GEOSPATIAL ASSESSMENT OF URBANIZATION, ARABLE LAND LOSS AND FOOD SECURITY IN JOS SOUTH PLATEAU STATE, NIGERIA

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Abstract

Urbanization is increasingly transforming agricultural landscapes in many developing countries, resulting in significant loss of arable land and raising concerns about food security. This study assessed urban expansion, arable land loss, and food security implications in Jos South Local Government Area of Plateau State, Nigeria, using geospatial techniques. Sentinel-2 satellite imagery for 2016 and 2026 was processed and analyzed using Geographic Information Systems (GIS) and Remote Sensing techniques. Supervised classification and post-classification change detection methods were employed to quantify land use/land cover (LULC) changes, while projection analysis was used to estimate future land use patterns for 2036. The classification achieved high accuracy levels, with overall accuracies of 94.67% and 93.33% and Kappa coefficients of 0.936 and 0.920 for 2016 and 2026, respectively. Results revealed significant land use transformations during the study period. Built-up areas increased from 30.74 km² (5.36%) in 2016 to 50.18 km² (8.75%) in 2026, representing an increase of 19.44 km². Conversely, arable land declined from 205.49 km² (35.85%) to 179.05 km² (31.23%), resulting in a loss of 26.44 km². Vegetation cover decreased by 17.09 km², while bare land expanded by 49.76 km². These changes indicate rapid urbanization, environmental degradation, and increasing pressure on agricultural resources. The 2036 projection suggests continued urban growth and further reduction of agricultural land if current trends persist. The study concludes that unchecked urban expansion poses a significant threat to agricultural productivity and food security in Jos South. It recommends sustainable land-use planning, farmland protection policies, and environmental conservation measures to promote balanced urban development and long-term food security.

Keywords: *Urbanization, Arable Land Loss, Food Security, Remote Sensing, GIS, Sentinel-2, Land Use/Land Cover Change, Jos South.*

1.0 Introduction

Urbanization is one of the most significant global demographic and land-use transformations of the twenty-first century. The increasing concentration of populations in urban areas, driven by natural population growth, rural–urban migration, economic opportunities, and improved access to social services, has accelerated the spatial expansion of cities worldwide. While urbanization contributes to economic development, technological advancement, and improved living standards, it also exerts considerable pressure on natural resources, particularly agricultural land (Samiullah, et. al., 2019). This challenge is especially pronounced in developing countries where rapid urban growth often occurs with limited land-use planning and regulatory enforcement (UN DESA, 2015). The UN DESA (2018) projections show that urbanization, the gradual shift in residence of the human population from rural to urban areas, combined with the overall growth of the world's population could add another 2.5 billion people to urban areas by 2050, with close to 90% of this increase taking place in Asia and Africa. This rapid urban growth, driven by population growth and socio-economic development, is leading to significant urban sprawl (Getu & Bhat, 2021; Deng et al., 2020; Bren et al., 2016).

The conversion of agricultural land to residential, commercial, industrial, and infrastructural uses has become a major environmental and socio-economic concern (Rahman et al., 2023; Ayele, and Tarekegn, 2020; Chaolin, 2020; Admasu, et al., 2019). Agricultural land plays a critical role in sustaining food production and supporting rural livelihoods; therefore, its loss directly affects food availability, accessibility, and long-term food security. Studies have shown that urban expansion is a leading cause of arable land depletion globally, particularly in regions experiencing rapid population growth and increasing demand for urban infrastructure (Ayele, and Tarekegn, 2020; Deepak et. al., 2020). Consequently, understanding the spatial dynamics of urban growth and its impact on agricultural resources has become essential for sustainable development planning.

Nigeria has experienced rapid urbanization over the past few decades, with urban centres expanding beyond their traditional boundaries into surrounding agricultural landscapes (Udeuhele, 2018). This expansion has resulted in the continuous conversion of fertile agricultural land to built-up areas, thereby threatening agricultural productivity and food security (Wang, et. al., 2020; Leng and Fu, 2014; Jiayu et. al., 2023). The situation is particularly concerning in peri-urban regions where urban growth is most pronounced and where some of the most productive agricultural lands are located. As the country's population continues to increase, the preservation of arable land has become a critical issue in ensuring sustainable food systems and environmental resilience.

Jos South Local Government Area (LGA) of Plateau State represents a typical example of a rapidly urbanizing peri-urban environment. Owing to its strategic location adjacent to Jos metropolis, the area has experienced substantial population growth, infrastructural development, and economic expansion. Historically recognized for its favourable climatic conditions and agricultural productivity, Jos South has served as an important agricultural zone supporting the production of food crops for local consumption and regional markets. However, increasing urban development has led to the gradual encroachment of built-up areas into farmlands, resulting in the reduction of cultivable land and raising concerns about the sustainability of agricultural production within the area.

The growing competition between urban development and agricultural land use underscores the need for accurate and timely information on land-use changes. Geospatial technologies, including Remote Sensing (RS), Geographic Information Systems (GIS), and Global Positioning Systems (GPS), provide powerful tools for monitoring and analyzing spatial and temporal patterns of land transformation. These technologies enable the detection, quantification, and visualization of urban growth and agricultural land conversion, thereby supporting evidence-based planning and resource management (Hasna et al., 2023; Roy, et al., 2023; Rimal et al., 2018; Wu, et al., 2016; Zhong, et al., 2011; Lambin, et al., 2001). The integration of geospatial techniques has been widely recognized as an effective approach for assessing land-use dynamics and evaluating their implications for environmental sustainability and food security.

Arable land is a finite and virtually non-renewable resource that requires careful management to balance development needs with agricultural sustainability Šalkauskienė et al., 2019; Getu and Bhat, 2021; Rahman et al., 2023). Despite the increasing rate of urban expansion in Jos South, limited empirical studies have quantified the extent of arable land loss and examined its implications for food security using geospatial approaches. Furthermore, inadequate land-use planning, weak policy implementation, and insufficient monitoring mechanisms have contributed to uncontrolled urban sprawl and the progressive conversion of productive agricultural land.

