ANALYSIS OF LANDUSE AND LANDCOVER DYNAMICS DOWNSTREAM OF SHIRORO DAM, NIGER STATE, NIGERIA

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Abstract
Landuse and Landcover are activities both natural and manmade that characterised the usage of land. While Landuse is described by arrangement and man's input in a certain land to produce changes and maintain it, Landcover on the other hand is biotic and abiotic features that cover the earth surface. Land degradation often associated with how man use the land for agriculture or farming is one of the parameters that influence the natural hydrologic cycle of a watershed. This paper is aimed at analysing the Landuse and Landcover dynamic downstream of Shiroro Dam in Niger State, Nigeria. Three different datasets (Landsat satellite imageries) of the area for 1990, 2010 and 2016 were classified and analysed using ArcGIS 10.2 and Idrisi Tiga GIS software. The result of the analysed data revealed that, vegetation cover reduced drastically from 62.84% in 1990 to 28.38% in 2010, water body significantly reduced from 2.03% in 1990 to 1.9% in 2016. On the contrary, agricultural land shows a significant increase from 22.43% in 1990 to 50.98% in 2016. Bareground and builtup areas also increased from 8.93% and 3.77% in 1990 to 12.34% and 6.37% in 2016 respectively. Consequently, it is evident that the increase in agric land, builtup area and bareground is as a result of increase in population, which led to increasing demand for food, shelter and deforestation for firewood. Consequently, it is recommended that the concern authorities should formulate effective landuse and landcover based development strategy.

Keywords: Landuse, Landcover, Environmental degradation, GIS

Introduction
Landuse is characterized by arrangements, activities, and inputs people undertake in a certain Landcover type to produce, change or maintain it. Land as a natural resource is a utilized resource by humans to meet their needs. Landuse that does not comply with the carrying capacity and soil and water conservation service will trigger land degradation. Land degradation is one of the parameters that affect the hydrological aspects of the watershed, especially runoff (Yusuf *et al.,* 2017). Surface runoff is a part of rainfall that flowss on ground surface after the interception, depression storage, and infiltration takes place. The amount of measured runoff is a function of rainfall, soil and Landuse type. High surface runoff is one cause of problems in a watershed (Yusuf *et al.,* 2017).

Protecting the global environment is one of the critical problems the world is facing now and this is due to several factors, such as population increase, depletion of natural resources and the pollution of the environment Study & Zanjan, 2009 cited in (Ade & Afolabi (2013)). The unplanned changes of the Landuse have become a major problem because of the absence of logical planning and consideration of environmental impacts (Study & Zanjan, 2009 cited in Ade & Afolabi, 2013).

For the past decades, Remote Sensing (RS) and Geographic Information Systems (GIS) technologies have been vital tools for mapping the Earth features, studying the environmental changes in time and space and managing the natural resources. This gives the most accurate means of measuring the extent and pattern of the changes at a particular landscape over time (Kumar & Pandey, 2016). This technology affords a practical means of analysing the changes in the Landuse pattern at the mine sites at inaccessible places. It has also become possible to get a synoptic coverage of a larger area, in a cost-effective and in a repetitive way.

Assessing landuse and landcover change has become a central component in the current strategies for managing natural resources and monitoring the environmental changes (Mark & Kudakwashe, 2010).

Study area

Niger State was created in 1976 and it lies between Longitude 3.38^0 East and 7.03^0 East of the Greenwich Meridian and Latitude 8.02^0 and 10.20^0 North of the Equator. Shiroro Dam is located between Longitude 9^{0}58'N and Latitude 6^{0}5'E while the study area (figure 1.0) is located between Longitude 5^{0}20'E to7'10'E and Latitude 8^{0}45'N to10^{0}15'N. With a population of over 4 million people, Niger State has a total land area of 72,200.14km^2. The Niger valley terrain covers 18,007.38km^2 (24.94%), the plains cover 24,181.04km^2 (33.49%), upland is 20616.09km^2 (28.55%) while the remaining 9593.3km^2 (13.01%) are made up of highlands (Mayomi *et al.* 2013). Shiroro Dam is situated 550 metres downstream of the confluence of Kaduna River with River Dinya as its main tributary, and is built on River Kaduna that takes its origin around the west and North-West of the Jos Plateau in North-Central Nigeria from where it flows westward and southwest-ward. (Ikusemoran *et al.*, 2014).

