Original Research Article

A Decade of Land Use Transformations in Akure's Peri-Urban Region (2011-2022)

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 45.0982 hectares (20.15%) to 159.7332 hectares (71.45%). However, this came at the cost of green spaces, which decreased from 97.0824 hectares (43.43%) to 32.9149 hectares (14.78%), indicating a loss of vegetation and natural areas. Similarly, open spaces decreased from 64.9901 hectares (29.42%) to 14.1954 hectares (6.46%). In Ipinsa, the built-up area expanded from 6.4732 hectares (6.50%) to 36.4344 hectares (36.40%), while green areas decreased initially but slightly increased later. Open spaces in Ipinsa declined consistently from 17.4637 hectares (17.50%) to 3.1448 (3.10%). Aule experienced steady development, with built-up areas increasing from 297.0687 hectares (56.86%) to 430.8376 hectares (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 has 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.

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.

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 [31, 32]. 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 [31] 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 [32] 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 [33]. 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 [34], 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 (Figure 1), owing to the city's recent rapid growth and development which lend support to this research.

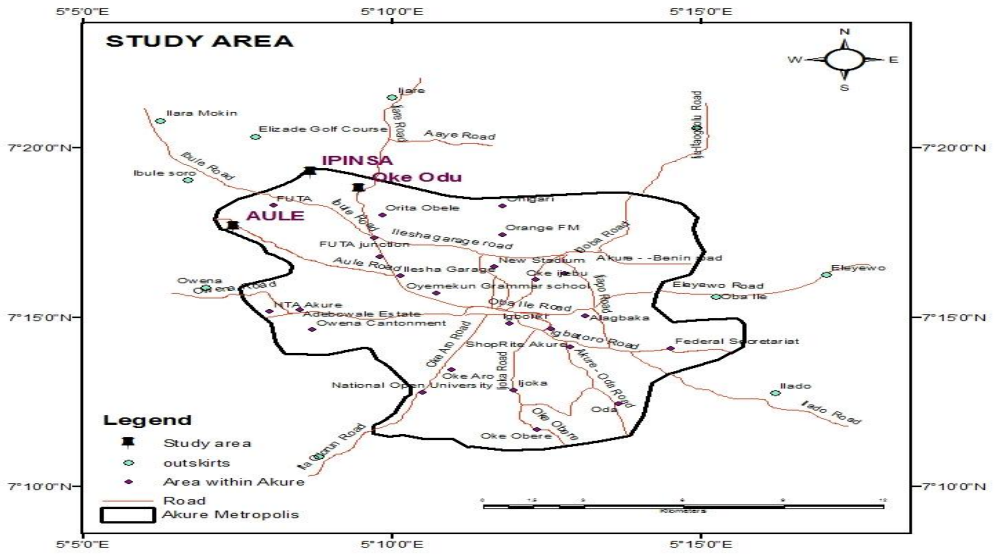

Fig 1: Map showing the three Selected Peri-urban areas of Akure Metropolis.
Source: Author

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. 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 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 [35]. Ground truth data for each evaluated year was obtained using high-resolution images from Google Earth.

