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SPECIAL ISSUE: CELEBRATING 20 YEARS OF GEOGRAPHY IN KADUNA STATE UNIVERSITY - ADVANCES AND FRONTIERS IN GEOGRAPHY

A Geographic Information System-Based Approach to Land Use and Land Cover Changes on Agricultural Lands in Oyo Metropolis

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ABSTRACT

The increasing conversion of agricultural lands as a result of urbanization, industrial expansion, and deforestation remains a critical challenge to developing countries, including Oyo metropolis in Oyo state of Nigeria. This study analyzed the land use and land cover (LULC) changes on agricultural lands in Oyo Metropolis from 2000 to 2024 using geospatial techniques. Landsat satellite imagery through a supervised classification technique was employed to analyse LULC to identify changes in five categories, such as built-up areas, farmland, open spaces, shrubs, and water bodies. The analysis revealed a significant decline in farmland, which accounted for 46.25% of the total land lost, while open spaces expanded by 53.37%, and built-up areas increased by 2.18%, reflecting urbanization and land conversion pressures. The study also observed an alarming annual farmland loss rate of -4,460.46 ha/year, highlighting the adverse effects of urban expansion on agriculture. Additionally, vegetation cover (shrubs) declined by 9.29%, indicating potential environmental degradation, while water bodies showed negligible change (-0.01%), suggesting relative stability. These findings underscore the urgent need for sustainable land use policies to mitigate the loss of agricultural land and ensure food security in the area. The study recommends implementing zoning regulations, promoting sustainable farming practices, and strengthening Geographic Information System (GIS) -based monitoring to track land use dynamics. By adopting these measures, policymakers and stakeholders can better manage land resources and minimize the negative impacts of rapid urbanization on agriculture.

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1 Introduction

Land use changes have significant implications for the environment, agriculture, and socio-economic development. These changes are often driven by human activities such as urbanization, industrial expansion, deforestation, and agricultural intensification (Bikis et al., 2025). The increasing demand for land due to population growth and economic development leads to the conversion of natural landscapes into built-up areas, agricultural lands, and other land uses. Understanding these changes is crucial for sustainable land management, environmental conservation, and planning for future growth (Ogunbode et al., 2025).

As the world's population continues to grow and demand for land to support residential, industrial, and agricultural uses increases, there is an urgent need to monitor these changes. Globally, urban sprawl is one of the major drivers of land conversion, significantly affecting ecosystems, natural resources, and land-based livelihoods (Muchelo et al., 2024). Effective management of land-use changes is therefore fundamental to achieving the Sustainable Development Goals (SDGs), particularly those related to environmental sustainability, food security, and climate action (United Nations Development Programme, 2019). Land use dynamics are key factors influencing food security and sustainable development. Therefore, understanding the extent and rate of these changes is crucial for implementing policies aimed at mitigating their adverse effects on agricultural land. The spatiotemporal monitoring of these land changes enables the identification of patterns and trends over time, providing valuable insights into the processes driving these changes and their impact on agricultural land management (Hassan, 2016).

The changes in land use associated with urbanization are evident in various forms, including the conversion of agricultural lands into built-up areas, the fragmentation of natural landscapes, and the depletion of vegetation cover (Angel, 2023). Although urban areas occupy a relatively small fraction of the earth's surface, their dynamic growth substantially impacts both natural and human environments across different geographic scales (Terfa, 2019). The land-use scenario of any region is shaped by human activities that modify the earth's surface for various uses over time, thereby influencing land availability and quality, particularly for agricultural purposes (Girma, 2022).

In Nigeria, rapid urbanization is a major driver of land-

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use transformation (Ologunde et al., 2025). With a population exceeding 200 million, the country faces increasing pressure on land resources to accommodate residential, commercial, and industrial development (Eririogu et al., 2020). As a result, natural vegetation and agricultural lands are often converted to urban and built-up areas, leading to the degradation of ecosystems, loss of biodiversity, and reduction in agricultural productivity (Ogunbode et al., 2025). Agriculture is a vital sector in Nigeria, providing livelihoods for a large portion of the population and contributing significantly to the country's economy (Opeyemi et al., 2021). The reduction of agricultural land due to land changes poses a serious threat to food security, rural livelihoods, and sustainable development. As farmland is lost or fragmented, agricultural productivity declines, and the resilience of local communities to environmental and economic shocks is weakened (Ololade, 2016). Particularly, Oyo State has experienced significant changes over the past few decades, driven by rapid population growth and the expansion of settlements. Oyo Metropolis, a key urban area in Oyo State, has witnessed considerable changes in its land use patterns, impacting the local agricultural landscape and natural environment (Jimoh et al., 2018).