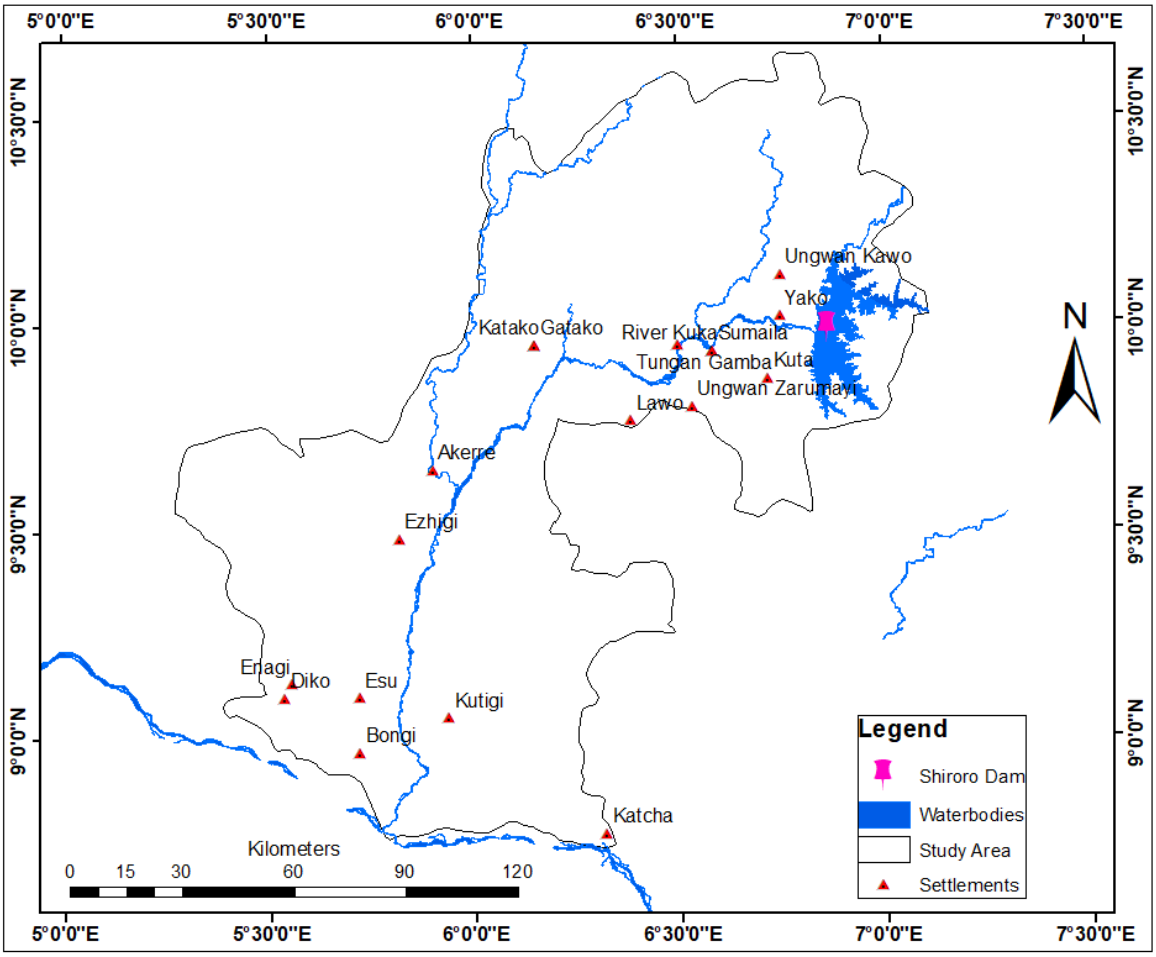

Figure 1.0: **Map of the study area**
Source : Author's work 2020

Data and Methods

Data

The data used in the research are shown in Table 1. This includes thematic maps of 1990, 2010 and 2016 that were extracted from Landsat imagery for the three time decade using Maximum Likelihood Supervised Classification.

Table 1: Details of Satellite Data Used

S/N	Sensor	Path / Row	Source	Year of Acquisition	Scale/resolution
1	Landsat TM	189/054	Glovis	1990	30
2	ETM+	189/054	Glovis	2010	30
3	OLI	189/054	Glovis	2016	30

Methods

In this study, two types of software were used:

(a). ArcGIS was used for creating slope constraint and providing the administrative shape file.

(b). IDRISI Tiga was used for change detection analysis and presenting change detection graphs and for modeling Landuse and Landcover.

