MONITORING URBAN GROWTH IN KADUNA METROPOLIS BETWEEN 1986 AND 2007 USING POST CLASSIFICATION COMPARISON CHANGE DETECTION TECHNIQUE

By

[a] Ahmed, M., [a] Mohammed, M. U., [a] Lamido, S. S. [b] Zubairu, S.M. [b] Abubakar, S. and [c] Dalhatu, Z. M.

[a] Department of Geography Bayero University, Kano
[b] Department of Geography, Ahmadu Bello University, Zaria
[c] Department of Urban and regional planning, Nuhu Bamalli Polytecnic, Zaria

Corresponding author's Email: ma7766554@gmail.com

ABSTRACT

Monitoring the rate of growth of many Nigerian urban centres have become intractable due to dearth of adequate skill and tool which urban planners can use .In recent times Remote sensing and Geographic Information System, of which post classification comparison change detection technique is a component, have been resourceful in monitoring urban growth which efficacy is examined in this study. This study identifies and maps the growth of Kaduna Metropolis between 1986 and 2007. The rate of change is examined in order to ascertain and monitor urban expansion. Satellite images of two different dates (1986 and 2007) were used in this study. Analytical procedure, such as geometric correction, image to image core registration maximum likelihood supervised Image Classification technique was performed in order to achieve the aim of the work. The extents of urban growth were presented in tabular forms. The result shows that the total urban of Kaduna metropolis area increased by 193,565ha between the periods of study. The built up area increased at the rate of 0.01% in every year. The paper recommends the use of GIS as a tool for not only monitoring but planning urban development in cities with similar growth characteristics in Nigeria.

Key words**:** Urban growth, Change detection, Post Classification Comparison, Kaduna Metropolis

INTRODUCTION

Urban growth refers increase in population or expansion of an urban area or community. The pace of urban population growth depends on the natural increase of the urban population and the population gained by urban areas through both net rural-urban migration and the reclassification of rural settlements into cities and towns. According to the United Nation report in 2006, the global urban population has quadrupled since 1950s, and cities of the developing world now account for over 90 percent of the world urban growth (UN-Habitat, 2006).The World Health Organization (WHO) in 2007 stated that one hundred years ago, 2 out of every 10 people lived in an urban area. By 1990, less than 40% of the global population lived in a city, but as of 2010, more than half of all people live in an urban area. By 2030, 6 out of every 10 people will live in a city, and by 2050, this proportion will increase to 7 out of 10 people. Currently, around half of all urban dwellers live in cities with between 100 000 - 500 000 people, and fewer than 10% of urban dwellers live in megacities (UN-Habitat, 2006). Management of urban space requires spatially accurate and new information on land use changing patterns. It also involves

monitoring to provide the planners and decision makers with information about current state of development. If changes are permitted to develop without proper monitoring may lead to urban environmental deterioration. It is difficult to monitor large urban environment using traditional method which is even expensive and time consuming. With the advent of GIS and Remote Sensing techniques, urban land use and growth can be detected with great ease and in no time. GIS and Remote Sensing technique provide an easy and speedy way of updating, analyzing and integrating data which is cheaper and even more accurate compared to the traditional method of carrying out land management, especially when regular monitoring and updates are needed (Abhas, *et al*, 2012).

Many urban areas in Nigeria have witnessed remarkable expansion, growth and developmental activities such as building, road construction, deforestation and many other anthropogenic activities, like the agricultural, housing, transportation etc. Falade (2003) stated that many factors are responsible for the invasion of people to a particular region within a geographical location; some of this factor includes education, employment, housing etc. This emigrational factor often results to over urbanization, which constitutes a "strike back" effect on the environment. This issue has therefore resulted in increased land consumption, modification and alterations of land cover over time.

