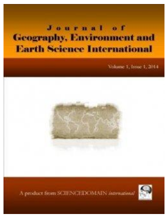

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Urban Extension in Calabar: A Remotely Sensed Assessment

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Urban places in the developing world like their advanced counterparts are experiencing unprecedented extensions, although mostly in an uncontrolled manner. Calabar is no exception to such urban extension, with notable sprawl especially with increased densification within the city and expansion along the fringes. This study aimed at assessing landuse/ land-cover (LULC) changes in Calabar between the year 2000 and 2018. 30 m Landsat imageries of both years were acquired from the Landlook platform. The imageries were subjected to the unsupervised classification process using the Iso Cluster and Maximum Likelihood Classification tools. Measurements were done on the raster outputs to allow for a comparison of the LULC statistics which assisted in identifying the rate of urban extension in Calabar over the period. Results showed that in the year 2000, out of the total 164.3 square kilometers (sqkm) covered by the city, the extent of urban built-up was 28.7 sqkm and 62.2 sqkm for green areas. However, in the year 2018, the urban built-up area increased to 44.8 sqm and green areas witnessed a reduction to 52.7 sqkm. Wet lands also reduced in the area by 5.2 sqkm. Likewise, built up areas had a percentage change rate of 56.10

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while green areas and wet lands had -15.27 and -9.3 percent change rates respectively. The spate of urban extension and encroachment into green areas and wet lands in Calabar is obvious and inevitable. It is thus necessary that measures be taken by relevant government agencies to monitor and manage the urban extension, such that the development is organized and sustainable.

Keywords: Urban extension; landuse; land-cover; geographic information systems; remote sensing; Calabar.

1. INTRODUCTION

Globally, land cover today is altered principally by direct anthropogenic factors like agriculture and livestock raising, forest harvesting and urban and suburban construction and development. Due to rapid human activities, the earth surface is being progressively altered in such manner that man's existence on earth and his use of land has had a deep effect on rather all meteorological attributes. The fast pace of urbanisation has been shown to be a serious global problem and is more evident in most of the developing countries. There is also every indication that the trend will continue, adding approximately two billion people to the urban population of the presently less-developed nations in the next 30 years [1].

The world is becoming increasingly urbanised with 45 percent of the population already living in the urban areas in the year 2000. The projection as at then was that half of the world will live in urban areas by 2007 [2]. It was also estimated that by the year 2025, 60 percent of the world's population will live in cities [3]. Land transformation has been asserted to be one of the most important fields of human-induced environmental transformation [4].

Urbanisation is one of the several anthropogenic activities that impact on land use/land cover. Urban population has been growing more rapidly than rural worldwide, particularly in developing countries [5]. It is measured by the rate at which the spatial extent of an urban settlement extends. In most countries, urban growth is recognised as a crucial phenomenon of economic growth and social change as it offers increased opportunities for employment, specialisation, production, goods and services [6], which in turn initiates a large number of people migrating from rural to urban areas [7].

Several empirical studies have shown that unplanned changes of land use due to urbanisation have become a major problem [8]. Most land use changes occur without a clear and logical planning without attention to their environmental impacts. Major flooding, air pollution in large cities as well as deforestation, urban growth, soil erosion, desertification, are all consequences of mismanaged planning without considering the environmental impacts of development plans.

This study focuses on urban extension in Calabar. Calabar is the capital city of Cross River State, in the southern region of Nigeria. The city lies between Longitudes 8º18′00″E to 8º24′00″E and Latitudes 4º54′00″N to 5º04′00″N, sandwiched in between Odukpani Local Government Area (LGA) to the north, the Calabar River to the west, Great Kwa River to the east and the creeks of the Cross River as it empties into the Atlantic Ocean in the South (Fig. 1). The Metropolis covers an approximate land area of 137.039 square kilometers (sqkm) and had a population of 328,878 in 1991 and 375,196 in 2006 according to the National Population Commission (NPC) and a projected population of 529362 in 2015 [9]. Calabar has witnessed observable urban extension over time. The built-up area continues to extend outward and has consumed prior agricultural and wetlands at a break-neck pace. Hectares of green areas are now covered by concrete and asphalt as new roads are created and existing ones are extended. Over 5000 hectares of greenery has been taken over by built up activities at Ekorinim, Esuk Utan, Edim-Otop, Anantigha, and Ikot Effanga areas of the metropolis [10].

