



Assessment of Land Use and Land Cover Changes in Benue North-West, Nigeria

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ABSTRACT

The study examined land use and land cover (LULC) changes in Benue North-West, Nigeria, from 1989 to 2019 using multi-date Landsat satellite imagery classified into built-up areas, forest, agricultural land, grassland, and water bodies. A multi-stage, stratified random sampling technique was employed, with two Local Government Areas (LGAs) selected from seven at a 30% sampling intensity. Secondary data sources, including remote sensing imagery, Google Earth, and relevant literature, were used to assess deforestation over four decades. The satellite images were pre-processed, subsetting, and analyzed using supervised classification based on a modified Level 1 scheme, while image processing techniques such as reconstruction, enhancement, optimal band combinations, and maximum likelihood classification were applied using Idrisi and ArcGIS software to produce accurate LULC maps. The results revealed significant deforestation and landscape transformation across the study area. In Gboko, forest cover declined drastically from 12.78% to 3.88%, and grassland decreased from 44.89% to 31.34%, while built-up areas expanded from 4.24% to 21.74%. Similarly, in Gwer-West, forest cover reduced from 19.89% to 9.68%, with a slight decline in agricultural land and a notable increase in built-up areas from 3.70% to 18.57%. The most pronounced deforestation occurred between 1989 and 2009, coinciding with rapid urban growth driven by population increase, urbanization, and agricultural expansion. These findings emphasize the urgent need for sustainable land management strategies that balance development and environmental conservation. Key recommendations include enforcing land use regulations, promoting reforestation and community-based conservation, adopting sustainable agricultural practices, implementing remote sensing monitoring systems, raising public awareness, and integrating ecosystem service valuation into land-use planning.

Keywords: Land Use, Land Cover Changes, Benue North-West

INTRODUCTION

Land use and land cover (LULC) dynamics are central to contemporary debates on environmental change, food security, and sustainable development, particularly in rapidly transforming landscapes across Nigeria. LULC refers to the combined effect of how land is appropriated for human purposes and the physical cover present on the Earth's surface, and its alteration is closely tied to population growth, urbanization, agricultural expansion, infrastructural development, and climate

variability (Ologunde *et al.*, 2025; Okeleye *et al.*, 2023). Over recent decades, Nigerian landscapes have experienced extensive conversion of forests, grasslands, and wetlands to cropland and built-up areas, with profound implications for ecosystem integrity and human livelihoods (Kile *et al.*, 2025; Alegbeleye *et al.*, 2025; Arowolo and Deng, 2017; Arowolo *et al.*, 2018). National and regional assessments consistently show that cultivated land expansion and urban growth are the dominant trajectories of change, often

occurring at the expense of forest, shrubland, and rangeland ecosystems (Alegbeleye et al.,2025; Arowolo and Deng, 2017; Arowolo et al.,2018). Between 2000 and 2010, conversions to cultivated land were the leading land use transition in Nigeria, largely replacing grassland, shrubland, and forests (Arowolo and Deng, 2017). At the national scale, forest, grassland/shrubland/rangeland, and wetlands declined by 5.7%, 12.8%, and 4.1%, respectively, over two decades, while built-up areas more than doubled in several regions (Alegbeleye et al.,2025). These transformations have reduced ecosystem service values-particularly climate and water regulation and cultural services-even where provisioning services linked to agriculture have increased (Alegbeleye et al.,2025; Arowolo et al.,2018).

Sub-national studies further underline the intensity and heterogeneity of LULC change. In southeastern Benue State, forest cover declined from 52% in 1991 to 17.45% in 2024, while grassland/pasture and settlements expanded markedly, reflecting agricultural expansion, logging, and settlement growth (Kile et al.,2025). In North Central Nigeria, including parts of Benue, vegetation, agricultural land, and water bodies have been widely converted to built-up and barren land, driving migration and threatening food security (Okeleye et al.,2023). Similar trends of deforestation and agricultural encroachment have been reported in forest reserves in Nasarawa and Cross River States, where cropland and built-up expansion have caused substantial forest loss and biodiversity threats (Olorunfemi et al.,2018; Chunwate et al.,2025; Duru et al.,2025; Chukwu et al.,2025). Across diverse Nigerian environments-from the Niger Delta to Ekiti, Ogun, Kano, and semi-arid northern regions studies document sharp declines in vegetated cover and wetlands, rapid growth of built-up and cropland, rising land surface temperatures, land degradation, and heightened hydrological and drought risks (Aondoakaa et al., 2026; Agumagu et al.,2025; Taiwo et al.,2023; Sambe et

al.,2025; Ojelabi et al.,2025; Olorunfemi et al.,2018; Ogunbode et al.,2025; Abdulhamid et al.,2025; Adeoye et al.,2025; Eze, 2023). Within this broader national context, Benue State often described as Nigeria's "food basket" is undergoing significant LULC transformations with direct implications for agricultural productivity, food security, migration, and resource conflicts. Evidence from Benue State indicates a reduction in agricultural land in favour of other land uses, with mixed effects on crop yields and a shift towards more economically valued crops under land use intensification (Ihemezie et al.,2020). Along cattle grazing corridors in Benue State, cropland and built-up areas have expanded at the expense of grassland and forest, constraining access to rangeland and contributing to farmer-herder conflicts, deforestation, and pasture scarcity (Odiji et al.,2022; Origbo et al., 2025). These pressures are compounded by broader land degradation and climate-related stress, which in semi-arid and frontier zones have manifested as increased bare land, dune encroachment, and desertification processes (Sambe et al.,2025; Eze, 2023).

