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. SPATIO-TEMPORAL DYNAMICS OF URBAN EXPANSION AND LAND USE/LAND COVER CHANGE IN UYO CAPITAL CITY, NIGERIA (1986–2024): A REMOTE SENSING AND GIS-BASED ANALYSIS

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Abstract

Rapid urban expansion in sub-Saharan Africa is increasingly occurring at the expense of natural ecosystems and agricultural lands, yet detailed spatio-temporal analyses for secondary cities remain critically scarce. This study assessed the trends, magnitude, and rate of urban expansion and associated land use/land cover (LULC) changes in Uyo Capital City, Akwa Ibom State, Nigeria, over 38 years (1986–2024). Using multi-temporal Landsat imagery (TM 1986, ETM+ 2004, OLI 2014, and OLI/TIRS 2024), supervised classification was performed in ERDAS Imagine 10.5 to map five LULC classes: forest, disturbed forest, compound farmland, farmland, and built-up/bare land. Accuracy assessment yielded overall accuracies ranging from 79% to 96% and kappa coefficients from 0.68 to 0.93, confirming classification reliability. Results revealed a dramatic transformation of the landscape. Built-up/bare land expanded from 6,022.08 ha (15.02%) in 1986 to 20,966.12 ha (52.30%) in 2024, representing a net gain of 14,944.04 ha (a 248% increase). Conversely, forest cover declined from 3,407.86 ha (8.50%) to 1,534.68 ha (3.82%), disturbed forest from 8,566.01 ha (21.37%) to 4,134.58 ha (10.31%), compound farmland from 11,628 ha (29.00%) to 4,897.28 ha (12.22%), and farmland from 10,468.26 ha (26.11%) to 8,559.55 ha (21.35%). The annual rate of change for built-up land accelerated dramatically from 12.33% (1986–2004) to 19% (2004–2014 and 2014–2024), indicating an intensifying sprawl process. The combined agricultural land (compound farmland + farmland) decreased from 55.11% to 33.57% of the study area, while combined forest cover fell from 29.87% to 14.13%. These findings provide empirical evidence of uncontrolled urban expansion consuming productive agricultural lands and natural habitats. The study concludes that Uyo is undergoing a phase of accelerated, unplanned urban sprawl, necessitating urgent policy interventions, including enforcement of master plans and establishment of a permanent GIS-based monitoring unit for sustainable land governance.

Keywords: *Urban expansion; land use/land cover change; remote sensing; GIS; urban sprawl.*

1. INTRODUCTION

1.1 Global Context of Urban Expansion

Urban centres worldwide are experiencing unprecedented population growth due to the concentration of economic activities, industrial expansion, and enhanced employment and trade prospects (Celik et al., 2024). This demographic surge attracts individuals from small towns, rural regions, and other countries, creating a phenomenon broadly termed urban expansion (Wilcox et al., 2017). Urban expansion describes the spatial growth of cities alongside human population increase, leading to the spread of construction infrastructure on the Earth's surface and the consequential physical transformation of

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surrounding landscapes (Rahman and Alam, 2021). While urban expansion is often associated with agglomeration economies and economic development indicators, it has a strong relationship with rural land use change, frequently resulting in the irretrievable loss of productive agricultural lands, forests, surface water bodies, and groundwater prospects (Hall & Barrett, 2018).
We are living in an increasingly urbanised world. In the early 1950s, approximately 66% of the world's population lived in rural areas. Today, cities are home to half of the world's population, and by 2030, about 60% of the global population will reside in urban areas (World Bank, 2010). More than 90% of this urbanisation is taking place in the developing world, with urban populations in developing countries projected to reach 2 billion within the next two decades, increasing at approximately 70 million per year, more than one million per week (UN-Habitat, 2010). The populations in urban areas of Africa and Asia will double by 2030, and 80% of the world's urban population will then live in developing countries (UN-Habitat, 2010).

1.2 Urban Expansion and Land Use/Land Cover Change

As the population increases in urban centres, there is a corresponding need for expansion in human settlements to accommodate the ever-growing urban population. The increasing population size of cities and the physical expansion of built-up areas beyond city limits, coupled with rising demand for land for various purposes, induce changes in urban land use (Uttah et al., 2023). This process represents one of the most profound human alterations of the natural environment, encompassing a spectrum of urban land use activities including commercial, transportation, industrial, residential, institutional, and recreational uses (Odama, 2013). Due to the absence of efficient social organisation and lack of adequate infrastructure, the growth of cities contributes to intensifying environmental problems worldwide. Recent environmental challenges arise from population growth, lack of development, and unintended repercussions of some forms of economic growth.
While urban centres grow in population and extent, peri-urban areas undergo a two-fold transformation: arable land comes under increasingly intense cultivation, and both arable and non-arable land are increasingly built over to provide space for commercial, industrial, and residential establishments (Agbo, Ikpe & Mayowa, 2022). This expansion takes place either in radial direction around a core or linearly along highways, a dispersed development often referred to as urban sprawl.

