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Research Article

GIS-Based Multi-Criteria Landform Classification for Sustainable Land Use Planning in Makurdi, Gboko, and Katsina-Ala Areas of Benue State, Nigeria

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ABSTRACT

Understanding landform distribution is essential for sustainable land-use planning and environmental management, particularly in regions with diverse terrain such as Benue State, Nigeria. Despite the importance of terrain information for agriculture, settlement development, and environmental conservation, quantitative landform classification in many parts of the state remains limited. This study aims to classify and analyse the major landforms of Makurdi, Gboko, and Katsina-Ala areas of Benue State and examine their implications for sustainable land-use planning. A GIS-based Multi-Criteria Analysis (MCA) approach was employed using secondary spatial datasets, including a 30 m Digital Elevation Model (DEM), satellite imagery, geological maps, soil data, and hydrographic information. Terrain parameters such as slope, elevation, curvature, drainage density, and land cover were derived and integrated through weighted overlay analysis in a GIS environment to produce a landform classification map. The analysis identified four dominant landform types: plains, hills, valleys, and plateaus. Plains constitute the most extensive landform, covering approximately 52% of the study area, mainly in Makurdi and parts of Gboko. Hills account for about 23%, plateaus approximately 10%, while valleys associated with the Benue River and its tributaries represent about 15% and exhibit high drainage density and susceptibility to seasonal flooding. The study highlights the need for land-use planning strategies that align with landform characteristics. Plains should be prioritized for agriculture, while hills and plateaus are more suitable for controlled development and conservation practices. Valley areas require careful management due to flood risks, including improved drainage planning and restrictions on settlement expansion in vulnerable zones.

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1 Introduction

Landforms are natural physical features of the Earth's surface, such as plains, hills, plateaus, and valleys, formed through geological and geomorphological processes. They represent the visible expression of terrain and play a crucial role in shaping environmental conditions and human activities. Landforms represent the physical configuration of the Earth's surface and play a critical role in shaping environmental processes and human activities. They influence key environmental variables such as soil development, vegetation distribution, hydrological patterns, and land capability, thereby determining the suitability of land for agriculture, settlement, infrastructure development, and environmental conservation. In recent years, the importance of understanding landform distribution has increased due to growing concerns about land degradation, rapid urbanization, and the need for sustainable land-use planning, particularly in developing regions (Etuonovbe et al., 2021; Mahmud et al., 2021).

The classification of landforms provides a structured approach to analyzing terrain variability and spatial patterns. Contemporary studies emphasize quantitative and reproducible methods for landform classification, moving beyond traditional field-based techniques toward geospatial approaches that utilize Digital Elevation Models (DEMs) and satellite imagery. These methods enable the extraction of terrain parameters such as elevation, slope, curvature, and drainage characteristics, which are essential for identifying and differentiating landform units across landscapes (Mahmud et al., 2021; Okeke et al., 2022).

Furthermore, the integration of Geographic Information Systems (GIS) with Multi-Criteria Analysis (MCA) has enhanced the accuracy and reliability of landform classification. MCA allows for the combination of multiple terrain variables by assigning weights based on their relative importance, thereby producing spatially explicit and analytically robust landform maps. This approach has been widely applied in recent studies to support environmental assessment, land suitability analysis, and sustainable land-use planning (Rahman et al., 2019; Okeke et al., 2022).

Understanding landform distribution is particularly important for sustainable land-use planning, as different landforms present varying opportunities and constraints for land utilization. Plains are generally associated with gentle slopes and favourable conditions for agriculture, while hills and plateaus often require conservation-oriented land uses due to their susceptibility to erosion. Valleys, especially those associated with major river systems, are characterized by high drainage density and

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are prone to flooding, which significantly influences settlement patterns and infrastructure development. Incorporating these terrain characteristics into planning frameworks is essential for reducing environmental risks and ensuring efficient land resource utilization (Aiyelabegan & Nwokolo, 2022; Oladipo & Olayinka, 2023).

