



Spatial Assessment of Urbanization Using GIS in Selected Neighbourhoods of Port Harcourt Metropolis

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Authors' contributions

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

Article Information

DOI: 10.9734/JGEESI/2020/v24i730240

Editor(s):

(1) Dr. Wen-Cheng Liu, National United University, Taiwan.

Reviewers:

(1) Yaguang Qin, Central South University, China.

(2) Manoj Kumar, All India Institute of Medical Sciences (AIIMS), India.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/62507>

Original Research Article

**Received 24 August 2020
Accepted 28 October 2020
Published 09 November 2020**

ABSTRACT

This study analyzed the spatial assessment of urbanization in Mgbougba, PH Township, Orazi Rumueme, and Eligbam Rumueme using GIS to determine the spatial and temporal changes. This study adopted data from a secondary source, which includes Landsat (7) TM Thematic Mapper of 1999, 2009 and 2019 of the study areas which were further analyzed to determine spatial and temporal changes that have occurred in the study areas. Findings from this study based on the classified Landsat imageries revealed that in Mgbougba, spatial changes were observed as a result of an increase in built area value of 591 in 1999 to 4066 in 2009 and to 6661 in 2019, hence, caused a reduction in vegetation cover with the value of 5038 in 1999 to 3733 in 2009 and to 1515 in 2019 and also a reduction of water body with a value of 363 in 1999 to 276 in 2009, with the absence of water body in 2019. Spatial changes also occurred in PH Township built-up areas indicating an increase in signature values from 3329 in 1999 to 4646 in 2009 and to 6276 in 2019.

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There was a decrease in vegetation cover of 2044 in 1999 to 1325 in 2009 and 1258 in 2019, bare land also showed a reduction in signature values of 1239 in 1999 to 1142 in 2009 and 791 in 2019 and finally a reduction of water body from 700 in 1999 to 658 in 2009 and 600 in 2019. In Orazi Rumueme, it revealed there was a significant expansion of built-up area value from 2514 in 1999 to 2978 in 2009 and 3936 in 2019. There was a decline in vegetation cover with a value of 678 in 1999 to 517 in 2009 and 426 in 2019. Spatial changes in Eligbam Rumueme, showed that built-up area value increased from 780 in 1999 to 878 in 2009 and 1164 in 2019, thus, resulting to a reduction in the vegetation cover with a value from 625 in 1999 to 537 in 2009 and 251 in 2019 which indicated that urbanization led to significant spatial changes in built-up areas, vegetation cover, bare land and water body in the selected neighborhoods. However, the identified pattern of urbanization in the study areas showed that the selected neighborhoods possessed more built-up areas as of 2019 when compared to 1999 and 2009. The spatial analysis of urbanization using GIS aided in understanding the spatial changes that have occurred in the selected neighborhoods and provided plans for sustainable development.

Keywords: Rapid urbanization; spatial and temporal changes; GIS; neighbourhods; Port Harcourt.

1. INTRODUCTION

Urbanization is a worldwide phenomenon which differs from developed to developing countries. There has been a major change in the last century of one of which is the increase number of populations as compared to that of the rural area. Based on the United Nations [1] about 66% of the world population is estimated to occupy the urban area, thereby increasing the number of mega cities around the world.

In other to have a clear understanding of Urbanization is necessary to understand the terms associated with it, which include urban and urbanize. Urban is generally referred to the demographic characteristics of a place which include population, size, density and economic function which include a significant majority of the population do not engage primarily in agriculture [2]. The term “urbanize” is referred to as making a predominantly rural area more industrialized and urban.

Urbanization can be referred to as the process whereby rural areas become urbanized as a result of economic development and industrialization [3]. Urbanization can also be defined as “the demographic process whereby an increasing share of the national population lives within urban settlement” [4]. It is important to acknowledge that the criteria for defining urbanization vary from context to context and country to country, which cautions us against a strict comparison of urbanization cross-nationally.

Generally urban immigration has exceeded the carry capacity of infrastructure available in

various cities, resulting to the depletion of the available resources. The rapid increase in urbanization and its negative impact that it has on land use means that it becoming increasingly for city planners to adopt appropriate sustainable land use plan [5].

1.1 Statement of the Problem

The uncontrollable rate of rural-urban migration is a major source of rapid urban growth in Port Harcourt metropolis. This problem and challenges posed by rapid urban growth are immersed; it is of greater concern of that of developing countries such as Nigeria.

