International Journal of Intellectual Discourse (IJID)
ISSN: 2636-4832 Volume 8, Issue 1. March, 2025

Spatial analysis of land use and land cover change in Akko Local Government Area of Gombe State, Nigeria

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Abstract
The objective of the study was to conduct a spatial analysis of land use, land cover changes in Akko LGA of Gombe state, Nigeria. Landsat (TM) images of 2003, 2013 and 2023 were used. The study used supervised digital image classification method using Erdas imagin 9.2 and Ilwis 3.1 and classified the land use into water body, vegetation, built up area, farmland and bare land. The images passed through the process of geo-referencing, image enhancement, image resampling and classification. Data was collected primarily as follows; Landsat imagery in ArcGis Pro software, Population data from National Population Commission, Questionnaire was drafted by the author and purposive sampling methods was used for collection of data. Vegetation cover recorded an increase in land area as opposed to the significant decrease recorded between the year 2013 and 2023, farmland had a slice increase between 2003 and 2013 but recorded a significant increase between 2013 and 2023, bare surface in the area has been decreasing since 2003 to 2023, hence built-up areas has increase in 2023 from 2003. The increase in land use for farmland surpass that of the built – up area, due to the increase in number of people and the subsequent need to have a source of livelihood which obviously is mainly agriculture. land use land cover change has caused erosion, through the conversion of vegetation land into farmland and built - up area, which has affected their houses as well as the livelihood system, and the economic activities of the people in the study area. Government intervention in the area of family planning to reduce the number of birth rate reducing overpopulation which causes land cover change. Government provision of capital to encourage entrepreneur and business to also reduce the population reliance on agriculture which also causes land cover change, Measures taken by the State Ministry of Urban and rural Planning to discourage indiscriminate building of houses in an unsustainable way that increases Land use and subsequent causes of erosion and land degradation.

Keywords: Land Use, Land Cover Change, Spatial Analysis, Akko LGA, Gombe State

1. Introduction

Land is about the most important natural resources on which all activities are based. 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 Bibi, Adam & Abubakar (2020). Land use land cover changes (LULCC) with its impacts on the environment has been one of the increasing focuses of global changes Jing & Guangjin, (2010). In the past two centuries the impact of human activities on the land has grown enormously, altering the entire landscapes, and ultimately impacting the earth's nutrient and hydrological cycles as well as climate De Sherbin, (2012). The

advancement in the concept of environmental mapping has greatly increased research on land use land cover change thus providing an accurate evaluation of the spread and health of the world's forest, grassland, agricultural resources and urban development and this has become an important research priority Mukhtar, *et al*., (2020).It has also been defined as the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it" Food and Agricultural Organization FAO (1999). Land cover change occur when one land cover type is converted to another, or is modified, such as change in agricultural lands to residential, or an intensification of existing use, such as light to heavy industry. Land cover is continually influence by land use due to human cultural, social and economic activities Nagarajan and. Poongothai, (2011).

There is an increasing need to be able to precisely describe and classify land cover and land uses in order to define sustainable land use systems that are best suited for each place. The driving force for most land use and cover changes is population growth, although there several other interacting factors involved in addition to human factors ,natural factors have also contributed to changes on the land with geology and landforms stable over long period of time ,climate factors affect land cover annually in the semiarid West African, have changed the land cover by desiccating soil, shrinking water bodies, stressing vegetation, and exposing bare soil and sandy substrate to erosion Nigus, (2021). One of the greatest challenges facing mankind today is land degradation although, the problem is an old as settled agriculture, its extent and impact on human welfare and global environment are now more than before Hundu, Anule, Kwanga, and Dam (2021). Land conversation is the greatest cause of extinction of terrestrial species, of particular concern is deforestation, where logging or burning is followed by the conversion of the land to agriculture or other land uses. Even if forest is left standing, the resulting fragmented landscape typically fails to support many species that previously existed there Vincent, Mohammed, & Sylvanus, (2022). Land use could be rural or urban, although sometimes, rural land use is commonly equated to agricultural land use, the non-agricultural land use is also important because it represents the focal areas of activities which directly or indirectly relate to, and whose socio-economic significance depends on the success of agriculture Aisha & Xiangzheng, (2017). It is imperative to say that, scientific investigation of the causes and consequences of land uses and land cover requires an interdisciplinary approach integrating both natural and social scientific methods which have emerged as the new discipline of land – change science Elli (2013). Thus, the gap that this research will be covering, is due to changing demands of land from agricultural activities (farming etc.), is changing in to housing which leads to the needs for this research work to be carried out in Akko LGA, Gombe State, Nigeria between 2003-2023 thus search to carry out the following objectives; To examine LULCC, detect changes of LULCC and determine the effect of land use land cover change in the study area.

