An Analysis of Urban Growth Pattern in Yola-North Local Government Area, Adamawa State, Nigeria

Bibi Umar Muhammed\textsuperscript{1,4}, Abdurrahman Belel Ismaila\textsuperscript{2} and Ibrahim Aliyu\textsuperscript{3}

\textsuperscript{1}Department of Geography, Federal University of Kashere PMB 182 Gombe State Nigeria
\textsuperscript{2}Department of Urban and Regional Planning, ModibboAdama University of Technology Yola, PMB 2076 Adamawa State Nigeria
\textsuperscript{3}Department of Geography, Adamawa State University Mubi, Adamawa State, Nigeria
\textsuperscript{4}bibi.muhammed@gmail.com

Abstract

Urban areas are important social, economic, political and industrial centers. Rapid urban growth in Africa is creating serious economic, social and environmental challenges. Apart from determining the rate of urban growth, previous studies on urban land cover change in Yola North Local Government Area did not address the relationship between urban growth, economic and development indices like per capita Gross Domestic Product (GDP) and Human Development Indices (HDI). This study is aimed at analyzing urban growth rate over a 28 year period (1988-2016). The study used 3 Landsat satellite image scenes (1988, 2002 and 2016), urban growth pattern, economic, and human development indices. The satellite imagery were classified using the maximum likelihood algorithm in QGIS software. Simple descriptive statistics was used to analyze changes in urban area over the separate period and then compared with annual data on per capita GDP and HDI. Landscape expansion index was used to determine the urban growth pattern. Result show that urban land cover increased from one tenth of the total land area in 1988 to one fourth of the land area in 2016. Periphery (edge) expansion is the dominant pattern of urban growth during this period. Simple comparison between urban growth rate, per capita GDP and HDI indicates a sharp contrast between the former two and the later. Many newly developed areas lack basic infrastructure such as roads, pipe borne water and drainages. Based on the findings, it was concluded that urban growth in the study area is unsustainable since increase in per capita GDP does not translate to increase in HDI and the provision of basic infrastructure. These economic and human development indices might have contributed to the pattern of urban growth in the form of edge expansion identified in this study. It is recommended that authorities should invest more on urban infrastructure and the promotion of outlying pattern of urban development.

Keywords: Urban Growth Pattern, Land Expansion Index, Sustainable Planning

1. INTRODUCTION

Urban growth within the context of this paper follows an earlier definition presented by Wilson et al. (2003) as changes in the extent and pattern of urban landscape. Where an urban area is a developed area meant for commercial, residential, industrial or any other reason land is put to use by humans. Wilson et al. (2003) identified three patterns of urban growth that can be analyzed using geographic information system and remote sensing methodologies in the study of urban land cover. These patterns include: Infill, the development of empty spaces mostly surrounded by urban area; Edge Expansion growth, also referred to as urban fringe development is the growth of urban area at the edges. In edge development a land cover type spreads in parallel strips from an edge; Outlying, change from non-developed to developed land cover class beyond existing developed area. Also, referred to as development beyond the urban fringe.

Globally, urban areas are important social and economic centers with an agglomeration of people, industries, ideas and wealth. Despite the significance of urban centres, urban growth in Africa is marred by several challenges. The major challenge of urban growth in Sub-Saharan Africa is urban poverty and lack of concrete urban planning policy that will guarantee sustainable growth (Arouri et al., 2014). A positive trend between urban growth and economic growth can be measured through development indices such as a country’s Gross Domestic Product (GDP) or human development index (HDI). While, urban growth and GDP in the rest of the world show a strong positive relationship it is less clear in Sub-Saharan Africa (Arouri et al., 2014). In recent years, there is an increase in both per capita GDP and HDI in Nigeria (Figure 1). However, at the peak of economic growth from 2011 – 2014 the country’s GDP increased by 27.4%, while, HDI increased by only 3.6% (World Bank, 2018). The economy started shrinking after 2014 in response to falling global crude oil prices.