Given the strategic importance of agricultural land for food production and livelihood sustenance, there is a need to assess the magnitude and spatial patterns of urban-induced land-use change in Jos South. Therefore, this study employs geospatial technologies to evaluate urban expansion, quantify arable land loss, and examine the potential implications for food security in Jos South LGA, Plateau State, Nigeria. The findings are expected to provide critical insights for policymakers, urban planners, and environmental managers in developing sustainable land-use strategies that promote urban development while safeguarding agricultural resources and food security.

2.0 Study Area

Jos South Local Government Area is one of the seventeen Local Government Areas in Plateau State, located in north-central Nigeria, with its administrative headquarters at Bukuru. Created in 1991 from the former Jos Local Government Area, it lies within the Jos Plateau region. The area is characterized by highlands, rocky outcrops, plains, and valleys typical of the Jos Plateau landscape.

Geographically, Jos South is situated approximately between latitudes 9°45′N and 9°55′N, and longitudes 8°45′E and 8°58′E. The area covers an estimated land area of about 1,037 square kilometres. It shares boundaries with Jos North to the North, to the East by Jos East, to the South by Barkin Ladi, to the Southwest by Riyom, and Northwest by Bassa LGAs.

The area experiences a cool and temperate climate due to its high elevation of about 1,200 –1,400 meters above sea level. It has distinct wet and dry seasons, with annual rainfall ranging from 1,200 mm to 1,500 mm and average temperatures between 18°C and 25°C. These favourable climatic conditions support extensive agricultural activities.

Vegetation in Jos South is mainly Guinea Savannah with cultivated farmlands. The fertile volcanic and lateritic soils support the cultivation of crops such as Irish potatoes, Maize, Tomatoes, Pepper, Green beans, Cabbage, Carrots, Onions, Pearl Millet, Sorghum, including some temperate crops like Strawberries, Beetroot, Turmeric and Peas,

Major settlements within the LGA includes Bukuru, Rayfield, Vwang, Kuru, Gyel, and Zawan, and the economy is driven by farming, livestock rearing, mining, trade, and civil service activities. Historical and ongoing tin mining has significantly influenced land-use patterns and the physical environment.

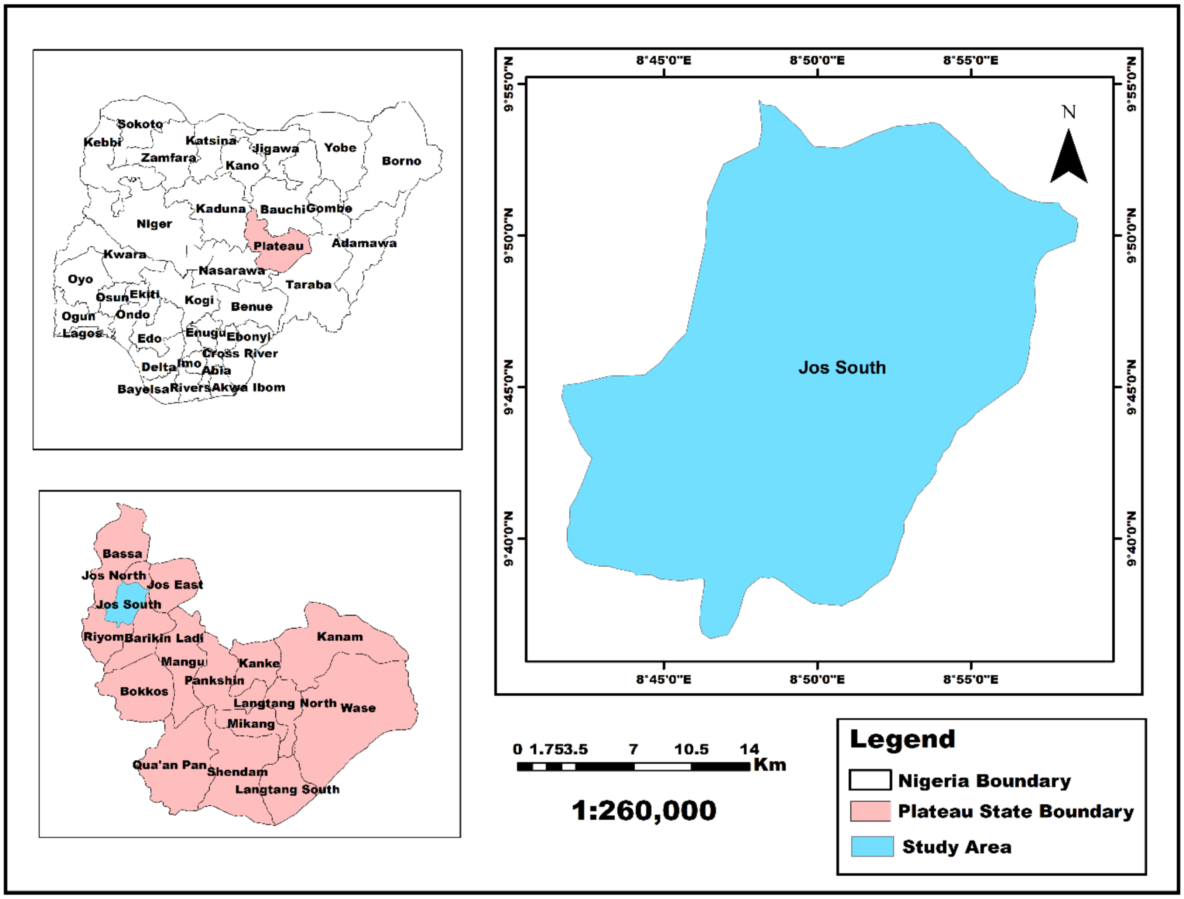

Figure 1: Geographical location of the study area (Jos South)

3.0 Methodology

3.1 Materials

Sentinel-2 satellite images of the year 2016 and 2026 were obtained through scihub.copernicus.eu.

Administrative boundary (Jos South)

ArcGIS 10.8 version and QGIS, Terrset, Microsoft office (Excel and Word) for data entry, preparation, and analysis.

3.2 Methodology

The methodology below provides a systematic framework for analyzing land use and land cover changes in Jos South LGA, over a ten-year period. The integration of satellite imagery, supervised classification techniques, and post-classification change detection enables a reliable and accurate assessment of the spatial and temporal dynamics of land use changes within the study area. This approach facilitates the identification, and monitoring of changes in land use patterns, thereby providing valuable insight for sustainable land management and planning.

