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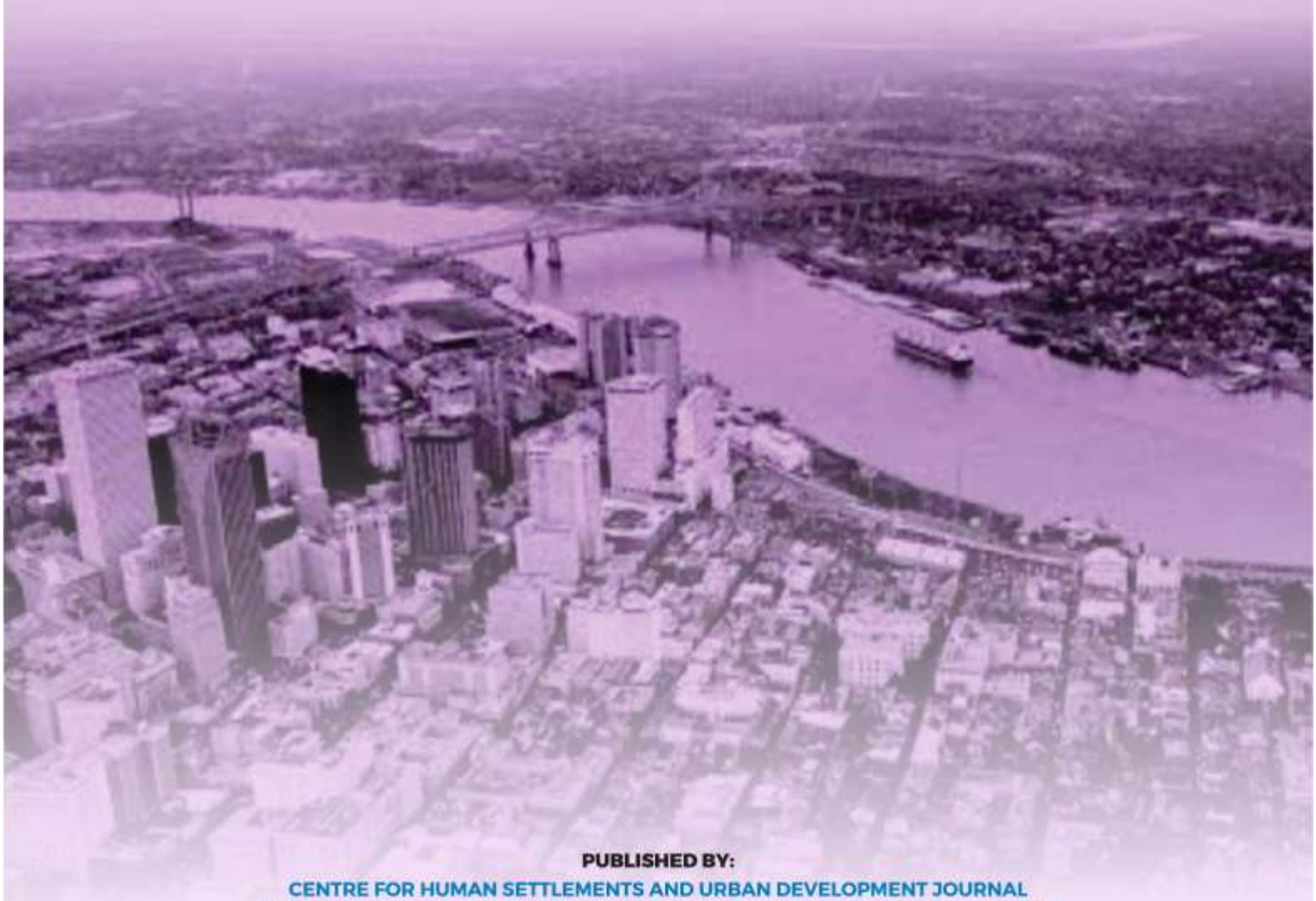

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Editorial Committee

EDITORIAL REMARKS

Dear Reader,

This year the Centre for Human Settlements & Urban Development (CHSUD) will mark her 20th anniversary. This edition of her journal is intended as a prelude to launching of the Anniversary Edition tagged "Managing Human Settlements in the Urban Century". This will highlight the requisites of having and keeping cities, towns and all forms of human settlements as humanity finally moved into the age where urbanization and urban activities, for the first time in history, dominates the planet. The special call for a focus on urbanization is further hinged on the fact that besides dominating human settlement types, urban related human activities have had the greatest impact on earth and its environment. This has resulted into a phenomenon now referred to as "The Anthropocene" – an interconnected, complex global systems in which humanity's impact has become clear.

This volume nine and particular edition (number one) feature works that explored elements and scenarios that increasingly dominates African cities today. Many of them exhibiting lack lustre state of bourgeoning cities and towns in sub-Saharan Africa. But shown here exhibiting the different efforts being made towards having sustainable living and livelihood. This is evident from widespread poverty and deprivations highlighted by "*Implications of Spatial Variation of Household Poverty Incidence in Neighbourhoods of Minna, Nigeria"*, to the explorations of the limitations of interventions shown by *"Climate Change Mitigation Paradox: Poverty and Greenhouse Gas Reduction in A Global South City".* The different negative effects of increasing human activities on the natural and social environment enumerated by "*Spatio-Temporal Analysis of Land Use and Land Cover Change of Birnin Kebbi for Sustainable Development",* and, "*Reduction in the Effects of Climate Change: Efforts Towards Safeguarding the Built Environment in Kaduna, Nigeria";* have drawn attention to the dimensions and consequences, at local, national and regional levels, the increasing effects of human activities dominated earth and arguably the planetary system.

