Asian Research Journal of Arts & Social Sciences

Volume 21, Issue 1, Page 42-52, 2023; Article no.ARJASS.104441
ISSN: 2456-4761

A Decade of Land Cover Transformations in Akure's Peri-Urban Region (2011-2022) Using Multispectral Landsat Imagery

Adeleke Oladele Asaju [a*] and Michael A. Olukolajo [a]

[a] Estate Management Department, Federal University of Technology Akure, Ondo State, Nigeria.

Authors' contributions

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

Article Information

DOI: 10.9734/ARJASS/2023/v21i1461

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/104441

Original Research Article

Received: 19/06/2023
Accepted: 24/08/2023
Published: 02/09/2023

ABSTRACT

Aim: To analyze the spatial distribution of land uses in the peri-urban areas of Akure, Nigeria between 2011 and 2022.
Study Design: Quantitative GIS research.
Place and Duration of Study: Oke-Odu, Ipinsa and Aule, Akure, Ondo-State, Nigeria, 2022.
Methodology: ArcGIS was employed in conjunction with Landsat images for 2011, 2016 and 2022 to conduct a supervised classification of land uses in Oke-Odu, Ipinsa and Aule Peri-urban areas of Akure, Nigeria. Data quality was considered such that cloud cover and scene cover of selected imagery downloaded are less than 10%. The classification method used was maximum likelihood, and three distinct classes were targeted: Built up areas, Green Areas and Open Spaces.
Results: Between 2011 and 2022, Oke-Odu, Akure, Nigeria, experienced significant development, with its built-up area growing from 45 ha (20.15%) to 160 ha (71.45%). However, this came at the cost of green spaces, which decreased from 97 ha (43.43%) to 33 ha (14.78%), indicating a loss of

**Corresponding author: Email: asajuadeleke@gmail.com;*

vegetation and natural areas. Similarly, open spaces decreased from 65 ha (29.42%) to 14 ha (6.46%). In Ipinsa, the built-up area expanded from 6 ha (6.50%) to 36 ha (36.40%), while green areas decreased initially but slightly increased later. Open spaces in Ipinsa declined consistently from 17 ha (17.50%) to 3 ha (3.10%). Aule experienced steady development, with built-up areas increasing from 297 ha (56.86%) to 431 ha (82.30%), accompanied by a decline in green spaces and open spaces over time. Overall, built-up areas and open spaces in Oke-Odu, Ipinsa, and Aule have significantly increased over time; however, in both Ipinsa and Aule, there was a slight recovery of green spaces in 2022.

Conclusion: The study shows that the pattern of land uses in Oke-Odu, Ipinsa, and Aule, Akure demonstrates a consistent trend of urbanization. Built-up areas have expanded substantially over time, while green spaces and open spaces have experienced significant declines, these trends align with global patterns of urbanization and raise concerns about environmental degradation and the need for conservation efforts. Therefore, this study recommends that sustainable development strategies be Implemented to ensure a balance between built-up areas and natural environments.

Keywords: Land cover transformations; Akure; urbanization; environmental degradation.

1. INTRODUCTION

Land is an indispensable factor in production and a vital resource for human consumption and livelihood [1,2]. It includes fertile agricultural land and sites for urban development to accommodate the increasing urban population [2,3,4]. Urbanization is a global trend with significant implications for land markets and housing affordability [5,6]. According to World Bank [7] and UN-Habitat [8], emerging countries are expected to witness a surge in urban population, with projections indicating that 4.4 billion people will be living in cities by 2050. This was further supported in the study of [9], which projected that 68% of the world's population is predicted to reside in cities by 2050, however, Asia and Africa will account for 90% of this urban population increase [9].

Moreover, this rapid urbanization leads to the encroachment of cities on rural areas, giving rise to peri-urban areas, which serve as transitional spaces between urban and rural regions [10]. In a similar vein, [11] noted that these areas continue to experience intense land use changes, impacting residential land values. They are considered centers of rapid urban transformation, blending urban and rural characteristics [12]. Furthermore, peri-urban areas are referred to by various names, such as Urban Outskirt or Fringe, Rural-Urban fringe, Urban Shadow, Urban Periphery, Urban Edge [13,14,15]. Pribadi and Pauleit [16] also describe it as native ecosystems facing high demand due to urban growth.

Recent research has found out that peri-urban areas attract middle-class and higher-income individuals exhibiting urban lifestyles in a rural setting and featuring diverse environmental and productive ecosystems [16,17]. They may encompass a mix of residential, commercial, and agricultural uses [17]. In addition, scholars [9] and [18] have observed that the global phenomenon of urbanisation has resulted in transformations in land markets. Factors such as population growth, economic progress, and rural-urban migration have contributed to a heightened demand for urban residential land. This trend however has been noted by [19] to result in soaring demand for built environments and residential land, resulting in uncontrolled spatial expansion. Scholars like Kimengsi et al. [20] and Onyebueke et al. [21] support these findings, indicating that the growing urban population outpaces the available supply of residential land. However, despite previous research revealing uncontrolled spatial distribution of land uses in peri-urban areas, these areas continue to undergo intense land use changes. Therefore, this study aims to analyze the spatial distribution of land uses in the peri-urban areas of Akure, Nigeria between 2011 and 2022.