Despite growing scholarship on LULC in Benue State and North Central Nigeria, most studies either focus on the state as a whole, on southeastern Benue, or on specific thematic corridors such as grazing routes or agricultural land change (Kile et al.,2025; Ihemezie et al.,2020; Odiji et al.,2022). There remains a notable gap in spatially explicit, integrative assessments of LULC change and its impacts in Benue North-West, a sub-region characterized by intense agricultural activity, expanding settlements, and strategic grazing and transport networks. Given Benue's central role in national food supply and its exposure to land-related conflicts and environmental degradation, understanding the trajectory and impacts of LULC changes in Benue North-West is critical for evidence-based land use planning, conflict mitigation, and sustainable resource management. This study therefore investigates the impact of land use and land

cover changes in Benue North-West, Nigeria, and analyzing their implications for environmental conditions and socio-economic systems. Building on advances in remote sensing, GIS-based change detection, and ecosystem-oriented assessments applied across Nigeria (Kile *et al.*,2025; Ologunde *et al.*,2025; Agumagu *et al.*,2025; Taiwo *et al.*,2023; Okeleye *et al.*,2023; Arowolo and Deng, 2017; Ojelabi *et al.*,2025; Olorunfemi *et al.*,2018; Adeoye *et al.*,2025), the study seeks to provide a sub-regional evidence base to inform policy and land management strategies aligned with sustainable development goals.

by quantifying multi-decadal LULC dynamics

METHODOLOGY

The Study Area

Benue State is one of the states located within the middle belt geopolitical zone of Nigeria. Geologically, it falls within the Benue trough from where the State derives its name. It lies between latitude $6^{\circ} 32'$ and $8^{\circ} 07' N$ and longitude $7^{\circ} 52'$ and $10^{\circ} 00' E$ (Figure 1) (Ocheri and Ahola, 2014). The State shares boundary with Nassarawa in the north and Taraba States in the northeast. In the south, it shares boundary with Cross River State, while its southwest boundary is shared with Enugu and Ebonyi States respectively (Halima and Edoja, 2016). To the west, it is bounded by Kogi States, while a short international boundary is shared with the Republic of Cameroon around Kwande Local Government Area (Nyagba, 1995).

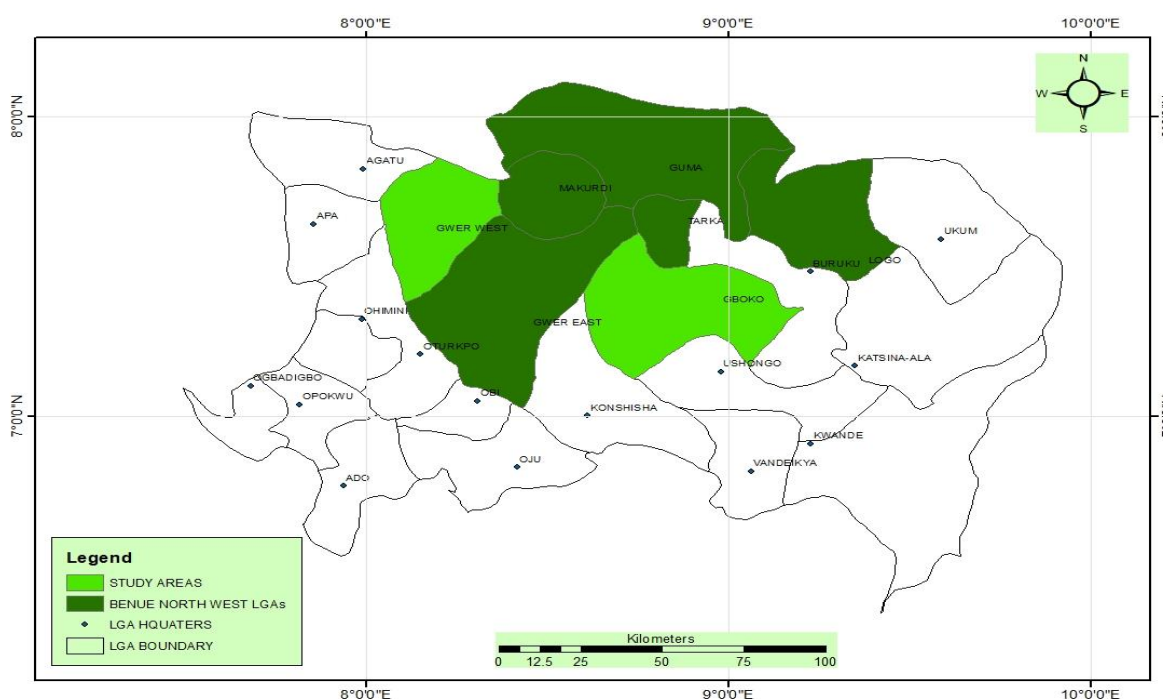


Figure 1: Map of the Study Area (Benue State)

Source: Remote Sensing and GIS Laboratory, Geography Department, Federal University of Technology, Minna (2020)

Sampling Techniques

A multi-stage sampling technique was adopted for the study to ensure adequate spatial representation and reliability of results. In the first stage, two (Gboko and Gwer-west) out of the seven Local Government Areas in the zone were randomly selected, representing a 30% sampling intensity in line with Dagba et al., (2017) to achieve unbiased representation. In the second stage, the selected LGAs were further delineated into communities, from which sample communities were chosen through random sampling techniques. In the third stage, the study area was stratified into major land use/land cover (LULC) classes; namely forest land, agricultural land, built-up areas, water bodies, and grassland. A stratified sampling approach was then applied to ensure that each land cover category was proportionately represented in the study. Finally, a systematic (grid-based) sampling technique was employed by overlaying a uniform grid (e.g., 1 km × 1 km) on the satellite imagery of the study area. Sample points were selected at regular intervals within the grid and used for ground-truthing and accuracy assessment of the classified imagery.

Data Collection

Data for this study were obtained from secondary sources, primarily remote sensing imagery, to evaluate the extent of deforestation in the study area. These sources included internet-based datasets and Google Earth imagery, as well as a review of literature from journals, theses/dissertations, and books.

