Sokoto Journal of Geographical Studies (SJGS)

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Volume 3, Issue 1, December 2025 Edition

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Volume 3, Issue 1, December 2025 Edition

TABLE OF CONTENTS

Volume 3, Issue 1, December 2025 Edition

SPATIO-TEMPORAL ANALYSES OF URBAN EXPANSION OF GOMBE METROPOLIS

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Abstract **https://doi.org/10.65760/sjgs.v3.i1.16**

In recent decades urbanization and consequential expansion of urban areas have become the central focus of development agenda. This phenomenon continues to attract considerable amount of interests from academia and overall global, regional and national socio-economic planning. The study used geospatial data comprising of four Land sat satellite imageries of the study area covering the entire period of this research (starting from 1999, 2006, 2011 and 2023). Furthermore, for the purpose of this study, Gombe metropolis was divided into four sections, ABC and D for easy analysis. In order to study and measure the trend in urban spatial and temporal expansion, satellite imageries of Gombe metropolis for the years 1999, 2011 and 2023 were downloaded from the United States Geological Survey (USCS) Earth explorer website www.usgs.gov. The Geospatial data which concerns the attributes of the study area was analyzed using ArcGIS 10.5 and classified in to non-built-up areas and bare surfaces and water bodies. The findings of this study reveals that, the built-up area has shown the most dramatic growth, with a shift from 25% to 53% over the 24-year period and farmland had experienced the largest decline, suggesting land conversion to urban or other non-agricultural uses. The findings also show that the reduction in vegetation and slight decline in rock outcrop indicate environmental impacts of human activities. The study concluded that Gombe metropolis has experienced significant urban growth in the past two decades, primarily driven by population growth, economic activities, and migration. It was also recommended that, there is a critical need for better urban planning policies to ensure sustainable growth.

Keywords: *Spatial, Temporal and Urban Expansion.*

Introduction

Urbanization is extremely related to increase productivity, consumption and new innovations (UN Habitat, 2015). It also has the capacity to impede the provision of basic services such as education, health, water and job opportunities for the nearly 1 billion urban poor who lives in shanty settlements (World Bank, 2019). Globally, urban areas account for just 3% of the total earth's surface, the ecological footprints associated with urban expansion has important environmental concern. Urban growth occurs on fertile agricultural lands, forests and is generally associated with increased energy use and pollution. The increase impervious surface associated with urban land conversion also lead to decrease infiltration, high surface runoff and sedimentation. It also leads to fragmentation of landscapes, destruction of environment and reduction in biodiversity (United Nations Conference on Trade and Development, 2018). This fact makes a thorough understanding of the factors driving urban expansion necessary to global environmental change researches and urban development agenda.

Urban expansion as a process of land use change in urban areas is a complex socio-economic phenomenon that is linked to geography, transport system, land use, economy and social structure. It is also regarded as urban growth, to imply the extension of urban built-up to the surrounding areas whose functions are basically non-agricultural (Yimam, 2017). This process of urban spatial growth is a vibrant phenomenon occurring in both developed and developing countries. The major forces behind rapid urban expansion in African cities are basically natural population growth, rural-urban migrations and economic growth (UN Habitat, 2015). This growth is believed to have caused more harm than good to the urban populace in the area of good health, education, housing, sanitation, transport and culture (UN Habitat, 2015). There has been a renewed focus on the studies of urban systems in the last few decades, as urbanization remains a major developmental problem exerting pressure on global sustainability agenda (UN Habitat, 2015).

Urban sprawl in Gombe metropolis is a result of population growth, frequent human activity such as industrialization, migration from rural to urban areas, and resettlement, all of which alter local and regional LULC patterns (Ridd&Hipple, 2006; and Bhatta, 2010). Most urban centers have been impacted by these changes, either directly or indirectly, as a result of a variety of environmental issues (Palmate *et al*., 2017; Abd-el-Hamid *et al*., 2020; and Koko *et al*., 2020). Aging, water bodies, woods, and other vegetated green spaces and barren land loss can exacerbate urban problems such as population density and housing conditions (Yang, 2011). According to Wakirwa (2015), all cities in Nigeria are experiencing sprawl, and Gombe is no exception, owing to the scale and type of development on some of the shape the landscape. metropolis's most agriculturally productive land. The metropolis's built-up area has increased dramatically in recent decades, absorbing previously agricultural land at an alarming rate Mbaya, 2012). This is a result of unchecked population growth (Alabi, 2009).

Statement of Research Problem

In recent decades urbanization and consequential expansion of urban areas have become the central focus of development agenda. This phenomenon continues to attract considerable amount of interests from academia and overall global, regional and national socio-economic planning. For instance, in United States some popular researches on urban expansion include: such studies by Redman & Jones (2015) which focused majorly on the environmental and social implication of urban expansion and sprawl in most cities in the country. Similarly, in China studies like that of Guangdong *et al*. (2018). Sumari *et al*. (2017) and Qiurong *et al*. (2018) focused on the quantitative analysis of the determinants of urban expansion in Chinese cities. Equally, Kaifang et al. (2016) and Andrea (2015) concentrate on economic impacts of urbanization and rapid spatial expansion in Indonesia's Java Mega metropolis. Whereas, in Nepal and India the works of Sunita (2013) and Lehner *et al*. (2016) geared toward Modeling Urban Growth in Kathmandu Valley and Ahmedabad with emphasis on the potentials of remote sensing in urban planning and India's Smart Cities Mission. Equally, in Portugal the study by Eduardo *et al*. (2018) focused on the effects of spatial proximity on urban growth in Torres Vedrasmetropolis a municipality in the Portuguese district of Lisbon. "Likewise, in Africa researches were also carried out to further examined the manifestation of urban expansion in different parts of the continent, Although, most of these studies focused more on the evaluation of inter-relationships between urbanization and urban agriculture, urban planning and infrastructural growth; For instance, the work of Alison (2017), Patrick *et al*. (2015), Ahlam (2017) and Richard (2015). Moreover, in Nigeria considerable amount of interests were vested in studying the growth of cities from different parts of the country, many studies have been conducted including those by; Benedine *et al*. (2017) which focused on geospatial analysis of urban expansion and its impact on vegetation cover; Ademola *et al*. (2017) the determinants of urban land use change.