Generally, there are several factors responsible for land cover change including urban growth patterns among these are social and economic factors (Yalew et al., 2016). A combination of these factors contribute to urban growth and determines the extent and pattern of change. There is little information available on the extent and magnitude of land cover change in Nigerian urban areas. Few studies such as Zemba (2010), Ismaila (2013), Haruna et al. (2013)
and Bashir (2014) have applied GIS and remote sensing techniques in making land cover analysis covering Yola North Local Government Area. There were no attempt in previous studies to determine the dominant pattern(s) of urban growth in the study area or relate urban growth with economic and human development indices for sustainable urban planning. It is for these reasons that this paper was conceived.

Sustainable development is the development that meets the needs of the present generation without compromising the future generation’s capacity in meeting their own needs (Brundtland, 1987). Sustainable development incorporates social, economic and environmental considerations. Likewise, sustainable planning also incorporates environmental, economic and social considerations.

In the following sections the area of the study, materials used in the study and methods applied is discussed. This is followed by a discussion of the research findings and concluding with recommendation.

1.1 The Study Area

The study area is Yola North Local Government Area in Adamawa State Nigeria (shown in Figure 2). The area lies between latitudes 9.20° – 9.35° north of the Equator and longitudes 12.32° - 12.50° east of the Greenwich Meridian. It is part of the greater Yola Metropolitan and the Capital of Adamawa State in Nigeria. It became a British trade outpost in the early 1900s and since in the 1950s the urban built up area has been rapidly increasing (Zemba et al. 2010).

2. MATERIALS AND METHODS

2.1 Types and Sources of Data

In order to fill the research gap identified in the previous section, satellite images, field observations and surveys were integrated as methods of studying urban growth pattern. The study used both primary and secondary sources of data. Structured questionnaire, Global Positioning System (GPS) and photographs of houses snapped from mobile cameras form the main source of primary data. Considering the limitations involved in carrying out the research a sample of 100 structured questionnaires were administered to respondents and the same number was retrieved. Secondary sources of data include three (3) satellite Landsat image scenes of 14 year intervals (1988, 2002 and 2016), shapefiles of the study area, published and unpublished documents. Details of the Landsat image scenes are presented in Table 1. Nigeria’s annual GDP and HDI for the period under review were secondary sources of data obtained from the World Band Report for 2017. A summary of the linkages between the aim of the study with the methodology is presented as the research model (see Figure 3).
Figure 2: The Study Area Yola North Local Government Area, while the inset is the map of Nigeria showing the study area

Figure 3: Research Model for Sustainable Urban Growth Planning
Table 1: Characteristics of Satellite Imagery

<table>
<thead>
<tr>
<th>Satellite platform</th>
<th>Sensor Type</th>
<th>Pixel Resolution</th>
<th>Date Captured</th>
<th>Date acquired</th>
<th>Download Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Landsat 5</td>
<td>TM</td>
<td>30m</td>
<td>11th November, 1988</td>
<td>7th February, 2017</td>
<td>USGS Earth Explorer</td>
</tr>
<tr>
<td>2 Landsat 7</td>
<td>ETM+</td>
<td>30m</td>
<td>18th December, 2002</td>
<td>7th February, 2017</td>
<td>USGS Earth Explorer</td>
</tr>
<tr>
<td>3 Landsat 8</td>
<td>TIRS</td>
<td>30m</td>
<td>7th January, 2016</td>
<td>7th February, 2017</td>
<td>Earth Explorer</td>
</tr>
</tbody>
</table>

2.2 Data Analysis Techniques

The 30m resolution Landsat image scenes were classified using maximum likelihood algorithm under supervised classification technique using Semi-automated Classification Plugin (SCP) in QGIS. Observations and location data acquired using a GPS were used for groundtruthing. A total of 50 ground points were randomly selected for groundtruthing and subsequently, assessing the accuracy of the classification. Since, the focus of the study is on urban change only two land cover classes was adopted for the supervised classification of the Landsat images. These two land cover classes are urban built up land cover type and all other land cover types grouped as “others”. LEI was adapted for studying the pattern of urban growth based on the equation developed by Liu et al. (2017).

\[
LEI = 100 \times \frac{A_O}{A_O + A_V}
\]  

Where LEI is the landscape expansion index for a newly grown patch, \(A_O\) is the intersection between the buffer zone and occupied land and \(A_V\) is the intersection between the buffer zone and vacant land.