This study aims to analyze the impact of land use changes on agricultural lands in Oyo Metropolis using a Geographic Information System (GIS)-based approach. This is to be achieved by identifying and mapping the various land uses in the metropolis from 2000 to 2024, determining the spatial extent, percentage change, and annual rate of change across the identified land use classes in the period under study, and examining the land use variations for the period. By examining multi-temporal satellite images, the research will identify the extent of land use changes over recent decades and assess the implications for agricultural sustainability. The findings will contribute to a better understanding of the land use transformations and help in formulating strategies for sustainable land management in the face of ongoing urban expansion.

2 Materials and methods

2.1 Study area

The study area is Oyo Metropolis, located between latitudes 7° 47′ N and 7° 55′ N and longitudes 3° 54′ E and 3° 59′ E of Oyo state, Nigeria. Atiba, Oyo West, and Oyo East are the three Local Government Areas in the metropolis (Salam et al., 2023). The area has experienced significant land use changes due to urban expansion, population growth, and increased demand for land for residential and commercial purposes (Jimoh et al., 2018). The study area covers approximately 2,427 square kilometers and features a mix of land uses, including agricultural land, shrubs, built-up areas, and water bodies (Salam et al., 2023). The choice of Oyo Metropolis as a case study is based on its rapid urbanization and the resultant impacts on agricultural land, making it a suitable area for analyzing land use dynamics.

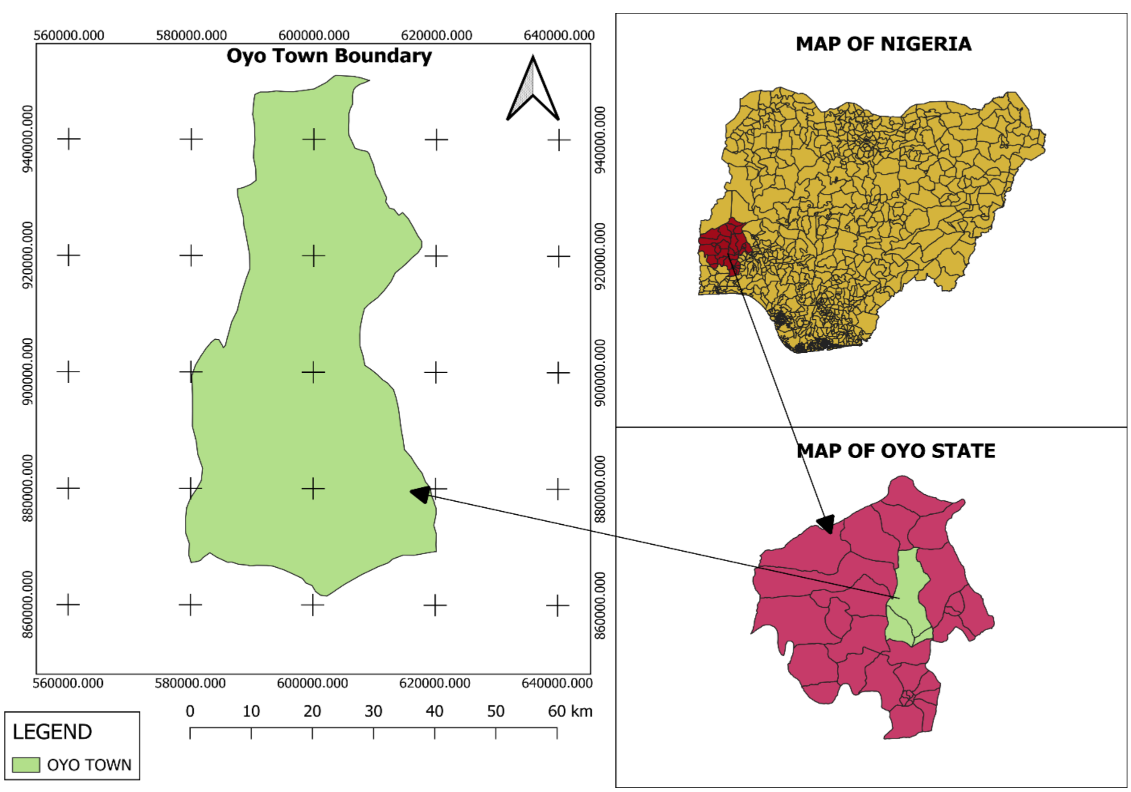


Figure 1: Map of the study area

2.2 Data Sources

The data used are primarily secondary data, which include the boundary map and administrative data of the study area, covering Atiba, Oyo West, and Oyo East Local Government Areas (LGAs), obtained from the Open Street Map (OSM) and Geographic Infrastructure and Demographic data for Development (GRID). To ensure coherence, satellite imagery of Oyo metropolis for three different years, 2000, 2012, and 2024, of the same resolution was obtained from the United States Geological Survey (USGS) through the USGS Earth Explorer (earthexplorer.usgs.gov).