This analysis covers land cover dynamics in peri-urban areas of Akure from 2011 to 2022, unlike previous studies. This scope captures recent trends and changes, revealing shifts in response to urbanisation, agriculture, and other factors. This study focuses on a specific region to examine land cover changes in a peri-urban context.

2. LITERATURE REVIEW

This review of the literature examines the spatial distribution of land uses in the peri-urban areas

of Akure, Nigeria, between 2011 and 2022. By reviewing previous research, we hope to obtain a comprehensive understanding of land use dynamics and spatial distribution trends.

GIS can be utilised to monitor and measure land use changes [22]. The study by White and Engelen [23] study was pioneering in utilising integrated GIS capability to model land uses in cities. This technique has been employed in succeeding research [24,25]. The spatial distribution of residential land in urban locations has been studied by academics [26,27]. Using GIS technology, previous research has examined the spatial distribution of residential land uses in peri-urban areas. Lasisi et al. [28] conducted a study to assess the progression of uncontrolled spatial expansion in eight peri-urban zones located within the local government areas of Olorunda and Osogbo. The purpose of this study was to determine the frequency, pattern, and effects of this phenomenon. The study utilised GIS and three Landsat images to analyse vegetation dynamics. The study found that urban expansion and land conversion for vegetation purposes have a detrimental impact on agricultural activities and farmland productivity. The study found that urban expansion into peri-urban areas had adverse effects on agricultural activities and farmland productivity. This study is limited to Olorunda and Osogbo local government areas and does not include Akure. There is a knowledge gap concerning the spatial distribution of residential land in peri-urban areas of Akure. This study aims to understand the features, patterns, and impacts of urban growth on residential land use in peri-urban Akure, where there is currently limited knowledge.

Karg et al. [29] utilised a multi-method approach to classify and map peri-urban areas in Tamale, Ghana, which is an average-sized sub-Saharan African city in development. The study utilised a qualitative and multi-dimensional approach to assess urban areas and their inhabitants. This approach included determining the state of the urban area, measuring available services, assessing household diversity in terms of living standards, evaluating accessibility to urban infrastructure, and monitoring changes in land use. Peri-urban areas tend to develop primarily along the main transportation route that spans administrative divisions, as well as in the form of peri-urban islands in rural areas, as indicated by spatial analysis.

Using GIS and remote sensing, [30] estimated the amount of arable land in Kano City. The property was sectioned up into five distinct areas: populated, agricultural, aquatic, forested, and undeveloped. Between 1995 and 2015, the research looked at how several factors affected settlement, vegetation, barren land, and agriculture. There has been a rise in the percentage of land that is not used for farming. The study does not include suburban or residential areas. There was no distinction made between urban, peri-urban, and rural areas in the study of land usage in Kano Metropolis. This research looks at the pattern of land use outside of the city of Akure, Nigeria.

Land use pattern in peri-urban Lagos was analysed by [26] using GIS. The population of the Lagos megacity region is unpredictable, and so is the demand for urban space. As a result, Ikorodu, Lagos's peri-urban landscape and natural resources are under increasing strain. Landsat pictures were utilised in the study to see how much land was being converted from forests and farms to cities from 1990 to 2011. The research focused not only on suburban sprawl but also on the urbanisation of formerly rural areas.

Fabolude and Aighewi [27] utilised GIS and remote sensing methodologies. The USGS has acquired Landsat data for the years 1987, 2002, and 2019. The data were preprocessed and categorised using the ENVI 5.2 software. The data was then exported to ARC-GIS for further analysis. The TerrSet 17.0 software utilised the 1987-2019 LULC classifications to predict the LULC of Benin City in 2050 through the application of the Markov and CA-Markov models. The study revealed a net loss of 284.56 km2 of forested areas between 1987 and 2019. During the same period, built-up and barren lands experienced a significant increase of 153.96 km2 and 81.58 km2, respectively. The projected increase in built-up area by 2050 is 236.92km2, while the percentage cover of barren land is expected to remain unchanged. The grassland area experienced a net increase of 52.16 km2, whereas the water area decreased by 3.60 km2. However, it is projected that both grassland and water areas will decrease by 157.58 km2 and 0.45 km2, respectively, by the year 2050. The study encompasses the years 1987 to 2019. The temporal scope may be inadequate for comprehending current land use changes in peri-urban areas. Incorporating up-to-date information would be advantageous in

capturing spatial distribution of land uses in peri-urban areas of Akure, Nigeria.

3. STUDY AREA

Akure, the capital of Ondo State in Nigeria, is situated at the geographical coordinates of 7'25°N latitude and 5'20°E longitude. Over the course of the last 25 years, the city has experienced significant growth and has emerged as one of the most rapidly developing metropolitan areas in south-western Nigeria. According to the data provided, the population experienced a significant increase over the course of 33 years, growing from 157,947 in 1990 to 744,000 in 2023 [31]. Following its establishment in 1976 as part of the reorganisation of the former Western Region, Akure acquired prominence within Akure South Local Government and Ondo State. The city's built-up areas, immigration, transportation, and commercial activities have expanded. The climate is tropical, mild, and humid, with an average annual precipitation of 1500 mm. The average annual temperature range in Nigeria is between 21.4 and 31.1 degrees Celsius, and the average relative humidity is 77.1% (based on data from 1980 to 2007). Western Nigeria's Akure has tropical rainforest vegetation and is situated on a flat plain about 250 metres above sea level. According to a study by [32], the dense forest has decreased by 33.8% due to deforestation, land degradation, farming, and human encroachment for construction. This study focuses on peri-urban areas in Akure, Nigeria (Fig. 1), owing to the city's recent rapid growth and development which lend support to this research.

