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Landuse and Landcover Changes in Anyigba Dekina Local Government Area of Kogi State, Nigeria

***[1]ADEMU, I; [2]SYLVANUS, HB; [3]OLUWOLE, OA**

Department of Geography, Nigerian Defence Academy (NDA), Kaduna, Nigeria

**Corresponding Author Email: adamuiliasu@gmail.com*
**ORCID: https://orcid.org/0009-0008-6223-1484*
**Tel: +2348079539726*

Co-Authors Email:heldabernard@gmail.com;oaoluwole@nda.edu.ng

ABSTRACT: The objective of this paper was to investigate the landuse and landcover (LULC) changes in Anyigba, Dekina Local Government Area of Kogi State, Nigeria to evaluate the annual rate of change, predicts future trends, and examines the implications of these changes using Landsat imagery from 1998, 2010, and 2022 obtained from the United States Geological Survey (USGS) and processed by ArcGIS. The findings reveal significant shifts in LULC patterns between 1998 and 2022. Urban areas expanded dramatically by 84.56 km² (1289.02%), with an annual growth rate of 3.52%, while agricultural land, once the dominant category, declined by 52.15 km² (34.58%). Similarly, bare surfaces shrank by 11.30 km² (57.95%). Projections for 2035 indicate continued urban expansion to 176.14 km² (79.50%), coupled with significant reductions in forest/vegetation cover (6.68%), bare surfaces (1.35%), and agricultural land (12.46%).These changes have profound implications, including the loss of forest and vegetation, increased urbanization, declining agricultural land, and diminishing bare surfaces. Such trends pose challenges for sustainable development and necessitate effective planning. The study underscores the importance of regular monitoring, control, and evaluation of LULC dynamics to mitigate haphazard development and its adverse effects on local communities.

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Landuse and landcover (LULC) constitute vital components in the planning and management of various human activities, serving as foundational elements in modeling and understanding Earth's systems (Dires and Temesgen, 2020). Although often used interchangeably, the terms "landcover" and "landuse" encapsulate distinct concepts. Landcover refers to the physical features on Earth's surface, while landuse pertains to human activities and economic functions associated with specific land parcels (Lillesand*et al.*, 2015). As one of Earth's most critical natural resources, land underpins all human endeavors, with historical evidence showing continuous modification to meet evolving human needs. In contemporary contexts, the pace, extent, and intensity of LULC changes (LULCC) are unprecedented, resulting in substantial disruptions to ecosystems and environmental processes on local, regional, and global scales (Wang*et al.*, 2022). The environmental implications of landuse and landcover change (LULCC) have gained significant attention due to their impact on global change, affecting nutrient cycles, hydrological systems, and climate patterns (Ahmad, 2014). Advances in mapping have enhanced LULCC assessments, revealing detailed interactions between landuse (agriculture, urban

**Corresponding Author Email: adamuiliasu@gmail.com*
**ORCID: https://orcid.org/0009-0008-6223-1484*
**Tel: +2348079539726*

development, etc.) and landcover (forests, wetlands, etc.) (Oladele and Oladimeji, 2011; Meyer, 1995). LULCC, a key driver of global environmental change and sustainable development discourse, reflects the complex interplay of natural and socio-economic factors, influencing ecosystems and resources (Rimal, 2011; Meyer, 1995). While natural events can alter landcover, human activities like agriculture and urban construction dominate the transformation, especially in tropical regions, raising concerns about biodiversity and sustainability amid increasing population pressures (Zubair, 2006; Ejaro and Abdullahi, 2013). Accurate landuse and landcover (LULC) information is crucial for effective planning and management, as it informs environmental processes and enhances living conditions (Sreenivasulus and Bhaskar, 2010). Poor land management in developing regions leads to challenges such as land degradation, reduced agricultural yields, and biodiversity loss (Ejaro and Abdullahi, 2013). In Africa, unplanned human interventions have caused significant environmental damage, with limited mitigation success, highlighted by issues like deforestation and resource overexploitation (Adesina, 2005). Anyigba town exemplifies these challenges, where government policies to regulate LULC changes have been largely ineffective (Ocholi and Adesola, 2019). The objective of this paper was to investigate the landuse and landcover (LULC) changes in Anyigba, Dekina Local Government Area of Kogi State, Nigeria to evaluate the annual rate of change, predicts future trends, and examines the implications of these changes using Landsat imagery from 1998, 2010 and 2022 obtained from the United States Geological Survey (USGS) and processed by ArcGIS

MATERIALS AND METHOD

*Study Area:*Anyigba lies approximately between Latitude 7° 29′ 36″and 7° 32′ 00″ North of the Equator and Longitude 7° 10′ 25″E and 7° 12′ 00″ East of the Greenwich meridian. It has a land mass of about 221 square kilometers and an average elevation of 354 meters above the sea level.