Mabogunje (2002) as cited in Omojola and Amen (2013) lamented that substandard and inadequate housing, slums, and lack of infrastructure, transportation problems, low productivity, poverty, crime and juvenile delinquency. Urbanization, according to him is the root cause of the high rates of environmental degradation, pollution and social delinquency and Nigeria ranks 151st on the Human Development Index of 177 countries worldwide. Increase in the urban population has resulted in the proliferation of slums and informal peri-urban settlements otherwise known as shantytowns (Omojola and Amen, 2013). The shantytowns as described by Aina (1990) are deprived settlements characterized by excessive residential densities, largely uninhabitable housing and the absence of sanitation, basic infrastructure and social services. They harbour migrants from the rural areas who are unable to fit into the economy of the city and so tend to find solace in informal activities and crime. The proliferation of these shantytowns results in the unwieldy expansion of the urban centers which poses a major planning problem as provision and management of roads, drainage and sewage systems among other infrastructure proves very difficult. Even though, problem of housing is universal (Lawanson, 2005).

The application of GIS and Remote Sensing coupled with database management systems has helped in quantifying, monitoring and modeling by predicting the rate of development and growth within a giving location (Civco *et al*., 2002). Akpu (2012) analyzed the spatio-temporal growth of the Kaduna metropolis using the direct digitization approach and the result shows that the growth and development is heading towards the areas liable to flood particularly around Nassarawa site which are closer to the flood plain. This study therefore monitored the expansion of Kaduna Metropolis using post image classification technique that classifies image based on pixels values. The work focus is between 1986 and 2007.

STUDY AREA

The study area is Kaduna Metropolis which is urban space formed by four local government areas (LGAs). These are Kaduna North LGA, Kaduna south LGA, and parts of Igabi and Chikun LGAs respectively (Fig.1). Previously a small town during the pre-colonial era, Kaduna became the colonial capital of the Protectorate of Northern Nigeria. From this colonial

capital status, it became administrative, educational and political centre with other trappings of urbanization whose growth overtime has captured adjoining rural settlements to become a metropolis. Kaduna metropolis is located between latitudes 10^0 17' 46''N and 10^0 54' 56''N and longitudes 7^0 16' 15''E and 7^0 45' 36''E. The population of Kaduna metropolis has undergone tremendous increase over the years. For instance in 1952, the town had a population of 40,000 which increased to 149,910 in 1963 while according to Olisemeka and Salim (2011) the area had a population of 1,570,331 in 2006 and 49 percent of the population was female. By 2015 the city is expected to have 2,057,078 people inhabitants (Federal Republic of Nigeria, 2009b).

The mean annual rainfall is about 1525mm and the length of the rainy season period is about 200 days. The mean monthly temperature reaches 28C in March and drops to 23.3C in December. The vegetation is shrub savannah interspersed with orchard bush, which represents a degradation of the natural vegetation. The drainage network is dominated by River Kaduna flowing southwest to join the River Niger (Ishaya *etal*, 2008).

Kaduna is one of northern Nigeria's leading manufacturing centres, specializing in textile production, petroleum refining, vehicle assembly, brewing, food processing, and printing and publishing. Presently it is well connected and accessible through state and Federal highways and it still remains the heart beat of most economic activities in the northern Nigeria. Due to these urban characteristics, many people from adjacent rural and urban communities move to Kaduna hence increasing the urban space. Although paucity of data on urban-oriented migration is a problem for urban planners in Nigeria, observation reveals that the size of Kaduna metropolis has increased tremendously hence monitoring the growth will be useful for future planning and environmental management.

MATERIALS AND METHODS

Landsat image of 1986 (30m resolution) and Nigeria sat-1 of 2007 (32m resolution) were use for the study. Both of the two images were medium resolution and therefore appropriate for urban studies (Mathew and Fosterm 1992). The Landsat data was acquired from Global land cover facility website while the Nigeria sat-1 of 2007 was acquired from National Space Research and Development Agency (NASRDA), Abuja.