In Nigeria, increasing population pressure and expanding urban and agricultural activities have intensified the demand for land resources, often leading to unsustainable land-use practices. Benue State, located within the Lower Benue Trough, exhibits diverse geomorphological features shaped by geological structures and fluvial processes. The areas of Makurdi, Gboko, and Katsina-Ala are characterized by a mixture of plains, hills, plateaus, and river valleys, each influencing agricultural productivity, settlement distribution, and environmental stability (Etuonovbe et al., 2021; Aiyelabegan & Nwokolo, 2022). Despite the significance of these landforms, there remains a limited number of studies that provide quantitative, GIS-based landform classification for these areas, creating a gap in spatial information required for effective planning (Okeke et al., 2022).

Advances in GIS and remote sensing now provide an opportunity to address this gap by enabling the integration of multi-source spatial datasets for detailed terrain analysis and classification. These technologies facilitate the generation of reliable and reproducible landform maps that can support agricultural planning, urban development, flood risk management, and environmental conservation.

This study, therefore, applies a GIS-based Multi-Criteria Analysis approach to classify landforms in Makurdi, Gboko, and Katsina-Ala areas of Benue State, Nigeria. The objectives are to identify and map the major landform types, quantify their spatial distribution, and examine their implications for sustainable land-use planning.

2 Materials and Methods

2.1 Study Area

The study focuses on three urban and peri-urban areas in Benue State, North-Central Nigeria: Makurdi, Gboko, and Katsina-Ala. Benue State lies within the Lower Benue Trough, a Cretaceous sedimentary basin characterized by structural deformation, sedimentary formations, and diverse geomorphological features (Etuonovbe et al., 2021). The state is located approximately between latitudes 6°20′N and 8°08′N and longitudes 7°50′E and 10°00′E (National Bureau of Statistics [NBS], 2021).

Makurdi lies along the southern bank of the River Benue between latitudes 7°43′N–7°50′N and longitudes 8°28′E–8°35′E (Anyadike, 2021). Gboko is situated northeast of Makurdi between latitudes 7°19′N–7°35′N and longitudes 8°55′E–9°05′E, while Katsina-Ala lies further northeast between latitudes 7°05′N–7°20′N and longitudes 9°15′E–9°30′E. Together, these areas form a contiguous landscape influenced by similar geological and environmental conditions.

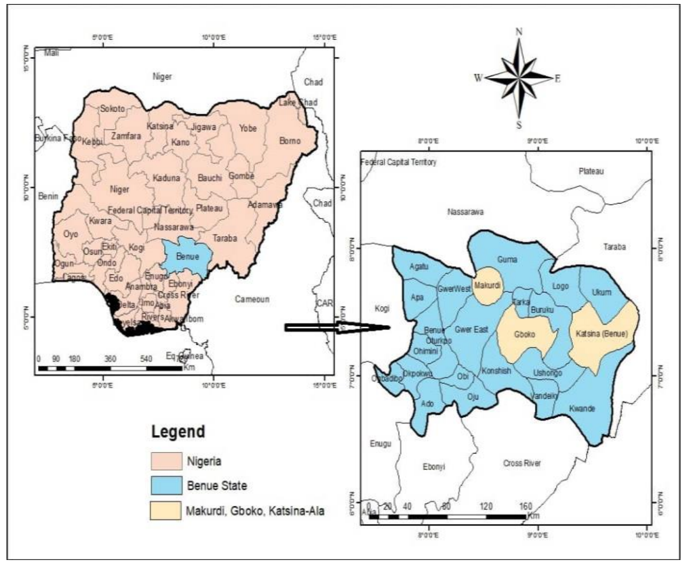

Figure 1: Location of Makurdi, Gboko, and Katsina-Ala within Benue State, Nigeria.

Source: Adapted and Modified from Administrative Map of Nigeria, 2026.

