Mapping the Spatial Distribution and Extent of Land Use of Benue State University, Makurdi Main Campus, Benue State, Nigeria

Alex S. Ortese [1] I. K. Samaila[2] Innocent E. Bello [3] M. Alkali[4] A. Mahmud[5]
[1]Department of Geography,
Nasarawa State University, Keffi, Nigeria
Email: ortesesesugh72@gmail.com
[2]Department of Geography,
Nasarawa State University, Keffi, Nigeria
Email: ikunden@ymail.com
[3]NASRDA, Obasanjo Space Centre,
Airport Road, FCT-Abuja, Nigeria
Email: innobello@gmail.com
[4]Department of Geography,
Nasarawa State University, Keffi, Nigeria
Email: madaki@nsuk.edu.ng

DOI: 10.56201/ijgem.vol.12.no7.2026.pg142.151

Abstract
This study examined the spatial distribution and extent of land use types within Benue State University (BSU), Makurdi Main Campus, using Geographic Information System (GIS) and remote sensing techniques. Satellite imagery obtained from the National Space Research and Development Agency (NASRDA) was processed and analyzed in ArcGIS 10.8. Land use classification was achieved through on-screen digitization supported by intensive field survey and ground-truthing. The results reveal a heterogeneous land use structure with a total mapped area of 166.69 hectares. Agricultural land use dominates with 20.35%, followed by residential (15.24%) and forest cover (12.29%). Environmentally sensitive land uses, including forestry, green areas, and marshlands, collectively account for 29.18% of the total mapped area, indicating significant ecological value. Institutional land uses (administrative, educational, and religious) account for 15.50%, while commercial and mixed uses constitute 9.29%. The findings highlight a semi-urban institutional landscape undergoing gradual transformation, with increasing development pressures. The study demonstrates the effectiveness of GIS in land use planning and recommends sustainable land management strategies to balance development with environmental conservation.

Keywords: *Land Use, GIS, Remote Sensing, Spatial Analysis, University Campus, Nigeria*

1. Introduction

land use is used to describe the human use of land (US EPA, 2023). It represents the economic and cultural activities (e.g., agricultural, residential, industrial, mining, and recreational uses) that are practiced at a given place. Public and private lands frequently represent very different uses (US EPA, 2023; Neal-Fogle, 2023). Kent (2021) considers land use to refers to the function or purposes related to how humans use the land. Land use is subject to zoning and other regulations. Some

examples of land use include agriculture uses like growing crops and ranching, residential uses like houses, condos, and apartments, for commercial and business uses like shopping malls and offices. Land use involves the management and modification of natural environment or wilderness into built environment such as settlements and semi-natural habitats (Hualou *et al*., 2021).

According to US EPA (2023), land use differs from land cover in that some uses are not always physically obvious (e.g., land used for producing timber but not harvested for many years and forested land designated as wilderness will both appear as forest-covered, but they have different uses). Land use changes occur constantly and at many scales, and can have specific and cumulative effects on air and water quality, watershed function, generation of waste, extent and quality of wildlife habitat, climate, and human health. Land use is an issue that impacts everyone in a community. The way that land is used is a key factor in how far one must travel to get to the store, work, school or medical facilities. It plays a key role in the amount of traffic in the neighborhood. It directly influences the sights, sounds and smells that surround one's residence. It affects the ability to make and grow a livelihood, and the likelihood for a community to be economically vibrant. Land uses impact the natural environment. As such, land uses (and land use regulations) that are conceived and developed without any consideration of the surrounding community and corresponding stakeholders can have far reaching and long-lasting implications (Neal Fogle, 2023). Land use planning is a critical component of sustainable development, particularly in rapidly expanding institutional environments such as university campuses. Universities often exhibit complex land use patterns that combine residential, academic, administrative, commercial, and ecological functions within a limited spatial extent.

The application of Geographic Information Systems (GIS) and remote sensing has significantly enhanced the ability to map, analyze, and monitor land use patterns with high accuracy. These technologies provide a robust framework for spatial decision-making, enabling planners to optimize land allocation and improve environmental management. Benue State University, Makurdi Main Campus, represents a dynamic institutional landscape experiencing increasing developmental pressure. Understanding its land use structure is essential for effective planning and sustainable management. This study therefore aims to identify, map, and analyze the spatial extent of land use types within the campus using GIS techniques.