ArcGIS10.1 GIS software was used to perform all the analysis. Prior to analyzing the digitally acquired remotely sensed data for detecting the urban growth, some analytical procedures were used so as to avoid deriving inaccurate results. This is to ensure that errors introduced into the data during the acquisition process were corrected. The data were radiometricallly and geometrically normalized to represent the landscape as near accurate as possible (Duggin and Robinove, 1990). In order achieving the aims and objectives of this study, image extraction and conversion, Geometric correction and radiometric normalization, Image to image co-registration, Image classification system, Image classification, classified image comparison, and finally Change analysis were carried out.

Geometric correction and radiometric normalization

Geometric distortions are introduced into satellite acquired data because of certain factors such as earth's rotation during the satellite movement, the curved nature of the earth's surface, the angle of view of the sensing system, the topography beneath the satellite, change in altitude of the satellite during acquisition of the data and instability of the satellite platform (Lillesand and Kiefer, 1994; Campbell, 1996).

Distortion introduced into the data can be corrected using two main approaches which are; Image to map transformation, using control points or Image to image co-registration (Choe *et al*, 2011). This work image to image correction were adapted, this involves the registration of one or more satellite images of the same geometric and geographic location to a referenced image, such that all corresponding terrain features appear on the same location on the two images. Here, the Nigeria sat-1 image of 2007 was used as the master image to correct the second or uncorrected image of 1986 (Landsat). The second image is normally referred to as the *slave image*. Errors on the second image are corrected by relocating attribute features on the second image in accordance with the first image which is the reference image.