It shares borders with adjacent towns such as Ologba to the North, Agbeji to the South, Egume to the East andAjiolo to the West all in Dekina Local Government Area as shown in Figure 1.

Anyigba, situated in Kogi State's Dekina Local Government Area, has an AW climate classification characterized by a dry season with monthly precipitation below 60mm and annual rainfall between 1200mm and 1500mm.

The climate, influenced by tropical maritime and continental air masses, features a wet season from March to mid-November and a dry season from November to February, with temperatures ranging from 18°C to 35°C. The region includes the Idah/Ankpa Plateau with gentle topography and a notable northern valley. The Ojofu River catchment, a crucial hydrological feature, supports agriculture in its floodplains. Vegetation consists of derived savanna ecosystems, while land use reflects a mix of residential, commercial, agricultural, and industrial activities, indicative of socio-economic dynamics and population growth (Ifatimehin*et al.*, 2011; Arome and Ejaro, 2012).

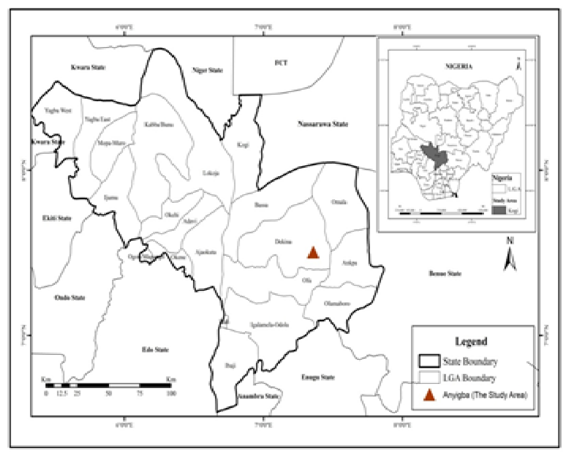

Fig.1: Anyigba in Kogi State

Source: Adapted from the Administrative Map of Dekina L.G.A Kogi State

Reconnaissance Survey: Reconnaissance survey was carried out to assess the field and some feasibility studies was carried out and noted.

Data Collection: The data type used for this study includes both primary and secondary data sources.

Primary Data Sources: Field surveys: This include ground trothing, GPS data collection and landuse surveys (conducting surveys to gather information about landuse patterns, such as agricultural activities, residential areas, and industrial zones amongst others).

Secondary Data Sources: The secondary data for this study include remote sensing data (Landsat imagery of the study area from 1998, 2010 and 2022. The satellite imageries was sourced from the United States Geological survey), maps, existing literature from journals, text books, seminar papers, theses, reports and web references. Table 1 presents the characteristics of the satellite images.

Table1: Satellite Data Characteristics

S/N	Data type	Landsat Product Id	Sensor Id	WRS type/path/row	Grid cell size	Cloud Cover %	Spatial Resolution (M)	Band	Output Format
1	Landsat (OLI)	LC08-L2SP-189054-20230215-20230223-02-T1	"OLI-TIRS"	2/189/54	30.0	<10	30	1,2,3, 4,5,6 and 7	GEOTIFF
2	SRTM (DEM)	SRTM1N08 E007V3	1-ARC						GEOTIFF

Source: United State Geological Service (USGS) Database, (2023) https://earthexplorer.usgs.gov

Secondary data geo-processing: The Band 4 and 5 of Landsat 8 OLI imagery covering the study area was extracted and used for a normalized difference vegetation index (NDVI) analysis, which will aid in performing a supervised classification for creating a land use/land cover map. While the digital elevation model (DEM) was used for creating a slope map of the area.

Supervised classification: Supervised classification uses the spectral signatures obtained from training samples to classify an image. In this study, the supervised classification was performed in order to create a land use/land cover map by classifying the area into different landcover categories.