3.3 Pre-processing (Sentinel-2)

Sentinel-2 satellite images covering the study area were downloaded from the scihub.copernicus.eu for the selected study periods. To ensure the acquired satellite images were suitable for the analysis they were pre-processed as presented below.

Atmospheric correction was carried out using the Sen2Cor algorithm to convert the images from Top of Atmosphere (TOA) reflectance to Bottom of Atmosphere (BOA) reflectance, thereby improving image quality and accuracy for analysis.

Cloud masking was performed using the QA60 band and Scene Classification Layer (SCL) to identify and remove cloud-covered and shadow-affected pixels from the imagery.

Image mosaicking was conducted to merge multiple Sentinel-2 scenes into a single seamless image covering the entire study area.

The mosaicked images were then subsetted or clipped to the boundary of the study area to retain only the relevant spatial extent for the research.

Finally, the processed images from different years were stacked and organized into a multi-temporal image series to enable temporal analysis and comparison of land use and land cover changes over time.

3.4 Data Analysis

Confusion Matrix and Land Use/Land Cover Statistics for 2016 and 2026 in excel file were analyzed.

4.0 Results and Discussion

4.1 Results

4.1.1 Classification Accuracy Assessment (2016)

Table. 1 Producer's and User's Accuracy

Land Cover Class	User's Accuracy (%)	Producer's Accuracy (%)
Built-up Area	96.0	96.0
Water Body	96.0	100.0
Bare Land	92.0	100.0
Arable Land	84.0	87.5
Vegetation	100.0	96.15
Rock Outcrop	100.0	89.29

The confusion matrix for the 2016 Sentinel-2 land use/land cover (LULC) classification indicates a high level of classification reliability. Six land cover classes were identified: Built-up Area, Water Body, Bare Land, Arable Land, Vegetation, and Rock Outcrop. The classification achieved an overall accuracy of 94.67% and a Kappa coefficient of 0.936, indicating an excellent agreement between the classified image and the reference data. According to commonly accepted classification standards, a Kappa value greater than 0.80 signifies a very strong classification performance, confirming that the resulting LULC map is suitable for further spatial analysis.

The producer's and user's accuracies (values presented in table 1) reveal varying levels of classification performance among the classes: Vegetation and Rock Outcrop recorded perfect user's accuracies (100%), indicating that all pixels classified into these categories were correctly identified. Similarly, Water Body and Bare Land achieved producer's accuracies of 100%, suggesting that all reference samples of these classes were successfully captured during classification. The lowest accuracy was observed in the Arable Land class, with a user's accuracy of 84% and a producer's accuracy of 87.5%. Misclassification occurred primarily between arable land and rock outcrops as well as built-up areas. This may be attributed to spectral similarities between exposed agricultural soils, harvested fields, and rocky surfaces during the image acquisition period.

4.1.2 Land Use/Land Cover Statistics (2016)

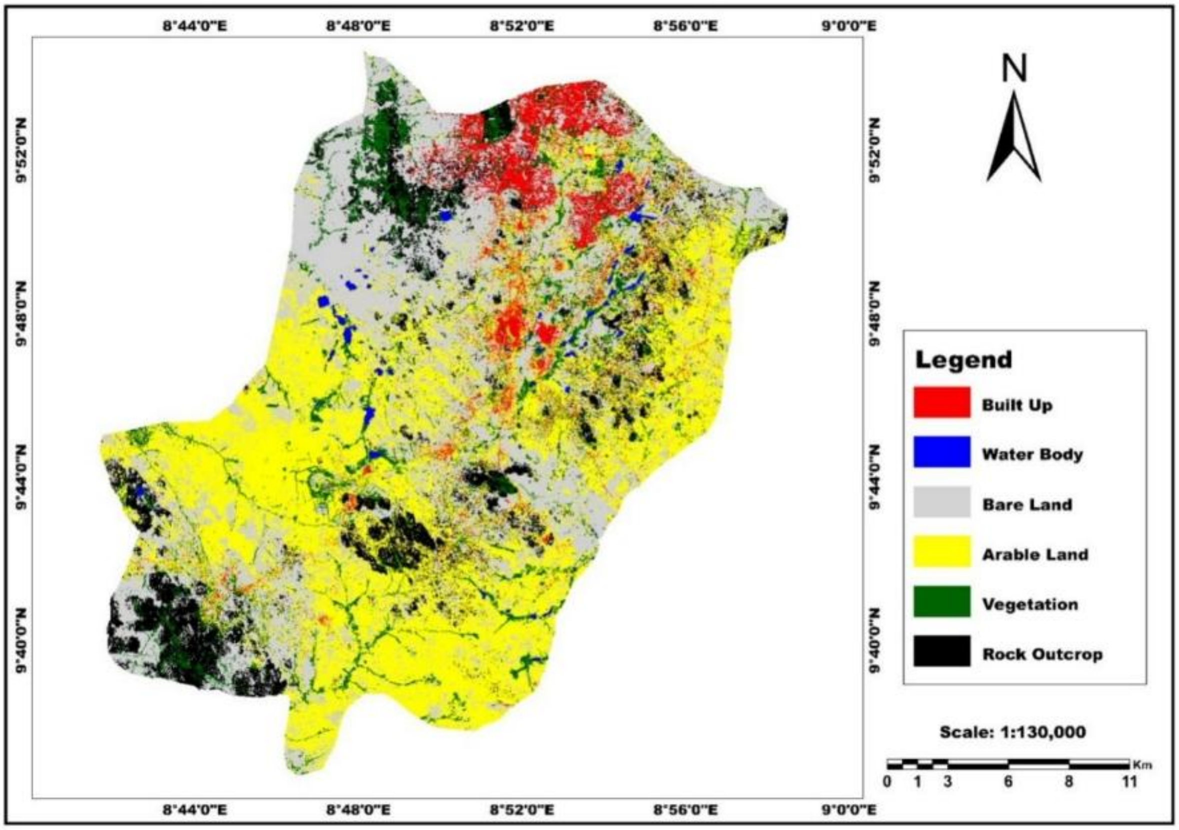

Figure 2: Land cover map of 2016

Table. 2 Land Use/Land Cover Distribution 2016

Land Cover Class	Area (km^2)	Percentage (%)
Bara Land	212.27	37.03
Arable Land	205.49	35.85
Rock Outcrop	72.06	12.57
Vegetation	47.99	8.37
Built-up Area	30.74	5.36
Water Body	4.73	0.82
Total	573.28	100