5. RESULT AND FINDINGS

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

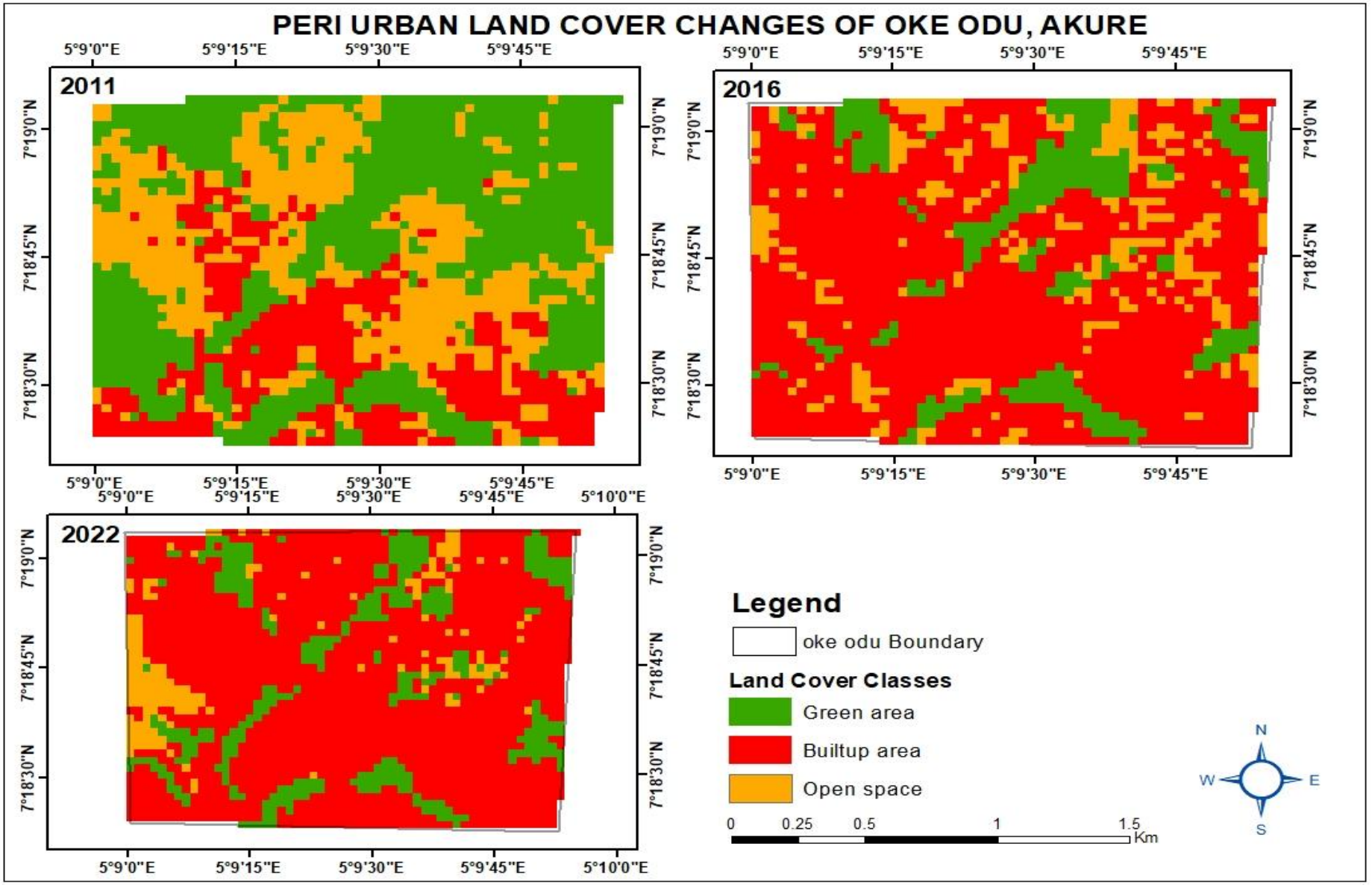

Figure 2: Spatial Distribution of Land Uses in Oke-Odu
Source: Author's Field Survey (2023).

