

Research Article

Geospatial Assessment and Monitoring of the Dynamics of Urban Expansion of Ogbomoso, South-Western Nigeria

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Abstract: This study focuses on the dynamics of urban expansion along with the Landuse/Landcover changes in Ogbomoso North and South LGAs, Oyo State, Nigeria, using Remote Sensing and Geographic Information Systems Technology. Ogbomoso has witnessed remarkable expansion, growth and development of large infrastructural facilities such as highway/expressway, power stations as well as the Ladoko Akintola University of Technology, the University Teaching Hospital Complex, modern markets, very many schools, a number of low cost housing estates, local authority offices, etc. This has therefore, resulted in loss of agricultural land, modification and alterations in the land use/land cover over time without any detailed and comprehensive evaluation of the changes. There is therefore, need for synoptic analyses of patterning, change and expansion at regional scales over time in the environment. LandSat imageries of 1990, 2000 and NigeriaSat-1 imagery of 2007 of the environment were subjected to supervised image classification using IDRISI Selva 17.0 software. Results obtained from classifications were cross-tabulated for change detection. The results reveal that water body appreciated from 1.2% (1990), 3.1% (2000) to 3.7% (2007). Built-up area appreciated from 6.4 to 20.3% (1990-2007). Arable land remained the largest land cover, with the value of 57.8% in 1990, 47.8% in 2000 and 62% in 2007. Compound Interest formula was used to determine the rate of urban expansion of Ogbomoso town and the expansion of the town was projected for the year 2020 and 2025. The average rate of urban expansion of Ogbomoso was found to be significantly high with a value of 8.92%.

Keywords: Change detection, geospatial assessment, Geographic Information System (GSI), Ogbomoso, remote sensing, urban expansion

INTRODUCTION

The land use/land cover pattern of a region is an outcome of natural and socio-economic factors and their utilization by man in time and space. Hence, information on land use/land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare (Belaid, 2003). This information also assists in monitoring the dynamics of land use resulting from the changing demands of the rapidly increasing population.

It is commonly known that there remain only few landscapes on the earth that are still in their natural state. Due to anthropogenic activities, the earth surface is being significantly altered in some manner and man's presence on the earth and his use of land has had a profound effect upon the natural environment thus resulting into an observable pattern in the land use/land cover over time. Remote Sensing (RS) and Geographic Information Systems (GIS) are now providing new tools for advanced ecosystem management. The

collection of remotely sensed data facilitates the synoptic analysis of earth-system function, patterning and change at local, regional and global scales over time; such data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of biological diversity (Wilkie and Finn, 1996).

Urban land use/land cover changes are very dynamic in nature and have to be monitored at regular intervals for sustainable environment development (Mohan, 2005). Since 1850, while total global population has increased six times, the earth's urban population has increased over 100 times (Hauser *et al.*, 1982). Aided by the industrial revolution, cities have gone from being a minor feature on our planet to a major one. The impact of urban land on economic and environmental systems is immense compared with its spatial extent. The world's urban areas are gaining an estimated 67 million people per year-about 1.3 million every week. By 2030, approximately 5 billion people are expected to reside in urban areas-60% of the

