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The Impact of Population Growth on Land Use/Land Cover Change in Kanam LGA, Plateau State, Nigeria.

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ABSTRACT

Rapid population growth in Nigeria has placed significant pressure on natural resources, leading to observable changes in Land Use and Land Cover (LULC). This study investigates the impact of population growth on LULC change in Kanam Local Government Area, Plateau State, Nigeria, between 1996 and 2026. Kanam LGA has experienced increasing demand for agricultural land, settlement expansion, and resource extraction, largely driven by demographic pressure and socio-economic activities. The study employed Remote Sensing and Geographic Information System (GIS) techniques. Multi-temporal Landsat satellite imagery for the years 1996 to 2026 were acquired, classified, and analyzed to detect LULC changes. Supervised classification was used to categorize the area into five major classes: built-up area, vegetation, farmland, bare surface and water body. Population data from the National Population Commission and field surveys were used to correlate demographic trends with observed LULC changes. Accuracy assessment was conducted to validate the classification results. Findings reveal a significant increase in built-up areas by 268.01%, while the remaining declined by -58.13%, -14.46%, -4.96% and -10.59% respectively over the 30-year period. The results indicate a strong positive correlation between population growth and the expansion of settlements and farmlands, at the expense of natural vegetation. The study concludes that population growth is a major driver of LULC change in Kanam LGA. It recommends integrated land use planning, afforestation programs and sustainable agricultural practices to mitigate environmental degradation and ensure sustainable development in the area.

Keywords: Population Growth, Land Use Change, Land Cover Change, GIS, Remote Sensing, Geospatial Analysis, Kanam LGA, Plateau State, Nigeria.

Introduction

Land cover is the physical material on the earth's or is the physical characteristics of the earth's surface, captured in the distribution of vegetation, soil, water and other physical features of the earth whereas; land use refers to how humans utilize that cover for socioeconomic purposes (e.g., agriculture, residential development, or conservation). (Akumu, Dennis, & Reddy, 2018; Liping et al., 2018). Though, land cover/land use are constantly used substitutable (Akumu, Dennis & Reddy, 2018; Liping et al., 2018). As mentioned previously, the variables that caused global land cover change is involved net of interrelated parameters, anthropogenic playing a vital impact (Admasu, Yeshitela & Argaw, 2023; Buthelezi et al., 2024).

The most critical environmental phenomena influencing several parts of the Earth's systems is Land use and land cover (LULC) change, including climate, hydrology, biodiversity, and land resources (Desta and Fetene, 2020). Land use can be termed as a strategize management of a specific land cover type by humans. Land cover enclosed, the characteristics of the Earth's surface both biological and physical. Particularly, it gives the characteristic of the location and the natural vegetative class. Land cover change refers to a total transformation or remodeling of an existing land cover into another type (Kassa and Forech, 2009; Aklile Negatu, 2014).

The cause Land degradation by land use and cover (LULC) change has many environmental and social effects (Desta and Fetene, 2020). The effects of LULC change, interplay directly or indirectly to increase of population, build-up areas, boost agricultural practices (e.g., since manures and pest management), deforestation and grassland reduction raised concerns about ecosystem sustainability (Sohl et al. 2012). Human activities influenced about half of the world's landscape or subject to setting in of some anthropogenic outcome, and numerous natural resources have been excessively used or dropped in the bad degree in the previous time (Goldewijk et al. 2011). The increase in water extraction, Climate change, the alteration of hydrological cycle, the damage of the water quality, degradation of the soil nutrient, acceleration of the surface erosion, and biodiversity loss, are all the factors of broad land use land cover reposition in the natural environment (Turner et al. 2007; Paiboonvorachat 2008; Siddhartho 2013).

The forces that drive LULC changes are categories according to direct and indirect causes (Lambin et al., 2003). The activities and conducts that instantly reach land use are seen as direct causes. In this case, the local people are the direct cause, because of their immediate activities in meeting their demands from land use. Development of agriculture, extraction of wood, infrastructural development, and many factors that remodel the physical level of landcover change. The rudimental factors that trigger direct causes, like economic policy, advancement of technology, demographic pressure, and cultural factors are all seen as indirect causes (Lambin et al., 2003).

Land use and Land cover (LULC) epitomize diverse yet interconnected perceptions, sparkly both human use and the physical appearances of the land (Olorunfemi et al). Countries that are developing or areas, commercial and industrial advances can make LULC changes worse, therefore, leading to climate change, erosion, landslides, desertification, land dilapidation, and biodiversity damage (Hasan et al. 2020; Zhang and Li 2022). Giving attention to LULC changes in such areas is necessary for managing natural resources, assessing environmental conditions, and creating policies for climate change mitigation. Nigeria is an example of a developing country in the western region of Africa experiencing rapid population growth and LULC changes. According to Adesola et al. (2024), Nigeria is the most populated country in Africa with a population of 218.5 million and a total area of 923,769 km2.

Over the years, due to the high birth rate, Nigeria has been undergoing a rapid increase in population growth and is currently the seventh most populated country in the world. It has been projected that by 2050, Nigeria's population will be the third largest in the world, surpassing the United States. In 2019, Nigeria's urban population increased to 51.2% from 29.7% in 1990 (Faisal Koko et al. 2021), implying a spatial increase of built ups in urban areas. The rapid population growth puts pressure on the country's limited natural land cover such as forests, leading to land fragmentation, deforestation, and climate change. The pattern and extent of natural ecosystem loss have been linked to direct and indirect human activities such as agricultural expansion, urban sprawl, clearcutting, firewood collection, and road construction among others (Olajuyigbe 2018; Adeyemi et al. 2022; Fashae et al. 2022; Oyediji and Adenika 2022).

Recently in Ethiopia, empirical evidence of substantial changes in land use and land cover have taken place some decades due to consequences of anthropogenic activities, population growth, and land-use changes like deforestation, over grazing, and inaccurate agricultural land cultivation, which has impacted in acceleration of soil erosion and cause soil nutrient damage (Bewket and Abebe, 2013; Tadele et al., 2019). The critical expostulation in environmental studies is to comprehend and expound the impacts of land use land cover change on the surrounding and socio-economic fabric (Aklile Nigatu 2014). four to five decades, Ethiopian ecosystems have been exposed to anthropogenic mediation through land-use changes (Muluneh, 2010). Environmental degradation, which can be defined in terms of land and water resource degradation, as well as biodiversity loss, is one of the key challenges preventing Ethiopia's sustain able development. Land degradation contributes to reduced agricultural production and food insecurity (Yakob and Fekad 2016).

Not long ago, In Ethiopia, the environment has become a serious concern. Pollution of water, soil erosion, deforestation, biodiversity loss, incessant drought, flooding, and water and air pollution are substantial environmental concerns in the country (EPA 2012). Thus, there are plethoras of studies conducted worldwide to assess the possible effects of LULC change on environmental resources (water, soil, and vegetation), there are few studies in Ethiopia, particularly in the Lake Ziway catchment using mixed method approach. Water pollution is a substantial environmental concern in the Central Rift Valley (CRV) of Ethiopia, particularly, in an area that are vulnerable to environmental issues. The catchment area, which includes lakes, streams, and wetlands with unique hydrological and ecological features, confronted with serious water pollution because of its environmental delicacy and compete resource demands (Basheer 2018; Tamiru, 2019).

Anthropogenic activities and climate change are natural factors that contribute to water pollution. Farming along lakeshores, cutting down of trees (deforestation), and the removal of buffer zones are Human activities which increase the problem (Tamiru, 2019). About 62% of land areas worldwide have witnessed a significant land use change, with a larger percentage of land being changed to farmlands, urban areas, and built-up regions (Afuye et al., 2022; Mpanyaro et al., 2024; Afuye et al., 2024). However, the GLC_FCS30D dataset pointed that globally, from 1985 to 2022, forest areas have reduced by about 2.5 million km², while farmland has increased by approximately 1.3 million km² (Zhao et al., 2024). Such derangement which can revise in commonness and acute influence of different aspects of the environment and recast land use and land cover (LULC) change, thereby affects deforestation, food security, and ecosystem service function (Ambarwulan et al., 2023).

A. Problem Statement

Nigeria's population has grown rapidly, making it the most populous country in Africa. This demographic pressure has intensified the demand for land for settlement, agriculture, and other livelihood activities, especially in rural areas. Plateau State, located in the North Central region, has experienced similar population-driven land demands due to farming, grazing, and internal migration.