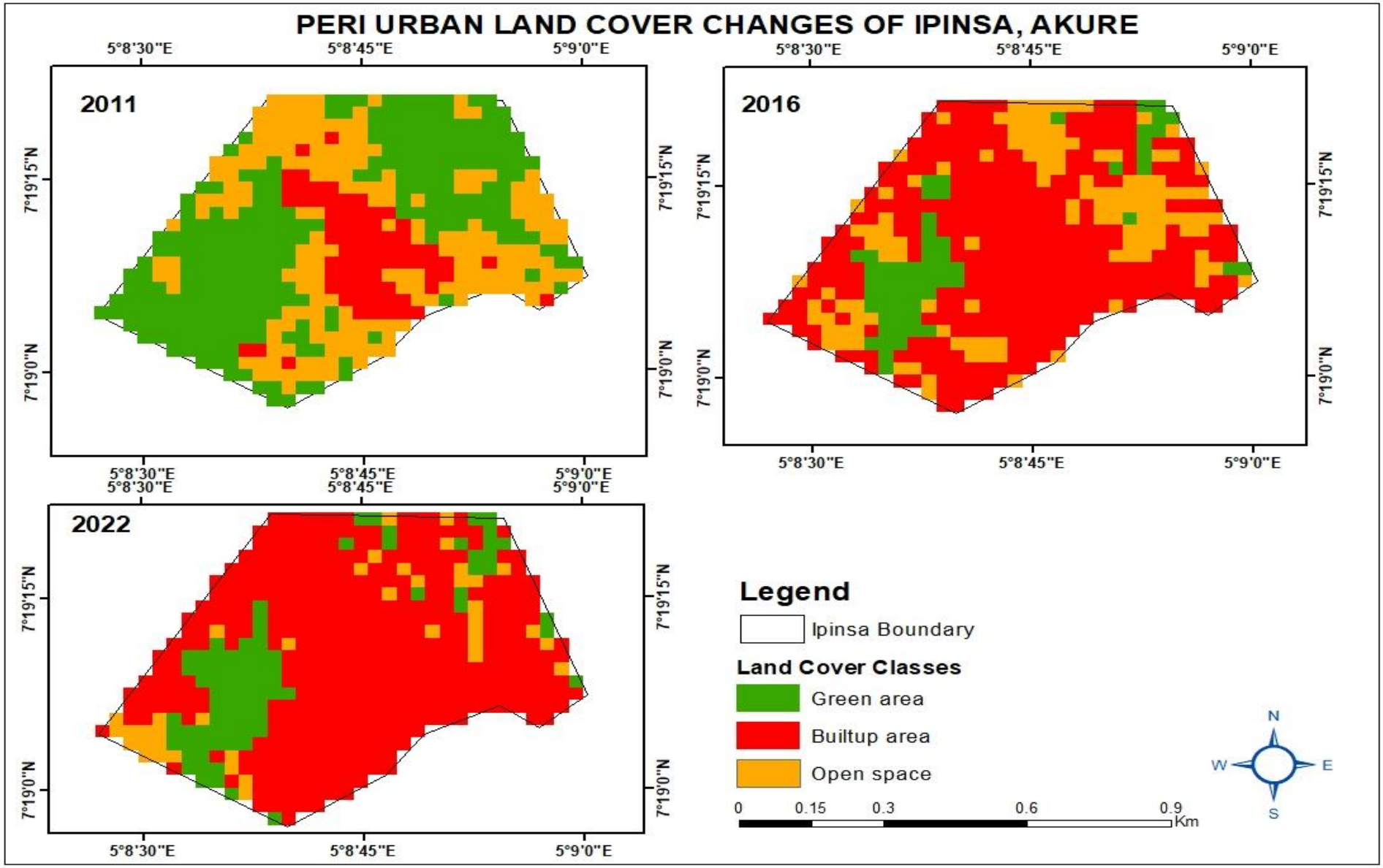

Figure 3: Spatial Distribution of Land Uses in Oke-Odu
Source: Author's Field Survey (2023).

