

SPATIO-TEMPORAL ANALYSIS OF URBAN EXPANSION IN KATSINA LOCAL GOVERNMENT AREA, KATSINA STATE, NIGERIA

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ABSTRACT

This study aimed at investigating spatio-temporal dynamic of urban expansion in Katsina Local Government Area. Field survey, Administrative map of the study area, Global positioning system, (GPS), Landsat TM 1996 and ETM+ 2006 and Nigeria Sat X 2016 satellite imageries, were the materials and methods used for the study. Also, Remote Sensing (RS), Geographic Information System (GIS) and descriptive statistics were combined in analyzing the data. The results of the study showed a rapid growth in built-up land use from 1222.83ha (16.86%) in 1996 to 4784.77ha (70.16%) in 2016 with 4.09% (1996-2006) and 3.243% (2006-2016) annual rate of changes, whilst vegetation decreases from 6031.17ha (83.14%) in 1996 to 2035.43ha (29.84%) in 2016. Farmland on the other hand occupies an average area of 4086.33ha in the 3 periods put together. In view of the rate at which urban land use types is encroaching into other land uses, there is urgent need to evolve relevant policies of urban planning that will focus on the provision of site and services plots as well as monitoring of unplanned development.

Keywords: Analysis, GIS, LULC, Remote Sensing, Urbanization

1. Introduction

Urban expansion has played a vital role in human development and has been the focus of a wide variety of demographic, socio-economic and cultural responses, leading to a complex interplay of institutional,

technological, demographic and environmental factors which cause urban areas to be one of the most dynamic systems as well as the centre of both ecological, demographic and socio-economic problems

(Ndabula *et al.*, 2014). Bhatta, *et al.*, (2010) defined urban expansion as a spatial and demographic process that lead to the increased importance of towns and cities as a concentration of population within a particular economy and society. The concept of expansion includes spreading outwards of a city and its suburbs to its outskirts, to low density, auto-dependent development on rural land, excessive, gluttonous or ineffective urban space consumption in an uncontrolled manner, with its associated impact on urban spatial form, rate of land conversion and land use intensity (Hasse and Lathrop, 2003). Major features of urban expansion, include rapid unplanned development, ineffective use of land, chaotic land use pattern, low density and squatter settlements (Ifatimehin and Ufuah, 2007).

In the year 2000, urban settlements in the world consumed about 400,000 square kilometers (km²). The land taken up by cities amounted to some 3% of arable land, estimated at 14 million km² in the same year. More so, cities are now expected to grow 2.5 times in area by the year 2030, consuming some 1 million km², or 1.1% of the total land area of countries. They may possibly consume as much as 5-7% of total arable land, depending on the rate of urbanization (Anthrop, 2004). In the developed countries, the degree of urbanization is high, whereas the rate is low (Anthrop, 2004). A typical example is Hong Kong, United Kingdom and United States with the projected average rate of 0.07%, 0.88% and 1.02% respectively (Central Intelligence Agency [CIA], 2015). In contrast, in the developing nations, urbanization rate is highest and faster than that of the developed world (Lopez *et al.*, 2011). Africa is reported to have the highest rate. Countries like Burundi (5.66%), Uganda (5.43%) and Niger (5.14%) are good example. In relation to Nigeria with 4.66% projected average rate of urbanization (CIA, 2015), and

estimated population of 45 - 142.6 million between 1960 and 2006, and projected to reach 190 million in 2017, is considered one of the most significant and the highest in sub-Saharan Africa with rapidly urbanizing cities and a complex growth of settlement (NPC, 2006; Bakare and Oderinde, 2011; Worldometers, 2018).