As the population of Calabar increases, so also is the desire to meet up these population thresholds through urbanisation. The extension of the urban area in Calabar has resulted not only in depletion of natural resources but the deterioration of the environment. The unregulated and haphazard growth of urban development has adversely affected Calabar's ecosystem which has potency to indirectly reflect on climate attributes and eventually leads to local weather modification. This study thus aimed at assessing spatial and temporal landuse and land-cover changes in Calabar between the year 2000 and 2018 using remotely sensed data and GIS techniques. GIS-based multi-temporal land use data and analyses provide a historical vehicle for determining and evaluating long-term changes in landuse due to urbanisation. The collection of remotely sensed data facilitates the synoptic analyses of changes on the earth surface at local, regional and global scales over time [11].

2. MATERIALS AND METHODS

The methodology of this study incorporated a reconnaissance survey, data acquisition, data processing and data analysis. The reconnaissance survey aimed at getting the researcher acquainted with the existing physical characteristics of the study area. The types of data used include Landsat imageries which were obtained from *Land Look* platform. Their attributes are presented in Table 1. Relevant literature materials were obtained from textbooks, journals and other existing literatures that are related to the research problem.

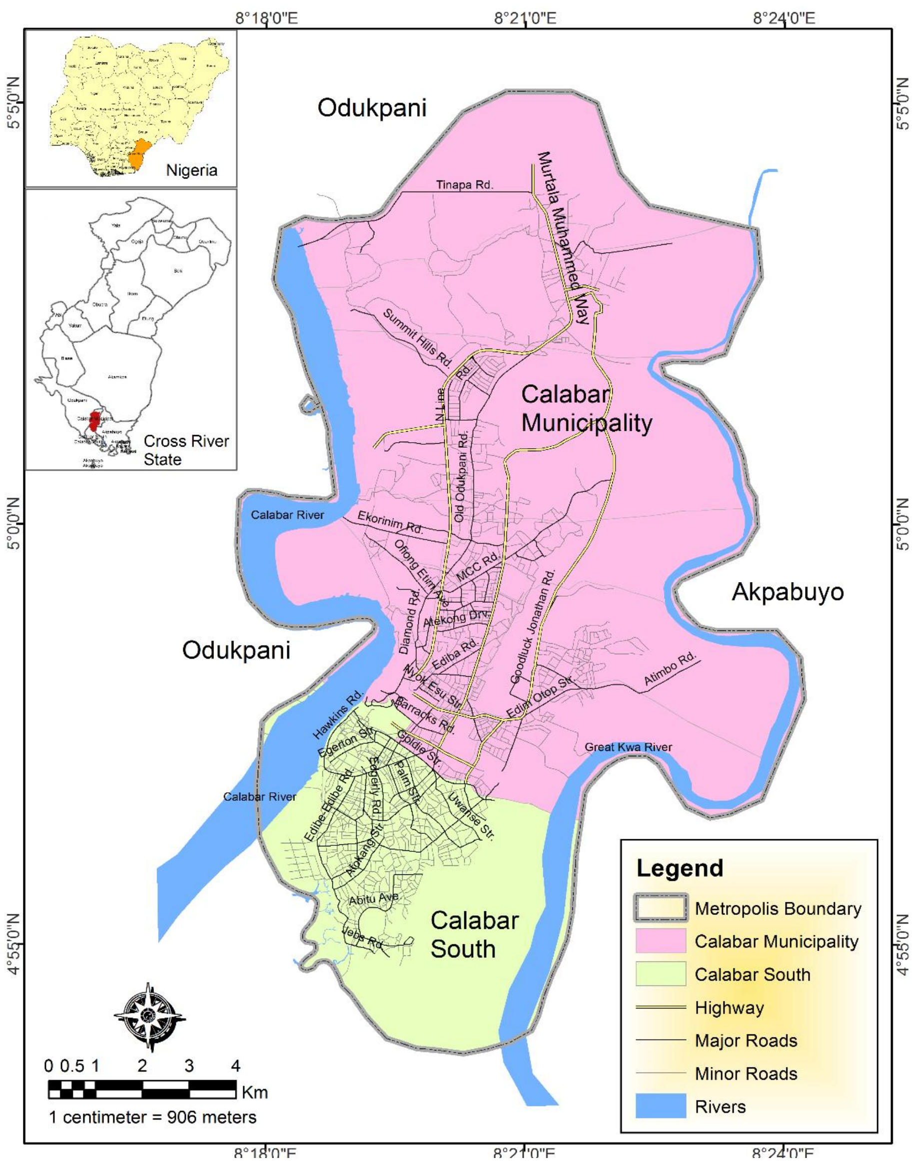

Fig. 1. Map of Calabar metropolis

Table 1. Attributes of acquired satellite imageries

	Data Type	Year	Resolution/Sensor	Source
1.	Landsat 7 image	2000	30m/ ETM+	LandLook
2.	Landsat 8 image	2018	30m/ OLI	LandLook

Table 2. LULC classification scheme adopted

S/N	Land Use Category	Description
1	Built-up	Land used for residential and transportation/communication purposes (i.e. settlements and roads, high residential area, industry and administrative blocks).
3	Wet lands	Land cover characteristically saturated; a marsh or a swamp.
4	Water body	Areas covered by body of water e.g. dam, lake and rivers.
5	Green area	Areas that are spatially cultivated e.g. farmland, irrigation areas etc. as well as urban greenery, grasses, shrubs and grass-like plants.