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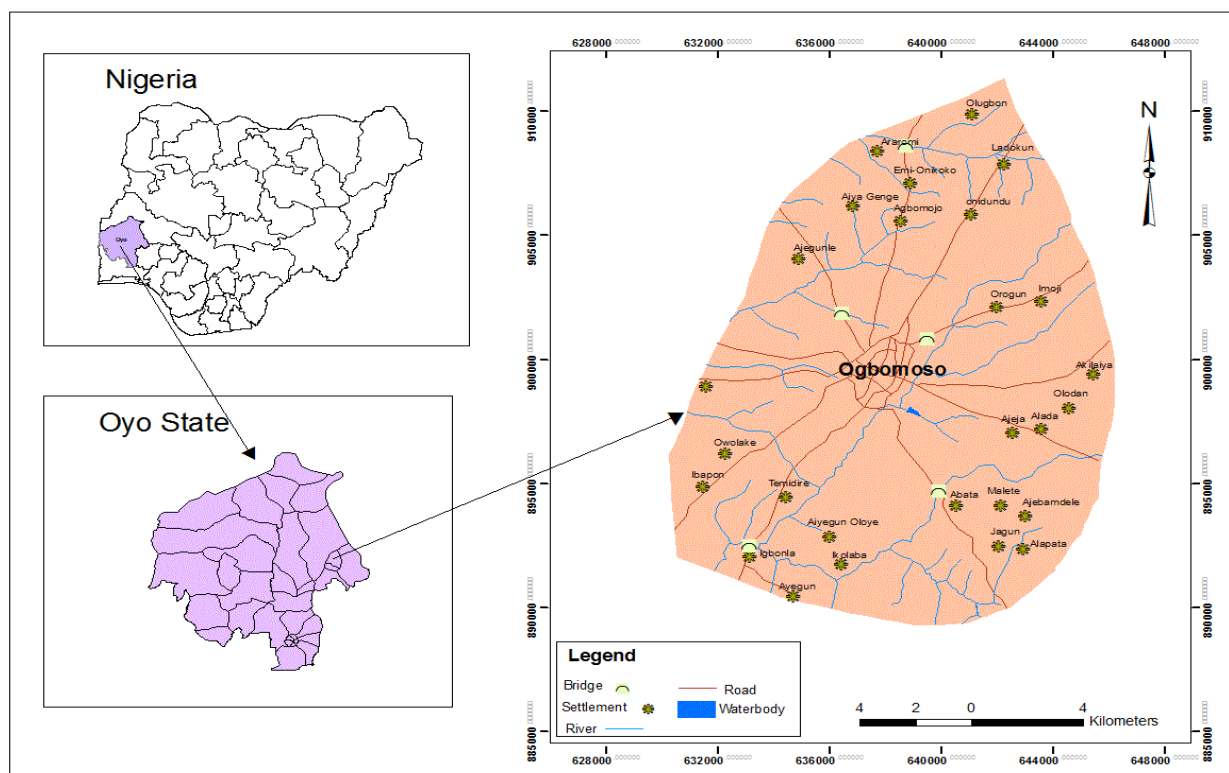


Fig. 1: Map of the study area (Ogbomosho North and South LGAs)

projected global population of 8.3 billion (United Nations, 2002). There are facts that there has been a rapid conversion of agricultural areas to urban (non agricultural) land uses in some parts of Southwestern Nigeria (Oyinloye and Kufoniya, 2011). Urban expansions of these cities have destroyed fertile agricultural land uses which cannot be recovered; the residential land use continues to spread to and beyond the hitherto distant location relative to the city core. Therefore, an attempt has been made in this study to evaluate the LULC characteristics of Ogbomosho Township and environs in Oyo State, Southwestern Nigeria, assess and monitor the urban development of Ogbomosho between 1990 and 2007 and determine the rate of urban expansion in Ogbomosho. Findings will be made on the changes that have taken place and consequently make predictions on the urban growth for 2020 and 2025 which are specific epochs put forward by some initiatives using Remote Sensing (RS) and Geographic Information System techniques (GIS).

The study area: Ogbomosho is located within latitudes $8^{\circ} 2' 35.20''$ N and $8^{\circ} 14' 34.25''$ N and longitudes $4^{\circ} 10' 52.92''$ E and $4^{\circ} 19' 40.59''$ E. Ogbomosho is located within a derived Savannah region, it is 104 km North East of Ibadan, 58 km North West of Osogbo, 57 km South West of Ilorin and 53 km North East of Oyo (Fig. 1). The physical and economic growth of the town began in the 19th century when there was an unrest

through-out the Yoruba land due to inter ethnic wars and Fulani Jihad. This brought more than 140 communities to seek refuge in Ogbomosho because of its strong defence. Most of these people took permanent residence in Ogbomosho and by the end of 19th century, a continuous built-up compact settlement was evolved from the hamlet, covering an extensive area of land (Chernow and George, 1993). The rapid growth of the town is also induced by the advent of missionary and establishment of schools. The deportation of Nigerians by Ghanaian government in 1969 also brought physical and economic growth to Ogbomosho. The establishment of Ladoke Akintola University of Technology in Ogbomosho is said to have induced its phenomenal growth since 1991. The urbanization process that resulted from the development mentioned above led to the demographic change over time. For instance, the population rose from 25,000 in 1885 (Bowen, 1957) to more than 166,000 by 1991 (National Population Commission, 1991) and was said to be about 299,535 by 2006 census.

