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Research Article

TEMPORAL CHANGES IN LAND USE AND LAND COVER IN SOUTHEASTERN BENUE STATE: EFFECTS ON SETTLEMENT PATTERNS

Dr. Chukwuma Ifeanyi Obot

Department of Geography, Rev. Fr. Moses Orshio Adasu University, Makurdi, Benue State, Nigeria.

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Abstract

The interplay between human activities and the environment is prominently reflected in land use and land cover (LULC) patterns. Land use denotes the ways in which humans exploit the natural environment for agriculture, settlements, industry, and recreation, while land cover represents the observable physical and biological characteristics of the landscape, including vegetation, water bodies, bare soil, and built structures. Understanding the dynamics of LULC is crucial, as these changes directly influence ecosystem services, biodiversity, and sustainable settlement development. This study examines the temporal and spatial patterns of LULC changes in Southeastern Benue State, Nigeria, from 1991 to 2024, with a particular focus on their implications for settlement development. Using historical datasets, satellite imagery, and GIS-based analysis, the study identifies the major drivers of land transformation, including population growth, urbanisation, agricultural expansion, and socio-economic development. Findings reveal a marked increase in built-up areas at the expense of agricultural and forested lands, reflecting the region's rapid settlement growth. These transformations have significant implications for environmental sustainability, land management, and planning strategies in the state. The study highlights the need for integrated policies that balance human settlement needs with the conservation of natural resources and ecosystem integrity.

Keywords: Land Use, Land Cover, Settlement Development, Southeastern Benue State, Land Use Dynamics

INTRODUCTION

The relationship between humans and the environment is expressed through various interactions, with land use serving as one of the most prominent manifestations of this relationship. Land use refers to the human utilisation of the natural environment for various purposes such as agriculture, settlement, industrial activities, and recreation. It reflects the socio-economic and cultural practices that shape how different areas of land are exploited and managed (Turner et al., 2007). On the other hand, land cover refers to the observable (bio) characteristics present on the Earth's surface, including vegetation, water bodies, bare soil, and artificial structures (Gregorio, 2016). While land cover describes the natural and man-made physical state of the landscape, land use describes how these physical elements are utilised and modified by human activities. In recent decades, the dynamics of land use and land cover (LULC) have undergone substantial transformations driven by both anthropogenic (human activities) and natural factors. These changes are closely linked to population growth, urbanisation, agricultural expansion, deforestation, climate change, and socioeconomic development (Hassan et al., 2016; Lambin & Geist, 2006). Settlement growth, for instance, drives the conversion of agricultural and

forested land into built-up areas, often resulting in habitat fragmentation, biodiversity loss, and alterations in ecosystem services (Seto et al., 2012).

Between 1992 and 2015, agricultural expansion in Nigeria was by far the biggest. As a result, farming and urbanisation have encroached on many historic grazing routes used for both daily grazing and migration (Usman & Nichol, 2022). Though humans have been modifying land to obtain food and other essentials for thousands of years, current rates, extents and intensities of land use and land cover change (LULCC) are far greater than ever in history, driving unprecedented changes in ecosystems and environmental processes at local, regional and global scales (Ejaro & Abdullahi, 2013). These two competing land uses (agriculture and human settlements mainly) are contributing to the decline of forest and woodland areas, and the rising demand for fuel wood and charcoal is also a major cause of deforestation. The rural settlement system is a socio-natural– anthropogenic system (Telichenko & Shcherbina, 2019) developing under the influence of exogenous/external factors (natural, climatic, industrial, infrastructural, and technological), that determine settlement types and forms, and endogenous/internal factors (socio-economic and managerial), that reveal settlement processes (Alekseev & Safronov, 2018; Diaz-Sarachaga, 2019; Shcherbina &Gorbenkova, 2019; Gorbenkova, et al., 2018). These processes have led to shrinking of cultivated land, alongside the inefficient and extensive utilisation of resources, small-scale and disorderly distributions of rural settlements that inevitably lead to hollowing village problems(empty-nests).

In the Southeastern Benue State of Nigeria, rural settlements are the main form of settlement and, like many other typical rural areas, have territorial functions of traditional agricultural production and processing. However, an increase in demands for food, shelter and means of livelihood resulting from the increase in human population has led to pressure on the natural resources with attendant impact on settlement and land-use patterns. This often results in land resource scarcity, fragmentation of farm plots, and ecological degradation, such as increasing emissions, soil erosion, deforestation, and the overuse of natural resources. This is evident in the rate of nonagriculturalization and scale of agricultural production factors, represented by labour force and cultivated lands, with continued growth that is accompanied by the transition of rural settlements and land use (Liu et al., 2022; Liu &Yang, 2017; Long, 2014). Facing the various problems and pressures of urban and rural development, rational planning and construction of land for rural settlement is essential.

Consequently, land use/land cover and settlement patterns in Southeastern Benue State, Nigeria, have undergone significant transformations over the past three decades due to various socioeconomic, demographic, and environmental factors. These changes have significant implications for sustainable development, resource management, and environmental conservation (Adepoju et al., 2019). The rapid expansion of human settlements, driven by population growth and urbanisation, has led to shifts in land use, often resulting in deforestation, agricultural land fragmentation, and increased pressure on natural resources (Ibrahim et al., 2021). Several factors contribute to land use change in the region. Population growth is a major driver, as increased demand for housing, infrastructure, and food production has led to significant land conversion (Nwafor & Onuoha, 2022). In addition, economic activities such as farming, logging, and commerce influence land utilisation patterns. The introduction

of agro-chemical and the use of improved varieties in agriculture and the expansion of cash crop farming have transformed traditional land use systems, often leading to loss of biodiversity and soil degradation (Umar et al., 2020). Rainfall variability patterns and rising temperatures have led to shifts in agricultural practices and the expansion of settlements into previously uninhabited areas (Ogundele & Adebayo, 2018). Furthermore, increased demand for land and land tenure systems affect land accessibility, sometimes resulting in disputes and unsustainable land use practices (Ezeh & Okeke, 2023).

The settlement distribution in Southeastern Benue State has evolved significantly between 1991 and 2024, with increased settlement growth and rural-urban migration. The rise of secondary cities and peri-urban areas has been fuelled by economic opportunities, improved transportation networks, and infrastructural development. The impact of these changes on the environment is considerable. The conversion of forests and wetlands to agricultural and residential land has led to habitat loss, soil erosion, and declining water quality (Chukwu et al., 2019). Socioeconomically, while expansion provides opportunities and improves access to services, it also worsens inequality, with some communities facing displacement and limited access to essential resources (Abubakar & Danjuma, 2020).

Southeastern Benue state which comprises four (4) of the biggest local government areas in terms of population size in Benue state, that is; Kwande (248,697), Konshisha (225,672) Ushongo (188,341) and Vandeikya (183,939) accounts for 17% of the population of Benue State seems to have witnessed unprecedented population growth in the last three decades. This rapid population growth coupled with traditional agricultural practices, alongside the 'Farmers-herdsmen crisis' have tremendously impacted on the land resources particularly where climatic conditions are more favourable for life and agricultural production. This may have altered and may be still altering the existing settlement pattern and land-use pattern with potential implications for human and food security, sustainable livelihoods and environment in the region. Therefore, understanding these changes is crucial for effective land management, sustainable development, and policymaking.