4. METHODOLOGY

ArcGIS was used to perform a supervised classification of three peri-urban areas in Akure, utilising Landsat images from 2011, 2016, and 2022. Landsat satellites with multispectral sensors observed changes in land cover over the period under consideration. ArcGIS and Landsat data were used to accurately classify land cover in the selected peri-urban areas. This method identified and mapped different land cover types using the spectral signatures from Landsat sensor data. The Landsat images were obtained from the website of the United States Geological Survey (USGS). The data quality was assessed to ensure that the cloud cover and scene cover of the downloaded imagery were both below 10%. The classification method employed was maximum likelihood, focusing on three distinct classes: green areas, open spaces, and built-up areas. The regions of interest included Ipinsa, Oke Odu, and Aule. The Landsat images underwent pre-processing using ENVI 5.3 software to correct radiometric and atmospheric distortions. The study employed a supervised classification method, specifically the maximum likelihood approach. This method involves the generation of class signatures, which are

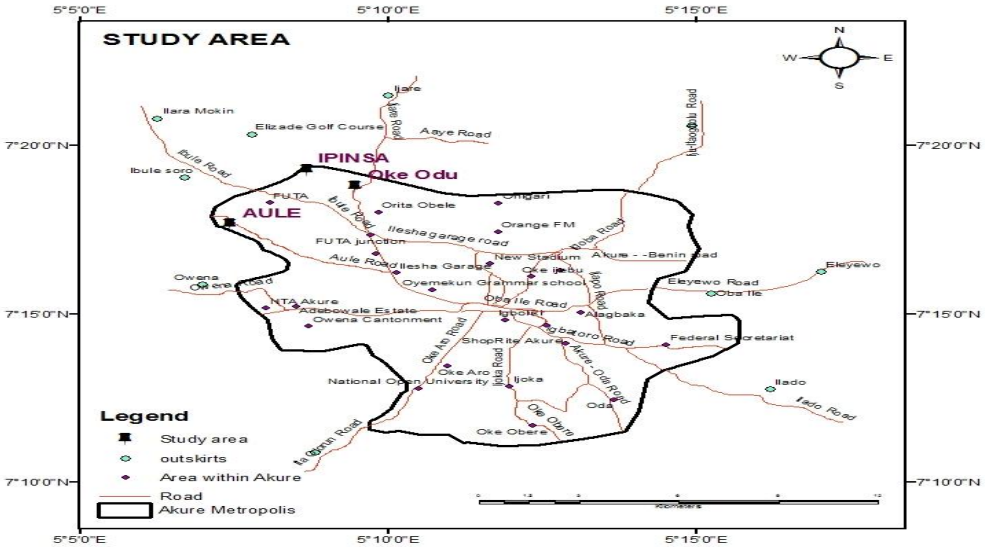

Fig. 1. Map showing the three Selected Peri-urban areas of Akure Metropolis
Source: Author

statistical representations of different land cover classes derived from training samples. The training samples were obtained from accurate data and expert knowledge of the study area. To generate class signatures, representative samples were selected from each class (green areas, open spaces, and built-up areas) at five-year intervals (2011, 2016, and 2022). The samples were selected meticulously to accurately represent the spectral properties of each class and reduce any potential spectral ambiguity. Next, the maximum likelihood classifier was utilised to classify the entire study area for each respective time period. The accuracy of classified images in the years 2011, 2016, and 2022 was evaluated using ENVI software's confusion matrix and ground truth image tools. The confusion matrix is a method used to evaluate the accuracy of image classification by comparing reference data with classified images. It provides measures such as overall accuracy, producer accuracy, user accuracy, and a multivariate Kappa coefficient ranging from 0 to 1 [33]. Ground truth data for each evaluated year was obtained using high-resolution images from Google Earth.

5. RESULTS

This session presents analysis of data on the spatial distribution of land uses in Oke-Odu. Ipinsa and Aule peri-urban areas of Akure, Nigeria between 2011 and 2022. This details Landsat imagery and data showing changes in land uses in the area.

Table 1 shows land cover changes in the Oke-Odu peri-urban area of Akure, Ondo State, Nigeria from 2011 to 2022, at five-year intervals. Land use is classified into three categories: built-up area, green area, and open space. Oke-Odu had a built-up area of 45 ha (20.15%) in 2011. In 2016, it grew to 148 ha (66.35%). By 2022, the built-up area increased to 159 ha (71.45%). Built-up area growth indicates development over time. This could be due to Oke-Odu's population growth, increased housing demand, or urban development projects. Oke-Odu's green space was 97 ha (43.43%) in 2011. By 2016, the green space had decreased to 31 ha (14.22%). In 2022, the green area decreased to 32 ha (14.78%). The decrease in green space means less vegetation and natural areas in Oke-Odu. This may be due to the conversion of green areas into built-up areas or human-caused degradation of natural land. Oke-Odu had 64 ha (29.42%) of open space in 2011. Open space decreased to 26 ha (11.92%) by 2016. In 2022, open space decreased to 14 ha (6.46%). Loss of open space means less public areas or leisure spaces in Oke-Odu. This may be due to development or changing land use priorities.

