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Research Paper

Urban Expansion Land Use and Land Cover Changes Using Remote Sensing and GIS: The Case of Minna Metropolis, Niger State Nigeria

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ABSTRACT: *The study used remote sensing to examine urban expansion, land use, and land cover changes in Minna Metropolis, Niger State, Nigeria. Using Landsat images of Minna Metropolis from 1986, 1996, 2006, and 2016, as well as geospatial techniques, the study discovered significant urban expansion from 1986 to 2016, with built-up areas expanding from 11,992.32km2 to 112,933.17km2. In 2006, the population was 128,998, the total land area was 241,010.55km2, and the built-up area was 63,966.51km2 in 2006, and 112,933.17km2 in 2016, with a population of 190,529. Using a model developed from Pham et al. (2015), the study discovered a 39.7% increase in built-up areas between 1986 and 1996, and a 47.9% increase between 2006 and 2016. GIS analysis for the years 1986, 1996, 2006, and 2016 demonstrated that Minna Metropolis is expanding, according to the study. To mitigate the effects of urban expansion in the research region, the study suggests that sustainable urban planning and development regulations be implemented.*
KEYWORDS: *Urban expansion, Land use, Remote Sensing, GIS, landsat images,Minna, Nigeria*

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I. INTRODUCTION

The earth's surface has been changing at various spatial and temporal scales since time immemorial. Natural occurrences and human actions both contribute to these changes, which occur over short periods of time and over years [1]. Human activities such as hunting with fire and clearing land for farming, as well as building and construction, cause changes to the ground surface, as do natural occurrences such as drought, flooding, earthquakes, and volcanic eruptions [2]. Even though natural processes can cause changes in land cover, the majority of these changes are caused by humans [2]. The current pace and magnitude of land cover changes are unprecedented in human history, resulting in multiple ecosystem alterations [3]. Urban growth and its consequences are better studied in megacities around the world, but they are less well documented in small and medium-sized cities in developing nations, owing to a lack of up-to-date and trustworthy demographic and geographic data [4]. Recent advancements in remote sensing data, such as improved spatial accuracy and the availability of free to low-cost satellite photos, combined with geographic information systems (GIS), enable quantitative evaluations of the rate and pattern of urban expansion at a cheap cost and with greater precision [5].

These urban residents and industries need land for residential and industrial uses, putting pressure on the available land and causing changes in land cover characteristics. Furthermore, the finding of gold in the state, where Minna is the capital and serves as a favorable location for gold mining due to the presence of access highways, has resulted in significant changes to the land cover. The population of Minna metropolis was 128,998 in 2006, but it is expected to rise to 190,529 by 2020. The city's growing urban population has put strain on the land cover, generating environmental issues.The land use and land cover of Minna Metropolis have altered throughout time as a result of the city's increasing urbanization and impermeable surface. The presence of the city increased the number of city residents and attracted a huge number of industries to the metropolis. This study aims to examine the dynamics of urban expansion, land use, and land cover in Minna Metropolis, Niger State, Nigeria. Introduction, materials and techniques, results and discussion, and conclusion are the main sections of this article. Some major portions, on the other hand, are divided into subsections.

II. MATERIALS AND METHODS

Study area

Minna lies between longitude 6° 34' E and 6° 42'E of the Greenwich meridian and latitude 9° 33' N and 9° 45'N of the equator. It is bounded in the North by Shiroro Local Government and in the South by Kachia Local Government. On the other hand, Wushishi Local Government lies in the west of the city while in the East the town shares boundaries withPaikoro Local Government Minna covers about eight hundred and eight five hectares that can be distributed into the following land use groups: Industrial and Commercial, Residential, Educational Institutions, Government Institutions and Other Institutions, Controlled Open Space. The town has yearly rain-fall of 1334mm. The rainy season begins from the month of April every year and last still October every year. Minna Town derives its name from Gbagyi word. "Min" and "Na" the word "Min" signifies spray and "Na" signifies Fire. The town formerly was on the mountain at Sayako and walls (Ganuwa) built around it. Many of the Gbagyi villages and towns in and around the present site of modem Minna. Minna accommodates over seventy percent economic activities like shopping centers, hotels, neighborhood markets, shops, banks and street vendors among others [6] (Figure 1)