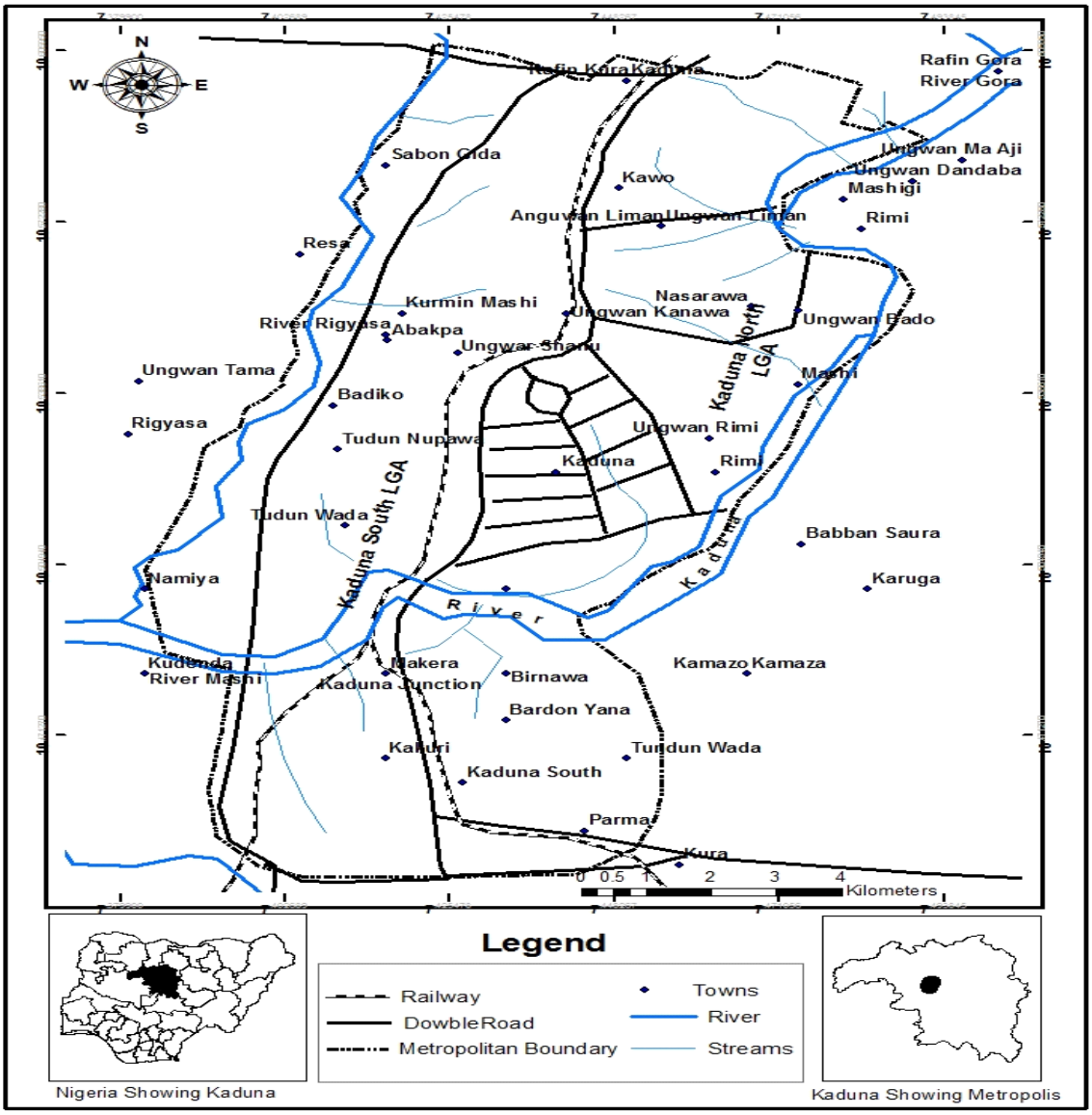

Figure 1: Kaduna Metropolis
Source: Min. of Environment, Kaduna State

Image classification system

The classification system adopted for this research was limited to two classes which are:
(1) *Non Built-Up Areas***:** This includes all areas that are not built, such as forest, farmlands, open land, bare surfaces, water body, grassland or water logged.
(2) *Built-up Areas***:** these are the built-up areas which includes residential, market areas, industrial areas, recreational areas (parks, gardens, etc), institutional areas (schools, banks, etc), roads, and social sentries (social clubs, hotels, motels, etc).

The classification was achieved using the Maximum likelihood supervised classification technique. This is a type of classification were the data is train first, and the training sites are used to classified the image. Higher resolution data (Google Earth data zoomed to lower level) was used as a referenced data to distinguish built-up areas which form the urban structures from non-built up areas (non urban land uses). Shape file were created in the ArcCatalog parts and given the datum of the imageries. The shape files were used to collect the signatures by using points as training sites. Both images and shape files were transformed to UTM CGS_Minna datum using spheroid Clarck_1880_RGS for the analysis.

Change Detection Technique

Classified image comparison or post classification is the most common method to change detection applied to multi-temporal satellite data (Jensen *et al*, 1993). In this method, rectified remotely sensed data are classified and later compared pixel- by- pixel based on the different classes of land cover. The results of changes are tabulated in change matrices showing the different classes of changes. The success of this method is that each image data must be classified as accurately as possible (Augenstein, *et al*, 1991). The advantage of the method is that it provides a (from- to) change class information of the change analysis (Jensen *et al*, 1993) However, its main disadvantage is that, in addition to aiming at high classification accuracy for each image, each individual image in the dataset has to be classified separately before comparison is made. The classified images of 1986 and 2007 images were cross tabulated to generate "from-to" images and cross tabulated table of the area. The two classified images were presented as figures 2 and 3.

To identify the rate of change, formula used by Yesseire (2009) was used:

The Change (Δ) = B (t_2) - A (t_1)

Where Δ change in hectare (ha), A is the areal extent of the built-up area in 1986 and B is the areal extent of the built-up area in 2007, t_1 is the earlier date and t_2 is the later date.

The extent of change in percent is ratio of change (Δ) to areal extent at the beginning of the study period (i.e. 1986). The rate of change per year is the ratio of extent of change to the time of study in years (i. e 21years).

