the metrics of dynamic attributes of urban spatial structure. The three key attributes considered for this work as they have been found suitable by (Angel and Civco, 2007) when remotely sensed and population data are utilized, include urban extent, urban density and contiguity of the built-up areas of cities and the increased fragmentation of open space in and around them. These key attributes, to a large extent, provided the basis for comparing and determining the extent of the temporal sprawling growth of the city between two periods (1986-2011), 1986 as T<sub>1</sub> when the measuring indices began to be more pronounced, and 2011 as T<sub>2</sub>.

#### 4 Results and Discussion

##### 4.1 Spatio-Temporal Analysis of Urban Expansion in Osogbo between 1962 and 2011

Tables 5a and 5b showed the spatio-temporal change in urban built-up areas of Osogbo within the study period. The spatial extent of the total urban built-up areas of Osogbo city in 1962 (see figure 2), according to table 5a was estimated at 3.95 km<sup>2</sup>, an equivalence of 395 hectares. The total urban built-up areas increased to 6.61 km<sup>2</sup> in 1972. This indicates that urban expansion has engulfed 2.66 km<sup>2</sup> of rural areas between 1962 and 1972. Thus, the rate of urban expansion within the period was estimated at 4.0 % with land consumption rate and land absorption coefficient estimated at 0.0036 and 0.0076 respectively (Table 6). This rapid rate of urban expansion has been found to have encroached on agricultural lands thereby accounting for a total loss of 57.01 % in agricultural land. This may be attributed partly to the increase in population growth as evident in Table 6. The City recorded an estimated population growth rate of 2.08 % in the end of the period, that is, 1972. This reveals that though the rate of urban expansion is above the annual population growth rate but the city's expansion of its urban influence is attributed to urban growth. The trend in the city growth may be traced to its locational advantage as the Zonal Station on the Western Railway Line and the capital of Osun Province in 1967. These reasons seemed to have boosted the commercial activities of this city within the period. This is in line with (Ajiboye, 2010) who reported that railway transport had impacted greatly on the spatial growth of Osogbo City. Moreover, the importance of River Osun cannot be over emphasized because the annual Osun Osogbo festival to a large extent has contributed to influx of tourists to the

city and so led to the expansion of the traditional dyeing industry. The period also witnessed the establishment of a Police Division Headquarter at Oke-Fia that beefed up the security within and around the city. The urban spatial structure exhibited during this period reflects urban form similar to that explained by the concentric model though the Oba's palace and traditional market constituted the core area instead of CBD, and the residential and commercial areas are interwoven as argued by (Egunjobi, 1995).

**Table 5a:** The Spatial Extent of Osogbo City from 1962 to 2011

Year	Built-up Area(km <sup>2</sup> )	Built-up Area (Ha)
1962	3.95	395
1963	4.11*	411
1972	6.61	661
1986	13.39	1339
1991	15.98	1598
1995	21.08	2108
2002	55.27	5527
2003	57.67	5767
2007	68.0	6800
2011	241.79	24,179
2025	1029.15*	102,915*

Source: Author's Imagery Analysis, 2011

\*Projection to 2025 using average expansion rate (10.9%) between 2003 and 2011

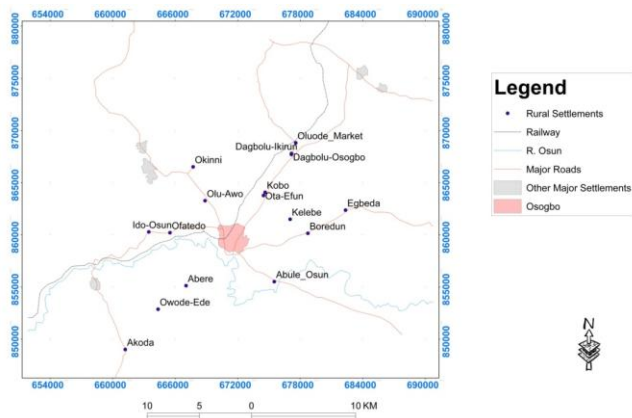
**Table 5b:** Spatio-Temporal Change in Urban Built-up Area of Osogbo from 1962 to 2011.

Periods	Expansion Area in (km <sup>2</sup> )	Expansion Percentage	Expansion Rate (%)
1962 - 1972	2.66	67.3	4
1972 - 1986	6.78	102.57	3.6
1986 - 1991	3.84	28.68	4.5
1991 - 1995	3.85	22.34	4.6
1995 - 2002	34.19	162.19	8.8
2002 - 2003	2.4	4.34	4.3
2003 - 2007	10.33	17.91	3.8
2007-2011	173.79	255.57	18
2011-2025	787.36*	325.64	5.5

Source: Author's Imagery Analysis, 2011

\*Projected Figure by the Author.

The 1972-1986 periods witnessed much more urban expansion than the preceding period. Tables 5a and 5b showed that the urban built-up areas of Osogbo were 6.61 and 13.39 km<sup>2</sup> in 1972 and 1986 respectively. This indicates a remarkable increase in the urban built-up areas of the city twice what obtained in the beginning of the period. This suggests that the expansion area that is the urban fringe area, in this period was 6.78 km<sup>2</sup>, representing 102.57 expansion percentage. In addition, it could be deduced that the average commuting distance of the urban residents has increased from 6.61km<sup>2</sup> in 1972 to 13.39 km<sup>2</sup>.



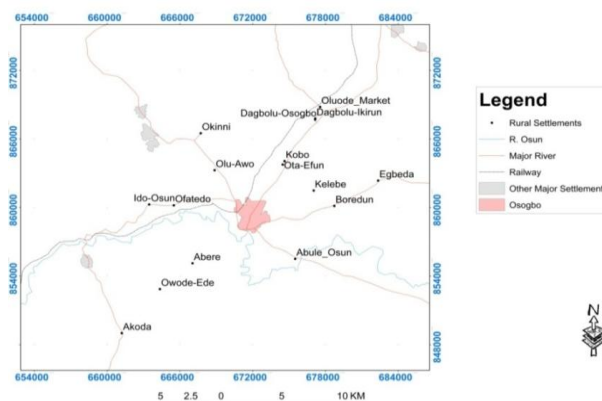
**Figure 2:** Osogbo and its adjacent rural settlements in 1962