Sadly, there is a lack of empirical studies focusing on the spatio-temporal analysis of these changes. Previous studies have shown the importance of understanding rural settlement dynamics and land use changes in various contexts (Lambin et al., 2001; Mbow et al., 2014; Lai, 2020; Guyassa et al., 2018; Fenta et al., 2017). However, few have specifically addressed the Southeastern Benue state region of Nigeria. Existing studies in Nigeria often focus on changes in urban areas, rural development at broader regional scales, neglecting the unique dynamics of rural settlements in specific localities (Nseabasi, 2012; Olayemi et al., 2019). In addition, while some studies have examined land use changes in Benue State, they often lack a temporal dimension or fail to analyse settlement patterns comprehensively (Adegun et al., 2017; Shaahu et al., 2020). Although Kile, et al (2024) worked on settlement restructuring for enhanced socio-economic development in Ushongo Local Government Area, Benue State, Nigeria. While Ortserga (2010) investigated the pattern of agricultural land use in the Ute district, Dam (2018) analysed the emerging urban systems in Vandeikya local government area. These studies, however, failed to address the issue of landuse changes covering the entire region. Thus, there exist significant research gaps in understanding the spatio-temporal dynamics of rural settlements and land use in Southeastern Benue state, which

this study seeks to address. This knowledge gap could hamper informed decision-making for sustainable development and land management in the region. Hence, it is imperative to conduct a systematic analysis to understand the changing spatio-temporal land use in Southeastern Benue state.

MATERIALS AND METHODS

Study Area

The southern Southeastern Benue State is located between latitudes $6^{0}033^{/}1$ and $7^{0}0\ 03^{/}1$ North and longitudes $8^{0}0\ 48^{/}1^{//}$and $9^{0}0\ 04^{!}$ East in the southern part of Benue state (Figure 1). The geographical terrain of Southeastern Benue State is a consummation of four Local Government Areas (LGAs) in contemporary Tiv society, namely: Konshisha, Kwande, Vandeikya, and Ushongo. Spatially, Southeastern Benue state shares boundaries with Gboko, Buruku, and KatsinaAla LGAs in the North. Gwer-East, Obi and, Oju LGAs in the West. While, in the South, the area shares a boundary with the Northern Cross River Basin inhabited by ethnic groups collectively known by the Tiv people as Udam with whom the Shangev-Ya, Kunav, Gaav, and Ishangev-Tiev shares common frontiers. In the East, Southeastern Benue shares a boundary with the Republic of Cameroun, characterised by the foothills of the Cameroon highlands and the Sonkwalla or Sankwura hills of the Obudu territory (Ortserga 2010).

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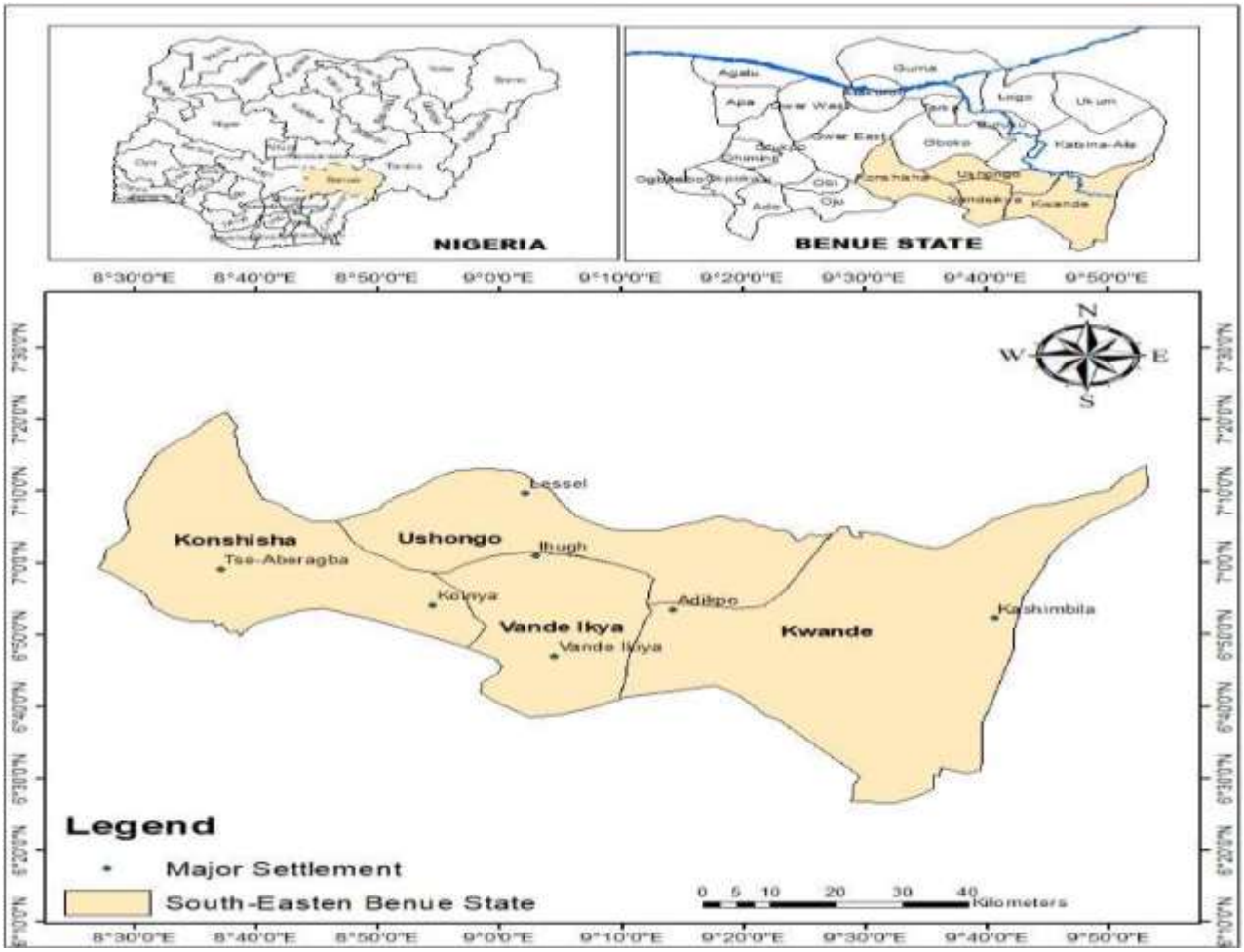

Figure1: South-Eastern Benue State, Nigeria

Source (Geography Dept Benue state University)

The settlement of the Southeasterrn Benue state is primarily rural, with its population scattered over its landscape in the forms of farmsteads, hamlets and small villages. Demographically, settlements in the study area have varying sizes and composition. Typically, the settlement in the study area is multi-dimensional a sit consists of dispersed pattern and a few pockets of nucleation in the bigger settlements which are in the form of big villages. The population densities range between 50 persons per sq.km in areas of farmsteads while, some are fairly populated with densities ranging between, 150-605 respectively. This wild dispersal can be said to be tied with the patrilineal or traditional affinity to kinship and the desire to expand ownership over land. This is important to the current discourse as it gives an insight into the population densities and how it impacts settlement character and also, human interference impacting landuse patterns and changes (Ortserga, 1988).