In terms of relief, the study area exhibits considerable variation in terrain. Makurdi is predominantly low-lying, characterized by extensive plains and floodplains with gentle slopes generally below 5°, making it highly suitable for agriculture but also vulnerable to flooding. Gboko, on the other hand, is dominated by undulating terrain with elevations ranging from approximately 201 m to 400 m above sea level, consisting mainly of hills and gently sloping uplands. Katsina-Ala presents a more dissected landscape, comprising valleys, rolling uplands, and localized plateau remnants, reflecting a more complex geomorphological structure. These variations in elevation and slope significantly influence landform distribution, soil development, and land-use patterns across the region (Aiyelabegan & Nwokolo, 2022).

The drainage system of the study area is largely controlled by the River Benue and its tributaries, including the Katsina-Ala River. These rivers play a crucial role in shaping the landscape through erosion, transportation, and deposition processes. Valley areas associated with these river systems are characterized by high drainage density and are prone to seasonal flooding, particularly during periods of intense rainfall. This hydrological characteristic has a strong influence on settlement patterns, agricultural activities, and infrastructure development (Oladipo & Olayinka, 2023).

Climatically, the study area falls within the tropical sub-humid zone, characterized by distinct wet and dry seasons. The wet season typically extends from April to October, while the dry season occurs from November to March (Ayoade, 2019). Mean annual rainfall ranges between 1,200 mm and 1,600 mm, supporting rain-fed agriculture, while average temperatures range from 24°C to 32°C, creating favourable conditions for crop growth and vegetation development (FAO, 2020). These climatic conditions interact with terrain and soil properties to influence erosion processes, vegetation cover, and land-use suitability.

Vegetation in the area is predominantly guinea savannah, consisting of grasses interspersed with scattered trees. However, this natural vegetation has been significantly modified due to agricultural expansion, urbanization, and other human activities. The reduction in vegetation cover in some areas has increased susceptibility to soil erosion, particularly on sloping terrains and in regions with intensive land use.

Socio-economically, the study area is characterized by rapid population growth, expanding urban centers, and intensive agricultural activities. Makurdi serves as the administrative and commercial hub of the state, while Gboko and Katsina-Ala function as important agricultural and residential centers. The economy of the region is largely agrarian, with crops such as yams, maize, rice, and soybeans widely cultivated. Increasing pressure on land resources due to population growth and urban expansion has led to changes in land use patterns, often without adequate consideration of terrain characteristics.

The interaction of geology, terrain morphology, drainage systems, climate, and human activities creates significant spatial variation in geomorphic processes across the study area. These characteristics, combined with increasing environmental pressures, make Makurdi, Gboko, and Katsina-Ala highly suitable for GIS-based landform classification and terrain analysis aimed at supporting sustainable land-use planning and environmental management.

2.2 Data Acquisition

This study employed secondary spatial datasets to perform a quantitative landform classification of Makurdi, Gboko, and Katsina-Ala areas (Table 1). The use of GIS-based desktop analysis enables comprehensive terrain assessment without the need for extensive fieldwork (Mahmud et al., 2021; Okeke et al., 2022).

Table 1: Spatial Data Sources and Characteristics

Data Type	Source	Resolution
Digital Elevation Model (DEM)	SRTM, USGS Earth Explorer (https://earthexplorer.usgs.gov/)	30 m
Satellite Imagery	Landsat 8, USGS Earth Explorer (https://earthexplorer.usgs.gov/) Sentinel-2, Copernicus Open Access Hub (https://scihub.copernicus.eu/)	Multispectral
Geological Map	Nigerian Geological Survey Agency (https://www.ngsa.gov.ng/)	Vector / Raster (processed by author from published map)
Soil Map	FAO (https://www.fao.org/geonetwork) / Open Data Nigeria (https://opendata.nigeria.gov.ng/)	Raster
Hydrography & Rivers	OpenStreetMap (https://www.openstreetmap.org/) / Nigeria GIS Portal (https://www.nigeriagis.com/)	Vector
Administrative Boundaries	GADM (https://gadm.org/) / OpenStreetMap (https://www.openstreetmap.org/)	

All datasets were projected to WGS 84 / UTM Zone 32N to ensure spatial consistency and facilitate seamless integration during analysis. Geological map layers were adapted and processed from official NGSA publications, not generated by the author.