The rate of urban expansion hence was estimated to be 3.6 % with land consumption rate and land absorption coefficient as 0.0054 and 0.011 respectively in 1986. The rapid urban expansion in this period may not be unconnected with the establishment of Iron Steel Rolling Mills and Nigeria Machine Tools at the outskirts of the city along Osogbo-Ikirun road. In fact, these industries initiated a new trend in urban development of the city by encouraging ribbon and leapfrogged developments outside the city centre particularly around Ota-Efun and Kobo rural settlements along Osogbo-Ikirun road (Figure 3 and 4). This ushered-in peri-urban development. This form of urban expansion resembles what the sector theory describes as ‘axial growth’ pushing out from the centre along transportation lines. Hence, Osogbo demonstrates a star-shaped pattern of city growth. It is evident that the siting of a Technical College and School of Nursing along Osogbo-Iwo road and at Agunbelewo along Ilobu road respectively also stimulated commercial strip development like petrol filling stations, shopping complexes, residential homes, food malls and restaurants along the transport arteries. This implies that the forested areas which were fragmented by road construction have increasing potentials for human impacts. This agrees with the finding of (Matlack, 1993) who reported that sites adjacent to roads were significantly more affected by human activities than those away from vehicle access. Moreover, this period coincided with time the Zonal power station was upgraded and located at Ota-Efun rural settlement near Osogbo. The State branch of West African Examination Council was cited at Alekuwodo in this period. These developments and others tend to have stimulated rapid urbanization process in the city, albeit the decentralization process of the Federal Government of Nigeria that succeeded in creating four states from old western region to make up nineteen states in the country in 1976. This culminated in the emergence of Oyo, Ondo, Ogun and Lagos States with their capitals at Ibadan, Akure, Abeokuta and Ikeja respectively. This development has an impact on the growth of the city as evident in population growth rate that dropped from 2.08 % to 1.93 % (see Table 6).

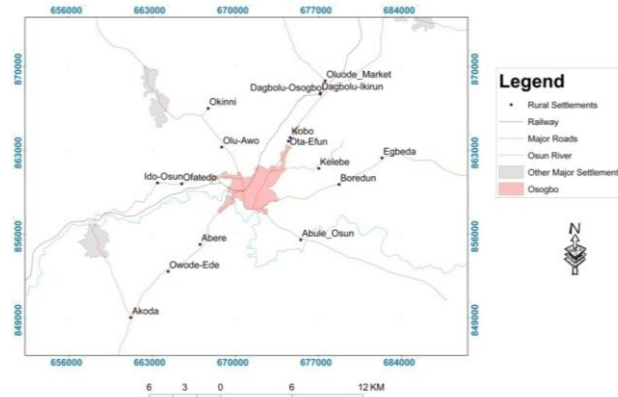
**Table 6:** Population Growth Rate and Rate of Expansion from 1962 to 2011

Year	Population	Population Growth rate (%)	Urban Extent	Land Consumption Rate	Land Absorption Coefficient	Agricultural loss (%)
			(Ha)			
1952	122,728	-	-	-	-	-
1962	151,077	2.1	395	0.0026	-	-
1963	152,424	2.1	411	0.0027	0.019	6.58
1972	183,774	2.08	661	0.0036	0.0076	57.01
1986	245836	1.93	1339	0.0054	0.011	102.57
1991	250,951	1.51	1598	0.0064	0.051	19.34
1995	280,587	2.83	2108	0.0075	0.013	22.34
2002	341,120	2.83	5527	0.016	0.056	162.19
2003	350,774	2.83	5767	0.016	0.025	4.34
2006	381,405	2.8	6551	0.017	0.026	13.59
2007	392,198	2.83	6800	0.017	0.023	3.8
2011	438,516	2.83	24179	0.055	0.038	255.57

Source: National Bureau of Statistics, 2011



**Figure 3:** Osogbo and its adjacent rural settlements in 1972



**Figure 4:** Osogbo and its neighbouring rural settlements in 1986

In the period between 1986 and 1995, Osogbo witnessed an appreciable urban growth. The built-up areas of the city remarkably increased from 13.39 km<sup>2</sup> to 21.08 km<sup>2</sup> as shown in Table 5a. This shows a total expansion area, that is urban fringe area, of 7.69 km<sup>2</sup>, representing 51.02 % expansion percentage. According to Table 5b, the rate of urban expansion at the end of this period was 4.6 % with

the land consumption rate increased to 0.0075 while the land absorption coefficient dropped down from 0.051 to 0.013 as table 6 depicted. This implies that the agricultural lands, particularly 'Oko Etile' have been seriously impacted with a total loss of 19.34 and 22.34 % in 1991 and 1995 respectively. This suggests that the lands that were utilized for food production were gradually being converted to urban uses in form of housing construction. This may constitute a serious threat to the food security in the city though it may be argued that food supply to the city is possible from neighbouring settlements but should be taken as supplement. The significant growth factors identified by the study include the creation of Osun State in 1991 with the capital at Osogbo city. Following this development, the defunct Divisional Teacher Training College located between Omo West area and Testing Ground was made to house the newly created state Ministries and Sole Administrator's Office. The influx of Civil servants and other business investors from Ibadan to Osogbo seemed to have culminated in increasing population growth that manifested in escalating housing demands. Response to this situation by both public and private sectors tends to have consolidated the outward expansion of the city along Osogbo-Ikirun, Osogbo-Iwo, Osogbo-Ilobu and Osogbo-Gbongan roads (Figure 3). The construction of a Ring road that connected Osogbo-Iwo and Osogbo-Ikirun roads constituted another growth factor. This double lane road continued to serve as centripetal force that attracted urban activities to the immediate surrounding and beyond. It was noticed during the field observation that the road had the strong tendency to generate sprawl towards the Agunbelewo area along Osogbo-Ilobu road and between the transport corridors. The creation of two local governments namely Olorunda and Osogbo from the city was another important growth factor. Others were Dualisation of Okefia-Olaiya Road Junction, establishment of High Court of Justice at Oke-Fia, Government House at Oke-fia, Nigeria Union of Journalist near Technical College, Construction of Osogbo Stadium along Osogbo-Ikirun road, establishment of Leisure Spring, Capital Hotel, Presidential hotel and Five Stars hotel and Osun state Cultural Centre along Kola Balogun Road, Osogbo constituted evidences of the modernization of the city. Within the period, the state secretariat was relocated to a newly constructed secretariat at abandoned Ayegbaju market, near Ogo Oluwa Area along Osogbo-Gbongan road. The urban expansion in this period as the city combines both features of a traditional and modern city together tends to be based on several discreet nuclei as explained by the multiple nuclei concept. This may be attributed to increasing decentralization of the city and increasing dependence of the city on commuters as argued by the model.

Between 1995 and 2002, Table 5a showed that the built-up area of the City increased from 21.08 km<sup>2</sup> to 55.27 km<sup>2</sup>. This indicates that the spatial extent of the city has nearly thrice its size within a period of seven years.