Dr Aliyu M. Kawu MNITP, RTP, MeRSA
Editor-in-Chief
CHSUD Journal

Papers for Journal

The journal accepts well researched papers, including case studies, from all disciplines in Environmental Sciences and other disciplines or subject areas related to the built environment. However, papers to be considered for a specific volume of the journal should fall within the theme and sub-themes specified. The theme for each volume of the journal will be specified.

Submission of Papers

All manuscripts should be submitted to the editor, CHSUD Journal. Three hard copies of papers should be forwarded to the editor with a letter of undertaking that the work is not under consideration elsewhere and it will not be sent to another journal until final decision has been made on it.

Electronic Version: In addition to three hard copies, an electronic version of the article should be forwarded to CHSUD e-mail.

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SPATIO-TEMPORAL ANALYSIS OF LAND USE AND LAND COVER CHANGE OF BIRNIN KEBBI FOR SUSTAINABLE DEVELOPMENT

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Abstract
The challenge of humanity in the 21st Century is clearly to meet the needs of the people, within the means of this extraordinary unique living planet, so that we and the rest of nature can thrive. Humanity is faced with a complex situation, at the same time we are solving for climate change; we are going to be building new cities, towns and urban centres for 3 billion people. If we fail to plan our cities right, then all the climate solutions in the world might not prevent mankind from the worst effects of carbon in the atmosphere. This study is aimed at assessing the land use and land cover change in Birnin-Kebbi between 1991 and 2018 and stimulate the 2027 land cover change using Geographic Information Systems and remote sensing methods. Supervised classification was applied to Landsat image of the study area from 1991, 2000, 2009 and 2018. Population growth and government policies within the period under review are the major underlying causes for LULC change in the study area. The results indicated an increase in urban/built-up from 1,687 hectares in 1991 to 7,725 hectares in 2018 and agricultural land cover types from 9,270 hectares to 43,921 hectares, while vegetation and bare land cover decreased respectively. This study recommends the deliberate measures to control natural increase in population through government partnering with NGOs such as Gate foundation, UNICEF and other aid organisation to invest more in the state in the area of family planning, education, poverty alleviation and green technology to improve child survival rate and ensure sustainable development.
Keywords: Land use, Land cover, Change, Built-up area, Growth, Landsat.

Introduction

The Earth environment is a dynamic system which includes many interacting components (physical, chemical, biological and human) that are constantly changing. The interactions and feedbacks among these components are complex and register high variability in time and space. Changes have always been present within the functioning of planet earth. But since 1950, human activities have produced an important impact in the Earth system (land surface, oceans, coasts, atmosphere, biological diversity, water cycle and biogeochemical cycles) causing changes well beyond natural variability (Vitousek 1992, Foley 2005, Levitus et al. 2012). The magnitude of these changes is increasing throughout the years due to the growing human population and the extension in scale of activities such as industry and agriculture.

After the industrial revolution, the world witnessed an increased gathering of its population in urban areas, as new job opportunities and improved living conditions increase. The 20th century witnessed the extreme and unprecedented growth of global urbanization. This trend is not new, but relentless and has been marked by a remarkable increase in the absolute numbers of urban dwellers, from a yearly average of 57 million between 1990-2000 to 77 million between 20102015 (MacLachlan, Biggs, Roberts and Boruff, 2017).

According to UN-Habitat (2016), the population in urban areas has increased from 14% in 1900 to 30% in 1950.With the world's population evenly split between urban and rural areas in 2008, it is predicted by the UN that by 2050 the urban population will increase again to 66%with nearly 90% of this increase being concentrated in Asian and African cities. Nigeria alone is projected to add 212 million urban dwellers between 2014 and 2050. Whereas cities are hubs for positive social and economic transformation, urban centres are concentrations of industries, transportation, and other activities that release large quantities of greenhouse gases (Kara 2017).

An urban area is an area with an increased density of human created structures in comparison to the areas surrounding it (Enoguanbhor et al, 2019). These areas may be cities or towns, created and further developed by the process of urbanization. Urban areas are highly dynamic and are continually undergoing rapid changes, one of which is changes observed in land-use/land-cover (LULC) also known as land change. The knowledge of land use/land cover change is important to understanding certain occurrences on the earth's biophysical composition. It entails a conversion of natural types of land to uses associated with growth of population and economy, transforming the landscape from its natural form to impervious urban lands termed cities and towns.

According to Hansen (2012), cities are the quintessence of man's capacity to induce and control changes in his habitat. Through urbanization, man has created new ecosystems by interacting with the different components of the environment, thereby creating some imbalance in the system. This goes to say that urbanization is not without its consequences; most notable is the modification of land surface and atmospheric boundary conditions that lead to a modified thermal climate which leaves the cities warmer than surrounding non urbanized areas, commonly known as Urban Heat Island. The aim of this paper therefore, is to assess the land use and land cover change in the study area from 1991 – 2018 and simulate the 2027 land cover change of Birnin Kebbi for sustainable development.

Study area

Birnin-Kebbi is the administrative headquarters of Kebbi State. The total population of the city in 2006 was 268,620 and an estimated population of 366,200 in the 2016 demographic statistics released by the National Bureau of statistics, (NBS, 2016). The rate of urbanisation in the state has being largely influenced by the fast growing population. Despite having a Master Plan, the unchecked and uncontrolled development has led to the replacement of soil and vegetation cover with impervious urban materials and the creation of slums and squatter settlements. These may, directly or indirectly, affect the albedo and runoff characteristics of the land surface.