A complex inter-relationship can be observed between the indicators of urban expansion such as land conversion, population growth, land use intensity and urban morphology with socio-urban use (Bhatta, *et al.*, 2010). For instance, increasing population following demographic trends if accompanied with poor land management can result to economic, demographic and environmental responses. These processes can in turn cast a larger urban shadow on the landscape than necessary because of externalities from adverse land use such as clearing of vegetation cover, development on fragile ecosystems such as floodplain, swampy land, and steep slopes especially as the poor move to the urban fringes or marginal lands which are cheaper for development (Hasse and Lathrop, 2003; Ndabula *et al.*, 2014). This is responsible for millions of people living in sub-standard and in some cases sub-human environment plagued by slums, filth and squalor and grossly insufficient social amenities (Bankole *et al.*, 2011). The consequences of all processes may be diverse including high rate of destruction of ecological resources resulting in ecological and environmental degradation which in turn reinforce poverty and other socio-economic difficulties (Adzandeh *et al.*, 2014). Therefore, urban expansion in itself may not be a problem, but rather the nature, patterns and the rapid rate of growth (Anthrop, 2004).

Understanding this phenomenon is critical to urban planners, resource managers and other stakeholders. This mandated the need for assessing dynamics of urban expansion at

spatio-temporal scale most especially in the study area. Since Land use land cover (LULC) changes are very dynamic in nature and have to be monitored regularly especially in marginal areas of semi-arid regions (naturally characterized by delicately balanced ecosystem) (Food and Agricultural Organization [FAO], 2005 in Yaro and Umar 2016). Change detection using remotely sensed data can therefore serve as a valuable resource. It is the most reliable process of identifying differences in the state of an object or phenomenon by observing it at different times (Environmental Systems Research Institute [ESRI], 2014). The situation in Katsina Local Government Area (LGA), characterized as marginal and fragile Sudan savannah ecosystem has reached an alarming rate. The natural land cover in the area have changed over time and still experiencing changes. Natural and anthropogenic factors have impacted on the landscape. The city being the capital, has witnessed unprecedented population growth and infrastructural development such as housing estates, highways, new institutions, and couple with the influx of people displayed from northeast due to Boko-haram insurgency (Suleiman, 2014; Yaro and Umar 2016). Pressure resulting from such influx on basic facilities have started manifesting in the study area. Therefore, the social and environmental repercussion could be catastrophic. More especially in loosely planned urban cities that have constantly experienced remarkable urban expansion in a short period of time (Barredo *et al.*, 2004).

The overwhelming consensus among some previous studies in Nigeria was that, rapid conversion of land uses in an uncontrolled and disorderly manner has been increasingly critical in most of the urban areas. Thus, built up areas were increasing in size, and these have impacted on the natural environment with vegetal cover suffering the most alarming anthropogenic effects (Shen, Liao and Zhang, 2003; Anavberokhai, 2007;

Abbas *et al.*, 2009; Dami *et al.*, 2011; Jibril, 2013; Sunday and Umar, 2013). This was evident in Anyigba town of Kogi state Nigeria, where Ifatimehin *et al.*, (2009) noted that, built-up area experienced the highest changes from 7.49% in 1995 to 29.84% in 2006, while vegetation cover suffered the greatest reduction from 31.50% in 1995 to 7.16% in 2005. Also in Lokoja, Kogi state of Nigeria, Ifatimehin and Ufuah (2006) discovered that, built-up area had increased in all directions most especially in the southern part of the town, whilst some 3380ha of vegetation cover was reported lost within the period due to the increasing population. Likewise in Kano Metropolis of Kano state Nigeria, Adzandeh *et al.*, (2014) discovered a rapid growth in built-up land between 13.2% in 1986 to 19.3% in 2005 and a reduction in vegetal cover from 33.9% by the year 1986 to 13.6% in 2005. It was also predicted that changes by the year 2015 may likely follow the same trend. Yaro and Umar (2016) studied LULC changes in semi-arid environments of northern Nigeria. The areas selected are located about 30 km away, south of Katsina city. Administratively, they comprised of parts of Batsari, Batagarawa, Bindawa, Charanchi, Dutsimma, Kankia, Kurfi, Mani and Rimi LGAs. Findings revealed a gradual deforestation from grassland into agriculture, settlements/built-up areas and bare sand surfaces between 1986 and 2011. The general aim of this paper is therefore to examine the spatio-temporal dynamic of urban growth in the study area.

