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Full Length Research

Assessment of land use/land cover changes in Auyo Local Government Area of Jigawa State, Nigeria

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ABSTRACT: Land use and land cover change analysis enables planners and policymakers to have adequate knowledge of what should be done to have equitable development that will be sustainable and eco-friendly. The understanding of human activities and the physical environment of any region is pertinent, and it requires constant study of its land use and land cover changes over time. This research, therefore, focuses on land use/land cover (LULC) changes in the Auyo Local Government Area of Jigawa State. In view of this, Landsat 5 Thematic Mapper (TM) of 2008 and Landsat 8 Enhanced Thematic Mapper Plus (ETM+) data of 2022 were used to examine the change in land use and land cover by classification of the two Landsat images. Results show that built-up increased from 21% in 2002 to 74% in 2022. Bare lands occupied 64% of the total area examined in 2002 but decreased to about 23% in 2022. In addition, the vegetation decreased from about 15% in 2002 to 3% in the years 2022. The research recommends the need for further research on urban-related studies, especially looking into the effect of anthropogenic activities on land surface dynamics. It also recommend regional developmental planning to encourage and regulate growth in land use and land cover for sustainable development to be achieved.

Keywords: Change, human activities, Landsat, land cover, vegetation.

INTRODUCTION

Sustainable development is the organizing principle for meeting human development goals while at the same time sustaining the ability of natural systems to provide the natural resources and ecosystem services upon which the economy and society depend. The desirable result of this is a state of society where living conditions and resource use continue to meet human needs without undermining the integrity and stability of the natural systems. Sustainable development is that development that meets our present needs without compromising the ability of future generations to meet their own needs (Rinner and Hussain, 2011).

According to the United Nations (2015), the components that work together to produce sustainable development are economic development, social development and environmental protection (UN General Assembly, 2005). These three must be conceptualized, planned and implemented together by a government to achieve the desired results. So, sustainable development in a way has a moral dimension that demands a great sense of responsibility from the leader (government) and the follower (citizen).

The SDGs came into effect in January 2016, and it is a policy guideline and funding programme for the next fifteen years. The goals are to be accomplished by all member nations (189 countries) by 2030. The Sustainable Development Goals (SDGs), also known as the Global Goals (CGs), are structured to end poverty, protect the environment and ensure that all people enjoy peace and prosperity [United Nations Development Programme, UNDP, 2024].

Land use information is a vital tool for all urban development efforts. Changes in the use of land are, to a large extent, a reflection of how society responds to socio-economic, institutional, and management practices (Hudak and Brocket, 2004). Yet, research reports relating to several urban areas in developing countries, such as Auyo Local Government Area, are replete with comments concerning the inadequacy of relevant land use information (Babalola and Akinsanola, 2016). Consequently, effective planning is rendered more difficult. The situation is compounded and partly caused by a lack of appropriate methodology to acquire background information to aid town planners and policymakers in tackling complex land challenges (Bounoua *et al.*, 2009).

Land use change is one of the dynamic activities which are continuous and ongoing, shaping the human environment positively and negatively. Land is the stage on which all human activities are conducted and the source of the materials needed for this conduct (Cohen, 2015). Human use of land resources gives rise to ‘‘land use’’ which varies with the purposes it serves; whether for food production, provision of shelter, recreation, extraction and processing of materials, and so on, as well as the bio-physical characteristics of land itself. Hence, land use is being shaped under the influence of two broad sets of forces, which are ‘‘human needs’’ and ‘‘environmental features and processes’’ (Chander *et al.,* 2009). Apart from air and the sea, almost all other natural resources such as forests, grassland, solid, fossil and gaseous minerals, agriculture, wetlands, soil and water bodies, just to name but a few, are located on land. It has also been observed that land seems to be the most valuable asset at the disposal of the grassroots people to meet their developmental needs for housing as well as agriculture. For instance, over 60 per cent of the population of West and Central Africa is dependent on the land for subsistence or commercial agricultural production (Chen *et al.*, 2006). Land is almost fixed in location (or limited in amount and exhaustible), it is subject to competing uses and change values (Wang, 2001). This could be the reason for harmonious and judicious use of land through advocacy land use planning.