Accuracy assessment: Ground control coordinates obtained using a Global Positioning System (GPS) from locations in relation to the classes under study were plotted on the images to verify the accuracy of the classified training sites as regards to their spectral signature.

Table 2: Confusion Matrix showing the accuracy of classification

Land use	Urban Land	Agriculture Land	Forest/ vegetated Land	Bare Surface	Water Body	Total	User's Accuracy
Urban Land	**17**	2	3	1	2	25	68%
Agriculture Land	2	**18**	2	2	1	25	72%
Forest/Vegetated Land	4	2	**15**	2	2	25	60%
Bare Land	1	1	2	**16**	3	25	56%
Water Body	2	3	1	3	**14**	25	64%
Total	26	26	23	24	22	**125**	
Producer's Accuracy	65%	69%	65%	67%	64%		

Source: Author's Analysis, 2024

As shown in table 2, urban/built-up areas had 17 of the 25 control points matching the points on the classified images and therefore, had a User's accuracy of 68% and Producer's accuracy of 65%. Agricultural land had the highest level of accuracy with 18 of the 25 control points matching the points on the classified images and therefore had a User's accuracy of 72% and also 69% Producer's accuracy. Forest/Vegetated land had a total of 15 control points of the 25 matching the points on the classified images, it had a User's accuracy of 60% and Producer's accuracy of 65%. Bare land had a total of 16 control points of the 25 matching the points on the classified image; it had a User's accuracy of 56% and Producer's accuracy of 67%. While water body had a total of 14 control points of the 25 control points matching the points on the classified image; it had a User's accuracy of 64% and Producer's accuracy of 64%. Therefore, table 2 reveals that 80 out of the 125 total control points matched their actual points on the classified image.

$$\text{Total Accuracy} = \left[\frac{17 + 18 + 15 + 16 + 14}{100}\right] \times 100 = 80\% \quad (1)$$

The calculation for the overall accuracy is obtained using *Kappa* statistic (Congalton, 1999).

$$\text{K} = \frac{Po - Pe}{1 - pe} \quad (2)$$

Where; A = Kappa; Po = Observed Accuracy; Pe = Expected Accuracy; Observed Accuracy = 0.71; Expected Accuracy = 0.5

$$\mathrm{K} = \frac{Po - Pe}{1 - Pe} = 0.71 - \frac{0.5}{1} - 0.5 = 0.41 \quad (3)$$

A kappa accuracy of 0.41 is said to be fair or good according to Congalton (1991).

Data analysis: Landuse and landcover maps of the study area were generated and the annual rate of change in landuses and landcover pattern of the study area was determined for the three time periods. The future pattern of landuse and landcover distribution of the study area was determined and the implication of land use and land cover change in the study area was outline and discussed.

The extent of lulc distribution in 1998, 2010 and 2022: Landsat 4 thematic mapper (TM) satellite image of 1998 with 30m spatial resolution was used to determine the extent of urban and other land use/land cover coverage of the study area in 1998. Landsat 7 enhanced thematic mapper plus (ETM^{+}) satellite image of 2010 with 30m spatial resolution was used to determine the extent of urban land use and other land use/land cover coverage of the study area in 2010. Landsat 8 operational land imager (OLI), with 30m spatial resolution was used to determine the area extent of urban and other land use/land cover coverage of the study area in 2022. The Landsat imagery was analyzed using supervised classification techniques, to map the LULC changes. The LULC maps of 1998-2010, 2010-2022 was compared to identify the changes that has occurred. The extent of LULC distribution of 1998,2010 and 2022 was analyzed by classifying the images into various classes. These set of data was compared by converting the resulting values to percentages and use as absolute data for the presentation of urban and other LULC distribution.

The annual rate of change in LULC of the study area from 1998 to 2022: The set of data for 1998, 2010 and 2022 was converted to percentages and use as absolute data. The rate of change was calculated using equation 1;

$$Rate\ of\ change\ (c) = B - A \quad (4)$$

$$E = \frac{C}{Base\ year \times 100\%} \quad (5)$$

The annual rate of change (D) will be calculated using equation 3;

$$A = \frac{C}{Nos\ of\ years\ between\ the\ period} \quad (6)$$

$$C = \frac{rate\ of\ change\ of\ each\ urban\ land\ use}{years\ between\ the\ period} \quad (7)$$

12 years for 1998 – 2010
12 years for 2010 – 2022
24 years for 1998 – 2022

RESULTS AND DISCUSSION

Table 3 presents the landuse/Landcover classes of Anyigba Dekina Local Government Area of Kogi state, for the years 1998, 2010 and 2022. It also includes the annual rate of change in urban landuse and landcover between 1998 to 2010, 2010 to 2022 and 1998 to 2022. Additionally, the table provides a projection of the future pattern of landuse and landcover of the study area by2035.