The relief in the study area is characterised by undulating terrain. Further northwest of the study area, there are however, outcrops and steep cliffs of limestone, reaching 15m in height in the town and up to 30m just outside. In general, elevations throughout the state are mostly less than 300m (Birnin Kebbi Master Plan, 1980-2000).

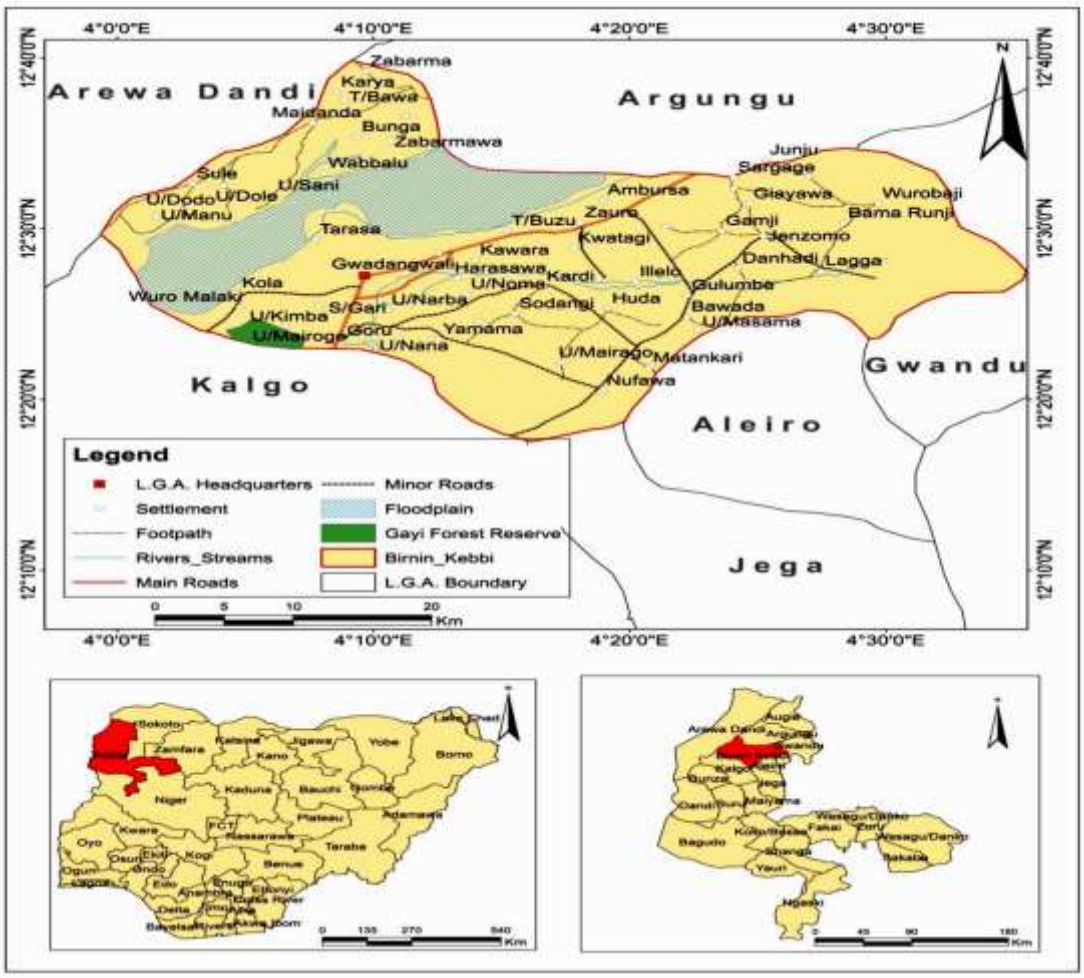

Figure 1: Map of Birnin Kebbi, Kebbi State, Nigeria
Adopted from Abubakar (2012)

Materials and Methods

Land use and land cover change detection was done using satellite imagery from 1991 – 2018 with a nine (9) year interval i.e. 1991, 2000, 2009 and 2018. In addition, the simulation/prediction of the land cover (under "business as usual") of 2027 was conducted using the Markov Chain Analysis. According to Macleod and Congalton (1998), there are four major aspects to be considered when monitoring change detection in natural resources. These are detecting the changes that have occurred; identifying the nature of the change; measuring the areal extent of the change; and assessing the spatial pattern of the change. These guidelines were used in detecting the changes that have occurred in the study area.

Data Type and Source

Table 1 Summary of remotely sensed data description

Spacecraft	Sensor	Resolution	No. of bands	Acquisition date	Source
Landsat 5	TM	30m	1,2,3,4& 5	17th, November 1991	USGS
Landsat 7	ETM+	30m	1,2,3,& 4	23rd, November 2000	USGS
Landsat 7	ETM+	30m	1,2,3,& 4	29rd, November 2009	USGS

LandsatOLI-8	OLI	30m	2,3,4,5 &6	30th, November 2018	USGS

Image Processing Techniques

Similarly, the spatial analysis was performed using ArcGIS (version 10.1) software. A supervised classification method was applied to derive land cover types. The supervised classification algorithm that was used in this study is the maximum likelihood classifier, which relies on the probability that different pixels belong to different classes (Lu et al, 2011) and assigns pixels to the class with the highest probability (Mather and Tso, 2009). This is because maximum likelihood algorithm has been demonstrated by Ganasri and Dwarakish, (2015) to produce high-accuracy results for land cover classification. The land cover classes were categorized into the most frequently occurring classes in the satellite imagery: urban/built-up, vegetation, bare land, and water (Table 2).

Table 2: Categories of land cover classes.