2. The Study Area

Katsina LGA of Katsina State, Nigeria is located between latitude $11^{\circ}08'05''$ N to $13^{\circ}22'20''$ N and longitudes $6^{\circ}52'05''$ E to $9^{\circ}20'20''$ E (Fig. 1). The LGA had a population of 318,459 as at the year 2006 and about 427,982 when projected (using NPC (2006): $[Po=P1(1+r)^n]$, at 3% growth rate) to the year 2016 (NPC, 2006). Katsina LGA has a total land area of 142 km² (Yaro and Umar, 2016).



Fig. 1: The Study Area

Source: Adopted from Administrative Map of Katsina State

However, the study area was made the capital city of Katsina State in 1987. Therefore, the need of the growing population for accommodation and the need to establish a new urban centre with a new functional role as a fully-fledged state capital was the major cause of the urban changes, especially with the influx of fortune seekers and the establishment of infrastructure by the governments. Between 1987 and 2015, about 140 new layouts were demarcated (Jamilu, 2015). The study area is predominantly underlain by crystalline rocks of Basement Complex origin. Lithologically, it consists largely of some coarse, purple and mottled

feldspatic grits. Maximum day temperature of about 38⁰C in the months of March, April and May are common and the Minimum temperature is about 22⁰C in the months of December and January. Rain fall duration rarely exceeds 190 days with single peak maxima in August. The area has an average rainfall of about 700mm. It lies within Sudan Savannah vegetation zone associated with a greater proportion of open trees (woodland) including perennial short grasses. Common species in this area belong to xerophytes groups with varying degree of adaptability to water deficiency (Yaro and Umar, 2016).

3. Methodology

3.1 Types and Sources of Data

The study made use of Landsat satellite imageries of Katsina LGA for the year 1996, 2006 and 2016, captured in the month of July respectively. Imageries for the three (3) dates used were acquired from Global Land cover Facility (GLCF) website. The focus here was to carry out change detection. There are many types of change detection methods of multi-spectral image data. They can be classified as three categories: characteristic analysis of spectral type, vector analysis of spectral changes and time series analysis. The most popular is the time series analysis, whose aim is to analyze the process and extent of changes by monitoring ground objects based on remote sensing continuous observation data (ESRI, 2014). Five spectral classes were identified in the images acquired. They include vegetal cover, farmland/cultivated land, water body, bare ground and built-up land. This was based on the Landsat pathfinder classification scheme of the United State Geological Survey (USGS) (Anderson *et al.*, 1976). Using the “Erdas Imagine” Software, the image data was classified (via supervised classification) for change detection.

The algorithm analysis generated statistics used to estimate the rate, extent and pattern of urban growth in Katsina LGA. Other studies (Olayinka *et al.*, 2012; Oyinloye and Kufoniya, 2011; Jesuleye *et al.*, 2013; Adzandeh *et al.*, 2014) have also used similar method. However, the classification scheme was generally based on ground truth sample points and pre-established spatial pattern. At the post interpretation stage of the exercise, accuracy assessment was carried out. On the other hand, the Global Positioning System (GPS) was used to obtain (coordinates) Ground Control Points at strategic locations. Administrative map of Katsina state obtained from the state’s Ministry of works, was then digitized in “ArcGIS” software environment to

obtain the study area boundary. Preliminary maps were validated and adjusted based on base map, ground truth information and GPS observation carried out. The classified imageries were then imported in to ArcGIS software interface for overlay operation and more exquisite visualization.

3.2 Techniques of Data Analysis

The statistics of the resultant image classification for each year (1996, 2006 and 2016) was computed and analyzed in order to obtain the distribution of urban LULC, from which a figure showing the area in hectare measured against each LULC feature class was developed to summarize the result. Reclassification, Raster calculation and overlay operations were used to identify changes in the area of built-up and vegetation. First was to reclassify the land cover of the three years into three: Built-up and vegetation (coded 1 and 2 respectively) and other land covers (coded 0). Raster Calculator was then used to add the three reclassified images to determine the pattern of urbanization in three scenarios. A figure is used to summarize the result.

The extent of urban expansion (change) was obtained by computing: $PC = \frac{X}{Y} \times 100$
Where: **PC** is the percentage change, **X** is the observed change, and **Y** is the sum of change.

While, the annual rate of such change was obtained by computing: $RC = \frac{PC}{100} \times n$

Where: **RC** is Rate of change, **PC** is the percentage change

n is the study year intervals = 10 (1996 – 2006 and 2006 – 2016 =10).