Kanam Local Government Area is predominantly agrarian, with a large portion of the population dependent on crop production and livestock rearing. Over the last two decades, anecdotal evidence and field observations suggest an expansion of farmlands and built-up areas, alongside the reduction of forest and grassland cover. This trend aligns with global findings that population growth is a primary driver of Land Use/Land Cover (LULC) change, often leading to deforestation, soil degradation, loss of biodiversity, and increased vulnerability to climate hazards such as flooding and erosion.

Studies across Nigeria have confirmed this relationship. For instance, Akinyemi et al. (2020) noted that rapid population increase in the Nigerian savanna has resulted in significant conversion of natural vegetation to cropland and settlements. Similarly, research in Jos and its environs, Plateau State, revealed that population growth between 1996 and 2026 led to a 44% increase in built-up areas at the expense of vegetation cover. However, there is a paucity of empirical and geospatial data specifically documenting LULC change in Kanam LGA. Most existing LULC studies in Plateau State have focused on urban centers like Jos, Barkin Ladi, and Pankshin, leaving rural LGAs such as Kanam understudied. This data gap makes it difficult to understand the local-scale dynamics between population growth and environmental change, and to formulate appropriate land use policies. Without baseline information on the extent and pattern of LULC change in relation to population growth, planners and policymakers in Kanam LGA cannot effectively address issues of land degradation, food security, and sustainable resource management.

Therefore, this study seeks to assess the impact of population growth on LULC change in Kanam LGA, Plateau State, Nigeria from 1996 to 2026 using Remote Sensing and GIS techniques. The findings will provide empirical data to support sustainable land use planning and environmental management in the area.

B. Objective

Aim of this rigorous study is to evaluate the dynamics of LULC change and their relationship with population growth in Kanam LGA of Plateau State, Nigeria, between 1996-2026 using multi-temporal Landsat imagery and GIS technique. Therefore, the specific objectives are to (i) Classify and map the major LULC classes of Kanam LGA for 1996, 2006, 2016 and 2026 using multi-temporal Landsat satellite imagery;(ii) To determine the spatial distribution, areal extent and rate of change of the identified LULC classes during the period 1996-2026; (iii) Examine the pattern and rate of population growth in the study area during the period; and (iv)Evaluate the statistical relationship between population growth and LULC changes, particularly the expansion of built-up areas and the reduction or expansion of vegetation and farmland.

Methodology

This section discusses the study area in terms of the location, climate, relief, drainage, rainfall, economic activities, population, soil, vegetation and land use. It also describes the data sources, method of data collection and the techniques used for data analysis. In order to meet objectives of the study, the methodology followed and the materials used are discussed in this chapter.

A. Study Area

Kanam Local Government Area is situated at the northcentral part of Plateau State, Nigeria, it covers an area of 2,600 km,^{2} and lies approximately between Latitudes 9˚ 30’ N and 10˚30’ N, and between longitudes 8˚ 30’E and 9˚ 30’ E. The region experiences a tropical savanna climate with distinct wet and dry season. Annual rainfall ranging between 1,000 -1,400 mm, typically beginning in late May and persisting until late October. The hottest period of the year occurs from March to May, with average temperature fluctuating between 24 -34˚C. Land use in Kanam is dominated by subsistence agriculture, livestock rearing, and artisanal mining. Major crops are maize, millet, sorghum, and ground nuts. Culturally, Kanam is home to two predominantly indigenous tribes the Bogghom and Jhar. Demographically, Kanam has experienced significant growth over the past few decades.

According to the 1991 national census, the population stood at 113,500. By the 2006 census, this figure had risen to 167,619, and 2026 projection estimate the population will reach 271,588. In just last year, Kanam’s population has grown by 6,475, which is reflecting a steady annual growth rate of approximately 2.44% According to Nigerian population census commission, with additional data sourced from the Nigeria LGA Census series (1991-2026) and the 2022 Nigeria LGA projection both as attributed by city population official records.

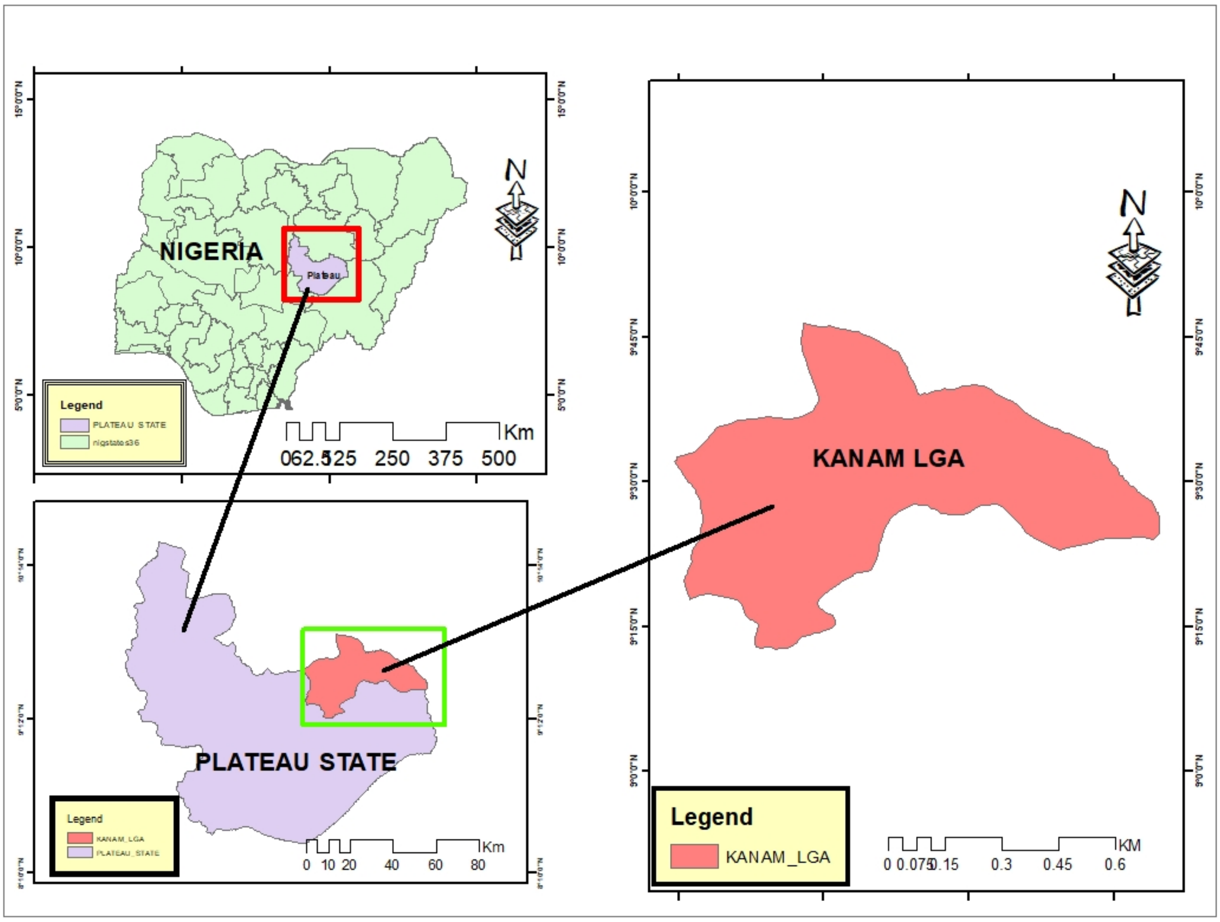

Figure 1: Study Area

B. Research Design

The study adopted a geospatial and quantitative research design to assess Land use/Land cover (LULC) dynamics and their implications for population growth in the study area. The employed remotely sensed satellite imagery, Geographic Information System (GIS), Population data and relevant ancillary information to identify, classify and quantify changes in major LULC classes between 1996 to 2026. The principal LULC classes considered were; Water body, Built-up Area, vegetation, farmland, and Bare Surface. The methodological framework involves Data acquisition, image processing, image classification, post-classification change detection, Area-change analysis and interpretation of the relationship between LULC transformation and population growth.

Materials and Data Sources

The materials and datasets used for the study included satellite imagery, administrative boundary data, population statistics and GIS/Remote-sensing software.