2. Literature Review

Ramesh, Asha, and Jamuna, (2023) in a study in Mettupalayam Taluk, Coimbatare district, Tamil Nadu, India observed the increase in cropland. He attributed this increase to the Land Reform and Resettlement Program. Large areas of forests were cleared for different farm related activities like opening new farming plots, wood for fuel, poles for building both homes and cattle pens, among other activities. The built-up area around the water bodies in Davangere city, Karnataka,

India has almost doubled between 1970 and 2005, at the cost of the agriculture land and scrub land (Begum *et al*. 2010). Idowu, (2013) studied land use/land cover change over a period of 40 years in Kaduna State Nigeria, major changes have been observed like area under built-up land and harvested land has increased whereas the area under forest and water body has decreased. Ojeh, Ahmed, and Usman, (2022) studied land use land cover change where due to mining activities from 2001 to 2010, study revealed that significant decrease has been observed in dense forest area, cultivate land and water body, however settlement, wasteland land and uncultivated land has increased mainly due to anthropogenic activities.

Vincent, Mohammed, and Sylvanus, (2022), have carried out land cover change analysis of Gurur Ganga watershed in Uttaranchal. The study from 1963 to 1996 and 1986 to 1996 revealed that the area under agriculture and settlement has increased whereas the forest and barren land show decline in area. Jing and Guangjin, (2010) studied land use change of Bharatpur district, the analysis in the study reveals that forest cover has been depleted whereas wasteland undulating terrain with or without scrub and rock out crops has been increased during 1986 to 1989. Conclusively, Land Use/Land Cover Studies Using Remote Sensing and GIS Techniques, in order to use land optimally, it is necessary to have the information on existing land use land cover. It is also important to have capability of monitoring the dynamics of land use resulting out of both changing demands of increasing population and forces of nature acting to shape the landscape. Land is in a continuous state of transformation as a result of various natural and man-made processes. These researches intend to use two approaches such as; land use land cover approach mapping and identifying assess the perception of the communities.

The Study Area - Location and Size

The study area is Akko Local Government, the area extends from latitudes 10º 50′ 0" N to 11º20′ 0"N and longitude 11º 0′ 0" E to 11º 30′ 0" E (Figure 1). It has an average altitude of 306 m. It is bounded in the West by Bauchi, State North by Dukku LGA, North East by Gombe LGA, East by Yamaltu Deba and South by Billiri and Kaltungo. Having a total land mass of 1,827 km^2. The population of Akko LGA is 337,853(Census, 2006), according to the projected population using the population projection equation for 2023 is about 378,395 people Muhammad (2023). The main economic activity within the study area is agricultural activities, different types of crops such as maize, beans, soya beans, guinea corn, rice, millet and sorghum are cultivated in the area. The settlement pattern in Akko is more of nucleated form with some dispersal. (Abubakar, 2010).