Urbanization has significantly transformed Gombe metropolis since it became the state capital in 1996, leading to the conversion of vast croplands, vegetation, and other prime areas into urban structures. The majority of research on the effects of urbanization has focused on identifying patterns of development and how they affect the city, with significant vegetation loss and the growth of the built-up area extending into the suburbs of Gombe city. Most of these studies have focused on socioeconomic and human activities, which have resulted in significant changes in the town's spatial distribution and expansion. Most of these studies cover the years 1996 to 2016, (Wakirwa, 2015; Maina, *et al*., 2017; Gadiga & Galtima, 2017; Hashidu & Muhammed, 2018a, b; Mbaya, at el., 2019; Muhammed, 2020). But this study fills in the gaps by examining the extent of urban spatial growth and determining the main drivers of this rapid expansion from 1999 to 2023.

Study Area and Methodology

Location, Position and Extent

Gombe is located on latitude $10^0$16'00''N to $10^0$19'00''N and longitude 11^0 08'00''E to $11^0$12'00''E as in Figure 1. It has an average altitude of about *500m* above sea level and covers an area of *175.94km*^{2}. Gombe metropolis is well linked by road to other regional centres like Biu/Maiduguri, Potiskum/Damaturu, Bauchi/Jos, Kari/Kano and Kumo/Yola.

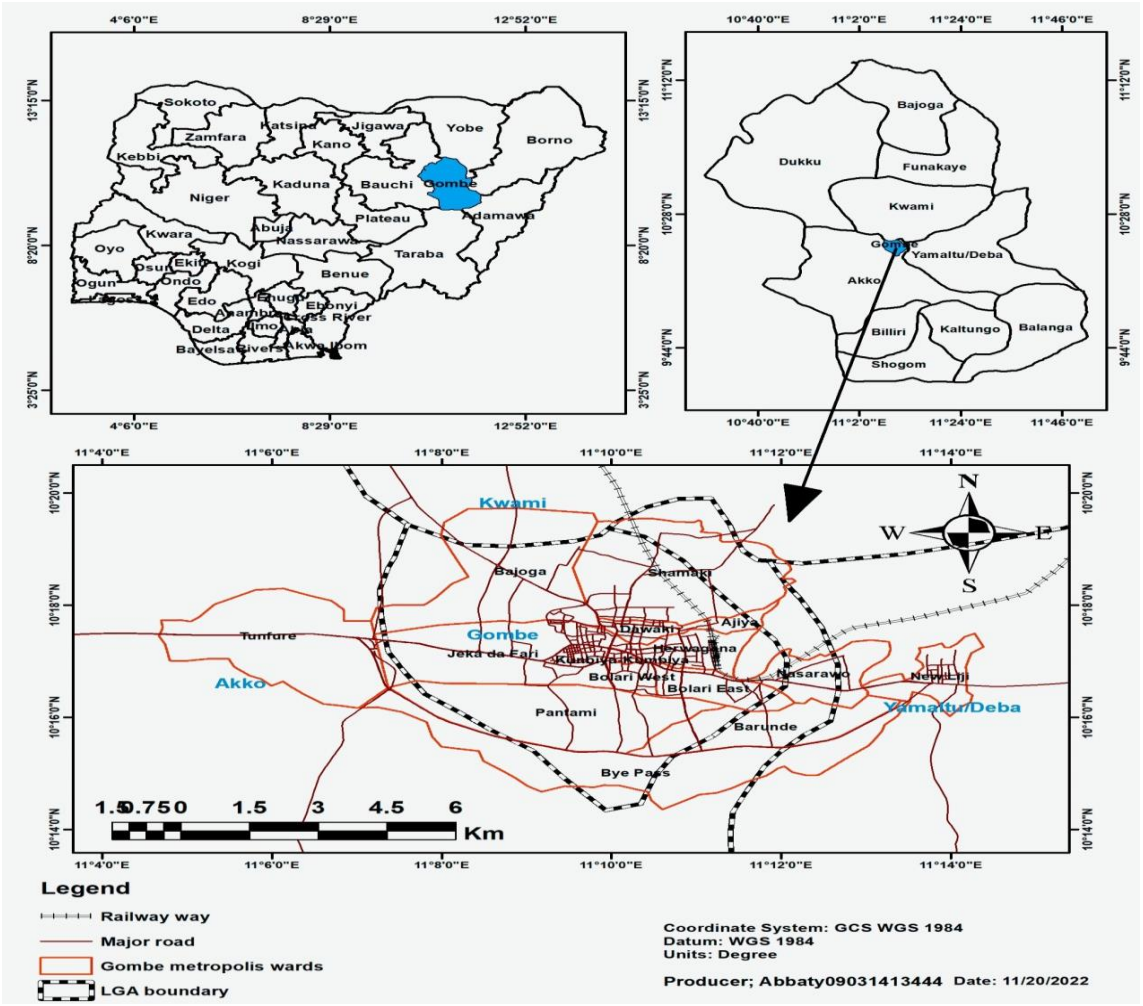


Fig 1: Study Area Gombe Metropolis
Source: Digitized and Clipped from Administrative Database/Nigerian Shape File (2016)

Methodology

Types and Sources of Data

Geospatial Data

The geospatial data comprising of four Land sat satellite imageries of the study area covering the entire period of this research (starting from 1999, 2006, 2011 and 2023).