2.3 Terrain Analysis

Terrain derivatives were extracted from the 30 m Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM) to quantify the surface morphology of the study area (Tang et al., 2016; Aiyelabegan & Nwokolo, 2022). These derivatives included slope, aspect, curvature, elevation, and drainage density, each of which provides critical information about terrain characteristics.

i. **Slope** represents the degree of steepness or inclination of the land surface and is an essential parameter for differentiating terrain types such as flat plains, gently undulating areas, and steep hills or plateaus. It also plays a significant role in determining erosion potential, as steeper slopes are generally more prone to soil loss due to increased surface runoff (Figure 2).

ii. **Aspect** refers to the direction that a slope faces and influences several environmental processes, including solar radiation exposure, soil moisture distribution, vegetation growth, and the direction of surface runoff. As a result, aspect is important for understanding variations in microclimate and drainage patterns across the landscape.

iii. **Curvature** describes the shape of the land surface and helps to distinguish between convex and concave features. Convex surfaces, such as ridges and hilltops, tend to shed water, while concave surfaces, such as valleys and depressions, accumulate water and sediments. This makes curvature a useful parameter for identifying landform features and assessing erosion and deposition processes.

iv. **Elevation values** were classified into lowlands (0–200 m), uplands (201–400 m), and highlands (>400 m) to reflect the dominant topographic variation within the study area (Figure 3). These thresholds were selected based on the observed elevation range of the terrain and are consistent with regional geomorphological characteristics of the Benue State landscape, where extensive plains generally occur below 200 m, moderately elevated and undulating terrains fall within 201–400 m, and isolated highlands and plateau remnants exceed 400 m (Aiyelabegan & Nwokolo, 2022). This classification scheme allows for meaningful differentiation of landform units and supports the interpretation of terrain suitability for various land uses, including agriculture, settlement, and conservation.

v. Drainage density was derived from the Digital Elevation Model (DEM) using hydrological analysis tools in a GIS environment. The process involved generating flow direction and flow accumulation layers, from which stream networks were extracted by applying an appropriate threshold value to the flow accumulation grid. These extracted streams were then used to compute drainage density as the total length of streams per unit area.

The resulting drainage density map was used to identify spatial variations in surface runoff and infiltration characteristics across the study area. Areas with high drainage density indicate closely spaced stream channels and are typically associated with impermeable surfaces, steep slopes, or highly dissected terrain, making them more susceptible to surface runoff, soil erosion, and flooding. In contrast, areas with low drainage density suggest higher infiltration rates and relatively stable terrain conditions. This analysis was particularly useful in delineating valleys, floodplains, and zones prone to waterlogging, thereby contributing to the identification of landforms and supporting sustainable land-use planning decisions. These terrain parameters were visualized using hill-shade and colour gradients (e.g., green = gentle slopes, red = steep slopes) to enhance spatial interpretation and highlight geomorphological variations.

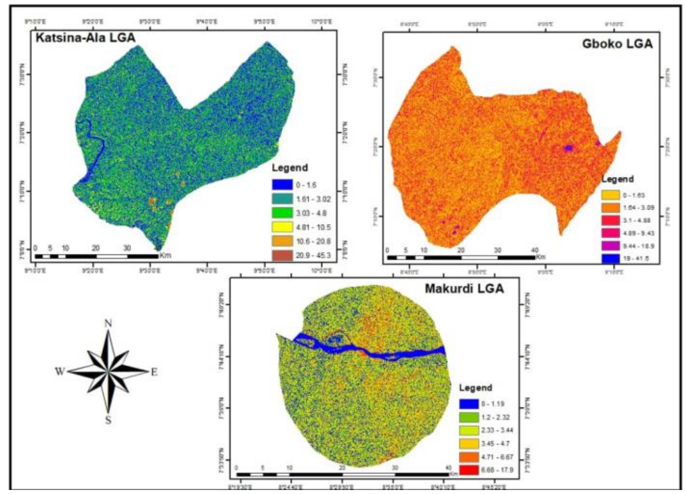

Figure 2: Slope map of Makurdi, Gboko, and Katsina-Ala showing variation in steepness across the study area.