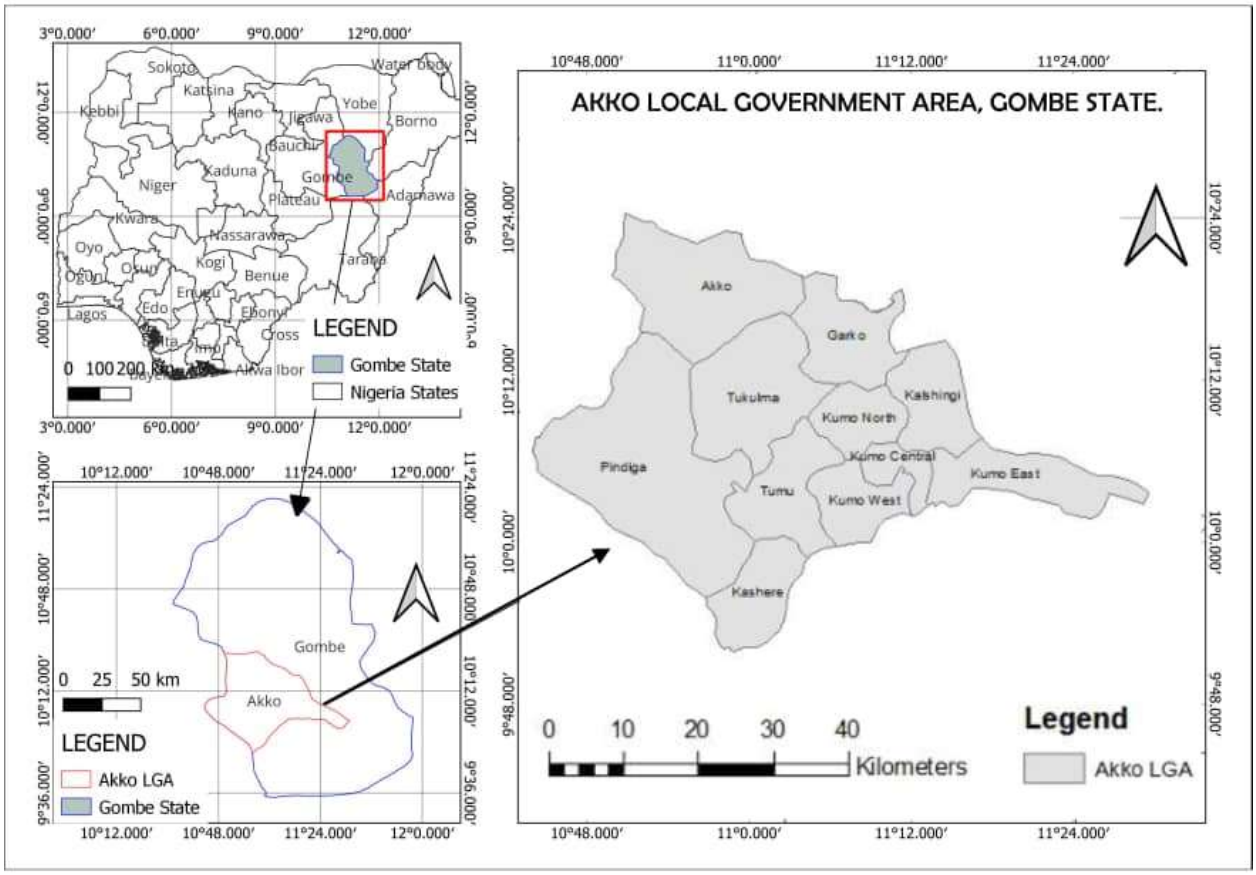

Figure1: Study Area Map
Source: Research Work, (2023)

3. Methodology

Procedure for Data Collection

Reconnaissance survey was carried out so as to get acquainted with the study area and interacted with the people on the land use changes of the area. Sources of data include; Landsat imagery was sourced in ArcGis Pro software, Population data was sourced in NPC, Questionnaire was drafted by the author and purposive sampling methods were used for collection of data.

Data Processing

Since the satellite images were digitally processed within, they were ortho-rectified there was no need for any geometric and radiometric corrections. The images were obtained in different layers and the layers were stacked together using ArcGIS Pro software; a subset of the study area was obtained using the ArcGIS Pro software subset tool.

Procedure for Data Analysis

To analyze the extent of land use/land cover coverage in 2003, 2013 and 2023. The images were classified into various classes based on the classification scheme presented in Table 1. The classification gave substantial information needed on the extent of land use/land cover coverage of the study area. The aerial extent land use/land covers were automatically calculated. To compare these sets of data, the resulting values were converted to percentages and used as absolute data for the presentation of urban and land use/land cover coverage.

