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A Comparative Assessment of Land Use and Land Cover Dynamics in Parts of Niger State, Nigeria

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ABSTRACT

There are growing concerns about land use and land cover changes and its attendant consequences on the environment. The study aimed at a comparative analysis of land use and land cover changes in Mokwa and Rijau Local Government Areas of Niger state. This was achieved through a time-series analysis of imageries for 1987, 2002 and 2017. Three classes of land use types were analysed namely: vegetation, non vegetation and water bodies. Supervised classification using maximum likelihood classifier was used for the study. The results showed a 10.2% and 15.5% decrease in the vegetation cover in Rijau and Mokwa Local Government Areas respectively during the study. There was a 15.42% increase in non-vegetation area in Mokwa during the period of study. In comparison, 10.97% upward trend was observed in Rijau. It was concluded from the findings of land use change detection that anthropogenic activities coupled with land management in the study area have contributed to the land use and land cover changes. The study recommends that urban planning strictly allocates land for various designated purposes and ensures continuous monitoring of physical developments to safeguard distortions to the natural environment. Also, Afforestation and Reforestation programs should be encouraged to help replenish the lost vegetation cover observed in the study area.

***Keywords**: Analysis, changes, increase, landcover, vegetation,*

INTRODUCTION

Africa is one of the most vulnerable continents to the impact of climate change and climate variability (IPCC 2013). There are now more concerns about land-use changes and its attendant consequences on the environment. It is evident that the Nigerian natural vegetation if not conserved and sustainably managed, will lose its natural state (Fashae *et al.* 2017). The increasing population and demand for land in the country, coupled with other anthropogenic activities threatening the existence of vegetal cover, demands effective measurement and understanding of vegetal cover's health dynamics across the country (Fashae *et al.* 2017). Vegetation cover on the surface of the earth likewise population has never in the history of humankind remained static, and as a result, it is always and constantly changing from one type to another. Studies have indicated that the land use and land cover changes have been ongoing in the study areas (Agbor, *et al.*, 2012). Thus, there is need for in-depth study and understanding of the pattern of change.

The use of remote sensing and Geographical Information System (GIS) is very useful in monitoring strategies to improve sustainable land use management in the study locations (Fashae, *et al.*, 2017). The effect of anthropogenic activities on land use changes and land cover is a continuous phenomenon (Fashae, *et al.*, 2017). This study provides a starting point for improved mapping of land use and land cover changes in Mokwa and Rijau Local Government Areas. Also, increase in population has resulted in increase in consumption of firewood for domestic purposes, environmental degradation and land-use changes (Agbor, *et al.*, 2012; Fashae, *et al.*, 2017). Bush burning and uncontrolled grazing are carried out within the study area, thereby contributing immensely to the vegetation dynamics. The thrust of this study is a comparative analysis of land use and land cover dynamics between Mokwa and Rijau Local Government Areas of Niger State, Nigeria.

Because Niger State constitutes a large land area with Mokwa Local Government Area located in the southern part of the state at a junction connecting the far North with the southern part of the country and Rijau Local Government Area situated in the far north of the state linking the state with Kebbi

State, The objectives of the study are to identify and assess similarities or differences in the land use and land cover in the Local Government Area. This was achieved through a time-series analysis of imageries for 1987, 2002 and 2017.

MATERIALS AND METHODS

Study Area

Mokwa Local Government Area (L.G.A.) is one of the twenty-five (25) Local Government Areas in Niger State. Its headquarters is in Mokwa town. The Local Government Area is located between Longitude 4°45'00" to 5° 45'05" East and Latitude 8°45' 00" to 9° 40' 00" N and covers a total land area of 4,338 km^2. The study area by 2006 national population census was 242,858 people with a projected population of 341,200 people by 2016 (National Population Commission of Nigeria). Mokwa is located in the southern part of Niger State experiencing two distinct seasons, dry and wet seasons with an annual rainfall of about 1000mm to 1,200mm (Adefolalu, 1986). The rain duration is sufficient to cover for the various crop farming that is predominantly the people's occupation.