A combination of image reconstruction which was carried out through sub-setting using boundary file of Area of interest (AOI) to extract the study area from the entire satellite image scene, image enhancement to improve visual quality and appearance of an image for easy interpretation by increasing apparent contrast among various features in the scene. The sensitivity of bands 4 and 3 to vegetation cover and sensitivity of Band 4 to water contents are crucial surface analysis (Robert *et al.,* 2009). The image visual interpretability was improved through` the image enhancement by increasing the various feature distinctions, After the enhancement process, band combination operations was performed to highlight brightness values associated with. A band combination of 4, 3, 2 was used for analysis of 1990 and 2010 while band 5, 3, 2 was used for 2016 Landsat 8 (OLI). Image reconstruction was carried out through sub-setting using boundary file of Area of interest (AOI) to extract the study area from the entire satellite image scene. This is because a single scene of Landsat image is larger than the study area. The major reason for this operation is to define the study area more precisely, reduce file size, less processing time and ensuring less computer storage space.

Based on prior knowledge of the area and field survey, a classification scheme on (Anderson *et al.,* 1976) level 1 classification was adopted and modified into five classes (see Table 1), representing built up, vegetation, farmland, Bareground/rock outcrops and water body.

Table 1: Classification Scheme Used for this Study

S/N	Class	Description
1	water bodies	Open water features such as rivers, streams, lakes and reservoirs, permanent open water, ponds, canals, permanent/seasonal wetlands, low-lying areas, marshy land, and swamps.
2	Bare ground/rock outcrops	Open dry sand on the body of water, excavation sites, open space, soils
3	Vegetation	Trees, natural vegetation, mixed forest, gardens, parks and playgrounds, grassland, vegetated lands, agricultural lands, and crop fields.
4	Agricultural land	Fallow land, earth and sand land in-fillings, construction sites, developed land, excavation sites, open space, bare soils, and the remaining Landcover types.
5	Built-up	Areas under urban and rural built-up including homestead area, residential, commercial, mixed use and industrial areas, villages, settlements, road network, pavements, and man-made structures.

Source: Adopted from Anderson *et al.* 1976 and modified

Accuracy assessment

After all the aforementioned processes, the result of the classification was subjected to accuracy assessment, as recommended by (Foody, 2002). Accuracy assessment for individual classification is essential for correct and efficient analysis of LULC change (Butt *et al*., 2015). It how indicates the degree of classified images agrees with reality or conforms to the truth. A total of 250 random points as recommended by congalton (1991) was utilized in IDRISI Tiga software.

These points represent the various sample points and these were checked against the classified imageries to determine the degree of conformance. The reason for this is to test the validity of the results derived from the classification process. This accuracy was reported so that users of the products can decide if the product from the accuracy of the classification if good enough or not.

Result and Discussion

Analysis of the Landuse and Landcover of 1990, 2010 and 2016 Satellite Imageries

This section revealed the raw colour composite and supervised maximum likelihood Classifications for the year 1990, 2010 and 2016 satellite imagery over the study area as well as the different classes of land features present over the area.

Raw Colour Composites of the Satellite Imagery

The colour composite of the Landsat imageries acquired over the study area were presented in Figure 2 for the years 1990, 2010 and 2016 respectively. Band 3 represent red wavelength, band 2 represent green wavelength and band 1 represent blue wavelength. This clearly revealed different reflectance of features on the surface for easy interpretation and classification to be carried out.