Sampling and Techniques

For the purpose of this study, Gombe metropolis was divided into four sections, ABC and D for easy analysis as follows; section A, covered all the newly established areas in the northern part of the metropolis comprising, Arawa, Gurama Quarters, Federal Low-Cost, Orji Estate and others areas; section B this covers the southern section of the metropolis comprising of Tumfure, Investment Quarters, Labor Quarters, Kumbiya Kumbiya, and others areas, section C also covers the eastern part of the metropolis specifically Government Reservation Area (GRA),Nayinawa, By-pass and Pantami and finally, section D, which made up the western parts of the metropolis including; Lamido Quarters, Faruk Quarters, Liji, and BCGA, areas where most of the expansions are infill in nature.

Method of Data Collection

i. Field Observation

Direct observation was carried out across all the sections of the metropolis in order to identify all the areas affected by the urban expansion. This exercise allowed the researcher to collect the spatial information, record pictures and ascertain the data regarding the physical characteristics of the study area including the types and arrangement of built-up structures in the area.

ii Interpretation of Satellite Imageries

Satellite imageries were very fundamental tools for land use and land cover change studies nowadays. They are used to provide more accurate and precise information (location, extent and distribution) of the phenomenon under study. In order to study and measure the trend in urban spatial and temporal expansion, satellite imageries of Gombe metropolis for the years 1999, 2011 and 2023 were downloaded from the United States Geological Survey (USCS) Earth explorer website www.usgs.gov. These imageries were used to produce the past and present land cover and land use in the study area.

However, Google earth images of the study area were also used to supplement the information obtained from both the field observation and interviews. They were used in ground truthing of the new urban developments that occurred in the area and in determining the nature of such development, as whether they are leapfrog, clustered or even an infill type of developments.

Method of Data Analysis

The analysis of the data collected for this study was carried out in the following manners. The Geospatial data which concerns the attributes of the study area was analyzed using ArcGIS 10.5. The software for all the satellite imageries of the study area before analyzing the Land sat data for detecting the rate of expansion some analytical procedures were employed to avoid producing inaccurate outcome and to ensure that errors that were introduced into the imageries during the

acquisition process are corrected and the data is radio metrically and geometrically normalized to depict the landscape as near accurate as possible, among these analytical procedures are;

i. **Geometric Correction and Radiometric Normalization:** Distortions are usually introduced into the satellite data due to several factors including, earth's rotation during the satellite movement, the angle of view of the sensing system, the topography beneath the satellite, change in altitude of the satellite during data acquisition (Ahmed, et al, 2013). The distortions introduced into the data were corrected using two major approaches namely: image to map transformation, using control points or image to image co-registration. It involves the registration of one or more satellite images of the same geometric and geographic location to a reference image, in such a way that all corresponding terrain features appear on the same location on the two images. In this work, the Land sat imagery of 2023 was used as the reference image in order to correct the anomalies observed in the preceding imageries of 2011and 1999.

ii. **Image Classification System:** the image classification system used in this research was limited to two classes of land use and land cover categories namely: Non-built up areas; which comprises of all the areas that are not built-up, like vegetation (forest, crop lands and grass land), bare surfaces and water bodies (water lodge areas). The Built-up areas; which comprises of all the built-up environments such as; residential areas, market spaces, industrial zones, recreational areas (parks, gardens, etc.) institutional (banks, schools) roads, and social centers.

Results and Discussions

This section presents and analyzes the data collected from the Geographic Information System (GIS)-based land use and land cover (LULC) analysis. The GIS-LULC analysis, covering the period from 1999 to 2023, highlights the physical transformations in land use and land cover, illustrating the extent of urbanization.

Land Use/Land Cover Trends

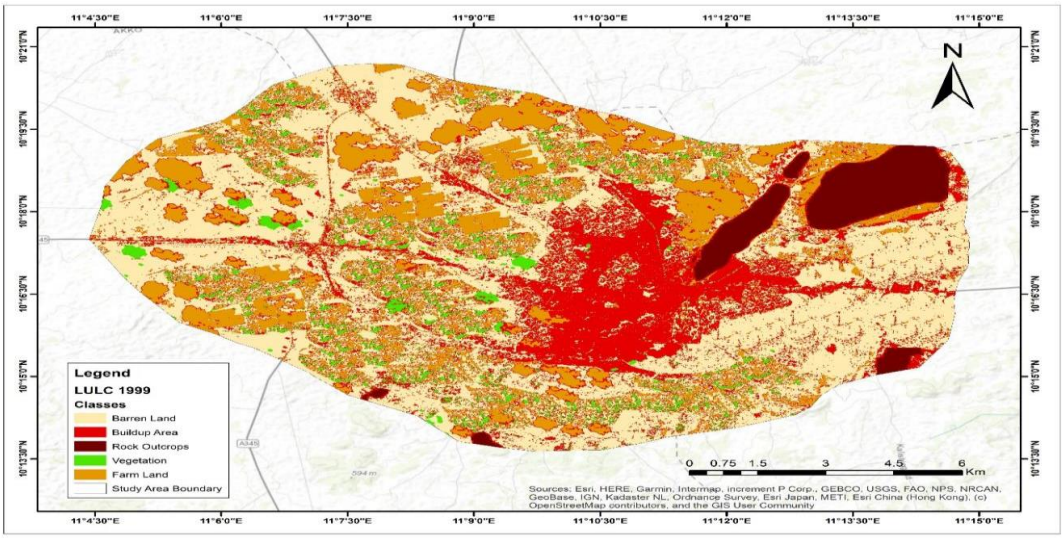
1. **Barren Land**
    - 1999: 42%
    - 2011: 38%
    - 2023: 35%

