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Remote Sensing and GIS Assessment of a Typical African Urban City: A Case Study of Ibadan, Nigeria

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ABSTRACT

Ibadan, a typical West African City, emerged from a traditional rural land use as a result of its socio-economic, educational, traditional and political uses. The perceived rapid growth of the now peripheral areas from the core Central Business District (CBD) tends to undermine a regimented planned land use system and as such constituting a menace to government zoning plans. This paper, therefore, synthesizes three epochs remotely sensed satellite images: 1972 Landsat (MSS), 1986 Landsat Thematic Mapping(TM) and 2000 Landsat Enhanced Thematic Mapper (ETM+) obtained from the USGS glcf website to examine the observed changes in land cover and land use pattern as well as urban growth process in Ibadan. GIS and remote sensing methods were used for image-processing, classification, and results from analyses. The study showed that in 1972, the buildup was 107 km2, it increased to 192 km2 in 1986 and almost doubled in 2000 (381 km2). The 2010 projection was 760 km2 and it is projected to 1520 km2 in 2020. The study further indicates that the city follows a trend of doubling in area size at least in every ten years. Decongesting the CBD through the provision of social amenities in the proximal urban fringes and rural areas are considered the most potent ways to remedy the seemingly urban menace.

Keywords: GIS,Landcover/Landuse, Remotely Sensed Imageries, Rural- Urban, Urban Growth

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Introduction

Urban growth is a process of human agglomeration in multi-functional settlement of relatively substantial size (Mabogunje, 1985). The process also refers to growth in size and numbers of urban centres (Ujoh, Kwabe and Ifatimehin, 2010). This process, as explained by Adesina (2003), is responsible for transforming towns, cities and metropolitan areas, while at the same time depopulating the rural setting through a process of direct rural-urban migration. Adegun (2011) affirmed the level of urban growth as the share of a country's total population that lives in urban areas. Thus, the extension of the urban environment in terms of territorial coverage and population has remained a common experience all over the world. The proliferation of urban centres has been phenomenal from the turn of the 20^{th} Century and urban growth has become a critical issue to most national governments the world over (European Environment Agency, 2006; Ujoh, et al., 2010).

The concern about the enhancement of urban quality has led to several global summits organized at various levels of government and international agencies, including the United Nations. Specifically among such are, the Millennium Development Goals (MDGs) Summits, the 2002 world summit in Johannesburg and the 2005 La-Havana United Nations (UN) sustainable cities documentation of experience programme among several others (Jiboye, 2011). In each of these summits, member nations reiterated the need for good and effective governance as a means of achieving sustainable development in the cities (Oladunjoye, 2005 and UNDPI, 2008). In explaining and rationalizing this global developmental issue, World Bank Report in 2000 and another of the International Monetary Fund in 2006, had reaffirmed that about 66 percent of the world's population lived in the countryside in the early 1950s; however, current estimate by the United Nations has put the world population at 6.572 billion people, of which 3 billion (about 50%) now live within the urban areas and by 2030, about 61 percent of the world population is projected to live in the cities and this growth is expected to occur mainly in developing countries such as Nigeria (UNCHS, 2007; UNFPA, 2007; Daramola and Ibem, 2011).

While continents like Europe and America have stabilized their urban population growth and economy to a large extent, most countries in Africa, Asia and Latin America, are still grappling with the challenge of ensuring a decent livelihood to their citizens. In a typical African setting, settlement expansion is gradually and, in some cases, rapidly encroaching into the proximal rural farmlands thereby overwhelming the natural environment and destroying the ecosystem. For example, housing developments on the rural-urban fringes have been happening at a very fast pace, often spontaneous, without much planning and coordination. The consequences of such over-sized, uncoordinated growth of the sub-urban area include negative ecological effects, massive traffic problems, inadequate and lack of infrastructural provision (Balogun 2007; Oyinloye, and Fasakin, 2014). This development has created great challenges for not only the government at various levels but also stakeholders and other interest groups in the country especially in the area of transportation networks, potable water supply, sanitation, effective and efficient waste management, elimination of social conflict and crime.

In addition, urban growths in most African cities have generated serious environmental menaces and concerns for both the governments and interested stakeholders. These menaces are more prominent in the developing urban centres and fringes, where growth and development of settlements have proven difficult to monitor because of relatively lower technological status compared to many developed countries in Europe and America. Notable among these menaces include the problems of urban slum resulting from congestion of unplanned settlements, deficit in accommodation, over-stretched and poorly maintained facilities, traffic congestion, undirected drainage systems and environmental health challenges resulting from urban heat island and poor waste management (Onokerhoraye, 1976; Ravalin, 2007; UN-Habitat, 2007; Olusola, 2012). In Nigeria, the uncontrolled and unplanned urban growth has further brought severe socio-economic, cultural and environmental problems (Onokerhoraye, 1976; Jiboye and Omoniyi, 2010; Ayedun, Durodora and Akinjare, 2011). These problems, no doubt, are very essential to the characterization of the health status of any settlement for which Ibadan City is no exemption.