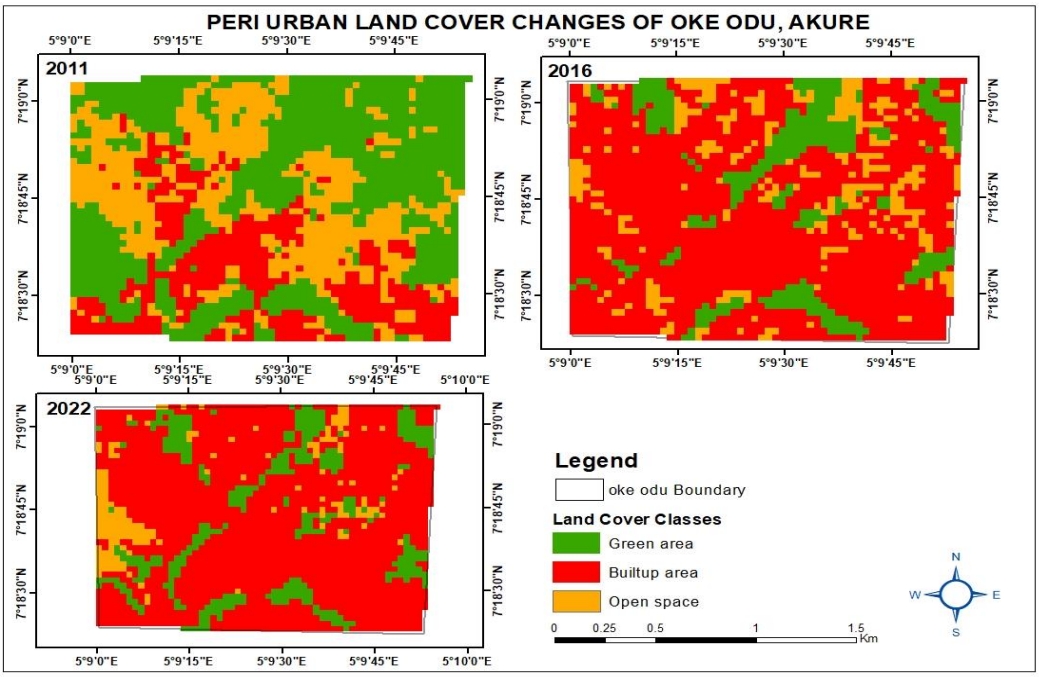

Fig. 2. Spatial distribution of land uses in Oke-Odu
Source: Author's Field Survey (2023)

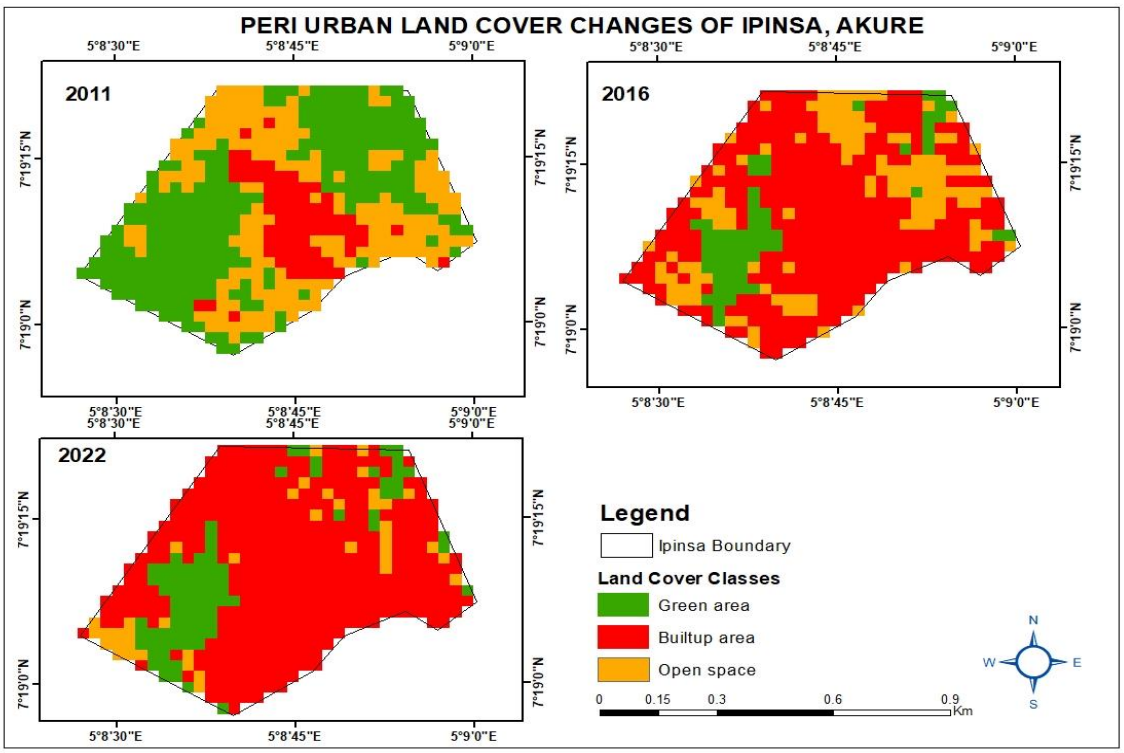

Fig. 3. Spatial distribution of land uses in Oke-Odu
Source: Author's Field Survey (2023)