Urbanization generates several challenges economically, socially and environmentally [6]. The influx of these migrants far outstretched the available infrastructural facilities in the urban environment. The most easily observed challenges in the urban environment include slum proliferation, inadequate housing facilities, lack of basic services, illegal construction within the city and its periphery, water, soil, and air pollution which finally leads to environmental degradation, climate change, and poor governance. Inadequate information on spatial growth taking place in selected Neighborhoods in Port Harcourt has limited the process of urban and regional planning and development in the urban areas.

1.2 Goal and Objectives of the Study

Considering the challenges resulting from rapid urbanization, hence the goal of this study is to access urbanization by analyzing the spatial and temporal changes that have occurred in the



Fig. A. Map of rivers state showing port harcourt metropolis, the study location

selected neighborhoods in Port Harcourt using GIS techniques.

The objective of the study is to:

- i. Identify and analyze spatial pattern of urbanization in the selected neighborhoods in Port Harcourt;

1.3 Study Area Description

This study covers selected neighborhoods' which include Mgbuogba, PH Township and Orazi Rumueme and Eligbam Rumueme in Port Harcourt city of River State. It is said to be one of Nigeria fastest growing cities, the rapid growth and urbanization of the city has been fueled by the massive influx of people from the surrounding hinterland to the city for job opportunities in various industries that sprang up as a result of the discover of petroleum in the Niger Delta [7].

Port Harcourt has been an important merchant port and today it is a centre of Nigerian's oil industry [8]. Most economic activities in River State is situated in Port Harcourt. The expansion of industrial and commercial activities during the consolidation period of 1925 – 1944 is what led to the creation of this industrial area and increase in economic activities naturally giving rise to population growth and urban development.

2. REVIEW OF RELEVANT LITERATURE

Urbanization can be referred to as the process whereby rural areas become urbanized as a result of economic development and

industrialization [3]. Urbanization can also be defined as “the demographic process whereby an increasing share of the national population lives within urban settlement” [4].

Olotuah [9], stated that developing countries are experiencing a rapid rate of urbanization. This is manifested more in Africa; within Africa the growth rate of the urban population is more visible in Nigeria than most other countries in the continent. According to [10], not only is Nigeria experiencing one of the fastest rates of urbanization in the world, the explosive rate of growth in Nigeria urban centres has posed great challenges to sustainable development; this has progressively complicated problems of human settlement and the environment and has also accelerated poverty. The demand for infrastructures, basic services and housing in expanding urban centres are on the increase, issues of sanitation, waste management are also in need for attention. The deplorable condition of the education, health, transportation, water and sanitation sector and most importantly the lack of resources and technical know-how to manage urban crises [11].

Urban sustainability consists of minimizing the consumption of resources and land, optimizing urban form to facilitate urban flows, protecting both human health and ecosystem, ensuring equal access to resources and services, and maintain cultural and social diversity and integrity [12,13]. However, developing sustainable cities is a difficult task because cities are the centers of socio-economic developments, the main sources of major environmental problems, and the living place of almost half of the world population.

The relationship between urbanization and sustainability is one the major sort about issue faced in the environment research. [14] pointed out that there is a significant relationship between urban form and sustainable development, although it is not simple and straightforward. Urbanization when ignored may intimidate sustainable development [15].

Mapping and monitoring urban areas land cover has been a widely recognized as an important step to better understand and provide solution for social, economic and environmental problems [16,17,18]. Spatial temporal urban growth indicates the spatial and temporal dimensions of land cover/ use change at the level of the urban landscape [19].

The explosive rate of growth in Nigeria urban centres in conjunction with high demand for infrastructures, basic services as well as housing pose a great challenge to sustainable development, this has progressively complicated problems of human settlement and the environment and has also accelerated poverty. There are few studies that have examined spatial and temporal changes influenced by urbanization over time.

Although most of the developed countries are well equipped with detailed land cover information [17,20] argued that our current understanding of the land cover change and its effects are largely limited by the lack of accurate and timely land cover data in the developing countries. Land cover data are inadequate or unavailable with inconsistent quality, and out of date; while generating it is time consuming and expensive [21]. This is attributed to the difficulties in accessing some regions because of equipment or funds to collect information properly, lack of trained personnel; or rapid changes [22]. With the wide requirement and application of land cover data, there has been an increasing interest in obtaining the data.