As Mokwa continues to grow in terms of population and physical growth, its commercial activities keep increasing, contributing to high demand for land and conversion of vegetation to non-vegetation cover. The Local Government Area is bordered to the North by Mashegu Local GovernmentArea with Edati, Lavun and Katcha Local Government Areas to the East and Borgu Local Government Area to the West. The long southern border of Mokwa Local Government Area is formed by the River Niger from Lake Jebba in the West beyond the River Kaduna's confluence in the East. Kwara State and Kogi State are across the River Niger from the Local Government Area as indicated in Fig 1.

Rijau Local Government Area (LGA) is isolated in the Northern axis of Niger State. It is located between Longitude 4°70'05" to 5° 47'00" East and Latitude 10°70' 05" to 11° 35' 02"N and covers a total land area of 3,196km^2, with a projected population of 341,200 by 2016 (National Population Commission of Nigeria). The Local Government Area is bordered to the Northern and Western axis by Kebbi State; Mariga Local GovernmentArea is to the East, while Magama Local Government Area is to the south as indicated in Fig 1.

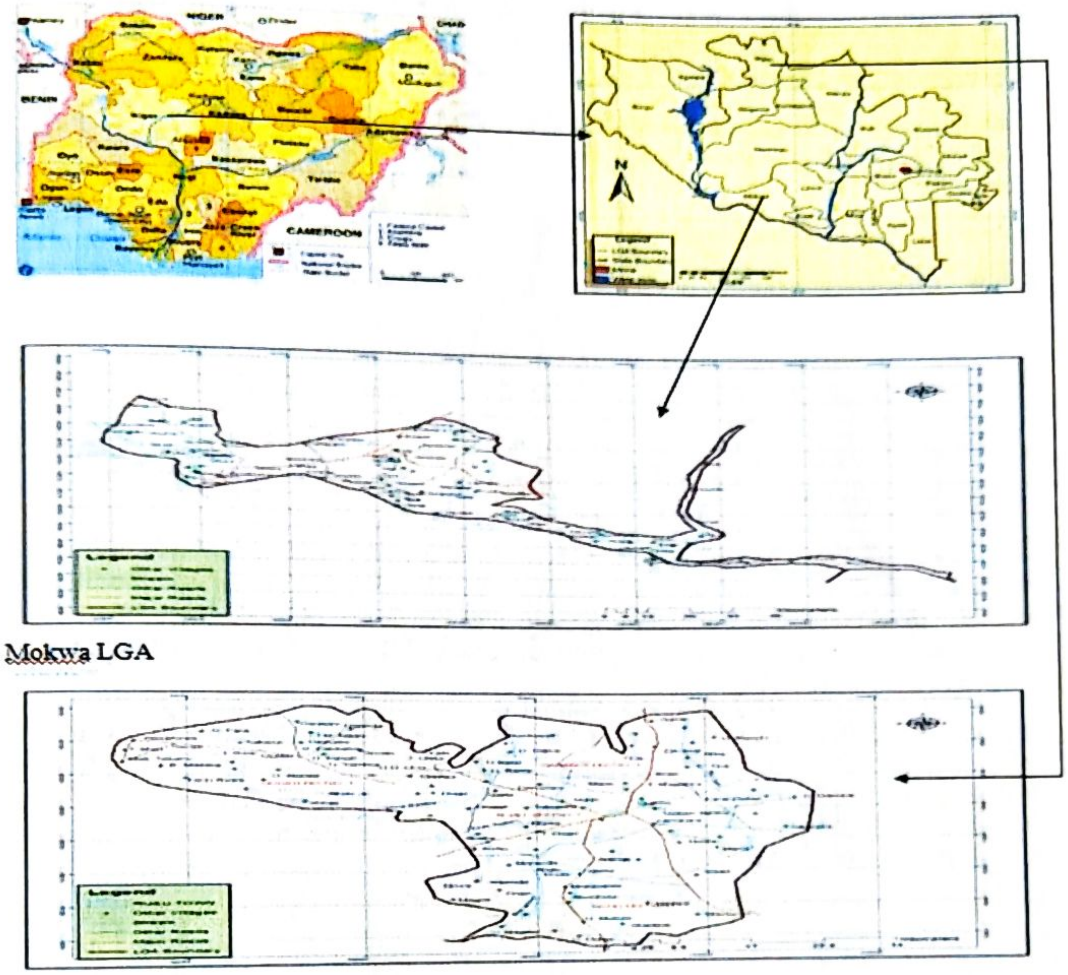

Figure 1: Geographical Location of the Study Area

Source: Niger State Ministry of Lands and Housing

Data Collection and Analysis

The land use and land cover change (LULC) in Mokwa and Rijau Local Government Areas, between 1987 and 2017, was determined using LandSat-5 image Thematic Mapper (TM) of 1987, Landsat 7 Enhance Thematic Mapper Plus (ETM+) of 2002 and Landsat 8 Operational Land Imager (OLI) of 2017, all with 30m Resolution. Table 1 shows the characteristics of the satellite imageries used for the study.

Table 1 Characteristics of the Satellite Imageries used for the Study.

System	Sensor	Number of Bands	Acquisition Date	Source
LandSat-5	TM	3 and 4	1987	www.usgs.gov
LandSat-7	ETM+	3 and 4	2002	www.usgs.gov
LandSat-8	OLI	3 and 4	2017	www.usgs.gov
Goggle Earth			2018	www.usgs.gov

Information extraction from satellite imageries was preceded by image pre-processing steps such as image registration, radiometric correction, image enhancement and display (Rodriguez-Galiano *et al.*

2012). Image registration is meant to correct image displacement, while a radiometric correction is meant to adjust the radiation values to the standard values. Failure to observe them or observance with imprecision may render change detection meaningless.

Three land cover types were analyzed in this research (as adopted by Agbor *et al.*, 2012). These are described in Table 2. The supervised classification, using Maximum Likelihood Classifier (MLC), was adopted for the study.