Google Earth was also utilized to obtain high-resolution images of the study area, which significantly aided the supervised classification process. To ensure consistency in spatial analysis, all datasets were projected to the Universal Transverse Mercator (UTM) coordinate system, aligning with the study's requirements. This approach ensured the accuracy and reliability of spatial analyses conducted throughout the research. See Table 1 below for the summary of data, sources, resolution, format, and purpose.

Table 1: Data Sources

Data	Year	Source	Format	Resolution
Satellite				
Landsat7 ETM+	2000			
Landsat 8 OLI	2012			
Landsat 9 OLI	2024	USGS	TIFF	30m
Digital Elevation Model (DEM)		USGS	TIFF	30m
Boundary of Oyo Town		GRID	SHP	
Population		NPC	Numbers	

Furthermore, ground control point coordinates are acquired for the execution of this project. The coordinates were acquired with the aid of a GPS for the purpose of ground truthing.

2.3 Data Processing

The Landsat satellite imagery used in this study was sourced from the United States Geological Survey (USGS), covering the entire study area as outlined. Despite its medium spatial resolution and the challenge of heterogeneous pixel issues, Landsat imagery is commonly used for urban land use and land cover (Land Use) mapping (Lu & Weng, 2007). The USGS provided images for each year with less than 10% cloud cover, ensuring high-quality data for analysis. Consequently, Landsat images from the years 2000, 2012, and 2024 were downloaded for further processing and analysis. This involves a series of actions taking on the various data sets to achieve the desired results. It includes the geometric data processing and the satellite images processing.

This was followed by manipulating, sorting, and pre-processing of gathered data in order to assess the land use dynamics of the study area, which is specifically committed to attaining the objective of the study. The satellite images obtained were processed using ERDAS Imagine 15 software. The coordinate system, layer stacking, and layer extraction all took place. Additionally, image enhancement (to improve the quality of the satellite images), clipping of the boundaries of the study area using the shape file or polygon data representing Oyo metropolis, and the combination of different bands of the Landsat imagery to create composite images for better interpretation of land use types.

2.4 Image Classification

In this study, supervised image classification was applied to the satellite images using the Maximum Likelihood Classification (MLC) algorithm to categorize land cover types. This method has the advantage of assigning spectral signatures to distinct land use and land cover classes based on predefined training samples. Secondly, it has the advantages of reliance on the quantity and quality of training data to provide high-quality classification results (Osisanwo et al., 2017) over an unsupervised classification method. This study adjusted the descriptions of some of the land use/land cover classes for the sake of simplicity, taking into account the study area's land use/land cover diversity. As a result, the images were categorized into key land-use/land cover classes such as built-up area, farm land, open-space land, and shrub according to Kaul and Sopan (2012), as indicated in Table 2.

Table 2: Land Cover classification scheme for the study area

Land Use	Description
Settlements	Urban and rural built-up including homestead areas such as residential, commercial, industrial areas, villages, settlements, road network, pavements.
Farmland	Includes all agricultural lands (both annuals and perennials) and grazing
Shrubs	Includes all forest vegetation types (evergreen, deciduous, and wetland), and non-forest vegetation types that are not typical of forest (pasture grasslands and recreational grasses.
Open space land	Includes a surface with little vegetation, open land, exposed soil, rocks, and sand, and also includes the vacant space & small amounts of grassland.
Water body	Includes areas covered by water bodies such as rivers, lakes, ponds, reservoirs, streams, and other surface water features.

2.5 Accuracy Assessment

Accuracy assessment was carried out through the collection of reference data through field visits and high-resolution satellite images. Ground truth points representing different land use classes were carefully selected to match the land cover types identified during classification. Additionally, a confusion matrix was developed to compare the classified data with the reference data. This helps to provide insights into the agreement and discrepancies between the predicted and actual land cover classes. From this matrix, key metrics such as overall accuracy, producer's accuracy, user's accuracy, and the Kappa coefficient were calculated. These metrics helped evaluate the performance of the classification model. The accuracy metrics demonstrated that the classification was reliable and could be confidently used for analyzing land use and land cover changes. This step is critical in ensuring that the study's findings provide meaningful insights into the dynamics of the study area's landscape.