Monica and Moses [23] conducted a study on spatial monitoring of urban growth using GIS and remote sensing of Nairobi Metropolitan Area, Kenya. The study captured the urban land use/cover in the study area from the imagery, data and image processing was done followed by temporal mapping and urban spatial change analysis. The images were classified into five feature classes namely: Built-up, Vegetation, Bare land, Water and Other lands using maximum likelihood classification algorithm in the

supervised classification technique. The twenty four urban centres within the NMR were singled out and the built up areas mapped to display the nature of changes in the years 1995, 2005 and 2015 classified images and found out that Significant urban growth influenced by both spatial and non-spatial factors occurred in the NMR within the study period especially after formation of the Ministry of Nairobi Metropolitan Development (MoNMeD) in the year 2008.

Abineh and Zabairul [24] examined the use of google earth for land use land cover change detection in the case of Gish Abba Sekela, West Gojjam, Amhara State, Ethiopia, where Google Earth data of the period 17th may 2013 was used for image classification. The land use land cover classification showed the majority of the area was covered by Agriculture land by 33.9%, grazing land and forest land covered the area by 29.1% and 28.8% respectively and buildings and other land use land cover were 3.3% and 4.7%.

Boori et al. [25] carried out a study on urbanization analysis through remote sensing and GIS in kuala Lumpur, Manila and Singapore cities, where specific satellite images used were Landsat TM for 1989, Landsat ETM+ for 2001 and finally Landsat 8 for 2014 an image captured by different types of sensor. All three cities examined in this study have grown on coastal area. In Kuala Lumpur the urban growth under the Kuala Lumpur Land Use Master Plan has been influenced by economic development. The rate of urbanization increased continuously after 1989 due to the economic boom in Manila and the adoption of the economic growth reforms marked a remarkable change in the progress of urbanization in Singapore.

Study by [26] on Remote Sensing and GIS applications in urban expansion and loss of vegetation cover in Kaduna Town, Northern Nigeria. Where remotely sensed satellites imageries (data) supported with serious ground truthing exercise was used to check the impact of urbanization on the vegetal cover of the town, the time span of the study covered 11 years (1990 – 2000). It was found that there has been fast transformation of savannah vegetation, range land, wetland vegetation cover to other land uses such as bare lands and built-up area, bare lands and Built-up area have increased more than any other land uses, bare lands and Built-up area have increased in all directions with most of built-up expansion in both the northern and southern part of the town.

3. RESEARCH METHOD

The study population includes the entire inhabitant of the selected neighborhoods of Port Harcourt which include Mgbuogba, PH Township, Orazi Rumueme, and Eligbam Rumueme. The selected neighborhoods' population from 1991 population was projected for 2019 using Microsoft excel using the growth rate of 4.24% [27].

Table 1 shows the selected neighborhoods' population from 1991 population was projected for 2019 using Microsoft excel and the growth rate of 4.24%.

Data for this study was essentially from a secondary source, which includes Landsat (7) TM Thematic Mapper of 1999, 2009 and 2019 of the study areas which was analyzed to show spatial and temporal changes in the study areas. The Landsat 7 imageries was downloaded from the archive of USGS (United States Geological Survey) and Earth Explorer to derive spatial and temporal changes in the study areas. ArcGIS 10.1 was used in developing, displaying and processing of the location maps, Landsat (7) TM Thematic Mapper was used in downloading maps of 1999, 2009 and 2019 of the study areas, Google Earth Pro was used in the delineation of the study areas imagery and Microsoft Word Office 2010 was used basically for the presentation of the research work. The various signature files that is of interest to the researcher was picked, they ranged from; Built up areas, Vegetation cover, Bare land and Water bodies. After the signature files have been carefully selected, it was further analyzed and the maximum likelihood analysis was carried out after which the signature files selected was further filtered to give us the desired output.

4. RESULT AND DISCUSSION

This section focuses on the presentation and analysis of findings during the course of the study.

The data presented in this study are imageries obtained from Landsat (7) TM Thematic Mapper of 1999, 2009 and 2019 of the selected neighborhoods in Port Harcourt.

4.1 Classified Landsat 7 Imageries showing Spatial and Temporal Changes

Table 2 shows the distribution of built up areas, vegetation covers and water body in the classified Landsat imageries of mgbuogba within the notable period of 3 years, where in 1999, built up areas value is at 591, vegetation cover value at 5038 and water body value at 363. In 2009, built up areas is at 4066, vegetation cover value at 3733 and water body value at 276. Finally, in 2019, Built up areas value is at 6661, vegetation cover value at 1515 and water body was no longer visible in Mgbuoba.