To analyze extent to which urban expansion influences land use/land cover change in the area. The extent Land Change Modelers (LCM) change analysis through transition map which shows all the transition that is, the change and spatial trend from all other land use/cover into

built-up between classified imageries of 2003, 2013 and 2023 and identify how much urban land has increased over the years at the expense of other land use/land cover during the study period.

Table 1: Land Use/Land Cover Classification Scheme

Classes	Description
Build-up	Residential, Commercial, Industrial, Villages
Bare soil/Landfill	Exposed Soil, Landfill and Area of active excavation and production
Cultivated land	Cleared forest land and deforested area, Farm lands
Vegetation	Any species of plants (flora), Forest
Water bodies	River, Lakes, Reservoirs
Rock outcrops	Any types of Rock Identified

Source: Author Work (2023)

Sample Size and Administration of Questionnaire

Data on the perception of the people on associated hazard resulting from land use / land cover changes and its effects on their livelihood was sourced using questionnaire. The questionnaire contains both open and close ended questions about the pattern of land use and how changes affect their livelihood activities of the people. The Yemen, (1967) sample size method was used to determine the number of questionnaires to be administered in some selected ward (Kashere, Pindiga, and Tumu) of Akko LGA to acquire data from respondents. Akko LGA has population of 337,853 according to the National Population Commission (NPC 2006). This population was projected for (2023) using population projection index as follows.

$$P_t = P_o \ (\underline{1+r})$$
$$100$$

Where:

P_t = Total Projection Population =?

P_o = Total present Population (2006) = 337,853

n = Number of Projected Years =20

^{r} = growth Rate =2%

Yamani, (1973) sample size determination is presented by the formula below:

$$n = \frac{N}{1+ Ne^2}$$

Where: n= Sample Size 1= constant N= total population of the area under study e = Level of precision (error 0.5) or reliability level of confidence.

4. Result and Discussion

From the questionnaire, 76% are male while 26 % are female. The age composition of the respondent is majority youth comprising of 36 % of the total population while we have 34% Adults still in the productive age group and 13%, while 17% are retirement age including those that are less productive. Majority of the respondent 23% are engaged in commercial activities (Business), 17% are Housewives likewise 16% are civil servants, the least are traders with 9% other activities include farming, carpentry, painting etc 35%. Based on the educational background 46% of the respondents have completed education to secondary school level while 19% have had education up to Tertiary level, 17% only had education primary school level, 15% had informal education (Arabic/ Islamic school) meanwhile, the least percent of the respondent have not had any form of education with only 3%. Based on the Marital status 65% of the respondents are married, while 28% are single, likewise 4 % are Widow the least of the respondent about 3% are Divorced.

Land Use Land Cover Change between 2003 – 2023 in Akko L.G.A Gombe state.