2. Materials and Method

2.1 Study Area

The Benue State University, (BSU) campus is located in Makurdi the Capital City of the State in the Central Region of Nigeria (Adama and Olalekan 2011). Makurdi Town lies approximately between latitudes 7^0 37' 30'' and 7^0 43' 00'' North of the equator, and longitudes 8^0 30' 00'' and 8^0 37' 00'' East of the Greenwich Meridian. The University is located by the bank of river Benue in the Benue trough (see Figure 1). The University was founded by Rev. Fr. Moses Orshio Adasu. It is near the southern bridgehead of the Benue River on sandy alluvial formation.

Makurdi experiences a tropical wet-and-dry (Aw) climate characterized by high temperatures throughout the year, with average temperatures ranging between 23°C and 39°C. The area has two distinct seasons: a rainy season from April to October and a dry season from November to March, influenced by the Harmattan winds. Humidity is generally high during the rainy season and lower during the dry season (Weather Atlas, 2024)**.** Rainfall in Makurdi follows a unimodal pattern, beginning in April and ending around October, with peak rainfall occurring in August and September. Annual rainfall ranges between approximately 1,120 mm and 1,800 mm, supporting extensive agricultural activities in the area. The wet season accounts for most of the annual

precipitation, while the dry season experiences little or no rainfall (Nigeria Geological Survey Agency [NGSA], n.d.). Makurdi is drained primarily by the Benue River, one of Nigeria's largest rivers, which divides the town into northern and southern sections. Several tributaries and streams, including the Idye, Urudu, Demepe, Kereke, Mu, and Kpege streams, contribute to the drainage network. The extensive river system supports irrigation, fishing, transportation, and seasonal floodplain agriculture (Adikwu et al., 2025). The vegetation of Makurdi falls within the Southern Guinea Savanna ecological zone, characterized by tall grasses and scattered deciduous trees. Common vegetation includes grasses reaching up to 2 meters in height, interspersed with shrubs and drought-resistant trees. This vegetation type supports farming, livestock grazing, and biodiversity conservation (Adebayo et al., 2024). Makurdi lies within the Benue Trough and is mainly underlain by Cretaceous sedimentary formations, particularly the Makurdi and Eze-Aku Sandstone Formations. The area contains thick sandstone deposits, fluvio-deltaic sediments, alluvial soils, limestone, and marble deposits. These geological formations influence soil development, groundwater occurrence, and construction suitability in the region (Nigeria Geological Survey Agency [NGSA], n.d.).