Table 3 shows the distribution of built up areas, vegetation covers, bare land and water body in the classified landsat imageries of Port Harcourt Township within the notable period of three years, where in 1999, built up areas value is at 3329, vegetation cover value at 2044, bare land value at 1239 and water body value at 700. In 2009, built up areas is at 4646, vegetation cover value at 1325, bare land value at 1142 and water body value at 658. Finally, in 2019, Built up areas value is at 6276, vegetation cover value at 1258, bare land value is 791 and water body is 600 in PH Township.

Table 4 shows the distribution of built up areas and vegetation cover in the classified landsat imageries of Orazi Rumueme within the notable period of 3 years, where in 1999, built up areas value is at 2514 and vegetation cover value at 678. In 2009, built up areas is at 2978 and vegetation cover value at 517. Finally, in 2019, Built up areas value is at 3936 and vegetation cover value at 426 in Orazi Rumueme.

Table 1. Study population of the selected neighborhoods of Port Harcourt

S/N	Neighbourhoods	Population Census 1991	Projected Population 2019
1	Mgbuogba	2308	7303
2	Port Harcourt Township	12369	39141
3	Orazi Rumueme	11014	34853
4	Eligbam Rumueme	2162	6842
	Total	23383	73994

Sources: Rivers State Ministry of Budget, 2013 and calculations by the researcher, 2019

Table 2. Classified landsat 7 imageries signature files and their values for Mgbouba

Signature File	Signature Value 1999	Signature Value 2009	Signature Value 2019
Built-Up	591	4066	6661
Vegetation	5038	3733	1515
Water Body	363	276	***** Not applicable

Table 3. Classified landsat 7 imageries signature files and their values for Port Harcourt township

Signature File	Signature Value 1999	Signature Value 2009	Signature value 2019
Built-Up	3329	4646	6276
Vegetation	2044	1325	1258
Bare-land	1239	1142	791
Water Body	700	658	600

Table 4. Classified landsat 7 imageries signature files and their values for Orazi Rumueme

Signature File	Signature Value 1999	Signature Value 2009	Signature Value 2019
Built-Up	2514	2978	3936
Vegetation	678	517	426

Table 5. Classified landsat 7 imageries signature files and their values for Eligbam Rumueme

Signature File	Signature Value 1999	Signature Value 2009	Signature Value 2019
Built-Up	780	878	1164
Vegetation	625	537	251