1.3 The Nigerian and Sub-Saharan African Context

Within Africa, urban dynamics are intensified by the continent's unprecedented urban growth rates. UN-Habitat (2014) has consistently reported that African cities are growing faster than any other region, but this growth is frequently characterised by informality and a lack of adherence to planning frameworks. The case of Accra, Ghana, is instructive: rapid urban expansion has led to significant loss of green spaces, increasing the city's vulnerability to flooding and heat stress (Aboagye, 2017). In Ethiopia, the rapid expansion of Addis Ababa into the surrounding Oromia region has sparked conflicts over land dispossession and the erosion of agricultural livelihoods (Abebe, 2019).
The Nigerian urban experience provides a potent microcosm of these continental challenges. Lagos, the megacity, has experienced massive land reclamation and destruction of mangrove forests, significantly altering the coastal ecosystem and increasing flood risk (Adelekan, 2016). Abuja, the purpose-built capital, has seen rapid peripheral growth devouring surrounding villages and farmlands, leading to conflicts between indigenous landowners and new urban elites (Mabogunje, 2015). State capitals like Port Harcourt and Ibadan have consistently mapped dramatic declines in vegetation cover corresponding with surges in built-up areas, linking these changes to increased land surface temperatures and biodiversity loss (Ejaro & Abubakar, 2013; Adegboyega et al., 2018).
While the macro-dynamics of cities like Lagos and Abuja are well-chronicled, there is a significant knowledge gap concerning the spatio-temporal dynamics of secondary cities like Uyo, which are absorbing a massive proportion of Nigeria's urban population growth yet receive disproportionately less scholarly attention. The few studies carried out in the study area are not up to date. Therefore, a detailed and up-to-date land use cover assessment and analyse of the changes in LULC of the study area between 1986, 2004, 2004 and 2014 of Uyo Capital City's using current geospatial technologies is urgently needed to provide an empirical baseline.

2. MATERIALS AND METHODS

2.1 Study Area Description

Uyo Capital City is located in Akwa Ibom State, south-eastern Nigeria. It became the state capital on September 23, 1987, following the creation of Akwa Ibom State from the erstwhile Cross River State. The study area comprises all areas within a radius of 10 kilometres measured from the city centre, as demarcated by the Uyo Capital City Development Authority law, CAP 136 of 1988. The

city limit incorporates parts of nearby local government areas, including Itu, Uruan, Ikono, Nsit Ibom, Ibiono Ibom, Ibesikpo Asutan, and Uyo. As shown in Figure 1, Uyo Capital City lies between latitudes 4°58′ and 5°04′ N and longitudes 7°51′ and 8°01′ E. It is bounded in the north by Ikono, Itu, and Ibiono Ibom LGAs, in the east by Uruan LGA, and in the south by Ibesikpo Asutan and Nsit Ibom LGAs. The capital city is situated on an average elevation of 60.96 metres above sea level and covers an area of approximately 214.31 square kilometres (Ofem and Udida, 2014; Njungbwen and Roy, 2010). The city is one of the fastest growing in Nigeria and is accessible by road via several major routes. Vegetation-wise, Uyo Capital City is located within the tropical rainforest belt, characterised by tall trees and thick ground cover. However, urbanisation and unsustainable environmental practices have resulted in the disappearance of this ideal vegetation type. The area is now in the modified rainforest locally known as the oil palm bush (Ituen, 2010).

2.2 Satellite Data Acquisition

Four Landsat satellite images were acquired from the United States Geological Survey (USGS) EarthExplorer portal. The selection criteria included cloud cover (<10%), dry season acquisition (November–February) to minimise atmospheric interference, and consistent spatial resolution. Table 1 presents the characteristics of the acquired images.

Table 1: Satellite Data Characteristics

Year	Satellite/Sensor	Path/Row	Spatial Resolution	Acquisition Date	Cloud Cover (%)
1986	Landsat 5 TM	188/57	30 m	15 January 1986	5
2004	Landsat 7 ETM+	188/57	30 m	22 February 2004	7
2014	Landsat 8 OLI	188/57	30 m	10 January 2014	3
2024	Landsat 8/9 OLI/TIRS	188/57	30 m	18 January 2024	2

Source: Researcher's Compilation, 2026

2.3 Image Pre-processing and LULC Classification Scheme

All images were georeferenced to the World Geodetic System (WGS) 1984, Universal Transverse Mercator (UTM) Zone 32N coordinate system. Individual spectral bands (bands 1–5 for TM/ETM+, bands 2–7 for OLI) were stacked into single multi-band images, the study area shapefile was used to extract the Area of Interest (AOI) from each image and Principal Component Analysis (PCA) was applied to reduce data redundancy and enhance feature discrimination. Based on prior knowledge of the study area and a reconnaissance survey, a modified Anderson et al. (2009) classification scheme was adopted. Five LULC classes were defined:

