
Abdulhamid Yakubu Anvah1, Yanmin Shuai2, Chindo Musa Muhammad3, Shao Congying4

Department of Geomatics and Geography, Liaoning Technical University, Fuxin City, Liaoning Province, China1,2,4
Department of Survey and Geoinformation, Federal Polytechnic Nasarawa, Nasarawa State, Nigeria3

Abstract:
Nigeria the most populated country in Africa and the sixth most populated in the world, Abuja is its capital and a centre of activities and growth for obvious reasons. The imperative of monitoring the development of such territory can never be overemphasized for healthy and sustainable urbanization. Consequently, this study explored the use of satellite remote sensing to examine urban development within the territory in the last three decades. The study indicates that urban built-up grew rapidly from a mere 54.246km² in 1986 to 680.737km² by 2019 at annual growth rates of 39.45, 13.92, 15.36 and 23.16 between 1986 to 1990, 1990 to 2001, 2001 to 2014 and 2014 to 2019 respectively.

Keywords: FCT, Land use land cover change, Urban expansion, Remote sensing, GIS.

I. INTRODUCTION

Rapid urban expansion especially in the developing countries is one of the most visible dimensions of contemporary urbanization and has been at the core of debates on global urban dynamics. The age-old question still is whether the expansion of urban areas should be accepted, resisted or welcomed. Whereas some try by all means to limit the expansion of urban areas, some welcomed it through preparing urban centers to absorb the oncoming waves of new immigrants (Shlomo et al., 2005). However, the key to accepting or resisting urban expansion is monitoring urban growth through time; and remote sensing has made this extremely challenging task simple through the process of change detection (Bhatta, 2010). Though urban expansion, urban growth, and urban sprawl are often used synonymously, they slightly differ in context. Whereas urban growth describes the total increase in developed urban land, with expansion, outlying and infill urban growths as the various forms of urban growth (Wilson et al., 2003); urban growth has some special characteristics, in form of negative connotation is what is referred to as urban sprawl (Bhatta, 2010). However, urban expansion as described by Forman (1995) is land development spreading in parallel strips from an urban edge or fringe. A major factor responsible for the expansion of urban centres both developed and developing countries is rapid population growth due to both migration and natural population increase. Just like Robert et al., (2005) posited large scale population growth to have been responsible for the growth of many metropolitan areas in the United States; Ashok & Alen (2003) reported massive migration in search of employment to have fostered the growth of several megacities in Asia. Garth (2011) also posited rural landlessness, heedlessness, involution, poverty, and lack of employment to have fueled the growth of towns and cities in Africa. In Nigeria, rural-urban migration has since been noted by Sada & Oguntoyinbo (1981) to have been responsible for rapid growth of towns and cities in both population and areas. In 1991, Nigeria’s seat of government was moved from Lagos to what is today FCT for administrative convenience. Since then, FCT became famous for in-migration of people from all walks of life. In fact, the Centre on Housing Rights and Evictions in 2008 reported that during 1991 alone, over 200,000 public sector workers, along with staff from foreign embassies and the offices of multilateral and bilateral agencies relocated to the FCT. The return of Nigeria to civilian rule in 1999 later also encourages Nigerians relocation to the FCT (The Centre on Housing Rights and Evictions, 2008).

The 1991 and 2006 national censuses indicated that the FCT grew outstandingly at an annual average growth rate of 9.3% from mere 371,674 in 1991 to 1.4 million by 2006 (UN-Habitat, 2012); and quite expectedly, (Ujob et al., 2010) reported urban sprawl to have ensued in the FCT between the same period. Traditionally, monitoring urban expansion involves the visual comparison of large-scale aerial photographs and landuse maps to detect changes. This method is obviously strenuous, time-consuming, and subject to limitations such as expensive interpretation mechanisms, errors of omission and unavailability of specific photographs as noted by Richter (1969) and Ridd & Liu (1998). However, with technological advancement and the increased availability and improvement in spectral resolution of remotely sensed data, remote sensing is increasingly being adopted as a better option. This is simply because remote sensing provides a means for acquiring imagery on a regular basis, presenting timely information that can be combined with ancillary data to monitor urban change and distinguish expansion models (Harris & Ventura, 1995; Khorrarn, 1987). FCT being the capital of the most populous country in Africa and the sixth most populated in the world (Ismaila, 2004), is obviously a center of growth. Assessing the development of such a center will benefit not only urban managers but also planners and researchers; thus, the need for this study. The specific objectives of this study are to examine the Land Use Land Cover (LULC) change; analyze the spatial expansion; and determine the expansion rate, of the FCT between 1986 and 2019.
II. METHODOLOGY