Table 2: Land Use and Land Cover Classification

S/NO	Land Cover Type	Description of the Land Cover Types
1	Vegetation	All Agricultural lands, forest, grasslands, trees, shrub land, natural and semi- natural vegetations
2	Non-vegetation	All residential, commercial and industrial areas, roads, Settlement and infrastructures
3	Water bodies	Rivers, streams, dams, lakes and ponds

Source: Agbor*et al.* (2012)

Supervised classification developed spectral signatures of known categories and each pixel allocated to the cover type to which it is most popular. This was achieved using sets of data acquired through ground-truthing. Image classification methods are many, but there is no single "best" method for image classification. However, the choice depends on available algorithms within the image-processing software (Horning *et al.* 2010).

Fieldwork was carried out to gather ground truth information for purposes of image classification. Ground truthing refers to the process of collecting field information to be used for training supervised classification and accuracy assessment of classification results. Garmin Etrex- 10 handheld GPS receiver was used to routes points of interest that were traversed. Ground truthing was performed at a similar time of acquisition of Landsat TM and ETM+ satellite images.

The next stage involved change detection. This was done using ArcGIS 10.3 tool by cross-tabulation analysis of the change/time series between 1987 and 2002; 2002 and 2017. Areas that are converted from each class to any of the classes were computed, and the change directions were determined through cross tabulation. The classified land use and land cover maps may contain some errors because of several factors, from classification technique to the method of satellite data capture. Accuracy assessment is done to produce information that describes reality on the ground in the study area. References (sample) were identified from Google Earth using different training sets. This was done using the Kappa coefficient (k), which considers significantly unequal sample sizes and likely probability of expected values for each class. Mathematically the equation is express in equation 1:

$$K = d - q / N - q \qquad 1$$

Where d = total number of cases in diagonal cells of the error matrix,

N = total number of samples, and

q = Constant

RESULT AND DISCUSSIONS

The Land Use Land Cover Changes in the Study Area from 1987 to 2017

Table 3 shows the result of the classification of land use and land cover change in Mokwa and Rijau.