2.6 Land Use Transition Maps

To create a land use transition map, representative areas for each land use class (e.g., vegetation, water bodies, built-up areas, bare land) were selected from the imagery. These areas formed the basis for defining spectral signatures. Then Maximum Likelihood Classification (MLC) algorithm was utilized due to its effectiveness in handling mixed pixels and variability in spectral responses.

Furthermore, misclassified pixels were corrected using ground truth data and spatial editing tools to improve classification accuracy. Overall, the process entails data acquisition (Landsat images), band combination, image correction, enhancement and rectification, validation/field verification, supervised classification, and the production of land use maps.

3 Results and Discussion

3.1 Spatial Extents, Changes across the Land Use Classes from 2000 – 2024

The classified Landsat satellite images, summarized in Table 3 and illustrated in Fig. 2a – 2c for the years 2000, 2012, and 2024, respectively, depict the spatial extents, percentage changes, and annual rates of change across the five land use classes (built-up area, farmland, open space, shrub land, and water body) from 2000 to 2024. As shown in Figures 2a-2c, significant spatial changes occurred in the land use of all three reference years. The results indicate a marked decline in farmland, historically the dominant land class, as urban expansion led to increased built-up areas and open spaces. This finding aligns with previous studies that examine the spatial analysis of urban expansion, land use dynamics in Oyo town, south-western Nigeria, which revealed a change in built-up areas over the preceding three decades because of urban expansion (Salam et al., 2023).

Table 3: Area statistics and Annual rate change of the LAND USE from 2000-2024

Land Use Types	2000		2012		2024	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
OPEN SPACE	47605.59	20.57	82433.7	35.6	171313.8	73.88
BUILTUP	2117.79	0.92	4286.25	1.91	7436.7	3.21
FARMLAND	130185.6	56.25	89294.49	38.58	23134.68	9.98
SHRUBS	50455.98	21.8	54459.81	23.49	28955.79	12.49
WATERBODY	1086.3	0.47	977.04	0.42	1040.22	0.45
TOTAL	231451.3	100	231451.3	100	100	231451.3

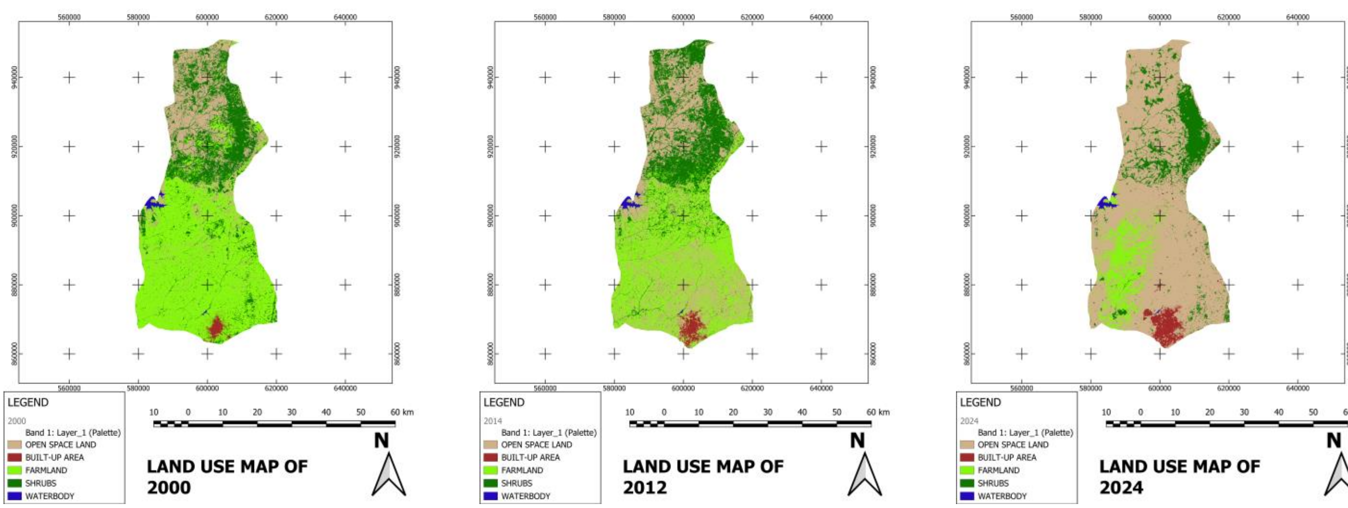
From the results in Table 3, from 2000 to 2024, farmland declined sharply from 56.25% to 9.98%, reflecting a substantial reduction in agricultural land use. Meanwhile, open space increased significantly, expanding from 20.57% in 2000 to 73.88% in 2024. Built-up areas also grew steadily, rising from 0.92% in 2000 to 3.21% in 2024. Shrub land showed a declining trend, dropping from 21.8% in 2000 to 12.49% in 2024. Water body coverage remained relatively stable, accounting for less than 0.5% of the total area throughout the study period. The study results reveal a significant and uneven shift in land use in the study area, driven by rapid urban expansion. In 2000, the built-up area accounted for 0.92% of the total land area. Over the subsequent 14 years, this proportion increased modestly to 1.91% in 2012. However, the pace of expansion accelerated between 2012 and 2024, with the built-up area reaching 3.21% of the total area (See Table 3).