MATERIALS AND METHODOLOGY

Satellite data: The primary data used for the study were landSat TM 1990, LandSat ETM⁺ 2000 and NigeriaSat-1, 2007 imageries. The LandSat imageries were downloaded from the Global Land Cover Facility (GLCF) website, while that of Nigeriasat-1 was

Table 1: Some fundamental characteristics of the remote sensing data used for the study

Imagery	Date of Acquisition	Location on WRS	Dimesion (in pixels)	Actual spatial resolution
LandSat TM	27/12/1990	P191R054	7763×7329	28.5×28.5 m
LandSat ETM ⁺	06/02/2000	P191R054	8597×7548	28.5×28.5 m
NigeriaSat-1	22/02/2007	P191R054		32.0×32.0 m

obtained from Nigerian agency on space technology, National Space Research and Development Agency (NASRDA). All the imageries were acquired within the dry season (between November and early February). The use of imageries of the same season for multi-temporal study is important for accurate change detection. The secondary data used for the study were basically the administrative boundary map of Nigeria and the topographic map covering the study area (Ogbomoso, Sheet 222) of scale 1:100,000. The fundamental characteristics of these imageries are given in Table 1.

Data processing: In this study the change detection method employed is that of individually classifying each image through supervised classification and registering the results to locate those pixels that have changed their landcover classification between any two selected image dates. The Nigerialsat-1 imagery, available for the study having a spartial resolution of 32 m, was resample to be of the same resolution (28 m) as the landsat imageries. Composite bands 5, 4, 3 were formed (for the Landsat imageries) using ArcGIS 9.3 software. The extracted imageries (clipped/subset with a shape file) of the study area were then exported as TIFF for further processing, in the IDRISI 17.0 software environment. The exported imageries were imported and then converted into the IDRISI (raster) format. The identified classes on the imageries were water body, shrub and arable land, built-up and bare land. Supervised classification was done on each imagery using maximum likelihood algorithm, after which the results of 1990 and 2000 were cross-tabulated and the same was done for the results of 2000 and 2007 in order to show the transition pattern among the features.

The cartographic presentation of the land use and land cover types in map form was carried out using ArcMap software, version 9.3.

Determining the rate of urban expansion of Ogbomoso town: This involved the demarcation (digitizing) of Ogbomoso town boundary out of the built-up feature for 1990, 2000 and 2007 imageries in order to determine the areas (in km²). Afterwards, the Compound Interest formula adapted from Oyinloye and Adesina (2006) was used to determine the rate of expansion (r) of Ogbomoso town between 1990 and 2000, then between 2000 and 2007; the average of the rates was taken as the rate of expansion between 1990 and 2007. The compound interest formula was also used to project the estimated spatial expansion (P_n) of the town by the year 2020 and 2025. The equation is given as follows:

$$P_n = P_0 \left(1 + \frac{r}{100}\right)^d \tag{1}$$

Therefore,

$$r = 100 \left(\frac{P_n}{P_0}\right)^{\frac{1}{d}} - 1 \tag{2}$$

where,

- P_n : Projected Area (in km²)
- P₀ : Known Area (of a particular year)
- r : Rate of expansion (in %)
- d : Difference between years of P_n and P₀

RESULTS AND DISCUSSION

Dynamics of land cover pattern in the study area: Five major land cover types were identified in the study area. They are water body, shrub, arable land, built-up area and bare land. The classification result of 1990 imagery showed that water body occupied 1.2% of the study area; shrub, 34.4%; arable land, 57.8%; built-up, 6.4% and bare land, 0.2% of the study area (Table 2). The differences in the features' changes (in %) over the years is shown in Table 3. Figure 2 shows a map of the

Table 2: Computed areas and percentage of the LULC classes produced from maximum likelihood classification

	1990 (km ²)	%	2000 (km ²)	%	2007 (km ²)	%
Water body	3.0300	1.20	7.8400	3.10	9.3600	3.70
Shrub	86.990	34.4	89.520	35.4	34.140	13.5
Arable land	146.16	57.8	120.87	47.8	156.78	62.0
Built-up area	16.180	6.40	34.390	13.6	51.330	20.3
Bare land	0.5100	0.20	0.2500	0.10	1.2600	0.50
Total	252.87	100	252.87	100	252.87	100

Table 3: Difference in the features' percentages over years

	% in 1990	% in 2000	% in 2007	Difference (1990 and 2000)	Difference (2000 and 2007)
Water body	1.20	3.10	3.70	+1.9	+0.60
Shrub	34.4	35.4	13.5	+1.0	-21.9
Arable land	57.8	47.8	62.0	-10.0	+14.2
Built-up area	6.40	13.6	20.3	+7.2	+6.70
Bare land	0.20	0.10	0.50	+0.1	+0.40