Trend: Continuous decline over time, likely replaced by other land uses, possibly urban development or agricultural activities.

2. **Built-up Area**
    - 1999: 25%
    - 2011: 35%
    - 2023: 53%

Trend: Steady increase, reflecting significant urbanization or infrastructural expansion.

Fig 2: Landuse/ Landcover Map of Gombe Metropolis in 1999



Source: Data Analysis (2024)

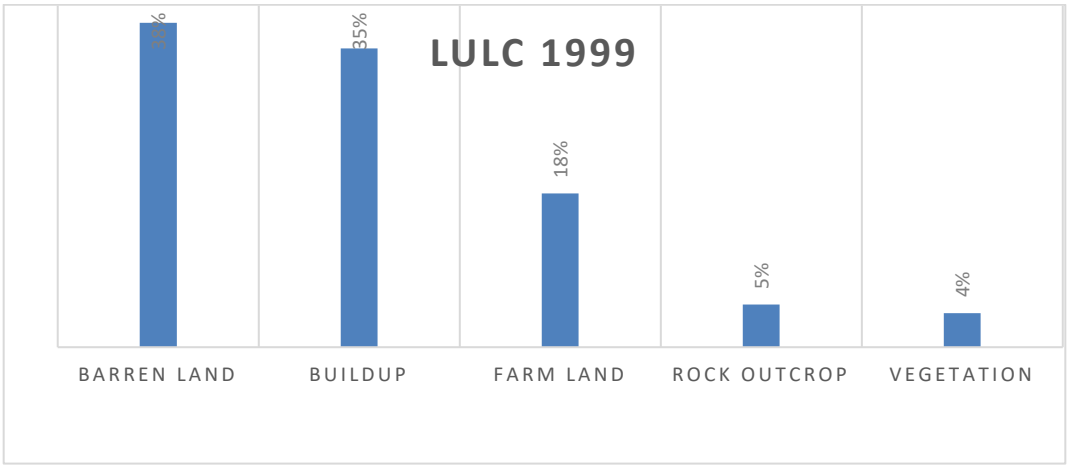
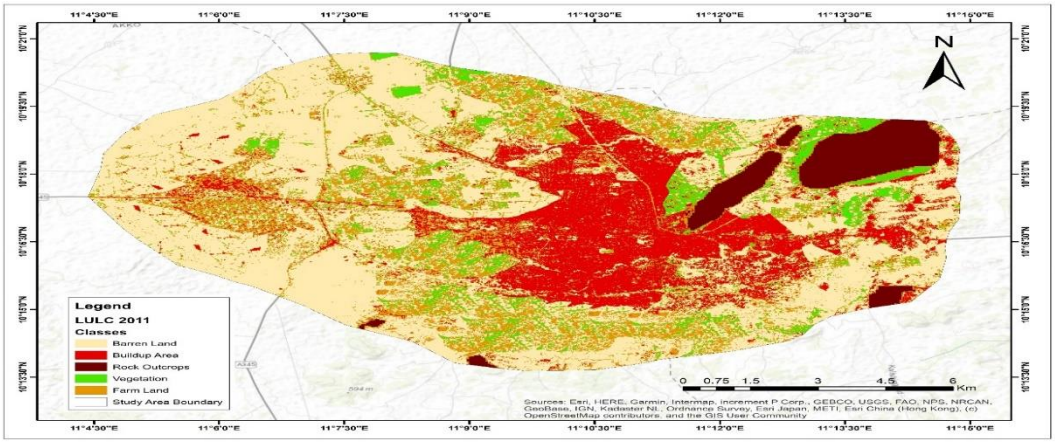


Fig 3: Landuse/ Landcover Map of Gombe Metropolis in 2011



Source: Data Analysis (2024)