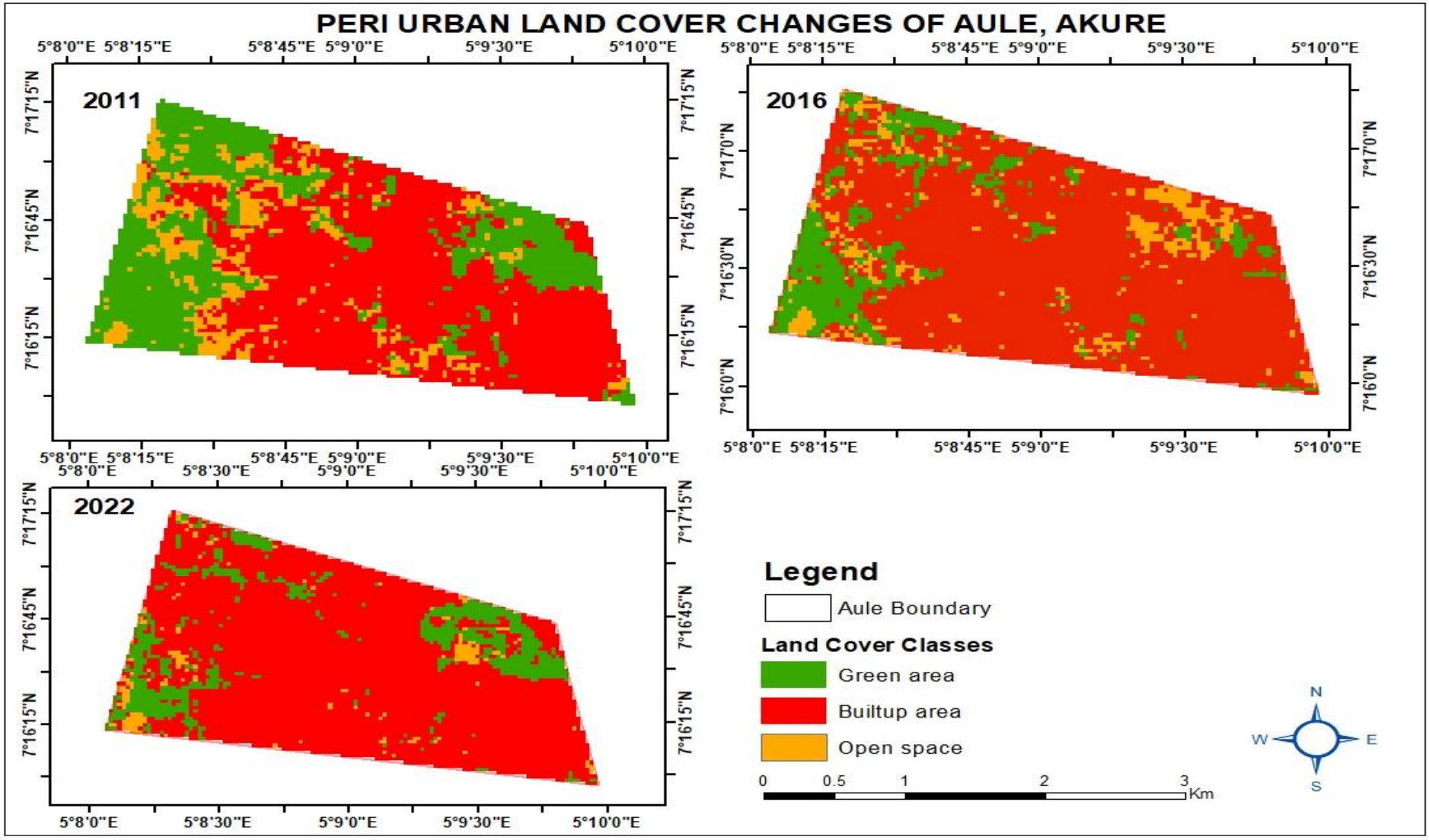

Figure 4: Spatial Distribution of Land Uses in Aule
Source: Author's Field Survey (2023).

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 Survey (2022).

Table 1 show land use 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 45.09827 hectares (20.15%) in 2011. In 2016, it grew to 148.9458 hectares (66.35%). By 2022, the built-up area increased to 159.7332 hectares (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 97.08242 hectares (43.43%) in 2011. By 2016, the green space had decreased to 31.64963 hectares (14.22%). In 2022, the green area decreased to 32.91493 hectares (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 64.99016 hectares (29.42%) of open space in 2011. Open space decreased to 26.2425 hectares (11.92%) by 2016. In 2022, open space decreased to 14.19541 hectares (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.

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 Survey (2023).

Table 2 shows land use changes in Ipinsa from 2011 to 2022. In 2011, Ipinsa's built-up area was 6.473293 hectare (6.50%), but it increased to 31.02866 hectare (31.00%) in 2016. In 2022, the built-up area increased to 36.43449 hectares (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 23.18668 hectares (23.20%) in 2011, but decreased to 5.409729 hectares (5.40%) in 2016 and 7.54247 hectares (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 area could indicate environmental protection or restoration efforts. In 2011, the open space area in Ipinsa was 17.46% (17.46 hectares), but by 2016, it decreased to 10.80% (10.80 hectares). In 2022, the area declined further to 3.144846 hectares (3.10%). 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: 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 (2023).