It has generally been accepted that land use/land cover change (LULC) is a key driver of global change, which has significant implications for many international policy issues (Obaje *et al.,* 1999). Studies on land use/land cover are beginning to take the centre stage of most human discussions because nations of the world are poised to overcome the problems confronting them as a result of their inability to properly harness their resources (Kato and Yamaguchi, 2005) and create a conducive living environment for living, working and recreation. The importance of land use/land cover, according to Anderson (1976), is that nations of the world are increasingly becoming aware of the challenges of haphazard and uncontrolled development, deteriorating environmental quality, loss of prime agricultural lands, destruction of important wetlands, and loss of fish and wildlife. In an attempt to quantify and qualify land use/land cover change, several studies have been undertaken, but remote sensing and Geographic information systems appear to be making the most significant contribution at regional and global scales beginning from the mid-1970s (Buyadi *et al*., 2013).

The concern about the environment today, highlighted by the recent rapid growth of the world's human population which has put pressure on natural resources, the increasing socio-economic interdependence of countries and regions, the growing awareness of the value of natural ecosystems and the perception that current land use practices may influence the global climatic system, has further widened the scope and operation of land use planning (Ferreira *et al.,* 2012).

Therefore, land use planning today is a tool for the decision-making process that “facilitates the allocation of land to uses that provide the greatest sustainable benefits”. Similarly, Tacoli *et al.* (2018) noted that the global environmental change questions, such as global climate system – warmer temperature, rising sea levels and potentially more frequent and severe extreme weather events such as hurricanes and tropical storms, ozone layer depletion, greenhouse effects and other negative effects of climate variability, have been traced to land use practices and subsequent land use land cover change.

Four broad categories of land use changes leading to climate change include: proximate causes such as agricultural expansion, wood extraction, infrastructure extension and other factors. Furthermore, the underlying driving forces could be divided into five broad clusters such as Demography, Economic, Technological, Policy and Institutional and Cultural factors which were equally further sub-divided into Natural Increment, Market Growth and Commercialization, Agro-technical Change, Formal Policies and Public Attitudes, Values and Beliefs respectively (CRED, 2021).

Land use/land cover classification (LULC) using remote sensing offers one of the most universally acceptable techniques in determining the evolution and the actual state of land use/land cover resources in our immediate environment. There is also a dearth of information on LULC, which can aid planning, environmental monitoring and the decision-making process, especially in agriculturally viable environments like the Auyo Local Government Area. This study will not only go a long way in sustaining effective land management, but it will also augment the decision support systems guiding land management with the latest advances in geospatial information technologies. This is the thrust of this research.

Research questions

In line with the problem already outlined, some fundamental research questions to answer are:

1. What are the changes that have occurred over the land use/cover between: 2002 to 2022 in the study area?

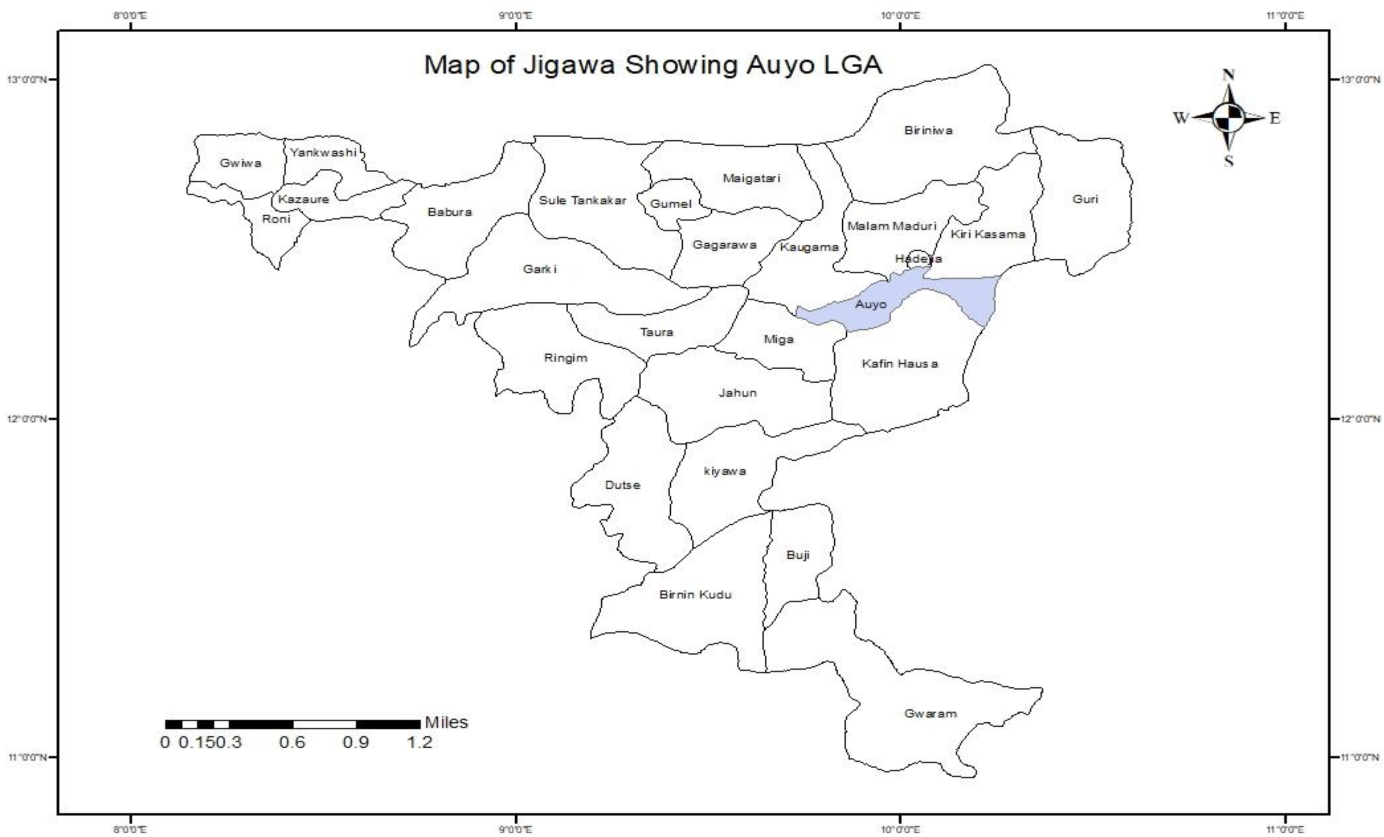

Figure 1. Map of Jigawa Sate Showing Auyo Local Government Area.

2. What are the extents of land use/cover changes in the study area?

Aim and objectives

Based on the research questions, this study aims to assess land use/cover changes in Auyo Local Government Area of Jigawa State. The specific objectives include:

1. To assess the changes in land use/land cover in the study area between 2002 to 2022 in the study area;
2. To examine the extent of different land use patterns in the study area.

MATERIALS AND METHODS

Study area

Auyo is one of the twenty-seven LGAs of Jigawa State, with an area coverage of about 512 km^2(Murtala, 2018). The area lies between latitudes 12°21'6.457"N to 12°6'7.808"N and longitudes 9°28'0.944"E to 10°15'28.924"E. It is bounded by Bauchi State in the east, Kafin-Hausa and Jahun LGAs in the south. In the northeast, by Hadejia, Malam-Madori and Kirikasamma LGAs, and in the north, it is bounded by Kaugama LGA. In the northwest, it is bounded by Taura and some parts of Jahun LGA (Figure 1).

The climate of the area is semi-arid. However, the micro-climate is modified by the local effect of the Hadejia River system. The mean annual temperature is about 25°C. The total annual rainfall ranges from 600mm to 762mm (Murtala et al., 2018a). The study area is part of an extensive downstream floodplain created by the Hadejia River. It comprises permanent lakes and seasonally flooded pools connected by a network of channels (Murtala et al., 2018b). The LGAs in Auyo have an approximate total population of 252,283 based on 2025 projections.