Table 3 shows the landuse distribution in Anyigba from 1998 to 2022. Forest/vegetated areas declined from 44.69 km² (20.17%) in 1998 to 23.56 km² (10.63%) in 2022. Agricultural land, dominant in 1998 at 150.79 km² (68.06%), decreased to 98.64 km² (44.53%) by 2022. In contrast, urban/built-up areas rose significantly from 6.56 km² (2.96%) in 1998 to 91.12 km² (41.13%) in 2022. Bare surfaces diminished from 19.50 km² (8.80%) to 8.20 km² (3.70%), likely due to state government reforestation initiatives, as noted by Arome and Ejaro (2012). Water bodies, initially absent in 1998, covered 0.02 km² (0.01%) in 2010 and maintained that area in 2022 due to the Ogane-Aji Dam. Furthermore, the table shows significant urban land use growth in Anyigba, with an increase of 61.41 km² from 2010 to 2022, more than double the 23.15 km² increase from 1998 to 2010. The annual increase rate was 17.22% post-2010, lower than the 29.41% rate from 1998 to 2010. This decline is likely due to rising land costs from increased demand, making it harder for less affluent farmers and locals to acquire land for development. These findings align with Ifatimehin*et al.,* (2012), who reported a 30.26 km² increase in urban land area from 1998 to 2010. Finally, the table revealed that by 2035 forest/vegetation in the study area is projected to decrease to 14.80 km² (6.68% of the total area), underscoring the need for conservation efforts due to their role in biodiversity, carbon storage, and ecosystem services. Bare surfaces will cover 2.98 km² (1.35%), agricultural land will span 27.60 km² (12.46%), and water bodies will remain minimal at 0.02 km² (0.01%). In contrast, urban/built-up areas are expected to expand significantly to 176.14 km² (79.50%), indicating potential increases in residential, commercial, and industrial developments driven by population growth, economic expansion, or urban planning initiatives.

Table 3: Land use and Land cover Distribution in 1998, 2010 and 2022

Year	1998		2010		2022	
Landuse	Km²	%	Km²	%	Km²	%
Urban Land	6.56	2.97	29.71	13.41	91.12	41.13
Forest Land	44.69	20.18	37.46	16.91	23.56	10.63
Agricultural land	150.79	68.07	141.18	63.73	98.64	44.53
Bare Surfaces	19.50	8.78	13.17	5.94	8.20	3.70
Water body	-	-	0.02	0.01	0.02	0.01
Total	**221.54**	**100.00**	**221.54**	**100.00**	**221.54**	**100.00**

The annual rate of change in urban landuse/landcover between 1998 to 2010, 2010 to 2022 and 1998 to 2022

Period	Year	Urban land use (Km²)	Increase		Arithmetic Mean (Rate of Increase)	
			Km²	%	Km²/Year	%/Year
1998 – 2010	1998	6.56	23.15	352.89	1.93	29.41
(12 Years)	2010	29.71				
2010 – 2022	2010	29.71	61.41	206.69	5.12	17.22
(12 Years)	2022	91.12				
1998 – 2022	1998	6.56	84.56	1289.0	3.52	53.71
(24 Years)	2022	91.12		2		

Future pattern of landuse and landcover of Anyigba by the year 2035

Year	2035	Percentage
Landuse	(Km²)	(%)
Urban/built-up areas	176.14	79.50
Forest/vegetated areas	14.80	6.68
Agricultural areas	27.60	12.46
Bare surfaces	2.98	1.35
Water body	0.02	0.01
Total	**221.54**	**100**

Source: Author's Analysis, 2024.

Figure 2 and 3 shows the annual rate of change in agricultural landuse and forest/vegetated landuse between the years 1998 to 2022. Between 2010 and 2022, agricultural land experienced a significant annual loss rate of 42.54km²(2.51%), compared to 9.61 km² (0.53%) from 1998 to 2010, primarily due to urban land expansion displacing agricultural areas. This reduction poses risks to food security and the livelihoods of those dependent on agriculture while potentially causing environmental degradation, as agricultural land is vital for soil conservation and biodiversity. Ocholi and Adesola (2019) highlight that such urbanization can lead to issues like congestion, pollution, and inadequate infrastructure, straining urban resources and services, ultimately diminishing residents' quality of life.