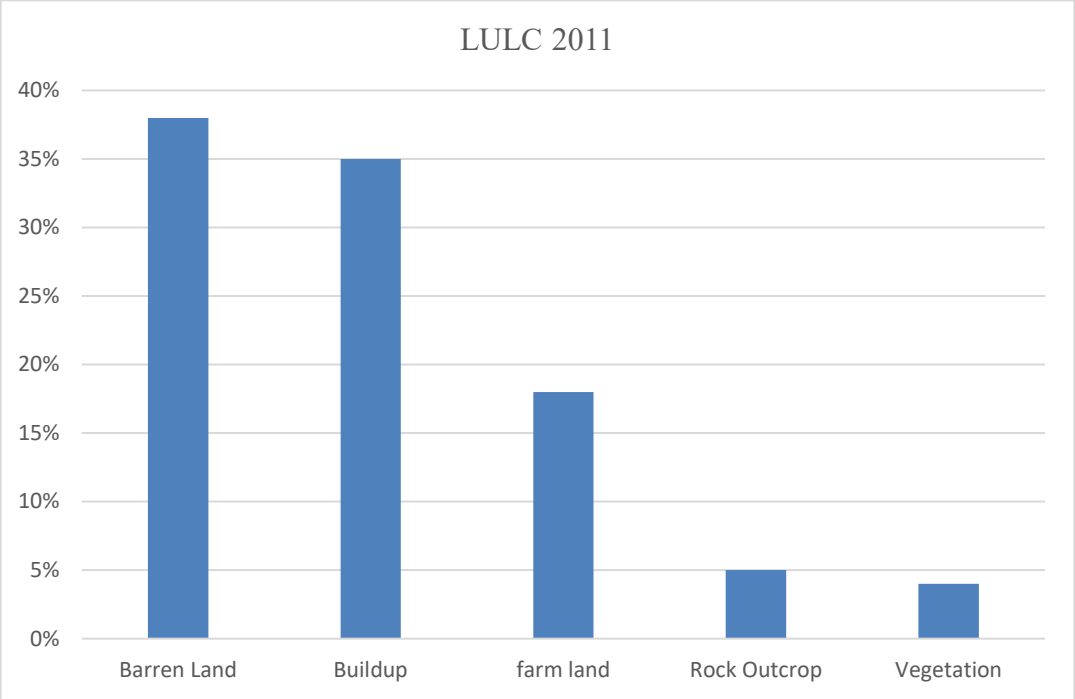
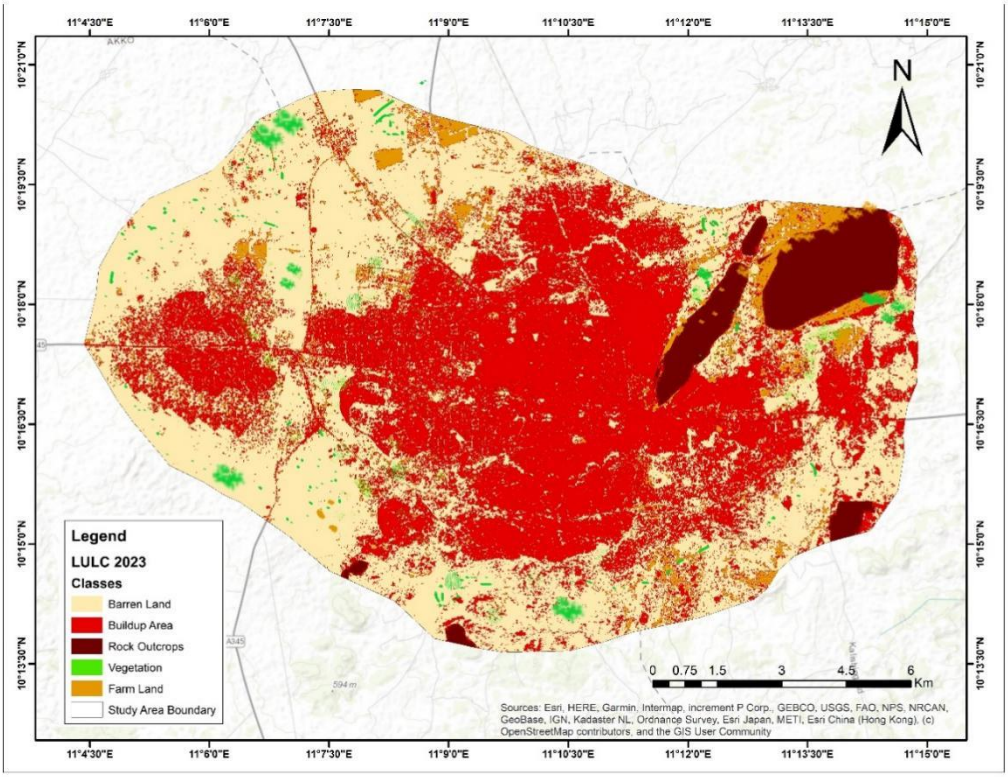