The Southeastern Benue state is a predominantly rural region. This typically means that, the mainstay of the people of the region is agricultural who employ land for various purposes of producing agricultural materials.

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Farming is mainly subsistence based on tuber crops, tree crops, and fruit trees. There are pockets of mining activities in the region as well as lumbering all of which contributes to its economic activities. The implication of land use activities in the region shows the manipulation of man through ecological processes that interferes with natural ecosystems that alter the base which supports human activities. Landuse patterns produced patterns on land, settlement types and farming rotation, and fallows. The patterns that are created by these activities are dynamic and the influencing factors change over time.

METHODS

The study utilised four sets of multi-temporal Landsat satellite images, Landsat TM (1991), Landsat ETM+ (2000, 2011), and Landsat 8 OLI (2024), all sourced from the USGS Earth Explorer platform. A topographic map of the study area guided the extraction and geo-processing of the images. Dry season imagery (November–March) was selected to minimise cloud interference. Ground truth data for land use/land cover (LU/LC) classes were obtained through GPS-referenced field points, supplemented by high-resolution Google Earth images for classification support and accuracy assessment. Five LU/LC classes were defined: Forest cover (dense tropical tree cover), Grassland (including agricultural/mixed farming areas), Settlement (urban/rural built-up areas and infrastructure), Waterbody (rivers, lakes, dams), and Rock Outcrop/Bare land (sparsely vegetated or exposed surfaces). These classes formed the basis for the classification of satellite-derived land cover maps across the selected years (Tables 1 and 2).

Table 1: Satellite data used

S/N	Data type	Date	Resolution	Path/Row	Source
1	Landsat TM imagery	January, 1990	30m	188/054	USSG Earth Explorer
2	Landsat ETM imagery	March, 2000	30m	188/055	USSG Earth Explorer
3	Landsat ETM imagery	November, 2010	30m	187/054	USSG Earth Explorer
4	Landsat 8 OLI imagery	November, 2020	30m	187/055	USSG Earth Explorer

Table 2: Land cover types used in the Classification of satellite-derived land cover types

Code	Land Cover	Description
1	Forest cover	The high density of trees with little or no undergrowth. Dominated by tropical trees such as *Kyaya senegalensis*, *Magniferaindica*,*Daniellaolivera*, *Isoberlinadoka* and *parkiabiglobosa*

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2	Grassland	An environment dominated by grasses and herbaceous plants typically, spear grass and elephant grass*(Andropogangayanun)* often used for grazing livestock. It is used here collectively to also include agricultural land or mixed farming area that describes land that constantly shifts between farm and fallow land. Typically, the vegetation cover has been removed or modified and replaced by other types of vegetation cover of anthropogenic origin
3	Settlement	This comprises urban and rural built-up including homestead areas such as residential, commercial, industrial areas, villages, road networks, pavement, and man-made structures.
4	Waterbody	Areas persistently covered by water typically lakes, dams, and rivers
5	Rock Outcrop/Bare land	Land of limited ability to support biotic life and in which less than one-third of the area has vegetation cover. These areas typically have less than 4% vegetation cover such as exposed river sand land in-filling sites, excavation sites, open space, and bare soils.

RESULT AND DISCUSSION

Landuse/Land Cover in Southeastern Benue State

The result of the Landuse/Land Cover in South-Eastern Benue State is presented in Figures 2-5 and Table 3. In 1991, the result revealed that forest cover dominated the region, occupying 3,353 km², equivalent to 52% of the total land area. Grassland and pasture followed closely, accounting for 2,957 km² or 45.86%, underscoring the significance of agriculture and grazing activities in the area. Settlements were minimal, covering only 63 km² or 0.98%, suggesting limited urbanisation and infrastructural development during the period. Water bodies occupied a mere 24 km² (0.37%), indicating scarce surface water availability and possible challenges in water resource management. Rock outcrops made up 51 km² (0.79%), suggesting the presence of rocky terrain, which could impact agricultural activities and settlement patterns. These results indicate a predominantly natural landscape with minimal anthropogenic influence, dominated by forests and grasslands. However, the low percentage of settlement and water bodies points to the developmental and water accessibility challenges in this area.

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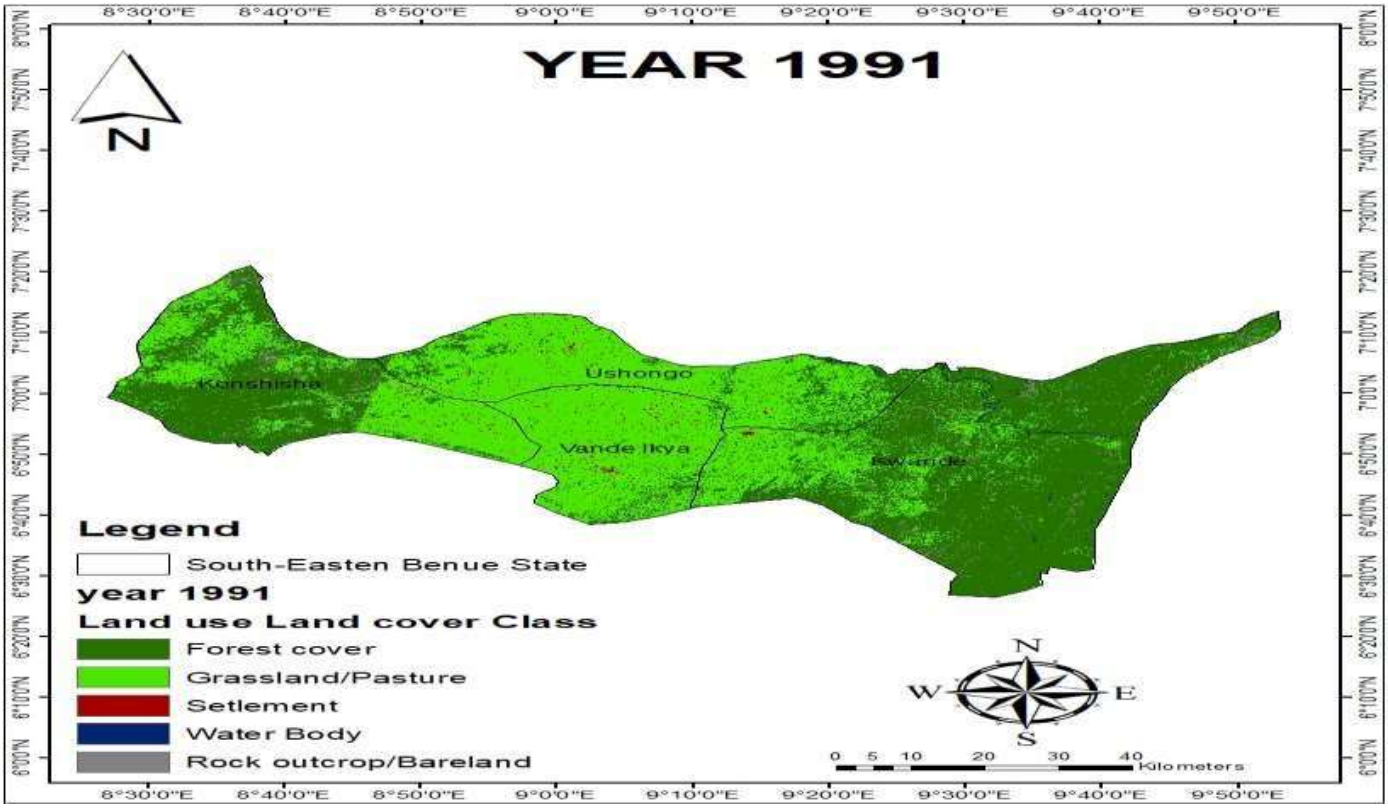