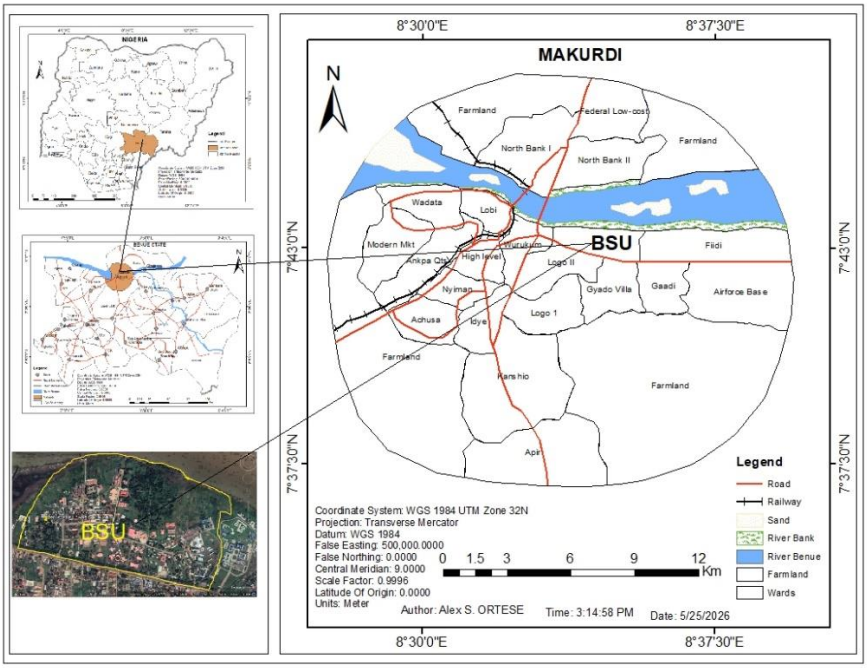


Figure 1: Location of Benue State University Main Campus in Makurdi

2.2 Methodology

The existing plan of the University containing surveyed parcel boundaries, corners and monument was obtained from Benue State University Physical Planning Unit, Handheld Garmin eTrex10 GPS receiver device was used to capture coordinates of the land use types. Satellite imagery of the study area was obtained from the National Space Research and Development Agency (NASRDA). Additional data (attribute data) were acquired through field survey and ground-truthing to validate land use classifications.

2.2.1 Data Processing and Analysis

The acquired satellite image was imported into ArcGIS 10.8, where georeferencing was performed using the Universal Transverse Mercator (UTM) Zone 32 coordinate system. On-screen digitization was conducted to delineate land use features into polygons, while point and line features (e.g., electrical poles, roads, reservoirs) were also mapped.

The geometric area calculation tool in ArcGIS was used to compute the spatial extent of each land use category in hectares. The resulting data were analyzed to determine the proportional distribution of land use types across the campus.

3. Results and Discussion

3.1 Identified Land Use Types

As shown in table 1, a total of nineteen (19) land use types were identified within the study area. These include residential, administrative, educational, mixed-use, healthcare, agricultural, commercial, plantation, parking lot, utility, park, sports centers, green area, religious, marsh, dam, recreational, forestry, and banking land uses. The diversity of land use types reflects the multifunctional nature of the university environment, combining academic, social, economic, and ecological functions.

Table 1: Identified Land Use Types and Description

S/N	Land Use	Description
i	Residential	Staff quarters and student hostels
ii	Administrative	Offices
iii	Educational	Lecture halls, Class rooms, Laboratory, Library.
iv	Mixed	Offices, lecture hall, laboratory, Library among others.
v	Healthcare	University Clinic.
vi	Agricultural	Crops cultivation.
vii	Commercial	Provision stores, book shops, cybercafé, restaurant among others.
viii	Plantation	Palm trees, orange trees, mango trees
ix	Parking Lot	parking of vehicles in the campus.
x	Utility	Electricity, gas storage, water
xi	Park	Parks and garden.
xii	Sports Centers	Volleyball court, football peach, basketball court among others.
xiii	Green Area	Landscape
xiv	Religious	Churches.
xv	Marsh	Water log area
xvi	Dam	Water treatment.
xvii	Recreational	Senior staff club
xviii	Forestry	Forest reserve
xix	Banking	Banking activities

i. **Residential:** It is used to house individuals in various groups. There are many different types of residential land, including low-density housing, medium-density housing, high-density housing, and mixed-use development. Each of these types is categorized by how many individuals can be living on the land. In this case, it is staff quarters and student hostels

ii. **Administrative land use:** Administrative land use comprises office buildings and administrative facilities, administrative land use is the purpose a particular building in the campus as a land use is been put into. In that regard, the study refers to administrative land use as offices.

iii. **Educational land use:** Administrative land use comprises office buildings and administrative facilities, educational land use is land that is used for Lecture halls, Class rooms, Laboratory, Library.

iv. **Mixed:** This land use is a development approach that combines residential, commercial, and recreational areas within close proximity to create walkable communities. Instead of separating these uses, a mixed-use area integrates them into a single neighborhood or even a single building, allowing people to live, work, and shop without long commutes. This approach promotes convenience, walkability, and a more vibrant, sustainable urban environment. In this study, the emphasis is on the functions performed within a particular building. In this case, there is office, lecture hall, laboratory and others.

v. **Healthcare:** This land use type refers to the portion of land allocated and utilized for the purpose of healthcare facilities such as clinics and hospitals among other related facilities.

vi. **Agricultural:** This land use is the management of land for the cultivation of crops and raising animals for food and other resources. It includes activities like planting crops, raising livestock, and practices such as crop rotation, irrigation, and grazing. This type of land use can be classified into categories like cropland, grazing land, and bushland, and it is influenced by factors like human demand, environmental conditions, and transportation costs. In this study, it is the utilization of land primarily for cultivating crops which is basically for human consumption.