Data Analysis

The secondary data were analyzed to meet the study objective of assessing deforestation over a period of four decades using remote sensing techniques. This objective was addressed with four multi-date Landsat satellite images: Thematic Mapper (TM) for 1989 and 1999, Enhanced Thematic Mapper Plus (ETM+) for 2009, and Operational Land Imager (OLI) for 2019. Raw images underwent pre-processing and were subsequently used for land use/land cover (LULC) classification based on the Landsat image characteristics presented in Table 1. The study area was extracted by sub-setting, and supervised classification was implemented following the modified Level 1 scheme of Anderson *et al.*, (1976). Five LULC classes were delineated across the study locations (Gboko and Gwer West Local Government Areas): built-up areas, forest, agricultural land, grassland, and water bodies. Three main image-processing operations were performed: (i) image reconstruction to extract the area of interest from the full satellite scene, (ii) image enhancement to improve visual interpretation by increasing contrast among image features, and (iii) optimal band combinations. Bands 2, 3, and 4 were used for the 1989, 1999, and 2009 images, while bands 3, 4, and 5 were used for the 2019 image in Idrisi and ArcGIS software, as these combinations produced superior enhancement compared with other options. Finally, a supervised maximum likelihood classifier was applied to categorize the identified land use and land cover types within the study area.

Table 1: Characteristics of Landsat images used within Benue north west, Nigeria

DA	S	P	R	MB	TB	SR	SR	So
1989	TM	188	55	1to5 and 7	6	10.45-12.45	30	
1999	TM	188	55	1to5 and 7	6	10.45-12.45	30	USGS
2009	ETM+	188	55	1to5 and 7	6	10.45-12.45	30	
2019	OLI and TIRS	188	55	1to7 and 9	10 and 11	10.60-12.51	30	

Foot Note: DA= Date of Acquisition, S= Sensor, P= Path, R= Row, MB= Multispectral Band, TB= Thermal Band, SR= Spectral Range (micrometers), SR= Spatial Resolution (pixel spacing), So= Source

Table 2: Software Components of the Research used within within Benue north west, Nigeria

S/N	Software	Purpose
1	Idrisi and ArcGIS 10.3	GIS analysis & classification of the Landsat images
2	Microsoft Excel	Statistical analysis for the calculation of percentage

RESULTS AND DISCUSSTION

Assessment of the Level of Deforestation in Benue North-West, Nigeria

Analysis and Classified Land Use and Land Cover Map of Gboko (1989, 1999, 2009 and 2019)

The landuse and landcover change (LULC) map for the study area in 1989 (Figure 2), revealed that grassland area was dominant land cover features covering about 44.89% (883.3257 Km²), followed by Agricultural land (37.39%), Forest area (12.78%, build up areas (4.24%) and water bodies (0.70%) which covers an area of 735.9021 Km², 251.4204 Km², 83.4561 Km² and 13.8438 Km² respectively. The LULC of the study area in 1999 indicated that Agricultural area accounted for about 807.7104 Km² (41.04%) while grassland, built up areas, water bodies and forest area on the other hand covers 864.9657 Km² (43.95%),

107.6274 Km² (5.47%), 13.3182 Km² (0.68%) and 174.3435 Km² (8.86%) respectively (Figure 3).

The analysis of 2009 satellite image (Figure 4) of the study areas revealed that there is continuous expansion of built-up area which covers about 275.7654 Km² (14.01%) while agricultural land, grassland, forest area and water bodies accounts for 831.9915 Km² (42.28%), 748.2141 Km² (38.02%), 99.1161 Km² (5.04%) and 12.6576 Km² (1.35%) of the total arear within the Benue North West, Nigeria. Figure 5 in 2019 indicated that, built up areas covers a total of 427.662 Km² (21.74%) while agricultural land, grassland, forest and water bodies occupies 820.4013Km² (41.69%), 616.5756 Km² (31.34%), 76.3614 Km² (3.88%) and 26.568 Km² (1.35%) respectively.