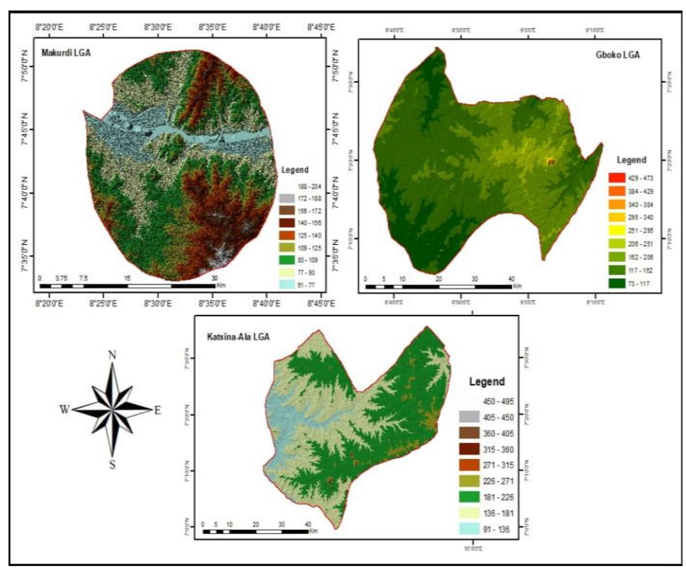

Figure 3: Elevation map of Makurdi, Gboko, and Katsina-Ala showing variation in steepness across the study area.

2.4 Multi-Criteria Analysis (MCA) for Landform Classification

To integrate multiple terrain parameters, a GIS-based Multi-Criteria Analysis (MCA) was employed (Malczewski, 2006; Rahman et al., 2019). MCA allows for assigning relative importance (weights) to each parameter based on geomorphological significance. The criteria and weights applied in this study are shown in Table 2.

Table 2: MCA Criteria and Weights for Landform Classification

Criterion	Weight (%)	Justification
Slope	30	Determines erosion potential and landform type
Elevation	25	Differentiates plains, hills, and plateaus
Curvature	20	Highlights valleys and ridges
Drainage Density	15	Identifies flood-prone areas and valleys
Land Cover	10	Accounts for human-modified landscapes

The weights assigned to each criterion were determined using a structured Multi-Criteria Analysis (MCA) approach based on their relative importance in influencing landform characteristics and terrain processes. The weighting was guided by a combination of literature review and expert judgment, considering the geomorphological relevance of each parameter to landform differentiation.

Slope was assigned the highest weight (30%) because it directly controls surface runoff, erosion intensity, and terrain steepness, making it a primary determinant of landform type. Elevation was given a weight of 25% as it defines vertical terrain variation and is essential for distinguishing between plains, uplands, and highlands. Curvature was assigned 20% due to its role in identifying surface shape, particularly in differentiating convex features such as ridges from concave features such as valleys.

Drainage density received a weight of 15% because it reflects hydrological processes, including runoff concentration and flood susceptibility, which are important for identifying valleys and flood-prone areas. Land cover was assigned the lowest weight (10%) since it represents human-induced modifications of the landscape, which, although important, are secondary to intrinsic terrain characteristics in landform classification.

Weighted overlay analysis in ArcGIS produced a classified raster map of the study area with four landform categories: plains, hills, valleys, and plateaus.

2.5 Spatial Analysis and Quantification

Following classification, the spatial extent of each landform type was quantified in square kilometres and expressed as a percentage of the total study area (Tang et al., 2016). Descriptive statistics were generated for slope, elevation, and curvature within each landform category to characterize terrain variability and support land-use interpretation.

Visual outputs included slope maps to highlight gentle versus steep zones, elevation maps with hill-shade to provide three-dimensional perspectives, landform classification maps to depict plains, hills, valleys, and plateaus, and histograms illustrating slope and elevation distributions per landform type.