vii. **Commercial:** This type of land use refers to the designated land for business activities in an area. Administrative land use comprises office buildings and administrative facilities, this land use type here includes; provision store, book shops, restaurant Cyber Cafe and others.

viii. **Plantation:** Plantations are farms specializing in cash crops, usually mainly planting a single crop, with perhaps ancillary areas for vegetables for eating and so on. Administrative land use comprises office buildings and administrative facilities, the plantation land use was palm trees, mango trees, orange trees among others.

ix. **Parking Lot:** Parking lot land use is a specific zoning classification or function for an open area designated for the off-street, temporary parking or storage of motor vehicles. This type of land use is distinct from other development types due to its specific purpose, design requirements, and associated environmental impacts. In this study, these types of land use refer the allocation of areas for vehicle parking.

x. **Utility:** This type of land use refers to the designated land utilized for providing essential services such as electricity, gas, water and others. Administrative land use comprises office buildings and administrative facilities, it is land used for providing electricity and gas reservoir

xi. **Park:** This is a type of land use designated for public outdoor leisure functions and recreation. For this study, it is referring to the areas designated for student outdoor functions within the campus.

xii. **Sports Centers:** This type of land use is complex, requiring large areas of land and having significant impacts on urban planning and the surrounding environment. This type of land use refers to the areas designated and utilized by provision of sports facilities where people engage in sports and exercise to keep fit. This can be volleyball court, football peach, basketball court among others.

xiii. **Green Area:** This type of land use refers to the areas where vegetation is present which is designed for managing the landscape of the area. This also provide opportunities like ecological services and improved air quality.

xiv. **Religious:** This refers to the use of property for religious purposes, such as houses of worship, religious schools, and community centers. In this study, it is referring to places of worship and where Clergy residences.

xv. **Marsh:** Marsh is a wetland, an area where land is saturated with water which can be seasonal or permanent. It is characterized by poorly drained mineral soil and dominated by herbaceous plants.

xvi. **Dam:** Dam Administrative land use comprises office buildings and administrative facilities is where water is being collected and treated before dispatch for use.

xvii. **Recreational:** Recreational land use refers to the designation and utilization of land for leisure activities and enjoyment.

xviii. **Forestry:** Forest land use refers to how land is managed and utilized for forestry purposes. This encompasses various activities like timber production, conservation and recreation. But Administrative land use comprises office buildings and administrative facilities, it is for conservation and recreation.

xix. **Banking:** Administrative land use comprises office buildings and administrative facilities, banking as land use refers to a portion of land designated for banking activities activities

3.2 Land Use Mapping

The GIS-based mapping produced a detailed spatial representation of land use distribution across the University campus. Land use features were categorized into point, line, and polygon representations for clarity and analytical efficiency.

The resulting land use map demonstrates the capability of GIS and remote sensing in accurately modeling and visualizing complex spatial patterns. The findings align with previous studies that have successfully applied GIS techniques in institutional and urban land use analysis.