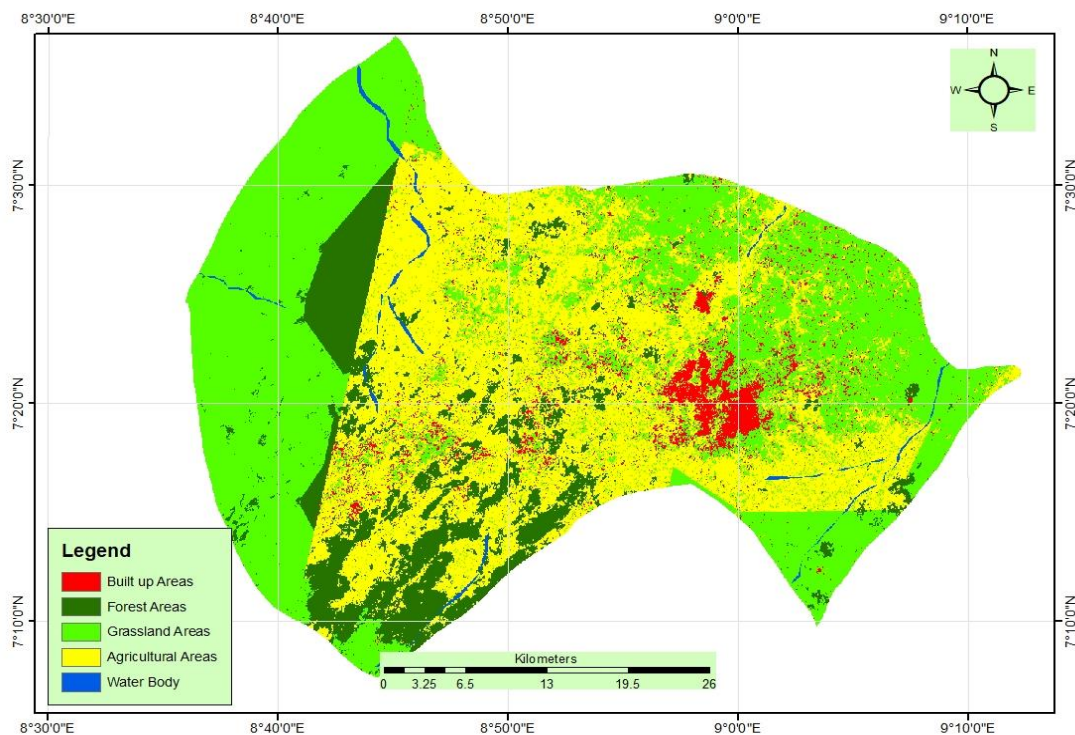


Figure 2: 1989 Land use/Landcover distribution Map generated from LandSat 4 TM

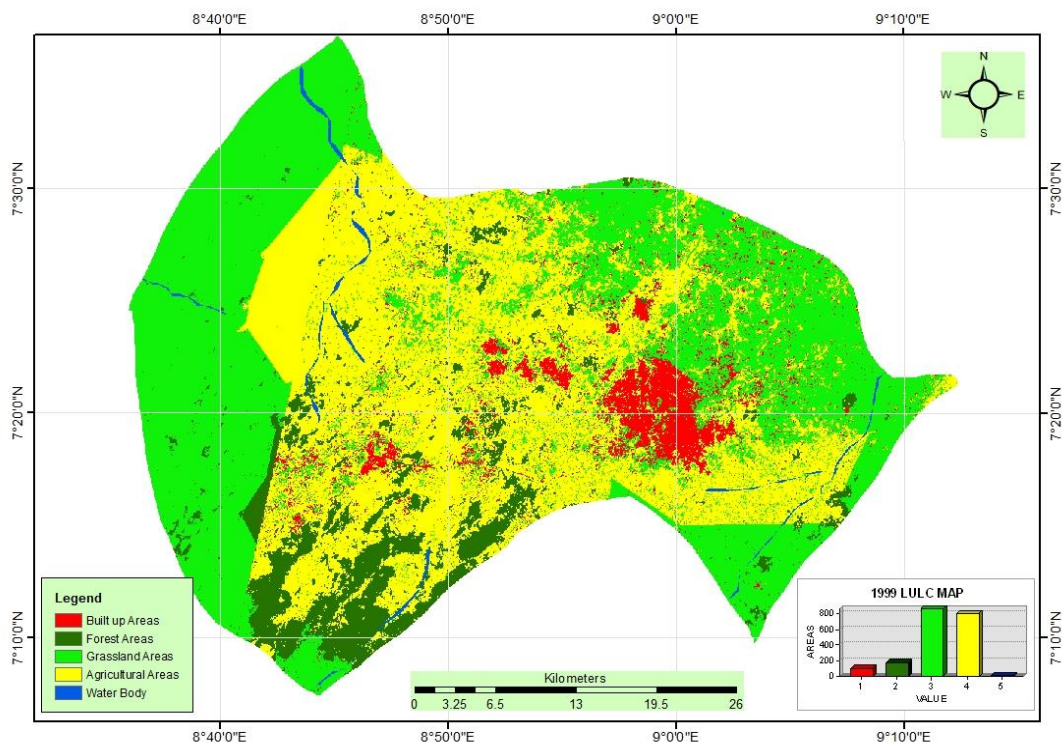


Figure 3: 1999 Land use/Landcover distribution Map generated from LandSat 4 TM

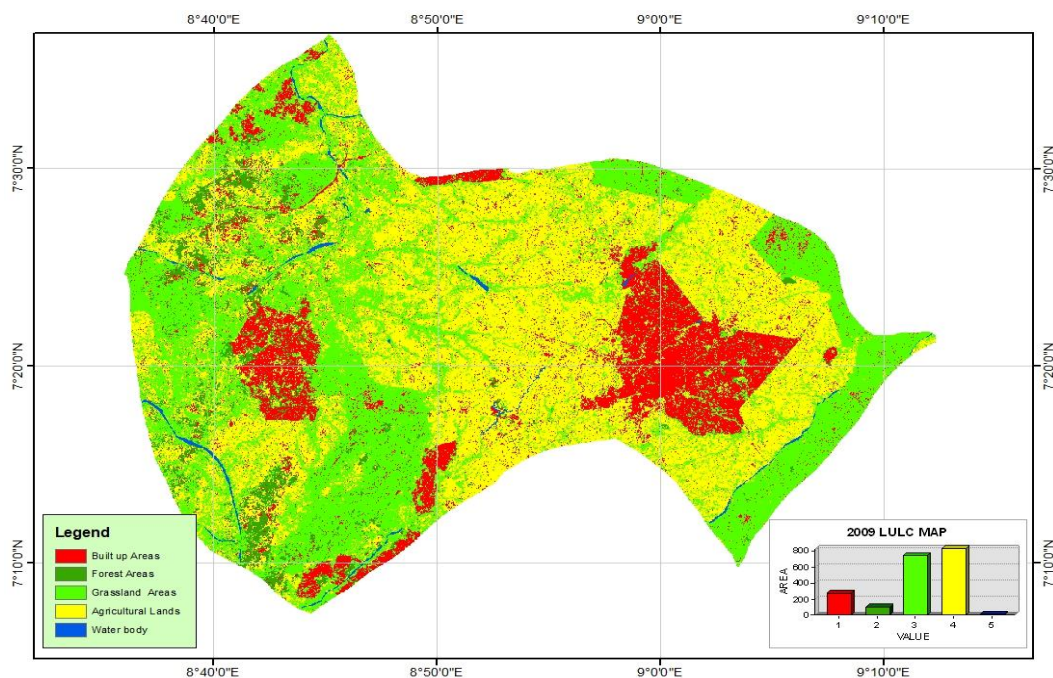


Figure 4: 2009 land use land cover distribution generated from LandSat8 (OLI)