The Land use land cover classified area of Jos South LGA in 2016 covered approximately 573.28 km². The classification identified six major land cover classes: Bare Land, Arable Land, Built-up Area, Rock Outcrop, Vegetation, and Water Bodies. The analysis as presented in table 2 reveals that Bare Land (212.27 km²) was the dominant land use class in 2016, accounting for approximately 37.03% of the total study area. The large extent of bare surfaces may be attributed to mining activities, exposed soils, fallow agricultural lands, and undeveloped areas that characterize parts of Jos South LGA. Crop Land occupied 205.49 km² (35.85%), making it the second largest land cover category. This indicates that agriculture remained a major economic activity within the Local Government Area, reflecting the importance of farming for food production and livelihoods. Rock Outcrops covered 72.06 km² (12.57%) of the study area. This significant proportion is consistent with the geological characteristics of the Jos Plateau, which is known for its extensive granite formations and exposed rocky surfaces. Vegetation accounted for 47.99 km² (8.37%) of the total land area. The relatively low vegetation cover suggests that natural vegetation had already experienced considerable reduction due to agricultural expansion, urban development, fuelwood extraction, and other human activities. The Built-up Area occupied 30.74 km² (5.36%), indicating a moderate level of urban development in 2016. The concentration of settlements around Bukuru and adjoining urban centers contributed to this proportion. Water Bodies represented the smallest land cover class with only 4.73 km² (0.82%). This low percentage reflects the limited spatial extent of rivers, ponds, reservoirs, and other surface water features within the study area.

4.1.3 Classification Accuracy Assessment (2026)

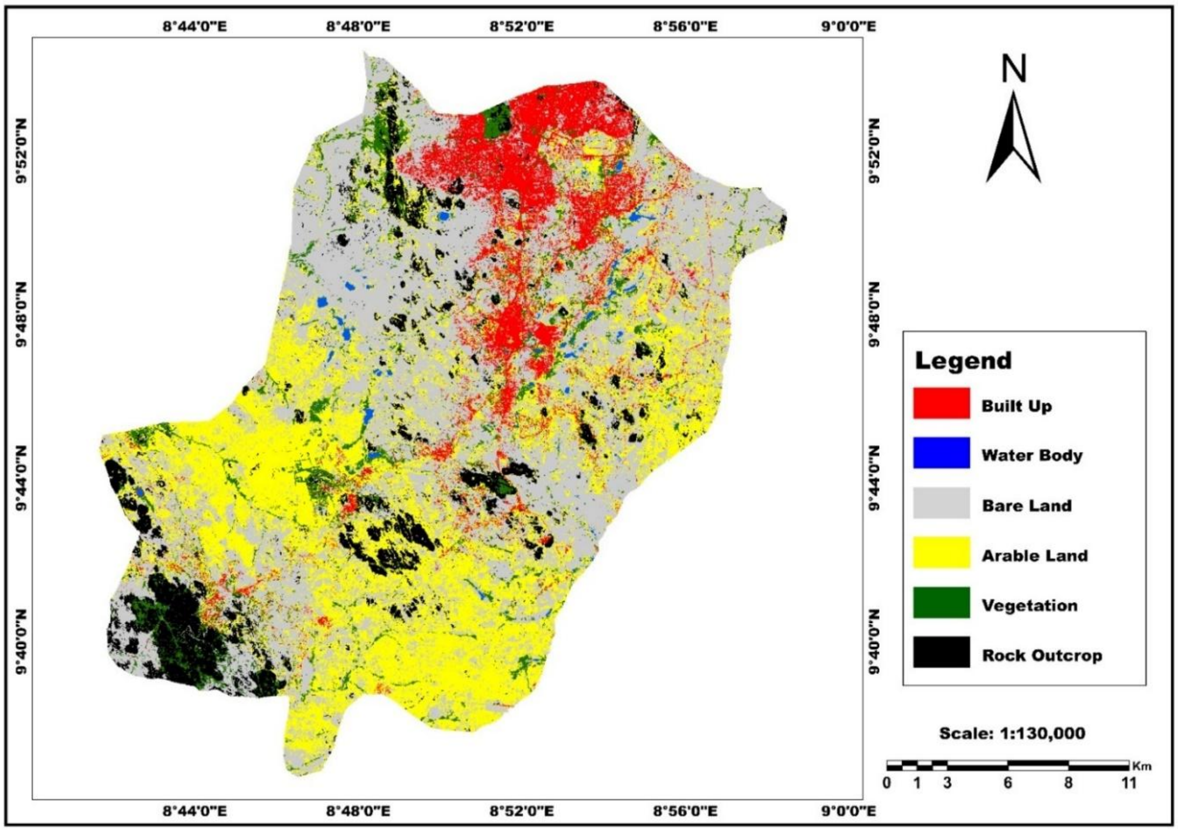

Figure 3: Land cover map of 2026

The producer's and user's accuracies for the individual land cover classes are summarized below:

Table. 3 Producer's and User's Accuracy 2026

Land Cover Class	User's Accuracy (%)	Producer's Accuracy (%)
Built-up Area	88.0	96.0
Water Body	96.0	100.0
Bare Land	96.0	85.71
Arable Land	100.0	100.0
Vegetation	92.0	85.19
Rock Outcrop	88.0	100.0

The classified area of Jos South LGA remains approximately 573.28 km² in 2026.

Table. 4 Land Use/Land Cover Distribution 2026

Land Cover Class	Area (km^2)	Percentage (%)
Bare Land	262.03	45.71
Arable Land	179.05	31.23
Built-up Area	50.18	8.75
Rock Outcrop	48.08	8.39
Vegetation	30.90	5.39
Water Body	3.04	0.53
Total	**573.28**	**100.00**

The confusion matrix for the 2026 Sentinel-2 land use/land cover (LULC) classification demonstrates a high degree of classification accuracy and reliability. Six land cover classes were identified: Built-up Area, Water Body, Bare Land, Arable Land, Vegetation, and Rock Outcrop.

The classification achieved an overall accuracy of 93.33% and a Kappa coefficient of 0.92, indicating a very strong agreement between the classified image and the reference data. According to standard accuracy assessment criteria, a Kappa value above 0.80 signifies excellent classification performance, confirming that the classified map is suitable for land use change analysis and environmental assessment.