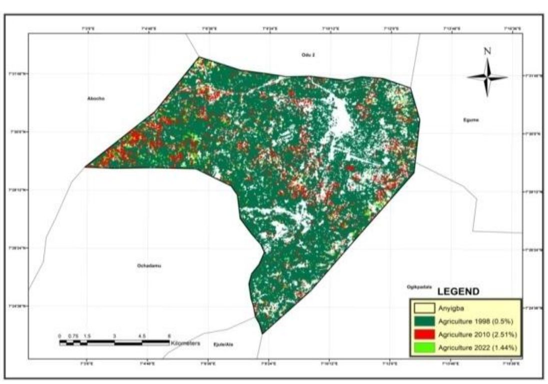

Fig. 2: The annual rate of change in agricultural landuse from 1998 to 2022.*Source: Author's Analysis, 2024*

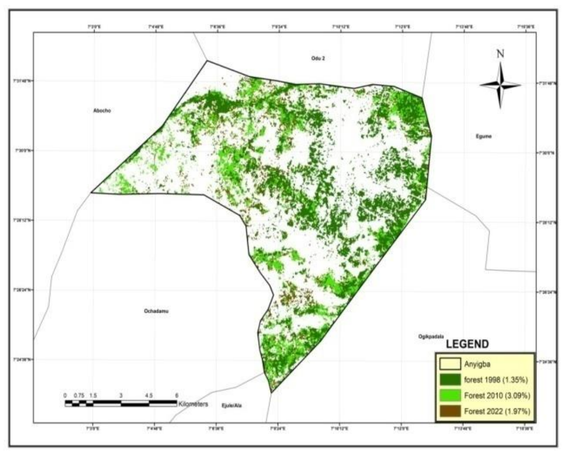

Fig. 3: The annual rate of change in forest landuse from 1998 to 2022.*Source: Author's Analysis, 2024*

Similarly, figure 3 shows that between 2010 and 2022 forest/vegetation landuse experienced an annual loss rate of 13.90 km² (3.09%), which is significantly higher than the 7.23 km² (1.35%) loss observed from 1998 to 2010. The overall loss rate from 1998 to 2022 averaged 21.13 km² (1.97%). This increasing trend, primarily attributed to anthropogenic activities, poses serious risks such as biodiversity loss, habitat destruction, soil erosion, and diminished ecosystem services. It highlights concerns raised by Ocholi and Adesola (2019) regarding the previous government's reforestation efforts, which the current administration has not prioritized. Urgent action is needed to address the causes of deforestation and promote sustainable land management.

The implications of landuse and landcover change in the study area: The landuse and landcover changes in Anyigba, Kogi State, reveal significant challenges for sustainable development. The reduction of forest and vegetated areas due to deforestation, urbanization, and agricultural expansion negatively impacts biodiversity and climate change. Rapid urban growth has led to the conversion of agricultural land, creating issues like pollution, habitat loss, and food security concerns. The decline in bare land surfaces emphasizes the need for efficient land use planning and sustainable practices. Projections for 2035 indicate further loss of forest cover and increased urban areas, necessitating proactive planning for sustainable land management and conservation. Integrated land use planning, environmental conservation, and community engagement are essential for ensuring the long-term sustainability and resilience of Anyigba.

Conclusion: This study demonstrates the effectiveness of GIS and remote sensing in analyzing land use and land cover changes in Anyigba, Kogi State, from 1998 to 2022. Increase in Urban land use is largely due to human activities linked to urban expansion projects such as those at Prince Abubakar Audu University and Nana College of Health Science and Technology. The findings indicate that urban land use significantly encroaches on other land types. To address current needs and plan for the future, it is vital to develop financially, technically, and environmentally viable strategies that consider local resources and environmental impacts. The study recommends periodic assessments of land use and cover changes to inform environmental policies, regular monitoring and evaluation to mitigate adverse impacts of uncontrolled development, and promoting vertical building construction to reduce urban encroachment on other land uses.

Declaration of Conflict of interest: The authors declare no conflict of interest.

Data Availability: Data are available upon request from the corresponding author.

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