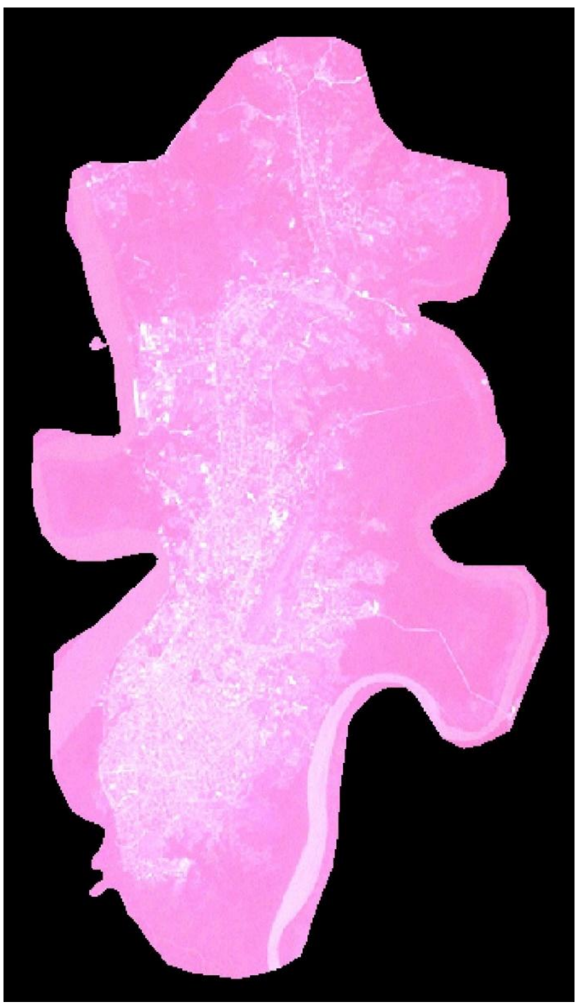

Fig. 2. Landsat imagery of Calabar in 2000

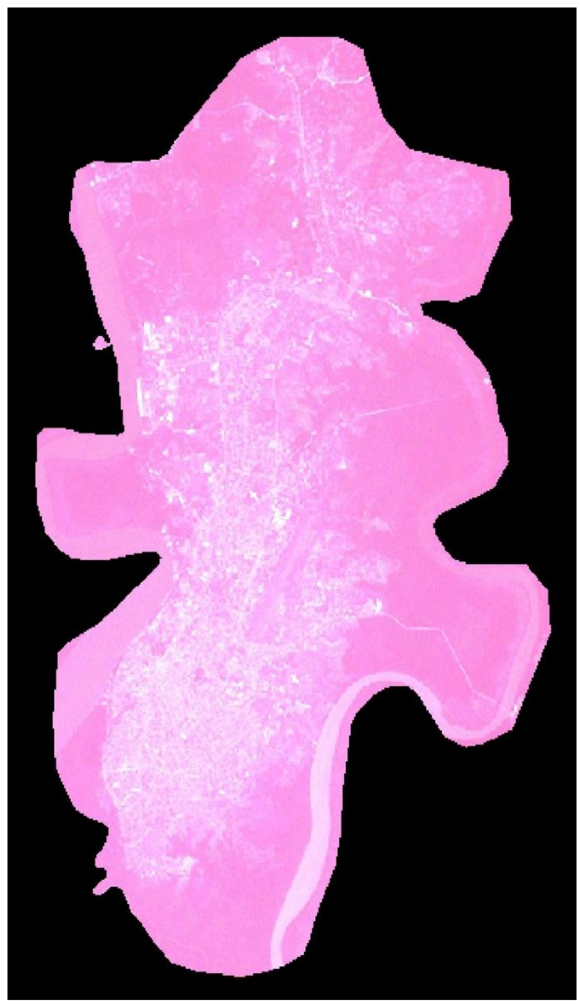

Fig. 3. Landsat imagery of Calabar in 2018

2.1 Image Processing and Classification

There was no need for georeferencing the images since they were already otho-rectified. The images were clipped with the boundary data of Calabar using the clip tool in the ArcMap platform. However, the images were geometrically corrected to Universal Transverse Mercator (UTM) Zone 32 North coordinate system on the same platform. To detect changes in the land use/cover at different years, post classification comparison of the change detection techniques was used.

The boundary data of Calabar metropolis was used to clip the Landsat imageries. The clipping helped to remove the extents outside the boundary of the satellite imageries (depicted in false colour in Figs. 2 and 3). After clipping, ERDAS imagine software was used for the pixel-based classification. The imageries were subjected to an unsupervised classification using the Iso Cluster (IC) and Maximum Likelihood Classification (MLC) spatial analyst tool. The ArcMap software was afterwards used for the final embellishment of the ERDAS outputs.

The classified raster output was converted to vector (polygons) to allow for measurements to be done. The area coverage of each of the LULC class was measured in sqkm for each of the years under consideration using the calculate geometry tool in the same ArcMap platform. A comparison of the land cover statistics assisted in identifying the change in sqkm/percentage, trend and rate of change in Calabar over the period. In this study, in line with Anderson, Hardy, Roach and Witmer (1976) land-use/land-cover classification scheme in [12], the various LULC types are modified and generalised into 4 classes within the study area as presented on Table 2. Further calculations were done using the simple percentage change formula (*percentage increase= increase ÷ original number × 100*) given in [13]. A positive percentage change answer implies an increase while a negative depicts otherwise.

3. RESULTS AND DISCUSSION

3.1 Land Use and Land Cover Scenario in Calabar from 2000 to 2018

To assess the LULC situation of Calabar in the past and present, the LULC analysis was executed. Tables and maps were used to illustrate the LULC status quo at Calabar in 2000 and 2018 respectively. As symbolised by the legend, the yellow colour represents the built-up area, the light green for green area, blue colour represents water body and the light blue for the wetlands.