The Arable Land class achieved both 100% user's accuracy and 100% producer's accuracy, (Table 3). indicating perfect classification performance. This suggests that all reference samples of farmland were correctly identified and that all pixels classified as farmland genuinely belonged to that class. Similarly, Water Body and Rock Outcrop attained producer's accuracies of 100%, indicating complete identification of reference samples for these categories. The Built-up Area and Rock Outcrop classes recorded the lowest user's accuracy (88%). Misclassification occurred mainly between built-up areas and vegetation, as well as between rock outcrops and other exposed surfaces. Such confusion is common in medium-resolution satellite imagery because impervious surfaces, rocky terrains, and sparsely vegetated areas often exhibit similar spectral signatures. Vegetation recorded a producer's accuracy of 85.19%, indicating that some vegetation pixels were misclassified as bare land or other land cover categories. This may be attributed to seasonal vegetation stress, sparse vegetation cover, or mixed pixels resulting from fragmented land cover patterns.

4.1.4 Land Use/Land Cover Dynamics (2016–2026)

Table. 5 Land Use Change Analysis (2016 - 2026)

Land Use Class	2016 (km²)	2026 (km²)	Change (km²)	Trend
Built-up Area	30.74	50.18	+19.44	Increase
Water Body	4.73	3.04	-1.69	Decrease
Bare Land	212.27	262.03	+49.76	Increase
Arable Land	205.49	179.05	-26.44	Decrease
Vegetation	47.99	30.90	-17.09	Decrease
Rock Outcrop	72.06	48.08	-23.98	Decrease

The analysis (Table. 5) reveals significant land use changes within Jos South LGA over the ten-year period. In 2016, the landscape was dominated by bare land (212.27 km²; 37.03%) and arable land (205.49 km²; 35.85%), indicating the predominance of agricultural and undeveloped land uses. Built-up areas occupied only 30.74 km² (5.36%), reflecting a relatively moderate level of urban development. By 2026, substantial changes had occurred. Bare land expanded to 262.03 km² (45.71%), while built-up areas increased to 50.18 km² (8.75%). Conversely, arable land declined to 179.05 km² (31.23%), vegetation decreased from 47.99 km² to 30.90 km², and water bodies reduced from 4.73 km² to 3.04 km².

The results demonstrate a clear trend of urban expansion and environmental transformation. Built-up areas increased by approximately 63%, reflecting rapid population growth, infrastructural development, and the outward expansion of settlements from Bukuru and surrounding communities. Simultaneously, arable land declined by 26.44 km², indicating increasing conversion of productive farmland into residential, commercial, and infrastructural uses.

The substantial increase in bare land suggests intensified land degradation, mining activities, construction activities, and abandonment of previously cultivated land. The reduction in vegetation cover further reflects pressure from urban growth, agricultural intensification, fuelwood harvesting, and other anthropogenic activities.

4.1.5 Projection of Land Use/Land Cover to 2036

Table. 6 Land use Land cover projection for 2036

Land Cover Class	Area (km²)	Percentage (%)
Bare Land	208.44	40.78
Arable Land	154.68	30.26
Vegetation	81.08	15.86
Built-Up Area	80.06	15.67
Rock Outcrop	45.25	8.86
Water Body	3.77	0.74
Total	**573.28**	**100**

The projected Land Use/Land Cover statistics for 2036 (Table 6) indicate significant variation in the spatial distribution of different land cover classes within Jos South Local Government Area. The total projected area covered by all classes is approximately 573.28 km².

The 2036 projection suggests that urban expansion will continue if current trends persist. Built-up areas are projected to increase to 80.06 km² (15.67%), while arable land is expected to decline further to 154.68 km² (30.26%). Bare land is projected to remain dominant, occupying approximately 208.44 km² (40.78%).

These projections indicate continued competition between urban development and agricultural land. If appropriate land-use planning measures are not implemented, future urban growth may significantly reduce agricultural land availability and increase pressure on food production systems. The projected increase in built-up areas highlights the urgent need for sustainable urban planning strategies that balance development needs with agricultural and environmental conservation.