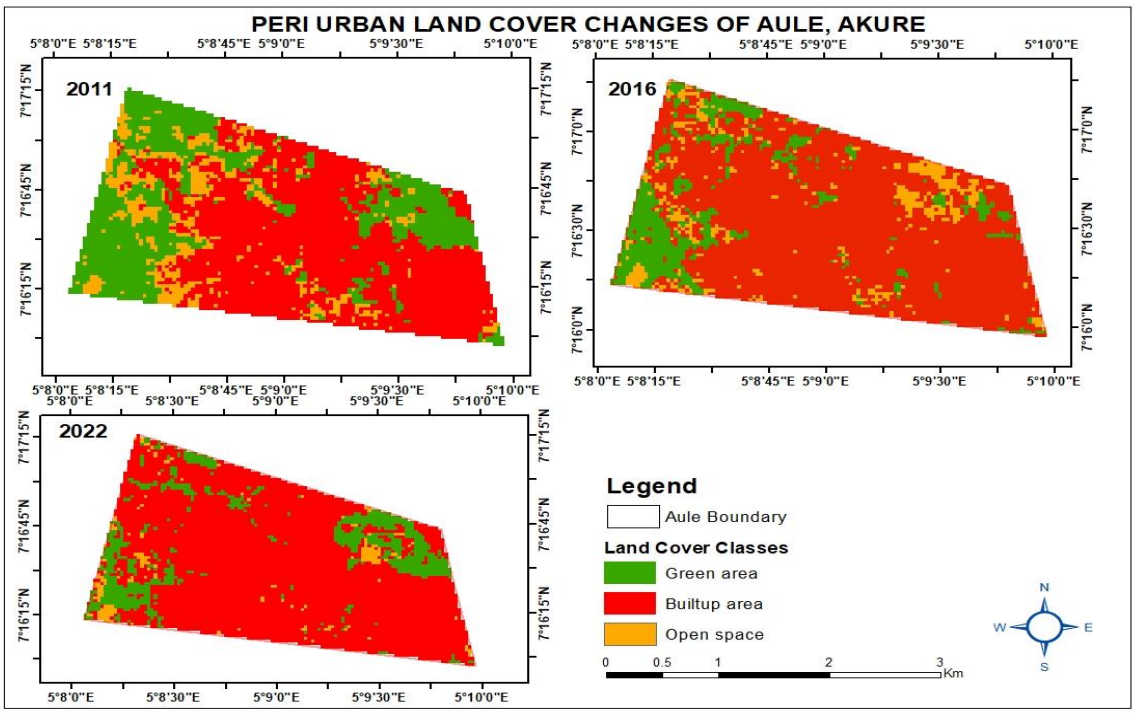

Fig. 4. Spatial distribution of land uses in Aule
Source: Author's Field Survey (2023).

Table 1. Spatial distribution of land uses in Oke-Odu peri-urban area of Akure 2011-2022

Class	2011	2016	2022
Built up area	45.09827	148.9458	159.7332
Green area	97.08242	31.64963	32.91493
Open space	64.99016	26.2425	14.19541

Source: Author's Field Survey (2022)

Table 2. Spatial distribution of land uses in ipinsa peri-urban area of Akure 2011-2022

Class	2011	2016	2022
Built up area	6.473293	31.02866	36.43449
Green area	23.18668	5.409729	7.54247
Open space	17.46377	10.79163	3.144846

Source: Author's Field Survey (2022)

Table 3. Spatial distribution of land uses in Aule peri-urban area of Akure 2011-2022

Class	2011	2016	2022
Built-up area	297.0687	407.0728	430.8376
Green area	157.041	72.3997	76.87051
Open space	68.46882	43.36364	15.36846

Source: Author's Field Survey (2022)

Table 2 shows land cover changes in Ipinsa from 2011 to 2022. In 2011, Ipinsa's built-up area was 6 ha (6.50%), but it increased to 31 ha (31.00%) in 2016. In 2022, the built-up area increased to 36 ha (36.40%). The built-up area of Ipinsa grew significantly from 2011 to 2022, indicating area growth. The expansion may be due to population growth and development in the area. In Ipinsa, the green area was 23 ha (23.20%) in 2011 but decreased to 5 ha (5.40%) in 2016 and 7 ha (7.50%) in 2022. In Ipinsa, the green area decreased from 2011 to 2016 but slightly increased by 2022. Land conversion for development may be the cause. The increase in green areas could indicate environmental protection or restoration efforts. In 2011, the open space area in Ipinsa was 17.46% (17 ha), but by 2016, it decreased to 10.80% (10 ha). In 2022, the area declined further to 3.10% (3 ha). The table shows a decrease in Ipinsa's open space area over the years. This decrease suggests that open space areas may have been converted to residential or commercial land uses.