Table 1: Materials and Data Sources for the Study

Material/Data	Source	Purpose
7ETM+ Landsat Satellite Imagery for 1996	U.S. Geological survey (USGS) Earth explorer	Mapping LULC conditions
7ETM+ Landsat Satellite Imagery for 2006	U.S. Geological survey (USGS) Earth explorer	Mapping LULC conditions

Material/Data	Source	Purpose
OLI/TIRS 8,9data Landsat Satellite Imagery for 2016	U.S. Geological survey (USGS) Earth explorer	Mapping LULC conditions
OLI/TIRS 9,8data Landsat Satellite Imagery for 2026	U.S. Geological survey (USGS) Earth explorer	Mapping LULC conditions
Kanam LGA Administrative Boundary	Administrative/GIS database	Delimitation of the study area
Population Data	National Population Commission (NPC), Nigeria LGA Census series (1991-2026), and the 2022 Nigeria LGA. Projection by city population official records.	Analysis of Population Growth
GIS Software	ArcGis	Image processing, classification, Spatial Analysis and Map layout
Microsoft Excel	Microsoft Office	Statistical Calculations, Tables, Graphs and Change-Detection Analysis.
Computer System	-	Data Processing and Analysis

C. Satellite Image Acquisition and Pre-Processing

The Multi-Temporal Landsat images covering the study periods were obtained from the United State Geological survey (USGS) Earth Explorer. Images corresponding from 1996 to 2026 were selected to provide a thirty-year period for evaluating LULC changes. Images with minimal cloud cover were preferred to reduce atmospheric interference and improve classification accuracy. The imagery was selected from comparable periods of the year, as possible, to minimize seasonal variation in vegetation and water-body conditions. The 1996 imagery provided a based line LULC condition, while the 2026 imagery represented the contemporary condition of the study area.

Satellite images were subjected to pre-processing before classification. Image downloading and inspection: appropriate cloud-free or low-cloud-cover scenes were identified and downloaded. Image mosaicking: where more than one scene was required to cover the study area, the scenes were mosaicked. Clipping/extraction to obtain the study area. Band combination: to improve the identification of vegetation, built-up area, farmland and bare surface.

D. Image and LULC Classification

The selected samples were used to classify the satellite images into the LULC classes. Unsupervised classification algorithm was applied to assign image pixels to the most appropriate LULC category. Following classification, the resulting maps were visually inspected and edited where necessary to correct obvious classification inconsistencies. The classified images were subsequently converted into LULC maps for 1996 and 2026. Unsupervised classification approach was adopted for the LULC mapping. Five major feature classes were identified based on their spectral characteristic, field observations and the objective of the study.

Table 2: Land Use/Land Cover Classification

Code	LULC	Description
1	Built-up Area	Resident Areas, Commercial areas, institutional areas, Roads and other constructed
2	Bare Surface	Exposed soil, rock, Sand, degraded land Areas with little or no vegetation.
3	Farmland	Cultivated Agricultural fields and Areas predominantly used for crop production.
4	Vegetation	Forest, woodland, Shrubland, Grassland and other predominantly vegetated areas
5	Water Body	River, Stream, Ponds, Reservoir and other permanent or seasonal water-covered surfaces

Results and Discussion

This chapter presents the results of the investigation into land use/land cover (LULC) dynamics and population growth in Kanam Local Government Area (LGA), Plateau State, between 1996 and 2026. The analysis focused on five major LULC classes: built-up area, farmland, vegetation, bare surface and water body. Remote sensing and Geographic Information System (GIS) techniques were employed to determine the spatial and temporal changes in these land-cover categories. The chapter also examined population changes over the same period and assessed the statistical relationship between population growth and changes in the different LULC classes. This section presents the results obtained and discussion with respects to the aim and objectives of the research work and linked with the literature reviewed.

A. Land Use and Land Cover of Kanam LGA 1996 to 2026

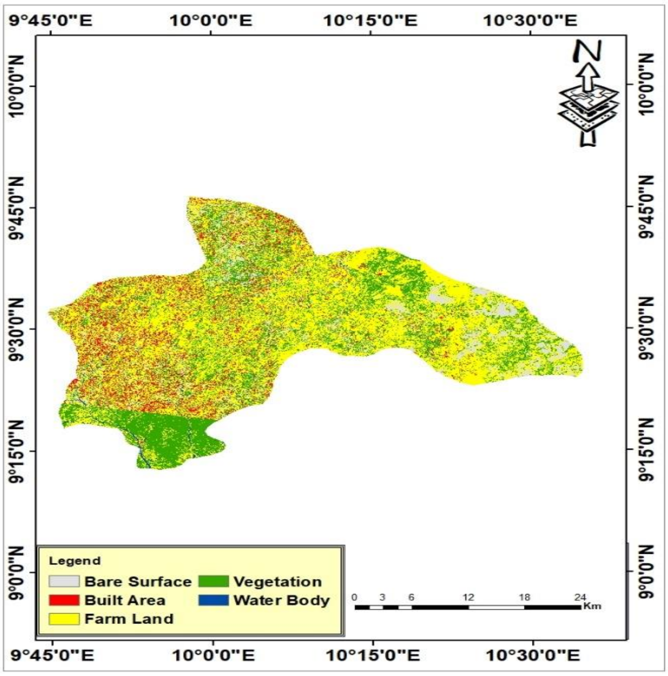

Figure 2: Map of Kanam LGA in 1996

The classified satellite images demonstrate considerable changes in the spatial extent of the five LULC classes during the study period such as bare surface, built up area, farm land, vegetation, and water body. In 1996, bare surface has 9%, bult up area, 9%, farm land 53%, vegetation 28% and water body has 1% respectively.