Ibadan City (Figure 1) is located in the south-western part of Nigeria. It lies approximately on longitudes 3º 5' to 4º 36' East of the Greenwich Meridian, and latitudes 7º 23' to 7º 55' North of the Equator. Ibadan is located at a distance of 145 km north of Lagos (Ayeni, 1994).

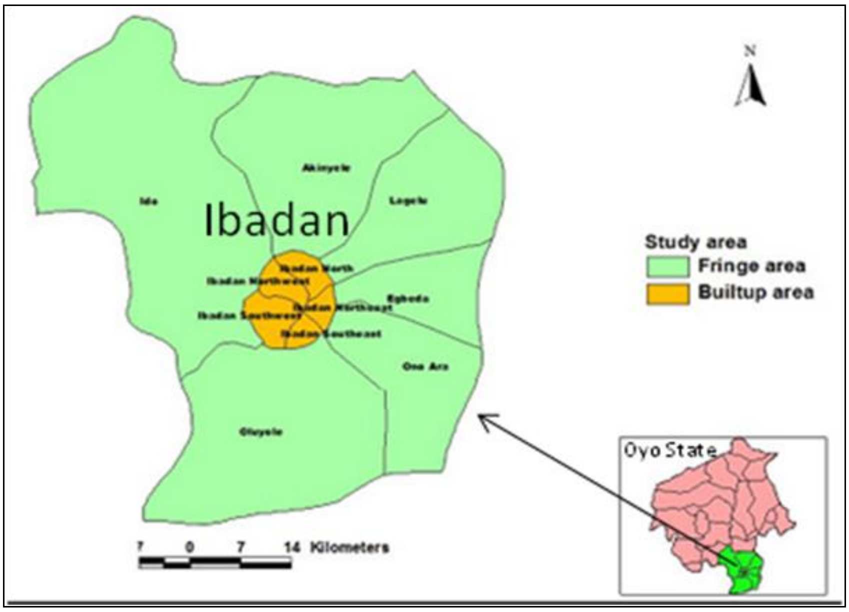

Figure 1: Study Area

In the early 80s, Ibadan metropolis covers about 250 km² of the area. The 2006 population census put the total population of Ibadan to 2,550,593 while the average population density was 828 persons per km² (NPC, 2006). The total population size of the wider Ibadan region was 1,258,625 in 1963 and 1,991,367 in 1991 (Afolayan, 1994). The population size of Ibadan urban was 627,379 in 1963 while that of Ibadan rural was 631,246. However, the development in the core area of the city has encroached and taken over most of these villages that surround the area. The growth of Ibadan is another classical example of African urban growth. Previous studies based on aerial photography at scale 1:25,000 shows that by 1973, the total land area of Ibadan had increased to about 112 square kilometres (Adediran, 1984; Onibokun, 1988a). All farmlands, fallow lands and river flood plains within the city had been built upon. The continuous development of the hitherto undeveloped area is a cause for concern.

According to Mabogunje and Robert (2004), the application of urban growth models in examine settlement expansion is in its infancy in Africa. One of the significant bottlenecks in addressing urban growth issues in the continent using these models is the dearth of data or information. This could be the result of unavailability of appropriate databases, unreliability of existing information, and lack of economic resources for research and data collection. As a result of lack of precise monitoring mechanisms in mapping urban growth, the application of remotely sensed and Geographic Information (GIS) technique have been adjudged as the most reliable method especially in obtaining geographic data in physically inaccessible terrain where hostilities, relief and bad topography constitutes a big problem (Mschelia, 1986; Ayeni, 1994; Congation, 1998; Shefali, 2000; Jiboye and Omoniyi, 2010).