Table 3 shows land cover changes in Aule from 2011 to 2022, categorized as built-up area, green area, and open space. In 2011, the built-up area was 297 ha (56.86%). The built-up area increased from 407 ha (77.81%) in 2016 to 430 ha (82.30%) in 2022. Aule's built-up area has been steadily increasing, indicating development. The increase from 2011 to 2016 shows fast growth, but the increase from 2016 to 2022 indicates slower development. In 2011, the green space was 157 ha (30.07%). In 2016, the green space decreased to 72 ha (13.83%). In 2022, the green area increased to 76 ha (14.67%). The green area in Aule decreased between 2011 and 2016, indicating a decrease in natural area. The drop may be due to land conversion for residential or other uses. The slight recovery in green area from 2016 to 2022 suggests efforts to conserve or repair green spaces in the area. In 2011, 13% of open space was inhabited, which is equivalent to 68 ha. The open space decreased to 43 ha in 2016 (8.31%). The open area decreased to 15 ha (2.94%) in 2022. Aule's open space has decreased over the years, suggesting a reduction in available open spaces. The decrease may be due to open spaces being converted to built-up areas. The decline from 2011 to 2016 suggests high growth, and the decrease from 2016 to 2022 shows ongoing development and limited open space. The table shows Aule's development over time, with more built-up area and less green and open spaces.

6. DISCUSSION OF RESULTS

The results reveal significant changes in land cover patterns across the three studied peri-urban areas, which include Oke-Odu, Ipinsa, and Aule. The increase in built-up areas in Oke-Odu over the studied period signifies a substantial shift towards urbanisation and residential expansion. The growth in built-up areas from

2011 to 2022 is indicative of urban development driven by factors such as population growth, housing demand, and urban projects, in line with the broader global urbanisation trend [34]. However, the troubling decrease in green space and open space highlights potential environmental consequences. This loss of vegetation and open areas could negatively impact biodiversity, ecosystem services, and community well-being. [35,36]. This finding aligns with studies indicating that rapid urbanisation leads to the conversion of natural land to built-up areas, ultimately contributing to land degradation [37,38,39,40]. The continuous expansion of the built-up area in Ipinsa underscores the ongoing urbanisation and development in the region. The decrease in green space and open space areas, coupled with the increase in built-up areas, reflects the global phenomenon of urban land cover expansion driven by population growth, infrastructure development, and economic progress [41]. The slight increase in green space in 2022 might suggest a recognition of the importance of environmental conservation efforts, aligned with broader global and local conservation trends [42,43]. However, the reduction in open space area raises concerns about limited recreational opportunities, urban heat island effects, and compromised urban resilience [43 and 44]. However, these findings also support the need for urban planning strategies to balance development with the preservation of natural environments.

The consistent increase in the built-up area of Aule over the years underscores the impact of urbanisation and development on land use patterns. The decline in green space and open space areas is consistent with the notion that rapid urban growth often leads to the conversion of undeveloped areas into built-up spaces [45,46]. The slight recovery in green space in 2022 may reflect efforts to preserve or restore natural areas, in alignment with global discussions on the benefits of urban green spaces for various aspects of human well-being and ecological balance [47,48]. The reduction in open space areas, as seen in Aule, is in line with global trends and emphasises the importance of sustainable urban planning to maintain a balance between built-up areas and open spaces [44,49]. The collective results across all three locations highlight the pervasive trend of increased built-up areas and urbanisation, which align with global patterns of urban growth. While some areas show slight increases in green space, the overall decrease in green areas and open spaces raises concerns about the loss of natural environments and recreational spaces. The differing magnitudes of change in different locations could be attributed to factors such as awareness, planning regulations, and conservation efforts. The findings underscore the importance of sustainable urban planning and conservation strategies to balance development with environmental preservation [49-53].

7. CONCLUSION AND RECOMMENDATION

This study has analyzed the spatial distribution of land uses in Oke-Odu, Ipinsa, and Aule, peri-urban areas of Akure, Nigeria. Land uses in Oke-Odu, Ipinsa, and Aule demonstrates a consistent trend of urbanization and development. Built-up areas have expanded substantially over time, while green spaces and open spaces have experienced significant declines. These trends align with global patterns of urbanization and raise concerns about environmental degradation and the need for conservation efforts, therefore, Therefore, this study recommends that sustainable development strategies be Implemented to ensure a balance between built-up areas and natural environments.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Nagya U, Udoekanem NB. Factors influencing access to urban land for private housing development in minna, nigeria. Journal Of African Real Estate Research. 2022;7(2):1–23. Available:https://doi.org/10.15641/jarer.v7i2.1205
2. Ajayi MA, Adebayo MA. Socio-economic factors affecting residential land accessibility in akure nigeria: A gender perspective. International Journal of Built Environment and Sustainability. 2017;4(3):165-171. Available:https://doi.org/10.11113/ijbes.v4.n3.209
3. Wondimagegnhu BA, Huluka AT, Nischalke SM. Determinants of farm livelihoods of smallholder farmers in yayu biosphere reserve, sw ethiopia: a gender disaggregated analysis. Cogent

Economics & Finance. 2019;7(1):1645583-164.
Available:https://doi.org/10.1080/23322039.2019.1645583