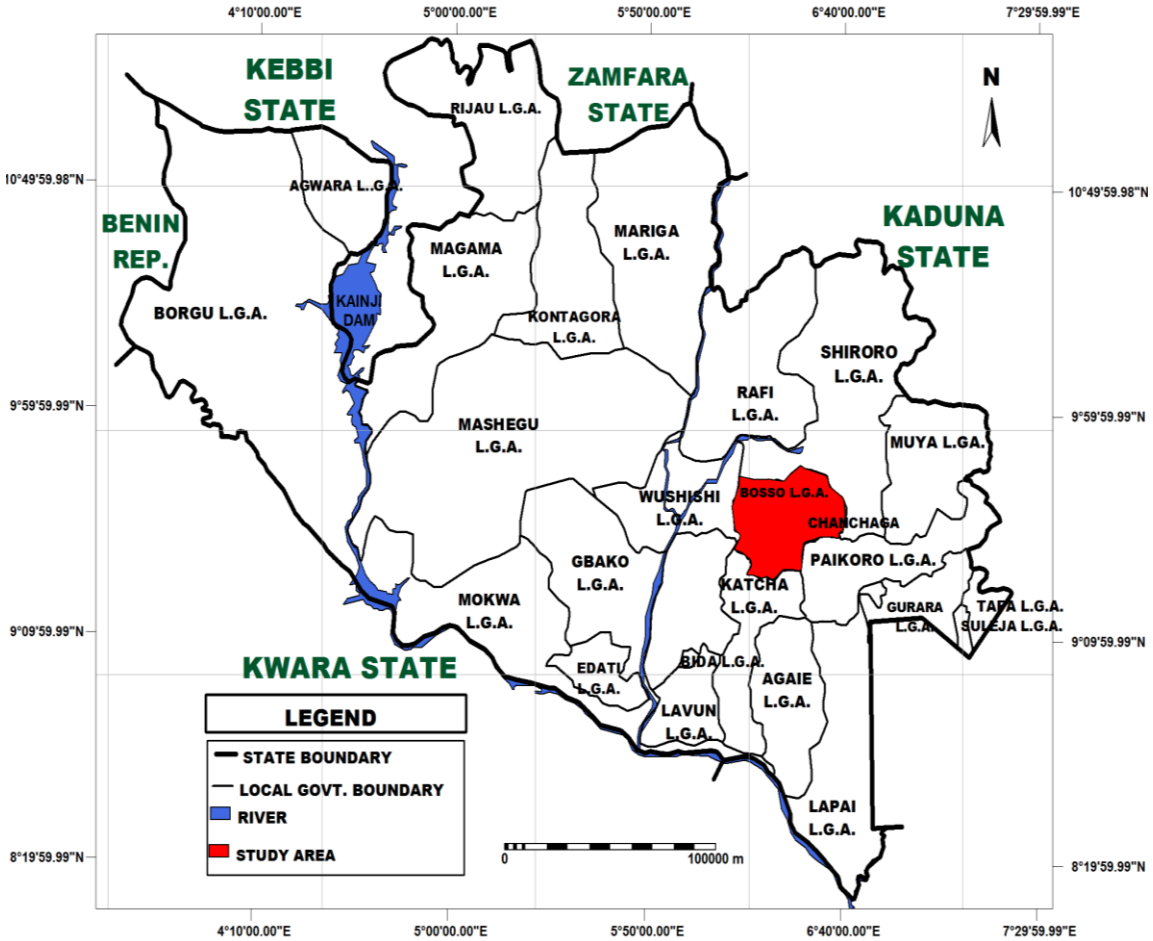

Figure 1: Niger State showing Minna
Source: *Ministry of Land and Housing Minna, 2015*