Table 3: Statistics of Land Use and Land Cover Changes

Classification types	1987 (Mokwa)	1987 (Rijau)	2002 (Mokwa)	2002 (Rijau)	2017 (Mokwa)	2017 (Rijau)	Change (Mokwa)	Change (Rijau)
Area coverage	Km^2 & %	Km^2 & %	Km^2 & %	Km^2 & %	Km^2 & %	Km^2 & %	Km^2 & %	Km^2 & %

Vegetation	2999.43	2613.05	2617.81	2319.34	2326.03	2288.01	672.39	325.03
	(69.12)	(81.76)	(60.30)	(72.57)	(53.62)	(71.59)	(15.5)	(10.17)
Non Vegetation	1008.42	374.57	1344.78	440.73	1676.33	725.17	668.92	350.60
	(23.26)	(11.72)	(31.00)	(13.79)	(38.62)	(22.69)	(-15.42)	(-10.97)
Water Bodies	330.55	207.74	376.10	435.29	336.19	182.17	5.64	25.56
	(7.6)	(6.5)	(8.67)	(13.62)	(7.75)	(5.7)	(-0.13)	(0.8)
Total	4338	3196	4338	3196	4338	3196		
	(100)	(100)	(100)	(100)	(100)	(100)		

Results from Table 3 show a vegetation cover of 2999.43 km² (69.12%) in 1987 in the Mokwa Local Government Area (Figure 2), while 2613.05km² (81.76%) in 1987 in Rijau (Fig 3). The non-vegetation areas in Mokwa were observed to cover 1008.42 km² (23.20%) in 1987 while in Rijau 374.57 km² (11.72%) was observed in the same year. The water bodies in Mokwa covered 330.55 km² (7.62%) in 1987 while Rijau covers 207.74 km² (6.5%). This high percentage of vegetation cover is in agreement with the work of Suleiman, *et al.* (2014), Agbor*et al.* (2012) and Mansur *et al.* (2017) who reported a high rate of vegetation cover in most parts of guinea Savannah of Nigeria in 1980.