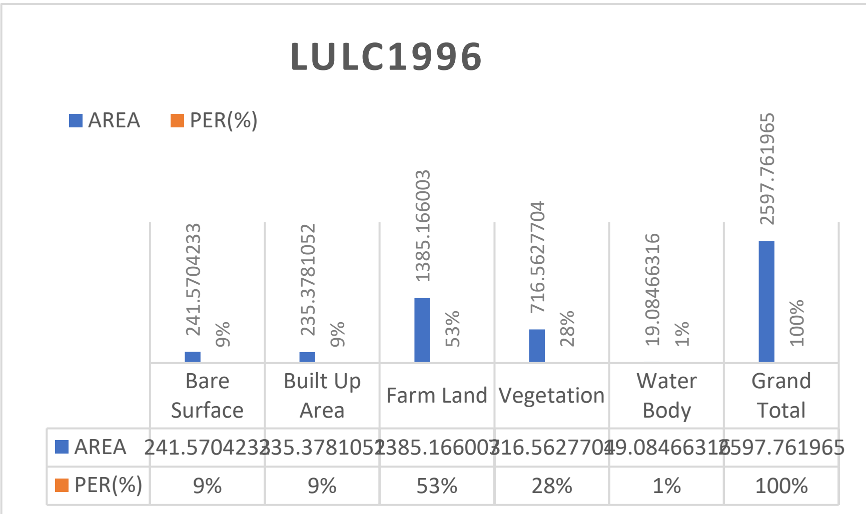

Figure 3: Land Use and Land Cover of Kanam LGA in 1996

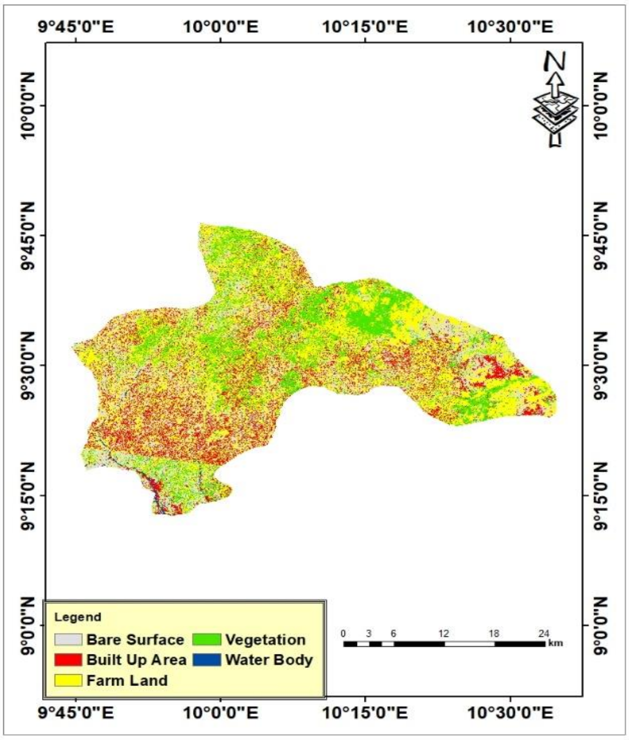

Figure 4: Map of Kanam LGA in 2006

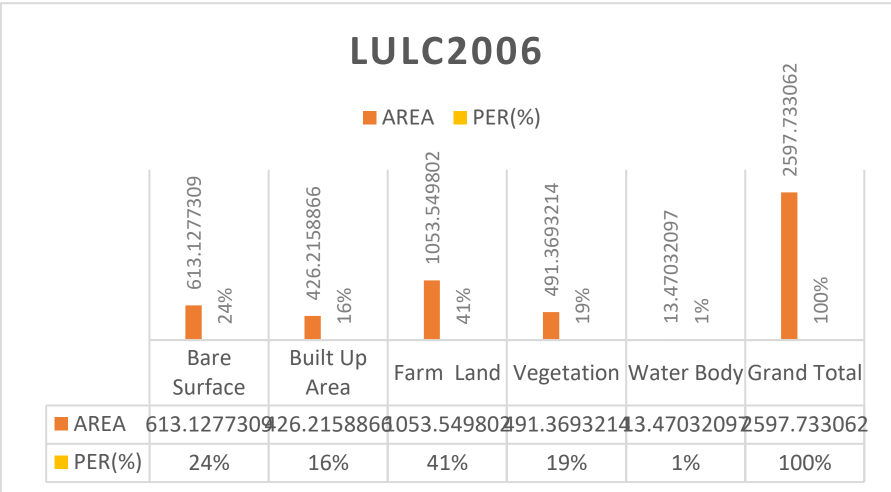

Figure 5: Land Use and Land Cover of Kanam LGA in 2006

In 2006, bare surface has 24%, built up area increases with 7% from 9 at 1996, farm land 41%, vegetation decreases with 9% from 28% has at 1996 and water body remained at 1%respectively.

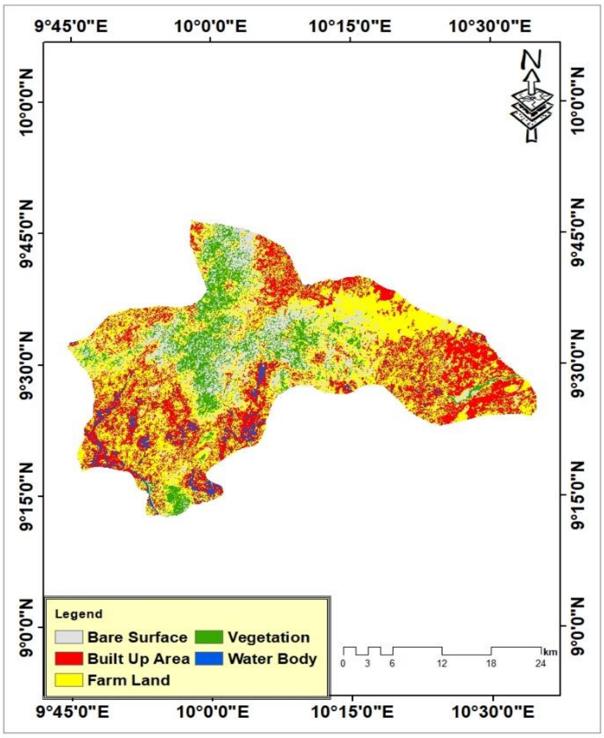

Figure 6: Map of Kanam LGA in 2016

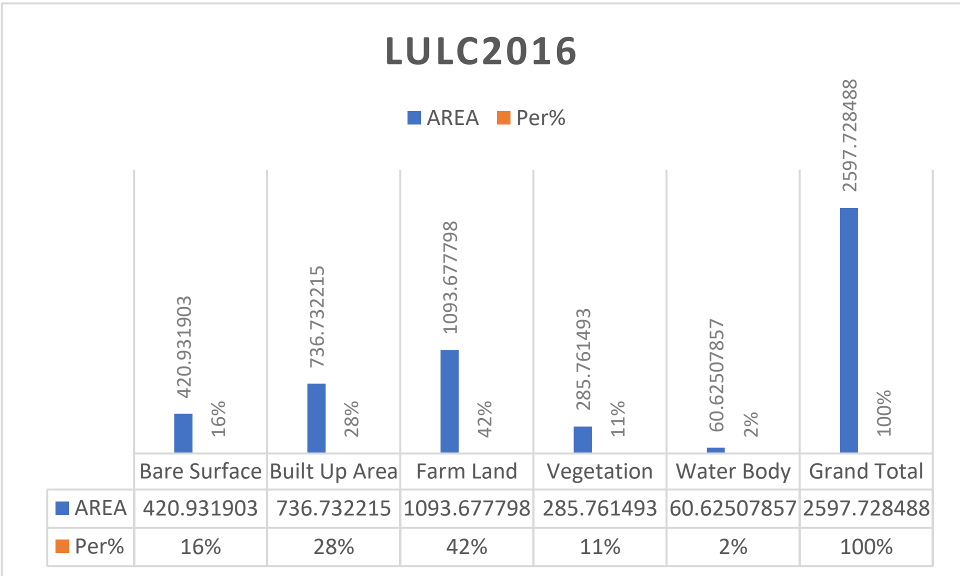

Figure 7: Land Use and Land Cover of Kanam LGA in 2016

Furthermore, in 2016, bare surface has 16%, built up area increases with 12% from 16 at 2006, farm land 42%, vegetation decreases with 8% from 19% has at 2006 and water body remained at 2%.

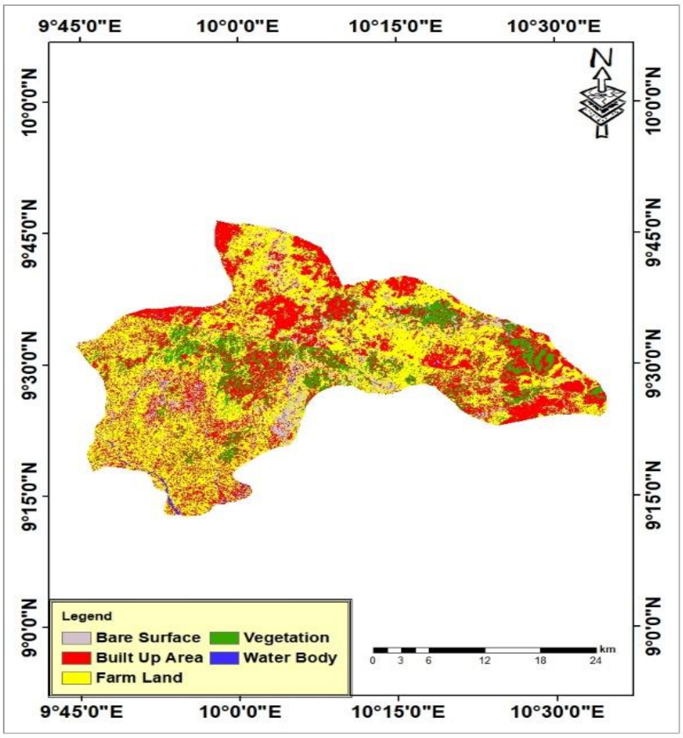

Figure 8: Map of Kanam LGA in 2026

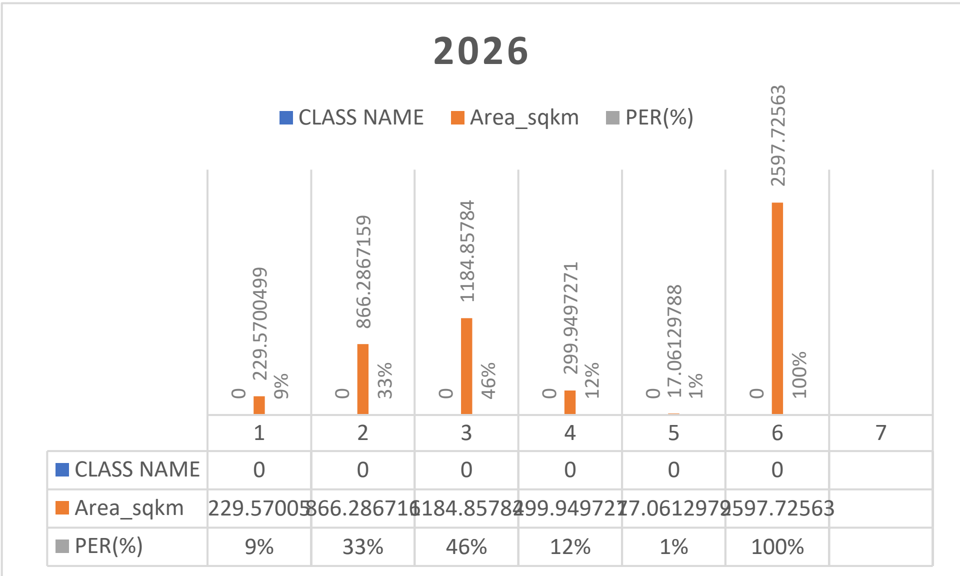

Figure 9: Land Use and Land Cover of Kanam LGA in 2026

Consequently, in 2026, bare surface has 9%, built up area increases with 5% from 28 at 2016, farm land 46%, vegetation 11%, and water body at 1%.