This suggests that the city grows at an average rate of 4.9 km<sup>2</sup> per annum which is faster than that of Ibadan metropolitan city (3.0km<sup>2</sup>) within the same period as reported by (Oyinloye, 2003; Adegboyega, 2008; 2012). The trend in the spatial growth of the city was a consolidated linear expansion which occurred along the major transportation arteries. The rate of urban expansion was estimated at 8.8% for the period. This suggests that the city is growing at an alarming rate. According to Table 6, the land consumption rate was found to have increased from 0.0075 to 0.016 while the land absorption coefficient also increased from 0.013 to 0.056. This indicates that even though the expansion is alarming but the carrying capacity of the city land can still cope with the rate at which the city has been growing. However, the urban expansion had encroached on rural areas and hence 162.19 % of agricultural lands had been lost to the city expansion. The identified significant growth factors were construction of new State House of Assembly near Abere along Osogbo-Gbongan road, Construction of new State Secretariat at Abere rural settlement, Commercial and Banking expansion, relocation of Osun State Broadcasting Corporation(OSBC) from Ita-kogun to Oke-Baale along Osogbo-Egbeda-Ibokun road, establishment of State Universal Basic Education Board(SUBEB) along Gbongan road and establishment of National Examination Council (NECO) State branch along Gbongan road. These urban functions had to a certain extent stimulated high population growth within the period that seemed to have culminated in increasing demand for housing as the expansion area, representing the urban fringe area was estimated at 34.19km<sup>2</sup>. It is important to note that River Osun constitutes the major limiting factor to the growth of the city towards the south (Ede North and Atakunmosa West) and West (Egbedore and Irepodun). It may be argued that the river seems to have contributed significantly to the morphological development of the city by influencing the direction of expansion of the city and producing some degree of spatial discontinuity to the built-up areas most especially in Isale Osun sector where Osun Groove is located. The emerging star-shaped pattern of growth observed of the city may also be seen as a response to transport accessibility emanating from the development of arterial roads that connect the city with the neighbouring urban centres. This observation is in line with the postulate of Homer Hoyt (1939) in the sector theory that major lines of transportation constitute lines of least resistance for growth in addition to their being important arteries along which similar types of land use are situated. Hence, urban expansion is 'axial growth' pushing out from the centre along transportation lines.

Figures 5 and 6 showed that urban expansion had fully encroached the following rural settlements between 1995 and 2002: In 1995 as the figure depicted, Ofatedo (5.11 kilometres from the city centre) located in Egbedore Local Government Area (LGA); Abere (4.79 kilometres from the city centre), a rural settlement in Ede North LGA; Ota-

Efun and Kobo with distance from the city centre estimated at 3.91 and 4.09 kilometres respectively were fully urbanized (see Table 7). These rural settlements were found to have been located along major transportation lines radiating from the traditional city centre. This suggests that transport accessibility to a large extent not only determines the spatial pattern of urban fringe but contributes to the dynamism of the urban fringe in the study area. The City expansion in 2002 further encroached on Olu-Awo village, 3.13 kilometres away from the City Centre located in Olorunda LGA and Abule-Osun with distance of 4.66 kilometres away from the City Centre in Osogbo LGA. This confirms the notion that the centripetal forces at the outer zone not only attract the functions to it but also hold them in the zone. Between 2003 and 2007, the spatial expansion of Osogbo City increased from 57.67 km<sup>2</sup> to 68.0 km<sup>2</sup>.

4	Kobo	4.09
5	Kelebe	4.38
6	Ota-Efun	3.91
7	Boredun	5.86
8	Okinni	6.64
9	Abule Osun	4.66
10	Abere	4.79
11	Owode-Ede	8.52
12	Dagbolu-Osogbo	8.48
13	Dagbolu-Ikirun	8.66
14	Idi Osan	4.32

Source: Author's Imagery Analysis 2011

This indicates that the urban fringe area of the City has been extended by 10.33 km<sup>2</sup>, an equivalence of expansion percentage of 17.9. According to tables 5a and 5b above, the rate of urban expansion within the period of four years was 3.8 % while the land consumption rate maintained the upward trend by increasing from 0.016 to 0.017 whereas land absorption coefficient continued to dwindling down from 0.056 to 0.025. This indicates that the carrying capacity of the city can no longer cope with the rapid urban expansion resulting into gradual conversion of wetlands to built-up area at Alekuwodo, Gbonmi and Atewolara where river channels have been gradually narrowed down as observed during the field observation.

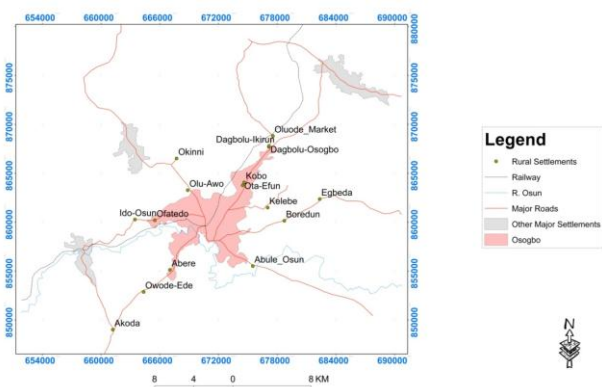


Figure 5: Osogbo City and its Fringe Areas in 1995

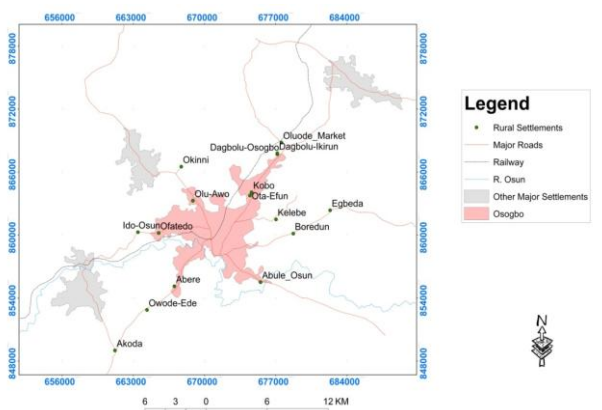


Figure 6: Osogbo and its Fringe Areas in 2002

Table 7: Rural Settlements on the Urban Fringe Area of Osogbo City

S/N	Rural Settlements	Distance from City Centre (KM)
1	Ido-Osun	7.04
2	Ofatedo	5.11
3	Olu Awo	3.13

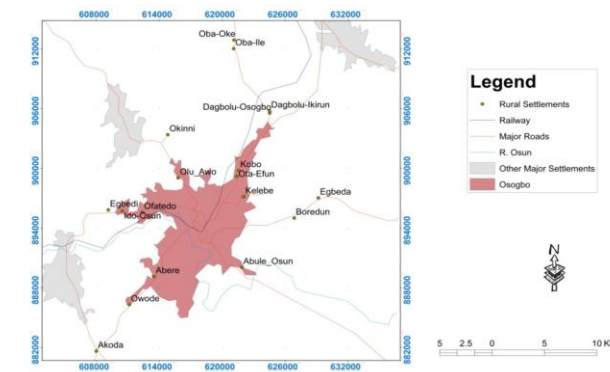


Figure 7: Osogbo City and its Fringe Areas in 2003

This prevailing condition tends to push people outwards into developing shelter in the peripheral areas. The emerging development may be described as ribbon and leapfrogged that tends to have extended the urban fringe of the City to settlements like Owode-Ede in Ede North, Ido-Osun in Egbedore, Abule-Osun and Kelebe in Osogbo LGAs (Figure 7). The significant growth factors include the full mobilization and relocation of the State Government functionaries to the new State Secretariat at Abere, establishment of Nigeria Teachers' Institute (NTI) along Gbongan Road and establishment of Nigeria Civil Defence at Oke Ayepe along Ilesa road.