Land Cover Classes	Description of Land Cover
Urban/built-up	Elements of urban/rural settlements such as buildings, roads, etc.
Vegetation (Forest and savannah vegetation):	Tall trees that form canopy as healthy vegetation. Isolated short trees mixed with grasses.
Farmland	All type of cropland
Bare land	All other surfaces such as open space with bare soil, rocks.
Water bodies and wetland	Seasonal and permanent wetlands, marshy lands, swamps, lakes and other water bodies.

Modified from Enoguanbhor et al. (2019)

- **LULC change detection analysis** In assessing the LULC change detection, two different analytical methods were applied:

1. Total LULC change in hectare was calculated as:

Total LULC = Area of a final year – Area of initial year Positive value indicates an increase in the specific class, while negative value implies a decrease in extent.

2. The percentage of LULC change was calculated based on the following equation:

$$\text{Percentage LULC (\%)} = \frac{\text{Area of final year} - \text{Area of initial year}}{\text{Area of initial year}} \times 100$$

- **Land Absorption Coefficient (LAC) and Land Consumption Rate (LCR)** In determining the relationship between land use and land cover and population, land absorption coefficient (LAC) and land consumption rate (LCR) of the study area was conducted. According to Opeyemi, 2015, "LAC is the measurement of variation in the consumption of new urban land by unit increase in urban population. While, LCR is the measurement of the compactness which indicate a progressive special expansion of a city". The formula for calculating these are:-

$$\text{LCR} = \frac{\text{Areal extent of the city in hectares}}{\text{Population}}$$

$$\text{LAC} = \frac{A_2 - A_1}{P_2 - P_1}$$

Where A_1 and A_2 are the areal extents (in hectares) for the early and later years, and P_1 and P_2 are population figure for the early and later years respectively (Opeyemi, 2015).

Results and Discussion

Land use and land cover change is a constant but gradual process occurring in any geographical location on the earth surface. This process may sometimes occur unnoticed over time and space. The Birnin-Kebbi land use and land cover analysis was examined using multi-temporal Landsat images between 1991 and 2018. The results (figure 3a and table 3) show that in 1991, with a population of 119,000 (UN-WPP, 2019) inhabitants, the urban/built-up areas were concentrated in the north-western part of the local government, with some isolated settlements in the other parts; development generally, was few and far between. The urban/built up class covered only 1.4% (1,687 hectares) of the total land area.