Methods of data collection and analysis

This study employs both primary and secondary sources of data. The assessment of land use and land cover changes was generated by utilising data from many sources. Landsat 5 Thematic Mapper (TM) of 2008 and Landsat 8 Enhanced Thematic Mapper Plus (ETM+) data of 2022 with a spatial resolution of 30 meters were acquired from the Earth Explorer Database were used.

Table 1. Primary data.

S/N	Data type	Source	Date acquired
1	Landsat 5 Image (Tm)	USGS Earth Explorer	2002
2	Landsat 8 Image (E)	USGS Earth Explorer	2022

Source: Authors analysis (2025).

Table 2. Classification scheme

No	Land use categories	Description
1	Built-up land	used for residential and transportation/communication purposes (i.e. settlements and roads, high residential areas, industry and administrative blocks)
2	Bare surface	Exposed soils, land devoid of vegetation cover.
3	Vegetation land	Covered with natural forest and natural vegetation that is predominantly grasses, shrubs and grass-like plants.
4	Waterbody	Areas covered by bodies of water e.g. dams, lakes and rivers.

Source: Modified from Anderson (1976).

Thus, the land use/land cover changes classification utilised satellite images from the years 2002 to 2022, with a spatial resolution of 30 meters.

In view of this, the methods of data collection and analysis for this study went through about nine (9) steps: data acquisition, preprocessing, image enhancement, image classification, post-classification processing, change detection, validation and accuracy assessment, map generation and interpretation, final output and reporting.

Data acquisition was done through Satellite Imagery. This process starts with acquiring relevant images, such as those from Landsat, Sentinel, and other high-resolution satellite platform like USGS Earth Explorer were used. Multispectral or Hyperspectral Data: These images capture data across multiple spectral bands, helping distinguish between different land cover types (Table 1).

In the same vein, Preprocessing was done through: Radiometric Correction: Adjusting for sensor and atmospheric distortions to ensure consistent reflectance values. Geometric Correction: Aligning the image to a reference coordinate system, ensuring accurate spatial referencing. Atmospheric Correction: Removing the effects of the atmosphere on the reflectance values to improve the accuracy of land cover classification. Cloud and Shadow Removal: For clearer imagery, especially in tropical regions where cloud cover can obstruct views.

Similarly, Image enhancement was carried out through Contrast Enhancement: Improving the visibility of features by adjusting image contrast. Band Combinations: Using various spectral bands in combination to highlight certain features (e.g., NDVI for vegetation). Noise Reduction: Using filters to remove noise and enhance important features.

In addition, Image Classification carried out in this study includes: Unsupervised Classification: Clustering pixels based on their spectral similarities without prior knowledge of the classes. Supervised Classification: Using known sample points (training data) to guide the classification of different land cover types (Table 2). Common methods include Maximum Likelihood Classification (MLC), Support Vector Machines (SVM), and Random Forest (RF). This study however employed MLC due to its effectiveness in simple classifications. Object-Based Classification: Dividing the image into objects or segments, rather than individual pixels, based on both spectral and spatial information, is often used in high-resolution imagery.

Moreover, Post-Classification Processing was done through smoothing and filtering by applying spatial filters to remove noise and smooth boundaries between classes. It was also done through Accuracy Assessment, which involved evaluating the classification results using ground truth data or reference datasets. Metrics like the confusion matrix, overall accuracy, and Kappa coefficient are commonly used to assess classification accuracy. Class Merging: In cases where multiple similar classes were detected, they may be merged into one (e.g., different vegetation types grouped together).

Besides, Change Detection involving Temporal Analysis was done through comparing classified images from different time periods to detect changes in land use and land cover over time. Change Detection Techniques: Methods like image differencing, post-classification comparison, or NDVI differencing can be applied to highlight changes.