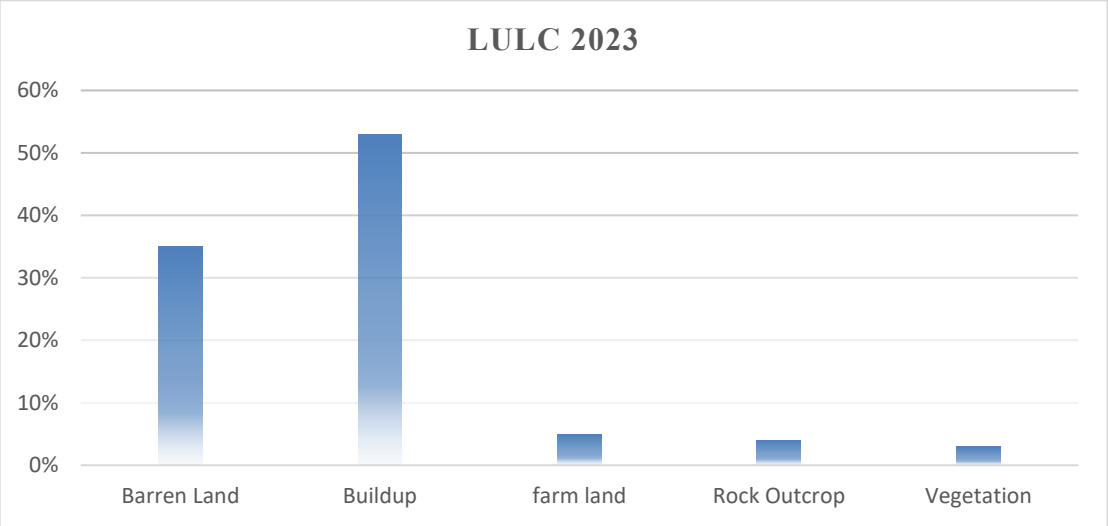
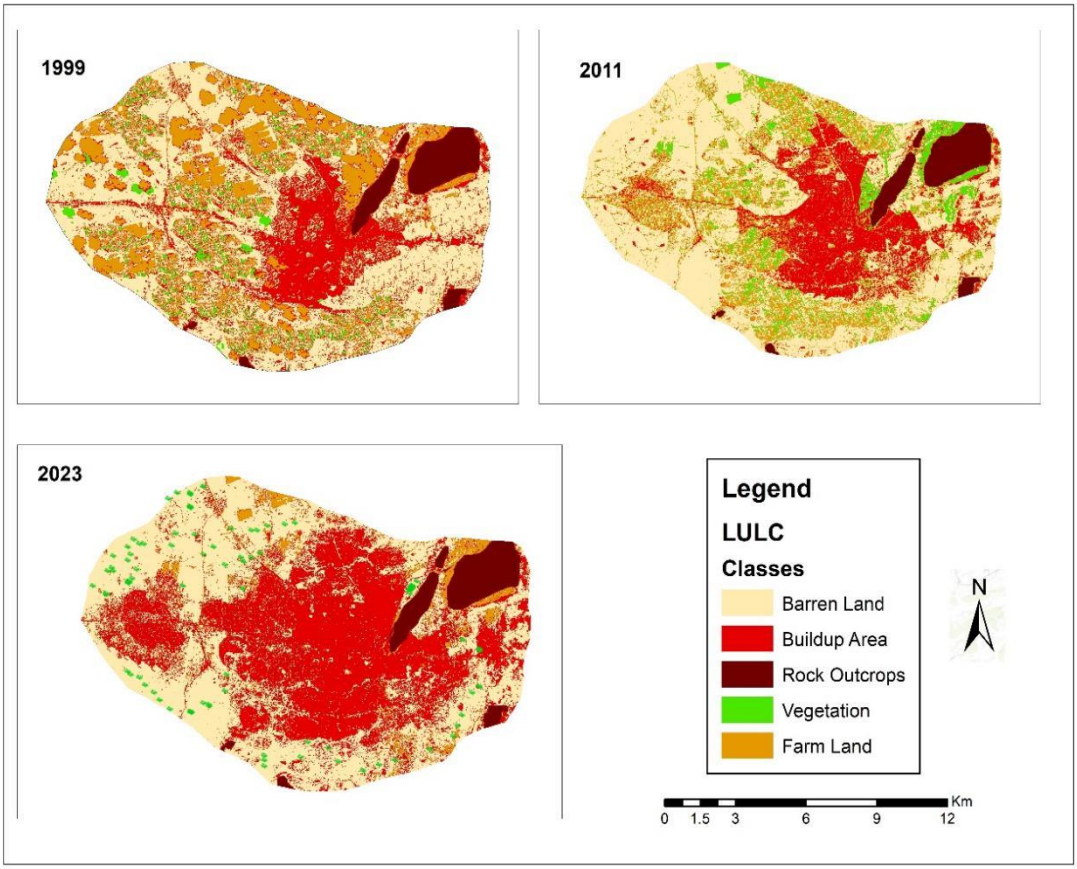