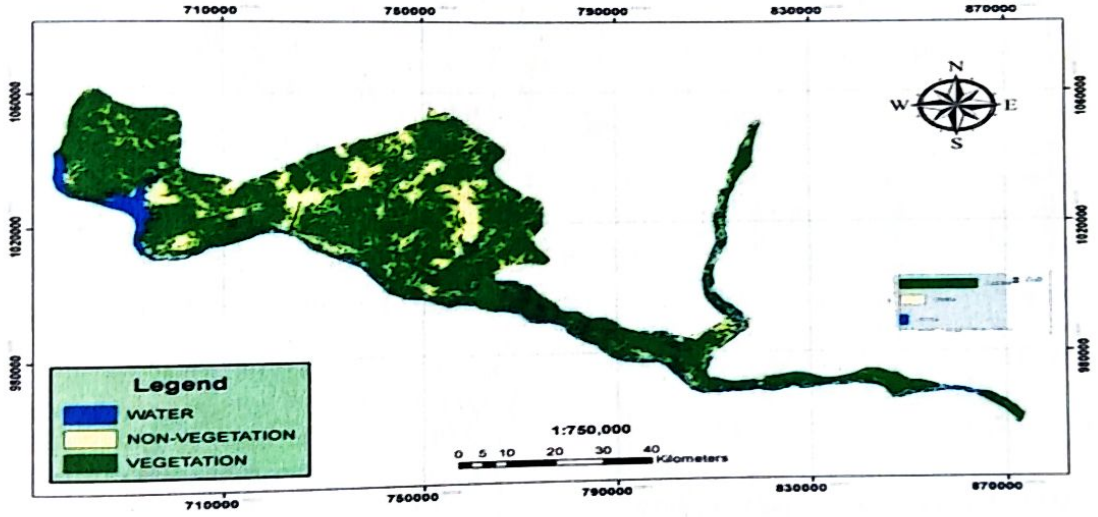

Figure 2: LULC of Mokwa 1987

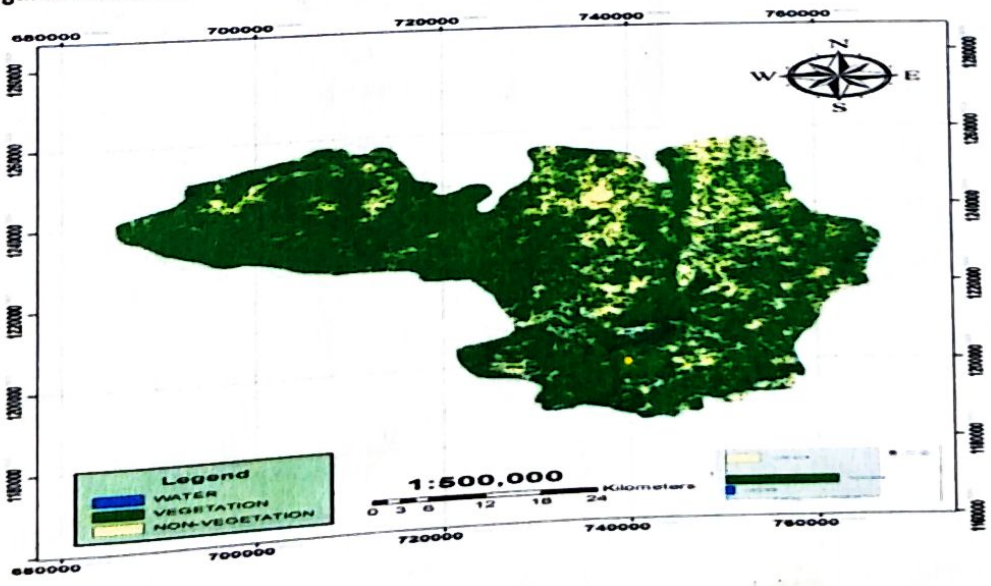

Figure 3: LULC of Rijau 1987

LULC Change for Mokwa and Rijau for 2002.

The LULC Changes in Mokwa by 2002 change from 2999.43 km² (69.12%) in 1987 to 2615.81 km² (60.30%) in 2002 while in Rijau 2319.34 km² (72.57%) was observed in 2002. As the vegetation cover decreases, the non-vegetation areas continue to increase from 1008.42 km² (23.20%) in Mokwa by 1987 to 1344.78 km² (31.00%) in 2002, while in Rijau the non-vegetation areas continued to increase from 374.57km² (11.72%) in 1987 to 440.73 km² (13.79%) in 2002. In 2002, water bodies were observed to have increased to 376.10 km² (8.67%) in Mokwa while an increase of 435 km² (13.62%) was observed in Rijau. This result corroborates the work of Suleiman *et al.* (2014), Agbor *et al.* (2012) and Mansur *et al.* (2017) who reported that the vegetation cover of Nigeria has been decreasing over the years in the North-central region of Nigeria using similar methodology.