Farmland, in contrast, experienced a substantial decline over the study period. Starting at 56.25% of the total area in 2000, it decreased to 38.58% by 2012 and further plummeted to just 9.98% in 2024, indicating a dramatic reduction in agricultural land use. Similarly, shrub land showed a declining trend, starting at 21.8% in 2000, slightly increasing to 23.49% in 2012, before contracting to 12.49% by 2024.

On the other hand, open space expanded significantly during the study period. From an initial 20.57% of the total area in 2000, it grew to 35.6% in 2012 and further surged to 73.88% in 2024, reflecting a consistent and rapid annual growth rate. These areas might represent land that has been altered through construction activities or other human interventions. The presence of these open spaces might be of environmental concern as it can result in loss of fertility, biodiversity, and even increased soil erosion. Water bodies remained relatively stable, covering less than 0.5% of the total area throughout the study period. These land use dynamics highlight the impacts of urban expansion, with significant increases in built-up and open spaces occurring at the expense of farmland and shrubland.

The observed changes in land use dynamics in this study are consistent with a similar trend in Bucharest-IIfov, Romania, on the impact of urban expansion on land use in an emerging territorial system where urban sprawl has led to dramatic changes in land use, with agricultural land being the category that has seen the largest reduction in area (Diaconu et al., 2025).

The summary of the land use types is shown in Table 3, while the visual representation of changes in land use for the three epochs is shown in Fig. 2a-2c.



a) b) c)

Figure 2: Land Use Map of Study Area in a) 2000, b) 2012, and c) 2022

Between 2000 and 2012, the open space area increased significantly from 47,605.59 ha (20.57%) to 82,433.70 ha (35.6%). This expansion continued into 2024, reaching 171,313.83 ha (73.88%). Built-up areas also grew notably, rising from 2,117.79 ha (0.92%) in 2000 to 4,286.25 ha (1.91%) in 2012, and further to 7,436.70 ha (3.21%) by 2024.

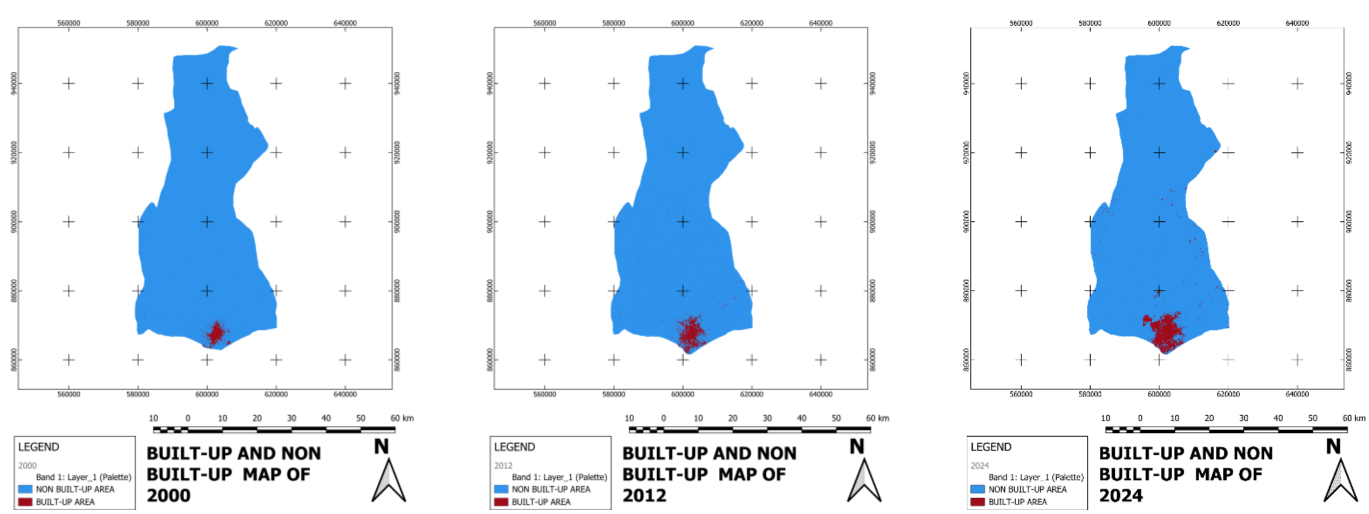
Conversely, farmland experienced a dramatic decline, shrinking from 130,185.63 ha (56.25%) in 2000 to 89,294.49 ha (38.58%) in 2012, and then to just 23,134.68 ha (9.98%) by 2024. Shrubland also decreased, albeit at a slower rate, from 50,455.98 ha (21.8%) in 2000 to 54,459.81 ha (23.49%) in 2012, before contracting to 28,955.79 ha (12.49%) by 2024. Waterbodies remained relatively stable over the period, covering 1,086.30 ha (0.47%) in 2000, 977.04 ha (0.42%) in 2012, and 1,040.22 ha (0.45%) in 2024 (see Table 3). Similar trends of decline in farmlands are evident globally; for instance, research by Bikis et al. (2025) in the Mizon Aman city, South Western Ethiopia, highlighted a significant decrease in forested land due to increasing demand for housing, infrastructure, and manufacturing. This emphasizes the role of human involvement in unsustainable changes in land use and land cover. Similarly, land use changes due to increased religious activities, small-scale businesses, government initiatives, and educational institutions in Iwo, Nigeria (Ogunbde et al., 2025) have contributed to declining green spaces. These findings highlight the importance of sustainable urban planning to balance growth with environmental preservation.