This integrated GIS-MCA approach provides reproducible, spatially explicit data to inform agricultural planning, urban expansion, flood risk management, and environmental conservation within Makurdi, Gboko, and Katsina-Ala areas (Aiyelabegan & Nwokolo, 2022; Mahmud et al., 2021).

3 Results and Discussion

3.1 Landform Classification

The GIS-based Multi-Criteria Analysis (MCA) produced a detailed landform classification for the Makurdi, Gboko, and Katsina-Ala areas, identifying four dominant landform types: plains, hills, valleys, and plateaus. Their spatial distribution is presented in Figure 4.

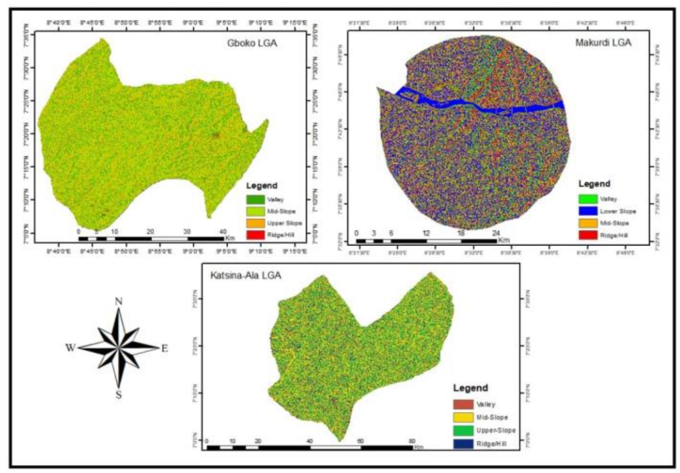

Figure 4: Landform classification map of Makurdi, Gboko, and Katsina-Ala showing plains, hills, valleys, and plateaus for terrain relief across the study area.

Plains are the most extensive landform, occupying approximately 52% of the study area, primarily in the central and northern portions. They are characterized by gentle slopes (<5°) and elevations below 200 m, making them highly suitable for mechanized agriculture due to flat terrain and fertile soils. Hills are concentrated in the south-eastern uplands, covering about 23% of the area. These features have moderate slopes (5–25°) and elevations ranging from 201 to 400 m. The terrain is suitable for forestry, tree crops, and limited agricultural activities, but less favourable for intensive farming due to slope constraints. Valleys occur along the Benue River and its tributaries, covering approximately 15% of the study area. These areas are characterized by concave curvature and high drainage density, which makes them prone to seasonal flooding, influencing settlement patterns and agricultural practices. Plateaus are isolated elevated regions, mainly in the south-eastern part of the study area, covering roughly 10%. With elevations exceeding 400 m, these landforms present opportunities for planned settlements, eco-tourism, and conservation initiatives.

3.2 Terrain Statistics

From Figure 5a, the quantitative analysis of terrain parameters highlights the variability and characteristics of each landform type
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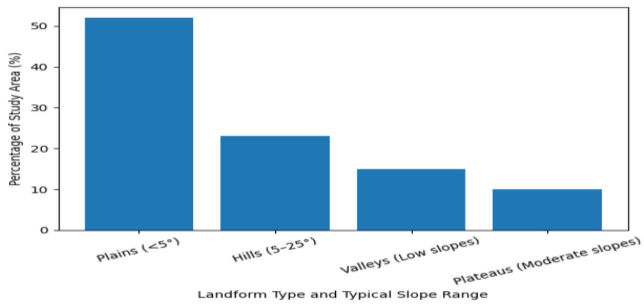

Figure 5a: Histogram illustrating slope distribution across plains, hills, valleys, and plateaus.

Slope Distribution: Plains exhibit predominantly gentle slopes (<5°), while hills and plateaus are dominated by moderate slopes (5–25°). Valleys generally display concave curvature, indicating potential flood zones.