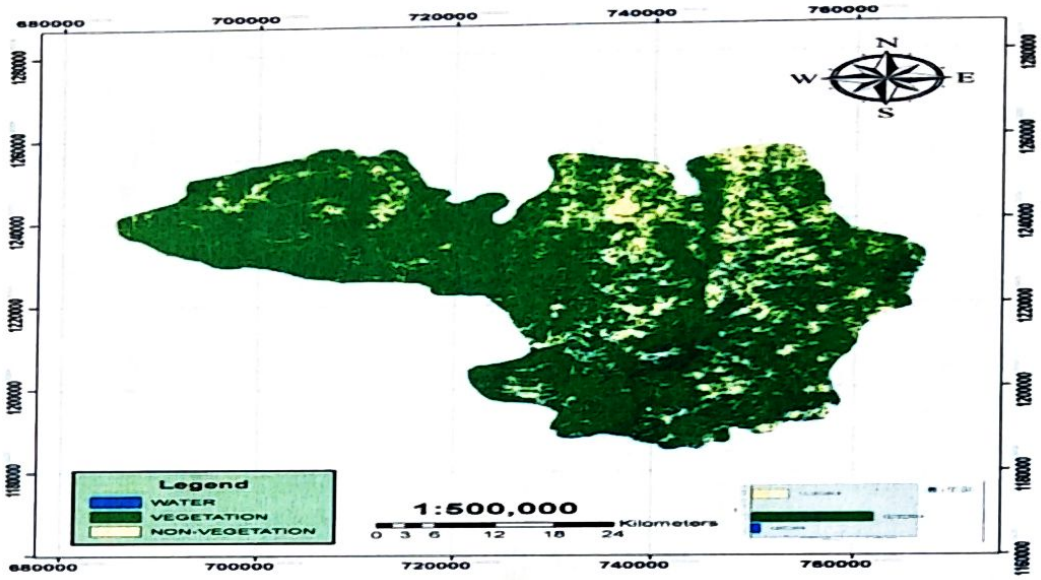

Figure 4: LULC for Rijau in 2002

The LULC changes in Mokwa and Rijau 2017

The result LULC changes in Mokwa and Rijau in 2017 are presented in Figures 6 and 7.