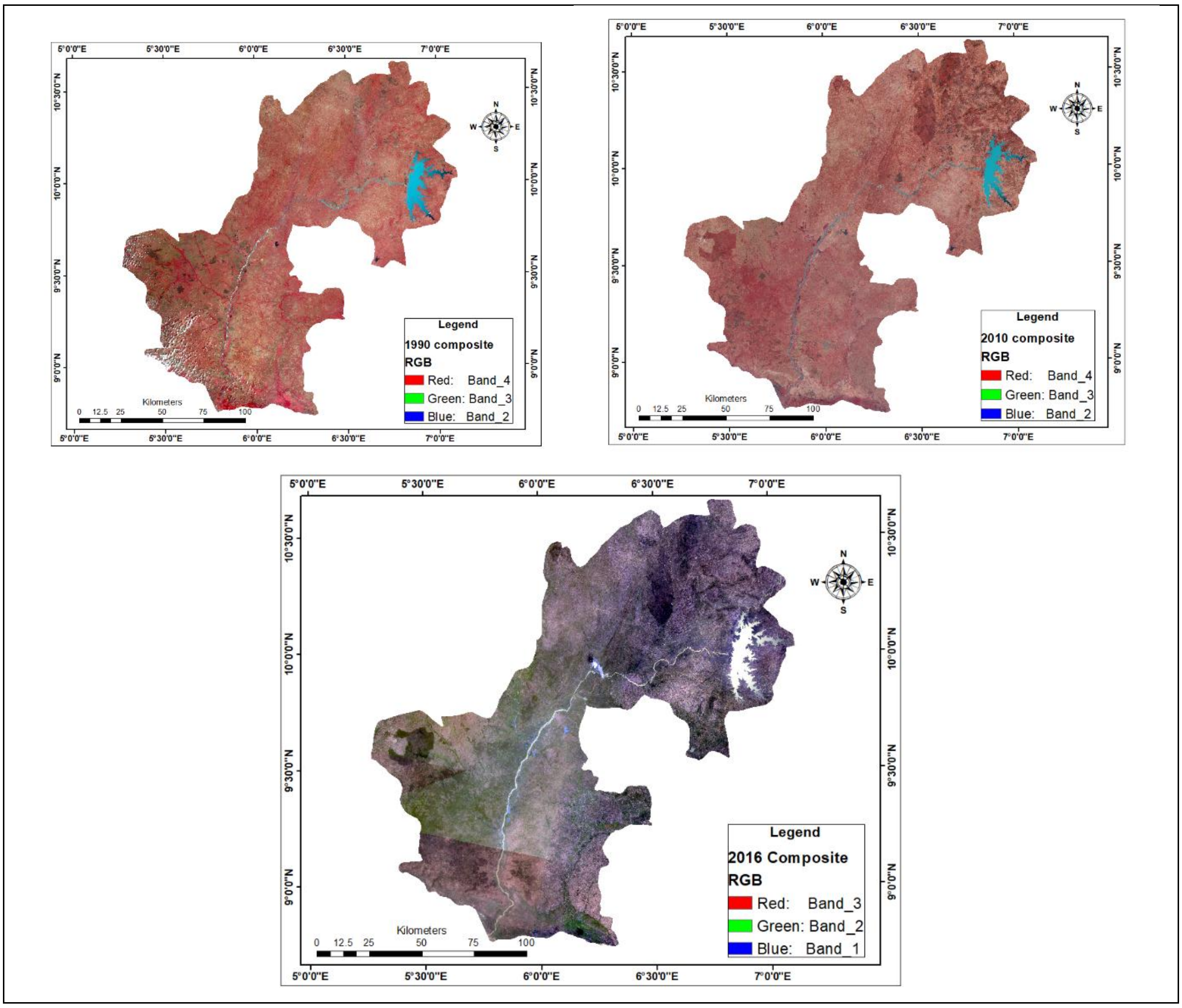

Figure 2: Colour Composite of Landsat TM, ETM+ & OLI of 1990, 2010 and 2016

Analysis of Landuse and Landcover Classification of 1990 Satellite Imagery

The result of the analysis of 1990 supervised maximum likelihood classification of the study area was presented in figure 3. The map revealed five (5) categories of Landuse and Landcover; vegetation, agriculture, built-ups, water body and bare-grounds/rock outcrops. The areal extent of these Landuse and Landcover classes revealed that the dominant Landcover in the study area is vegetation with an aerial coverage amounted to 126,229,8ha (62.84% of the total area), located in almost all parts of the study area. The next largest is agriculture with areal coverage of 450,573ha (22.43%). Bare ground/rock outcrops also covers a significant area of 179,293ha (8.93%). Water body and builtup areas however, have the least areal coverage of 407,51ha (2.03%) and 758,15ha (3.77%) respectively, see figure 3.0.

The dominance of vegetation covering 62% of the study area in relation to water body that covers (2.03%), indicate the role of vegetation in reducing the rate of surface runoff, thereby increasing infiltration and decreasing the likelihood of flooding in the study area. This agrees with the result of Wagner *et al.* (2013). These conditions were considered as a reference point for change detection over the study period.