3.2 Land Use Variations of Built-up Areas

Table 4 highlights the changes in built-up areas over time. During this study period, the land use pattern showed significant changes. From 2000 to 2024, built-up areas expanded notably, while non-built-up areas decreased. In 2000, built-up areas covered 0.92% of the total area, increasing to 1.91% in 2012 and further to 3.21% in 2024. On the other hand, non-built-up areas covered 99.08% of the total area in 2000, decreasing to 98.09% in 2012 and further to 96.79% in 2024. The comparative variations in the build-up areas and non-built-up areas are shown in Fig. 3a-3c for years 2000, 2012, and 2024, respectively, indicating the extent of urbanization and infrastructural development within the metropolis. This significantly reflects. the level of urban expansion, industrial activities, and population density. The above assertion is similar to the work of Odoh et al. (2024) in Rivers state, Nigeria, who suggested careful urban planning to balance development with environmental sustainability and also to address issues such as habitat loss, pollution, and increased demand for resources.

Table 4: Built-up and non-built-up areas (2002- 2024)

LAND USE	2000		2012		2024	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
BUILT-UP AREA	2117.7	0.9	4286.25	1.91	7436.7	3.21
NON-BUILT-UP AREA	229333.5	99.1	227165	98.09	224014.6	96.79
TOTAL	231451.3	100	231451.3	100	231451.3	100



a) b) c)

Figure 3: Built-Up and Non-Built-Up Map of a) 2000, b) 2012, and c) 2024

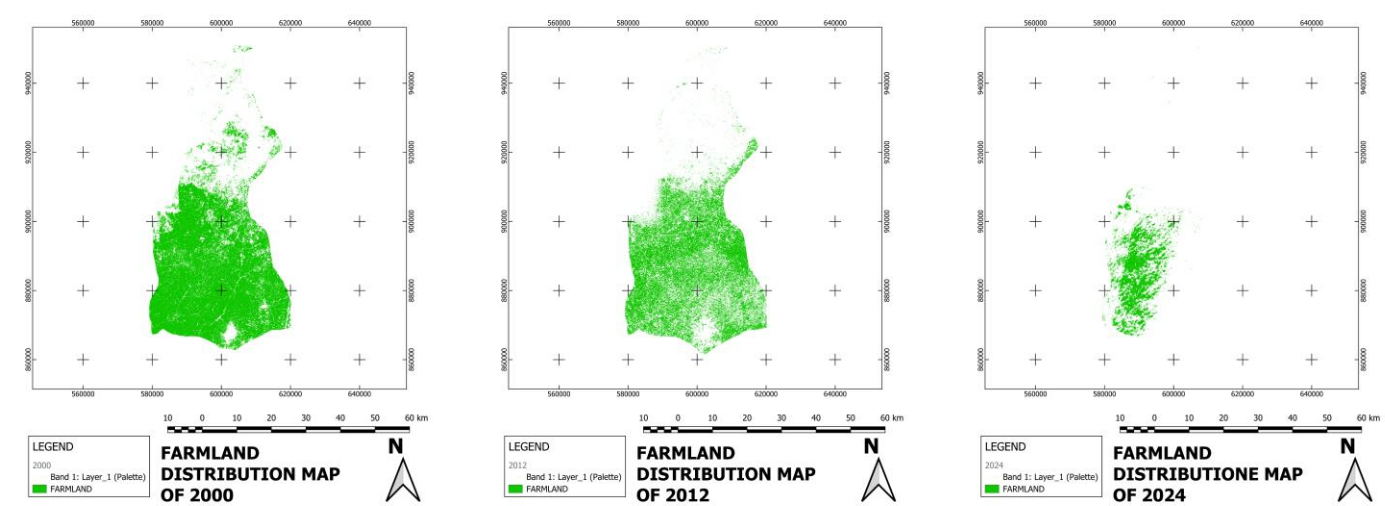
3.3 Land Use Variations of Agricultural Lands