Table 2: Land Use Land Cover (LULC) Class Descriptions

Class	**Description**
Forest	Original undisturbed natural vegetation dominated by trees and undergrowth.
Disturbed/Secondary Forest	Regrown forest after major disturbance (fire, harvest, slash-and-burn); single canopy, closer tree spacing
Compound Farmland	Farming around dwelling houses; multi-generational, annual cropping with mixed/sequential cropping; very short fallow periods
Farmland	Arable land used for cultivation of specific crops; ploughed and sown land
Built-up/Bare Land	Non-linear built areas covered by impervious structures; includes residential, commercial, industrial, transportation, and recreational areas, as well as bare soil areas

Source: Researcher's Compilation

2.4 Supervised Classification

Supervised classification using the maximum likelihood algorithm was performed in ERDAS Imagine 10.5. The procedure involved:

i. **Training signature collection:** For each LULC class, 50–80 training polygons were digitised across the image using prior knowledge and reference data.

ii. **Signature evaluation:** Separability analysis was conducted using Jeffries-Matusita and Transformed Divergence measures. All classes achieved separability >1.9, indicating good discrimination.

iii. **Classification:** The maximum likelihood classifier was applied to assign each pixel to the class with the highest probability.
iv. **Post-classification smoothing:** A 3×3 majority filter was applied to remove isolated pixels (salt-and-pepper effect).

2.5 Accuracy Assessment

Accuracy assessment was performed using 200 random reference points per image, generated via stratified random sampling. Reference data were obtained from: High-resolution Google Earth imagery for 2004, 2014, and 2024. Ground truth points collected using GPS during field surveys (November–December 2024) for the 2024 classification. Historical aerial photographs and topographic maps for the 1986 classification. An error matrix was constructed for each year, and overall accuracy, producer's accuracy, user's accuracy, and kappa coefficient were calculated using the following formulae:

Overall Accuracy = (Total number of correctly classified pixels / Total number of reference pixels) × 100

Kappa Coefficient (K) = (TS × TCS) − Σ(Column Total × Row Total) / (TS^2 − Σ(Column Total × Row Total))

Where: TS = total number of reference pixels, TCS = total number of correctly classified pixels.

2.6 Change Detection and Rate Analysis

Post-classification change detection was performed by comparing the classified images of different years at the pixel level. The following metrics were computed:

- Magnitude of change (ha): Difference in area between two time periods for each class
- Percentage change (trend): (observed change / sum of all changes) × 100
- Annual rate of change (ARC): (Percentage change × Number of years) / 100

The annual rate of change provides a standardised measure of how quickly each land cover class is expanding or contracting per year, allowing comparison across different time intervals.

3. RESULTS

3.1 Land Use Land Cover (LULC) Status for 1986, 2004, 2014 and 2024

Table 3 presents the LULC distribution for each study year, and Figures 2 - 5 showed the corresponding classified image maps.

Table 3: Status of Land Use Land Cover in 1986, 2004, 2014, and 2024

LULC Class	1986 Area (ha)	1986 (%)	2004 Area (ha)	2004 (%)	2014 Area (ha)	2014 (%)	2024 Area (ha)	2024 (%)
Forest	3407.86	8.50	3055.37	7.62	2813.76	7.01	1534.68	3.82
Disturbed Forest	8566.01	21.37	6980.68	17.41	5985.29	14.93	4134.58	10.31
Compound Farmland	11628.00	29.00	7815.53	19.49	6186.60	15.43	4897.28	12.22
Farmland	10468.26	26.11	12487.06	31.15	10133.64	25.28	8559.55	21.35
Built-up/ Bare Land	6022.08	15.02	9753.57	24.33	14972.92	37.35	20966.12	52.30
Total	**40092.21**	**100**	**40092.21**	**100**	**40092.21**	**100**	**40092.21**	**100**

Source: Researcher's Compilation, 2026
Extracted from Landsat 1986, 2004, 2014 and 2024