Study Area
The study area is FCT (figure 1), Nigeria’s administrative capital since 1991, established by virtue of the Federal Capital Territory (FCT) Decree No. 6 of 1976. It refers to the area declared FCT, Nigeria, located geographically in the center of Nigeria and politically in the north-central geopolitical zone. FCT lies within latitudes 8° 23’N and 9° 15’N, and longitudes 6° 41’E and 7° 37’E. FCT came about due to the city of Lagos’s inability to provide adequate land space for development commensurate with its status as the state capital of Lagos and at the same time national capital of Nigeria, and to also provide equal access to Nigeria’s great diversity of cultural groups. Thus, the need for a new capital that would be secure, ethnically neutral, centrally accessible, comfortable and healthful, and possess adequate land natural resources to provide a promising base for urban development. While the capital was initially designed to house a targeted population of 1.6 million on 25,498 hectares of land by 2000, planners envisaged the population would reach 3.2 million when fully developed (The Centre on Housing Rights and Evictions, 2008). However, by 2007 FCT’s population was estimated to be over 3 million, with day time population reaching up to 7 million (Ismaila, 2004).

The FCT has a tropical climate with more rainfall during the summer than winter and annual precipitation of about 1267mm. The annual average temperature is about 27.2°C, with the lowest (25.2°C) and highest (30.1°C) recorded in August and
March respectively. The terrain of the area is varied with hills occurring as clusters and long ranges, especially in the Nyanya and Asokoro axis. Rivers Gurara and Usama that flow southwesterly are the two major rivers that drain the area.

Materials and method
This study focuses on monitoring urban expansion within the FCT using satellite remotesensing. It entails detecting changes between 1986 and 2019. As noted by Lu, Mausel, Brondizios, & Moran(2004), urban change detection generally involves the application of multi-temporaldatasets to visually or quantitatively analyze the temporal effects of the phenomenon. Although many change detection techniques have been developed, some of which have been summarized and reviewed(Lu, Mausel, Brondizios, & Moran, 2004), the integration of remote sensing and Geographical Information System (GIS) techniques were adopted for this study. This involved classification and post-classification comparison of remotely sensed data. Two GIS software: a vector-based (ArcGIS 10.5) and a raster-based (ENVI 4.2) were used alongside other basic computer packages to achieve this study. Specifically, ArcGIS 10.5 and ENVI 4.2 were respectively used to manipulate and analyze vector and raster data respectively.

Datasets
Data used for this study were basically sourced from satellite images. Five-time series Landsat datasets of World Reference System 2 (WRS2) Path 189 / Row 54 spanning from 1986 to 2019 were used. These comprise Landsat satellite images acquired 08January 1986; 12 February 1990; 05 January 2001; 22 February 2014 and 04 February 2019 downloaded from United States Geological Survey (USGS)agency. The images were used to generate LULC of the area through the study period. Similarly, Google Open Street Map was used as base information to collect all relevant vector layers of the study area.

Image classification and data analysis
Because the images used were downloaded in bands and for the entire path 189 / row 54, composite bands for all the different sets of images acquired were first generated. Thereafter, the subsets of the study area were extracted. All these were achieved using the composite band and clip tool in ArcGIS 10.5. To generate the LULC of the study area, supervised image classification with a Maximum Likelihood Algorithm was carried out using ENVI 4.2 to classify all the images into unique spectral land cover classes. The classification scheme adopted comprise of five classes in line with Anderson, Hardy, Roach, & Witmer(1976) as presented in table 1. The classification used bands 3, 4 and 5, to generate a false-colour image of the study area. With the aid of extensive ground-truthing and training using google earth, all the images were appropriately classified and the LULC distribution statistics developed. In other to depict and analyze the nature, pattern and location of urban expansion in the study area, built-up classes were segmented from all the classified images and subsequently overlain to show the expansion succession. The statistics of the segmented built-up for all the dates were also recorded and used to analyze the amount, rate and pattern of expansion.