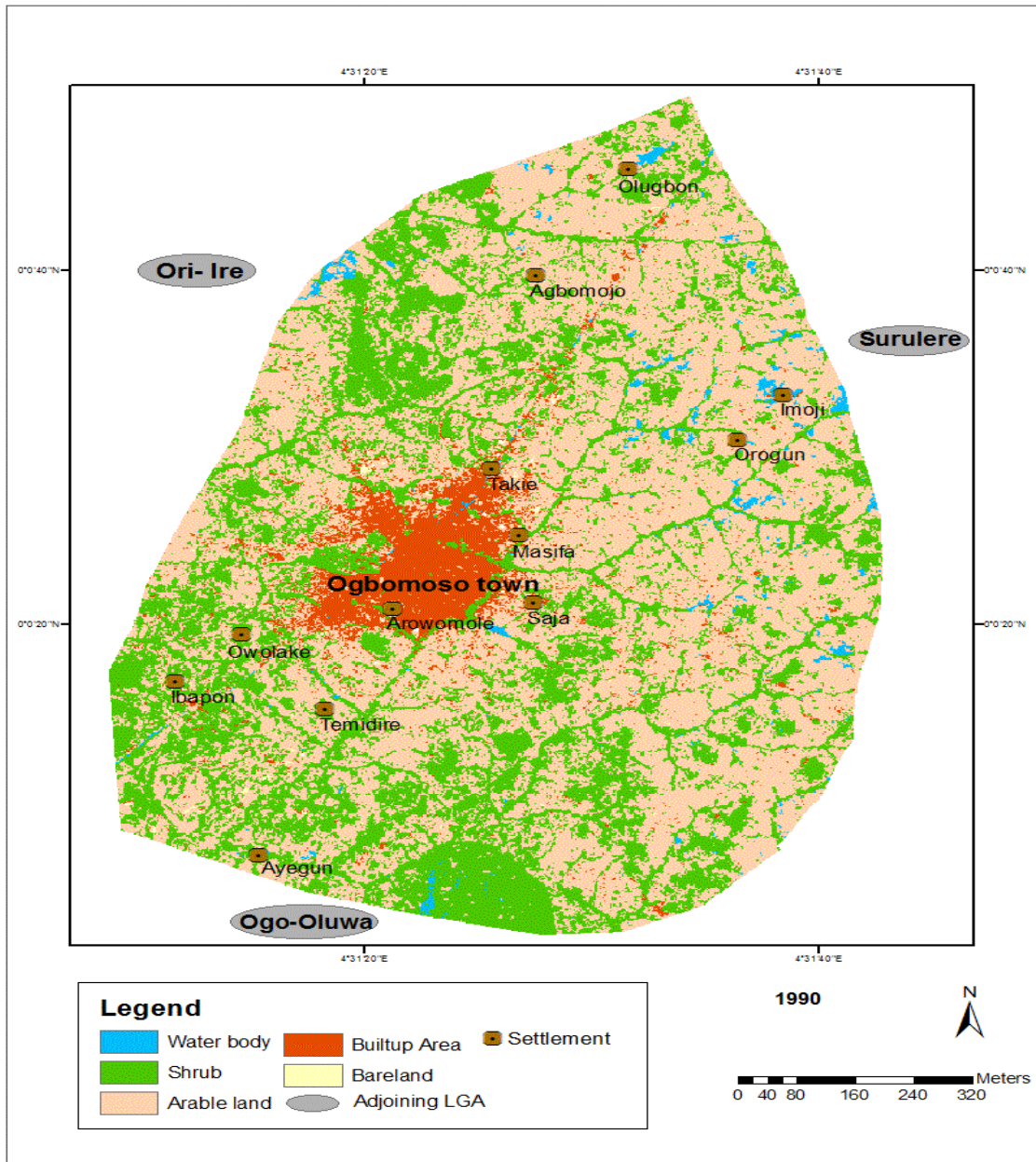


Fig. 2: Classified image of the study area-1990

classified imagery of 1990 while Fig. 3 and 4 presents the resulting maps of the year 2000 and 2007 imagery classifications showing the changes in the land cover features (classes). The summary of the features changes is illustrated with Fig. 5. Water body was slightly on the increase over the years of study. It increased to 3.1% in 2000 and 3.7% in 2007. Generally, variations in volumes of rain per year could result in variations of water retention in an area. The increase could also be due to water impounded (e.g., dams).