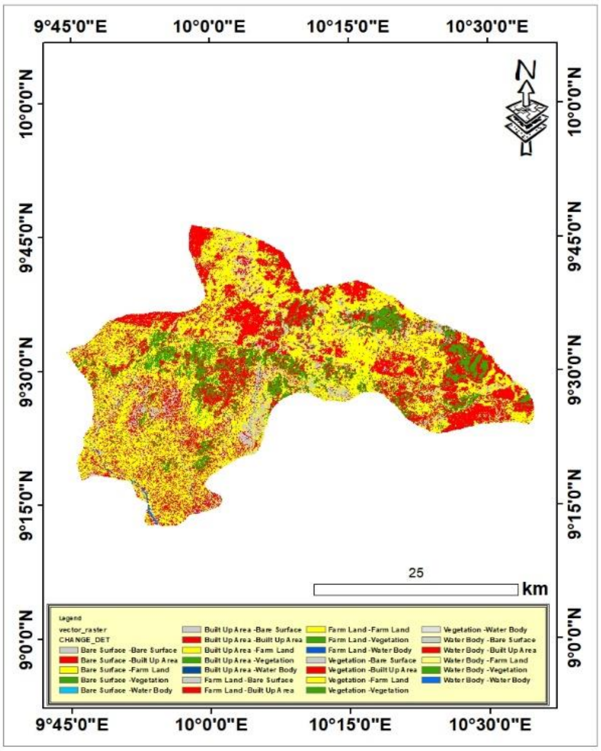

Figure 10: Change Detection Map of Kanam LGA from 1996 to 2026

Table 3: Land Use/Land Cover Classification

LULC Feature Class	**1996 Area**	**2026 Area**	**Net Change**	**Percentage Change (%)**	**Status**
Water Body	19.08	17.06	-2.02	-10.59	Decreased
Vegetation	716.38	299.92	-416.46	-58.13	Decreased
Farmland	1384.79	1184.58	-200.21	-14.46	Decreased
Built-up Area	235.32	865.99	630.67	268.01	Increased
Bare Surface	241.50	229.52	-11.98	-4.96	Decreased
TOTAL	2597.07	2597.07	0.00		—

The LULC analysis shows significant changes in the study area between 1996 and 2026, while the total area remained constant at 2,597.07 km². Vegetation declined substantially by 416.46 km² (58.13%), indicating considerable loss of natural vegetation. Farmland decreased by 200.21 km² (14.46%), suggesting increasing conversion of agricultural land to other uses. Built-up area increased dramatically by 630.67 km² (268.01%), reflecting rapid urbanization and expansion of human activities. Overall, the results indicate a major transformation from vegetation and agricultural land towards built-up development, with important environmental and planning implications.

B. Population Dynamics in Kanam Local Government Area

The population of Kanam Local Government area (LGA) showed a signed upswing throughout the study period. From 129,252 residents in 1996 to 167,619 in 2006. 213,362 in 2016 and approximately 271,588 in 2026. The population increased by about 110.1% between 1996 and 2026. The estimated population increased were According to Nigerian population census commission, with additional data sourced from the Nigeria LGA Census series (1991-2026) and the 2022 Nigeria LGA, Projection both as attributed by city population official records.

Table 4: Population Dynamics of Kanam LGA from 1996 to 2026

Year	Population	Period	Increase (%)
1996	129,252	---------	
2006	167,619	38,367	29.68
2016	213,362	45,743	27.29
2026	271,588	58,226	27.29

The 1996, 2016 and 2026 figures are projection/estimates rather than direct census enumerations. The detected population path gives an imperative demographic context for understanding the LULC dynamics of Kanam LGA. The Population rise can increase demand for residential land, settlement, agricultural production and other resources, possibly resulting in changes in the spatial formation of natural and anthropogenic land-cover classes. However, demographic growth alone does not necessarily explain all LULC transitions because Land-use decisions are also influenced by socioeconomics, climatic, institutional, and environmental factors.

C. Spatial and Temporal Dynamics of LULC

The classified satellite imagery identified five principal LULC categories in Kanam LGA: Bare surface, Built-up Area, Farmland, Vegetation, and water body. The spatial distribution and temporal dynamics of these classes indicates considerable transformation of the landscape between 1996 and 2026.

Table 5: LULC distribution in Kanam LGA

LULC Class	1996(km^2)	2006(km^2)	2016(km^2)	2026(km^2)
Bare Surface	241.57	613.13	420.93	229.57
Built-up Area	235.38	426.22	736.73	866.29
Farmland	1,385.17	1,053.55	1,093,68	1,184.86
Vegetation	716.56	491.37	285.76	299.95
Water Body	19.08	13.47	60.63	17.06

The most remarkable feature of the LULC trajectory is the continuous expansion of built-up land. Built-up area growth from about 235.38 km^2 in 1996 to 886.29km^2 in 2026, representing an increase of approximately 630.91km^2. In difference, vegetation declined from 716.56km^2 to 299.95km^2 representing net reduction of approximately 416.61km^2. Farmland decreased between 1996 and 20006 but subsequently increased, reaching approximately 1,184.86km^2 in 2026. This pattern suggests that agricultural land dynamics were not strictly linear and may reflect periodic conversion between agricultural, vegetation, bare surface and built-up area.

The bare-surface class displayed significant temporal variability, increasing from 241.57km^2 in 1996 t0 613.13km^2 in 2006, before declining to 60.229.57km^2 by 2026. Water bodies exhibited substantial instability, increasing from 19.08km^2 in 1996 to 60.63km^2 in 2016, before going down to 17.06km^2 in 2026. Such variability may reflect differences in rainfall, surface-water condition, seasonal effects, classification conditions and changes in land management.

D. Population Growth and Built-up Extension

The strong increase in built-up areas aligns closely with the observed population growth. Between 1996 -2026, population increased by about 142,336 residents, while build-up area increased by approximately 630.91km^2. Pearson correlation analysis revealed a very robust positive association between population and built-up area(r = 0.977; R^2 = 95.5%; p = 0.023).

Table 6: Pearson Correlation between Population and Built-up Area

Parameter	Value
N	4
Pearson's r	0.977
R^2	0.955
R^2(%)	95,5
p-value	0.023
Significance level	0.05
Interpretation	Very strong association
Statistical decision	Significant

The positive relationship indicates that periods of higher population are linked with larger built-up areas. The high R^2 value suggests that population variation and built-up area expansion followed a closely related temporal pattern across the four-observation year.

This finding is consistent with the general expectation that population growth increases demand for residential accommodation, roads, commercial facilities, and public infrastructure. Yet, the correlation should be interpreted as an association rather than directs causation, particularly because only four temporal observations were used.

E. Population Growth and Vegetation Undercurrents

Vegetation showed a markedly different temporal pattern from built-up land. Its area declined from 716.56km^2 in 1996 to 299.95km^2 km^2 in 2026, although, a slight recovery occurred 2016 and 2026.

Table 7: Pearson Correlation between Population and Vegetation

Parameter	Value
Pearson's r	-0.863
R^2	0.798
R^2(%)	79.8
p-value	0.107
Significant level	0.05
Interpretation	Very strong negative association
Statistical decision	Not significant

A very strong negative correlation (r = -0.893) was noticed between population and vegetation. The negative coefficient suggests that the population growth coincided with declining vegetation cover. But the relationship did not reach statistical significance at the 5% level (P= 0.0107). The observed decline in every vegetation may reflect the combined influence of settlement expansion, agricultural activities, fuelwood extraction and other forms of land conversion. However, the available data does not permit the conclusion that the population growth alone caused the vegetation decline.