Fig 4: Landuse/ Landcover Map of Gombe Metropolis in 2023

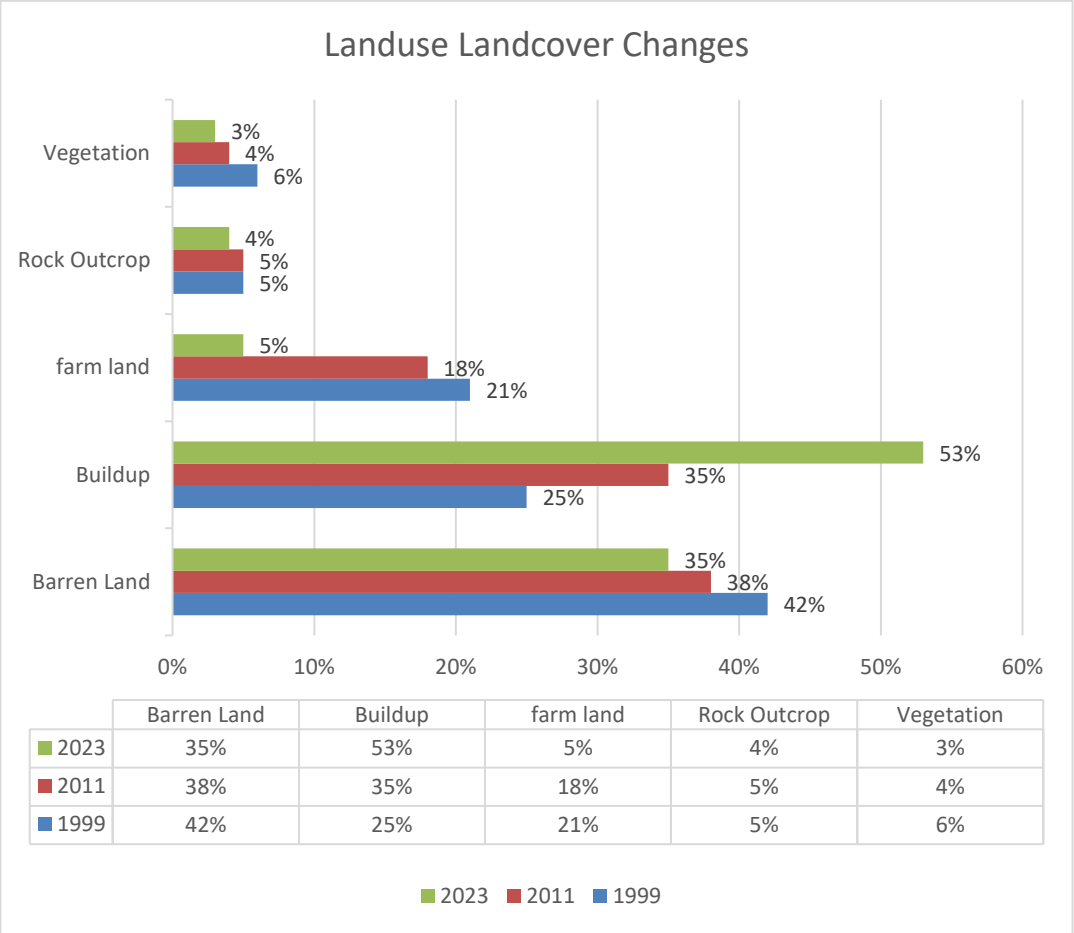


Source: Data Analysis (2024)





Source: Authors Data Analysis (2024)



	Barren Land	Buildup	farm land	Rock Outcrop	Vegetation
2023	35%	53%	5%	4%	3%
2011	38%	35%	18%	5%	4%
1999	42%	25%	21%	5%	6%

Source: Authors Data Analysis (2024)

3. **Farmland**
   - 1999: 21%
   - 2011: 18%
   - 2023: 5%

Trend: Sharp decline, indicating possible conversion into built-up areas or other uses.

4. **Rock Outcrop**
   - 1999: 5%
   - 2011: 5%
   - 2023: 4%

Trend: Relatively stable with a slight decrease.

5. **Vegetation**

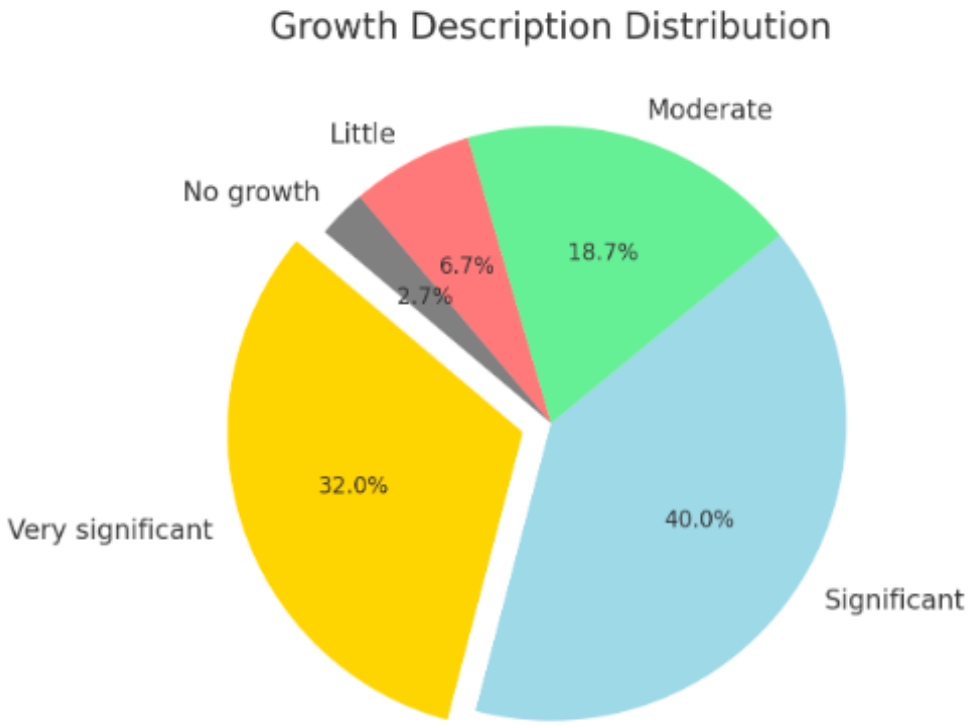
   - 1999: 6%
   - 2011: 4%
   - 2023: 3%

Trend: Gradual reduction, potentially due to deforestation or land-use change.

- The built-up area has shown the most dramatic growth, with a shift from 25% to 53% over the 24-year period.
- Farmland has experienced the largest decline, suggesting land conversion to urban or other non-agricultural uses.
- The reduction in vegetation and slight decline in rock outcrop indicate environmental impacts of human activities.
- The decrease in barren land aligns with increased land utilization for urban or industrial purposes.