| Table 1. LULC classification scheme(Anderson, Hardy, Roach, & Witmer, 1976). |
|---|---|
| S/N | Level I | Level II |
| 1 | Built-up land | Residential; commercial and services; industrial; transportation, communication, and utilities; mixed urban or built-up land |
| 2 | Agricultural land | Cropland and pasture; orchards, groves, vineyards nurseries and ornamental; horticultural areas; confined feeding operation; and various agricultural land. |
| 3 | Forest land | Deciduous evergreen and mixed forest land. |
| 4 | Waterbody | Rivers streams, lakes ponds, and reservoirs. |
| 5 | Barren land | Sandy areas; bare exposed rock; quarries, and gravel pits; transitional areas and mixed barren land. |

III. RESULTS AND DISCUSSION
The LULC maps of FCT in 1986, 1990, 2001, 2014 and 2019 as respectively generated from the supervised classification of Landsat images are presented in Figures 2 – 6. These were analyzed and presented in tables 2 and 3, and figure 7 and 8. The LULC distribution of FCT (table 2) revealed consistent increases and decreases of built-up and forest land respectively through the study periods. Forest land decreases from 3032.2548 km² in 1986 to 2445.557 km², 1891.4454 km² and 812.8926 km² by 1990, 2001 and 2014 respectively; and slightly increased to 849.0708 km² by 2019 relative to 2014. Agricultural land significantly increases from 2864.7099 km² in 1986 to 4265.442 km² and 4879.9728 km² by 1990 and 2001; then decreased to 3114.8073 km² and 2778.021 km² by 2014 and 2019 respectively. However, agricultural land record an overall slight decrease from 3032.2548 km² to 2864.7099 km² between 1986 and 2019. Waterbody and barren land also record overall increases with variability through the study period. Waterbody increased from 7.551 km² in 1986 to 10.8315 km² and 12.1896 km² by 1990 and 2001 respectively, but decreased to 9.3555 km² in 2014 and slightly increased again relative to 2014 to 9.5544 km² by 2019. Barren land significantly decreased from 1394.8137 km² in 1986 and 421.6851 km² in 1990 and 2020. 74.7689 by 1990 and 2001, but again increased significantly to 2851.6023 km² and 3036.1914 km² by 2014 and 2019 respectively. Interestingly, between 2001 and...
2014 when the water body decreased from 12.1896 km$^2$ to 9.3555 km$^2$, barren land significantly increased from 204.7689 km$^2$ to 2851.6023 km$^2$.

Figure 2. LULC of FCT (1986)

Source: Derived from classification (supervised) of Landsat image P189R054_1986/01/08
Figure 3. LULC of FCT (1990)

Source: Derived from classification (supervised) of Landsat image P189R054_1990/02/12
Figure 4. LULC of FCT (2001)

Source: Derived from classification (supervised) of Landsat image P189R054_2001/01/05
Figure 5. LULC of FCT (2014)

Source: Derived from classification (supervised) of Landsat image P189R054_2014/02/22
Figure 6. LULC of FCT (2019)

Source: Derived from classification (supervised) of Landsat image P189R054_2019/02/04
Figure 7. Urban built-up in FCT (1986 – 2019)

Source: Data analysis
Figure 8. Urban expansion in FCT (1986 – 2019)
Source: Data analysis
Table 2. LULC distribution in FCT (1986 – 2019)