Results are presented in table, showing the extent of urban land use change in hectares, the percentage change and annual rate of the percentage changes for each year (1966, 2006 and 2016) measured against the urban land used. Opeyemi (2007); Adzandeh *et al.*, (2014); Yaro and Umar (2016) and many more have also used similar method.

4 Results and Discussion

4.1 Pattern of Urban Expansion in Katsina LGA

Fragmentation of the statistics obtained are observed across time to describe the type of urban land use within 20 years (1996, 2006 and 2016) in the study area. LULC distribution of the area for the 3 study periods is shown in Figure 2. Land cover maps were produced for the period to show spatial structure (Figure 3-4).

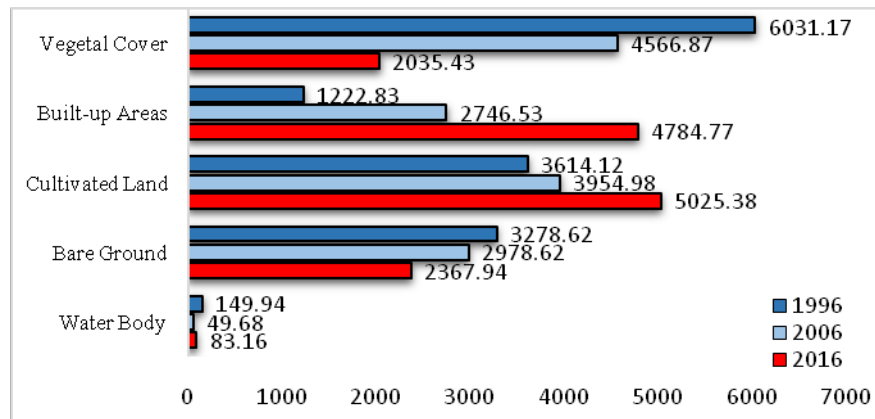


Fig. 2: LULC Distribution of Katsina LGA (1996-2016)

Source: Remote Sensing and GIS Analysis, 2017

Figure 2 reveals that, vegetal cover loss to the other land cover classes from 6031.17ha to 2035.43ha (1996-2016) and likewise bare ground, reduced from 3278.62ha to 2367.94ha. Built-up appreciated within the study period from 1222.83ha to 4784.77ha. Water-body occupies an average of 227.34ha of the area in 3 periods put together. Farming seems to be highly practiced however, as cultivated land appreciated within the study period from 3614.12ha to 5025.38ha. Alongside the consideration of the dates (farming season) of which the imageries were

taken, a major factor was the ancient traditional setting of the city, where farming form the basis for living (Suleiman, 2014). 10 km away south of the study area, about 69.230km² X 34.340km² of land area had experienced similar gradual deforestation into agriculture and built-up areas (Yaro and Umar, 2016). This was not the case in in Kaduna metropolis in Kaduna state, as Saleh *et al.*, (2014) revealed that, the area has experienced a significant reduction in agricultural land and these leads to continued disappearance of farmlands.