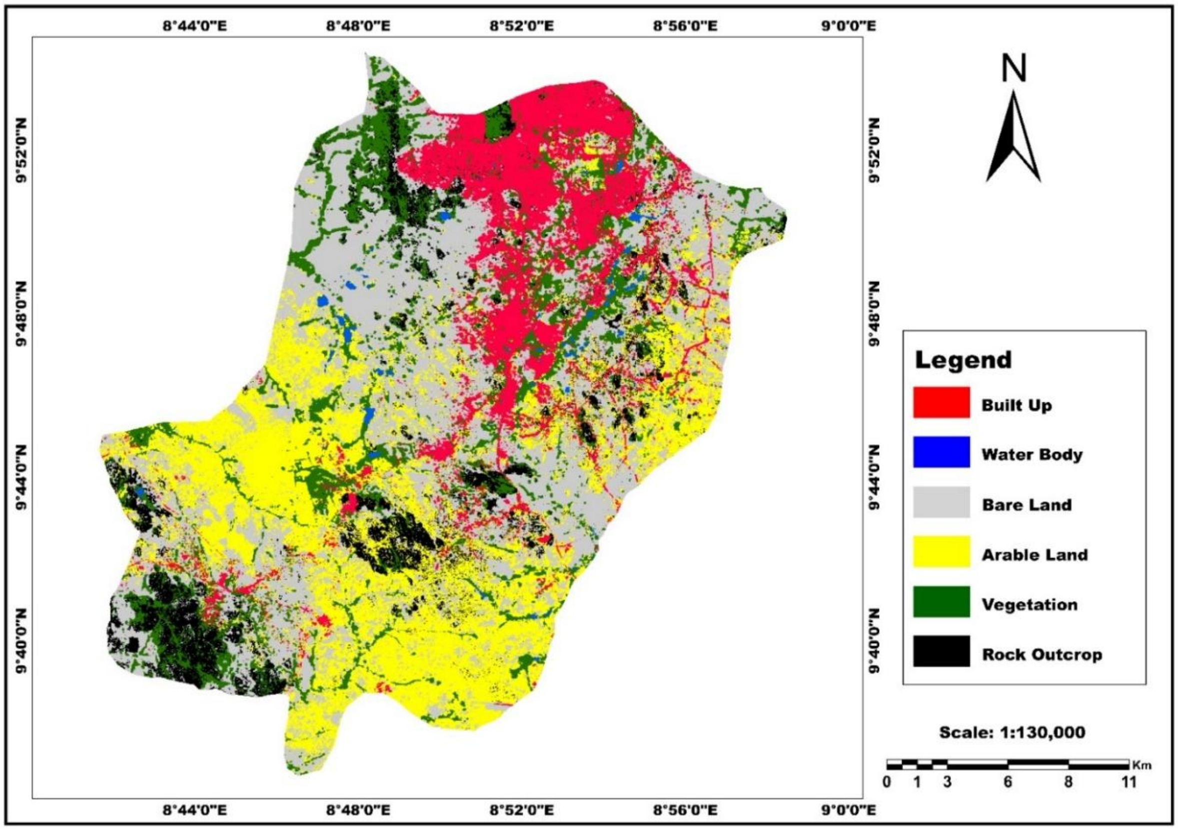

Figure 4: Projected Land use Land cover for 2036

4.2 Discussion

4.2.1 Discussion of 2016 Land Use/Land Cover Statistics

The 2016 land use pattern shows that Jos South LGA was predominantly characterized by agricultural land and bare surfaces, which together accounted for approximately 72.88% of the total area. This dominance suggests that the area was largely rural-agricultural in nature, although signs of urban growth were evident through the expansion of built-up areas. The relatively small proportion of vegetation cover raises concerns about environmental sustainability, as continued conversion of vegetated land to agricultural and urban uses could lead to biodiversity loss, soil degradation, and increased vulnerability to erosion.

This 2016 dataset serves as an important baseline for assessing subsequent land use changes and evaluating the impacts of urbanization, agricultural expansion, and environmental transformation in Jos South LGA between 2016 and 2026.

4.2.2 Discussion of Classification Performance

The overall accuracy of 93.33% demonstrates that the supervised classification procedure successfully distinguished the major land cover classes within the study area. Although slightly lower than the 2016 overall accuracy (94.67%), the 2026 classification still falls within the range considered highly reliable for land use/land cover studies. The perfect classification of arable land is particularly significant because agricultural land constitutes a key variable in studies of urban expansion and food security. The result suggests that agricultural areas exhibited distinct spectral characteristics that enabled accurate discrimination from surrounding land cover classes. The relatively lower producer's accuracy for vegetation and bare land suggests some degree of spectral overlap. In semi-arid and rapidly urbanizing environments, vegetation cover may become fragmented and intermixed with exposed soil surfaces, making classification more challenging. Likewise, bare land areas can be confused with rocky surfaces or recently cleared agricultural fields.

The slight reduction in overall accuracy compared with 2016 may reflect increasing landscape heterogeneity associated with urban growth, land conversion, and changing vegetation patterns. As urbanization progresses, the landscape often becomes more fragmented, increasing the likelihood of mixed pixels and classification uncertainty.

4.2.3 Discussion of 2026 Land Use/Land Cover Statistics

The 2026 Land Use/Land Cover (LULC) classification of Jos South Local Government Area (Table 4) reveals significant spatial variations in land cover distribution, reflecting the combined effects of urbanization, agricultural activities, environmental degradation, and natural landscape characteristics. Bare Land emerged as the dominant land cover category, covering 262.03 km², which represents 45.71% of the total study area. The predominance of bare land indicates extensive exposure of soil surfaces across the landscape. This condition may be associated with land degradation, quarrying and mining activities, abandoned agricultural fields, overgrazing, construction activities, and vegetation removal. The large proportion of bare land suggests increasing environmental stress and reduced land productivity, which may have adverse implications for soil conservation, biodiversity, and ecosystem sustainability.

Arable Land occupied 179.05 km² (31.23%), making it the second-largest land cover category. Although agriculture remains a major land use activity within Jos South, the proportion of arable land indicates that productive agricultural areas are under increasing pressure. Compared with earlier periods, the decline in arable land may be attributed to urban encroachment, infrastructure development, and conversion of farmland into residential and commercial uses. This trend is of particular concern because the reduction of cultivable land threatens agricultural productivity and food security, especially in a region where farming constitutes a major source of livelihood.

The Built-up Area covered 50.18 km² (8.75%) of the study area. The expansion of built-up land reflects ongoing urban growth and settlement development within Jos South LGA. This increase is likely driven by rapid population growth, rural-to-urban migration, improved transportation networks, and increasing demand for housing and public infrastructure. The expansion of urban areas around Bukuru and adjoining communities demonstrates the continuing transformation of formerly agricultural and natural landscapes into developed land uses. Such growth, while contributing to economic development, often occurs at the expense of agricultural land and natural vegetation.

Rock Outcrops accounted for 48.08 km² (8.39%) of the total area. The presence of extensive rock outcrops is characteristic of the geological formation of the Jos Plateau. Although this class remains relatively stable, slight variations in its spatial extent may result from classification differences, mining activities, or land surface modifications associated with human development. The distribution of rock outcrops continues to influence land suitability for agriculture, settlement, and other land use activities.

Vegetation covered only 30.90 km² (5.39%) of the study area, indicating a relatively low level of natural vegetation cover. The reduction in vegetation may be linked to urban expansion, agricultural intensification, fuelwood harvesting, and other anthropogenic activities. The loss of vegetation is environmentally significant because vegetation plays a critical role in maintaining ecological balance, reducing soil erosion, regulating local climate, and supporting biodiversity. Continued decline in vegetation cover could increase the vulnerability of the area to land degradation and environmental instability.

Water Bodies represented the smallest land cover category, occupying only 3.04 km² (0.53%) of the total study area. The limited extent of surface water reflects the semi-arid nature of the area and the relatively small number of rivers, ponds, and reservoirs. Although water bodies occupy a small proportion of the landscape, they are essential for domestic use, irrigation, livestock production, and ecosystem functioning. Their limited spatial coverage highlights the need for sustainable water resource management to support future agricultural and urban development.