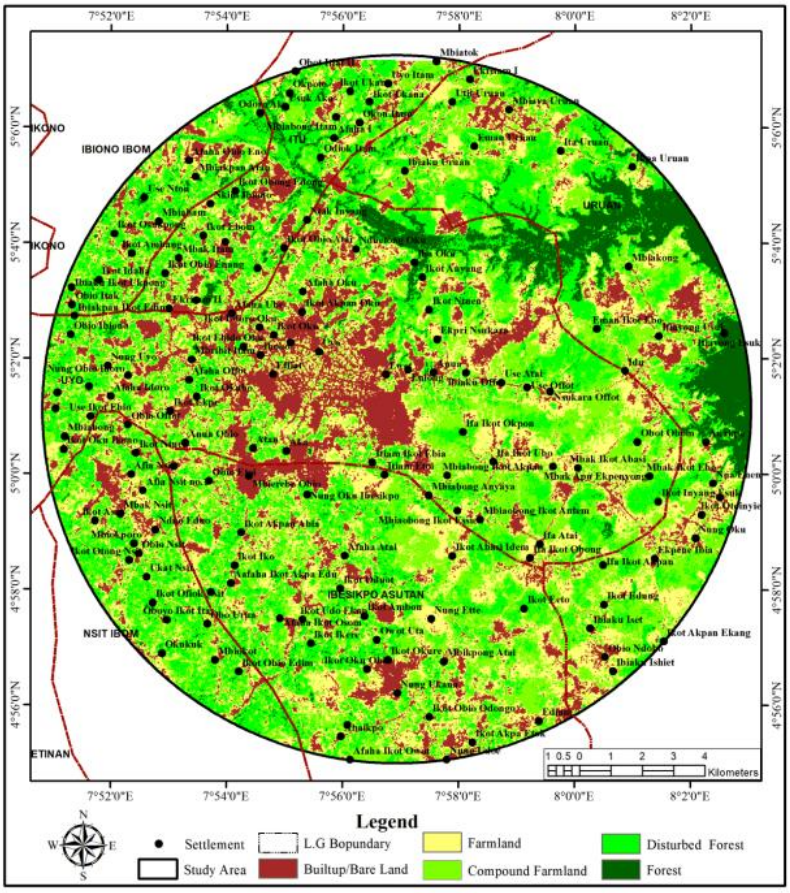

Figure 2: Land Use Land Cover Image Map of Uyo Capital City 1986
Source: Researchers' 2026 (extracted from Landsat 5 TM imagery of 1986)

In 1986, the landscape was predominantly agricultural, with compound farmland (29.00%) and farmland (26.11%) together covering more than half of the study area. Forest and disturbed forest covered 29.87%, while built-up areas occupied only 15.02%. This reflects Uyo's character before becoming state capital: a predominantly agrarian settlement with moderate urban development concentrated in the city centre.

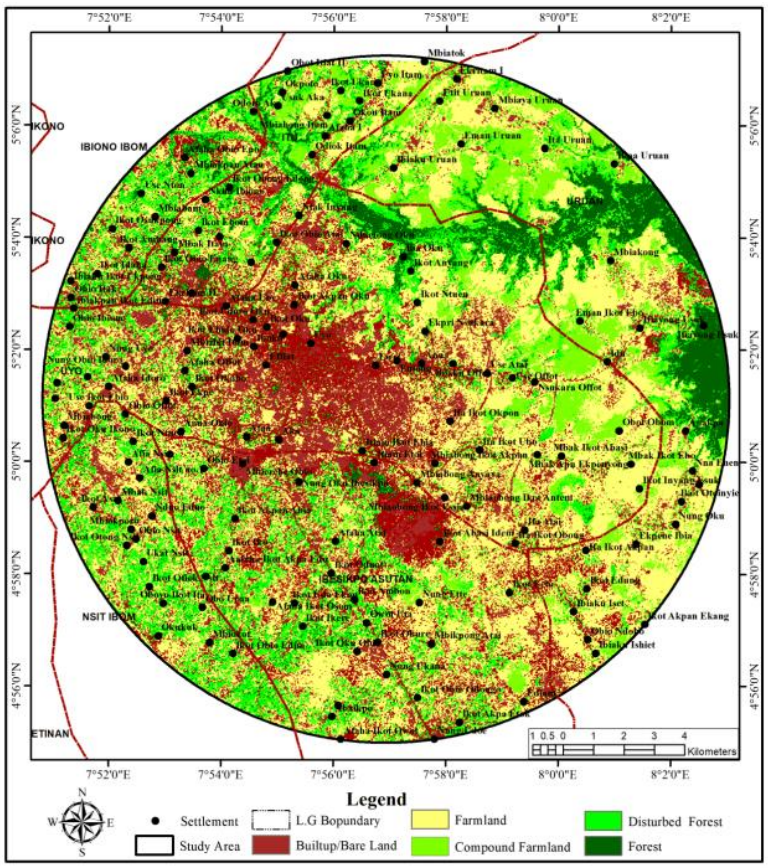

Figure 3: Land Use Land Cover Image Map of Uyo Capital City 2004
Source: Researchers' 2026 (extracted from Landsat 7 TM imagery of 2004)

By 2004, 18 years after becoming state capital, noticeable changes had occurred. Built-up area increased to 24.33% (a gain of 9.31 percentage points). Farmland increased to 31.15% (a gain of 5.04 percentage points), possibly reflecting agricultural intensification or displacement to peri-urban areas. However, compound farmland decreased to 19.49% (a loss of 9.51 percentage points), and disturbed forest declined to 17.41% (a loss of 3.96 percentage points). Forest remained relatively stable at 7.62%.