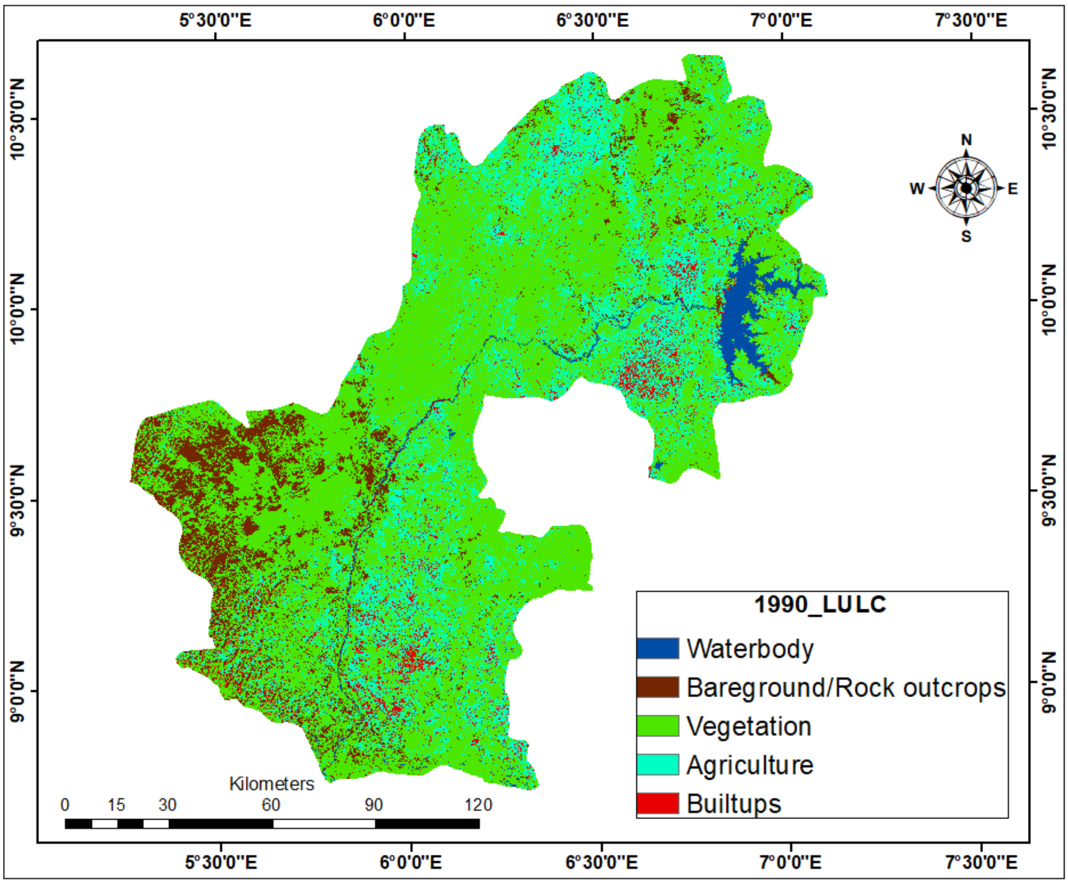

Figure 3: Landuse and Landcover of 1990

Analysis of Landuse and Landcover Classification of 2010 Satellite Imagery

This period as shown in figure 4 witnessed a considerable decrease in vegetation cover from 62.84% during the previous decade to 868,716ha (43.25%) of the total area. This in turn resulted in an increase in agricultural land and builtup areas from 407,51ha (2.03%) and 758,15ha (3.77%) to 861, 345 ha (42.88%) and 972,30ha (4.84%) respectively in 2010. This is attributed to increase in population, thereby increasing the need for food and shelter (evident from the increase in agricultural land and builtup areas) to meet the demand of the communities. While the water body and bare ground/rock outcrops amount to 374.93Km^2 (1.87%) and 1439.46 Km^2 (7.17%) respectively. The decrease in water body can be attributed to siltation of the water due to the fact that the satellite imageries used were of dry season period. This agrees with the works of (Vivekananda, *et. al.*, 2020) Multi-temporal image analysis for LULC classification and change detection at Ananthapuramu, findings shows that the area under built-up land and agriculture land increased considerably, whereas the area under vegetation land and water bodies drastically decreased.