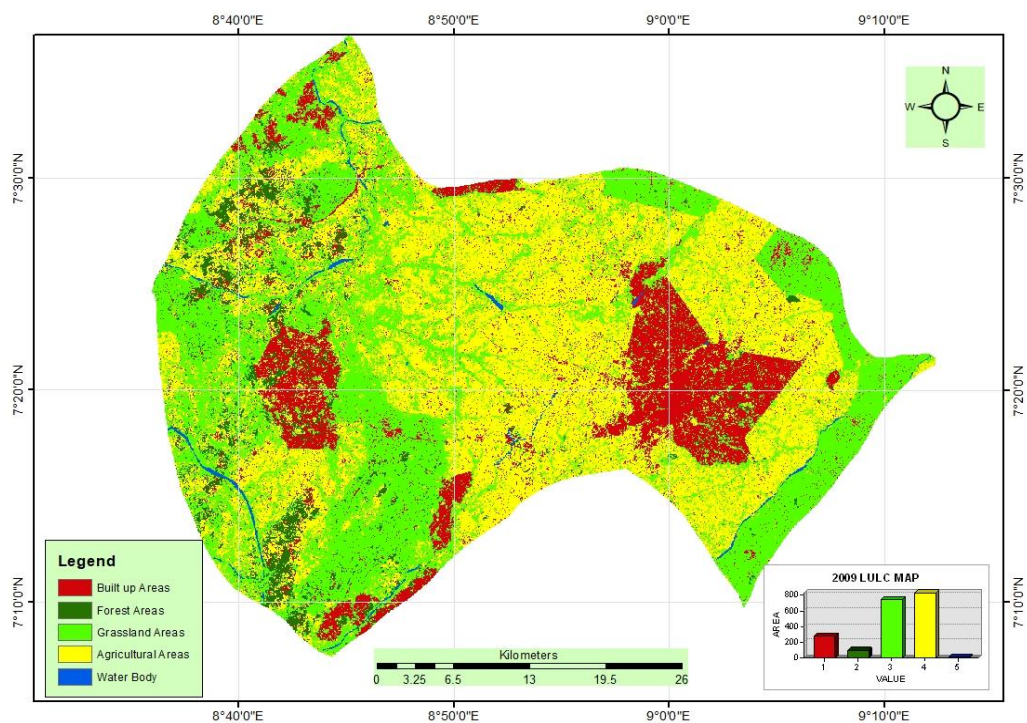


Figure 5: 2019 land use land cover distribution generated from LandSat8 (OLI)

Analysis and Classified Land use and Land cover Map of Gboko (1989-2019)

The land use and land cover (LULC) changes in Gboko, Nigeria, from 1989 to 2019 show a clear trend of urban expansion and reduction in natural vegetation. In 1989, grassland was the dominant land cover (44.89%), followed by agricultural land (37.39%) and forest area (12.78%), but by 2019, built-up areas had increased significantly to 21.74%, while grassland and forest areas declined to 31.34% and 3.88%, respectively, indicating rapid urban growth at the expense of natural ecosystems (Jande *et al.*, 2019). This pattern aligns with broader Nigerian trends where urban areas have expanded considerably, often leading to forest loss and changes in agricultural land use, as seen in other regions like Ado-Odo Ota and northern Nigeria (Ologunde *et al.*, 2025; Sambe *et al.*, 2025). The decline in forest cover and grasslands has implications for ecosystem services, including water regulation and climate regulation, which have been shown to decrease with such land cover changes across Nigeria (Alegbeleye *et al.*, 2025; Arowolo *et al.*, 2018). Studies also highlight that cropland expansion often replaces natural vegetation, driven by socio-economic factors and population pressures, which is consistent with the observed agricultural land dynamics in Gboko (Arowolo and Deng, 2017; Akinyemi and Speranza, 2024). Overall, these findings emphasize the need for sustainable land management policies to balance urban growth with conservation of natural resources in Gboko and similar Nigerian contexts (Jande *et al.*, 2019; Sambe *et al.*, 2025; Arowolo *et al.*, 2018).

Analysis of Classified Land use and Land cover Map of Gwer-West (1989, 1999, 2009 and 2019)

The land use and land cover (LULC) map of the study area in 1989 (Figure 7), reveals that agricultural area (44.05%) was dominant land cover features covering about 529.3062 Km², followed by grassland (31.54%) forest area 19.89%) built up areas (3.70%) while water bodies (0.82%), covers an area of 379.0062 Km², 239.0256 Km², 44.5149 Km² and 9.8163 Km² respectively. Figure 8 showed LULC of the study area in 1999 which indicates that, agricultural area now accounted for about 479.1942 Km² (39.89%) followed by grassland (34.29%), built up areas (5.59%), water bodies (0.84%) and forest areas (19.38%) which accounted for a total cover of 411.9282 Km², 67.2237, 10.0989 Km² and 232.8696 Km² respectively.

The land use and land cover change map of the study area (Gwer-West) in 2009 (Figure 9), revealed that, agricultural area was still the most dominant land cover features (476.0244 Km²) which occupies 39.63% of the total area. This is followed by grassland (415.7154 Km²), forest areas (205.4214 Km²), built-up areas (93.2112 Km²) and water bodies (10.8675 Km²) with a total percent of 34.61%, 17.10%, 7.76% and 0.90% respectively. The 2019 classified satellite image (Figure 10) analysis of the study areas indicated that, built up areas covers a total of 223.0578 Km² (18.57%) followed by agricultural land, grassland, forest areas and water bodies which covers a total of 486.9702 Km² (40.54%), 364.1121 Km² (30.31%), 116.3376 Km² (9.68%) and 10.8243 Km² (0.90%). However, water bodies remain relatively stable at in 2019.