Shrub showed an unstable trend during the period of study. It increased to 35.4% in 2000 and declined to 13.5% in 2007. Though one land use affects the others,

it could be viewed that shrub availability would depend on the farming intensity in an area. When a portion of land is not tilled for farming and not being used for other activities, weeds and the like would in no doubt cover the portion in no time. In Table 2, farming (arable land) reduced, making the shrub to increase in 2000, it was the other way round in 2007 when arable land increased causing the shrub to reduce in size.

Arable land is the portion of land being cultivated for agricultural produce. Arable land in the study area declined to 47.8% in 2000 and picked up again in 2007 to 62%. Farming is very lucrative in Ogbomosho. Some of the crops grown in commercial quantity are maize,

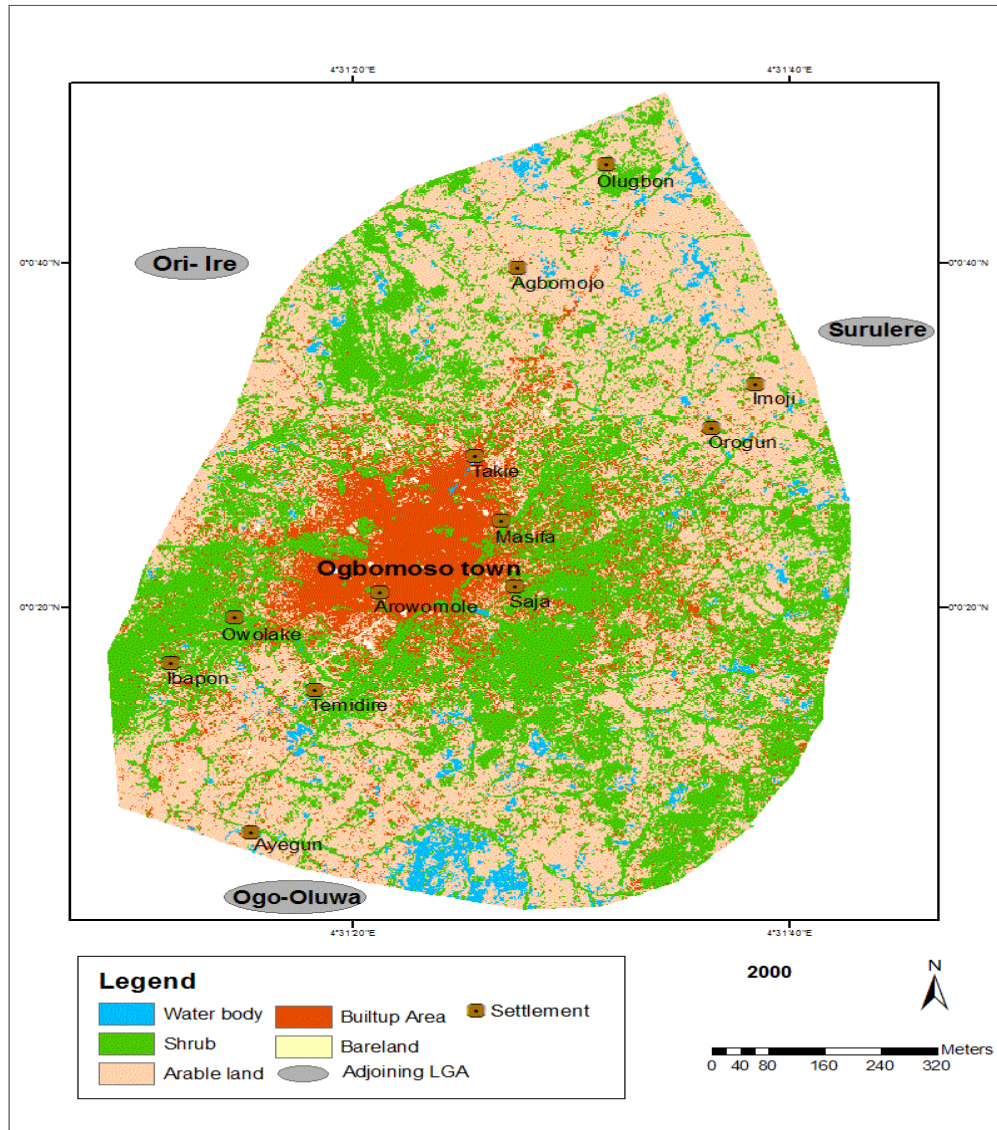


Fig. 3: Classified image of the study area-2000

guinea-corn, cassava, yams, among others. The settlement area kept increasing, in terms of spatial extent, over the years of the study. Starting from 1990 with 16.18 km² (6.4%) of the study area, rose to 34.39 km² (13.6%) in 2000 and 51.33 km² (20.3%) in 2007.