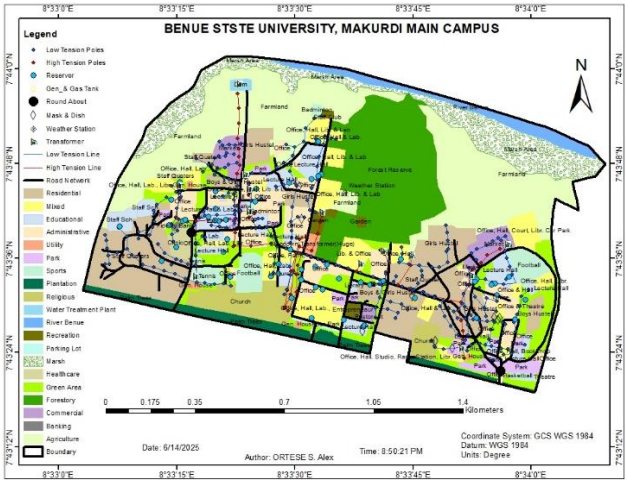


Figure 2: Land Use of Benue State University Main Campus

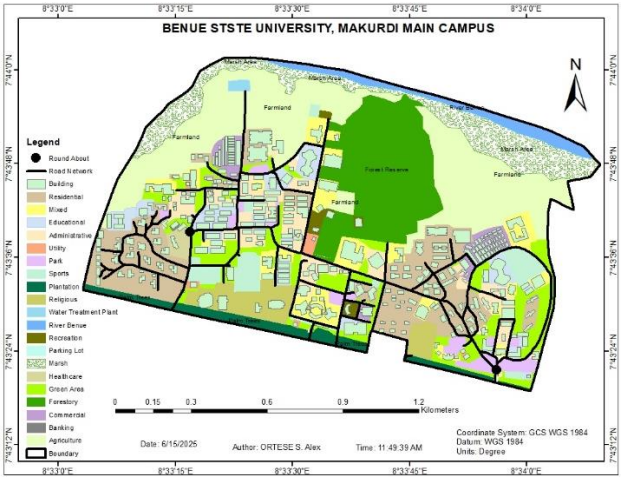


Figure 3: Buildings Overlay on Land Parcels

3.3 Extent of Land Use

The total mapped area of the campus is approximately **166.69 hectares**, characterized by a heterogeneous land use structure. The land use extent is presented in figure 4.

Agricultural land use constitutes the largest share at **33.92 hectares (20.35%)**, indicating the continued importance of agricultural activities within the campus. Residential land use follows with **25.40 hectares (15.24%)**, reflecting significant accommodation demand.

Environmental land uses are prominent, with forest cover (**12.29%**), green areas (**8.53%**), and marshlands (**8.36%**) collectively accounting for **29.18%** of the total land area. Institutional land uses (administrative, educational, and religious) together account for **15.50%**, indicating a well-developed organizational framework. Commercial and mixed-use land uses represent **9.29%**, suggesting emerging economic activities. Recreational and social infrastructure, including parks and sports facilities, account for a moderate proportion, while essential services such as healthcare, utilities, and parking occupy a relatively small fraction (**1.33%**). This implies that the land use structure reflects a semi-urban settlement pattern undergoing gradual transformation. While agriculture remains dominant, the significant share of residential and administrative land uses suggests increasing development pressures. Furthermore, the substantial proportion of environmentally sensitive land underscores the importance of integrating conservation measures into future development plans.