F. Population Growth and Farm Dynamics

Farmland was the largest LULC category during most of the study period. Its area declined from 1,385.17km^2 in 1996 to 1,053.55km^2 in 2006, before increasing to 1,184.86km^{2}in 2026.

Table 8: Pearson Correlation between Population and Farmland.

Parameter	Value
N	4
Pearson's r	-0.413
R^2	0.171
R^2 (%)	17.1
p-value	0.587
Significance level	0.05
Interpretation	Moderate negative association
Statistical decision	Not significant

The moderate negative correlation (r = -0.423) indicates that population and farmland area tended to vary inversely during the observation period. However, the relationship was weak in statistical terms (p= 0.587) and therefore was not significant at the 5% level. The non-linear behavior of farmland suggests that agricultural land dynamics may be influenced by several factors beyond population growth, including agricultural expansion or abandonment, soil conditions, market demands, farming practices and conversion of agricultural land to settlements.

G. Population Growth and Bare-Surface Dynamics

Bare surface exhibited considerable temporal fluctuation, increasing substantially between 1996 and 2006 and subsequently declining.

Table 9: Pearson Correlation between Population and Bare Surface

Parameter	Value
N	4
Pearson's r	-0.242
R^2	0.059
R^2 (%)	5.9
p-value	0.758
Significance	0.05
Interpretation	Weak negative association
Statistical decision	Not significant

The weak negative correlation (r = -0.242) indicates little linear association between population growth and surface area. The very low R^2 value (5.9) further indicates that population variation explains little of the observed variation in this class. The temporal variability in bare surface may instead be associated with seasonal agricultural cycles, soil exposure, construction activities, erosion processes and classification variability.

H. Population Growth and Water Body Dynamics

Water bodies represented the smallest LULC category and showed considerable temporal variation, increasing from 19.08 km^2 in 1996 to 60.63 km^2 in

2016, before declining to 17.06 km^2 in 2026.

Table 10: Pearson Correlation between Population and Water Body

Parameter	Value
N	4
Pearson's r	0.183
R^2	0.003
R^2(%)	3.3
p-value	0.817
Significance	0.05
Interpretation	Very weak positive association
Statistical decision	Not significant

The correlation coefficient (r = 0.183) indicates a very weak positive association between population and water body area. The relationship was not statistically significant (p= 0.817), suggesting that population growth was not an Important linear predictor of water body variation during the research period.

The observed fluctuations in water bodies are more plausibly associated with hydrological conditions, rainfall variability, surface water dynamics, and other environmental processes.

I. Comparative Assessment of Population-LULC Relationships

Table 11: Summary of Pearson Correlation Analysis

LULC Class	Pearson's r	R^2 (%)	p-value	Association	Significance
Built-up Area	+0.977	95.5	0.023	Very strong positive	Significant
Bare Surface	-0.242	5.9	0.758	Very weak Negative	Not significant
Farmland	-0.413	17.1	0.587	Moderate negative	Not significant
Vegetation	-0.893	79.8	0.107	Very strong negative	Not significant
Water Body	+0.183	3.3	0.817	Very weak positive	Not significant

Overall, the analysis demonstrates that the strongest demographic-land-use association occurred between population growth and built-up expansion. The opposite relationship between population and vegetation was also pronounced, although it was not statistically significant at the 5% level. The remaining LULC classes exhibited relatively weak or moderate association with population.

These results indicate that the principal land-use transformation associated with demographic growth in Kanam LGA was the expansion of built-up areas. The concurrent reduction in vegetation suggests increasing anthropogenic pressure on natural land cover. However, the LULC changes observed should be understood within a broader socioeconomic and environmental context rather than attributed exclusively to population growth.

J. Implications for Land Management.

The expansion of built-up land from approximately 235.38km^2 to 866km^2 over the study period has important implications for sustainable land management in Kanam LGA. Continued demographic growth without adequate spatial planning could increase pressure on agricultural land and remaining vegetation.

The result highlights the need for:

i. Integrated land-use planning to guide settlement expansion.

ii. Protection of remaining vegetation, particularly areas vulnerable to conversion

iii. Agricultural land management to minimize unnecessary conversion of productive farmland

iv. Gis-based monitoring of settlement expansion and land-cover transition

v. Periodic remote-sensing assessment to identify emerging areas of environmental pressure.

K. Statistical Limitations

An important limitation of the correlation analysis is the small number of temporal observations (n=4). With only four observations, the analysis has two degrees of freedom, substantially limiting statistical power. Consequently, the correlation coefficient should be interpreted as indicative temporal association rather than definitive causal relationships. Furthermore, population figures for 1996, 2016 and 2026 are estimates/projections rather than direct census enumerations. This uncertainty should be put in notice when interpreting the statistical relationship between population and LULC.

L. Key Finding

The principal finding of this study is that population growth in Kanam LGA was strongly and significantly associated with expansion of built-up land, while population growth coincided with a substantial decline in vegetation cover. The evidence therefore suggests increasing anthropogenic transformation of the landscape, particularly through settlement expansion although the influence of other socioeconomic and environmental drivers cannot be excluded.

Summary, Conclusion and Recommendations

This section presents the summary, conclusion and recommendations of the study on Land Use/Land Cover (LULC) Change and Population Growth in Kanam Local Government Area, Plateau State, Nigeria, from 1996 to 2026. It draws together the major findings presented and discussed in section three and relates them to the objectives of the study.

The study examined the spatial and temporal changes in major land use/land cover classes within Kanam Local Government Area and assessed the relationship between population growth and changes in the identified LULC classes. Five major LULC categories were considered: built-up area, bare surface, farmland, vegetation and water body.

Moreover, it organised into the following sections: summary of the study, summary of major findings, conclusion, recommendations, contribution to knowledge, limitations of the study and suggestions for further research.

A. Summary

The study was undertaken to examine the changes that have occurred in the land use/land cover pattern of Kanam Local Government Area over a 30-year period and to determine how these changes relate to population growth. Land use/land cover is an important component of environmental management because changes in the use of land can affect agricultural production, vegetation resources, settlement development, water resources, soil conditions and ecosystem services. Population growth can increase demand for land for housing, agriculture, infrastructure, commerce and other socioeconomic activities. Consequently, understanding the relationship between population dynamics and land-cover transformation is important for sustainable land-use planning.

The study employed spatial analysis of LULC classes for 1996, 2006, 2016 and 2026. The identified land-cover classes were built-up area, bare surface, farmland, vegetation and water body. The areas occupied by each class were compared across the study years to determine the magnitude and direction of change. Population data were also examined for the corresponding years. Pearson correlation analysis was subsequently used to examine the relationship between population growth and the different LULC classes. The analysis revealed considerable changes in the landscape of Kanam LGA during the study period. The most prominent change was the continuous expansion of built-up land, while vegetation experienced substantial overall decline. Farmland remained the dominant land-cover class, although its area fluctuated over time. Bare surface and water body also showed considerable temporal fluctuations.

The study revealed a substantial increase in built-up area. Built-up area increased from 235.38 km² in 1996 to 426.22 km² in 2006, 736.73 km² in 2016, and 866.29 km² in 2026. The total increase between 1996 and 2026 was therefore 630.91 km², representing approximately 268% growth. This was the largest increase recorded among the five LULC classes and demonstrates the rapid expansion of developed land within Kanam LGA. The continuous growth of built-up land occurred alongside a substantial increase in population. The correlation analysis produced a very strong positive relationship between population and built-up area, with $r = 0.977$, $R^2 = 0.955$, and $p = 0.023$. The result indicates that population growth and built-up expansion were strongly associated during the study period.

Vegetation cover experienced substantial overall decline. Vegetation decreased from 716.56 km² in 1996 to 491.37 km² in 2006 and further declined to 285.76 km² in 2016. A slight increase occurred in 2026, when vegetation reached 299.95 km². Despite the slight recovery between 2016 and 2026, vegetation recorded an overall reduction of 416.61 km², equivalent to approximately 58.13% between 1996 and 2026. The correlation between population and vegetation was negative ($r = -0.863$), indicating that population growth occurred alongside a general decline in vegetation. However, the reported p-value of 0.107 means that the relationship was not statistically significant at the 5% level. The finding therefore suggests an important environmental trend but does not provide sufficient statistical evidence to conclude that population growth alone explains vegetation loss.