It has been observed that urbanization has been a driving force towards the rate at which a particular land use or land cover changes over time (Fabiya, 1999). This was acknowledged by Lambin and Geist (2006) as they believed that humans are increasingly being recognized as a dominant force in global environmental change.

Bare land could take several forms some of which are open land parcel, a piece of land cleared and prepared for planting and so on. Bare land in the study area had an area of 0.51 km² in 1990, declined to 0.25 km² in 2000 and rose to 1.26 km² in 2007.

Transition among the classes/features: The results of maximum likelihood classification of the multi-temporal images were cross tabulated using IDRISI software in order to view the transition trend and patterns among the classes. Cross tabulation module shows which class or feature transform to the other over a period of time. This gives a detailed account of the land cover transitions in a study area.

On the cross tabulation table, the columns consist of the classes of the earlier year while the rows represent the classes of the recent year. For the purpose of discussion, a cell (the intersection of a column and a row) name shall be given in order of “column, row”. Cell 2, 1 will therefore mean cell of second column and first row on the cross tabulation table; Also, cell 4, 3 will refer to the cell of fourth column and third row.

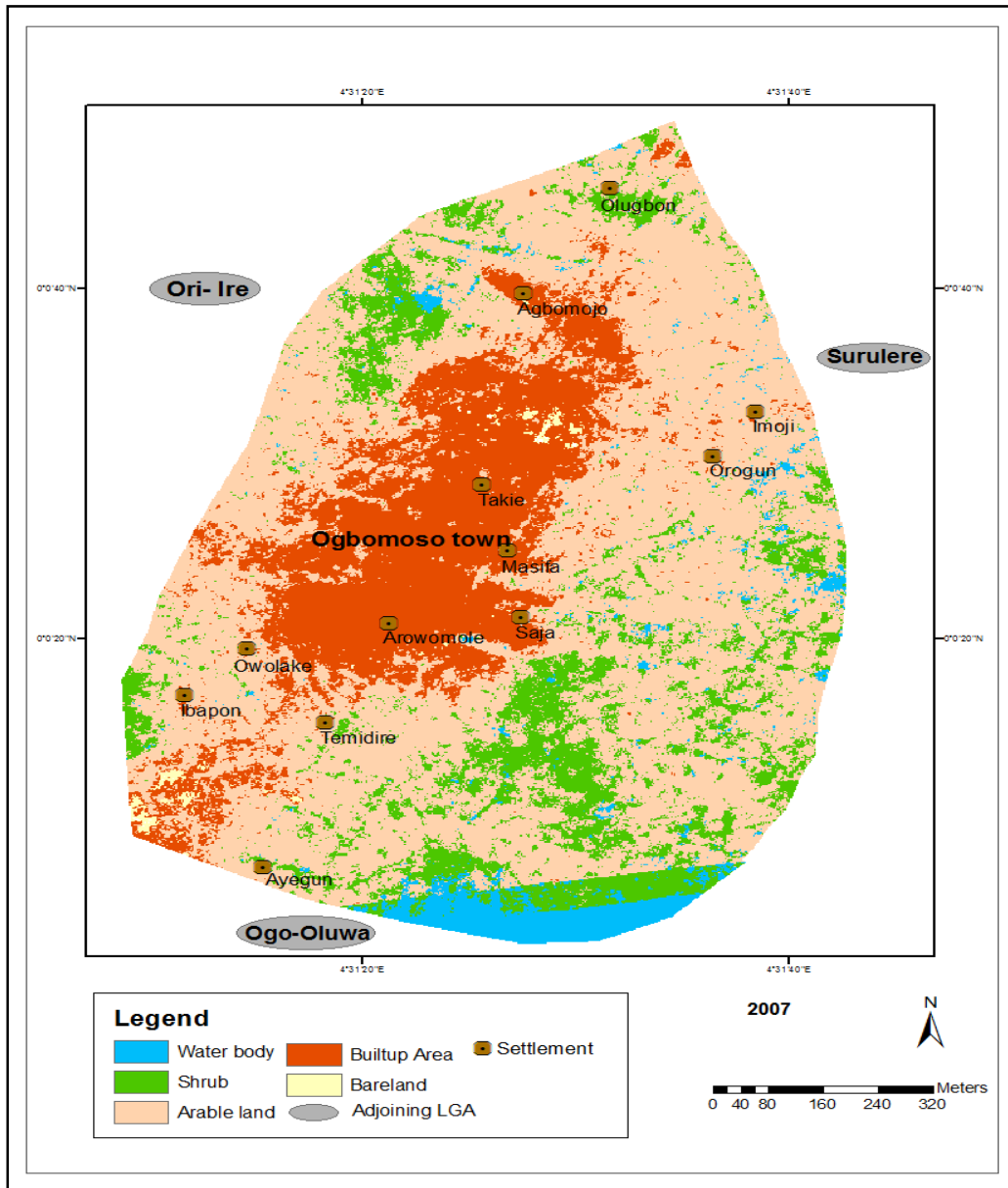


Fig. 4: Classified image of the study area-2007

Table 4: Cross tabulation of the imagery classification results of 1990 and 2000

2000/1990	Water body	Shrub	Arable land	Built-up	Bare land	Total
Water body	1337	16500	15935	369	26	34167
Shrub	3645	202272	176908	6775	393	389993
Arable land	7350	135222	369980	10911	1497	524960
Built-up	819	24424	71369	52093	580	149285
Bare land	0	195	830	163	49	1237
Total	13151	378613	635022	70311	2545	1099642

Table 5: Cross Tabulation of the imagery classification results of 2000 and 2007

2007/2000	Water body	Shrub	Arable land	Built-up	Bare land	Total
Water body	7215	10930	20998	1169	0	40312
Shrub	5895	76501	57611	6695	63	146765
Arable land	18654	241529	356664	54845	507	672199
Built-up	1679	54098	77847	85349	617	219590
Bare land	19	1114	3444	694	51	5322
Total	33462	384172	516564	148752	1238	1084188

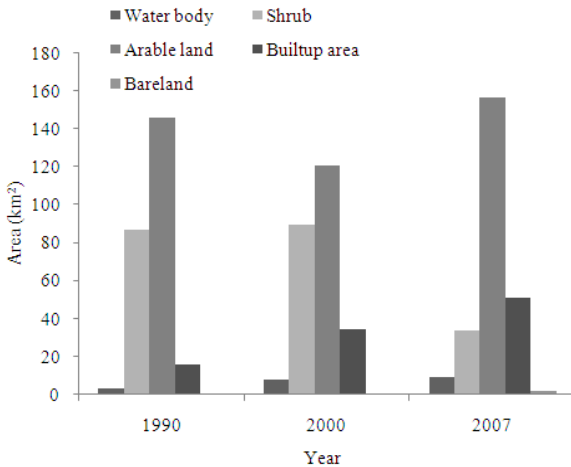


Fig. 5: Bar chart illustrating the LULC changes in the study area, 1990-2007

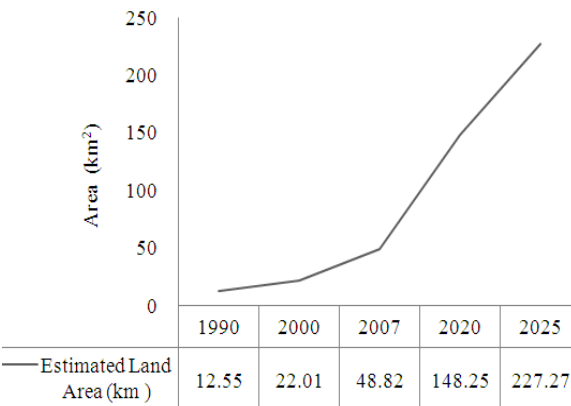


Fig. 6: The chart illustrating the urban growth of Ogbomoso Town (Year 1990-2025)

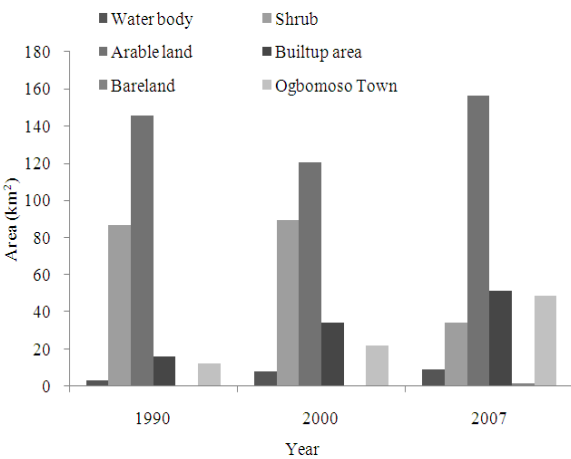


Fig. 7: The chart illustrating the classified features and the Demarcated Ogbomoso town (1990-2007)