Figure 2: Land use Land cover (LULC) Change for South-Eastern Benue State for 1991

The spatial distribution of various Land Use and Land Cover (LULC) types in southeastern Benue State in 1991 presented in Figure 2 reveals several distinct patterns. Forest cover, represented in dark green, dominates the landscape, indicating that most of the area was forested during this period. The forests are widespread but vary in density, with thicker forested parts concentrated in areas further from settlements and roads. These dense forest areas are particularly prominent in the southern and eastern parts of the map, especially within Kwande Local Government Area. Grasslands and pastures, shown in light green, are extensive and often interspersed with forest cover. These areas are particularly noticeable in central locations such as Ushongo. They may represent transitional zones between dense forests and areas modified for human activities like agriculture and settlements. This mix of grasslands and forests indicates the region's natural diversity and multiple land uses.

The result further sows that settlements are sparsely distributed and relatively small. They are concentrated near major localities such as Konshisha, Ushongo, and Vandeikya. The spatial distribution of these settlements suggests a preference for locations near likely transportation or access routes, where land has been cleared for habitation and agricultural purposes. The sparse and limited settlement distribution indicates that this region was largely rural with minimal urban development at the time (1991). The result further showed that water bodies, depicted in blue, are relatively few and appear as narrow lines, suggesting the presence of rivers or streams rather than large lakes. These hydrological features are located in areas where rivers likely flow through the region,

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serving as critical resources for local agriculture and influencing settlement patterns. Although not widespread, these water bodies play a vital role in the region's ecological and socioeconomic activities. Similarly, rock-outcrops and barelands, shown in grey, are minimal and occur sporadically. These areas are located in terrains unsuitable for vegetation growth or agricultural use, such as elevated rocky areas. Their limited presence indicates that most of the land was vegetated or otherwise suitable for natural ecosystems.

Overall, the region in 1991 was characterized by a dominance of natural vegetation, with forests and grasslands being the primary land cover types. Human influence, as indicated by settlements and barelands, was minimal, reflecting limited urbanization or deforestation at the time. The presence of water bodies, though sparse, significantly shaped settlement and agricultural activities. This spatial distribution provides a baseline for understanding changes in land use over the study period (1991-2024).

Table 3: Land use land cover change Statistics in South-Eastern Benue state from 1991-2024

1991	2001	2011	2024					
LULC Class	**Area in (Km2)**	**Area in (%)**	**Area in (Km2)**	**Area in (%)**	**Area in (Km2)**	**Area in (%)**		
2598.0	40.2	1125.0	2353.0		2609.0			
Forst cover	0	52.00	0	40.46	0	9	0	17.45
Grassland/Pastur	2957.0		3653.0		3656.0	56.7	4617.0	
e	0	45.86	0	56.65	0	0	0	71.60
Settlement	63.00	0.98	116.00	1.80	120	1.86	442.00	6.85
Waterbody Rock	24.00	0.37	19.00	0.29	20.00	0.31	20.00	0.31
outcrop/Bare								
land	51.00	0.79	51.00	0.79	54.00	0.84	244.00	3.78
Total	**6448.0 0**	**100.0 0**	**6448.0 0**	**100.0 0**	**6448.0 0**	**100**	**6448.0 0**	**100**

Source: The land use/land cover (LULC) statistics for South-Eastern Benue State in 2001 reveal the dominant land use categories in the region (Figure 11).

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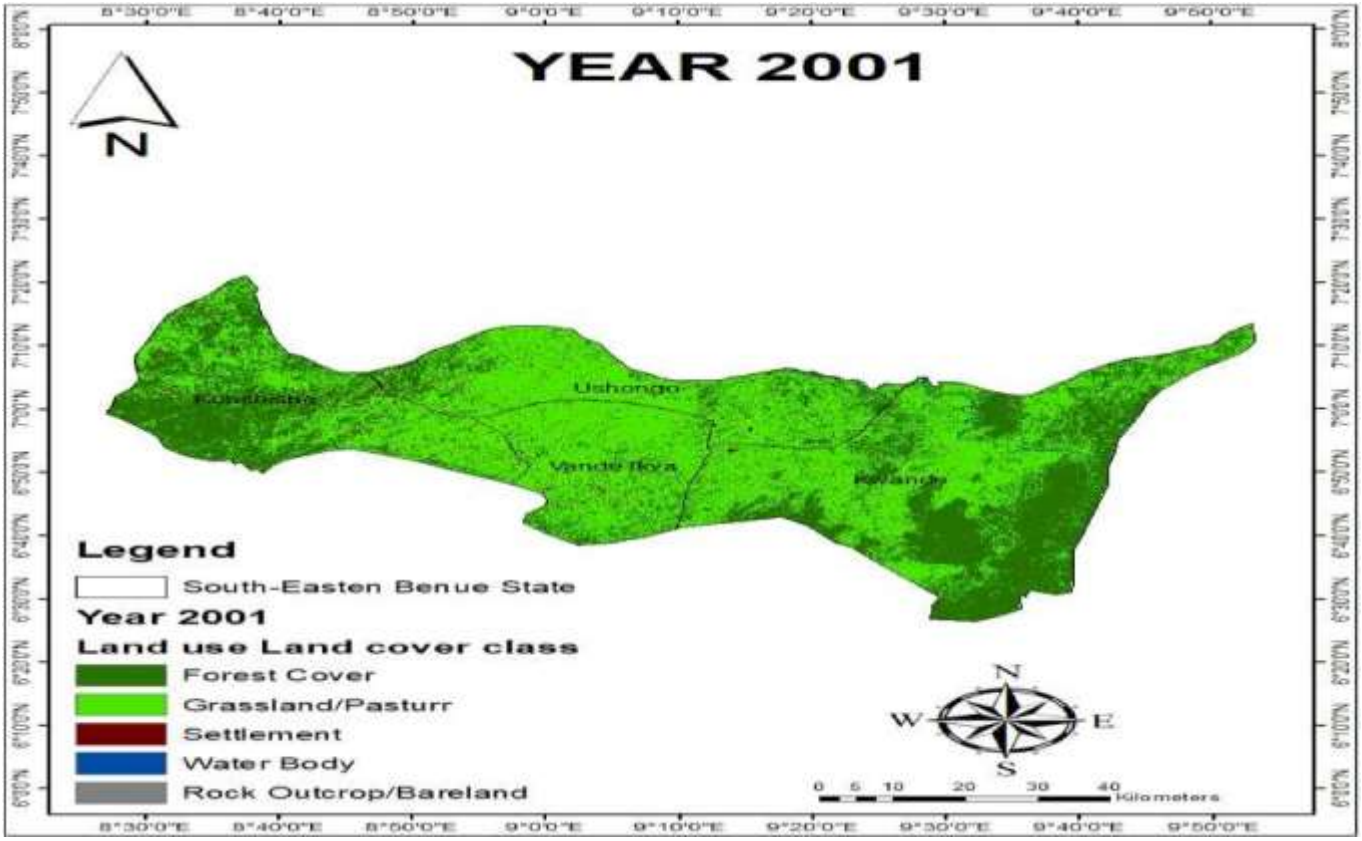