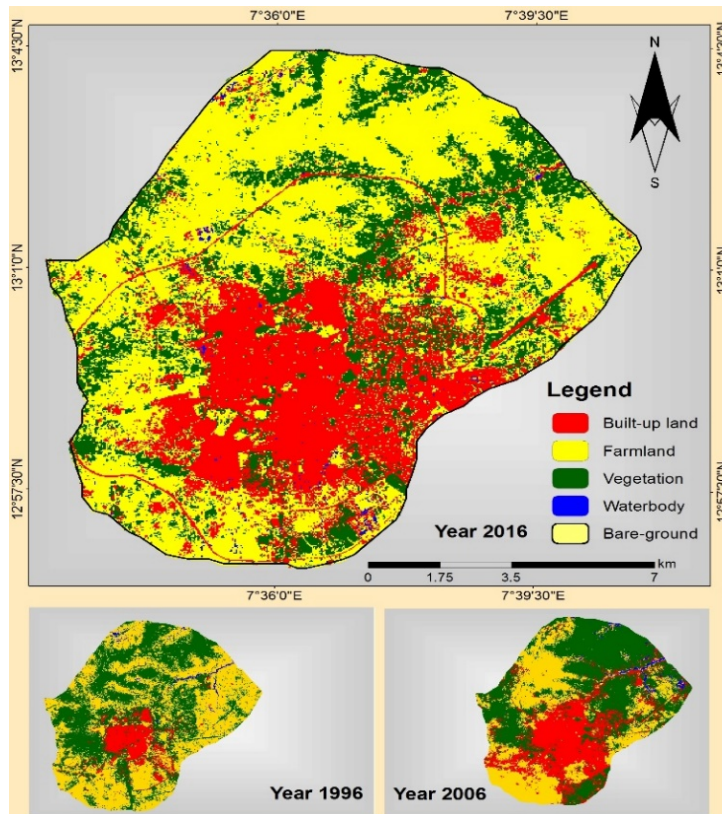


Fig. 3: Spatial Structure (1996-2016) of Katsina
Source: Remote Sensing and GIS Analysis, 2017

The nature and location of urban change process involved a pixel to pixel comparison of the study year imageries through overlay. In terms of urban expansion, the emphasis is on built-up land. The change between 1996 and 2016 is shown in figure 3. It was observed that the growth progress is moving away from the city center with more growth in the south particularly, and the southeast of the area. As such, there is consistency with the findings of

Yaro and Umar (2016). In Kano metropolis, the growth was more in the north and northwest (1986-2005) and predicted to maintain the same trend by the year 2015 due to the nature of population growth through natural birth and immigration owing to siting of educational institutions and the location of industries and large markets (like Sabon-Gari, Singer, Kantin-kwari etc.) in the area, as well as the glamour of the urban life (Adzandehet *al.*, 2014).

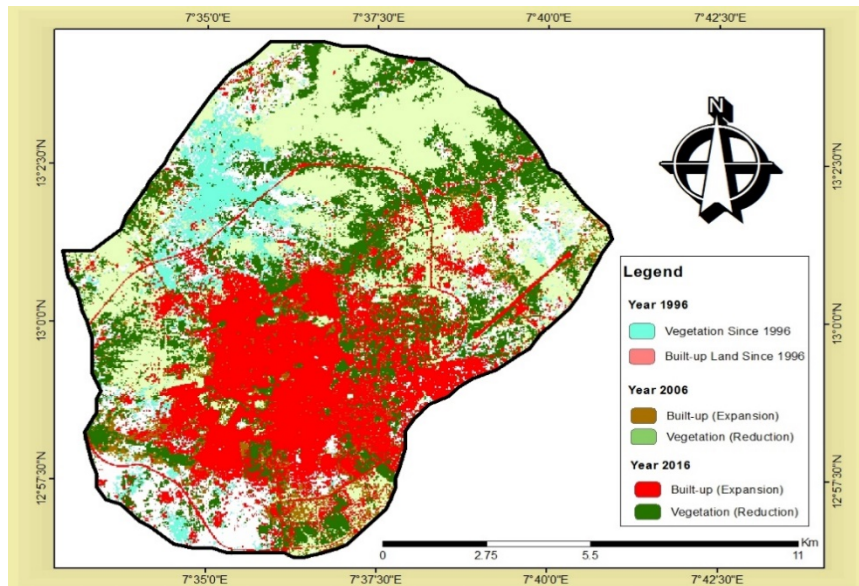


Fig. 4: Spatial Structure of Urban Expansion (1996-2016) in Katsina

Source: Remote Sensing and GIS Analysis, 2017

Visual analysis further shows that, areas at the fringes of the northern Katsina has been within the 3 periods marginally advantaged in terms of vegetal cover than most of the areas (Fig. 4). Though, Iguda (2014) lamented that, majority of the type of plants in Katsina were not in good condition and as such could not provide effective cover in the urban area. Therefore factors like: high demand for fuel wood; poorly enforced laws; lack of awareness on the relevance of vegetation; semi-arid climate of the area; government negligence and uncontrolled urbanization may continue to jeopardize the quantity and quality of vegetal cover. Ruma and Sheikh (2010) corroborated that, the LGA has in the last few decades witnessed uncontrolled urbanization. Residential developments have taken place in

environmentally sensitive areas. Also many areas (like kudu 1, kudu 2 and kudu 3 wards with noticeable development within Kofar Kaura layout) that were once occupied by vegetation have been converted to residential uses.