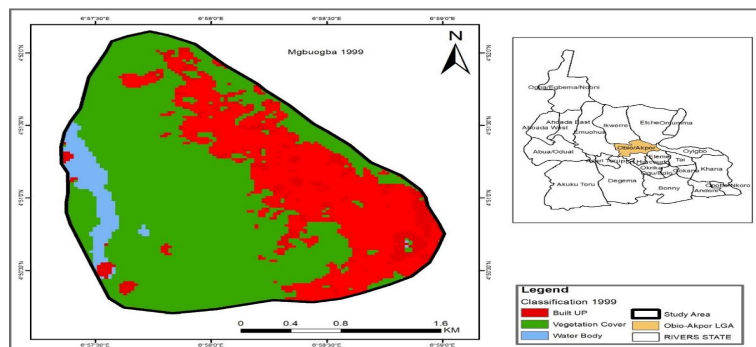


Fig. 1. 1999 classified landsat 7 imageries of Mgbouba

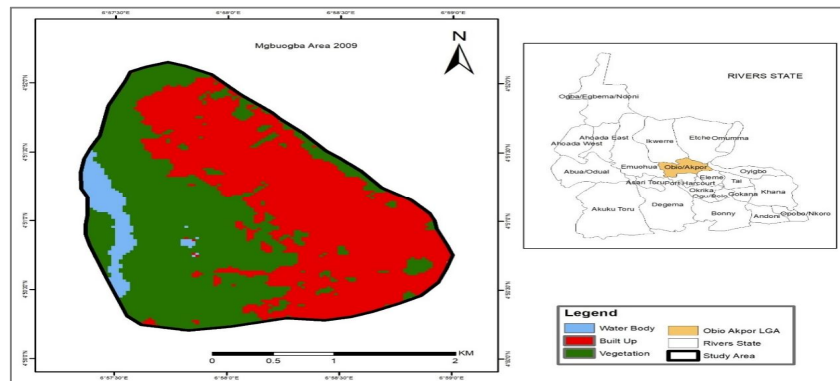


Fig. 2. 2009 classified landsat 7 imageries of Mgbouba

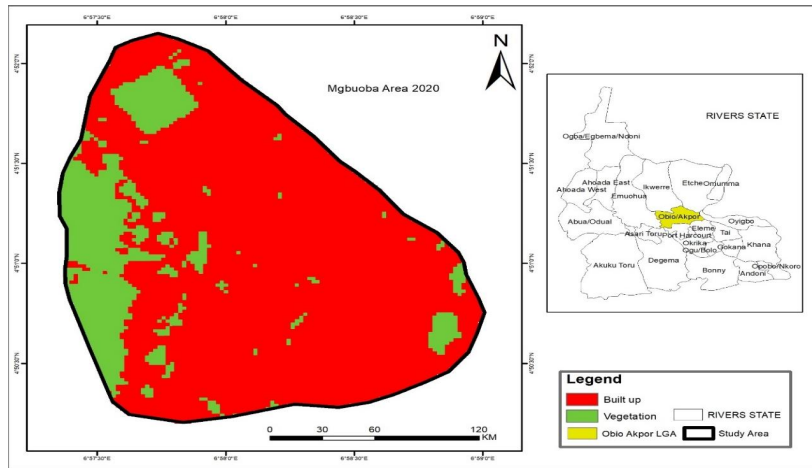


Fig 3. 2019 classified landsat 7 imageries of Mgbuoba

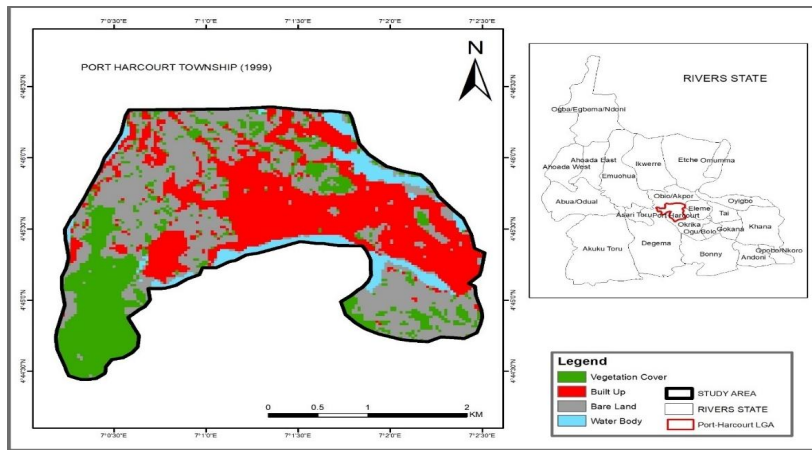


Fig. 4. 1999 classified landsat 7 imageries of Port Harcourt township

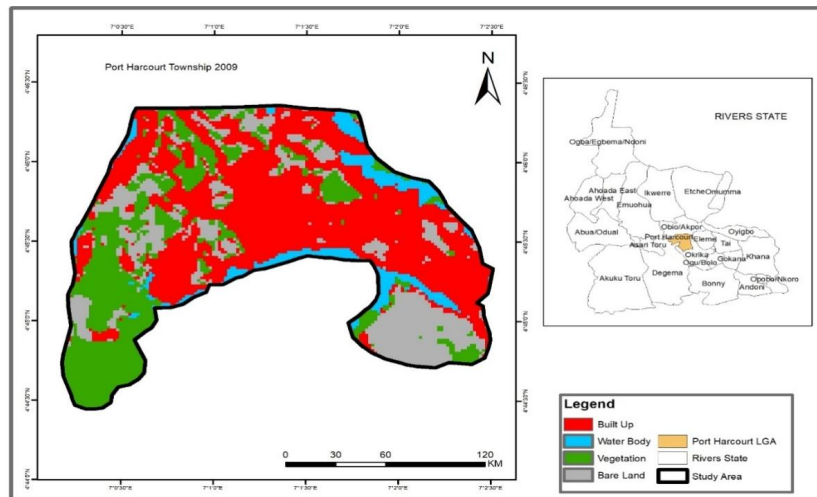


Fig. 5. 2009 classified landsat 7 imageries of Port Harcourt township

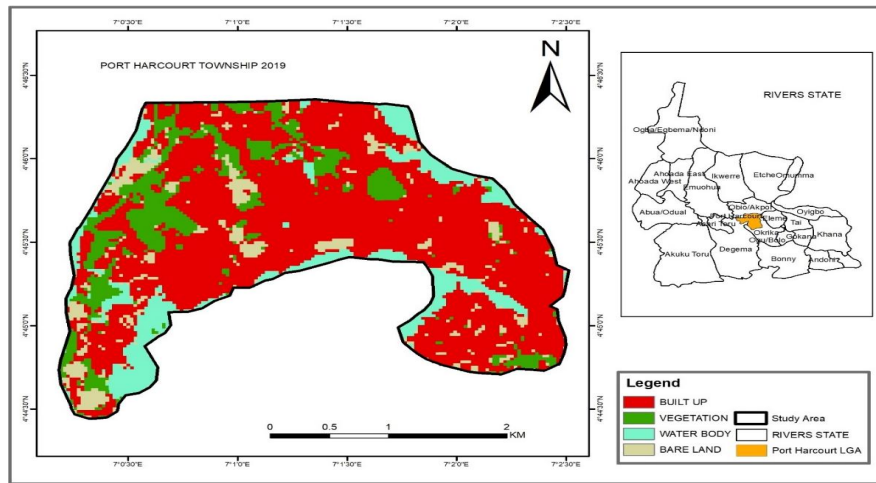


Fig. 6. 2019 classified landsat 7 imageries of Port Harcourt township

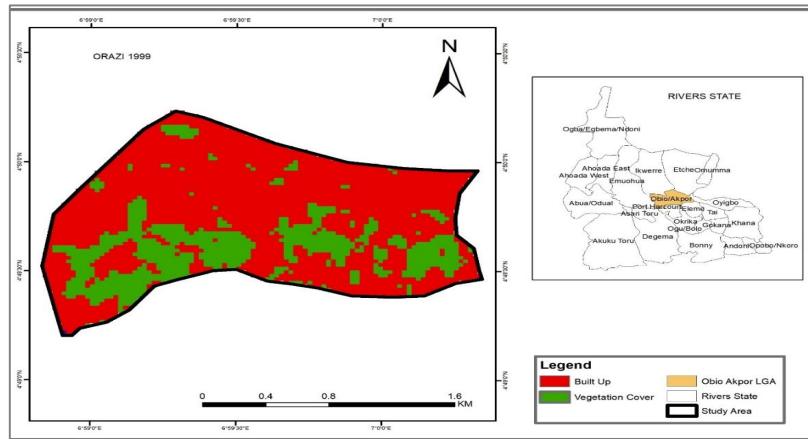


Fig. 7. 1999 classified landsat 7 imageries of Orazi Rumueme

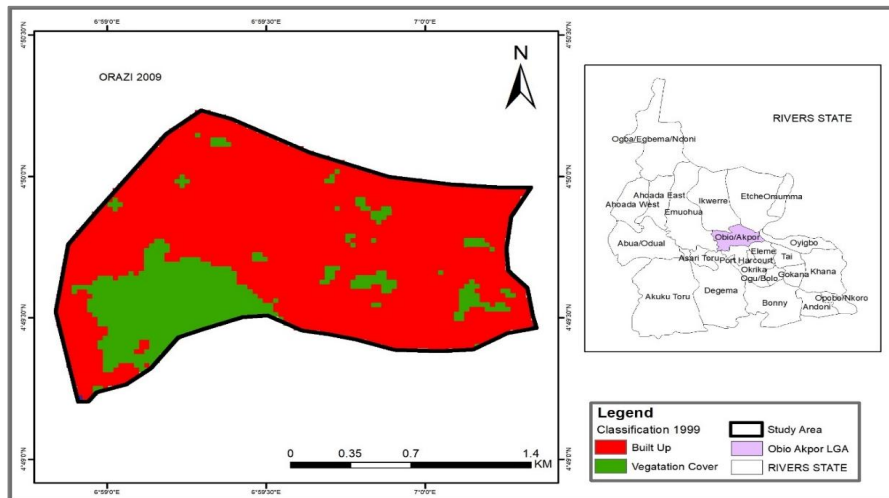


Fig. 8. 2009 classified landsat 7 imageries of Orazi Rumueme

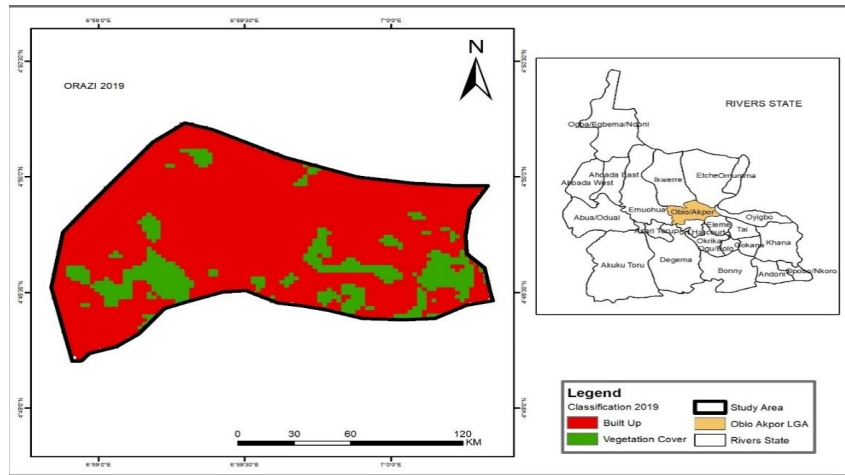


Fig. 9. 2019 classified landsat 7 imageries of Orazi Rumueme

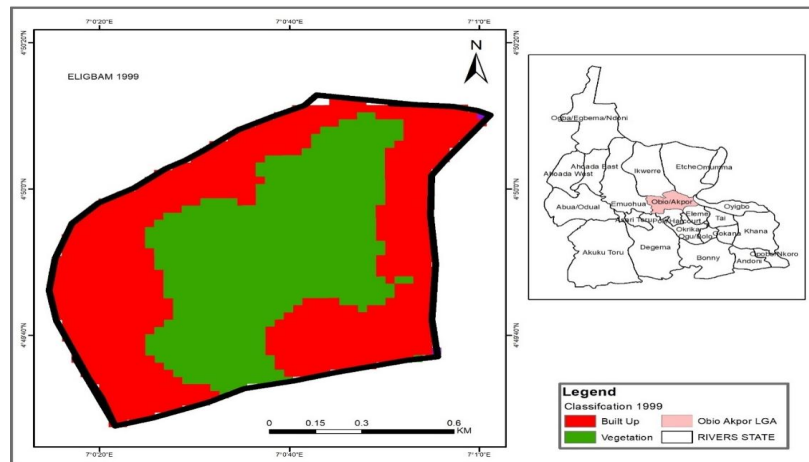


Fig. 10. 1999 classified landsat 7 imageries of Eligbam Rumueme

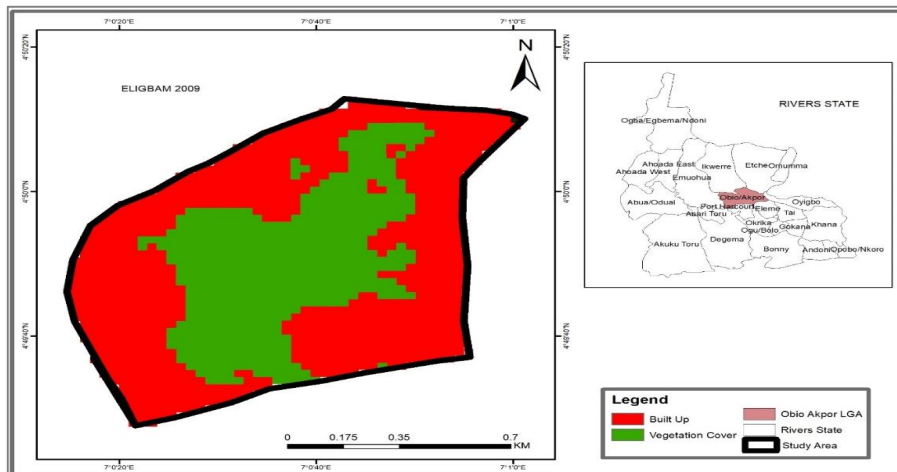


Fig. 11. 2009 classified landsat 7 imageries of Eligbam Rumueme

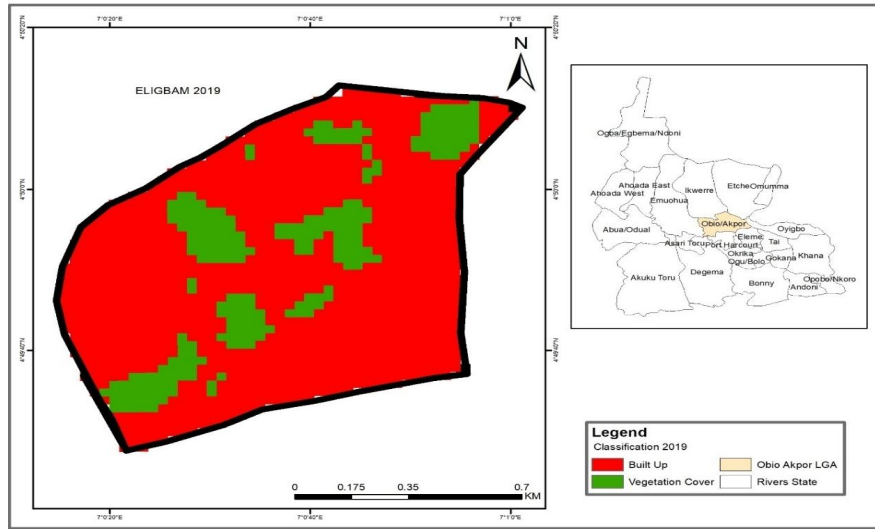


Fig. 12. 2019 classified landsat 7 imageries of Eligbam Rumueme