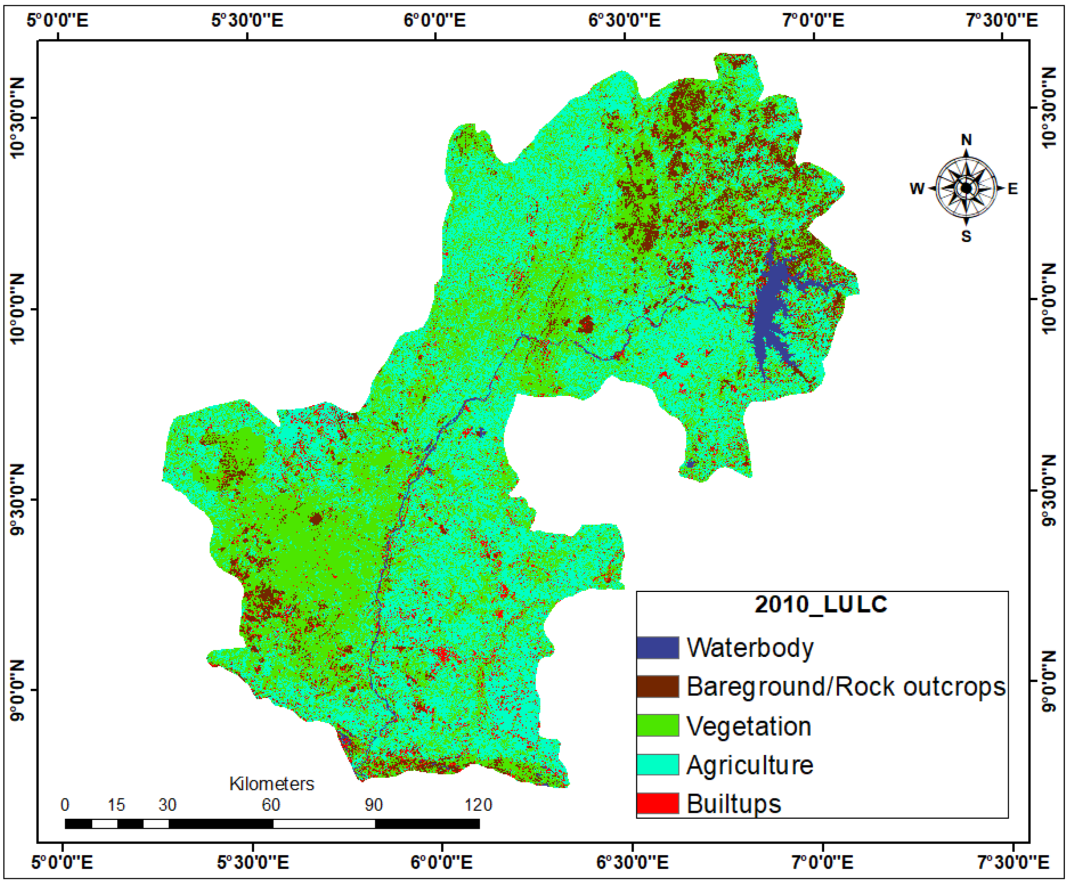

Figure 4: 2010 Landuse and landcover map of the study area
Source: Authors' Data Analysis

Analysis of Landuse and Landcover Classification of 2016 Satellite Imagery
Furthermore, the Landuse and Landcover classification for the 2016 revealed that vegetation covers have continue to reduced drastically to 5692.71 Km^2 (28.34%) by 2016, from 868,716ha (43.25%) in 2010. However, bare ground/rock outcrops to 2479.14Km^2 (12.34%) and builtups covers 1280.3 Km^2 (6.37%) and Agriculture increased greatly for the year 2016. This progressive increase in built-up areas is in agreement with the work of Ade and Afolabi (2013). Agricultural land has the largest areal coverage of 10241.01 Km^2 (50.98%) of the total area. Whereas water bodies have the least areal cover of 394.14 Km^2 (1.96%) of the total area as presented in figure 5. The increase Agricultural area cover on the study areas can be linked to government efforts towards farmers by providing farm inputs such as fertilizer, pesticide and the anchored borrowers program for soft loans which is aimed at boasting food supply to meet the need of ever-increasing demand for food by the population. Niger state is one of the state who produce agricultural produce in large amounts which is been transported to other states of Nigeria.