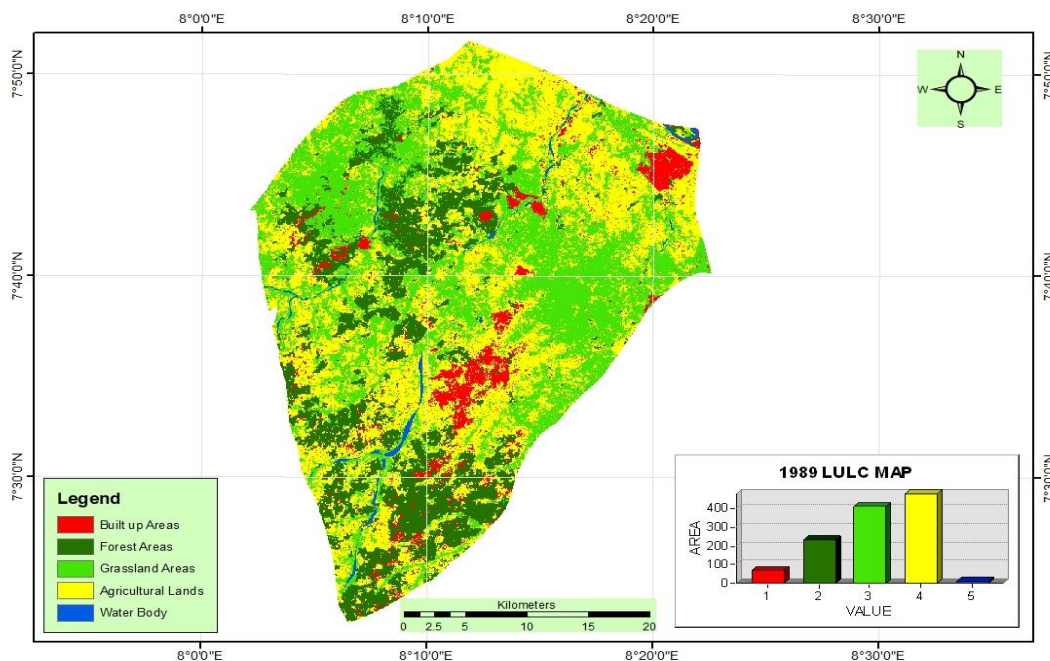


Figure 7: 1989 Gwer West LULC distribution Map generated from LandSat 4 TM

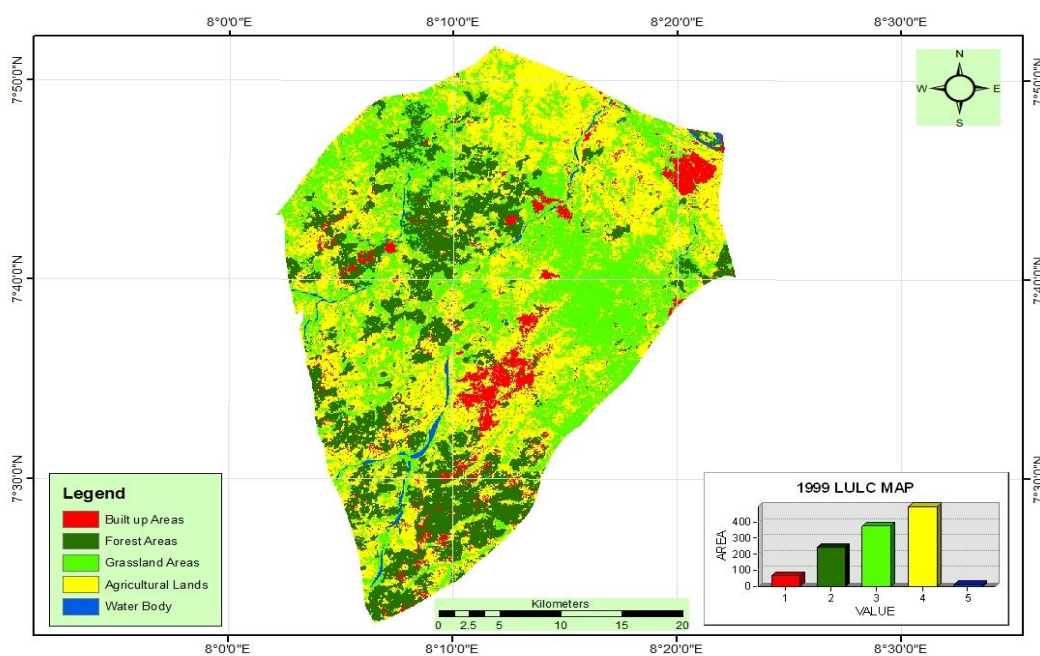


Figure 8: Gwer-West 1999 LULC distribution Map generated from LandSat 4 TM

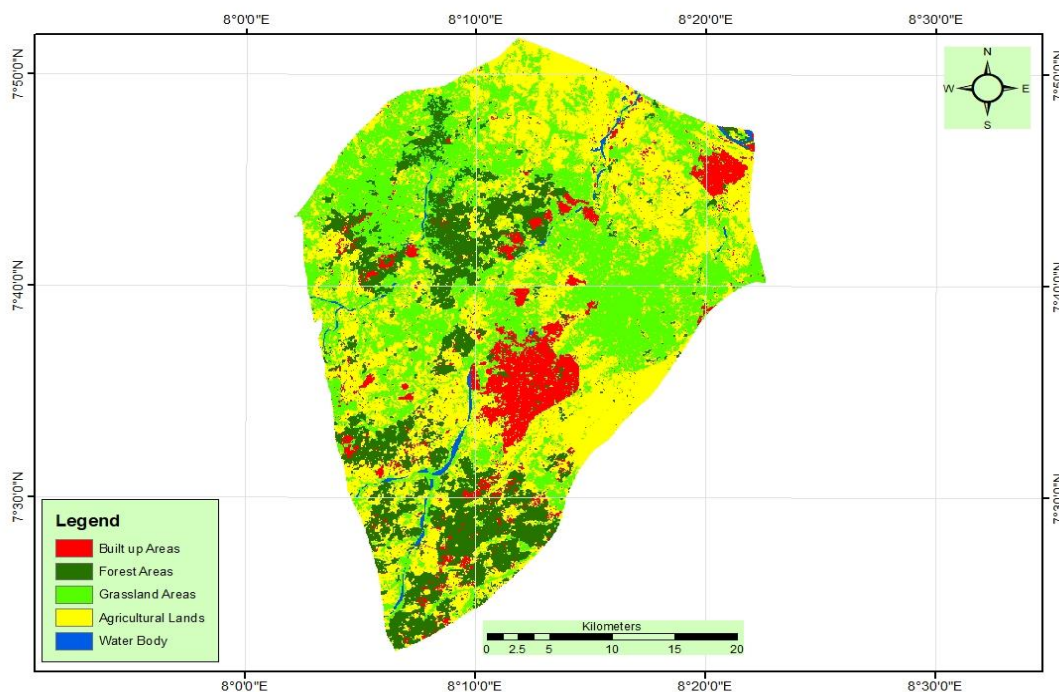


Figure 9: Gwer-West 2009 LULC distribution Map generated from LandSat 7 ETM+

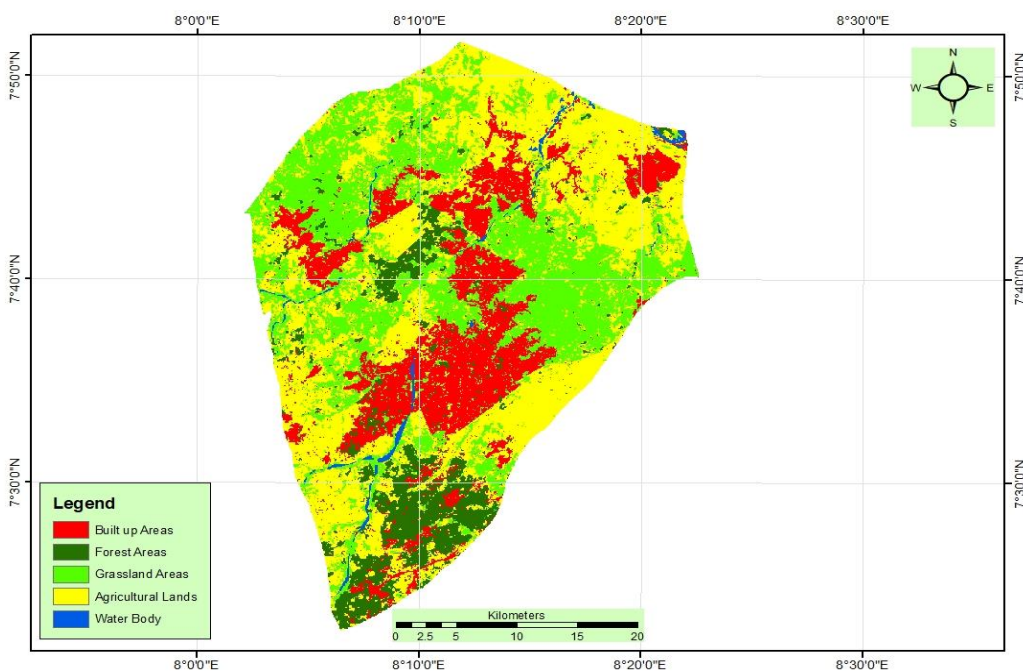


Figure 10: Gwer West 2019 land use land cover distribution generated from LandSat8 (OLI)

Similarly, Figure 11 indicated that, built up areas are on the increase while forest

decreased throughout the study period while grassland and agricultural were

fluctuating between 1999 and 2009. Also, grass land decreases while agricultural land increased however, water bodies was relatively stable. Result of Table 3 revealed the rate at which deforestation occur in Benue north west Nigeria. The result indicated that, between 1989 -1999 buildup area and agricultural land increase at the rate of 24.1713 and 71.8083 while forest, grassland area and water bodies decreases at the rate of 77.0769, 18.36 and 0.0256 respectively. Between 1999 to 2009, build up area and agricultural land also increase at the rate of 168.138 and 24.2811 while forest, grassland and water bodies on the other hand decreases at the rate of 75.2274, 116.7516 and 0.6606 due to deforestation activities. In addition, 2009 to 2019 also revealed a continuous increase of buildup areas and water bodies at the rate of 151.8966 and 13.9104.

In this study, forest and grassland area covered were at a continuous decline with a slightly decrease in agricultural land at the rate of 22.7547, 131.6385 and 11.5902

which may be due to the present non-governmental incentives and encouragement to increase food production by providing the necessary incentives there by leading to increased farming activities. Result of land use and land cover change of Gwer west indicate that between 1989-1999, build up area, grassland and water bodies increase at the rate of 22.7088, 32.922 and 0.2826 while forest and agricultural land decrease to 6.156 and 50.112 respectively. In 1999 to 2009, there was also a continuous increased in buildup areas and grassland area while water bodies remain stable with 25.9875, 296.2128 and 0.7689. Forest and agricultural land on the other hand decreases at the rate of 27.4482 and 3.1698. Similarly, from 2009 to 2019 buildup areas and agricultural lands continued to increase at the rate of 129.8466 and 10.9458 while forest areas and grasslands decrease to 89.0838 and 248.3967 and water bodies remain relatively constants with 0.0432 respectively.