Farmland remained the largest LULC category throughout the study period. It declined from 1,385.17 km² in 1996 to 1,053.55 km² in 2006, before increasing to 1,093.68 km² in 2016 and 1,184.86 km² in 2026. The overall change between 1996 and 2026 was a decrease of 200.31 km², representing approximately 14.46% reduction. The pattern demonstrates that farmland was not characterised by a continuous decline. Rather, it experienced considerable fluctuations. The relationship between population and farmland was moderately negative, with $r = -0.413$, but the relationship was not statistically significant ($p = 0.587$). This indicates that population growth alone does not adequately explain the changes observed in farmland.

Bare surface showed substantial temporal fluctuations. It increased from 241.57 km² in 1996 to 613.13 km² in 2006, before declining to 420.93 km² in 2016 and 229.57 km² in 2026. Although considerable changes occurred between individual periods, the overall 1996–2026 change was a decrease of 11.98 km², representing approximately 4.96%. The correlation between population and bare surface was weak and negative ($r = -0.242$), with $R^2 = 0.059$ and $p = 0.758$. The relationship was therefore not statistically significant. The fluctuations in bare surface suggest that this class may be influenced by several factors, including land clearing, agricultural cycles, construction activities, exposed soil and environmental conditions.

Water body was the smallest LULC class and demonstrated considerable fluctuations. Water body decreased from 19.08 km² in 1996 to 13.47 km² in 2006, increased substantially to 60.63 km² in 2016, and subsequently declined to 17.06 km² in 2026. The overall change between 1996 and 2026 was a reduction of 2.02 km², equivalent to approximately 10.59%. The correlation between population and water body was very weak and positive ($r = 0.183$), with $R^2 = 0.033$ and $p = 0.817$. The result indicates that population growth had no statistically significant relationship with changes in water-body extent. The study revealed a continuous increase in population within Kanam LGA. Population increased from:

- 129,252 persons in 1996
- 167,619 persons in 2006
- 213,362 persons in 2016
- 271,588 persons in 2026

The overall population increase between 1996 and 2026 was 142,336 persons, representing approximately 110.1% growth.

The population therefore more than doubled during the study period. The continuous increase in population indicates increasing demographic pressure and demand for land and resources. The population trend is particularly important when considered alongside the substantial expansion of built-up land. The correlation analysis produced different relationships between population and the five LULC classes.

Table 12: Summary of the Relationship between Population and LULC

LULC Class	r	R^2	p-value	Decision at 5%
Built-up	+0.977	0.955	0.023	Significant
Vegetation	−0.863	0.798	0.107	Not significant
Farmland	−0.413	0.171	0.587	Not significant
Bare surface	−0.242	0.059	0.758	Not significant
Water body	+0.183	0.033	0.817	Not significant

The findings demonstrate that the strongest relationship was between population and built-up land. This relationship was positive and statistically significant. Population had negative relationships with vegetation, farmland and bare surface, but none of these relationships was statistically significant at the 5% level. The relationship with water body was weakly positive and statistically insignificant. The findings therefore indicate that population growth was most clearly associated with settlement expansion, while the other LULC changes were likely influenced by a combination of demographic, agricultural, socioeconomic, environmental and possibly climatic factors.

B. Conclusion

Based on the findings of the study, it is concluded that Kanam Local Government Area experienced substantial land use/land cover transformation between 1996 and 2026. The most significant transformation was the expansion of built-up land. Built-up area increased from 235.38 km² in 1996 to 866.29 km² in 2026, representing approximately 268% growth. This expansion indicates increasing human modification of the landscape and increasing demand for land for settlement and associated socioeconomic activities. During the same period, population increased from 129,252 to 271,588 persons, representing approximately 110.1% growth. The strong positive and statistically significant correlation between population and built-up land demonstrates that population growth was closely associated with settlement expansion.

The study also established a substantial decline in vegetation. Vegetation decreased by approximately 416.61 km², representing 58.13% reduction. Although population and vegetation showed a strong negative association, the relationship was not statistically significant at the 5% level. Therefore, population growth should not be regarded as the sole explanation for vegetation loss.

Farmland remained the dominant land-cover category, although it experienced an overall reduction of 14.46%. Its fluctuations suggest that agricultural land is subject to competing demands and dynamic processes. Bare surface and water body also experienced considerable fluctuations, indicating that their changes may be influenced by environmental conditions, land management, agricultural activities and other factors beyond population growth.

Overall, the study concludes that population growth is strongly associated with the expansion of built-up land in Kanam LGA, while broader LULC transformation results from interacting human and environmental processes. The findings support the need for integrated spatial planning that accommodates population growth while protecting agricultural land, vegetation resources and other environmentally important areas.

C. Recommendations

Based on the findings of the study, the following recommendations are proposed.

1. Strengthening of Land-Use Planning

The relevant planning authorities should strengthen land-use planning and development control within Kanam LGA. The rapid expansion of built-up land demonstrates the need for a clearly defined spatial development framework that identifies appropriate areas for residential, commercial, institutional, agricultural and conservation uses. Development should be guided by approved land-use plans to reduce uncontrolled and incompatible land conversion.

2. Controlled Expansion of Built-Up Areas

Settlement expansion should be properly controlled through effective development regulations. New developments should be guided towards suitable locations while environmentally sensitive areas, productive agricultural land and important vegetation areas should be protected. The planning authority should discourage indiscriminate development and ensure that expansion occurs in a planned and sustainable manner.

3. Protection and Restoration of Vegetation

The substantial decline in vegetation requires urgent conservation measures. The Local Government and relevant environmental agencies should establish programmes for:

- Afforestation and reforestation.
- Protection of existing vegetation.
- Community-based tree planting.
- Sustainable harvesting of forest resources.
- Prevention of indiscriminate vegetation clearing
- Restoration of degraded areas.

Community participation should be incorporated into vegetation conservation programmes because local communities are important users and managers of land resources.

4. Protection of Agricultural Land

Since farmland remained the dominant LULC class and experienced an overall decline, productive agricultural areas should be protected from unnecessary conversion. Agricultural land-use planning should identify important agricultural zones and minimise their conversion to residential and commercial developments. Farmers should also be encouraged to adopt sustainable agricultural practices that maintain soil fertility and productivity.

5. Integration of Population Projections into Land-Use Planning

The strong relationship between population and built-up land indicates the importance of incorporating population projections into spatial planning. Before approving major development projects, planning authorities should consider expected future population growth and the resulting demand for housing, transportation, water, sanitation, schools, healthcare and other services. This approach can reduce unplanned settlement expansion and improve the efficient use of land.

6. Continuous GIS and Remote-Sensing Monitoring

The study recommends continuous monitoring of LULC changes using Geographic Information Systems (GIS) and remote sensing. Satellite imagery should be analysed periodically to identify:

- Settlement expansion.
- Vegetation loss.
- Agricultural land conversion.
- Environmental degradation.
- Changes in water bodies.
- Emerging development corridors.

A geospatial database for Kanam LGA should be established and periodically updated to support evidence-based planning and decision-making.

7. Establishment of Development Setbacks and Conservation Zones

Appropriate setbacks should be maintained around environmentally sensitive locations, drainage channels, water bodies and other areas requiring protection. Conservation zones should also be identified for important vegetation and environmentally sensitive areas. Such measures can reduce the environmental consequences of uncontrolled development.

8. Promotion of Sustainable Urban and Rural Development

Development policies should integrate urban and rural land-use considerations. Rather than treating settlement, agriculture and environmental conservation as separate issues, planning should recognize their interdependence. A sustainable development strategy for Kanam should seek to accommodate population growth while maintaining agricultural productivity and environmental quality.

9. Public Environmental Awareness

Environmental education and awareness programmed should be strengthened. Residents should be educated about the consequences of indiscriminate vegetation clearing, uncontrolled settlement development, inappropriate agricultural practices and environmental degradation. Traditional leaders, community organizations, youth groups, farmers' associations and other stakeholders should be involved in environmental management initiatives.

10. Strengthening Institutional Collaboration

Effective management of LULC change requires collaboration between relevant institutions. The Local Government, Plateau State planning authorities, environmental agencies, agricultural agencies, traditional institutions and local communities should work together in monitoring and managing land resources. Such collaboration would improve enforcement, reduce conflicting land-use decisions and promote sustainable development.

D. Contribution to Knowledge

This study contributes to knowledge in several important ways. First, it provides a 30-year assessment of land use/land cover dynamics in Kanam LGA, covering the period from 1996 to 2026. Second, the study provides quantitative evidence of the transformation of the landscape, particularly the substantial increase in built-up land and reduction in vegetation. Third, the study demonstrates the usefulness of integrating remote sensing/GIS-based LULC analysis with population data to investigate human-environment relationships at the local government level. Fourth, the study provides statistical evidence showing that the strongest relationship between population and LULC change occurred in relation to built-up land. Fifth, the study provides information that can assist planning authorities, environmental managers and other stakeholders in developing appropriate strategies for managing future land-use changes in Kanam LGA. Finally, the study establishes a useful baseline against which future LULC assessments in Kanam LGA can be compared.