Growth of Gombe Metropolis (1999–2023)

Fig 5: Growth of Gombe Metropolis (1999–2023)

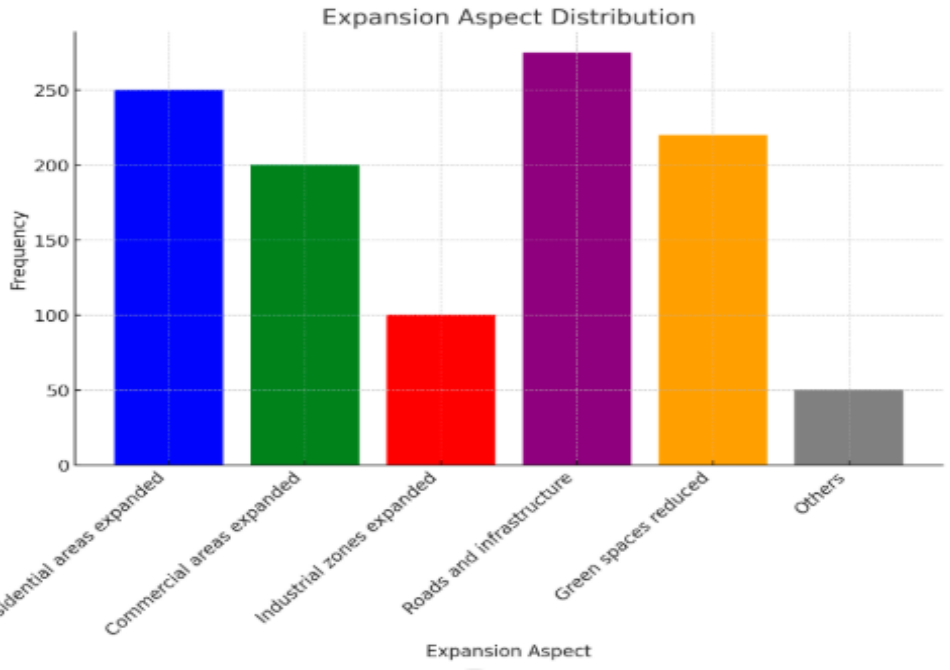


Source: Authors Field work (2024)

Spatiotemporal Expansion of Gombe Metropolis

The majority of respondents (40.00%, 150) rated the growth of Gombe Metropolis over the past two decades as "Significant," while 32.00% (120) described it as "Very Significant." This indicates that over 70% of participants perceive notable urban growth. A smaller proportion reported "Moderate" growth at 18.67% (70), while only 6.67% (25) and 2.67% (10) observed "Little" or "No Growth," respectively. These findings reflect a general consensus about substantial urban expansion during this period.

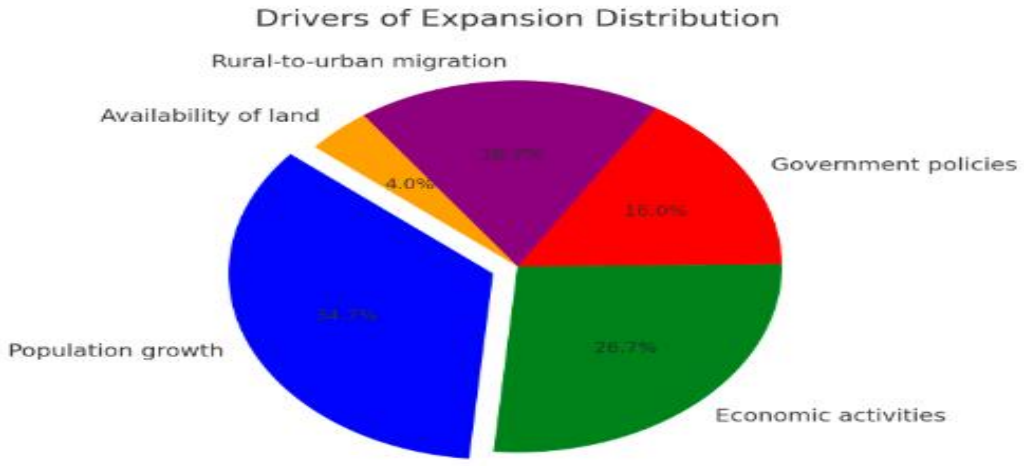
Fig 6: Spatial Expansion Aspects (Multiple Responses)



Source: Authors Field Work (2024)

The most prominent aspect of spatial expansion in Gombe metropolis is the development of roads and infrastructure, reported by 73.33% (275) of respondents. Residential area expansion is the second most observed change, with 66.67% (250) affirming its growth. The reduction of green spaces is another significant trend, noted by 58.67% (220). Commercial area expansion follows at 53.33% (200), while industrial zone expansion is less common, with only 26.67% (100) noting it. Other aspects, such as unspecified changes, were mentioned by 13.33% (50). These responses underline that infrastructure, housing, and environmental degradation dominate the urban landscape change.

Fig 7. Primary Driver of Urban Expansion



Source: Authors Field Work (2024)

Population growth emerges as the most cited driver of urban expansion, with 34.67% (130) of respondents identifying it as the primary factor. Economic activities rank second, with 26.67% (100) attributing urban growth to business and trade. Rural-to-urban migration accounts for 18.67% (70), indicating the role of internal migration. Government policies, such as planning and zoning, were identified by 16.00% (60), while availability of land was the least cited factor at 4.00% (15). These results suggest that population dynamics and economic opportunities are the key forces shaping urbanization in Gombe metropolis.

Conclusion And Recommendations

The study concluded that Gombe metropolis has experienced significant urban growth in the past two decades, primarily driven by population growth, economic activities, and migration. The expansion of residential, commercial, and infrastructural areas has transformed the metropolis, although this growth has not been without its challenges. The GIS-based LULC analysis also provided valuable insights into the spatial aspects of urbanization, complementing the findings from the survey and helping to visualize the extent of land use changes. The reduction of green spaces, in particular, points to the environmental costs of urban expansion. It was also recommended that, there is a critical need for better urban planning policies to ensure sustainable growth. These policies should address the expansion of residential and commercial zones, with a focus on preserving green spaces.

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