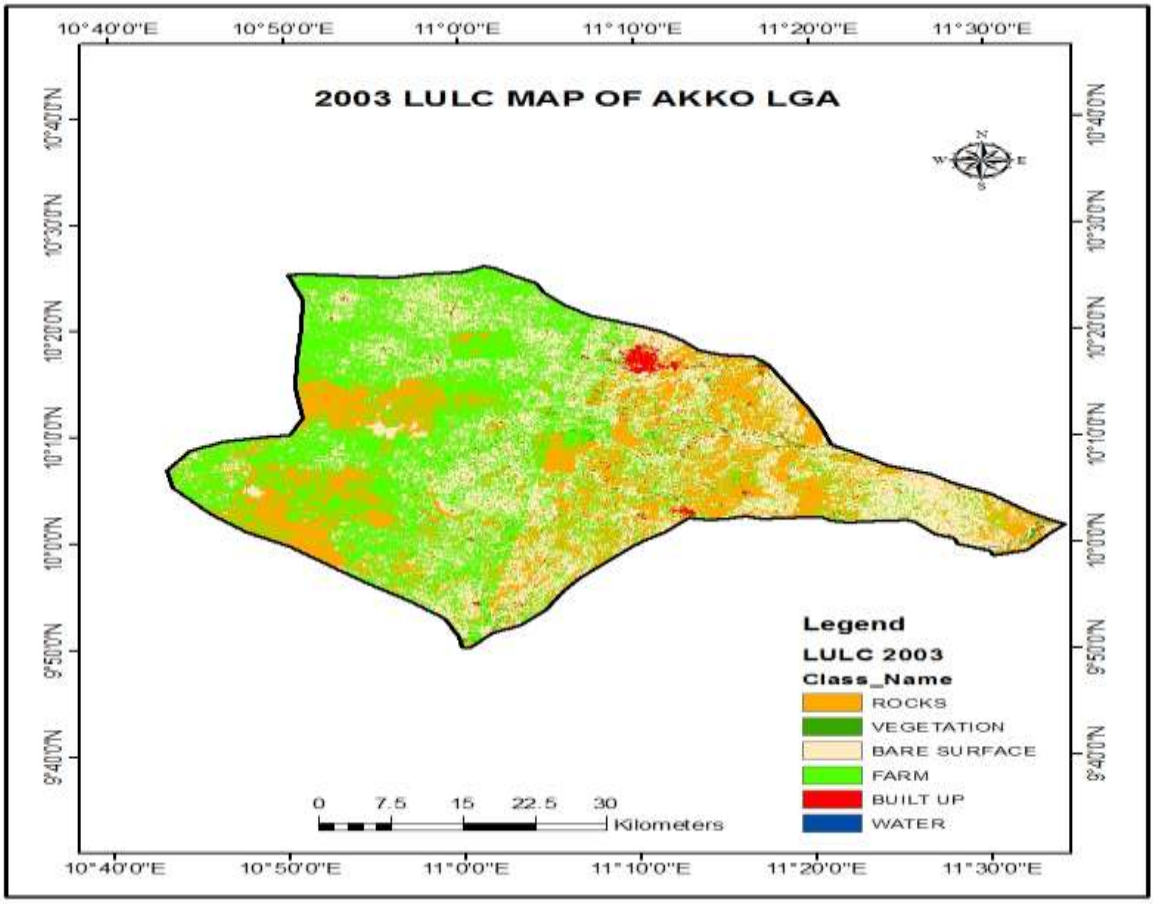

Figure 2: Showing LULC Map of Akko LGA 2003.
Source: Author work

From the figure above, the study reveals that in 2003 the parameters used to map land use land cover change are; Rocks, Vegetation, Bare surface, Farm, Built up and Water ways. Based on observation, the most common type of class that occupied space the most are Rocks and Farm while the least type of class that didn't occupy space the most are Vegetation and water ways. Built up area began to occupy land at the northern hemisphere on the map of the study area where boundary lines are located. This result clearly supports the findings that land is naturally used for agricultural purpose from the inception of time before urbanization came to existence in the study area.