Figure 3: Land use Land cover (LULC) Change for South-Eastern Benue State for 2001

Forest cover accounted for 40.46% of the total land area (2609 km²), suggesting the significant presence of forested areas in the region. Grassland and pastureland, comprising 56.65% (3653 km²), represented the largest land use category, indicating a predominance of grazing and agricultural activities in the area. Settlements, covering 1.80% (116 km²), showed a relatively low human settlement density compared to the other land uses. Water bodies covered just 0.29% (19 km²) of the area. Rock outcrops, at 0.79% (51 km²), were also relatively minimal in terms of land coverage. These statistics suggest a predominantly rural landscape with significant forest and grassland areas and relatively low urban development.

The land use and land cover (LULC) results for South-Eastern Benue State in 2011 reveal a dominant presence of grassland/pasture, occupying 56.7% (3,656 km²) of the total land area. Forest cover follows, contributing 40.29% (2,598 km²) of the area, indicating significant forest preservation despite other land use activities. Settlements account for a small fraction, just 1.86% (120 km²), indicating relatively low urbanization in the region. Water bodies contribute only 0.31% (20 km²), suggesting minimal water features within the study area. The area covered by rock outcrops is 0.84% (54 km²), which is a small yet notable feature in the landscape. These results indicate that the majority of the land is still dominated by natural cover, such as grasslands and forests, with minimal human settlement expansion and water features. The dominance of grassland suggests a significant

space for grazing and agriculture, possibly linked to local livelihoods. The small area of water bodies may indicate a need for increased water resource management in the region. The rock outcrop category may point to geological factors that could influence land use planning and development strategies.

The spatial distribution of the various Land Use and Land Cover (LULC) types in southeastern Benue State for the year 2001 is presented in Figure 3. The result shows that **f**orest cover continues to dominate the landscape, particularly in the southern and eastern parts of the region, such as Kwande Local Government Area. However, the density of forested areas appears to have reduced slightly compared to earlier years, with some areas showing fragmentation. This indicates an increasing encroachment due to human activities such as agriculture, logging, or settlements. Grasslands and pastures occupy a substantial portion of the central region, especially around Ushongo. These areas act as transitional zones between forested regions and settlements or agricultural lands. The spread of grasslands suggests deforestation and expansion of settlements and agricultural activities.

The result revealed that settlements appear more prominent and slightly more widespread than in 1991. Concentrations are notable near major localities such as Konshisha, Ushongo, Vandeikya, and parts of Kwande. This pattern suggests increasing human habitation and development along major access routes. Water bodies remain limited and appear as thin linear features, indicating the presence of rivers or streams. Their spatial consistency suggests limited changes in major watercourses over time. Also, barelands or rocky outcrops remain minimal and sporadic, occurring in terrains unsuitable for vegetation or agriculture. These areas appear relatively stable compared to other LULC types, reflecting their inherent geological characteristics. The 2001 LULC map suggests that while forest cover and grasslands still dominate, there is a noticeable increase in human influence. Settlements have expanded, leading to more significant land use changes, such as deforestation and conversion of natural vegetation to agricultural areas.

The spatial distribution of Land Use and Land Cover (LULC) types in southeastern Benue State for the year 2011 is presented in Figure 12.

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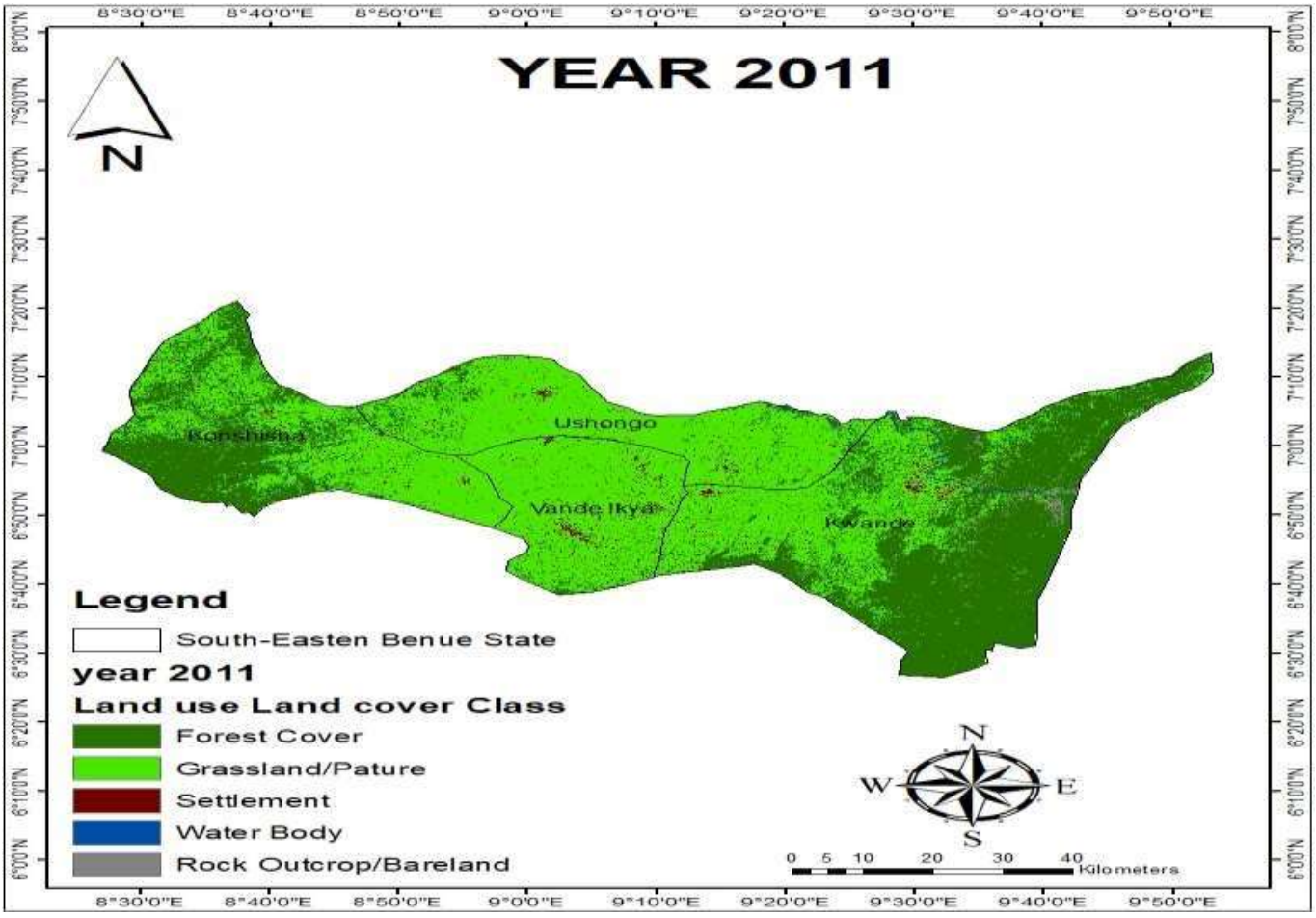