Consequently, Validation and Accuracy Assessment were done with the aid of Ground Truthing. That is, by verifying classification results through field visits, or using high-resolution imagery or existing maps to ensure accuracy. Confusion Matrix: A statistical method to assess how well the classification performed, calculating metrics such as user's accuracy, producer's accuracy, and overall classification accuracy.

Last but not least, Map Generation and Interpretation

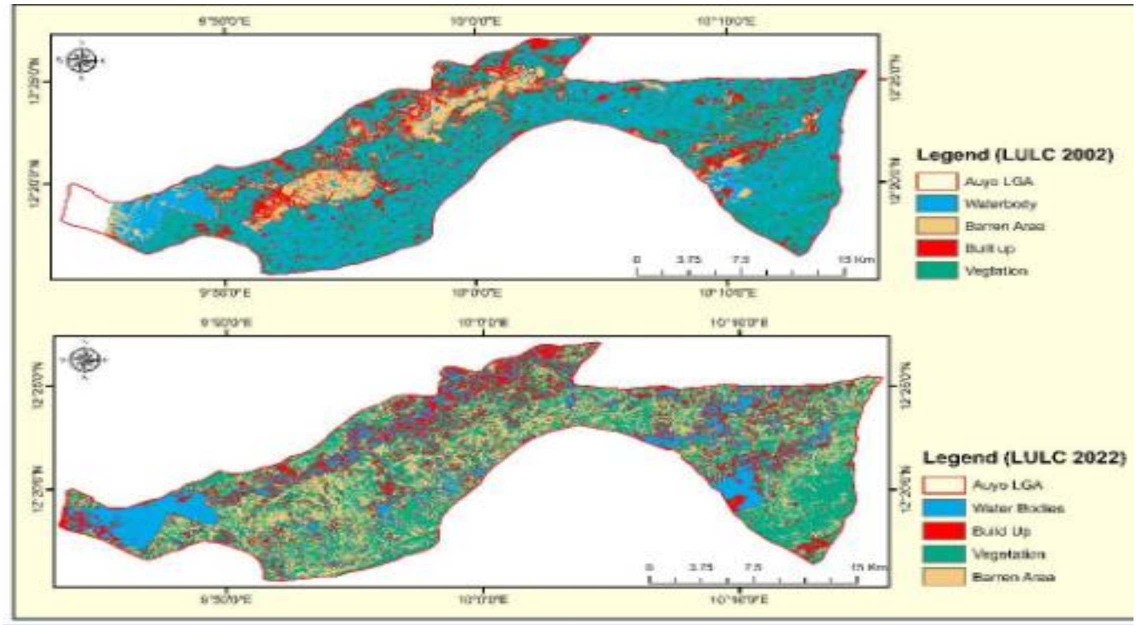

Figure 2. The spatial extent of land use/land cover changes in 2002 and 2022.

procedure through Map Production: creating thematic maps that visualise different land use/land cover classes. Interpretation by analysing the LULC data to draw conclusions, such as understanding deforestation trends, urban expansion, or agricultural land use patterns.

Final Output and Reporting was the last step. This includes Reporting: Summarising the findings in reports, maps, or datasets for stakeholders, planners, or policy-makers. GIS Integration: Integrating the classified land cover maps into Geographic Information Systems (GIS) for further spatial analysis, modelling, or decision-making.

RESULTS AND DISCUSSION

The spatial extent of land use/land cover changes in 2002 and 2022

The results of land use and land cover changes analysis for the period between 2002 and 2022 showed that the build-up area has increased within the study period from 14% to 20% (Figure 2). Similarly, water bodies, vegetation cover and bare land have decreased to 30%, 41% and 8.7%, respectively. Eastern and Western parts of the study area showed a decrease in water bodies and vegetation cover. This could be a result of the increase in the extent of build-up areas in these areas.