Table 5 shows the distribution of built up areas and vegetation cover in the classified landsat imageries of Eligbam Rumueme within the notable period of 3 years in, where in 1999, built up areas value is at 780 and vegetation cover value at 625. In 2009, built up areas is at 878 and vegetation cover value at 537. Finally, in 2019, Built up areas value is at 1164 and vegetation cover value at 251 in Eligbam Rumeme.

4.2 Discussion

Findings from the classified Landsat imageries shows changes in the land cover classes for the selected neighbourhoods in Port Harcourt. For Mgbuoba, the classification result presented shows built-up areas value increased from 591 in 1999 to 4066 in 2009 and to 6661 in 2019 causing a reduction in vegetation cover with the value of 5038 in 1999 to 3733 in 2009 and to 1515 in 2019 and also the water body which was present had the value of 363 in 1999 reduce to 276 in 2009 and in 2019 the water body was no longer visible. The expansion of built-up area in the neighborhood has encroached into the water bodies as it is observed in 2019 the water body was no longer visible.

In PH Township, findings from the classified Landsat imageries reveals built-up areas value increased from 3329 in 1999 to 4646 in 2009 and to 6276 in 2019, there was a decrease in vegetation cover value of 2044 in 1999 to 1325 in 2009 and 1258, there was also a decrease in