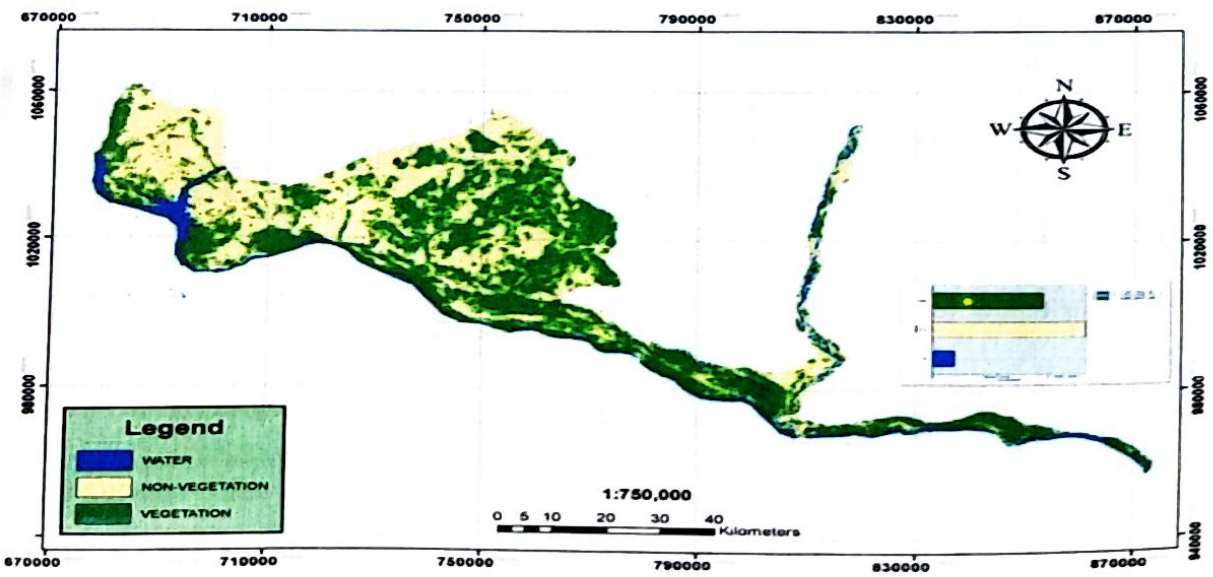

Figure 6: LULC of Mokwa 2017

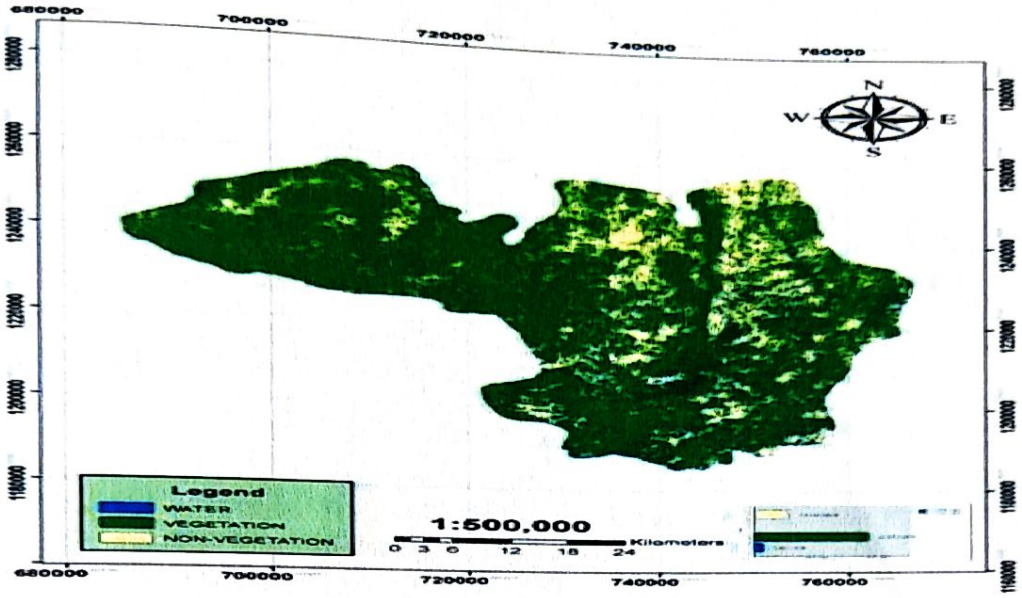

Figure 7: LULC for Rijau 2017

The result of the classification shows that in 2017, vegetation cover decreased to 2326.03 km^2 (53.62%) and 2288.01 km^2 (71.59%) in Mokwa while in Rijau respectively. However, the non-vegetation areas in Mokwa increased to 1675.33 km^2 (38.62%) by 2017 while in Rijau, the non-vegetation areas increased to 725.17 km^2 (22.69%). Water bodies were observed to have decreased to 336.2 km^2 (7.75%) in Mokwa and 182.17 km^2 (5.70%) in Rijau.This result implies that demand for land for built-up land uses, agriculture and other uses due to increased population is responsible for the changing landuses observed in both Local Government Areas.

There is no doubt that due to rising population, food supply increases are at the expense of the natural vegetation, biodiversity and habitats for wildlife. Trees and shrubs are being cut-down and used as fuelwood while clearing the land for farming or grazing or for construction purposes. An indicated on land use/cover map of Rijau, the percentage of land area occupied by non-vegetation changed from11.72% in 1987 but increased to 22.69% in 2017. A major implication of this change is increased degradation in the study area.

Accuracy Assessment

Classification accuracy assessment for the Study Area

The classification accuracy assessment for Mokwa (Figure 8) shows that the overall accuracy for 1987, 2002 and 2017 are 77%, 78% and 80% with Kappa coefficients 0.712, 0.738, and 0.760 respectively. These accuracies are similar to classified maps produced using similar methodology by (Fashae *et al.* 2017 and Agbor *et al.* 2012).