4.2 Extent of Urban Land Use and Rate of Change in Katsina LGA

When the observed statistics of the urban LULC classes was compared, there was a percentage of change that shows extent of urban expansion. Likewise, when the percentage changes were computed, there was a percentage that shows the rate at which the changes occurred within the stipulated period of study. This is detailed in Table 1.

Table 1: Extent and Annual Rate of Change between 1996 and 2016 in Katsina LGA

Urban LULC Classes	Extent of Change (1996 – 2006)		Extent of Change (2006 – 2016)		Annual Rate of Change	
	(Ha)	(%)	(Ha)	(%)	1996 – 2006 (%)	2006 – 2016 (%)
Vegetation	–1464.3	–39.26	–2531.44	–40.3	–3.93	–4.03
Built-up Land	+1523.7	+40.9	+2038.24	+32.43	+4.09	+3.243
Farmland	+340.86	+9.1	+1070.4	+17.03	+0.91	+1.703
Bare-Ground	–300.0	–8.04	–610.68	–9.71	–0.804	–0.971
Water body	–100.26	–2.7	+33.48	+0.53	–0.27	+0.053
Total	±3729.12	±100	±6284.24	±100		

Source: Authors' Analysis, 2017

Key: (+) = expansion, while (-) = reduction

Change detection analysis (Table 1) reveals that, between 1996 and 2006, bare ground reduced by 8.04% at an annual rate of 0.804% and by 9.71% at the rate of 0.97% from 2006 to 2016. Water body changes by 2.7% (1996-2006) and gained by 0.53% (2006-2016) at an annual rate of 0.27% and 0.053% respectively. This could be attributed to widespread construction of earth dams across the state to meet portable water demand. Within these periods increased in farmlands (9.1% and 17.03%) occurred at an annual rate of 0.91% and 1.703%. likewise, built up gained (40.9% and 32.43%) with an annual rate of change of 4.09% and 3.243% respectively. There was remarkable increased in annual rate of change in the vegetal cover within the study periods, it was initially (3.93%) but grew to (4.03%) of which about 39.26% (1996-2006) and 40.3% (2006-2016) was lost. The comparison of LULC of Katsina LGA (Table 1), shows that percentage change in land categories of the LGA is comparatively high due to rapid urbanization. Thus, the population of Katsina continued to rise steadily when it increased from 100,418 in 1977 to 115,220 in 1980, 233,644 in 1991 and rose to 293,758 in 2000. By 2006 the population had reached 318,459 and projected to reach 427,982 and 455,550 in 2016 and 2017 respectively (NPC, 2006 as cited in Jamilu, 2015).

The rapid urban growth could be attributed to increase in population, not only via natural birth but also migration of people from rural areas and neighboring LGAs to the capital city in search for jobs, commercial activities, farming and so on. Hence, the demand for land by the households and firms who inhabit the city and the policy constraints that manage land use as well as the spatial interactions and deforestation in the area, might have accelerated the expansion at the expense of ecological resources. A similarity can be drawn from some empirical researches in Nigeria. For instance, urban expansion in cities like: Dutse LGA of Jigawa state between 1976 and 2000; Maiduguri urban area of Borno state (1961-2002); Lokoja LGA (1987-2005) and Anyigba town (1995-2006) in Kogi state; Suleja LGA of Niger state (1982-2012) and Kano metropolis of Kano state (1976 and 2015) appeared to follow the same trend of changes (Ifatimehin and Ufuah, 2006; Anavberokhai 2007; Ifatimehin *et al.*, 2009; Dami *et al.*, 2011; Sunday and Umar, 2013; Adzandeh *et al.*, 2014). Therefore, most of the areas located 10 km away south of the study area, also experienced such rapid expansion with vegetation cover suffering the most alarming and rapid anthropogenic effects (Yaro and Umar, 2016).