bare land from 1239 in 1999 to 1142 in 2009 and 791 in 2019 and also there was a decrease in the presence of water body from 700 in 1999 to 658 in 2009 and 600 in 2019. These changes can be attributed population growth, rapid deforestation, conversion of bare land to the built-up category. Thus, the changes in the landcover reveals rapid urban development as a result to fit the demand for the growing population.

Classified Landsat imageries of Orazi Rumueme reveals there was significant expansion in built area value from 2514 in 1999 to 2978 in 2009 and 3936 in 2019. There was decline in vegetation cover with value of 678 in 1999 to 517 in 2009 and 426 in 1999. An explanation for these changes may be attributed to rapid urban growth and urban expansion in the neighbourhood.

Also, the classified Landsat imageries of Eligbam Rumueme shows built-up area value increased from 780 in 1999 to 878 in 2009 and to 1164 in 2019 this resulting to a reduction in the vegetation cover with value from 625 in 1999 to 537 in 2009 and to 251 in 2019. Due to the growing population the high demand for residential and commercial structure as well as other development structure has resulted to the clearing of vegetation for physical development.

The findings in this study is consistent with the findings of [23], that conducted spatial monitoring of urban growth using GIS and remote sensing in Nairobi metropolitan area, Kenya and discovered

that from the classified images the built-up land cover increased from 1254.30km² (3.9%) in 1995 to 2030.05km² (6.3%) in 2005 to 3494.62km² (10.9%) in 2015 while bare land and vegetation class areas reduced between 1995 and 2015 which indicated a takeover. Also, study by [28] on geospatial approach in spatio-temporal pattern of urban growth in Benin City, Nigeria found that the high rate of urban growth can be attributed to the increase in demand for infrastructure resulting from the high rate of influx of people into the city.

5. CONCLUSION

Based on the classified landsat imageries obtained, this study was able to show that spatial and temporal changes in Mgbougba, PH Township, Orazi Rumueme and Eligbam Rumueme have occurred from 3 notable periods; 1999, 2009 and 2019 which has resulted in significant spatial changes in Built up areas, Vegetation cover, Bare land and Water body that have occurred in the selected neighborhoods' as a result of rapid urbanization,. However, the identified pattern of urbanization in the study areas showed that the selected neighborhoods possess more of Built up areas as of 2019 when compared to 1999 and 2009. The spatial analysis of urbanization using GIS could support in understanding the spatial changes that occurred in the selected neighborhoods' and provide plans for sustainable development.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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