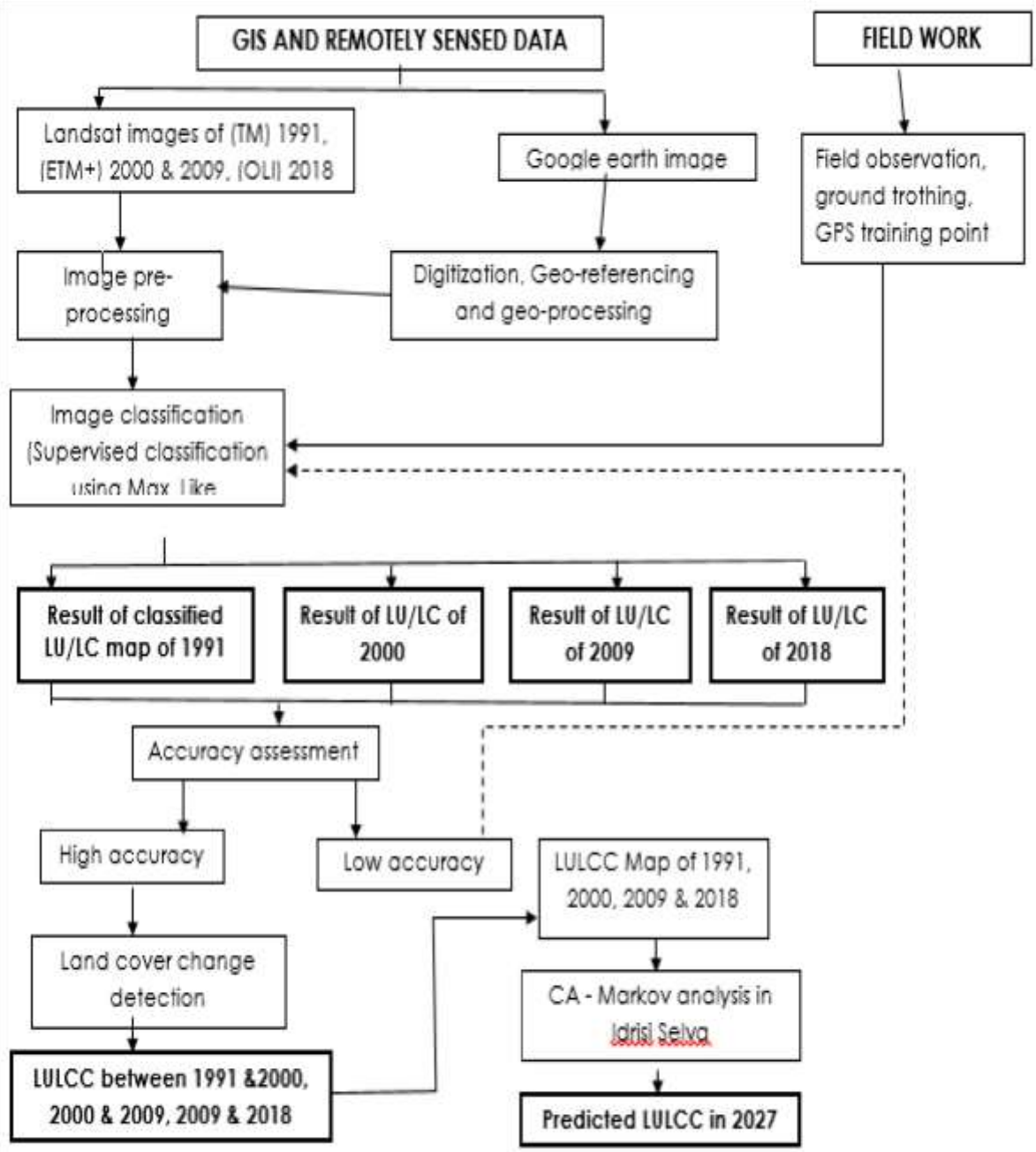

Figure 2: Method for Research Analysis

The low urban spread in 1991 is largely attributed to the fact that Birnin-Kebbi at this period was just elevated to the capital of a newly created state (Kebbi State), from Sokoto State. Also, vegetation covered 73,030 ha (58.5%), water body covered 0.04%, about 9,270 ha (7.4%) of the total land was used for agricultural purpose while bare land covered 40,773 ha (32.7%).

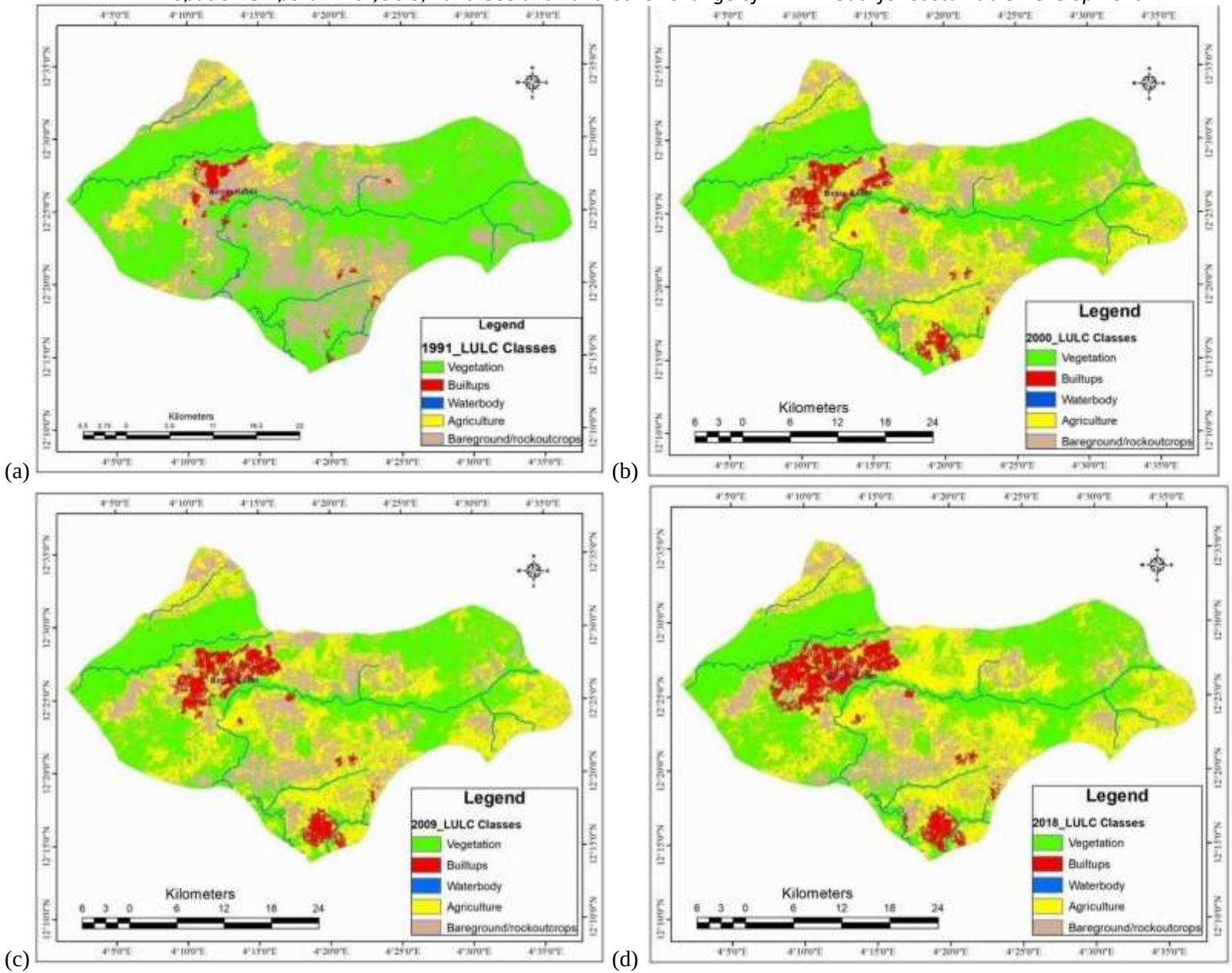

Figure 3: Land Cover of Birnin Kebbi (a) 1991, (b) 2000, (c) 2009 and (d) 2018

In 2000, (figure 3b and table 3), the population increased to 160,000 people (UN-WPP, 2019). The pattern of urban distribution indicates a gradual spread in the built up areas from the north-western part of the state capital, moving towards the western part in a linear pattern. There was also a rapid development of settlements in the southern part of the state capital. This led to the overall increase in the percentage of built up area in the year 2000 to 3.4% of the total land coverage. Also, vegetation covered 46.3%, water body covered 0.02%, and agricultural land covered 32.2% while bare ground covered 18.2%.