Between 2007 and 2011, the built-up area of Osogbo increased from 68.0 km<sup>2</sup> in 2007 to 241.79 km<sup>2</sup> in 2011. This period had recorded a remarkable extension of the urban fringe area estimated at 173.79 km<sup>2</sup>, representing 255.57 expansion percentage (see Table 5b). This suggests that 255.57% of potential agricultural lands have been lost to the sprawling growth of the City. Also, the rate of urban expansion in this period was estimated at 18.0% which was found to be alarming. This may be explained in the context of greater decentralization of urban functions as described by ‘flight from blight theory’ occasioned by competition for space, high rent inadequate space, increasing population growth and poor infrastructure in the city centre. The trend in land consumption rate remained high and increased from 0.017 to 0.055 while land absorption coefficient increased from 0.023 to 0.038. This suggests that the continuing encroachment on the rural lands by the urban expansion may be said to have reduced the pressures on the carrying capacity of the City. According to (Figures 8 and 9), the spatial expansion of Osogbo City had fully encroached on Dagbolu-Osogbo, Dagbolu-Ikirun along Oba Ile-Oba Oke road, fused together with Okinni along Ilobu road and Ido-Osun in Egbedore. The factors responsible for this development may include expansion of road network in the City such as dualisation of Akoda-Osogbo road that facilitate smooth flow of traffic, establishment of State branch of Central Bank of Nigeria that tends to boost the commercial and banking activities in the city, conversion of one state hospital to Latoke University Teaching Hospital (LAOTECH) that employs many medical personnel, security and administrative staff, establishment of Osun State University Main Campus at Oke Baale along Osogbo-Ibokun road admits substantial number of students and corresponding appointment of both teaching and non teaching staff and establishment of Fountain University behind the Osun Groove. These factors to a large extent have contributed to the population growth of the city which tends to have triggered increasing demands for housing that are promptly responded to by the private individual developers. During the field observation, the construction of new houses was occurring on the fringe areas of the city along the major highways. The emerging land use pattern reflects the situation explained by (Briassoulis, 1999) in which the private individual developers serve as agents acquire land previously used for farming and later dispose them for urban development thereby leading to urban fringe development as observed earlier. The interplay of concepts of centrifugal and centripetal forces as explained in the agent-based theory centripetal forces tend to play vital roles in continuous sprawl of urban development while centrifugal forces, on the other hand,

seems to be responsible for the dispersion of other land use at the city edge and beyond.

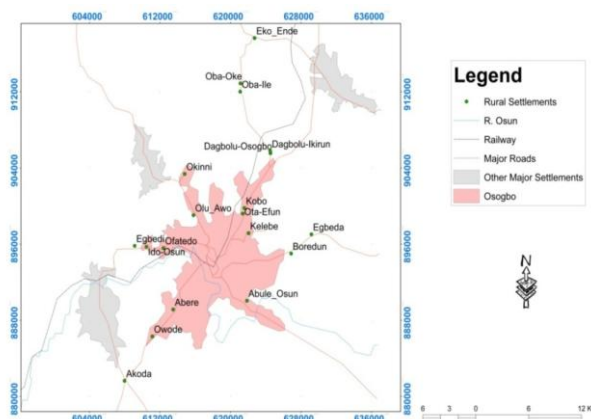


Figure 8: Osogbo City and its Fringe Areas in 2007

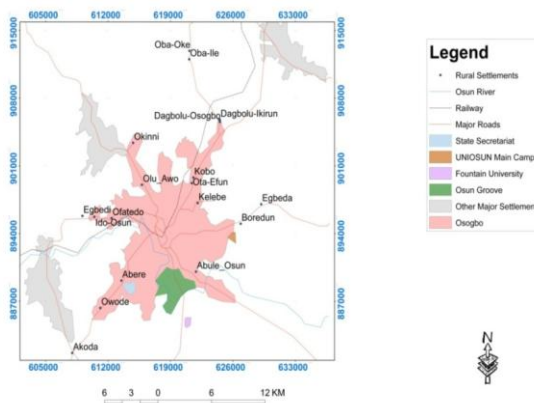


Figure 9: Osogbo City and its Fringe Areas in 2011

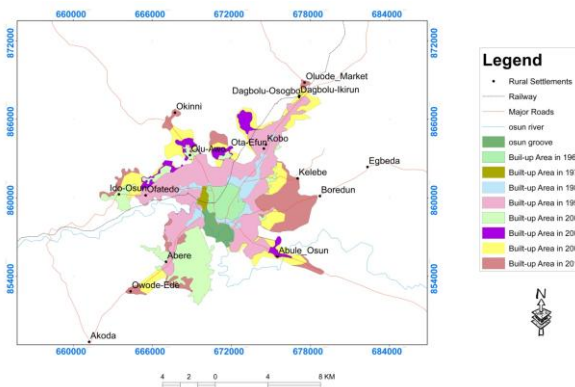
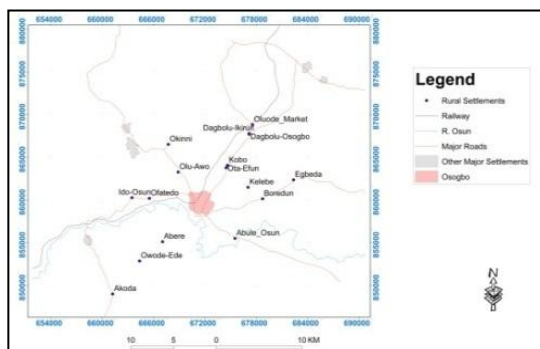