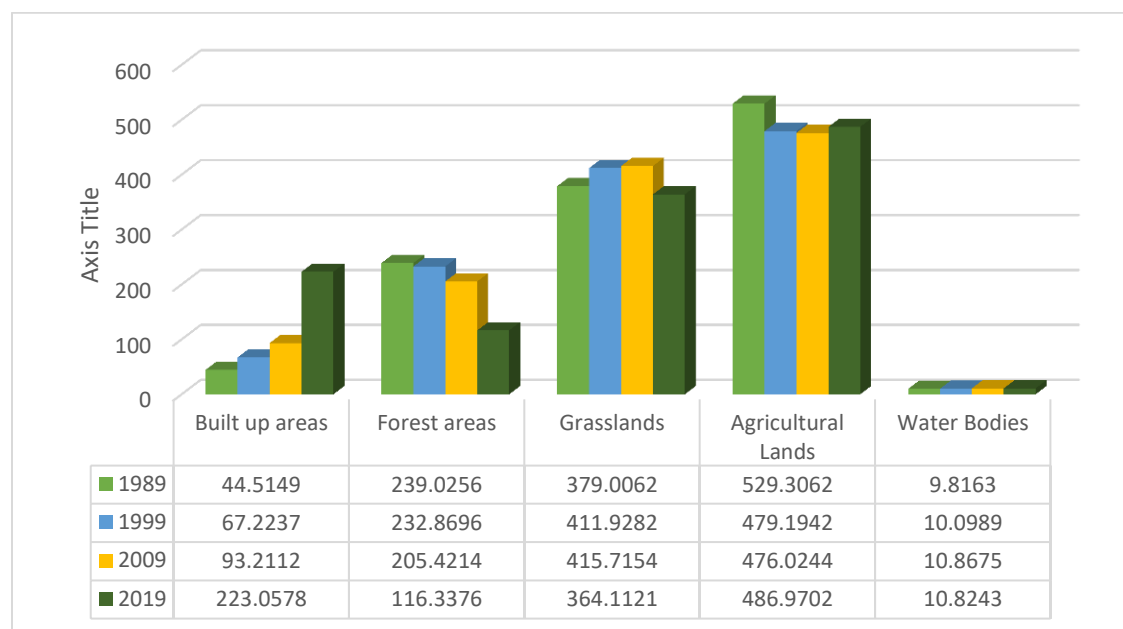


Figure 11: Trends of the Various Land use and land cover Category for Gwer-West

Table 3: The rate of change of land use and land cover of Gboko and Gwer- West LGAs

Variables	Build up area	Forest area	Grassland area	Agricultural land	Water bodies
Gboko					
1989-1999	24.1713	77.0760	18.36	71.8083	0.0256
1999-2009	168.138	75.2274	176.7516	24.2811	0.6606
2009-2019	151.8966	22.7547	131.6385	11.5802	13.9104
Gwer-west					
1989-1999	22.7088	6.156	32.922	50.112	0.2826
1999-2009	25.9875	27.4482	296.2128	3.1698	0.7689
2009-2019	129.8466	89.0838	248.3967	10.9458	0.0432

Source: Field survey (2020)

Analysis of Classified Land use and Land cover Map of Gwer-West (1989-2019)

The land use and land cover (LULC) changes in Gwer-West from 1989 to 2019 show a clear trend of increasing built-up areas and fluctuating but generally declining forest and grassland covers, while agricultural land remains dominant but slightly decreases over time. Built-up areas expanded significantly from 3.70% in 1989 to 18.57% in 2019, reflecting rapid urbanization consistent with broader Nigerian trends where urban growth often comes at the expense of natural vegetation and agricultural lands (Ologunde *et al.*,2025; Sambe *et al.*,2025). Forest cover declined sharply from 19.89% to 9.68%, mirroring widespread deforestation observed across Nigeria due to agricultural expansion, logging, and settlement growth (Aondoakaa et al., 2026; Alegbeleye *et al.*,2025; Fasona *et al.*,2020; Chukwu *et al.*,2025). Grassland also decreased notably, while water bodies remained relatively stable, indicating localized hydrological resilience despite land cover changes

(Ologunde *et al.*,2025; Barnieh *et al.*,2020). The rates of change highlight intense deforestation and grassland loss alongside increases in built-up and agricultural areas, driven by population growth and economic activities, which aligns with national studies showing cultivated land expansion often replaces natural ecosystems (Arowolo and Deng, 2017; Arowolo *et al.*,2018). These dynamics underscore the urgent need for sustainable land management policies in Gwer-West that balance food production, urban development, and conservation to mitigate environmental degradation and preserve ecosystem services critical for climate regulation and biodiversity (Alegbeleye *et al.*,2025; Arowolo *et al.*,2018; Chukwu *et al.*,2025 and Jande *et al.*, 2024).

CONCLUSION

The land use and land cover (LULC) changes across the study locations (built-up areas, forest, agricultural land, grassland, and water bodies) of Benue State from the late 20th century to recent years consistently showed rapid urban expansion

(151.8966km²) and agricultural growth (71.8083km²) at the expense of natural vegetation, particularly forests (6.156km²) and grasslands (18.36km²). In Gboko, built-up areas (21.74%) increased significantly from 1989 to 2019, while forest cover (31.34%) declined sharply, reflecting urban growth that threatens ecosystem services such as water and climate regulation. Similarly, Gwer-West experienced a rise in built-up (18.57%) and agricultural lands alongside halving of forest cover (9.68%), indicating ongoing deforestation driven by settlement and farming activities. These patterns align with broader Nigerian trends where urbanization and cropland expansion lead to ecosystem degradation, biodiversity loss, and reduced ecosystem service values. Despite fluctuations in agricultural land, water bodies have shown relative stability in some areas, suggesting partial resilience amid landscape changes. Lastly, these findings highlight the urgent need for integrated land use planning that balances economic development with environmental conservation to sustain ecological functions and support climate adaptation.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

- i. enforcing comprehensive land use policies and zoning regulations to control urban sprawl and protect remaining forests through reforestation and community-based conservation programs.
- ii. Promoting sustainable agricultural practices can enhance productivity while minimizing further encroachment on natural habitats.
- iii. Establishing robust environmental monitoring systems using remote sensing technologies will improve

detection of LULC changes and support enforcement of regulations.

- iv. Public awareness campaigns are crucial to educate communities on the ecological impacts of deforestation and the importance of ecosystem services.
- v. Finally, integrating ecosystem service valuation into land use decision-making can guide sustainable development that safeguards natural resources while accommodating economic.

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