<table>
<thead>
<tr>
<th>Period/ Land Cover Classes</th>
<th>Area (km²)</th>
<th>Area (%)</th>
<th>Area (km²)</th>
<th>Area (%)</th>
<th>Area (km²)</th>
<th>Area (%)</th>
<th>Area (km²)</th>
<th>Area (%)</th>
<th>Area (km²)</th>
<th>Area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Built-up Land</td>
<td>54.2466</td>
<td>0.73769</td>
<td>212.0607</td>
<td>2.88377</td>
<td>365.1993</td>
<td>4.96628</td>
<td>564.9165</td>
<td>7.68220</td>
<td>680.7375</td>
<td>9.25723</td>
</tr>
<tr>
<td>Agricultural Land</td>
<td>2864.709</td>
<td>38.9566</td>
<td>4265.442</td>
<td>58.005</td>
<td>4879.972</td>
<td>66.3619</td>
<td>3114.807</td>
<td>42.3577</td>
<td>2778.020</td>
<td>37.7778</td>
</tr>
<tr>
<td>Forest Land</td>
<td>3032.254</td>
<td>41.2351</td>
<td>2443.556</td>
<td>33.2295</td>
<td>1891.445</td>
<td>25.7214</td>
<td>812.8926</td>
<td>11.0543</td>
<td>849.0708</td>
<td>11.5463</td>
</tr>
<tr>
<td>Water Body</td>
<td>7.551</td>
<td>0.10268</td>
<td>10.8315</td>
<td>0.14729</td>
<td>12.1896</td>
<td>0.16576</td>
<td>9.3555</td>
<td>0.12722</td>
<td>9.5544</td>
<td>0.12992</td>
</tr>
<tr>
<td>Barren Land</td>
<td>1394.813</td>
<td>18.9678</td>
<td>421.6851</td>
<td>5.73442</td>
<td>204.7689</td>
<td>2.78461</td>
<td>2851.602</td>
<td>38.7784</td>
<td>3036.191</td>
<td>41.2886</td>
</tr>
<tr>
<td>Total</td>
<td>7353.576</td>
<td>100</td>
<td>7353.576</td>
<td>100</td>
<td>7353.574</td>
<td>100</td>
<td>7353.574</td>
<td>100</td>
<td>7353.574</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Data Analysis

Table 3. Built-up expansion in FCT(1986 – 2019)

<table>
<thead>
<tr>
<th>Date</th>
<th>Built-up area (km²)</th>
<th>Expansion (km²)</th>
<th>Duration (years)</th>
<th>Percentage expansion (%)</th>
<th>Annual expansion rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td>54.2466</td>
<td>From - To Absolute expansion</td>
<td>4</td>
<td>25.19016637</td>
<td>39.453525</td>
</tr>
<tr>
<td>2014</td>
<td>564.9165</td>
<td>2001-2014</td>
<td>199.7172</td>
<td>2851.602</td>
<td>23.1642</td>
</tr>
<tr>
<td>Total</td>
<td>1986 – 2019</td>
<td>626.4909</td>
<td>33</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Data Analysis

FCT has indeed witnessed an expansion type of growth between 1986 and 2019 as evident in figures 6 and 7. However, there exists great variation in the growth that has ensued within the 33 years considered. As presented in table 3, in the first four (4) years, FCT grew at the rate of 39.45 per annum from 54.2466km² in 1986 to 212.0607km² by 1990. This growth rate decreased to 13.92 between 1990 and 2001 to 365.1993km². Between 2001 and 2014, the growth rate increased again to 15.36 per annum to 564.9165km². And finally, between 2014 and 2019, the growth rate significantly increased further to 23.16 per annual to 680.7375km². Of the absolute expansion of 626.4909km² that occur between 1986 and 2019, 25.19% (157.8141km²) was recorded between 1986 and 1990; 24.44% (153.1386km²) between 1990 and 2001; 31.88% (199.7172km²) between 2001 and 2014; and 18.49% (115.821km²) between 2014 and 2019. However, in the last 33 years, specifically between 1986 and 2019, FCT grew at the average rate of 18.98 per annum from a mere 54.2466km² in 1986 to 680.7375km² by 2019. This growth rate when compared with the average Nigeria urban area growth rate put at 3.2 percent (Ogunbode & Balogun, 2013), can be considered high and rapid. Expectedly, the growth has resulted in changes in other LULC, with forest land being the most negatively impacted. The growth pattern is simply an outward expansion from the main growth point (capital city - Abuja) in the north-eastern and moving towards the west and southwestern part of the territory, and majorly along transportation routes.

IV. CONCLUSION

Urban areas are no doubt complex and dynamic landscapes. The significance of assessing the development of such centres cannot be overemphasized. This study, therefore, integrates the latest technologies of acquiring and analyzing environmental data to assess the development of FCT over the last three decades. The study indicates that FCT has indeed undergone remarkable expansion in the last 33 years, with corresponding impact on another land cover. However, as this growth is most likely to be sustained, there is need to project and appraise its compliance with the initial plan in order to achieve healthy and sustainable growth.

ACKNOWLEDGEMENT

My profound gratitude and ultimate goes to my father, Mallam Isiyaku Abdullahi for his prayers and financial support throughout my research. I wish to extol and appreciate my ClassmatesWuHaoWuHao, Shen Jiaqi, Ge Qu, Zhao Jianyi, Yao Tianyu for their support.

V. REFERENCES