There was a significant increase and decrease in the different land cover types in the study area in the year 2000. This was attributed to the increase in population due to natural growth and the influx of people into the study area; and the need to develop critical infrastructure to provide the necessary services to support the new status of the place. Built up area increased from 1,687 ha in 1991 to 4,189 ha in 2000, vegetation reduced from 73,030 ha in 1991 to 57,790 ha in 2000 while, water body decreased from 51 ha to 29 ha. Similarly, agricultural land increased from 9,270 ha to 40,134 ha and bare ground decreased from

40,773 ha to 22,669 ha.

Table 3 The land cover types for the different years and their percentage

Land cover type	**1991(Ha)**	**%**	**2000(Ha)**	**%**	**2009(Ha)**	**%**	**2018(Ha)**	**%**
Built-up areas	1,687	1.4	4,189	3.4	5,580	4.5	7,725	6.2
Vegetation	73,030	58.5	57,790	46.3	55,035	44.1	54,992	44.1
Water body	51	0.04	29	0.02	39	0.03	41	0.03
Agriculture	9,270	7.4	40,134	32.2	42,122	33.8	43,921	35.2
Bare ground	40,773	32.7	22,669	18.2	22,035	17.7	18,132	14.5
TOTAL	**124,811**	**100**	**124,811**	**100**	**124,811**	**100**	**124,811**	**100**

The 2009 classified image (figure 3c and table 3) shows that the built up areas are becoming densely populated, as land previously used for farming or agricultural purposes close to settlements are gradually being converted to building or settlements. The population also increased 160,000 in 2000 to 239,000 in 2009. It also shows that there was not much increase or

expansion in terms of the extent of built up area but densification of the existing urban space.

Interaction with the Director, Town Planning, Ministry of Lands, Housing and Urban Development, Kebbi State, revealed that there was a deliberate effort in 2007/2008 from the ministry to monitor and control urban growth, enforce the existing land use plan and encourage the reforestation programme in the state capital.

Table 4 Rate and percentage change of LULCs in Birnin-Kebbi

LULC Category	**1991 – 2000 Rate (Ha)**	**%**	**2000 – 2009 Rate (Ha)**	**%**	**2009 – 2018 Rate (Ha)**	**%**
Built up area	2,502	148.3	1,391	33.2	2,145	38.4
Vegetation	-1,524	-20.9	-2,755	-4.8	-43	-0.09
Water body	-22	-43.1	10	34.5	2	5.1
Agriculture	30,864	332.9	1,988	4.9	1,799	4.3
Bare ground	-18,108	-44.4	-634	-2.8	-3,903	-17.7

Source: Authors analysis, 2019.

Subsequently, built up areas increased by 1,391 ha in 2009 (see table 4), with a marginal increment of 33.2% from the 2000 classified image. Vegetation decreased by 2,755 ha and water body increased slightly by 10 ha. Also, agriculture increased 1,988 ha in 2009, while bare ground decreased by 634 ha.

The 2018 classified image of LULC (figure 3d) shows significant expansion in the built up area in the north-west and the southern part of Birnin Kebbi, with some emerging settlements scattered

around the study area. This is as a result of population increase, as Birnin Kebbi now records approximately 339,000 inhabitants. These settlements are isolated and located close to the river channels and surrounded by agriculture/farm lands. The figure 3, table 3 and table 4 shows that built up area now covered 6.2% of the total land

further explained that "Kebbi is one of the major rice producing states in Nigeria, and the favourable condition in Birnin Kebbi, coupled with the incentive given to the farmers by the state government, more people have moved into the state to either start farming or work in the different rice processing companies in the state capital".

Table 5 Land Consumption Rate (LCR) and Land Absorption Coefficient (LAC)

Year	L.C.R	Year	L.A.C
1991	0.014	1991/2000	0.061
2000	0.026	2000/2009	0.018
2009	0.023	2009/2018	0.022
2018	0.023		

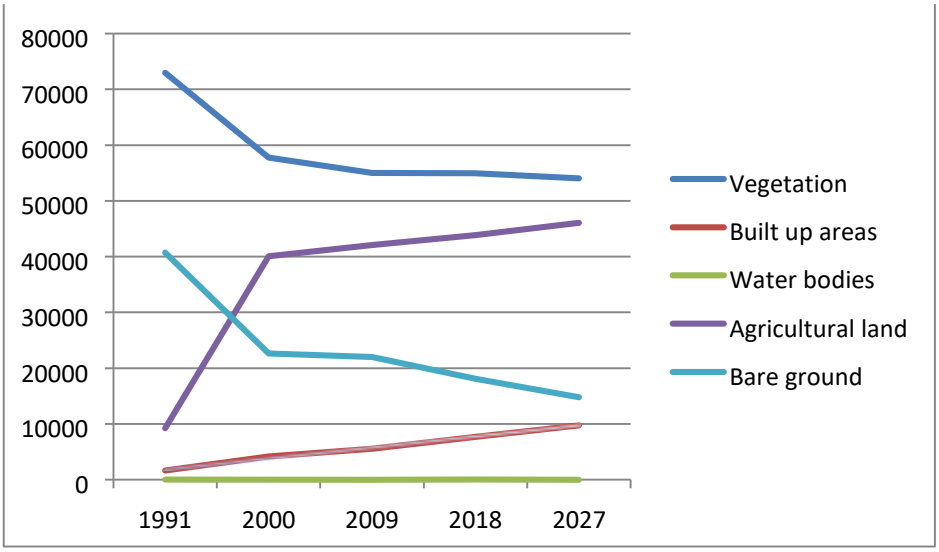

Figure 4: Trend analysis of LULC Classification of the Study Area
Source: Authors' Data Analysis, 2019.

area, gaining about 2,145 ha; vegetation decreased by 48 ha and water body increased by 2 ha. Similarly, agricultural land now covered 35.2% of the total land surface, by adding 1,799 ha and bare ground decreased by 3,903 ha.