Table 3 shows land use changes in Aule from 2011 to 2022, categorised as built-up area, green area, and open space. In 2011, the built-up area was 297.0687 hectares (56.86%). The built-up area increased from 407.0728 hectares (77.81%) in 2016 to 430.8376 hectares (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 157.041 hectares (30.07%). In 2016, the green space decreased to 72.3997 hectares (13.83%). In 2022, the green area increased to 76.87051 hectares (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, 13.07% of open space was inhabited, which is equivalent to 68.46882 hectares. The open space decreased to 43.36 hectares in 2016 (8.31%). The open area decreased to 15.36846 hectares (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 spatial distribution of land uses in Oke-Odu shows changes in residential land in the Oke-Odu Per-urban Area of Akure, Ondo State, Nigeria, from 2011 to 2022. Residential land development in Oke-Odu has significantly increased. In 2011, the built-up area was 45.09827 hectares, but by 2016, it increased to 148.9458 hectares. The expansion will reach 159.7332 hectares by 2022. These findings suggest urbanisation and residential expansion over time. Population expansion, housing demand, and urban development projects often drive these patterns [36]. This aligns with the global trend of urbanisation, where cities are growing to accommodate growing populations and economic activity [9].

The data shows a troubling trend of decreasing vegetation in Oke-Odu. In 2011, there were 97.08242 hectares of green space. By 2016, it had shrunk to 31.64963 hectares, and by 2022, it was 32.91493 hectares. This decrease in green areas implies loss of vegetation or conversion to built-up areas. Human activities like deforestation and land conversion cause natural land degradation [37]. Loss of green space affects biodiversity, ecosystem services, and environmental quality. Oke-Odu's open space has decreased over the years. In 2011, there were 64.99 hectares of open space. This decreased to 26.24 hectares in 2016 and further to 14.20 hectares in 2022. This decline suggests a decrease in available public or recreational spaces. Urbanisation, development, and land use can lead to open space loss which can negatively impacts community well-being by limiting physical activity, social connection, and access to nature. [38].

Peri-urbanization and its impact on land use change have been extensively studied globally. Rapid urbanisation can lead to the expansion of built-up areas at the expense of green spaces and open spaces [39]. This aligns with Oke-Odu trends. Idowu, Kiplangat, and Waswa [40] found that urbanisation led to the conversion of agricultural land and green regions into built-up areas, reducing vegetation cover. A study in Addis Abeba, Ethiopia, highlighted the loss of open areas due to urbanisation [41]. These findings confirm the trends in Oke-Odu and emphasise the significance of long-term urban planning and management. In Lagos, Nigeria, urbanisation led to the conversion of green regions into built-up areas, resulting in the loss of vegetation and open spaces [42]. A study in Abuja, Nigeria, examined urban growth and its impact on land use planning [43].

The built-up area in Ipinsa increased from 6.473293 hectares in 2011 to 31.02866 hectares in 2016, and then to 36.43449 hectares in 2022. The region is rapidly urbanising or developing. Urban expansion trends are similar worldwide. Urban land cover is increasing globally due to population growth, infrastructure development, and economic growth [44]. Africa has the highest urbanisation rate globally, leading to a significant increase in urban population and land conversion [45]. This relates to the increase in Ipinsa's built-up area. Ipinsa's green area decreased from 23.18668 hectares in 2011 to 5.409729 hectares in 2016, but slightly increased to 7.54247 hectares in 2022. The drop may be caused by land conversion for urbanisation and development, leading to the loss of natural vegetation and ecological services. Studies globally show urbanisation harms green spaces. Grimm et al. [46] highlighted the importance of protecting urban green spaces for biodiversity, climate change mitigation, and overall quality of life. The slight increase in green area in Ipinsa in 2022 may suggest environmental conservation efforts, aligning with global and local conservation measures. The table shows a significant decrease in the open space area in Ipinsa from 17.46377 hectares in 2011 to 10.79163 hectares in 2016, and further to 3.144846 hectares in 2022. This reduction results in the loss of open space areas that could have been used for other purposes. Global studies emphasise the importance of open spaces in cities. Pickett et al. [47] found that open spaces provide mental and physical health benefits, social cohesiveness, and climate regulation. Preserving open spaces is critical in Africa.