The distribution of LEI values in relation to each growth pattern is in Table 2. Analysis of LEI was carried out in an ARGIS 10.41 environment using the LEI Plugin. The three different patterns of growth i.e. infill, edge and outlying are represented in Figure 4

Table 2: Urban growth pattern in relation to LEI values

<table>
<thead>
<tr>
<th>Urban Land Growth Pattern</th>
<th>LEI Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infilling</td>
<td>LEI ≥ 50</td>
</tr>
<tr>
<td>Edge Expansion</td>
<td>0 &lt; LEI &lt; 50</td>
</tr>
<tr>
<td>Outlying</td>
<td>LEI = 0</td>
</tr>
</tbody>
</table>

Figure 4: Three (3) patterns of urban growth (Adapted from Nong et al., 2018).

3. RESULTS AND DISCUSSION

3.1 Urban Land Cover change 1988 - 2016

The final classification of the 3 image scenes were compared by observing the changes in built up area 1988 – 2002 and 2002 – 2016 periods, respectively.
extent of the built up area in 2002 increased to 22.6 Km² covering 17.24% of the study area. In 2016 the extent of urban built up area in Yola North LGA reached 33.43 Km² (25.47%). Thus, within the 28 year period (1988 – 2016) under review the extent of urban built up area increased by three fold. In the 14 year interval image scenes analysed urban built up area increased by more than two third (2/3) of its previous extent (1988 – 2002 by 63.76% and 2002 – 2016 by 67.69%, respectively). This suggests that there was a rapid and steady increase in the extent of urban built up area in Yola North LGA during the 28 years under review. In a previous study by Zemba et al. (2010) after analysing Landsat image scenes of 1986 and 2008 of greater Yola Metropolis (incorporating Yola Town and Jimeta), a 55.7% increase in the size of urban area was observed within the 12 year interval. The accuracy of the 3 classified image scenes is presented in Table 4.

Increase in built up area identified in this paper and in similar studies was a precursor for investigating the pattern of urban growth and likely causes of urban growth in order to understand the dynamics of such increase and for the purpose of informed planning process in the future.

**Table 3: Changes in Urban Built up Area Land Cover Type in Yola North 1988 - 2016**

<table>
<thead>
<tr>
<th>Land Cover</th>
<th>1988 Area Km²</th>
<th>%</th>
<th>2002 Area Km²</th>
<th>%</th>
<th>2016 Area Km²</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Built Up</td>
<td>14.43</td>
<td>10.99</td>
<td>22.63</td>
<td>17.24</td>
<td>33.43</td>
<td>25.47</td>
</tr>
<tr>
<td>Others</td>
<td>116.82</td>
<td>89.01</td>
<td>108.62</td>
<td>82.76</td>
<td>97.82</td>
<td>74.53</td>
</tr>
<tr>
<td>Total</td>
<td>131.25</td>
<td>100.00</td>
<td>131.25</td>
<td>100.00</td>
<td>131.25</td>
<td>100.00</td>
</tr>
</tbody>
</table>

**Table 4: Accuracy of Land cover Classification**

<table>
<thead>
<tr>
<th>Year</th>
<th>Overall Accuracy</th>
<th>Kappa index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>76%</td>
<td>0.71</td>
</tr>
<tr>
<td>2002</td>
<td>86%</td>
<td>0.76</td>
</tr>
<tr>
<td>2016</td>
<td>84%</td>
<td>0.73</td>
</tr>
</tbody>
</table>