Table 5 shows the changes between farm land and non-farm land area from 2000 to 2024. For the farmland, there was a decline from 56.25% in 2000 to 38.58% in 2012 and to as low as 9.98% in 2024. In contrast, in the non-farmland area, there was an increase from 43.75% in 2000 to as high as 90.02% in 2024. That is, while farmland occupies 9.98% of the total area, non-farmland occupies a larger percentage of 90.02% in the year 2024.

Table 5: Trends of agricultural land during the study period

LAND USE	2000		2012		2024	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
FARMLAND	130185.6	56.25	89294	38.58	23134.68	9.98
NON-FARMLAND AREA	101268.7	43.75	142156.8	61.42	208317.3	90.02
TOTAL	231451.3	100	231451.3	100	231451.3	100

Agricultural activities, which are a very important occupation, reflect a downward trend in the metropolis over the study period. The most significant substitute of functionalities between farm land and non-farm land as illustrated in Figure 4, 5a, 5b and 5c from 2000 to 2024 in the metropolis took place between 2012 – 2024 where farmland declined from 38.58% to 9.98% (that is about 74% decrease) and non-farm land area increased from 61.42% to 90.02% (about 46.56% increase). The process of change in the functions of the land may not be unconnected with new modernization projects, such as road construction in the metropolis.



a) b) c)

Figure 5: Distributions of Farmland Map in a) 2000, b) 2012, and c) 2024

3.4 Land Use Change Analysis

The change of spatial area extent in hectares, percentage change, and the annual rate change within the study area of each land cover category were presented in Table 6 below from 2000 to 2024 and also illustrated in Figure 6a, 6b, and 6c for the years 2000-2012, 2012- 2024, and 2000-2024, respectively.

Table 6: Change of Land Use between 2000 and 2024

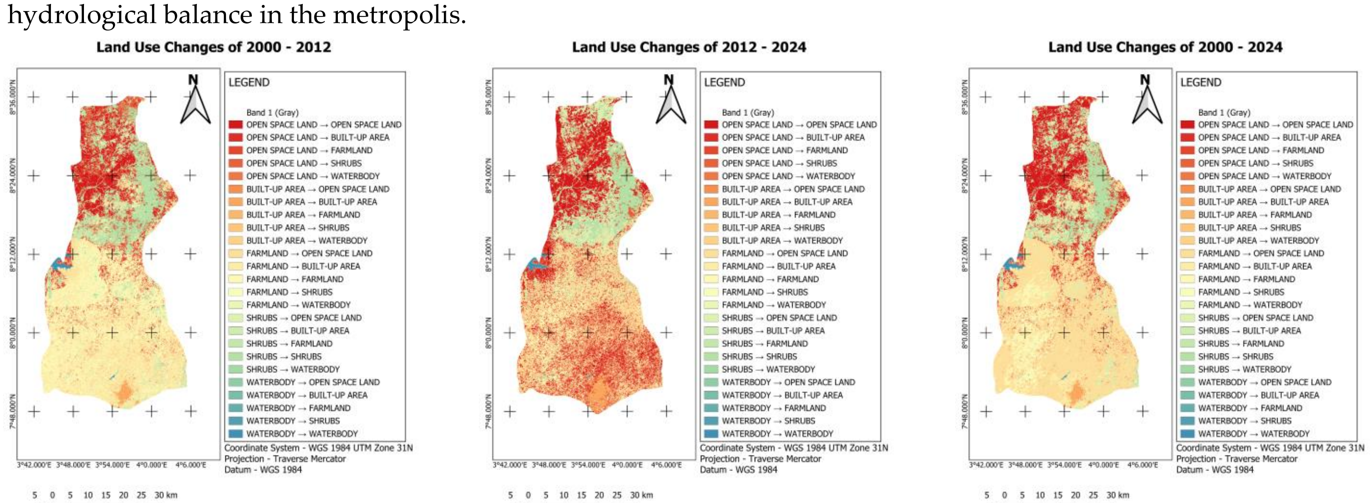
Land Use Types	2000-2012		2012-2024		2000-2024	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
OPEN SPACE	34828.11	15.05	88764.57	38.28	123539.3	53.37
BUILTUP	2168.46	0.94	3003.75	1.29	5061.24	2.18
FARMLAND	-40891.1	-17.67	-66319.4	-28.6	-107051	-46.25
SHRUBS	4003.83	1.73	-25512.1	-11.002	-21503.5	-9.29
WATERBODY	-109.26	-0.05	63.18	0.027	-46.08	-0.01