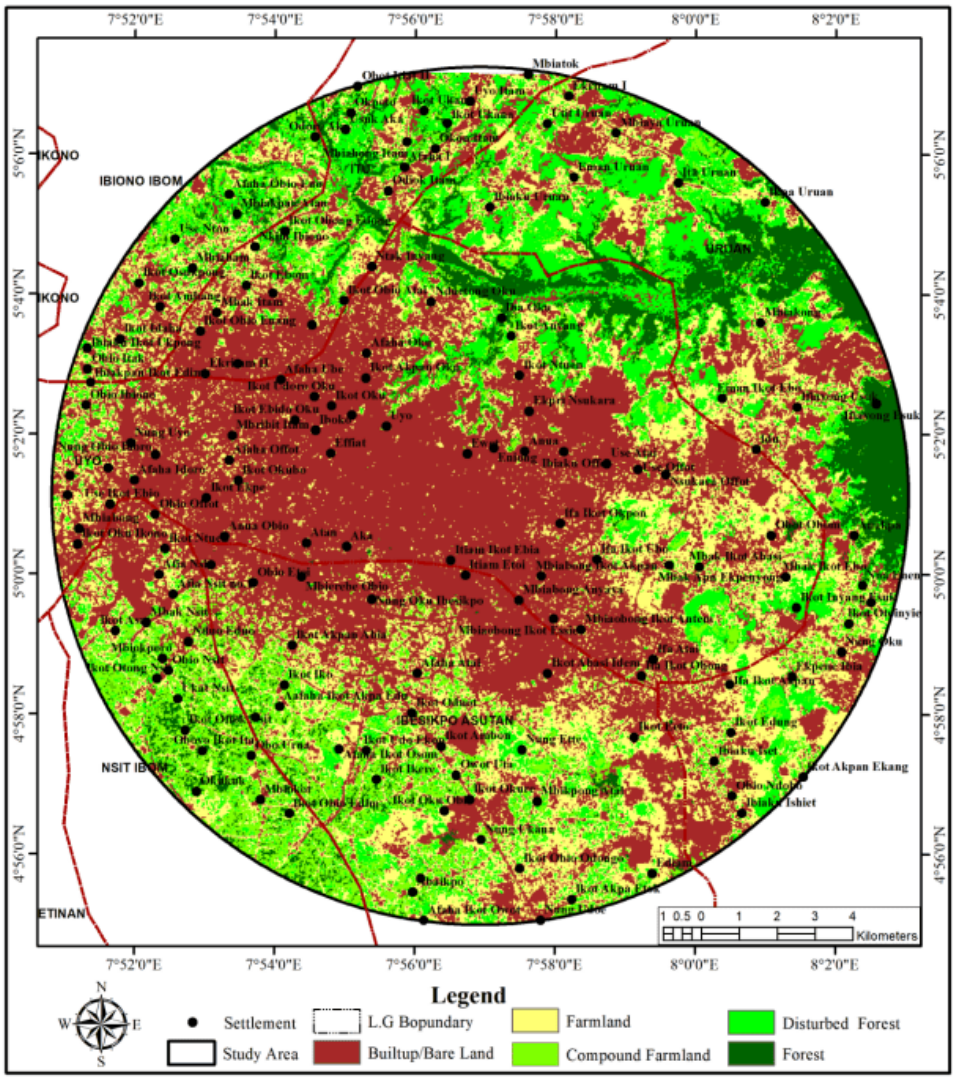

Figure 4: Land Use Land Cover Image Map of Uyo Capital City 2014
Source: Researchers' 2026 (extracted from Landsat L8 OLI_TIRS imagery 2014)

In 2014, the transformation accelerated. Built-up area surged to 37.35% (a gain of 13.02 percentage points in one decade). Farmland decreased to 25.28% (a loss of 5.87 percentage points from 2004), compound farmland fell to 15.43% (loss of 4.06 percentage points), and disturbed forest declined to 14.93% (loss of 2.48 percentage points). Forest decreased marginally to 7.01%.