Although the study provides important findings, some limitations should be recognized. The statistical relationship between population and LULC was based on four observation years: 1996, 2006, 2016 and 2026. Consequently, the correlation analysis has a very small sample size. The results should therefore be interpreted as indicative rather than definitive evidence of long-term causal relationships. Remote-sensing classification can be affected by image quality, atmospheric conditions, seasonal differences, spatial resolution and similarities between different land-cover classes. Such factors may influence the estimated area of some LULC classes, particularly bare surfaces, agricultural areas and water bodies. Population figures for years that do not correspond to direct national census years may involve estimates or projections. Such figures should therefore be clearly identified as estimates where applicable.

The study primarily examined the relationship between population and LULC change. Other factors such as road development, agricultural expansion, economic conditions, government policies, migration, climatic variability and local development patterns were not fully quantified in the correlation model. Consequently, the observed LULC changes should not be attributed exclusively to population growth.

Based on the limitations and findings of the study, future research should consider the following areas.

1. Annual LULC monitoring: Future studies should analyse annual or more frequent satellite images to provide a more detailed picture of land-cover trajectories.

2. Multivariate analysis: Future researchers should incorporate additional explanatory variables such as rainfall, road density, and distance from settlements, household size, agricultural activity, economic indicators and infrastructure development.

3. Higher-resolution imagery: The use of higher-resolution satellite imagery could improve the identification of small settlements, narrow water bodies, fragmented vegetation and mixed land-use areas.

4. Future LULC prediction: Future research should use models such as Cellular Automata-Markov, Random Forest, SLEUTH or other appropriate spatial modelling approaches to predict future LULC conditions.

5. Climate-LULC interaction: Further research should examine the relationship between LULC change, rainfall, temperature, drought and other climatic variables.

6. Socioeconomic surveys: Household and community surveys could be used to investigate the underlying socioeconomic reasons for vegetation clearing, agricultural expansion and settlement growth.

7. Urban growth and environmental impact: Further studies should investigate how increasing built-up land affects runoff, soil erosion, surface temperature, drainage and local environmental quality.

8. Land-cover change and agricultural productivity: Future research should assess whether reductions or spatial redistribution of farmland are affecting agricultural productivity and rural livelihoods.

The study has demonstrated that Kanam Local Government Area has undergone substantial land use/land cover transformation between 1996 and 2026. The most prominent feature of this transformation is the rapid expansion of built-up land, which occurred alongside significant population growth.

The strong relationship between population and built-up expansion suggests that demographic growth is an important factor associated with settlement development in the study area. At the same time, the substantial decline in vegetation demonstrates the environmental consequences that may accompany landscape transformation.

However, the findings also show that population growth does not explain all LULC changes. The fluctuations in farmland, bare surface and water body demonstrate that land-cover dynamics are complex and influenced by several interacting factors.

The future sustainability of Kanam LGA therefore depends on the ability of planning authorities and local communities to manage population growth and land development while protecting agricultural resources, vegetation and environmentally sensitive areas. The integration of GIS, remote sensing, population analysis and participatory land-use planning provides an appropriate framework for achieving this objective.

References

Akumu, C. E., Dennis, S., & Reddy, C. (2018). Land cover land use mapping and change detection analysis using geographic information system and remote sensing. International Journal of Human Capital in Urban Management, 3: 167-178.

Aklile Nigatu (2014) Impact of land use land cover change on soil erosion risk: the case of Denki River catchment. Addis Ababa University School of Graduate Studies', Ethiopia

Admasu, S., Yeshitela, K., & Argaw, M. (2023). Impact of land use land cover changes on ecosystem service values in the Dire and Lege Dadi watersheds, central highlands of Ethiopia: Implication for landscape management decision making. Heliyon, 9(4), 1-14.

Desta H, Fetene A (2020) Land-use and land-cover change in Lake Ziway watershed of the Ethiopian central rift valley region and its environmental impacts. Land Use Policy 96:104682. https:/ /doi.org /10.1016 /j.landusepol.2020.104682

Kassa, Tadele, Forech G (2009) 'Watershed Hydrological Responses to Changes in Land Use and Land Cover, and Management Practices at Hare Watershed, Ethiopia'. Ph.D. thesis, University of Siegen, Germany: 229

Sohl TL, Sleeter BM, Sayler KL, Bouchard, Michelle A, Reker RR, Bennett SL, Sleeter, Rachel R, Kanengieter RL, Zhu (2012) 'Spa tially explicit land-use and land-cover scenarios for the Great Plains of the United States.' Agriculture,Ecosystems and Envi ronment 153:1–15

Goldewijk K, Beusen A, Drecht G, Vos M (2011) The HYDE 3.1 spa tially explicit database of human-induced global land-change over the past 12,000 years. Glob Ecol Biogeogr 20(1):73–86

Turner B, Lambin E, Reenberg A (2007) The emergence of land change science for global environmental change and sustainability. Proc Natl Acad Sci 104:20666–20671 PNAS

Paiboonvorachat C (2008) Using remote sensing and GIS techniques to assess land use/land cover changes in the Nan Watershed, Thailand. Unpublished thesis. Carbondale: Dept, of Geography and Environmental Resources, Southern Illinois University

Siddhartho SP (2013) 'Analysis of land use and land cover change in kiskatinaw river watershed: a remote sensing, GIS & Modeling Approach'. Thesis: 1 = 155

Lambin Eric F, Helmut J, Geist, Lepers E (2003) Dynamics of Land Use and Land- cover change in tropical regions. Annu Rev Envi ron Resour 28:205–241

Bewket Woldeamlak, and Solomon Abebe (2013) Land-use and land cover change and its environmental implications in a tropical Highland watershed, Ethiopia. Int J Environ Stud 70(1):126–139

Muluneh Alemayehu (2010) Synthesis of research on land use and land cover'. UNU-Land Restor Train Programme : 1–39

Yakob G, Fekadu A (2016) Diversity and regeneration status of woody species: the case of Keja Araba and Tula Forests, Southwest Ethiopia. OALib 03(04):1–15

EPA (2012) 'United Nations Conference on Sustainable Development (Rio + 20), National Report of Ethiopia

Basheer AA (2018) Chemical chiral pollution: impact on the society and science and need of the regulations in the 21st century. Chi rality 30(4):402–406. https: / doi.org / 1 0.1002 /chir . 22808

Tamiru Lemi (2019) Threats and opportunities of central Ethiopia rift Valley lakes. Int J Environ Sci Nat Res. https: / /doi.org / 1 0 .1 9 0 8 0 / IJESNR. 2019. 22. 556082

Enoguanbhor, E. C., Gollnow, F., Nielsen, J. O., Lakes, T., & Walker, B. B. (2019). Land cover change in the Abuja City-Region, Nigeria: Integrating GIS and remotely sensed data to support land use planning. *Sustainability, 11*(5), 1313.

Lambin, E. F., Geist, H. J., & Lepers, E. (2003). Dynamics of land-use and land-cover change in tropical regions. *Annual Review of Environment and Resources, 28*, 205–241.

Turner, B. L. II, Lambin, E. F., & Reenberg, A. (2007). The emergence of land change science for global environmental change and sustainability. *Proceedings of the National Academy of Sciences, 104*(52), 20666–20671.

Spatiotemporal analysis of land use land cover changes and built-up expansion projection in predominantly dystric nitosol of Ebonyi State, Southeastern Nigeria. (2021). *Environmental Challenges, 4*, 100145.

National Population Commission. (2024). _Nigeria population estimates 2024_. Abuja: NPC.

Akinyemi, F. O., & Abiodun, O. J. (2020). Population pressure and land use land cover change in the Nigerian savanna. _Journal of Environmental Management_, 260, 110136.

Dim, L. A., & Ezirim, A. I. (2018). Assessment of land use/land cover change in Jos metropolis, Plateau State, Nigeria. _International Journal of Geosciences_, 9(5), 287-301.

Lambin, E. F., & Meyfroidt, P. (2011). Global land use change, economic globalization, and the looming land scarcity. _PNAS_, 108(9), 3465-3472.