4.2.4 Implications for Arable Land Loss and Food Security

The observed decline in arable land presents significant implications for food security in Jos South LGA. Agricultural land constitutes the foundation of local food production and rural livelihoods. The loss of approximately 26.44 km² of arable land between 2016 and 2026 represents a reduction of about 12.9% of the 2016 agricultural land base. This reduction is likely to decrease agricultural productivity, reduce food availability, increase dependence on food imports from neighbouring areas, and elevate food prices. The conversion of fertile arable land into urban land uses may also threaten the long-term sustainability of local food systems, particularly given the increasing population and demand for food.

Furthermore, the concurrent decline in vegetation cover and water resources may exacerbate environmental challenges such as soil erosion, declining soil fertility, biodiversity loss, and reduced ecosystem resilience, all of which can negatively affect agricultural production.

The findings of this study align with broader empirical evidence from sub-Saharan Africa and other rapidly urbanizing regions of the developing world. Research from Ethiopia by Ayele and Tarekegn (2020) documented comparable patterns of agricultural land loss driven by urban encroachment, while Rahman et al. (2023) similarly reported significant farmland depletion in peri-urban zones of Pakistan resulting from infrastructural expansion. The trajectory observed in Jos South, characterized by simultaneous growth of built-up surfaces, expansion of bare land, and contraction of cultivable agricultural area, is consistent with findings from analogous studies in developing cities and reflects a systemic challenge confronting peri-urban landscapes globally. This convergence of evidence underscores the fact that the land use dynamics observed in Jos South are not isolated phenomena but are part of a broader pattern of unsustainable urban-rural interface transformation that demands urgent policy attention.

The approximately 63% increase in built-up area recorded between 2016 and 2026 is particularly significant when interpreted in the context of Nigeria's rapidly growing urban population and the inadequacy of formal urban planning infrastructure. Jos South LGA occupies a strategic peri-urban position adjacent to the Jos metropolis, rendering it especially susceptible to spillover urban growth driven by land pressure within the core city. The outward expansion of settlements into the LGA's agricultural hinterland follows a well-documented pattern of concentric urban growth whereby rising land values and housing demand in the urban core push development into surrounding rural and peri-urban zones. This process, often described as urban sprawl, frequently occurs in an unplanned and spatially unregulated manner, accelerating the fragmentation and loss of contiguous agricultural land (Getu and Bhat, 2021; Bren et al., 2016). The inability of formal planning systems to adequately guide or contain this expansion in Jos South is reflected in the scale and pace of land use transformation documented in this study.

The expansion of bare land, which increased by 49.76 km² over the study period to account for 45.71% of the total land area by 2026, warrants particular analytical attention. Bare land expansion of this magnitude is rarely attributable to a single cause; rather, it reflects a confluence of degradative processes operating simultaneously across the landscape. In the context of Jos South, historical and ongoing tin mining activities have left behind extensive tracts of disturbed, unproductive land characterised by eroded soils, tailings deposits, and compacted surfaces that resist vegetation re-establishment. Superimposed on this mining legacy are the impacts of construction-related land clearance, where vegetation and topsoil are stripped in preparation for development but the land remains bare due to delays in construction or land speculation. Additionally, overgrazing by livestock and the harvesting of fuelwood from previously vegetated surfaces have contributed to the progressive denuding of formerly productive land. The ecological consequences of large-scale bare land expansion include accelerated soil erosion, reduced water infiltration capacity, elevated surface temperatures due to reduced albedo regulation, and the loss of organic matter that underpins soil fertility. These cascading effects compound the direct loss of arable land and collectively undermine the agricultural potential of the wider landscape.

The decline in vegetation cover from 47.99 km² to 30.90 km², a reduction of 17.09 km² or approximately 35.6% of the 2016 vegetation base, carries significant ecological and agricultural ramifications that extend beyond the immediate study area. Vegetation in peri-urban environments performs multiple provisioning and regulating ecosystem services that are frequently undervalued in urban development planning. These include the regulation of surface runoff and groundwater recharge, the moderation of microclimatic conditions through evapotranspiration, the provision of organic matter inputs that sustain soil fertility, and the maintenance of biodiversity corridors that support pollinator populations essential to crop production. The progressive fragmentation and loss of vegetation in Jos South therefore does not merely represent an aesthetic or biodiversity concern; it directly diminishes the biophysical conditions upon which sustainable agriculture depends. Moreover, the loss of tree cover and natural vegetation increases the exposure of agricultural soils to direct rainfall impact, promoting splash erosion and surface runoff that degrade topsoil quality over time. In the highland context of the Jos Plateau, where soils are already inherently shallow and vulnerable to erosion on sloped terrain, this dynamic poses a particularly acute risk to long-term land productivity.

The reduction in water body extent from 4.73 km² to 3.04 km², representing a contraction of approximately 35.7%, is a concerning indicator of hydrological change within the study area. Although water bodies constitute a small proportion of the total land cover, their reduction signals deteriorating water resource availability with direct consequences for irrigation-dependent agricultural activities and domestic water supply. In semi-arid and sub-humid environments such as the Jos Plateau, surface water bodies serve as critical reservoirs during the dry season when rainfall is insufficient to sustain crop growth. Their diminution may be attributed to sedimentation resulting from increased runoff from bare and degraded land surfaces, encroachment by built-up development, and reduced watershed vegetation that previously sustained baseflows. The interplay between reduced vegetation, expanded bare land, and declining water body extent represents a mutually reinforcing cycle of environmental degradation that progressively narrows the productive agricultural base and increases the vulnerability of smallholder farming communities to climate variability and seasonal water stress.

From a food security standpoint, the implications of arable land loss in Jos South must be assessed within the broader framework of the four pillars of food security: availability, accessibility, utilisation, and stability. The 12.9% reduction in agricultural land area between 2016 and 2026 directly compromises the availability dimension by reducing the physical productive capacity of the local agricultural system. Jos South has historically served as a significant supplier of food crops, including Irish potatoes, tomatoes, maize, and a range of temperate vegetables, to both local and regional markets, owing to its favourable highland climate. The progressive contraction of cultivable land therefore threatens not only household food availability within the LGA but also the regional food supply system that depends on the agricultural output of the Plateau State hinterland. As arable land becomes scarcer and more contested, land rental costs and food production costs are likely to rise, thereby eroding the accessibility dimension of food security for low-income farming households and urban consumers alike. Furthermore, the degradation of soil quality associated with bare land expansion and vegetation loss may reduce yields per unit area on remaining farmland, compounding the effect of quantitative land loss with a decline in land productivity. This dual pressure, shrinking agricultural area and declining per-hectare productivity, represents a structural threat to the long-term stability of food supply in the area.