**3.2 Urban Land Cover Change, Economic Growth and the provision of basic Urban Infrastructure**

In this study, economic growth an important factor responsible for urban growth is measured as an increase in the per capita GDP of the country and HDI. GDP almost doubled from 1988 – 2002 ($257.29 – $459.46), however, the growth in GDP is much greater from 2002 – 2016 ($ 459.46 - $2175.67) increasing almost by 500% (Figure 6). Data on HDI was only available for 2011 – 2016.
Nevertheless, the rate of increase in GDP is not at par with HDI suggesting that increasing national wealth does not translate to better living condition for most of the citizens and this may also explain the lack of basic infrastructure in many of the newly developed areas. It was observed that many newly developed areas have no basic infrastructure such as tarred roads, drainages, pipe borne water or proper waste disposal facilities.

![Figure 6: Changing urban area and Nigeria per capita GDP 1988 – 2016](image)

Urban area expanded by 8.2Km² from 1988 – 2002 and 10.8Km² from 2002 -2016. The pattern of urban growth was investigated using LEI and the results of the analysis are presented in Table 5. All three type of urban expansion were identified over the two separate periods. Edge expansion is the most dominant growth pattern in both 1988 – 2002 and 2002 – 2016 (7.56Km² and 10.145Km²) periods, respectively. This is followed by outlying with a much smaller fraction (0.639Km² and 0.633Km²). The least type of urban expansion is infilling increasing by 0.01% of the total urban growth area from 1988 – 2002 and 0.20% from 2002 – 2016. However, when comparing urban growth through infilling under the two separate periods there is a significant increase during the 2002 – 2016 period. The results are similar to the findings made by Nong et al., (2018) on urban growth patterns in Hanoi from 1993 to 2010.

Table 5: Extent of different urban growth patterns 1988 - 2016

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Infilling</td>
<td>0.001</td>
<td>0.022</td>
</tr>
<tr>
<td>2</td>
<td>Edge expansion</td>
<td>7.560</td>
<td>10.145</td>
</tr>
<tr>
<td>3</td>
<td>Outlying</td>
<td>0.639</td>
<td>0.633</td>
</tr>
</tbody>
</table>

The lack of basic infrastructure may be the reason for higher growth pattern through edge expansion rather than outlying since development will tend to cluster close to areas where such infrastructure is available. And this may also explain the low rate of expansion through outlying. Sub urban growth is a typical outlying pattern of growth and requires initial planning for basic infrastructure especially roads to connect to the central district.

4. CONCLUSION

In this paper, three (3) aspects of urban growth was investigated: rate of urban growth over a 28 year period using 3 separate image scenes of 14 year intervals, the influence of economic growth on the
rate urban growth in the study area, and the pattern of urban growth. Results indicate that the urban area has increased from one tenth of the total land cover area in 1988 to a quarter of the total land cover area in 2016. Applying simple comparison show significant increase in GDP over the years is not at par with HDI or the development of basic infrastructure for sustainable urban growth in the study area. These reasons may explain edge expansion as the dominant pattern of urban growth in the study over the 28 year period. It is concluded that present approach to urban growth is not sustainable and may only lead to the growth of slums within and around the study area.

The following recommendations are made in order to achieve sustainable growth in the study area:

1. Increased investment on urban infrastructure in the study area such as access roads, drainages, pipe born water and waste disposal system.
2. Develop programmes that will improve the living standards of citizen so that growth in per capita GDP translates to increasing HDI and therefore improved living standards.
3. Feature urban development schemes should adopt a sub-urban type of development to reduce the pressure on infrastructure in the central district.
4. Feature studies of this nature can be carried out in other major Nigerian cities for the purpose of drawing inference.
5. More constructive methodologies can be applied in similar studies such as correlation or linear regression incorporating other factors of urban growth such as population growth in order draw a much significant inference and avoid speculations.

REFERENCES