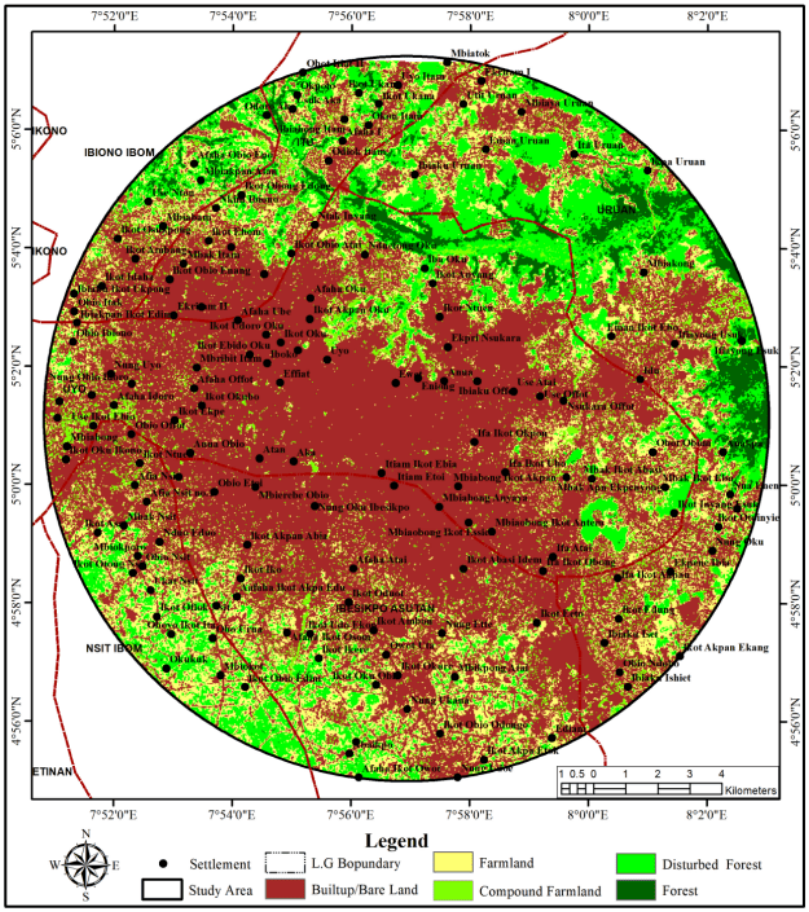

Figure 5: Land Use Land Cover Image Map of Uyo Capital City 2024
Source: Researchers' 2026 (extracted from Landsat L8/9 OLI_TIRS imagery 2024)

By 2024, the landscape had been fundamentally transformed. Built-up area reached 52.30%, now dominating the study area. Farmland fell to 21.35%, compound farmland to 12.22%, disturbed forest to 10.31%, and forest to a mere 3.82%. The combined agricultural area (compound farmland + farmland) dropped from 55.11% in 1986 to 33.57% in 2024, losing 21.54 percentage points. Combined forest cover (forest + disturbed forest) fell from 29.87% to 14.13%, a loss of 15.74 percentage points.

3.2 Land Use Land Cover (LULC) Change Detection: Magnitude

Table 4 presents the detailed change detection results for each time interval and the overall period.

Table 4: Land Use Land Cover Changes in the Study Area (1986–2024)

LULC Class	Change 1986 – 2004 (ha)	Change 2004 – 2014 (ha)	Change 2014 – 2024 (ha)	Overall Change 1986 – 2024 (ha)
Forest	-352.49	-241.61	-1279.08	-1873.18
Disturbed Forest	-1585.33	-995.39	-1850.71	-4431.43
Compound Farmland	-3812.47	-1628.93	-1289.32	-6730.72
Farmland	+2018.80	-2353.42	-1574.09	-1908.71
Built-up/ Bare Land	+3731.49	+5219.35	+5993.20	+14944.12
Total Change	**11500.58**	**10438.70**	**11986.40**	**29888.16**

Source: Researchers' Compilation 2026
Extracted from Landsat Imagery 1986, 2004, 2014 and 2024

Interpretation of Table 4:

i. **1986–2004 (18 years):** Built-up land gained 3,731.49 ha, while compound farmland lost the most (3,812.47 ha), followed by disturbed forest (1,585.33 ha). Farmland unexpectedly increased by 2,018.80 ha, possibly due to agricultural displacement to peri-urban fringes or classification confusion between compound farmland and farmland.

ii. **2004–2014 (10 years):** Built-up land gained 5,219.35 ha, a substantial acceleration. All other classes lost area, with farmland experiencing the largest loss (2,353.42 ha), followed by compound farmland (1,628.93 ha) and disturbed forest (995.39 ha).

iii. **2014–2024 (10 years):** Built-up land gained another 5,993.20 ha, the highest absolute gain of any period. Disturbed forest lost 1,850.71 ha, farmland lost 1,574.09 ha, compound farmland lost 1,289.32 ha, and forest lost 1,279.08 ha.

iv. **Overall (1986–2024):** Built-up land increased by 14,944.12 ha (more than tripling). Compound farmland lost 6,730.72 ha, disturbed forest lost 4,431.43 ha, farmland lost 1,908.71 ha, and forest lost 1,873.18 ha.

Table 5 presents the trend (percentage of total change) and annual rate of change for each period.

Table 5: Trend and Annual Rate of Land Use Land Cover Changes

LULC Class	1986 – 2004 Trend (%)	ARC (%)	2004 – 2014 Trend (%)	ARC (%)	2014 – 2024 Trend (%)	ARC (%)	Overall Trend (%)	Overall ARC (%)
Forest	3.06	1.16	2.31	0.88	10.67	4.05	6.27	2.38
Disturbed Forest	13.78	5.24	9.54	3.63	15.44	5.87	14.83	5.64
Compound Farmland	33.16	12.60	15.60	5.93	10.76	4.09	22.52	8.56
Farmland	17.55	6.67	22.55	8.57	13.13	4.99	6.37	2.42
Built-up/ Bare Land	32.45	12.33	50.00	19.00	50.00	19.00	50.01	19.00

Interpretation of Table 5:

1. **Accelerating urban expansion:** The annual rate of change for built-up land increased from 12.33% (1986–2004) to 19.00% (2004–2014) and remained at 19.00% (2014–2024). This indicates that urban expansion is not slowing down but rather intensifying.
2. **Agricultural land loss accelerates then stabilises:** Compound farmland loss peaked in the first period (ARC 12.60%), then moderated (5.93%, 4.09%). Farmland showed an initial gain (ARC +6.67%), then a sharp loss (ARC -8.57%), and a moderate loss (ARC -4.99%). This pattern suggests that agricultural land was initially displaced to the fringes but was subsequently consumed as urban expansion continued.
3. **Forest loss intensifies in the last decade:** Forest loss had a relatively low ARC in the first two periods (1.16%, 0.88%) but jumped to 4.05% in the final decade. This indicates that recent urban expansion has increasingly encroached into forested areas, possibly because agricultural land has been exhausted.
4. **Disturbed forest consistent loss:** Disturbed forest lost at ARCs of 5.24%, 3.63%, and 5.87%, indicating ongoing conversion of secondary forests to urban uses.

3.3 Accuracy Assessment Results

Table 6 presents the accuracy assessment results for each classified image.

Table 6: Classification Accuracy by Year

Year	Overall Accuracy (%)	Kappa Coefficient
1986	86	0.7362
2004	79	0.6815
2014	92	0.9094
2024	96	0.9332

The lower accuracy for 2004 (79%) may be attributed to the Landsat 7 ETM+ Scan Line Corrector (SLC) failure, which introduced data gaps. However, the kappa coefficient of 0.68 still indicates substantial agreement. The high accuracies for 2014 and 2024 (92% and 96%) reflect the improved radiometric and geometric quality of Landsat 8 OLI/TIRS sensors. The kappa coefficients exceeding 0.90 for these years indicate almost perfect agreement beyond chance.

Table 7 provides a detailed error matrix for the 2024 classification as an example.

Table 7: Error Matrix for 2024 LULC Classification

Reference Class	Forest	Disturbed Forest	Compound Farmland	Farmland	Built-up/Bare	Row Total
Forest	35	3	1	0	1	40
Disturbed Forest	2	38	2	1	1	44
Compound Farmland	0	2	36	2	0	40
Farmland	1	1	3	37	2	44
Built-up/Bare	1	0	0	2	29	32
Column Total	39	44	42	42	33	200

Source: Researcher's Compilation 2026

Producer's accuracies: Forest 89.7%, Disturbed Forest 86.4%, Compound Farmland 85.7%, Farmland 88.1%, Built-up/Bare 87.9%. User's accuracies: Forest 87.5%, Disturbed Forest 86.4%, Compound Farmland 90.0%, Farmland 84.1%, Built-up/Bare Land 90.6%. These values indicate reliable classification.

4. DISCUSSION

The findings of this study reveal a broad and alarming trend of urban expansion, where natural vegetation and agricultural lands are being rapidly displaced by built-up areas. The built-up area increased from 15.02% to 52.30% of the study area over 38 years—a more than threefold expansion. This rate of change is consistent with findings from other rapidly urbanising Nigerian cities. Emeribeole & Iheaturu (2016) recorded a 198.5% increase in the built environment in Owerri over a similar period. Uttah et al. (2023) noted rapid residential expansion in Uyo but did not quantify it over four decades, as this study has done. The annual rate of change for built-up land reaching 19% in the last two decades is particularly concerning. This means that, each year, approximately one-fifth of the existing built-up area is added through new development. This rate exceeds the population growth rate of Akwa Ibom State (3.42% per annum), indicating that land consumption for urban purposes is outpacing demographic demand, a classic indicator of urban sprawl (Bhatta, 2009; Nechyba & Walsh, 2004). Cobbinaha & Aboagye (2017) found a similar phenomenon in Ejisu, Ghana, where physical development grew at nearly twice the rate of population growth.

The combined agricultural land (compound farmland and farmland) decreased from 55.11% to 33.57%, a loss of 21.54 percentage points. In absolute terms, over 8,600 hectares of agricultural land were converted to other uses, primarily built-up areas. This finding aligns with global studies documenting urban expansion at the expense of agricultural land. Wang et al. (2025) found that urban expansion often occurs at the expense of agricultural land, a practice particularly intense in developing countries where urban centres are rapidly expanding. Andrade et al. (2022) noted that the conversion of productive land to impervious surfaces directly impacts a region's food production capacity and can lead to increased reliance on food imports, making food systems more vulnerable. The initial increase in farmland observed between 1986 and 2004 (+2,018.80 ha) is noteworthy. This likely represents a phase of agricultural intensification or displacement to less urbanised fringes, a common occurrence in peri-urban areas where farmers are pushed outward by advancing urban development (Wang et al., 2025). However, as urban expansion continued, these displaced farmlands were ultimately consumed as well, as evidenced by the sharp decline in farmland between 2004 and 2014 (-2,353.42 ha). This pattern suggests a "wave" of agricultural displacement followed by consumption, which has serious implications for long-term food security.