The livelihood implications of agricultural land loss in Jos South must also be considered in relation to the socio-economic profile of the affected population. A significant proportion of households in Jos South LGA depend on smallholder farming as their primary or supplementary source of income and subsistence. For these households, the loss of farmland, whether through outright land sale under economic pressure, involuntary displacement associated with infrastructure development, or progressive encroachment of urban uses onto farming plots, represents not merely an economic setback but a fundamental disruption of livelihoods and cultural identity. Smallholder farmers displaced from their land frequently lack the financial capital, skills, and social networks to transition successfully into urban employment, making them particularly vulnerable to poverty and food insecurity. Research by Admasu et al. (2019) in Ethiopia documented similar dynamics in which peri-urban farmers dispossessed of agricultural land through urban expansion suffered significant livelihood deterioration. The Jos South context therefore necessitates that land use planning interventions be designed with an explicit awareness of these social dimensions, ensuring that urban development policies do not inadvertently exacerbate rural poverty and food insecurity among the most economically marginalised communities.

The classification accuracy results achieved in this study, with overall accuracies of 94.67% and 93.33% and Kappa coefficients of 0.936 and 0.920 for 2016 and 2026 respectively, provide a high degree of confidence in the reliability of the land cover maps and the change statistics derived from them. These accuracy levels surpass the commonly accepted threshold of 85% for acceptable remote sensing classification performance and are consistent with, or superior to, accuracy levels reported in comparable geospatial land use change studies in West Africa and similar tropical environments (Rimal et al., 2018; Wu et al., 2016). The use of Sentinel-2 satellite imagery, with its 10-metre spatial resolution in visible and near-infrared bands, facilitated detailed discrimination of land cover features at a scale appropriate for local government-level analysis. The slight reduction in overall accuracy observed in the 2026 classification relative to 2016 is consistent with expectations, as increasing landscape heterogeneity associated with urban growth, land fragmentation, and mixed land uses typically elevates spectral confusion among classes in medium-resolution imagery. Notwithstanding this marginal reduction, the 2026 classification remains well within acceptable accuracy parameters and the resulting land use statistics can be relied upon as a credible basis for policy analysis and planning.

A further dimension of the discussion concerns the governance and institutional framework within which land use change in Jos South is occurring. Nigeria’s Land Use Act of 1978 vests ownership of all land in state governments, theoretically providing a mechanism for the regulation of land use in the public interest. However, the practical implementation of this framework has been widely critiqued for its ineffectiveness in preventing speculative land acquisition, informal development, and agricultural land conversion. At the local government level, inadequate planning capacity, including insufficient staffing, limited GIS-based planning tools, and weak enforcement of development control regulations, has allowed urban expansion to proceed with minimal oversight. The results of this study highlight the tangible consequences of these governance deficits at the landscape level. The 19.44 km^2 increase in built-up area documented between 2016 and 2026 reflects, in part, the cumulative effect of thousands of individual land conversion decisions made in the absence of effective regulatory oversight. Addressing this governance gap is therefore a prerequisite for any meaningful intervention aimed at containing agricultural land loss and protecting food security in Jos South and analogous peri-urban localities across Nigeria.

The spatial evidence generated by this study also raises critical questions about the adequacy of current agricultural productivity intensification strategies in offsetting the effects of quantitative land loss. Given that the total arable land base is contracting, maintaining or improving food output in Jos South would require commensurate increases in yield per unit area through improved agronomic practices, input supply, and extension services. However, the deteriorating biophysical environment, characterised by declining soil quality, reduced water availability, and loss of vegetation, actually works against productivity intensification by degrading the natural resource base upon which crop production depends. This creates a compound vulnerability in which smallholder farmers face simultaneously shrinking land endowments and deteriorating land quality, a combination that significantly constrains the scope for on-farm productivity responses to land loss. Policy responses must therefore address both the spatial and qualitative dimensions of agricultural resource depletion, combining land protection measures with investments in soil restoration, water harvesting infrastructure, and climate-adapted agricultural technologies.

5.0 Conclusion

This study employed geospatial techniques using Sentinel-2 imagery, GIS, and remote sensing to assess urbanization, arable land loss, and food security implications in Jos South Local Government Area between 2016 and 2026, with projections to 2036.

The results revealed substantial land use changes characterized by rapid urban expansion, increasing bare land, declining vegetation cover, and significant loss of arable land. Built-up areas increased by 19.44 km^2, while arable land decreased by 26.44 km^2 over the study period. These changes indicate increasing pressure on agricultural resources arising from population growth, infrastructure development, and urban sprawl.

The decline in arable land poses serious concerns for food security, as the reduction of productive agricultural land may limit local food production capacity and threaten livelihood sustainability. Additionally, the expansion of bare land and reduction in vegetation cover suggest ongoing environmental degradation, which could further undermine agricultural productivity and ecosystem stability.

The 2036 projection indicates continued urban growth and further reduction of arable land if current trends remain unchecked. Therefore, sustainable land-use planning, farmland protection policies, environmental conservation measures, and effective urban growth management are essential to ensure balanced development, food security, and ecological sustainability in Jos South LGA.

6.0 Recommendation

1. Implement Farmland Protection Policies: Government should designate and legally protect prime agricultural lands from indiscriminate urban development and land conversion.
2. Strengthen Land-Use Planning Regulations: Urban planning authorities should enforce zoning regulations to guide urban growth and minimize encroachment into productive agricultural areas.
3. Establish Continuous Geospatial Monitoring Systems: GIS and Remote Sensing technologies should be routinely used for monitoring land use changes and supporting evidence-based planning decisions.
4. Rehabilitate Degraded Lands: Areas affected by mining, erosion, and land degradation should be restored through afforestation, soil conservation, and ecological restoration programmes.
5. Promote Urban and Peri-Urban Agriculture: Local authorities should encourage urban agriculture initiatives to supplement food production and improve food availability.
6. Develop Food Security Strategies: Government should integrate food security considerations into urban development policies to ensure that urban growth does not compromise local food production.

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