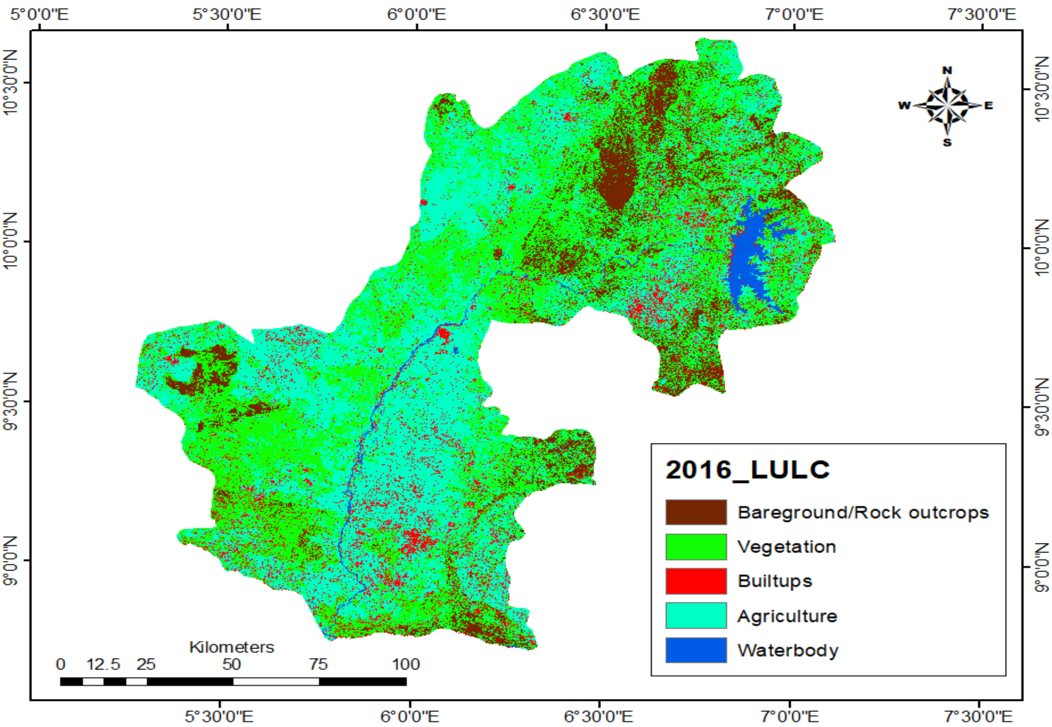

Figure 5: Landuse and landCover of the study area 2016
Source: Authors' Data Analysis

Accuracy assessment

Table 3.0 shows summary of the results of accuracy assessment generated from the LULC maps of the study area (i.e. the producer, user and overall accuracy and kappa coefficient) which was calculated using error matrix.

Table 3: Comparison of Classification Accuracy (1990, 2010 & 2016) LULC Imagery

Class Name	1990		2010		2016	
	Producer's Accuracy (%)	User's Accuracy (%)	Producer's Accuracy (%)	User's Accuracy (%)	Producer's Accuracy (%)	User's Accuracy (%)
Water body	86.33	97.8	95.35	97.34	87.10	96.1
Bare-grounds/rock outcrops	80	68.29	80.1	87.09	84.5	97.1
Vegetation	85.71	89.30	83.74	95.38	96.3	65.6
Agriculture	84.29	85.65	93.20	85.67	79.5	79.5
Built-up	81	79.76	87.7	78.20	95.5	87.10
Overall Classification Accuracy (%)	**81.75**		**84.36**		**85.67**	
Overall Kappa	**0.785**		**0.827**		**0.831**	

The result shows higher accuracy of 81.75% in 1990, 84.36% in 2010 and 85.67 % in 2016 respectively and the corresponding Kappa statistics was 0.785, 0.827 and 0.831, respectively. In general, the overall accuracy of the classification was consistently high which indicates high level of agreement between classified image and Landcover categories on the field. These accuracies agree with other studies carried out using similar methodology such as Vivekananda, Swathi, and Sujith, (2020), Naikoo, Rihan, & Ishtiaque, (2020).

Conclusion

This paper explored the characteristics of LULC change. The study area has experienced a trend of rapid changes in the years under study. Reducing the disaster risk brought about by the rapid process has been a long-term goal of planning and flood plain management. Quantitative research on the runoff changes brought about by environmental degradation process is of great significance to environmentalist. This paper integrated the use of GIS and remote sensing technology, combined to assessed the impact of Landuse change on surface runoff in the study area. The research reveals the fundamental factors such as Landuse pattern, low relief, increased in built-up and human activities will continue to intensify flooding in the area. Therefore, there is a need to develop adequate understanding of structural urban dynamics in order to have absolute foundation for formulating sound, sustainable and effective urban policies.

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