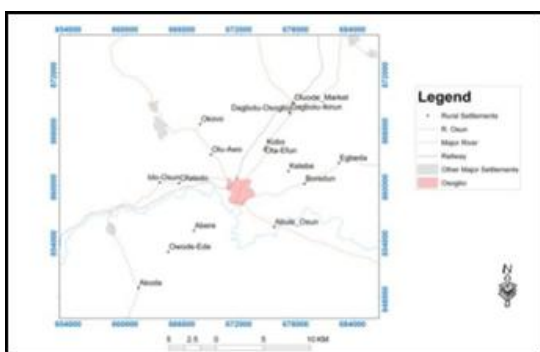
Figure 10: Overlaid map of Osogbo Built-up Area from 1962 to 2011

From the overlaid map of Osogbo built-up areas (see figure 10), it is obvious that the city has tremendously grown in size. The spatial extent of the city that was 3.95 km<sup>2</sup> in 1962 had increased to 241.79 km<sup>2</sup> in 2011 (see Figure 11) which was 62 times its size in forty-nine years ago. This indicates that the city has been growing at a fast rate which averaged 4.9 km<sup>2</sup> per annum. Giving the total

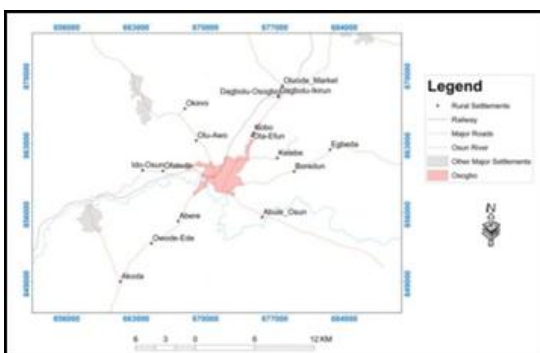
agricultural land loss over the study period to be 237.84 km<sup>2</sup>, it is therefore projected, based on average expansion rate between 2003 and 2011, that the spatial extent of Osogbo City will be 1029.15 km<sup>2</sup> in 2025. This suggests that the urban fringe areas of Osogbo would have been increased by 787.36 km<sup>2</sup> within the next fourteen years.



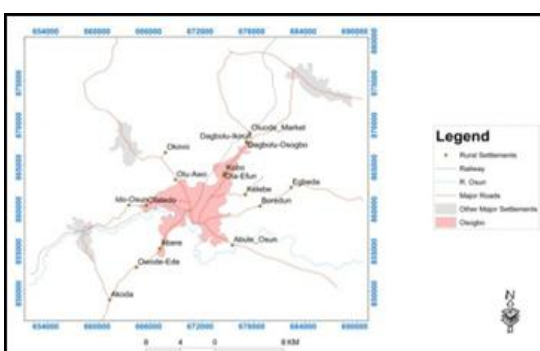
(1962)



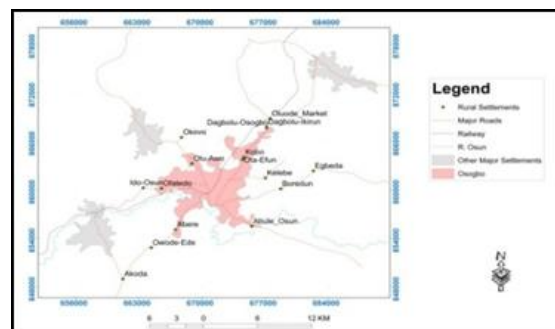
(1972)



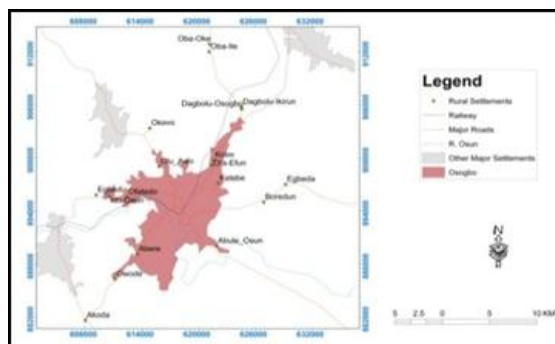
(1986)



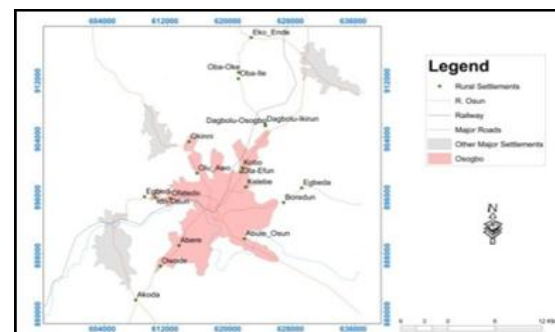
(1995)



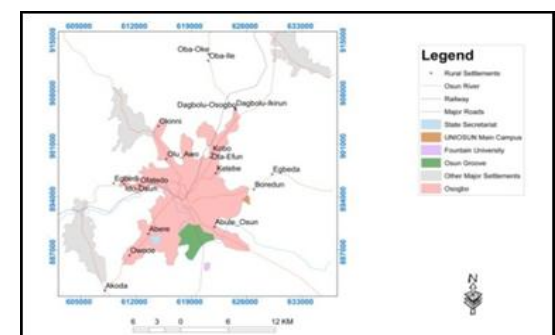
(2002)



(2003)



(2007)



(2011)

**Figure 11:** Spatial Expansion of Osogbo and its Fringe Areas between 1962 and 2011

#### 4.2 Measuring Urban Sprawl in Osogbo City

Table 8 identified sprawl manifestation metrics include the main urban core, secondary urban core, urban fringe, scatter development (urban scatter) and ribbon

development (urban ribbon) in Osogbo. In 1986, the proportion of the built-up area that constituted the main urban core was estimated at 6.01 km<sup>2</sup>, representing 43.24 % of the total built-up area. The secondary core was quantified to be 0.04 km<sup>2</sup>, an equivalence of 0.29 %. Whilst the urban fringe, ribbon and scatter development were estimated at 6.72, 0.10 and 1.03 km<sup>2</sup> (48.35, 0.72 and 7.4 %) respectively. The table further showed that in 2011 as the built-up area was increasing at an average of 9.12 km<sup>2</sup> per annum, representing 65.61%, the area covered by the main urban core was found to be almost five times what it obtained in the previous period that was 29.0 km<sup>2</sup>. This suggests that main urban core has been increasing at an average of 0.92 km<sup>2</sup> within the measuring period of twenty-five years. The secondary core increased to 17.2 km<sup>2</sup> reflecting the modernity of the city while the urban fringe skyrocketed to 173.79 km<sup>2</sup>. This implies that the proportions of the total built-up area that constitute secondary core and urban fringe tend to have increased at average of 0.69 and 6.68 km<sup>2</sup> per annum respectively. It is significant to note that the area covered by urban fringe in 2011 is nearly one hundred and sixty-two times what obtained in the previous period, suggesting the dynamic nature of the fringe area. Contributing to this is tremendous growths of ribbon and scatter development that have increased in area extent by 9.11 and 12.8 km<sup>2</sup> respectively. Ribbon and Scatter development have been found to be increasing at average of 0.36 and 0.47 km<sup>2</sup> per annum respectively. This lends credence to the postulate of (Angel & Civco, 2007) that in sprawling cities, low density developments such as ribbon and scatter are expected to increase over time.