As observed from the analyses outputs presented in Table 3 and Figs. 4-5, there were evident changes in the LULC of Calabar during the 18 year period considered. From the year 2000 to 2018, there was little change in the extent of the water bodies with only a slight decrease on 0.9 percent. The Calabar and Great Kwa rivers are tidal rivers mostly influenced by their closeness to the Atlantic Ocean. The rivers are minimally influenced by urban activities as the wetland bordering them still shield the rivers from direct urban extension impacts.

Within the same period under review, built-up areas increased by 16.1 sqm, with a coverage of 28.7 sqkm in the year 2000 and 44.8 in 2018. As pictured in Fig. 5, the city visibly extended majorly to the northern fringes with new developments in the 8th mile, Ikot Nkebre, Adiabo and other areas at the northern fringes. There is also evidence of increased urban densification in the central portions of the city (around the Margret Ekpo International Airport). The introduction of the Tinapa resort at the north western fringes also played a significant role in distorting the urban landscape of the city. The resort attracted the emanation of new built up activities, a minute extension of the Calabar River inland (for water transportation and recreational purposes) and the introduction of new wetland areas.

There was also no significant extension in the southern area which houses the Calabar South LGA. This southern area had witnessed significant development before the year 2000, most of which had caught up with the rivers and wetlands which limit construction activities especially where resources are weaned, thus the restrain of further drastic urban extension in that axis. Residents have concentrated their development activities more where dry portions of land are available. This has geared the increase of built up activities in the Municipality LGA through an unconscious vertical development of the city toward the northern fringes into Odukpani LGA. The direct impact of the urban built-up extension is on the green

Table 3. LULC characteristics of Calabar in the year 2000 and 2018

Landuse class	2000 area coverage (Sqkm)	Percentage	2018 area coverage (Sqkm)	Percentage	Area coverage (+/-)	Percentage (+/-)	Percentage rate of change
Built up	28.7	17.5	44.8	27.4	16.1	9.9	56.10
Green areas	62.2	37.8	52.7	32	-9.5	-5.8	-15.27
Wet lands	55.9	34	50.7	30.8	-5.2	-3.2	-9.30
Water bodies	17.5	10.7	16.1	9.8	-1.4	-0.9	-8
Total	164.3	100	164.3	100			