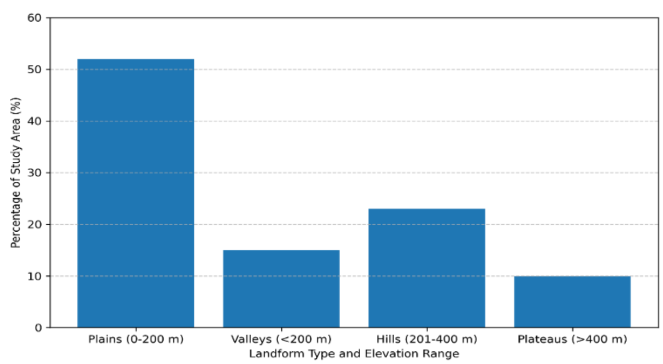

Figure 5b: Histogram of elevation ranges for each landform type.

Elevation Range: Plains are located at elevations of 0–200 m, hills at 201–400 m, and plateaus exceed 400 m. Valleys typically fall below 200 m but are influenced by river incision, creating localized depressions and floodplains (Figure 5b).

Curvature Analysis: Positive curvature values correspond to convex hilltops and plateau surfaces, whereas negative curvature identifies concave valleys and lowlands.

Drainage Density: Valleys and floodplains exhibit the highest drainage density, correlating with flood risk areas and zones of alluvial deposition. This confirms the suitability of valleys for limited agriculture and the necessity for flood mitigation measures.

3.3 Area Coverage and Distribution

The total area of each landform type within the study region was calculated and expressed as a percentage of the total study area, as summarized in Table 3.

Table 3: Landform Area Coverage in Makurdi, Gboko, and Katsina-Ala Areas

Landform Type	Area (km^2)	% of Study Area	Dominant Characteristics
Plains	18,500	52%	Gentle slopes, fertile soils
Hills	8,200	23%	Moderate slopes, upland regions
Valleys	5,400	15%	Concave terrain, high drainage density
Plateaus	3,400	10%	Elevated flat-topped areas
Total	35,500	100%	—

Plains dominate central and northern regions, providing high agricultural potential. Hills and plateaus are concentrated in the southeast, offering suitable terrain for forestry and eco-tourism. Valleys are aligned with major river networks and require careful management due to flooding susceptibility.

4 Discussion

The GIS-based classification revealed that plains dominate central Makurdi and parts of Gboko, covering over half of the study area. These low-lying areas with gentle slopes (<5°) are ideal for mechanized agriculture (Ogunrinade & Omotosho, 2020; Aiyelabegan & Nwokolo, 2022). Hills and plateaus, mainly in south-eastern Gboko and Katsina-Ala, correspond to remnants of ancient geological uplifts. Their moderate slopes and higher elevations favour forestry, conservation, and eco-tourism rather than intensive farming (Etuonovbe et al., 2021; Okeke et al., 2022). Valleys along the Benue River and tributaries exhibit concave curvature and high drainage density, making them prone to flooding and necessitating mitigation strategies (Oladipo & Olayinka, 2023). Figures 2–4 clearly illustrate these topographic contrasts and synthesized landform units for planning.

Landform distribution informs land-use decisions. Plains support crop cultivation (yams, maize, rice, soybeans), while hills and plateaus accommodate tree crops, agroforestry, and grazing with reduced erosion risk (FAO, 2020; Aiyelabegan & Nwokolo, 2022). Valleys require flood management through drainage or seasonal cropping. For settlements, elevated hills and plateaus provide safer zones, whereas valleys may serve as green corridors or recreational areas. Soil and water conservation measures are best implemented on uplands, while riparian buffers in valleys help maintain water quality and reduce sedimentation (Ocheni & Agboola, 2017).

The spatial distribution of landforms has practical implications for sustainable land-use planning. Agriculture**:** The gentle slopes of plains are ideal for crops such as yams, maize, rice, and soybeans. Hills and plateaus, with moderate slopes, are suitable for tree crops, agroforestry, and grazing, which help reduce soil erosion.

Urban and Infrastructure Planning: Valleys are flood-prone and unsuitable for dense settlements, whereas hills and plateaus, being elevated, offer safer zones for residential, commercial, and institutional development. Environmental Conservation: Hills and plateaus provide suitable locations for soil and water conservation measures. Riparian zones along valleys require protection through buffer strips to reduce sedimentation, maintain water quality, and protect biodiversity.