5 Conclusion and Recommendations

This study discovered that, Katsina LGA has been undergoing remarkable urban expansion. The growth in built up was prolonging both from urban centre to adjoining non-built up areas in all directions, but mainly to the south and southeast along Batagarawa and Kaita LGA axis. It is but, worthy to note that, being the state capital and the center of an agricultural region, employment opportunities might have attracted many, alongside migration of people from the troubled north eastern Nigeria due to insecurity. A gradual change could however be observed due to emergence and expansion of some settlements and built-ups that were not in existence. The situation could have also led to the widespread conversion of scrubland into farmlands for cultivation and possibly grazing activities. In due course, informal housing

practices, undesirable urban development patterns (thus, making space more homogenous and simultaneously unstable) as well as direct population potential, seem to fuel urban expansion in the area. The mechanisms by which the observed expansion transpires, land fragmentation might have emerged as a side-effect. The established dynamic equilibrium amongst urban network and natural ecosystems might have being disrupted and the neighboring communities might have already started changing their structure seeking a different role in the regional context. In view of the rate at which urban land use types is encroaching into other land uses, there is urgent need to evolve relevant policies of urban planning that will focus on the provision of site and services plots as well as monitoring of unplanned development in the study area.

References

- Abbas, I.I., Muazu, K.M., and Ukoje, J.A. (2009). Mapping Land Use-land Cover and Change Detection in Kafur Local Government Area Katsina state, Nigeria (1995-2008) Using Remote Sensing and GIS, *Research Journal of Environmental and Earth Sciences* 2(1): 6-12, 2010 ISSN: 2041-0492
- Adzandeh, E.A., Fabiyi O.O. and Bello Y.A. (2014). Statistical Analysis of Urban Growth in Kano Metropolis, Nigeria. *International Journal of Environmental Monitoring and Analysis*. Vol. 2, No. 1. Pp. 50-56.
- Anderson, J.R. Hardy, E.E. Roach, J.T. and Witmer, R.E. (1976). *A Land Use and Land Cover Classification System for use with Remote Sensor Data*. Geological Survey Professional Paper 964. A revision of the land use classification system as presented in U.S. Geological Survey Circular 671, United States Government Printing Office. Washington DC.
- Anavberokhai, O.I. (2007). Mapping land Use in north-western Nigeria. A case study of Dutse Local Government Area, Jigawa State. *A published B.Sc. Research in Geomatics University of Gavl*.
- Anthrop, M. (2004) Landscape Change and the Urbanization Processes in Europe. *Landscape and Urban Planning*, 67(1-4), Pp. 9-26.
- Bankole, M.O., Bakare, H.O., and Oderinde, F.O., (2011). Changing Trend of surface To Built-up Environment and its Effects on Urban Climate of Ibadan, Nigeria. *The Journal of the Zaria geographer*, Vol. 15, No 1.
- Barredo, J.I., Demicheli, L., Lavelle, C., Kasanko, M., and McCormick, N. (2004). Modelling future urban scenarios in developing countries: An application case study in Lagos, Nigeria. *Environment and Planning B: Planning and Design*, (2004). Vol. 32, Pp. 65-84.
- Bhatta, B. Saraswati, S. and Bandyopadhyay, D. (2010). Quantifying the Degree-of-Freedom, Degree-of-Sprawl, and Degree-of-Goodness of Urban Growth from Remote Sensing Data. *Elsiever Journal of Applied Geography*, Vol. 30. Pp. 96-111.
- CIA (2015). *World Factbook*. Marshall Facts on every country, dependency and geographic entity in the world Central Intelligence Agency United State of America, (USA) Government. Also available on <http://v.cia.gov/library/publications/the-world-factbook/> Accessed on 10th August, 2018
- Dami, A., Adesina F.A. and Garba S.S. (2011). Land Use Changes in the Adjoining Rural Land of Maiduguri from 1961-2002; Trends and Implication in the Environmental Management in Borno State, Nigeria. *Journal of Environment and Agriculture in Developing countries*, Vol.3 No. 20Pp 159 -168
- ESRI, (2014). What is Image Classification? ArcGIS 10.3 Desktop Help Centre, Copyright 1995-2014 Environmental Systems Research Institute all rights reserved.
- FAO, (2005): *Yearbook of Forest Products* 2003. Food and Agriculture Organization, Rome, Italy
- in Yaro, A. and Umar, A. (2016). Application of Delta Classification Algorithm in Land CoverChange Detection in a Semi-Arid Environment of NorthernNigeria. *Civil and Environmental Research*. ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online) Vol.8, No.3, Pp. 1-12
- Hasse J.E., and Lathrop, R.G., (2003) Land Resources Impact indicator of Urban Sprawl. *Applied Geography* 23: Pp. 159-175.
- Ifatimehin, O.O, Musa, S.D and Adeyemi, J.O. (2009). An Analysis of the Changing Land Use and its Impact on the Environment of Anyigba Town, Nigeria. *Journal of SustainableDevelopment in Africa* Vol. 10, No.4. Pp. 34-50
- Ifatimehin, O.O., and Ufuah, M.E. (2006) Application of Geographical Information System to Urban and Vegetation Studies in Lokoja. *The Journal of Zaria geographers*. Vol.17 No. (1): Pp. 28-36.
- Jamilu, S. (2015). Urbanization in the 20th Century: Some Reflections on Katsina Town, Nigeria. *Journal of the Geographical Association of Tanzania*, Vol.36, No. 1: Pp. 135–147
- Jesuleye, I.A. Oyinloye, R. Adzandeh, E.A. and Eguaroje, E. (2013). Geospatial Assessment and Monitoring of the Dynamics ofUrban Expansion of Ogbomoso, South-Western Nigeria.*Research Journal of Environmental and Earth Sciences*. Maxwell Science Publications.