Figure 4: Land use Land cover (LULC) Change for South-Eastern Benue State for 2011

The result shows that forest cover still occupies significant portions of the region, particularly in the southern and eastern parts, such as Kwande Local Government Area. However, there is visible fragmentation in the forested areas compared to 2001, indicating an ongoing reduction in forest density. This trend suggests further encroachment by human activities, likely driven by agriculture, logging, and settlement expansion. Grassland and pasture areas continue to expand, covering more of the central regions, especially around Ushongo. The increase in grasslands may signify further deforestation or land clearance for agricultural purposes. These areas continue to serve as transitional zones between forests and human-modified land.

Again, settlements show a marked increase in both size and distribution compared to 2001, with the concentration of settlements intensifying around key localities such as Konshisha, Ushongo, Vandeikya, and parts of Kwande. This spatial expansion indicates growing population pressures, with settlements extending along transportation routes and areas of economic activity. Water bodies remained relatively stable in their distribution. The stability of water bodies suggests that no significant hydrological changes occurred during this period. Barelands and

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rocky outcrops also remained sparse and scattered, occupying areas unsuitable for vegetation or agriculture. Their distribution appears unchanged from previous years, reflecting the natural stability of these features.

Table 3 presents the land use/land cover (LULC) statistics for South-Eastern Benue State in 2024. The result indicates that the majority of the land area is occupied by grassland/pasture, covering 4,617,000 m² (71.60%). Forest cover, though significant, is relatively small, with 1,125,000 m² (17.45%) of the total area. Settlements make up 6.85% (442,000 m²) of the region, indicating a moderate level of urbanization. Water bodies, at just 0.31% (20,000 m²), are minimal in the region. Rock outcrops, including rocky terrains, account for 3.78% (244,000 m²) of the area, which is typical of certain topographic features in the region. The prominence of grassland/pasture may reflect agricultural or grazing activities that dominate the region. The relatively small proportion of forest cover suggests ongoing land use changes, from deforestation or agricultural expansion. The limited water bodies could impact water resources in the area, particularly during dry seasons. The spatial distribution of the Land Use and Land Cover (LULC) types in southeastern Benue State for the year 2024 is presented in Figure 5. The Figure reveals significant landscape transformations compared to previous years (1991, 2001, and 2011).

Figure 5: Land use Land cover (LULC) Change for South-Eastern Benue State for 2024

Figure 5 indicates that the forest cover has continued to decline, particularly in the eastern and southern parts of Kwande Local Government Area. While forested areas still exist, they are now more fragmented, with visible encroachment along the boundaries. This decline indicates intensified deforestation activities, likely due to

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agriculture, logging, or settlement expansion. Grassland and pasture areas dominate the landscape, expanding further into areas previously occupied by forest cover. The central regions around Ushongo and Vandeikya exhibit a broad stretch of grasslands, suggesting ongoing deforestation and land conversion for farming or even grazing. The dominance of this class indicates the region's reliance on and extensive agriculture.

Settlements have significantly expanded in size and distribution, with notable growth around Konshisha, Ushongo, and Vandeikya. These areas exhibit higher settlement densities, indicating urbanization and population growth. Linear settlement patterns along transport corridors suggest infrastructure development and increased connectivity. Water bodies, represented by rivers and streams, maintain a stable distribution. However, encroachment by settlements and agricultural activities near these water bodies may lead to environmental degradation, such as pollution or reduced water quality. Similarly, the distribution of rock outcrops and bareland remains sparse and relatively unchanged. These areas are primarily found in the northern parts of the region, where the terrain may be unsuitable for vegetation or human activities.

Overall, the 2024 LULC provided empirical evidence of significant deforestation and fragmentation of forest cover; expansion of grasslands into areas previously occupied by forests; urbanization and settlement growth, particularly in central and southern areas; and a stable presence of water bodies, though under potential threat from human activities. These changes point to growing anthropogenic pressures on the environment, driven by population growth, agricultural intensification, and settlement (urbanization) expansion. The implications include loss of biodiversity, altered ecosystem functions, and challenges for sustainable land management in the region.

Annual and Decadal Land use land cover change in South-Eastern Benue State

Tables 4 and 5 present the decadal land use/land cover (LULC) change in South-Eastern Benue State from 1991 to 2024, showing shifts in various land categories.

Table 4: Annual Land use land cover change in South-Eastern Benue state from 1991-2024

LULC Class	1981-1991 Area in Km2)	Area (%)	1991-2001 Area in (Km2)	Area ((%)	2001-2024 Area in	Area (%)	1991-2024 Area in	
Forst cover	-74.40	-1.15	-1.10	-0.02	147.30	-2.28	-74.27	-1.15
Grassland/Pasture	69.60	1.08	0.30	0.00	96.10	1.49	55.33	0.86
Settlement	5.30	0.08	0.40	0.01	32.20	0.50	12.63	0.20
Waterbody	0.00	0.00	0.30	0.00	19.00	0.29	6.43	0.10
Rock outcrop/Bare land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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The results of annual land use and land cover (LULC) change revealed that forest cover experienced a notable annual decrease across all periods. Between 1981-1991, the forest cover reduced by 74.40 km² (1.15%), followed by a slight decrease of 1.10 km² (0.02%) from 1991-2001 annually. The most significant annual decline occurred from 2001-2024, where 147.30 km² (2.28%) of forest was lost, leading to a total reduction of 74.27 km² (1.15%) over the entire 19912024 period. This indicates a persistent trend of deforestation in the region.

Conversely, grassland and pasture areas saw a general annual increase over the study period. From 1981-1991, grassland expanded by 69.60 km² (1.08%) annually. The growth slowed down to 0.30 km² (0.00%) between 1991-2001, but the period from 2001-2024 marked a substantial increase of 96.10 km² (1.49%), resulting in a total increase of 55.33 km² (0.86%) over 1991-2024. This growth in grassland and pasture could be linked to increased agricultural activities and the encroachment of previously forested areas.