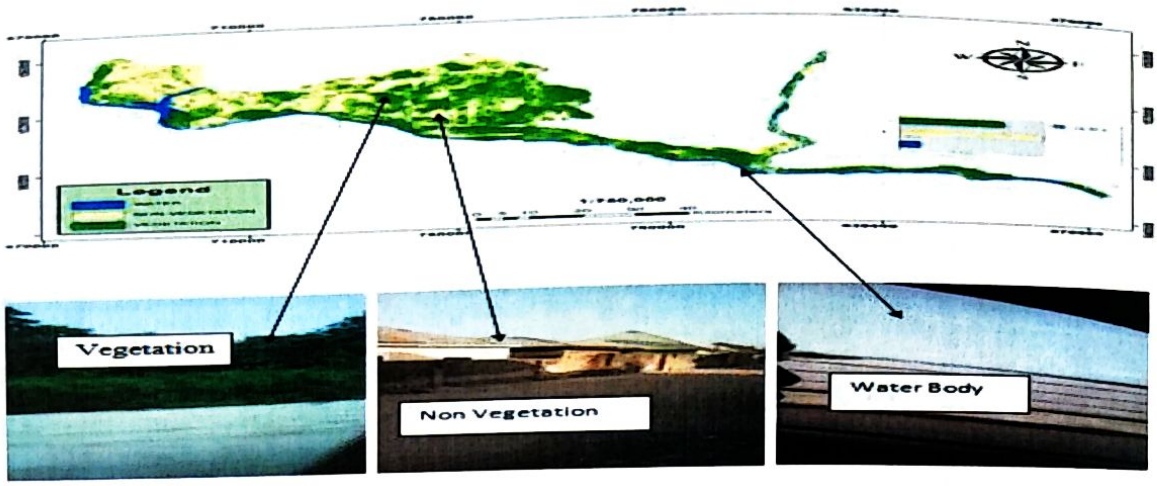

Figure 8: Classification accuracy assessment for Mokwa

The overall Classification accuracy assessment for Rijau (Figure 9) shows that the accuracy for 1987, 2002 and 2017 are 78%, 80% and 81% with Kappa coefficients 0.738, 0.760, and 0.768 respectively. The result agrees with Bamba (2015), obtained using a similar method.

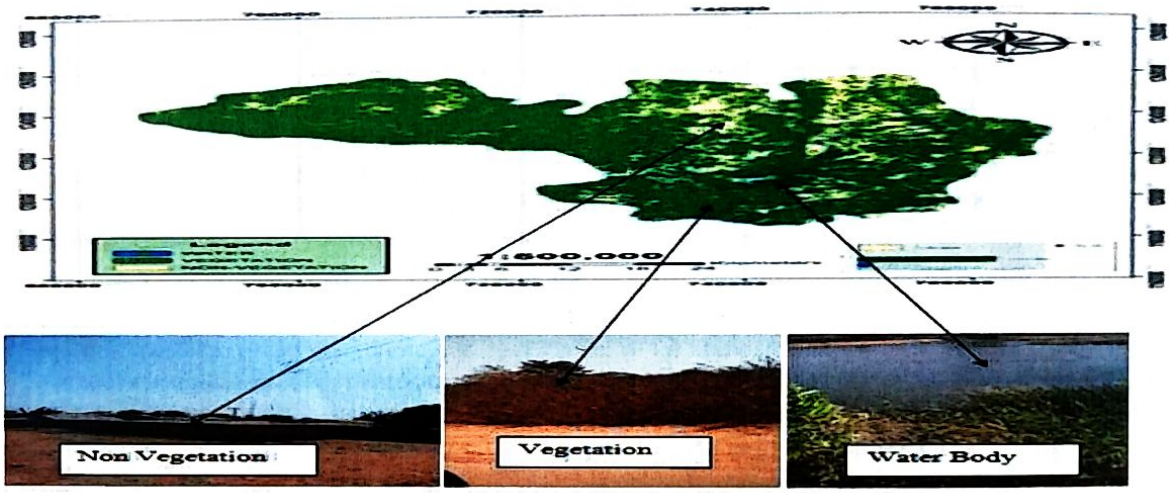

Figure 9: Classification accuracy assessments for Rijau

CONCLUSION AND RECOMMENDATIONS

The spatial and temporal changes in vegetation cover LULC revealed that the vegetation cover has changed into non-vegetation LULC type during the study period. High negative changes were seen in vegetation cover. In contrast, the increased rates of change were seen in non-vegetation areas with water bodies maintaining a slight positive change. The negative changes in vegetation cover may be attributed to the high demand for lands for agriculture, buildings and other landuses through conversion of vegetation cover to non-vegetation by timber miners. However, the increasing number of lumbering in the outskirts of Mokwa and neighbouring communities pose a great danger to the ecosystem, biodiversity, and the climatic condition of the area.

The LULC in Mokwa Local Government Area shows a significant change in land use when compared with Rijau with moderate changes in land use due to the effect of population, urbanization, commercial and deforestation activities going on in Mokwa which has also made it more prone to serious

environmental challenges such as erosion, flood, wind storm and air pollution. Based on the findings of this study, it is recommended that urban expansion due to population increase should be checked by re-planning Mokwa and Rijau townships to fill the undeveloped areas, the master plan of the study areas be strictly adhered to while ensuring continuous monitoring of physical developments to safeguard distortions to the natural environment. Afforestation and Reforestation programs should be encouraged by the government through the Ministry of Environment and Forestry, civil society organizations, community leaders and individuals to help replenish the loss vegetation cover observed in the study areas. Similarly, the government should subsidize gas and kerosene prices to discourage the use of firewood and charcoal for domestic uses.

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