urbanized area of the city comprising built-up area and urbanized open space was 19.2 km<sup>2</sup> in 1986, but increased remarkably in 2011 by covering 540.22 km<sup>2</sup>, representing 138.1% showing an average increase of 20.8 km<sup>2</sup> per annum. This showed that as built-up area of the city continued to increase at average of 9.12 km<sup>2</sup> per annum, more open space was encroached upon at average of 11.7 km<sup>2</sup> per annum. It is significant to note that developable proportion of the urbanized open space was found to be 0.57 km<sup>2</sup> in 1986 but as the city expanded it increased to 51.3 km<sup>2</sup> in 2011. This suggests that 4.73 km<sup>2</sup> and 247.13 km<sup>2</sup> of the urbanized open space in 1986 and 2011 tend to be non-developable area which may be regarded as wetlands and area with excessive slopes. It is important to note that the non-developable area increases at an average of 9.7 km<sup>2</sup> per annum. Conversion of such area to built-up area narrows down the erosion channels and undermines natural flood control capability of the urban environment. This probably accounts for devastating urban flooding the city experienced in July 2010, particularly around Alekuwodo, Gbonmi and Atewolara sections of the city.

The table further showed that urban footprint comprising the built-up area; urbanized open space and peripheral open space estimated at 32.4 km<sup>2</sup> in 1986 had increased more than almost forty-nine times in 2011, that is 1573.12 km<sup>2</sup>. It is interesting to note that the city may seem to have extensive peripheral open space and open space but according to the table, the proportion of the land considered to be developable is 264.6 km<sup>2</sup>, suggesting that larger proportions of the land under peripheral open space and open space may be regarded as non-developable area.

**Table 8:** Sprawl manifestation metrics for Osogbo City (1986-2011)

Metrics	T <sub>1</sub>		T <sub>2</sub>		Annual Change (ΔT)	
	KM <sup>2</sup>	%	KM <sup>2</sup>	%	KM <sup>2</sup> /YR	%
Built-up Area	13.9	100	241.8	100	9.12	65.61
Main Core	6.01	43.24	29	11.99	0.92	15.31
Secondary Cores	0.04	0.29	17.2	7.11	0.69	1725
Urban Fringe	6.72	48.35	173.8	71.88	6.68	99.4
Urban Ribbon	0.1	0.72	9.11	3.77	0.36	360
Urban Scatter	1.03	7.4	12.8	5.29	0.47	45.63

Source: Author's Image Classification 2011

Tables 9, 10 and 11 showed the three attributes of urban sprawl in Osogbo city. According to Table 9, the urban extent attribute of the city over the period of twenty-five years was measured and quantified using the metrics such as built-up area, urbanized area, urbanized open space, buildable urbanized area, urban footprint, peripheral open space, buildable urban footprint and open space (see figures 12 & 13). The table revealed that

**Table 9:** Urban Extent calculations for Osogbo City

Metrics	(T <sub>1</sub> )		(T <sub>2</sub> )		Annual Change (ΔT)	
	km <sup>2</sup>	%	km <sup>2</sup>	%	km <sup>2</sup> / yr	%
Built-up Area	13.9	100	241.8	100	9.12	65.61
Urbanized Area	19.2	138.1	540.2	223.4	20.8	108.3
Urbanized open space	5.3	38.1	298.4	123.4	11.7	220.8
Buildable urbanized area	0.57	4.1	51.3	21.2	2.02	354.4
Urban Footprint	32.4	233.1	1573	650.6	61.6	190.1
Peripheral Open space	13.2	95	1033	427.2	40.8	309.1
Buildable urban footprint	2.22	16	264.6	109.4	10.5	473
Open space	146.75	1055.8	1331	550.6	47.4	32.3

Source: Author's Image Classification 2011

Table 10 showed that the population of Osogbo city increased by 3.1% per annum between 1986 and 2011. In

this regard, the population density calculated for the period of twenty-five years revealed that the built-up area density was declining by 5.59% per annum. The table also showed that the urbanized area density and urban footprint density receded by 3.75 % and 3.85 % per annum respectively while the buildable urbanized area density and buildable urban footprint density equally declined by 3.92 % and 3.94 % annually. This suggests that Osogbo city has experienced a persistent decline in urban densities for the measuring period. This conforms to the postulate of (Angel & Civco, 2007) that population densities are expected to decline over time in sprawling cities. It is also in agreement with the findings of the (Angel & Civco, 2007), on the study of urban sprawl in Bangkok and Minneapolis, who reported that the built-up area, urbanized area, buildable urbanized area, urban footprint and buildable urban footprint densities declined by 3.2%, 2.9%, 2.9%, 1.2% and 1.2% for Bangkok, 0.9%, 0.9%, 0.8%, 0.5% and 0.7% for the Minneapolis.

**Table 10:** Density calculations for Osogbo City

Metrics (Densities in persons / km <sup>2</sup> )	(T <sub>1</sub> )	(T <sub>2</sub> )	Annual Change(ΔT)
Population	245836	438516	3.10%
Built-up area density	17686.04	1813.62	-5.59%
Urbanized area density	12803.96	811.74	-3.75%
for buildable area	431291.23	8548.1	-3.92%
Urban Footprint density	7587.53	278.76	-3.85%
for buildable area	110736.94	1657.3	-3.94%

Source: Author's Image Classification 2011

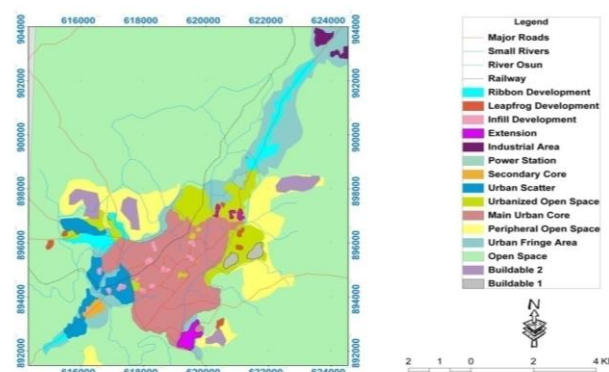
Table 11 showed the measurement of the decreasing contiguity of the built-up area of Osogbo city in the measuring period. According to the table, the measuring indices of new development and openness include Infill, Extension, Leapfrog and open space fragmentation. The table revealed that Infill development covered 0.42km<sup>2</sup> in 1986 but increased upward in 2011 by 43.8km<sup>2</sup>. This indicates that infill development increases at an average of 1.74km<sup>2</sup> per annum. Similarly, Extension development increased in areal extent from 0.58KM<sup>2</sup> in 1986 to 78.8km<sup>2</sup> in 2011, suggesting an average increase of 3.13km<sup>2</sup> per annum. The table further showed that Leapfrog development estimated at 0.35km<sup>2</sup> in 1986 was found to have increased by 45.2km<sup>2</sup> in 2011. This suggests that leapfrog development increases at an average of 1.79km<sup>2</sup> per annum. It is evident from the table that leapfrog and extension development recorded 511.43 and 539.66 % of the new development respectively. This suggests that urban expansion of the city tends to have demonstrated a pattern of non-contiguous patches that has culminated in open space fragmentation. From the table, open space fragmentation index showed that the value estimated was higher in 2011 than 1986, averaged 12.57% per annum. This is a strong evidence of sprawling growth that has been