Settlement areas remained minimal but showed gradual expansion. From 1981-1991, settlements increased by 5.30 km² (0.08%), with a marginal increase of 0.40 km² (0.01%) in the next decade (1991-2001). The most significant increase occurred from 2001-2024, with an area of 32.20 km² (0.50%) added to settlement zones, contributing to a total increase of 12.63 km² (0.20%) over the entire 1991-2024 period. This suggests a gradual but consistent growth in human habitation. Waterbody areas experienced minimal changes, with an addition of 0.30 km² (0.00%) from 19912001, followed by a more significant increase of 19.00 km² (0.29%) from 2001-2024, resulting in a total increase of 6.43 km² (0.10%) between 1991 and 2024. The category of rock outcrop/bare land showed no significant changes throughout the study period, remaining constant across all intervals

Table 5: Decadal Land use land cover change in South-Eastern Benue state from 1991-2024

LULC Class	1991-2001 Area in (Km2)	1991-2001 Area in (%)	2001-2011 Area in (Km2)	2001-2011 Area in (%)	2011-20024 Area in (Km2)	2011-20024 Area in (%)	1991-2024 Area in (Km2)	1991-2024 Area in (%)
Forst cover	-744.00	-11.54	-11.00	-0.17	-1473.0	-22.84	-2228.0	-34.55
Grassland/Pasture	696.00	10.79	3.00	0.05	961.00	14.90	1660.00	25.74
Settlement	53.00	0.82	4.00	0.06	322.00	4.99	379.00	5.88
Waterbody	-5.00	-0.08	1.00	0.02	0.00	0.00	-4.00	-0.06
Rock outcrop/Bare land	0.00	0.00	3.00	0.05	190.00	2.95	193.00	2.99
Total	6448.00	100.00	6448.00	100.00	6448.00	100	6448.00	100

The result in Table 5 shows that over the period (1991-2024), there was a significant reduction in forest cover by 2,228 km² (34.55%), indicating extensive deforestation. This loss is more pronounced in the period between 2011 and 2024, with a decrease of 1,473 km² (22.84%), indicating the accelerating rate of forest degradation in recent

years. In contrast, grasslands and pastures show a notable increase, growing by 1,660 km² (25.74%) over the entire study period. The 1991-2001 decade saw an increase of 696 km² (10.79%), while a slight 3 km² (0.05%) growth occurred between 2001 and 2011. However, the period from 2011 to 2024 experienced a more substantial rise of 961 km² (14.90%). This suggests that the expansion of grasslands is possibly linked to agricultural activities, settlement expansion, or changes in farming practices, especially in response to diminishing forest areas.

Settlement areas also increased significantly, from 53 km² (0.82%) in 1991-2001 to 379 km² (5.88%) by 2024. This growth indicates that rural settlements are gradually being transformed into semi-urban settlements as a result of the increased human population in the region. The change in settlement area, especially the notable 322 km² increase between 2011 and 2024 (4.99%), could be attributed to migration, and agricultural expansion. However, the percentage of total land area dedicated to settlements remains relatively small, suggesting that while growth is significant, the overall extent of settlements about other land uses is still modest, suggesting that the area is still largely rural.

Water bodies experienced a slight change, with a decrease of 5 km² (-0.08%) from 1991 to 2001, a slight increase of 1 km² (0.02%) from 2001 to 2011, and no change from 2011 to 2024. The overall decrease in water bodies by 4 km² (-0.06%) is negligible, suggesting that there has been little variation in water availability or that water bodies have been relatively stable throughout the decades. Rock outcrops and bare lands saw an overall increase of 193 km² (2.99%) over the 19912024 period. This increase is primarily attributed to the 190 km² (2.95%) rise between 2011 and 2024. This may reflect changes in land use, possibly linked to mining, construction, or the natural process of soil erosion and degradation in areas previously covered by vegetation. Overall, the result reveals significant land cover changes in South-Eastern Benue State, with forest cover and water bodies declining, while grasslands, settlements, and rock outcrops have expanded.

Implication of the observed LULC for Settlement Patterns in Southeastern Benue State The LULC results indicate that settlement expansion in Southeastern Benue State has been gradual but sustained over the study period, reflecting a transition from a predominantly rural landscape to one with emerging semi-urban features. In 1991, settlements occupied less than 1% of the total land area, signifying a highly dispersed, rural settlement pattern with small nucleated villages surrounded by extensive forests and grasslands. This low settlement density implied limited infrastructure, basic service provision challenges, and a high dependence on natural resources for livelihoods. By 2001, settlements expanded slightly to 1.8%, suggesting early signs of urban growth, possibly influenced by improved road networks, market expansion, and population growth. Between 2011 and 2024, settlements experienced significant spatial expansion, reaching 6.85% of the total land area by 2024, with growth following linear patterns along transportation corridors. While this form of expansion facilitates trade, mobility, and access to services, it also risks ribbon development, which can strain infrastructure and reduce agricultural land availability. The decline in forest cover, from 52% in 1991 to 17.45% in 2024, indicates that settlement growth is strongly linked to deforestation, with much of the cleared land converted to grassland/pasture. This has resulted in biodiversity loss, microclimatic changes, and potential human-wildlife conflicts. Settlement expansion

has been most prominent around major administrative and economic centres such as Konshisha, Ushongo, and Vandeikya, while in Kwande LGA, rugged terrain and forest reserves have constrained spread, leading to clustering in more accessible lowlands.

The limited distribution of water bodies (0.31% in 2024) suggests that water scarcity may influence settlement location, with most communities preferring areas near rivers and streams. However, encroachment on these water sources increases the risk of pollution and degradation. Rock outcrops and barelands, though covering only 3.78% by 2024, pose physical constraints to settlement expansion in some elevated areas, and their growth may indicate land degradation processes affecting settlement suitability. The expansion of grasslands to 71.6% of the total area by 2024 shows that settlements are increasingly embedded within agricultural landscapes, potentially creating conflicts between land for housing and farming. The decentralised settlement pattern, with scattered clusters, limits economies of scale for infrastructure development but helps maintain rural livelihoods and reduces intense urban environmental problems. The spatial fragmentation of forest cover suggests that future settlements may expand into previously remote areas as access improves, accelerating habitat loss and reducing ecological resilience. Although settlement growth remains slower compared to grassland expansion, the sharp rise between 2011 and 2024 indicates intensifying urbanisation pressures. Without proper planning, this could result in informal settlements with poor drainage, inadequate sanitation, and vulnerability to environmental hazards. Overall, the results point to a settlement pattern in transition, from sparsely distributed rural hamlets to expanding semi-urban centres, shaped by agricultural expansion, deforestation, and infrastructural connectivity.