Transition among the features of 1990 and 2000: As given in Table 4, where the columns represent the classes of 1990 while the rows represent the classes of

Table 6: Urban growth of Ogbomoso Town, 1990-2025

Year	Estimated Land Area (km ²)	Expansion rate (%)*
1990	12.55	-
2000	22.01	5.78
2007	48.82	12.05
		Average: 8.92
Projected Estimated Land Area*		
2020	148.25	8.92
2025	227.27	

*: Using compound Interest

Table 7: Areas of the classified features and the demarcated Ogbomoso town

Feature	1990 (km ²)	2000 (km ²)	2007 (km ²)
Water body	3.03	7.84	9.36
Shrub	86.99	89.52	34.14
Arable land	146.16	120.87	156.78
Built-up area	16.18	34.390	51.330
Bare land	0.510	0.2500	1.2600
Ogbomoso town (demarcated)	12.55	22.010	48.820

2000, the cell values are number of pixels that transform from one feature to another. In cell 2,2 a total number of 1337 pixels that were classified as water in 1990 land cover map still remained as water in the 2000 map. In cell 2, 6 no portion of water body on 1990 transform to bare land in 2000. Moreover an area of bare land that is an equivalent of 1497 pixels in 1990 changed to arable land in 2000 (cell 6, 4).

Transitions among the features of 2000 and 2007: In Table 5, the transitions among the features of 2000 and 2007 are given. Shrub portion of 1114 pixels in the year 2000 map transformed to bare land in 2007 map. It could be seen from the table that no portion of the bare land in 2000 changed to water body in 2007. It is remarkable to see that out of the total 3,484,172 pixels of shrub in 2000 a larger portion of shrub transform to arable land in 2007 (with 241,529 pixels) while only 10930 pixels of shrub remained unchanged in 2007. This is the clue behind shrub declining from 89.52 km² in 2000 to 34.14 km² in 2007 and the arable being 120.87 km² in year 2000 expanding to 156.78 km² in 2007.

Urban expansion of Ogbomoso town: The average rate of expansion of Ogbomoso town between 1990 and 2007 is 8.92% using the adapted Compound Interest formula Eq. (2), Table 6. This rate of urban expansion is significantly high in a third world country like Nigeria where provision of social amenities and infrastructural planning are, to say the least, very poor. Consequently the estimated land area of Ogbomoso town Eq. (1) by the year 2020 is projected to be 148.25 km² while that of the year 2025 is 227.27 km²; Table 6 and Fig. 6.

An overall view of the LULC features classified in the study is shown in Table 7. Figure 7 is an illustration of the information captured in that regard.

CONCLUSION AND RECOMMENDATIONS

Conclusion: The study has addressed geospatial assessment and monitoring of the dynamics of urban expansion of Ogbomoso, South-Western Nigeria. The aim of which is to use Remote Sensing and GIS technology to have knowledge of the urban expansion of the city. Guiding objectives are to evaluate the LULC characteristics of the township and environs (Ogbomoso North and South LGAs); secondly, to assess the urban development of Ogbomoso town between 1990 and 2007; and thirdly to determine the rate of urban expansion of Ogbomoso. Synergy was formed with Landsat imageries of 1990, 2000 and 2007 of the environment. The datasets were subjected to supervised image classification using IDRISI software, version 17.0 (Selva edition). Results for 1990 and 2000 as well as 2000 and 2007 classifications were cross-tabulated for LULC change detection. The Compound Interest equation was used to determine the rate of urban expansion in Ogbomoso town and the expansion of the town was projected for the year 2020 and 2025. It could be deduced from this study that the settlements in the study area kept growing (spatial expansion) which is as a result of the rapid increase in population. The rate of urban expansion in the study area was found to be significantly high.

Recommendations: At the rate of urban expansion of Ogbomoso town, there is need for:

- Proper urban planning so as to avoid the current infrastructural failures in the town
- Urban restructuring to change the Northeast-Southwest expansion pattern along the principal (trunk A) road from Ibadan to Ilorin
- Ogbomoso, being a major stop-over for the food crop merchants from the Northern part of Nigeria, which trade in beans, groundnut, millet, guinea corn, onion, sugarcane, tomato, pepper, sorghum and some vegetables (carrot, cucumber, watermelon, etc.), there is need to create two major vehicle parks; one in the Northern part and the other in the Southern part of the town to avoid traffic congestion which sometimes culminate in total road blockage.

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