This result was in agreement with the study conducted by Oyinloye and Fasakin (2014), where a rapid growth in built-up areas was observed in Akure from 997.2 hectares in 1972 to about 3852.70 hectares in 2002 due to an increase in the population of Akure within this period, corresponding to a 500% increase. On a similar note, studies done by Frimpong *et al.* (2023) revealed an increasing trend in built-up areas at the expense of other Land use/land cover change types.

In a similar vein, Mohammed (2023) was of the opinion that degradation and desertification of the earth threatens people's livelihood at the global level. 20 million hectares of fertile land are deteriorating each year. About one-third of all agricultural land on the planet became Bora through the degradation process of the previous 40 years. Developing countries are more vulnerable to desertification and land degradation because they lack the infrastructure and capital to deal with these threats and implement land management in a sustainable manner.

Land use/land cover changes of 2002 and 2022 in km^2 and percentages

The results of land use/land cover changes in km^2 and percentages are presented in Table 3. As shown, the built-up area occupied about 11.1 km^2 (21.5%) in 2002 but increased to 38.3 km^2 (74%) in 2022. Bare lands decreased from 64% in 2002 to about 23% in 2022. The vegetation also decreased from about 15% in 2002 to 3.3% in 2022.

The decrease in bare land and vegetation throughout the study period might have been caused by the increase in the built-up areas, as supported by Weng (2001) and Blakime *et al.* (2024), who revealed an increase in residential areas to the detriment of other land use types in Lome.

More so, Figure 2 shows the spatial extent of individual land u se/land cover classes (bare surfaces, vegetation,

Table 3. Result of land use/land cover changes of 2002 and 2022 in square kilometer and percentages.

Land use categories	Square Kilometer (km^2)		Percentages (%)	
	2002	2022	2002	2022
Barren area	49.70789887	44.592947	9.708573999	8.709559961
Built up area	74.64462952	102.3875835	14.5790292	19.9975749
Vegetation	215.5471662	209.9622932	42.09905589	41.00826038
Waterbody	172.1003054	155.0571763	33.61334091	30.28460475
Total	512	512	100	100

Source: Authors analysis (2025).

water bodies and built-up areas) in Auyo Local Government Area from 2002 and 2022.

Consequently, these findings were in line with Action Aid (2016) and Centre for Research on Epidemiology of Disasters [CRED] (2021) who observed that built up areas along and around drainage channels may subject areas to more risk of flood hazard because building in a water channel blocks the natural course of the flowing water thereby subjecting areas to frequent occurrence of flood incidence.

Conclusion and Recommendation

The results indicate a significant increase in built-up areas from 14% in 2002 to 20% in 2022, representing a 6% increase over two decades. This suggests rapid urbanisation and expansion of human settlements, infrastructure, and development. This results in a decline of water bodies, vegetation cover, and bare land percentages from 2002 to 2022. This suggests environmental changes, potentially due to urbanisation, climate change, or human activities. Therefore, there is a need for sustainable environmental management, conservation efforts, and responsible land use practices to forestall environmental degradation that may arise, especially decreases in water bodies and vegetation cover, which can lead to loss of biodiversity, reduced ecosystem services, and increased vulnerability to climate change.

Conclusion and Recommendations

This study has assessed landuse/landcover changes in Auyo using Landsat 5 Thematic Mapper (TM) and Landsat 8 Enhanced Thematic Mapper Plus (ETM+) data of 2022 were used to examine the change in land use and land cover by classification of the two Landsat images. Built-up areas increased within the study period were enormous, and bare lands total areas decreasing. These changes observed in this study could generally reflect broader trends of urbanization and urban growth areas. Based on the findings and possible implications derived from this study, here are some recommendations:

1. There should be implementation of sustainable land use practices to balance development with environmental conservation.
2. Reforestation and afforestation programmes should be encouraged by the tiers of government through advocating tree planting and reforestation efforts to restore vegetation cover and mitigate climate change.
3. Water-saving measures, such as efficient irrigation systems and rainwater harvesting, to reduce water loss and promote sustainable water use should be encouraged.
4. The government should establish and enforce policies to protect water bodies, vegetation, and natural habitats from pollution, degradation, and destruction in various communities in the study area.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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