manifested in new developments that either extend outward from existing development or leapfrog away from existing development.

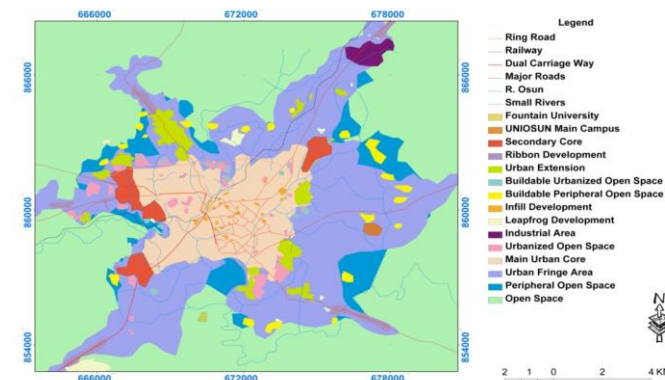
**Table 11:** Contiguity and openness indices for Osogbo City

Metrics		T <sub>1</sub>	T <sub>2</sub>	Annual Change(ΔT)
New Development	Km <sup>2</sup>	1.35	167.8	6.7
	%	100	100	496.3
Infill	Km <sup>2</sup>	0.42	43.8	1.74
	%	31.11	26.1	413.1
Extension	Km <sup>2</sup>	0.58	78.8	3.13
	%	42.96	47	539.66
Leapfrog	Km <sup>2</sup>	0.35	45.2	1.79
	%	25.93	26.9	511.43
Open space fragmentation		1.33	5.51	12.57%

Source: Author's Image Classification 2011, NB: Annual Change= (T<sub>2</sub> -T<sub>1</sub>) km<sup>2</sup>/yr



**Figure 12:** Manifestations and Attributes of Urban Sprawl in Osogbo City (1972-1986)



**Figure 13:** Manifestations and Attributes of Urban Sprawl in Osogbo City (1995- 2011)

**Conclusion and Recommendation**

In conclusion, the study revealed the spatial extent of the city that was 3.95 km<sup>2</sup> in 1962 had increased to 241.79 km<sup>2</sup> in 2011, indicating that Osogbo city had been sprawling at an average rate of 4.9km<sup>2</sup> per annum between 1962 and 2011. With this unprecedented rate of sprawling growth, the adjacent rural areas had been increasingly perforated by uncoordinated urban expansion thereby paving way for a serious urban

encroachment on the rural settlements and farmlands. The study also showed that the pattern of sprawling was linear, leapfrogged and scattered along the major transport arteries thus, reflecting a star-shaped pattern. This kind of spatial pattern of urban sprawl has continued to accelerate urban influence of the city into the adjacent Local Government Areas such as Egbedore, Ede North, Ifelodun, Boripe, Orolu and Boripe that may result into political conflicts over the territory jurisdiction and ownership of lands in the future against Osogbo and Olorunda LGAs that domicile in the city. The study therefore advocates integration of the on-going urban renewal programme into a consciously evolved digital master plan and set up a task force to enforce compliance and demonstrate sincere political will to prosecute non compliance as the case may be. This can be strengthened by institutionalizing the recently adopted Geographic Information System (GIS), by the State of Osun, to evaluate, monitor and manage land development in the peri-urban areas of the fast growing medium-size city of the developing countries.