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- Jibril, M. S. (2013) Land Use Land Cover mapping in Ilorin and its Environs Kwara State Nigeria. *The Journal of the Zaria geographer*, Vol. 20, No 1.2013 ISSN: 0795-7599
- Lopez, E., Bocco, G., Mendoza, M., and Duhau, E. (2011) Predicting Land cover/Land use Change in the Urban Fringe. A case in Morelia City, Mexico. *Landscape and Urban Planning*, 55, Pp. 271-285.
- Ndabula, C., Jidauna, G.G., Averik, P.D., Oyatayo, T.K., Abaje, I.B. and Ali, A.Y. (2014). Characterization of Sprawling in Kaduna Metropolitan Area. *American Journal of Environmental Protection*; Vol. 3(3): Pp. 131-137
- NPC, (2006). *"Nigeria national population census report, 2006*. Retrieved from: Nigeria Population Commission (NPC) Office, Katsina state.
- Opeyemi, Z.A. (2007). *Change Detection in Land use and land cover using Remote Sensing and GIS. (A Case Study of Ilorin and its Environs in Kwara State)*. Unpublished M.Sc. Thesis, Department of Geography, University of Ibadan, Nigeria.
- Oyinloye, M. and Kufoniya, O. (2011). Analysis of Land use Land cover Change and Urban Expansion in Akure, Nigeria. *Journal of Innovative Research in Engineering and Sciences*, 2011. Vol. 2(4), Pp. 234 -248.
- Shen, Q., Liao, J., and Zhang, F., (2003). Changing Urban Growth Patterns in a Pro-Smart Growth State: The Case of Maryland, 1973-2000. Also available on: http://www.smartgrowth.umd.edu/research/pdf/ShenLiaoZhang_ChangingUrban Accessed on 10th August, 2018
- Suleiman, I. L. (2014) Achieving Effective Vegetation Cover in Katsina Urban Area, Katsina State Nigeria. *Global Journal of Science Frontier Research: H Environment and Earth Science*, Vol. 14. Online ISSN: 2249-4626 and Print ISSN: 0975-5896
- Sunday, P. E. and Umar A. (2013). Spatiotemporal Analyses of Land Use and Land Cover Changes in Suleja Local Government Area, Niger State, Nigeria. *Journal of Environment and Earth Science*, Vol. 3, No.9.
- Worldometers, (2018). *World Population Prospects: The 2017 Revision*, (Medium-fertility variant). Worldometers' RTS algorithm, gathered from the United Nations Population Division. Available at <http://www.worldometers.info/world-population/nigeria-population/> accessed on 8th August, 2018