Flood Risk Management**:** High drainage density in valleys emphasizes the need for levees, retention basins, and planned drainage channels to mitigate flood risk. This comprehensive analysis demonstrates the effectiveness of GIS-MCA in producing spatially explicit, quantitative data to guide land-use planning, flood risk management, and conservation in Makurdi, Gboko, and Katsina-Ala.

The desktop GIS-MCA approach offers a cost-effective, reproducible method for landform classification without extensive fieldwork (Mahmud et al., 2021). It produces spatially explicit maps, enabling quantitative assessment of slope, elevation, curvature, and drainage density to guide agriculture, urban planning, flood management, and environmental conservation.

Findings align with previous research: plains dominate central Makurdi and Gboko (Ogunrinade & Omotosho, 2020; Aiyelabegan & Nwokolo, 2022), hills and plateaus reflect ancient uplifts (Etuonovbe et al., 2021), and flood-prone valleys correspond to prior observations along the Benue River (Oladipo & Olayinka, 2023), confirming the reliability of MCA-based desktop classification.

5 Conclusion

This study demonstrates the effectiveness of integrating Geographic Information Systems (GIS) with Multi-Criteria Analysis (MCA) for the classification and spatial analysis of landforms in Makurdi, Gboko, and Katsina-Ala areas of Benue State, Nigeria. By combining terrain parameters such as slope, elevation, curvature, and drainage density, the study produced a detailed and spatially explicit representation of the physical landscape, identifying four dominant landform types: plains, hills, valleys, and plateaus.

The results reveal clear spatial differentiation in landform distribution, with plains dominating central Makurdi and parts of Gboko, while hills and plateaus are more prominent in the south-eastern portions of Gboko and Katsina-Ala. Valleys were found to be closely associated with the River Benue and its tributaries, reflecting the strong influence of fluvial processes on landscape formation. These variations highlight the dynamic interaction between topography and hydrological systems in shaping the region's geomorphology.

Beyond classification, the study provides important insights into the relationship between landforms and land-use suitability. Plains, characterized by gentle slopes, present favourable conditions for large-scale agriculture, whereas hills and plateaus require more controlled and conservation-oriented land-use practices due to their susceptibility to erosion. Valleys, identified as zones of high drainage density, are particularly vulnerable to flooding and therefore demand careful planning and management.

The study makes a significant contribution by demonstrating that GIS-based MCA offers a reliable, cost-effective, and reproducible approach to landform classification, especially in data-limited environments. The outputs generated provide a valuable spatial framework for supporting informed decision-making in agriculture, urban development, environmental conservation, and flood risk management.

The study therefore recommended that land-use planning in Makurdi, Gboko, and Katsina-Ala should be guided by the spatial distribution of landforms identified in this study. Plains, which dominate the study area, should be prioritized for intensive agricultural activities due to their gentle slopes and favourable soil conditions. In contrast, hills and plateaus should be utilized for agroforestry, conservation practices, and controlled development, while valley areas require careful management because of their susceptibility to flooding.

Flood-prone zones, particularly along river valleys and areas with high drainage density, require the implementation of effective flood management strategies. These include improved drainage systems, construction of retention structures, and strict regulation of settlement development in vulnerable areas to minimize environmental and socio-economic risks.

Soil and water conservation practices should be encouraged, especially on sloping terrains. Techniques such as contour farming, terracing, and the maintenance of vegetative cover are essential for reducing soil erosion, preserving soil fertility, and sustaining agricultural productivity.

There is a need for the integration of Geographic Information Systems (GIS) into land-use planning and environmental management. The adoption of GIS-based landform maps and spatial databases will support evidence-based decision-making, improve planning accuracy, and enhance monitoring of environmental changes over time. Environmentally sensitive areas, including riparian zones and degraded landscapes, should be protected and restored through reforestation and conservation initiatives. At the same time, urban and infrastructural development should be directed toward stable and less vulnerable landforms to ensure long-term sustainability and reduce environmental risks.

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