The Canadian Centre for Remote Sensing (CCRS, 1992) defined Remote Sensing as a group of techniques for collecting image or other forms of data about an object from measurements made by satellite sensor at a distance from the object, and the processing and analysis of the data. Similar definitions include those of Congalton (1996), United Nations (2000) and Sabins (2001). The general remote sensing image forming process and analyses are well illustrated and discussed by Shefali (2000). The timely detection of trends in landuse change and a quantification of such trends using remotely sensed data and GIS techniques are of specific interest to planners (Olujimi, 2009). The Landsat TM for example is built to record radiation in only some parts of the electromagnetic spectrum - these parts are known as bands (Boyd, 2005). The TM records the reflectance or emittance for each of its band. It does this in a digital format, 0 for no radiation reflectance and 255 for the maximum. These numbers are then transmitted to the earth and are used to construct remotely sensed images (Cushnie, 1987; Jensen, 2007; Balogun, 2007). In using remotely sensed image data, an interpreter in a Geographic Information System (GIS) or remote sensing environment uses the elements of tone, texture, pattern, colour, shape, size, shadow, site and association to derive information about land cover (Mschelia, 1986). This important property of matter makes it possible to identify different substances or features and separate them by their spectral signatures or spectral curves (Chukwu, Ijeh, and Olunwa, 2013). Newer satellite imaging systems are commonly equipped with enhanced instruments to generate additional data that permit more accurate mapping and analysis. Remotely sensed data enable scientists to study the earth's biotic and abiotic components. These components and their changes have been mapped from space at several temporal and spatial scales since 1972 (Salami and Balogun 2004).

Several studies have been conducted with the integration of remote sensing and GIS to capture, store, retrieve, manipulate, analyze and present georeferenced geographic data of the environment. For instance, Arvind and Nathawat (2005) carried out a study on land use and land cover mapping of Panchkula, Ambala and Yamunanger districts of Hangana State in India. Sedigueh (2001) also used aerial photograph and satellite stereo images to provide an urban growth map in Singapore. The study revealed that there is an extensive urban growth within a period of ten years of study. Similar approach was found in Herold, Jessica and Richard, (2003) using a data set compiled from interpreted aerial photography and IKONOS imagery of Netherlands. Likewise, Moeller (2005) used satellite images (ASTER, ETM+, TM, MSS) from different sensors to analyze growth directions and distances in Kenya. They observed that the spatio-temporal form or changes of urban physical growth was progressive and at the same time goes along with socio-economic growth. As a proof-of-concept, this paper aimed at analyzing the trend of urban growth of Ibadan City and the amount of changes that have occurred using remotely sensed data and GIS analyses techniques.

Materials and Methods

Data are observations we make from monitoring the real world, collected as facts or evidence that may be processed to give them meaning and turn them into information (Heywood, 1995). Since the nature of land use and land cover monitoring requires images of different time period, change detection analysis is carried out most effectively with not less than three images. Topographic map was used to have a general idea about the study area. Three remotely sensed data from the United State Geological Services were downloaded from the Global Land Cover Facilities (glcf) website. The images included the 1972 Landsat Multispectral Scanner (MSS) (which was resampled to 30m), the 1986 Thematic Mapper (TM) and the 2000 Enhanced Thematic Mapper plus (ETM+) images with spatial resolution of 30m respectively. The images covering the study area were used to monitor the urban growth for three periods (1972, 1986 and 2000) giving a total period of 28 years under review. The image processing and analyses procedure includes image composite creation and display using Idrisi 32 software, image enhancement and classification scheme design, training site selection (Table 1) and image classification using the maximum likelihood algorithm, results analyses. The supervised image classification was performed on false colour composites into the following land use and land cover classes: builtup area, thick vegetation, light vegetation and exposed rock outcrop. Information collected during the field surveys was combined with the digital topographic map to assess the accuracy of the classification.

Table 1: Training Sites interpretation

S/N	**LULC Classes**	**Description**
1	Built up area	Area occupied by people for habitation
2	Bare Land	Open spaces
3	Vegetation	Area of farming activities forest
4	Rock Outcrop	Area of hard mineral aggregate

Source: Researcher field work, 2015/16.

Results and Discussion

Figure 2 shows the results of the three epochs examined in the study. Explicitly shown are the observed urban growths in red. The deep green represents the thick vegetation, light green is the light vegetation (including farm lands), and grey represents the rock outcrops. Since the focus of this study is the urban growth, shown in Table 2 is the changes within the 28 years examined. The study reveals that, as expected, the increasing demand for accommodation, business locations, land for social, academic, political and all other sundary services are partly responsible for the increase in land area size of the built up from 107 square kilometers in 1972, to 192 square kilometers in 1986 and the observed drastic increase to 381 square kilometers in 2000.