DISCUSSION

Findings from related studies at large are consistent with the findings of this current study. For instance, the study by Salman et al. (2021) provides evidence of intense LULC changes in Barishal from 2000 to 2020, revealing significant urban expansion and the decline of natural vegetation and agricultural land. These findings agree with the current study on Southeastern Benue State, where similar trends of deforestation and settlement expansion have been observed, albeit at different magnitudes and time frames. Both studies show the dominance of natural landscapes in earlier periods, with forests and vegetation giving way to urban and agricultural land due to human activities. Salman et al. (2021) recorded urban growth of 69.22% over two decades, while the current study in South-Eastern Benue State shows more gradual settlement expansion from 1991 to 2024. In addition, the reduction of vegetation in Barishal (16.28%) mirrors the decline in forest cover observed in Benue, where fragmentation and encroachment intensified over the years. Both studies used GIS and remote sensing tools, such as NDVI analysis, to quantify these changes, underscoring the reliability of spatial data in environmental studies. However, while Salman et al. (2021) noted notable increases in water bodies in Barishal, the current study indicates minimal change in water features in Benue, emphasising regional variations in hydrological dynamics. The annual change rates documented in Barishal also show faster LULC transitions compared to southeastern Benue state, likely due to differing socio-economic pressures. Both studies underscore the necessity of sustainable land management to mitigate adverse effects, such as agricultural degradation and unplanned urbanization.

In a related study Abebe et al. (2022) agrees with the current study in demonstrating the significant role of human activities in driving Land Use/Land Cover (LULC) changes. Abebe et al., (2022) reported that cultivated areas and settlement areas increased by 9% over 30 years in Northeastern Ethiopia, whereas the current study for Southeastern Benue State shows a steady rise in settlements from 0.98% in 1991 to 6.85% in 2024. Both studies emphasise the reduction of ecologically important LULC types—forest cover in Abebe's study declined drastically from 8.9% to 2%, paralleling a drop from 52% to 17.45% in Southeastern Benue State. The expansion of grasslands and pastures, noted as transitional zones, is also common, signifying deforestation and land conversion for agriculture in both regions. Population growth, agriculture, and poverty are identified as key drivers of LULC changes in both studies. The Ethiopian study links these to land tenure insecurity and lack of public awareness, while the current study suggests urbanisation and infrastructural development pressures. The spatial fragmentation of forests, observed in both cases, reflects increasing encroachment, particularly near settlements and roads. Again, both studies underscore the urgent need for sustainable resource management to mitigate further LULC degradation and maintain ecosystem services.

The findings of Hundu et al. (2021) on land use and land cover (LULC) changes in Katsina-Ala Local Government Area provide a valuable understanding of trends observed in the current study of Southeastern Benue State. Both studies showed significant deforestation, with Hundu et al. (2021) reporting a -53.19% reduction in forest cover from 1990-2020 and the current study identifying continued forest fragmentation and decline in Kwande LGA. This reflects persistent pressures from agriculture, logging, and settlement expansion across the broader region. Similarly, the increase in farmland in Hundu et al.'s study parallels the expansion of grasslands and pastures in the current study, suggesting widespread agricultural intensification. The annual rate of forest loss (-1.77%) and farmland gain (1.44%) in Katsina-Ala aligns with trends in Southeastern Benue, where grasslands now dominate the landscape. Built-up areas which increased by 9.2% in Hundu et al.'s findings, are consistent with the observed urbanisation and settlement expansion in Konshisha, Ushongo and, Vandeikya. Water bodies, although stable in Hundu et al.'s research, remain minimal in both areas, suggesting ongoing challenges in water resource management. The stability of rock outcrops in both studies suggests limited influence on LULC changes. Collectively, these studies demonstrate a regional pattern of deforestation and agricultural expansion at the expense of natural ecosystems, driven by similar socio-economic pressures. This underscores the need for coordinated policies addressing sustainable land management and ecological preservation across Benue State.

The study by Ogunkolu (2018) demonstrated the significant role of Remote Sensing and GIS in monitoring urbanisation and land use changes, particularly in Chikun LGA of Kaduna, Nigeria, where built-up areas expanded drastically from 13.54 km² to 590.49 km² between 1990 and 2014. Comparatively, the current study of Southeastern Benue State reveals slower but steady settlement growth, from 63 km² in 1991 to 442 km² in 2024. Both studies demonstrate an inverse relationship between urbanisation and vegetation cover, as forests in Chikun declined sharply by 1,405.90 km², while in Southeastern Benue, forest cover reduced from 3,353 km² to 1,125 km² over a longer period. Ogunkolu's findings on population influx and security-driven migration in Chikun resonate with the current study's observation of settlement expansion along transportation routes, suggesting

economic and infrastructural factors as common drivers. However, Southeastern Benue exhibits a dominance of grassland expansion, driven by agricultural reliance, unlike the compact urbanisation seen in Chikun. Both studies underscore the need for sustainable land use policies to mitigate land degradation and conserve natural resources. Ogunkolu's emphasis on integrating geo-information technologies aligns with the current study's call for improved water resource management and environmental planning to balance development and ecological preservation. Musa et al. (2022) study on the Gidan Kwano watershed revealed significant changes in land use and land cover (LULC) from 1975 to 2015, showing a notable decline in vegetation and wetlands, primarily due to urbanisation and construction activities. Similarly, the current study on Southeastern Benue State reported a persistent decrease in forest cover from 1991 to 2024, with grasslands and pastures expanding significantly. The findings of both studies are consistent with each other in that they indicate deforestation and agricultural expansion as key drivers of LULC changes, underscoring the impact of human activities on natural ecosystems. In Musa et al.'s study, vegetation dominated the landscape in 1975 but reduced from 50% to 34% by 2015, reflecting intensified anthropogenic pressures. Likewise, the current study notes forest cover declining from 52% in 1991 to 17.45% by 2024, with settlements expanding from 0.98% to 6.85%. These findings suggest the growing encroachment of settlements and agriculture at the expense of forests, consistent with the broader trends observed in Nigeria's rural and urban dynamics. In addition, both studies emphasise the implications of these changes on environmental and socio-economic systems. Musa et al. noted decreased surface water infiltration due to paved areas, while the current study identifies challenges in water resource management due to the limited availability of water bodies. This parallel indicates a shared concern for hydrological impacts stemming from LULC changes.

CONCLUSION AND RECOMMENDATIONS

The study concludes that the rural settlements in Southeastern Benue State are undergoing significant changes, driven by population growth, land-use shifts, and socio-economic activities. The movement towards larger, more clustered settlements reflects increasing demands for infrastructure and services, but also indicates challenges such as land scarcity and environmental degradation. These changes, particularly the reduction in forest cover and expansion of agricultural areas, underscore the need for sustainable land management practices to address land fragmentation, resource depletion, and conflicts. Furthermore, the study concludes that the growing competition for land, driven by migration and population pressures, is intensifying socioeconomic disparities and contributing to rural conflicts. Future settlement patterns will likely see more concentrated areas, which could strain existing resources and infrastructure if not properly managed. Based on the findings and conclusion, the study recommends a balanced approach to rural development, which would ensure that population growth, agricultural expansion, and infrastructure development occur in harmony with environmental sustainability and social wellbeing.

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