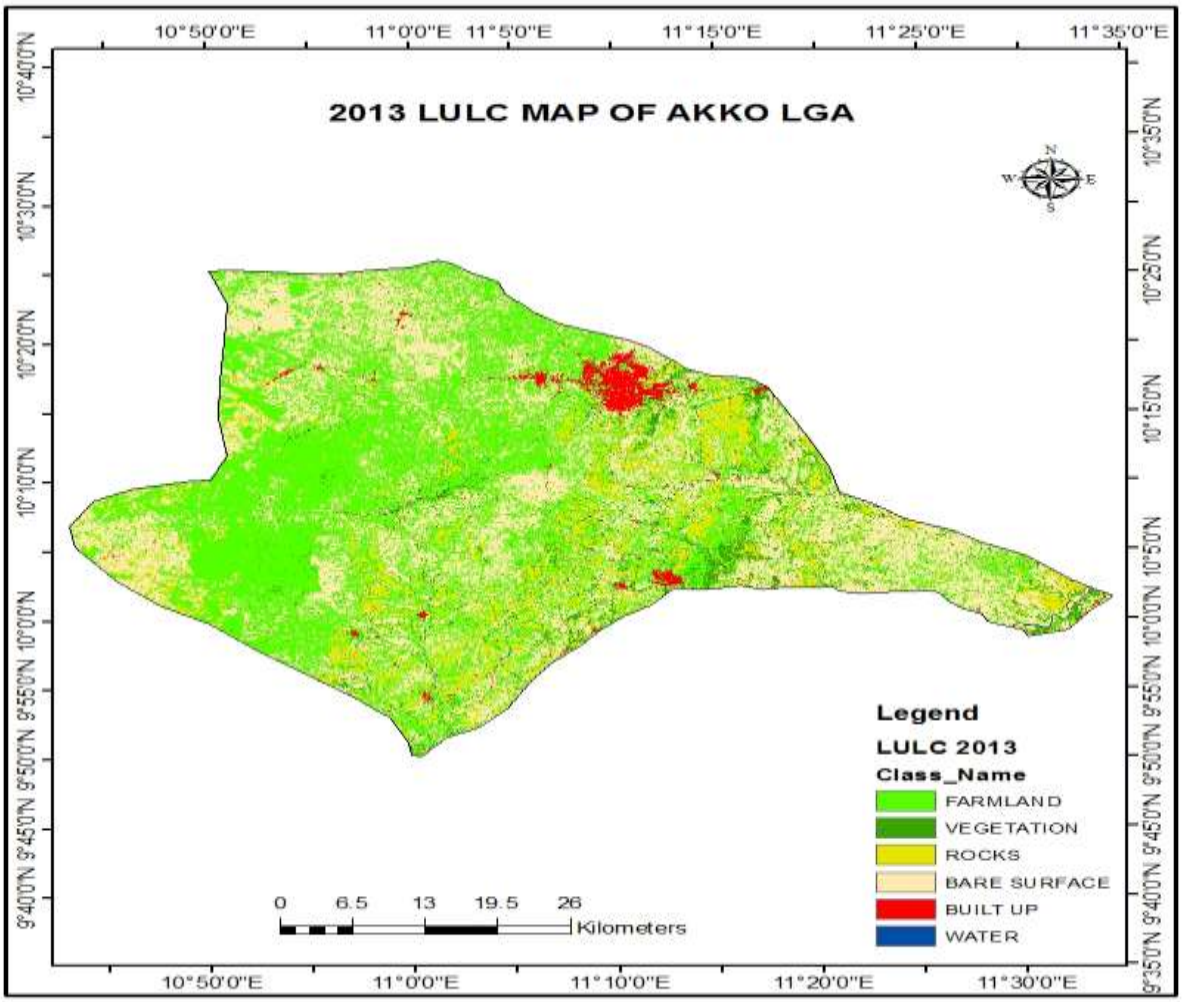

Figure 3: Showing LULC Map of Akko LGA 2013.
Source: Author work

The study reveals that in 2013 there is an increase in agricultural activities and built-up areas are spreading towards the southern part of the study area in the map. Disappearance of rocks is very evident in 2013 so also bare surface. Increase in vegetation cover is evident on the eastern part of the study area on the map.