4. Semin AN, Namyatova LE. Land as a factor of production in agriculture and features of agricultural practices. International Journal of Mechanical Engineering and Technology. 2019;10(02): 1515-21.
5. Sassen S. Expulsions: Brutality and complexity in the global economy. Harvard University Press; 2014:304.
Available:https://doi.org/10.2307/j.ctt6wpqz2
6. Farrell K. Rapid urbanization: an inquiry into the nature and causes of the urban transition in developing countries (doctoral dissertation, kth royal institute of technology); 2018.
7. World Bank Group. Building sustainable communities.
Available:https://www.worldbank.org/en/topic/sustainable-communities
8. UN-Habitat. World Cities Report 2016: Urbanization and Development - Emerging Futures. *United Nations Human Settlements Programme*; 2017.
Available:https://unhabitat.org/world-cities-report-2016
9. Nations U. United nations department of economic and social affairs. United Nations, New York; 2018.
Available:https://www.un.org/en/
10. Angel S. Making room for a planet of cities: from planet of cities. InThe City Reader 2020: 665-677. Routledge; 2012. ISBN 978-0-429-26173-2
11. Reimer B, Barrett J, Vodden K, Bisson L. Rural–urban interactions and interdependence. InThe Theory, Practice and Potential of Regional Development. 2019;149-182. Routledge.
DOI: 10.4324/9781351262163-8
12. Abdulai IA, Enu-kwesi F, Agyenim JB. Peri-urbanisation: A blessing or scourge?. Journal of Planning and Land Management. 2020;1(2):12-22.
DOI: 10.36005/jplm.v1i2.23
13. Sharma A, Chandrasekhar S. Growth of the urban shadow, spatial distribution of economic activities, and commuting by workers in rural and urban india. World Development. 2014;61:154-66.
DOI: 10.1016/j.worlddev.2014.04.003
14. Lincaru C, Atanasiu D, Ciucă V, Pirciog S. Peri-urban areas and land use structure in romania at lau2 level: An exploratory spatial data analysis. Procedia Environmental Sciences. 2016;32:124-37.
Available:https://doi.org/10.1016/j.proenv.2016.03.017
15. Wandl A, Magoni M. Sustainable planning of peri-urban areas: Introduction to the special issue. Planning Practice & Research. 2017;32(1):1-3.
DOI: 10.1080/02697459.2017.1264191
16. Pribadi DO, Pauleit S. Peri-urban agriculture in jabodetabek metropolitan area and its relationship with the urban socioeconomic system. Land Use Policy. 2016;55:265-74.
DOI: 10.1016/j.landusepol.2016.04.008
17. Appiah DO, Asante F, Nketia BA. Perceived agricultural land use decisions in a peri-urban district, ghana. Journal of Agricultural and Crop Research. 2017;5(1):1-0.
18. Surya B, Ahmad DN, Sakti HH, Sahban H. Land use change, spatial interaction, and sustainable development in the metropolitan urban areas, south sulawesi province, indonesia. Land. 2020;9(3):95.
Available:https://doi.org/10.3390/land9030095
19. Oyalowo B. Implications of urban expansion: Land, planning and housing in lagos. Buildings and Cities. 2022;3(1).
Available:https://doi.org/10.5334/bc.243
20. Kimengsi JN, Nguh BS, Nafoin AS. Peri-urban land use dynamics and development implications in the bamenda iii municipality of cameroon. Sustainability in Environment. 2017;2(3):273-88.
DOI: 10.22158/se.v2n3p273
21. Onyebueke V, Walker J, Lipietz B, Ujah O, Ibezim-Ohaeri V. Urbanisation-induced displacements in peri-urban areas: Clashes between customary tenure and statutory practices in ugbo-okonkwo community in enugu, nigeria. Land Use Policy. 2020 ;99:104884.
DOI: 10.1016/j.landusepol.2020.104884
22. Harris B, Batty M. Locational models, geographic information, and planning support systems. In R. K. Brail & R. E. Klosterman (eds.), Planning Support Systems. Redlands, California: ESRI Press. 2001;25-57.
23. White R, Engelen G. High-resolution integrated modelling of the spatial dynamics of urban and regional systems. Computers, Environment And Urban Systems. 2000;24(5):383-400.