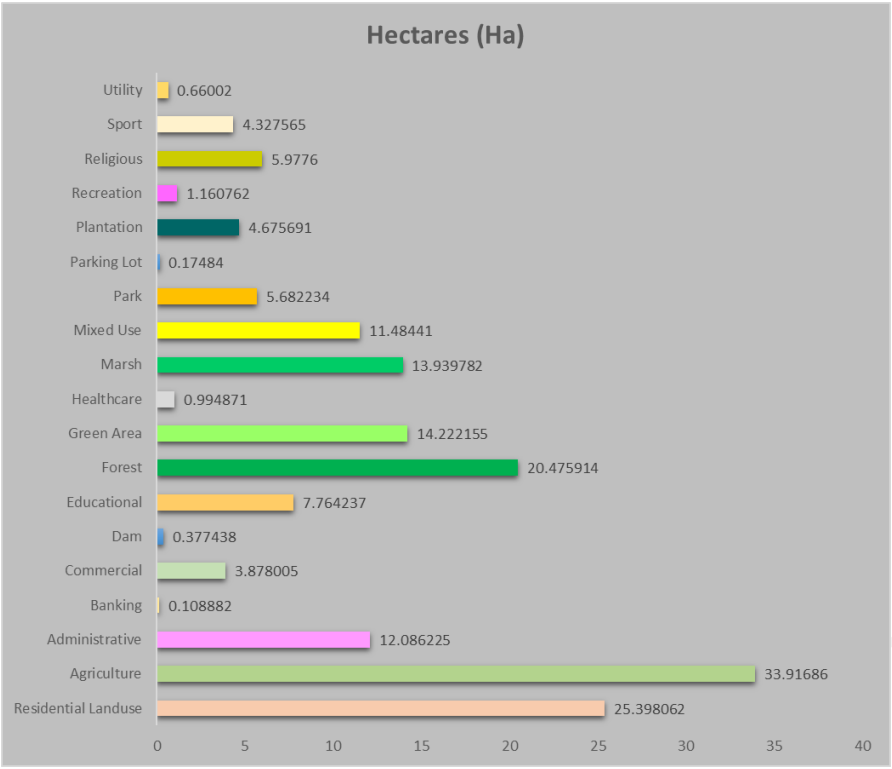


Figure 4: Spatial Extend of Land Use

4. Discussion

The results indicate that BSU Makurdi Main Campus exhibits characteristics of a semi-urban landscape undergoing gradual transformation. The dominance of agricultural land use suggests that, despite ongoing development, traditional land use practices remain relevant.

The significant proportion of residential and administrative land uses reflects increasing population pressure and institutional expansion. This trend is consistent with patterns observed in growing university environments where infrastructure development often follows rising student enrollment.

The presence of extensive environmentally sensitive areas highlights the ecological importance of the campus. These areas provide ecosystem services such as climate regulation, biodiversity conservation, and flood mitigation. However, increasing development pressure may threaten these resources if not properly managed. The relatively low proportion of commercial and service-related land uses suggests limited economic diversification within the campus, potentially resulting in dependence on external urban centers for certain services. In summary, the study underscores the importance of integrating GIS-based analysis into land use planning to ensure efficient resource allocation and sustainable development.

5. Conclusion

This study used GIS and remote sensing techniques to map and analyze land use patterns within Benue State University, Makurdi Main Campus. The findings revealed a diverse land use structure covering approximately 166.69 hectares, with agricultural land use accounting for the largest proportion (20.35%), followed by residential land use (15.24%). Environmentally sensitive areas, including forests, green spaces, and marshlands, constitute a significant portion of the campus, highlighting their ecological importance.

The study concludes that GIS is an effective tool for land use mapping, monitoring, and planning. The generated land use information provides a valuable basis for informed decision-making and sustainable campus development, ensuring a balance between infrastructural expansion and environmental conservation.

6. Recommendations

Based on the findings of the study, the following recommendations were made;

i. Implement GIS-based land use monitoring systems for continuous assessment and planning.
ii. Develop policies to protect environmentally sensitive areas such as forests and marshlands.
iii. Promote efficient land use through controlled expansion and mixed-use development.
iv. Enhance infrastructure planning to support increasing population and institutional needs.

References

Adebayo, A., Yusuf, M., & Ibrahim, S. (2024). *Socio-economic and environmental impact of sand mining on the floodplains of River Benue, Makurdi Town, Benue State, Nigeria*. *International Journal of Research and Innovation in Applied Science*.

Adama, A., & Olalekan, A. (2011). *Benue State University and its spatial development*. Makurdi: Benue State University Press.

Adikwu, P. I., Agber, S. O., & Okwori, E. T. (2025). Assessment of urbanization's environmental impact in Makurdi Metropolis, Benue State, Nigeria. *International Journal of Environmental Impacts, 8*(2), 218–230.

Bello, M. O., & Ikhuoria, I. A. (2015). GIS-based modeling of educational land use. *Journal of Environmental Planning, 12*(2), 45–60.

Hualou, L., Long, H., & Tu, S. (2021). Land use transition and sustainable land management. *Land Use Policy, 102*, 105251.

Kent, M. (2021). *Land use planning and management: Principles and practice* (3rd ed.). Routledge.

Kuznetsov, A., Ivanov, P., & Smirnov, D. (2021). GIS-based 3D modeling for urban health assessment. *Urban Science Journal, 8*(3), 112–125.

Neal-Fogle, R. (2023). *Land use and community planning*. Planning Advisory Service.

Nigeria Geological Survey Agency. (n.d.). *Geotechnical mapping of Makurdi and its environs*. Nigeria Geological Survey Agency. https://ngsa.gov.ng/geotechnical-mapping-of-makurdi-and-its-environs/

United States Environmental Protection Agency. (2023). *Basic information about land use and land cover*. https://www.epa.gov

Weather Atlas. (2024). *Climate and monthly weather forecast of Makurdi, Nigeria*. https://www.weather-atlas.com/en/nigeria/makurdi-climate