The built-up area in Aule has continuously expanded over the years. In 2011, the built-up area was 297.0687 hectares. By 2016, it increased to 407.0728 hectares and further expanded to 430.8376 hectares by 2022. This trend shows urbanisation and development in the area. The rapid growth from 2011 to 2016 suggests intensive urban development with a substantial increase in built-up areas. The smaller increase from 2016 to 2022 suggests slower development, possibly due to factors like infrastructure saturation or planning regulations. Urbanisation globally impacts land use and ecological systems due to the expansion of built-up areas. Aliyu and Ahmadu [48] found that urban areas worldwide are expanding by over 58,000 km2 per year, causing environmental, social, and economic challenges. These findings support the global trend of increasing built-up area in Aule. Seto et al. [44] found that urban areas in Africa expanded by 1.2 million km2 from 2000 to 2030. These findings suggest Aule's growing built-up area is part of a broader African urban development trend. Urbanisation is prominent in Nigeria. Nigeria has seen rapid urban growth and population increases. Akinrinola [49] found that urban areas in Nigeria grew by about 14% per year from 1984 to 2013. This expansion has changed land use, converting open spaces into built-up areas. The expansion of built-up areas in Aule reflects urbanisation in Nigeria. Aule's green area decreased from 157.041 hectares to 72.3997 hectares between 2011 and 2016. In 2022, the green area expanded to 76.87051 hectares, showing a slight recovery. This suggests a decrease in natural or undeveloped areas, possibly due to land being converted for urbanisation. Efforts are being made to preserve or restore green spaces in the residential area. Urbanisation is causing a global loss of green areas. Studies highlight the need to protect green spaces for ecological balance, biodiversity, and human well-being. Nowak et al. [50] found that urban forests and green spaces have benefits such as improved air quality, reduced urban heat island effects, and enhanced mental health. Maintaining green areas in urban environments is significant and aligns with the slight recovery observed in Aule. Loss of green spaces in Africa is a concern. Mensah [51] found that urbanisation reduced and degraded green areas. The research highlighted the need for green spaces in urban planning to improve the environment. The decline and recovery of green areas in Aule reflect trends seen in Nigerian urban contexts. Aule's open space has consistently declined over the years. In 2011, the open space was 68.46882 hectares. It decreased to 43.36364 hectares in 2016 and further decreased to 15.36846 hectares by 2022. This

suggests a decrease in open areas, possibly due to development or other land uses. Urban areas globally are losing open spaces. Reducing open spaces has consequences, including limited recreational opportunities, increased urban heat island effect, and compromised urban resilience. Kong, Yin, and Nakagoshi [52] emphasised the importance of urban planning strategies for protecting and enhancing open areas. The findings support the ongoing decrease in open space in Aule. Urbanisation in Africa is causing a decrease in open spaces. Olubi and Fadamiro [53] emphasised the importance of sustainable urban planning for balancing built-up areas and open spaces. The decline of open space in Aule is similar to other urban areas in Nigeria. The table shows increasing built-up area in Aule, at the expense of green areas and open spaces. These findings align with studies on urbanisation and land use changes globally, in Africa, and in Nigeria. Loss of green areas and open spaces raises concerns about the loss of natural environments and recreational spaces. Consider sustainable urban planning and conservation strategies to balance development and preserve the natural environment in the future.

Overall, Tables 1, 2, and 3 show increased built-up areas in all three locations, indicating urbanisation and residential expansion. Most places saw a decrease in green space, suggesting the loss of plants and natural areas. There were fewer open locations overall, resulting in fewer public or recreational spaces. Land covered by buildings increased significantly in Oke-Odu and Aule, but not as much in Ipinsa. Aule had less open land than Oke-Odu, but Oke-Odu had the largest decrease in green space. There was a slight increase in green space in Ipinsa and Aule. This may be because people are becoming more aware of the importance of preserving the environment and the benefits of having green spaces, resulting in more projects to create green areas. There may be limited knowledge in Oke-odu about this issue, which could explain the decrease in green areas over the past decade. Urbanisation and expansion are ongoing in all three locations, transforming previously undeveloped land into built-up regions. Consider the impact of these changes on climate, quality of life, and the need for environmentally responsible urban development and conservation initiatives.

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.

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