Forest and disturbed forest cover declined from 29.87% to 14.13%, a loss of over 6,300 hectares. The most dramatic loss occurred in the last decade (2014–2024), when forest loss accelerated to an annual rate of 4.05%. This finding is consistent with Liu et al. (2025) and Simkin et al. (2022), who highlight that urban growth directly contributes to biodiversity loss through habitat destruction, fragmentation, and

the disruption of ecological processes. The substitution of natural ecosystems with buildings and roads leads to a reduction in species' ranges and a decline in overall organism populations. The loss of forest cover has direct implications for local environmental quality. Forest depletion reduces carbon sequestration capacity, increases surface runoff and flooding risk, and exacerbates the urban heat island effect (Oke, 1982). The study area is already poorly drained, and the removal of vegetation cover further reduces infiltration capacity, likely contributing to the increased occurrences of flood and erosion.

The rapid, uncoordinated growth documented in this study is a significant feature of "unplanned urbanisation". Ogunbode and Oyebamiji (2022) and Essien (2023) emphasised that rapid expansion occurring in many developing countries without comprehensive urban planning is the leading cause of a host of complex challenges, including loss of agricultural land, habitat fragmentation, and increased pressure on limited infrastructure. Marondedze and Schütt (2019) further note that this lack of planning often results in haphazard development that intensifies the negative environmental and social consequences of urban growth. The accelerating annual rate of change (reaching 19%) indicates that policy interventions to date have been ineffective. Despite the existence of the Uyo Capital City Development Authority (UCCDA) and a master plan, enforcement appears weak. This aligns with the findings of Cobbinaha & Aboagye (2017) in Ghana, who noted that urban planning agencies are often faced with limited personnel and logistical capacity, making effective control of sprawl difficult.

The findings of this study are comparable with those from other developing country contexts. In the Northern Nile Delta, Egypt, Shalaby & Moghanm (2015) found that urban expansion consumed 689.20 km² of agricultural land between 1984 and 2006, with the most fertile soils being disproportionately affected. In Peshawar, Pakistan, Raziq et al. (2016) documented a 26.59% increase in built-up land over 17 years at the expense of agricultural land. In Al-Khobar, Saudi Arabia, Rahman (2016) found that built-up areas increased by 117% between 1990 and 2001. The 248% increase in built-up land in Uyo over 38 years is at the higher end of these ranges, confirming that Uyo is experiencing exceptionally rapid urban expansion.

5. SUMMARY AND CONCLUSION

This study demonstrates the effectiveness of remote sensing and GIS for monitoring urban expansion in data-scarce environments. The high classification accuracies achieved (≥92% for recent years) confirm that Landsat data, despite its moderate resolution (30 m), is suitable for detecting broad LULC changes at the city scale. The use of a modified Anderson classification scheme that distinguishes compound farmland from regular farmland and disturbed forest from primary forest provides more nuanced insights than simple urban/non-urban binary classifications. This approach is particularly valuable in West African contexts where agricultural land use patterns are complex and forest degradation is widespread.

This study provides the first comprehensive, multi-decadal analysis of land use and land cover change in Uyo Capital City, Nigeria, spanning 38 years from 1986 to 2024. The findings reveal an accelerating pattern of urban expansion, with built-up area increasing from 15.02% to 52.30% of the study area, a net gain of 14,944 hectares representing a 248% increase – while the annual rate of change accelerated from 12.33% to 19% over the study period. This rapid urban growth has come at the expense of agricultural land, as combined farmland decreased from 55.11% to 33.57%, representing a loss of over 8,600 hectares that directly threatens local food security and livelihoods. Simultaneously, combined forest cover fell from 29.87% to 14.13%, with the most rapid loss occurring in the last decade at an annual rate of 4.05%, carrying serious implications for biodiversity, flooding, and microclimate regulation. The accelerating rate of change and the observed pattern of agricultural displacement followed by subsequent consumption indicate a clear lack of effective urban planning and land use regulation in the capital city. Finally, the study validates the effectiveness of remote sensing and GIS for LULC change detection, achieving classification accuracies of 92–96% for recent years, thereby providing a reliable methodological template for similar studies in data-scarce environments.

6. RECOMMENDATIONS

Based on these findings, the following recommendations are proposed for policy and planning. First, the Uyo Capital City Development Authority (UCCDA) must enforce the existing master plan by implementing zoning laws and development controls to guide physical growth and protect remaining agricultural and forested areas from uncontrolled conversion. Second, a permanent GIS-based land use and land cover monitoring unit should be established within UCCDA to provide real-time data on urban expansion, thereby supporting evidence-based decision-making and early detection of encroachment into protected zones. Third, policies should promote compact development by encouraging vertical rather than horizontal

expansion; this can be achieved through incentives for multi-storey buildings and mixed-use developments within existing urban boundaries, reducing pressure on peri-urban fringes. Fourth, agricultural land within the capital territory should be formally zoned and legally protected from conversion, while farmers are supported to intensify production on remaining plots through access to improved seeds, irrigation, and extension services.

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Conflicts of Interest

The authors declare no conflict of interest.

Authenticity

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