The analysis of Land Use changes highlights significant shifts in the study area over the period from 2000 to 2024. These changes, as summarized in Table 6, revealed that between 2000 and 2012 (12 years), the study area experienced an increase in built-up land by 2,168.46 ha (0.94%) and open space by 34,828.11 ha (15.05%), reflecting steady urban growth and expansion of open land. At the same time, farmland declined substantially by 40,891.14 ha (17.67%), showing a major loss of agricultural land. Shrub cover increased slightly by 4,003.83 ha (1.73%), while water bodies saw a small decrease of 109.26 ha (0.05%).

Over the entire period (2000–2024), there were notable transformations. Built-up areas increased by 5,061.24 ha (2.18%), and open spaces expanded significantly by 123,539.31 ha (53.37%), indicating consistent growth in urban and open areas. Conversely, farmland saw a substantial loss of 107,050.95 ha (46.25%), and shrub cover declined by 21,503.52 ha (9.29%). Water bodies showed minimal overall change, with a slight net decrease of 46.08 ha (0.01%). The minimal change in water bodies, although still present in the metropolis, is very important in the support of the aquatic ecosystem and also a veritable source for human consumption. These water bodies can also contribute to the overall diversity in the environment and to maintaining hydrological balance in the metropolis.

This is similar to the findings of Diaconu et al. (2025), who assessed the impact of urban expansion on land use, indicating a strong trend of urbanization and the expansion of open spaces, which has come at the expense of farmland and shrub cover. This, in no small measure, has contributed to structural changes in biodiversity, with natural areas being heavily affected by uncontrolled development. The illustrated maps further illustrate these patterns, showing clear evidence of land cover conversion across the study area. The spatial pattern of change in land use highlights different intensities.

This spatial visualization gives room for a targeted approach for addressing the menace of uncontrolled urbanization, thus enabling policy to imbibe integrated land use planning for a sustainable environment.



a) b) c)

Figure 6: land use change map of a) 2000-2012, b) 2012-2024, and c) 2000-2024

4 Conclusion

This study analyzed the dynamics of land use in Oyo Metropolis from 2000 to 2024 using Landsat satellite imagery and geospatial tools. The results revealed significant changes in the spatial and quantitative distribution of land use among five classes: built-up area, farmland, open space, shrubs, and water bodies. Farmland consistently declined over the study period, while built-up areas and open spaces expanded considerably. Farmland accounted for 46.25% of the total area lost between 2000 and 2024, while open spaces grew by 53.37%, indicating land abandonment or deforestation. The built-up area increased by 2.18%, reflecting urbanization and infrastructure development.

The annual rate of farmland loss (-4,460.46 ha/year) highlights the urgent need to address the pressures of urban sprawl and land conversion. Similarly, the decline in vegetation cover (shrubs) by 9.29% signals ecological concerns such as biodiversity loss and environmental degradation. On the other hand, water bodies showed a negligible change (-0.01%), indicating relative stability. The study further demonstrated that land use changes significantly impact agricultural productivity by reducing available farmland and altering the ecological balance. The study concluded that rapid urbanization and land conversion significantly contribute to the decline of agricultural lands in Oyo Metropolis. The observed expansion of built-up areas and open spaces at the expense of farmlands poses serious threats to food security, ecological sustainability, and environmental stability.

Based on the findings, the study underscores the necessity of sustainable land use policies to mitigate adverse effects on agricultural lands and ensure food security in Oyo Metropolis through integrated land use planning by all stakeholders that prioritizes agricultural preservation while accommodating urban growth.

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