RESULTS AND DISCUSSION

The relative distribution concentrations of the growth of the city between 1986 and 2007 are represented in tables 1. Areas were classified into built-up and non built-up area. Built-up areas include educational, health, and socio-economic facilities like games/sport viewing centers, stadiums and gymnasiums, shops and malls, residential area, market areas, industrial areas, recreational areas (parks, gardens, etc), institutional areas (schools, banks, etc), roads, and social sentries (social clubs, hotels, motels, etc. The non-built-up areas include all open space (non-cultivated land and rock outcrop), water bodies (rivers and streams), agricultural (cultivated and irrigated land) and any other land that has not been built-up.

Extent of the Metropolis in 1986 and 2007

Since the metropolis composes of urban land use which were classified as built-up areas in this work, the extent of the metropolis as at 1986 is 990353 ha (figure, 2). Like most cities, Kaduna metropolis expands within the period of the study. The extent of the metropolis increases from 990535 in 1986 to 1183918 ha in 2007. Indeed the expansion has been clearly shown by increase in population of the city. According to Olisemeka and Salim (2011) the population of the city in 2006 is 1,570,331 and is expected to reach 2,067,078 in 2015.The non-built-up areas are found to cover an area of about 78.2% in the year 1986 and 74 in the year 2007 which show a decrease. On the other hand built-up area covered about 21.7% in 1986 and 26% in 2007, hence there is increase in urban area as the non-built up area which form the non-urban used were taken over by built area forming the urban land uses (table 1).