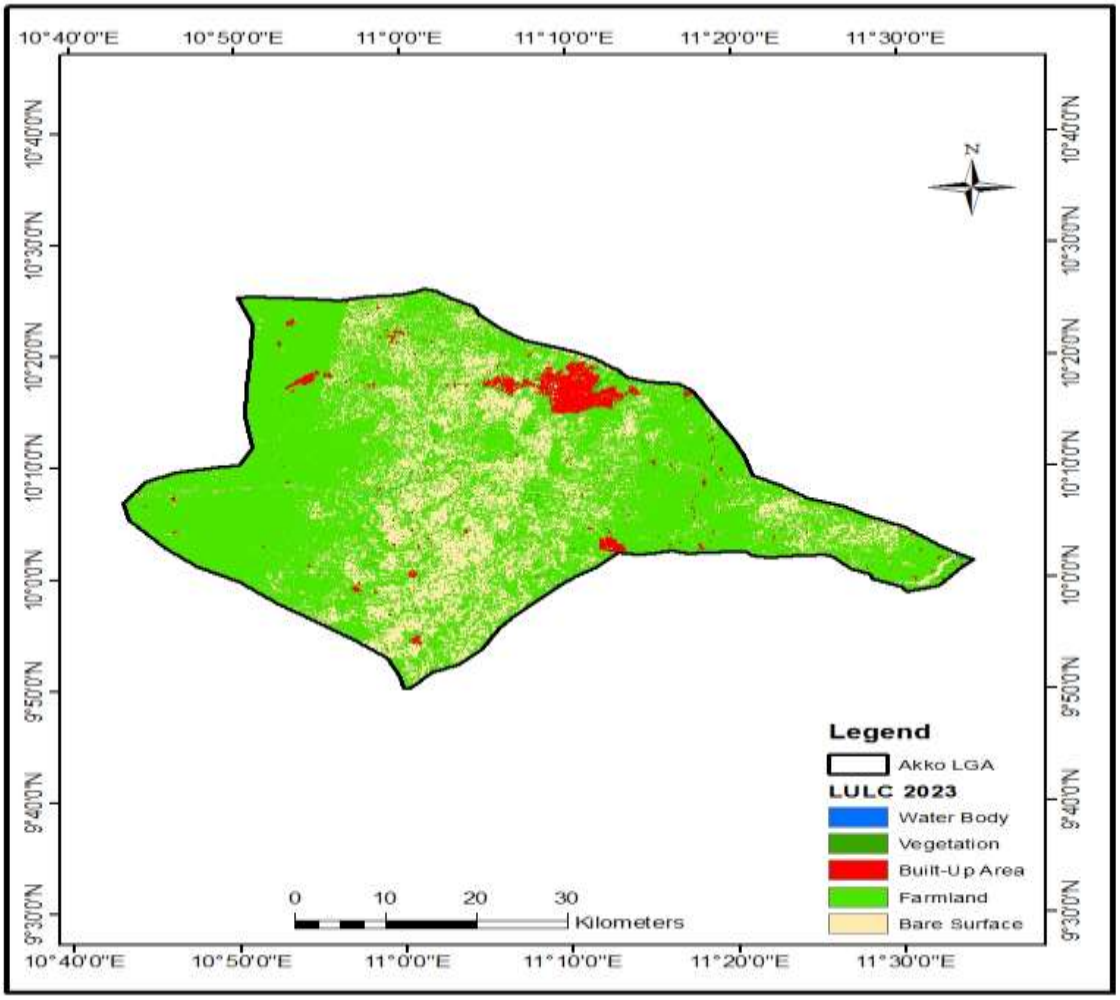

Figure 4: Showing LULC Map of Akko LGA 2023.
Source: Author work

From figure 4 above, the result shows that in 2023 there are no visible rocks in the study area so also water body is absent, no visible vegetation available. Bare surface has also been covered by built up or farmland. It can be seen that in 2023 spread of built-up structures has increased.

Changes of Land Use Land Cover Change between 2003 – 2023 in Akko L.G.A Gombe State.

Table 2: Land Use Land Cover Change (2003)

Class2003	Area	Percentage
Water Body	0.484482	0%
Vegetation	27.482824	1%
Built-Up Area	25.919376	1%
Farmland	1589.073648	56%
Bare Surface	1210.326311	42%

The study reveals area and percentage estimate of Waterbody, Vegetation, Built up area, Farmland and Bare Surface of LULCC 2003. Waterbody has no percentage 0% and with an area of about 0.484482m while the highest class is Farmland with an average of 56% and area occupying about 1589.073648m followed by Bare surface with an average percentage 42% and area of about 1210.326311m. Based on findings, in year 2003 is seen that the area most covered in the study area is farmland used for agricultural purpose and the absence of rivers and streams in the study area makes waterbody the least area covered by land use activity.

Table 3: land use land cover change table for 2013

Class	Area	Percentage
Water Body	1.732334	0%
Vegetation	126.603581	4%
Built-Up Area	53.464945	2%
Farmland	1636.6157	57%
Bare Surface	1035.22645	36%

In 2013 the water body has an increase in land area of 1.732334km still at 0%, vegetation also has an increase in land area of 126.603581km 4%, as against the 1%, in 2003, built up area has also increase since in 2003 with a land area 53.464945km at 2% as against the 1% in 2003, farmland has also increase with an area of 1636.6157km at 57% as compared to 56% in 2003, Bare surface has decrease in land area from 1210.32631km at 42% to 1035.22645km at 36% due to increase in other land use such as, that cover by vegetation, built up area, farmland and water body (which does not have ,a significant change in the total area. The two major class used on land is Farmland and Bare surface. In 2013 the bare surface has reduced significantly due to agricultural activities on farms. The study reveals that built up areas have gradually begun to occupy space while vegetation is also increasing.