Available:http://dx.doi.org/10.1016/S0198-9715(00)00012-0
24. Wu F, Webster CJ. Simulation of land development through the integration of cellular automata and multicriteria evaluation. Environment and Planning B: Planning and design. 1998;25(1):103-260. Available:http://dx.doi.org/10.1068/b250103
25. Samat N, Hasni R, Elhadary YA. Modelling land use changes at the peri-urban areas using geographic information systems and cellular automata model. Journal of Sustainable Development. 2011;4(6):72. DOI:10.5539/jsd.v4n6p72
26. Dekolo SO, Nwokoro II, Oduwaye OA. Peri-urban land use change in the Lagos Megacity; 2013.
27. Fabolude G, Aighewi IT. Evaluation of the extent of land use-land cover changes of benin city, edo state, nigeria from 1987-2019. Journal of Applied Sciences and Environmental Management. 2022;26(8):1443-50. DOI:10.4314/jasem.v26i8.18
28. Lasisi M, Popoola A, Adediji A, Adedeji O, Babalola K. City expansion and agricultural land loss within the peri-urban area of osun state, nigeria. Ghana Journal of Geography. 2017;9(3):132-63.
29. Karg H, Hologa R, Schlesinger J, Drescher A, Kranjac-Berisavljevic G, Glaser R. Classifying and mapping periurban areas of rapidly growing medium-sized sub-Saharan African cities: A multi-method approach applied to Tamale, Ghana. Land. 2019;8(3):40. Available:https://doi.org/10.3390/land8030040
30. Haruna M, Ibrahim MK, Shaibu UM. Assessment of land use and vegetative cover in kano metropolis (from 1975-2015) employing gis and remote sensing technology. Nigerian Journal of Basic and Applied Sciences. 2019;27(2):1-7. Available:http://dx.doi.org/10.4314/njbas.v27i2.1
31. Macrotrends. Akure nigeria metro area population 1950-2023. Available:http://www.macrotrends.net/
32. Ifeoluwa AB, Debo ZA, Ahmed AB, Tobi EM. Analysis of urban expansion and land use changes in akure, nigeria, using remote sensing and geographic information system (GIS) techniques. Journal of Geography and Regional Planning. 2011;4(9):533-41.
33. Comber AJ. Geographically weighted methods for estimating local surfaces of overall, user and producer accuracies. Remote Sensing Letters. 2013;4(4):373-80. Available:https://doi.org/10.1080/2150704X.2012.736694
34. Mansour S, Al-Belushi M, Al-Awadhi T. Monitoring land use and land cover changes in the mountainous cities of oman using gis and ca-markov modelling techniques. Land Use Policy. 2020;91:104414. Available:https://doi.org/10.1016/j.landusepol.2019.104414
35. Gibbs HK, Rausch L, Munger J, Schelly I, Morton DC, Noojipady P, Soares-Filho B, Barreto P, Micol L, Walker NF. Brazil's soy moratorium. Science. 2015;347(6220):377-8. DOI: 10.1126/science.aaa0181
36. Chitrakar R, Baker D, Guaralda M. Emerging challenges in the management of contemporary public spaces in urban neighbourhoods. International Journal of Architectural Research. 2017;11(1):29-43.
37. Idowu TE, Kiplangat NC, Waswa R. Land cover changes and its implications on Urban Heat Island in Nairobi County: A GIS and Remote Sensing Approach; 2023.
38. Gessesse B, Bewket W. Drivers and implications of land use and land cover change in the central highlands of ethiopia: Evidence from remote sensing and socio-demographic data integration. Ethiopian Journal of The Social Sciences and Humanities. 2014;10(2):1-23.
39. Salami WA, Tayo-Badru MA, Adeofun CO, Oguntoke O. effects of urban expansion on vegetation cover loss in Lagos state, Nigeria. African Journal of Science and Nature. 2020;10:146-63.
40. Aragaw MT. Urban open space use in addis ababa: The case of meskel square; 2011.
41. Seto KC, Fragkias M, Güneralp B, Reilly MK. A meta-analysis of global urban land expansion. PloS One. 2011;6(8): e23777. Available:https://doi.org/10.137/journal.pone.002377714
42. Grimm NB, Faeth SH, Golubiewski NE, Redman CL, Wu J, Bai X, Briggs JM. Global change and the ecology of cities. Science. 2008;319(5864):756-60.
43. Pickett ST, Cadenasso ML, Grove JM, Boone CG, Groffman PM, Irwin E, Kaushal SS, Marshall V, McGrath BP, Nilon CH,

Pouyat RV. Urban ecological systems: Scientific foundations and a decade of progress. Journal of Environmental Management. 2011;92(3):331-62.
Available:https://doi.org/10.1016/j.jenvman.2010.08.022

44. Kong F, Yin H, Nakagoshi N. Using gis and landscape metrics in the hedonic price modeling of the amenity value of urban green space: A case study in jinan city, china. Landscape and Urban Planning. 2007;79(3-4):240-52.
Available:https://doi.org/10.1016/j.landurbplan.2006.02.013
45. Aliyu AA, Amadu L. Urbanization, cities, and health: The challenges to nigeria–a review. Annals of African Medicine. 2017;16(4):149.
DOI: 10.4103/aam.aam_1_17
46. Akinrinola AJ. Spatial pattern of urban growth using remote sensing and landscape metrics. Journal of Geomatics. 2019;(1).
47. Nowak DJ, Hirabayashi S, Bodine A, Greenfield E. Tree and forest effects on air quality and human health in the united states. Environmental Pollution. 2014;193:119-29.
48. Mensah CA. Urban green spaces in africa: Nature and challenges. International Journal of Ecosystem. 2014;4(1):1-11.
DOI: 10.5923/j.ije.20140401.01
49. Olubi AR, Fadamiro JA. Implications of urbanization on sustainable cities' developments in Nigeria. European Journal of Development Studies. 2022; 2(4):4-13.
Available:https://doi.org/10.24018/ejdevelop.2022.2.4.94
50. McGee T. The spatiality of urbanization: the policy challenges of mega-urban and desakota regions of southeast asia. Unu-ias working paper no. 161. Yokohama: United Nations University-Institute for Advance Studies; 2009.
51. McGee T. Rethinking the urban fringe in southeast asia, policy and research agendas. Inworkshop On Issues In The Peri-Urban Regions And Ways Towards Sustainable Peri-Urban Futures; 2011.
52. Angel S, Sheppard S, Civco DL, Buckley R, Chabaeva A, Gitlin L, Kraley A, Parent J, Perlin M. The dynamics of global urban expansion. Washington, DC: World Bank, Transport and Urban Development Department; 2005.
Available:http://www.williams.edu/Economics/UrbanGrowth/DataEntry.htm
53. Laros M, Jones F. The state of African cities: Re-imagining sustainable urban transitions; 2014. ISBN: 9789211325980

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/104441