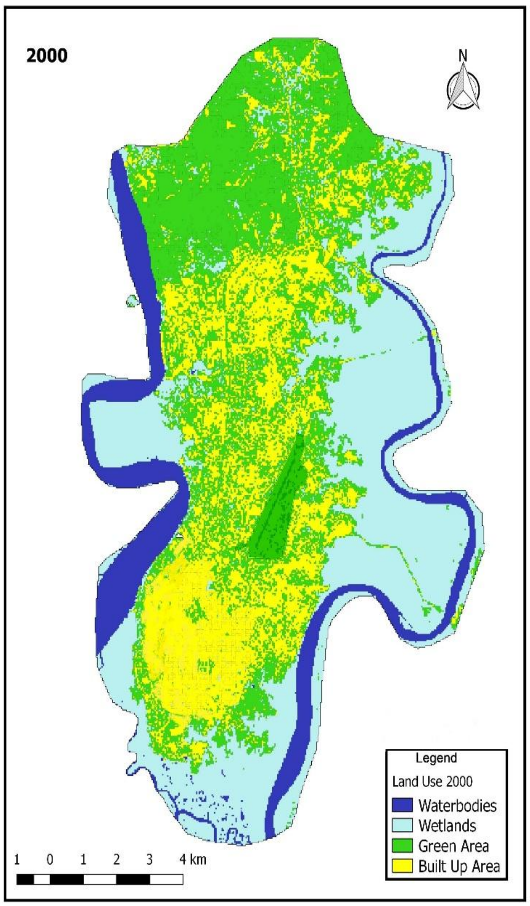

Fig. 4. Output of LULC analysis in the year 2000

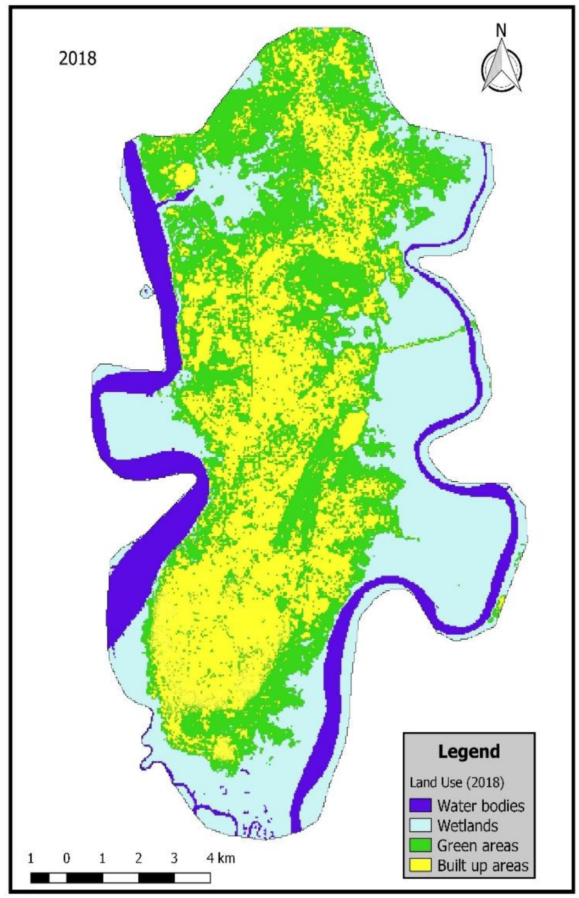

Fig. 5. Output of LULC analysis in the year 2018

areas which saw a reduction of 9.5 sqkm from an initial 62.2 sqkm in the year 2000. The wetlands on both sides of the city also reduced by 5.2 sqkm.

Further calculations in Table 3 revealed a 56.1 percent rate of change (increase) for built up areas accompanied by a 15.27, 9.3 and 8 percent change rate (decrease) in the green areas, wetlands and water bodies land classes respectively. The extension in the urban built-up follows from the swelling population and increased socio-economic activities within the study area. Notably, the urban extension evident in these fringe areas of Calabar are haphazard and uncoordinated, thus requiring the attention of relevant agencies to ensure sustainable urban development in the area.

4. CONCLUSION AND RECOMMENDATIONS

Typical to urban centers, urban extension in Calabar has been triggered by increased human activities, resulting in LULC changes. The impacts of these changes are worrisome in the face of uncoordinated planning policies and implementation. The application of remote sensing and GIS provided quantification, estimation and understanding of LULC changes in Calabar. There was an apparent extension in the urban built-up area of Calabar with the greenery mostly suffering the impacts of the extension.

Following from the findings from the study, the study recommends that:

i. Landuse planning should be instituted and implemented in Calabar to ensure that the usage of land, especially in the fringe, is sustainable. This effort should involve the sectoral integration of the relevant state ministries, boards and bodies of the LGA Council.
ii. Intensive sensitization should also be embarked upon and pursued holistically with a view to ensuring that the inhabitants of the study area understand the negative effects and consequences that are associated with uncoordinated landuse development.
iii. Deliberate efforts such as the declaration, reservation and preservation of the ecologically fragile greenery and wetland areas of Calabar should be instituted and logically pursued by government.
iv. Finally, smart development of diverse-mixed landuse should be encouraged so as to reduce the rapid rate and large amount of urban land being converted for construction of homes, offices and commercial buildings.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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