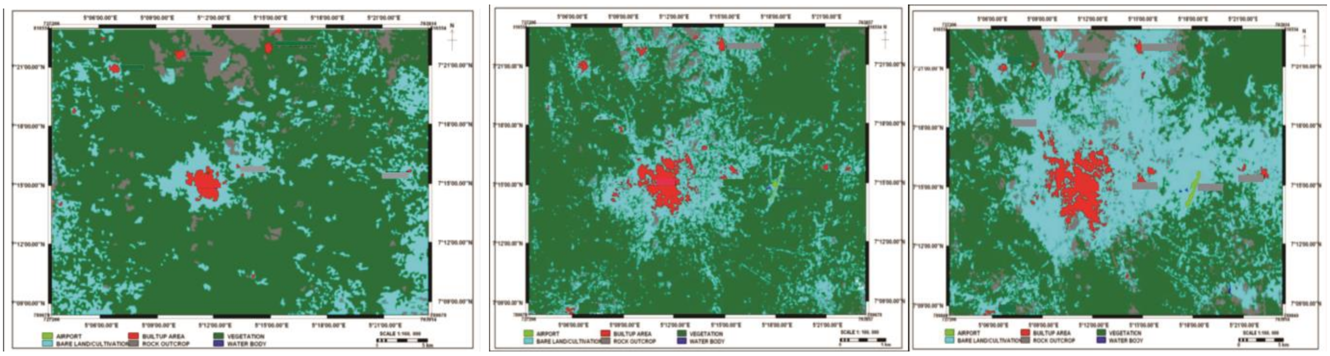

Figure 2: Urban growth analyses

Table 2: Percentage change in buildup landuse/lancover: 1972, 1986 and 2000

S/N	year	Build-Up Area in Square Kilometres
1	1972	107
2	1986	192
3	2000	381

Source: Researcher field work, 2015/16.

Table 2: Projection in buildup landuse/lancover: 2010 and 2020

S/N	year	Build-Up Area in Square Kilometres
1	2010	760
2	2020	1502

Source: Researcher field work, 2015/16

The findings as shown in Table 2 and figure 2 respectively have shown that urbanization has led to the degradation and consequent alteration of the ecosystem thus, the observed deforestation and environmental deterioration of plant covers. This in itself is a blight not only affect the forest ecosystem but also the health quality of the urban space economy as well as urban health island. No doubt, there will be increase in urban temperature and the corresponding noise pollution from increased population due to vehicular traffic. The implication of the observed persistent increase in urban builtup is that more social facilities and basic infrastructures will be needed. However, going by the lack of maintenance culture of existing facilities in most traditional African cities, there is the likelihood of having an urban centre that cannot boast of meeting the needs of her geometrically increasing population size. In other words, if there are no corresponding provisions for the teeming population size, there are the possibilities of experiencing urban slum due to tragic rural-urban migration occasioned by the perceived greener pasture in urban centres. In addition, there will be increase in collapse of available infrastructures as a result of over usage without appreciable repair or replacement. Another very fundamental menace may include increase in urban crime, debilitating health challenges due to presence of stagnant pools of water, occasional urban heat island due to continuous development into the peripheral neighbourhood. Also, there will be some environmental challenges such as flood, erosion, and blockage of sewers/culverts. Another implication of the findings is that in similar cases, the need to meet the daily menace of traffic congestion with its attendant incivilities that heralds most public transport managers (cab owners, drivers and conductors) is further brought to the fore in view of the ever increasing demand of passengers. The above observed urban menaces if not properly managed now will further worsened in view of the projected urban growth (Table 2) which has seemingly doubled from 381km^2 in year 2000 to 720km^2 in year 2010, and from 720 km^2 in year 2010 to 1502 km^2 in year 2020.

Conclusion

Research findings show that while cities in Nigeria, as in other developing countries, have been growing at a very rapid rate, there has been no commensurate growth in the rate at which social services and infrastructural amenities are provided. The result has been a gradual decline in the quality of the environment and in the quality of life. Educational facilities such as primary, secondary and tertiary schools have not been able to accommodate the sharp increase in the number of pupils and prospective students. The ratio of population to health facilities such as dispensaries, maternity homes and hospitals is unfavourable. Health facilities are neither well staffed nor adequately equipped. The same findings apply to housing, employment opportunities and crime prevention facilities. The pattern and trend of the characteristics of urban growth in Nigeria, as evidence in this paper calls for measures aimed at: (a) monitoring the growth of the city; (b) controlling the rate of rural-urban migration; (c) improving the quality of life in both urban and rural areas, and (d) training of planners and administrators to acquire more knowledge in the use of GIS and remote sensing techniques to enhance efficiency in urban growth analysis, monitoring and management as this is the crux of technological advancement in the 21st Century.

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