Table 4: Showing Land Use Land Cover for 2023

LULC 2023	Area (Sq.km)	Percentage
Water Body	1.289891	0%
Vegetation	11.846226	0%
Built-Up Area	85.842717	3%
Farmland	2093.972487	73%
Bare Surface	660.74066	23%

In 2023 the land use in Akko Local Government Area had some increase and decrease, a closer look at the land use land cover change water body has a significant decrease from 1.732334km to 1.289891km but still at 0%, Vegetation significantly decrease from 126.603581km to 11.846226km at 0%, and critical point of concern, built up area is on the increase covering a land area of 85.842717 at 3% as against the 2% in 2013, farmland has increase to 73% as against the 57% in 2013, covering an area of 2093.972487km, bare surface has decrease from 36% in 2013 to 23%, in 2023 covering a land area of 660.74066km. **T**here is also an increase in agricultural activity like farming to occupy more land and reduce bare surfaces. This clearly shows for almost 20years all the classes were affected by

changes over time. This result shows that overtime the area covered by bare surface will gradually be occupied by built up structures while vegetation cover will be cleared to become farmlands**.**

The Effect of Land Use Land Cover Change in the study area

From the study, 45% of the respondents are residents for 10 to 20 years, 35% are residents for 21 to 30 years, and 20% of the respondents are residents for over 30 years. This has direct bearing on the observable changes in land use land cover in the study area over the past years, as those residents who have been in the area for the past 20 years can give account of experiences as it relates to the observable changes caused by land use changes in the study area. 35% viewed population increase as the causes of Land use land cover change, 41% of the respondents emphasize that Agriculture is the main driver of Land use land cover change, the least of them think that urbanization result to land use land cover change with 24%. From the findings 88% witness that the changes are visible while other respondents said that the changes are not visible with making up 12% of the total population. This means that the changes are visibly in the study area at a considerable impact level. 66% of the respondent's perceived that Land use land cover change has problem to the environment and 34% of the respondents viewed Land use land cover change as not posing any problem to the environment. The problem ranges between erosion, land degradation by increase in population and Agricultural activities. Majority of the respondents making up 41% of the study area perceived the rate of land use land cover change to be at a steady rate. It is neither rapid nor slow but rather at a steady rate, 20% of the respondents view the rate of land use land cover change to be rapid arguably a function of urbanization. 19% of the respondents perceived that land use land cover change to be at a slow rate, while 13% of the respondents perceived the rate of Land use land cover change to be at a very rapid rate and then 7% look at the rate of Land use Land cover change to be at a very slow rate in the study area.

5. Conclusion and Recommendations

Conclusion

The supervised classifications provided a clear and coherent and much satisfying result through findings in the research. It aided the distinguished characteristics as regards the classification of land use in the study area between 2003, 2013 and 2023. Vegetation cover recorded an increase in land area as opposed to the significant decrease recorded between the year 2013 and 2023, farmland had a slice increase between 2003 and 2013 but recorded a significant increase between 2013 and 2023, from 56% in 2003 to 73% in 2023, bare surface in the area has been decreasing since 2003 from 42% to 23% in 2023, hence built-up areas has increase to 3% in 2023 from 1% in 2003, thus, impacting agricultural land and the general area. People increased in number giving rise to the need to convert bare land and vegetation areas into agricultural land and built-up areas that has some negative effect causing soil erosion and land degradation.

Recommendations

Government intervention in the area of family planning to reduce the number of birth rate reducing overpopulation which causes land cover change. Government provision of capital to encourage entrepreneur and business to also reduce the population reliance on agriculture which also causes land cover change, Measures taken by the State Ministry of Urban and rural Planning to discourage indiscriminate building of houses in an unsustainable way that increases Land use and subsequent causes of erosion and land degradation.

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