## References

- [1]. Adegboyega, S. A. (2008), Urban Sprawl Measurement in Egbeda Local Government Area, Ibadan, Nigeria.
- [2]. Unpublished M.Sc Thesis, Department of Geography, OAU, Ile-Ife.
- [3]. Adegboyega, S.A. (2012), Geo-Spatial Assessment of Urban Sprawl and Fringe Dynamics in Osogbo, Osun State.
- [4]. Unpublished Ph.D Thesis, Department of Geography, OAU, Ile-Ife, Nigeria.
- [5]. Adenaike, F (1991), The Pioneers. Ministry of information, Osun State of Nigeria.
- [6]. Adesina, A. (2007), Socio-Spatial Transformations and the Urban Fringe Landscape in Developing Countries. A paper presented at United Nation University Institute for Environment and Human Security. Munich, Germany.
- [7]. Agbola, T. (1992), Osogbo City Profile. Cities Volume 9, Issue4, pp249-260
- [8]. Agbola, T. (2006), Sustainable Urbanization and the New Urban Planning: Dilemma of New Opportunities and the Challenges for Nigeria Technocratic Planners. A paper presented at the Dept of Urban and Regional, Rufus Giwa Polytechnic, Owo, Nigeria.
- [9]. Aguda, A.S. and Olayiwola, A.M. (2011), "Challenges to the Provision of Infrastructural Services in Nigeria's Urban Areas". In Remi Adeyemo (ed) : Urban Agriculture, City and Climate Change. Proceedings of Humboldt International Conference, O.A.U, Ile-Ife. 5<sup>th</sup> – 9<sup>th</sup> December, 2010. Cuvillier Verlag, Nonnenstieg 8, 37075 Gottingen pp. 184-190
- [10]. Ajiboye, A. (2004), The Socio-Cultural Responsiveness of Household size on Housing Quality in Osogbo, Nigeria. *Anthropologist* 6(3): 169-174.
- [11]. Ajiboye, A. (2010), Evaluating Users' Household-Size and Housing Quality in Osogbo, Nigeria. *Ethiopian Journal of Environmental Studies and Management* Vol.3 No.2, 77-85p
- [12]. Angel. S. and Civco, D. (2007), Urban Sprawl Metrics: An Analysis of Global Urban Expansion Using GIS. A paper presented at ASPRS 2007 Annual Conference Tampa, Florida. May 7-11, 2007
- [13]. Awe, B. and Albert, O. (1995), Historical development of Osogbo. In: Model of Growing African Town. C. O.
- [14]. Adepegba (Ed). Institute of African Studies University of Ibadan, Nigeria
- [15]. Ayeni, B. (1979), Concepts and Techniques in Urban Analysis. London Croom Helm Ltd.
- [16]. Bourne, L.S. (1996), "Reinventing the Suburbs: Old Myths and New Realities", *Progress in Planning*, 46(3): 163-184
- [17]. Briassoulis, H. (1999), Analysis of Land Change: Theoretical and Modelling Approaches. The Web Book of Regional Science, Regional Research Institute, West Virginia University. Pp 7-10.
- [18]. Brueckner, J. K. and Kim, H. (2003), Urban sprawl and the property tax. *International Tax and Public Finance*.
- [19]. Burgess, E. W. (1925), "The growth of the city: An introduction to a research project". In : The City, eds. Park, R. E., Burgess, E. W. and R. D. McKenzie, 44-62, Chicago: The Chicago University Press.
- [20]. Colby, C.C. (1933), "Centrifugal and Centripetal Forces in Urban Geography". In *Annals of the Association of American Geographers*. Vol.23, No. (1) pp 1-10
- [21]. Daniels, T. and Lapping, M. (2005), "Land Preservation: an Essential Ingredient in Smart Growth", *Journal of Planning Literature*, 19(3): 316-329.
- [22]. Egunjobi, L. (1995), Aspects of urbanization, physical planning and development Osogbo.. In: Model of Growing African Town. C. O. Adepegba (Ed). Institute of African Studies, University of Ibadan, Nigeria pp.13-28.
- [23]. Fadare, S.O. (2010), Urban Form and Households' Travel Behaviour-Implications for Nigeria. An Inaugural Lecture series 230 delivered at Obafemi Awolowo University, Ile-Ife.
- [24]. Harris, C.D. and E.L. Ullman (1945), The nature of cities, *Annals of the American Academy of Political and Social Sciences*, pp 7-11
- [25]. Hoover, E.M. and Giarrantani, F. (1984), An Introduction to Regional Economics. Third Edition. The Web Book of Morgantown, WV, pp131
- [26]. Hord, R.M. (1982), Digital Image Processing of Remotely sensed data. Academic Press, New York
- [27]. Hoyt, H. (1939), "The Structure and Growth of Residential Neighbourhoods in American Cities", Washington, DC (Federal Housing Administration). <http://www.census.gov/ipc/www/>
- [28]. ITC-ILWIS (2001), ILWIS User's Guide. International Institute for Aerospace Survey and Earth Science (ITC). Enschede, The Netherlands.
- [29]. Krugman, P. (1995), Development, Geography and Economic Theory: Cambridge, Ma: The MIT Press, pp22-25.
- [30]. Lee, C. M. and Ahn, K. H. (2003), "Is Kentlands Better than Radburn?: The American Garden City and New Urbanist Paradigms", *Journal of the American Planning Association*, 69(1): 50-71.
- [31]. Ma, et al (2010), Remote Sensing Monitoring and Driving force Analysis of Urban Expansion in Guangzhou City, China. *Habitat International*, volume 34, Issues 2, April 2010, PP 228-235.
- [32]. Mabogunje, A.L. (1968), Urbanization in Nigeria, London University Press.
- [33]. Mabogunje, A.L. (2011), "Urban Governance and Resource Management: Revisiting the 1976 Local Government Reform in Nigeria". In Remi Adeyemo (ed) : Urban

- Agriculture, City and Climate Change. Proceedings of Humboldt
- [34]. International Conference, O.A.U, Ile-Ife. 5<sup>th</sup> – 9<sup>th</sup> December, 2010. Cuvillier Verlag, Nonnenstieg 8, 37075 Gottingen pp. 179-183.
- [35]. Matlack, G.R. (1993), Sociological edge effects: Spatial distribution of human impact in suburban forest fragments. *Environ. Manag.* 17, pp. 829-835. View Record in Scopus| cited by Scopus (43)
- [36]. Mieszkowski, P. and Mills, E. S. (1993), The causes of metropolitan suburbanization. *Journal of Economic Perspectives*, 7, 135–147.
- [37]. Murphy, R. (1966), *The American City: An Urban Geography*, New York: McGraw Hill Ojo, G. J. A. (1966), *Yoruba Culture*. University of Ife and London University Press pp 131-157.
- [38]. Okewole, E.A. (2002), Controlling urban sprawl in developing countries through effective urban governance. A seminar paper: Department of Urban and Regional Planning, O.A.U., Ile-Ife
- [39]. Olujimi, J. (2009), "Evolving Strategy for Managing Urban Sprawl in Nigeria". *Kamla-Raj Human Ecology*, 25(3):201-208.
- [40]. Onimode, B. (1989), Economic survey of Osogbo. In: *Osogbo: Model of Growing African Town*. C.O. Adepegba (Ed.). Institute of African Studies, University of Ibadan, Ibadan pp. 30 – 40
- [41]. Osunade, M.A. (1989), *Nomenclature and Classification of Traditional Land Use Types in Southwestern Nigeria*. Ife Research Publications in Geography, Vol. 3, pp 13-33
- [42]. Oyinloye, R.O. (2003), *Generation of Environmental Sensitivity Index (ESI) Map of Impacts of Urbanisation in Ibadan using remote sensing technique*, unpublished M.Sc. Thesis. Institute of Ecology and Environmental Studies, O.A.U.,
- [43]. Redman, C. L. and Jones, N .S. (2004), "The Environment, Social, and Health Dimensions of Urban Expansion", Population Environment Research Network (PERN) Cyber seminar "Urban Expansion: The Environmental and Health Dimension" 29Nov.-15Dec.2004. (<http://www.PopulationEnvironmentResearch.org/seminar>).
- [44]. Rodwin, L. (1950), *The Theory of Residential Growth and Structure*. *The Appraisal Journal*, 18, 451-3
- [45]. U.S Census Bureau (2010), *International Database*. (Published May, 2010).
- [46]. UN-HABITAT (2008), *The State of African Cities: A framework for addressing urban challenges in Africa*. UN-HABITAT, Nairobi, Kenya.
- [47]. United States Environmental Protection Agency, (2001), "Why should we be concerned about sprawl?" The Environmental Protection Agency. Available online: [www.epa.gov/region4air/sue/sprawl/ htm](http://www.epa.gov/region4air/sue/sprawl/htm)
- [48]. Waldheim, C. (2006), *The Landscape Urbanism*. Princeton Architectural Press, New York Walmsley, A. (2006), "Greenways: multiplying and diversifying in the 21st century", *Landscape and Urban Planning*, 76(1-4): 252–290,
- [49]. Yeates, M and Garner, B. (1976), *The North American City*, Harper and Row Pub. New York.