The table 3 and 4 also revealed significant changes in the different land cover component. It shows that there was a rapid increase in the built up area when compared to 2009. The built up area increase from 5,580 ha in 2009 to 7,725 ha in 2018, indicating 38.4% increment. Also, agricultural land increased from 42,122 ha to 43,921 ha. According to the Director, Town Planning, "The drastic increase in both built up area and agricultural land is a result of the federal government policy to encourage the production and consumption of local rice". He

Subsequently, bare ground decreased from 22,035 ha to 18,132 ha.

Though, more vegetated land were converted to either farm land (agriculture) or built up area, the government effort to plant more trees has compensated for the loss of vegetative areas. Therefore, vegetation recorded a "simple negative" change when compared to 2009, i.e. only 43 ha of vegetation were lost between 2009 and 2018. Similarly, water body increased by 5.1% over the same period.

The period between 2000 and 2009 witnessed a drop in the rate of Birnin Kebbi physical expansion, when compared to between 2009 and 2018. The city experience it most years of physical growth

within 1991 to 2000, with a land absorption coefficient of 0.061.

Projected and the simulated land use and land cover of 2027

The results (figure 4 and table 6) show the projected LULC for 2027 and the expected changes in the different classes of the land cover. The state of 2027 LULC depends majorly on the state of 2018. With a uniform time period or duration of 9 years interval i.e. from 2009-2018 and 2018-2027, the projection agrees with Araya (2009) findings as cited in Alemayehu et al (2019), where he said "trend of LULC change in future time can be detected when predicted LULC at time t2 compared to the base year at time t with reference to the class area metrics". Therefore, when compared to the base year of 2018 in 2027, built up area and agricultural land are predicted to increase by 2,034 ha and 2,192 ha respectively, while vegetation, bare ground and water body are predicted to decrease by 920 ha, 3,300 ha and 4 ha respectively.

The growth in the built up area and agriculture is expected to come largely from bare ground and vegetation. This is because of the continuous increase in population due to migration and natural process, and the high demand on fuel wood for cooking energy (see plate II). So, the over dependent on fuel wood will lead to the destruction of vegetation. Similarly, the drive to make Nigeria self-sufficient in rice production will have a direct impact on vegetation, water body and bare ground in the future, as Kebbi state and Birnin Kebbi, in particular, is the major contributor to the total rice production in Nigeria.

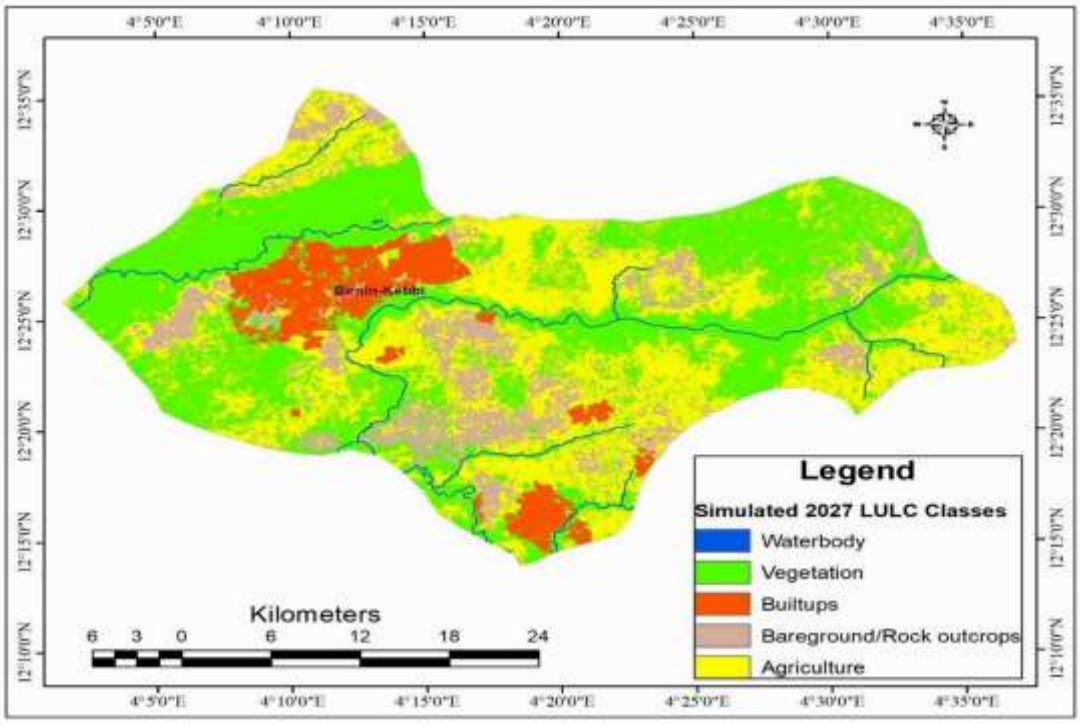

Figure 5: 2027 Projected Land Cover of Birnin Kebbi Author's Data Analysis, 2019

Table 6: Projected LULC matrix for 2027 and the predicted change between 2018 and 2027

Years	Classes	Built ups	Vegetation	Water body	Agriculture	Bare ground	Total
2027	Area (Ha)	9,759	54,070	37	46,113	14,832	124,811
	Area (%)	7.8	43.3	0.03	36.9	11.9	100
2018–2027 change	Area (Ha)	2,034	-920	-4	2,192	-3,300	
	Area (%)	26.6	-1.7	-9.8	4.9	-18.2	

Source: Authors work, 2019.