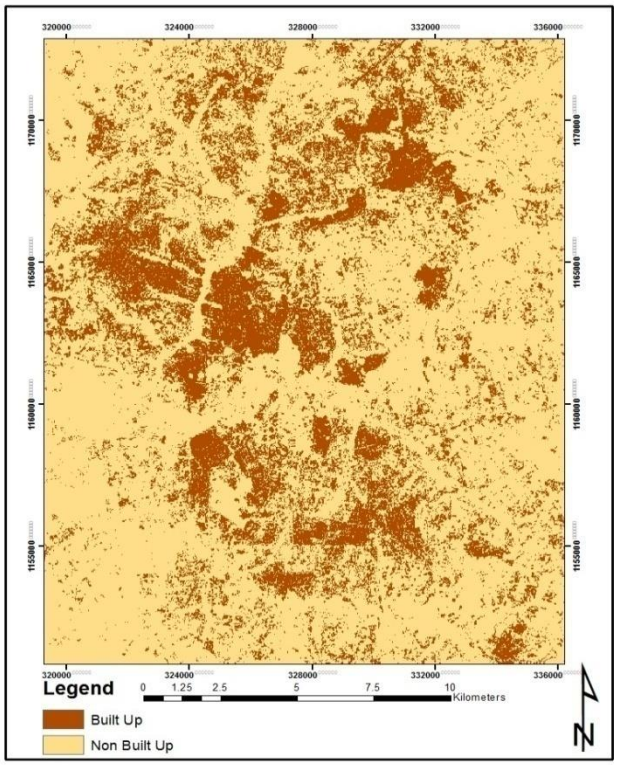

Figure 2: Classified image 1986

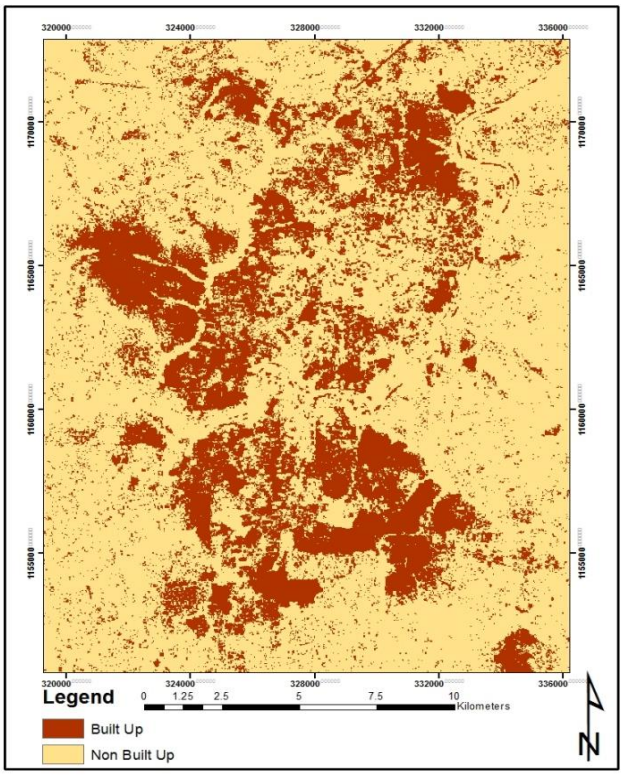

Figure 3: Classified image of 2007

Table 2 indicates that the land uses in order to find the changes (Δ ha), extent and rate of change that took place within the study period. The change between 1986 and 2007 in built up area is 193565 ha which shows an increment in built up areas within the period. The non built-up areas have decreased by same extent within the study period. The rate of expansion is about 0.010% per year.

Table 1: Land Use Change between 1986 and 2007

Land cover type	Area Covered 1986		Area Covered 2007	
	Area (ha)	%	Area (ha)	%
Built-up area	990353	21.7	1183918	26.0
Non-built-up area	3569134	78.2	3375549	74.0
Total	4561474	100	4561474	100

Source: Data Analysis

The extent and rate of the change were calculated from the table result and presented in table 2.

Table 2: Extent and Rate of Urban growth in Kaduna Metropolis (1986 and 2007)

Land Use	1986-2007		
	Change (Δ ha)	Extent (%)	Rate of Change(% /Year)
Built Up	193565	0.2	0.010
Non Built Up	-193585	-0.1	-0.003

Source: Data Analysis

The study area experienced an increase in population in areas around the metropolis, such as Hayin Rigasa in the western part of the city, Riga chikun in the northern part of the city, Sabon tasha and Gonin gora in the south, and Hayin Dan-bushiya in the eastern part of the city (the Kaduna millennium city). The city shows a pattern of suburbanization and ex-urbanization, where the inner ring or commuter belt grows at the expense of the urban core.

The analysis shows a huge growth of the city's suburbs since 1986. South of River Kaduna it is based on the growing industrial/employment opportunities. Ribbon development has also taken place along the major roads out of the city to the north, south- east and west in particular. It is obvious the sub-urban area shows a great sign of development as they change from areas that have no building, to areas that are built-up. Most of the lands at the out sketch of the metropolis are covered with Agricultural activities in 1986, but because of the population expansion, constructions and other economic forces which are regarded as the dominant influence of urban change the area are now occupied by urban structures The rate of change in the Kaduna Metropolis is also likely to be influenced by the rate of industrial activities in the area.

CONCLUSION

So far it has been possible to examine the urban growth of Kaduna Metropolis between 1986 and 2007. The results have shown that the city expands between 1986 and 2007 and this can be attributed to increase in human population, change in life style, urbanization and migration. The paper concludes by making the following recommendations:

Remote sensing and GIS can be used as a means for not only monitoring but planning of urban development in Kaduna metropolis and similar urban centres in Nigeria. It has become imperative that state urban development planning departments should include it in their toolkits particularly establishing Geographic Information System in their work domain.

Monitoring urban growth can reduce serious threat to other peri-urban farming activities since most of the land changed to built-up areas are farmlands and open spaces. There is need to control and monitor development because some of built-up areas are located on the water ways or stream channels and these can be liable to flood disaster. It is recommended that future studies can be carried out to know the detail changes and the impact of urban expansions on the environment.

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