Plate II: Fuel wood depot, Birnin-Kebbi

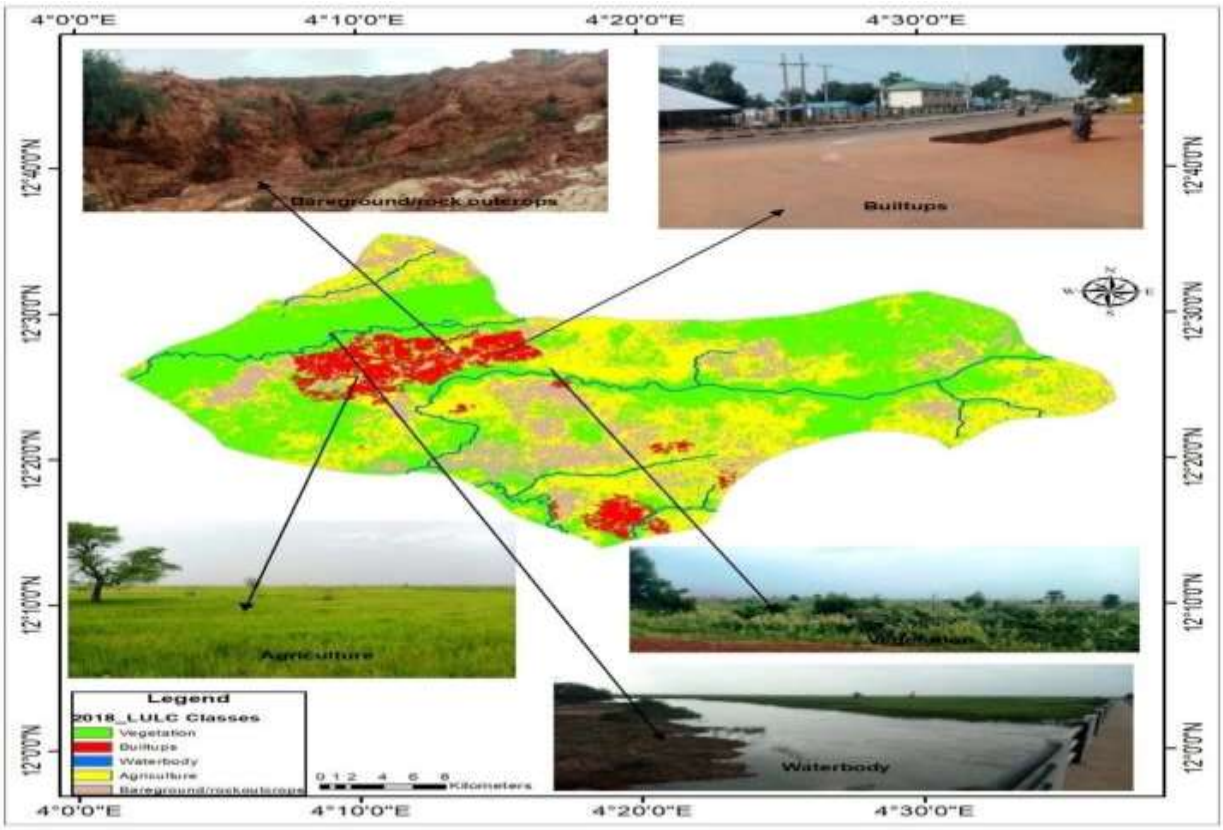

Figure 6: Classified image with the picture classes

Conclusion and Recommendation

It was discovered that there had been a steady increase in the rate of urbanisation and agricultural land (farmland) in the study area, with a corresponding decrease in vegetation cover and bare ground. The 2027 projection shows a similar trend and this is not environmentally sustainable.

Recommendation

1. There is a need to sensitive and reorientate the people of Birnin Kebbi about the effect of using firewood as a source of cooking energy and it impact on climate change. The conscious reduction in the use of firewood for other sustainable alternatives like the LPG and electricity can lead to low patronage in the wood selling business and ultimately save the trees in the forest.
2. Sustainable skills development programmes, financial opportunity or material loans in terms of micro-credit schemes should be initiated by the government, through a coordinating ministry or NGO to provide LPG cooking system for private individuals and commercial food vendors at an interestfree loan to enable them stop the use of firewood.
3. The state government started a laudable project of planting trees within the urban areas in 2006-2007, this trees compensated for the loss in vegetation cover to farmland, leading to a small loss in vegetation between 2000 – 2009. The government should continue this project and encourage private organisations and individuals to plant trees. Primary and secondary school pupils can be motivated to plant a "Tree of Life" in their school environment.
4. The rate of land conversion from vegetation to agricultural purposes needs to be controlled, and more sustainable system of farming introduced.
5. Deliberate measures to control natural increase in population: if nothing is done to ensure a sustainable population size in the study area, all other effort to make Birnin Kebbi a sustainable city will be ineffective. The government need to synergize with Gate foundation, UNICEF and other aid organisation to invest more in the state in the area of family planning, education, poverty alleviation and green technology to improve child survival rate and ensure sustainable development.

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1. Manuscripts not more than 15 pages of A4 size (including abstract, tables, figures, references and appendices), typed in double spacing and font size 12.
2. Each paper must be complied in one column; all texts should be left and right margins of an A4 paper. Decimal numbering of all sections of the articles is recommended (with exception of the reference and acknowledgment section).
3. To ensure anonymity in the pair reviewing process, articles must be structured in such a way that the title of the paper, authors names, address and affiliation are written on the first page, followed by the abstract and body of the paper in that order.
4. Each article should contain an abstracts of not more than 200 words.
5. Each article should contain between 5 to 8 keywords (avoid the use phrases).
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