Data

The information used for this is divided into two categories: reference data and remote sensing data. Landsat pictures, Thematic Mapper (TM), Enhanced Thematic Mapper Plus (ETM+), and Operational Land Imager (OLI) data from 1986, 1996, 2006, and 2016 were used as remote sensing data. The Landsat photos were obtained using a criterion of images with less than 10% cloud cover from the US Geological Survey Earth Explorer. The path and row of the Landsat photos utilized were 190/53. The collected images had a spectral and spatial resolution of 3030m for all of them, therefore they were used to outline the study's objectives. The study employed four photographs to gain a better understanding of how land cover has evolved over time; however, the image intervals were inconsistent due to a lack of data with a cloud cover of less than 10%.

TABLE 1: Data used for the Study

Remote sensing data	Resolution	Date acquired	Source	No of bands
Landsat TM	30m	02/02/1986	USGS	7
Landsat TM	30m	01/011996	USGS	7
Landsat ETM+	30m	06/01/2006	USGS	8
Landsat OLI	30m	20/01/2016	USGS	11
Reference data				
Google earth images		1986, 1996, 2006, 2016	Google earth explorer	
Land cover maps		1986,1996,2006,2016	National remote sensing jos	

Image Pre-processing

The pre-processing was done via picture enhancing methods. In order to restore distorted picture data to its original scene, the acquired images were geometrically and radiometrically rectified and restored using ERDAS 9.6 application software in ortho-rectified format. The photos were improved further to improve graphical clarity and the identification of homogeneous image pixels belonging to the same land cover class.

Accuracy assessment

In this work, ArcGIS 10.2 software was used to do post-classification processing using a confusion matrix and a kappa coefficient. As a result, four land use and land cover types have been identified in Minna city.

Change detection

Change detection is the act of observing changes in the state of an object over time by comparing images obtained at different times. Post-classification change detection was employed to examine changes in land cover. The post-classification change detection was done in ArcGIS, and it was used to find changes in land cover at three different periods (1986-1996; 1996-2006; and 2006-2016).

Urban expansion measurement

To measure the rate of urban expansion, the land cover maps of 1986, 1996, 2006 and 2016 were first reclassified into build-up and non-build-up areas. The rate of urban expansion in the study area during the study period (1986- 2016) was determined using the formula adapted from Pham et al (2015) as follows:

$$r = \frac{\ln\left(\frac{A_2}{A_1}\right)}{t}$$

Where:

r = rate of sprawl

A1 = area extent of urban sprawl the initial time (t1)

A2 = area extent of urban sprawl at later time (t2)

ln = natural log (2.71828).

t = t2- t1.

III. RESULTS AND DISCUSSIONS

TABLE 2: Expansion of built-up area of Minna Metropolis

Year	Total area (km2)	Area of built-up (%)	Changes in built-up areas (km2)
1986	11,992.32	4.98	-
1996	17,492.04	7.26	3.97
2006	63,966.51	26.54	8.85
2016	112,933.17	46.86	18.69

Table 2 shows that there has been significant urban expansion between 1986 and 2016. Between 1986 and 2016, the built-up area rose from 11, 992.32km2 to 112,933.17km2. The total land area in 1986 was 240,952.32 km2, with a built-up area of 11.992.32 km2 and a non-built-up area of 228,960 km2. The research area had a total land area of 241, 010.55 km2, with a built-up area of 63,966.51 km2 and a non-built-up area of 177.044.04 km2. The population in 2006 was 128,998, and the total land area of the study area was 241, 010.55 km2. In 2016, the total land area was 241,010.55km2, with a population of 190,529 and built-up areas of 112,933.17 km2 and non-built-up areas of 128,077.38 km2. Table 2 summarizes the changes in built-up throughout the years 1986 to 2016. The study finds that between 1986 and 2016, built-up areas increased by 39.7% and 47.9%, respectively, according to the formula developed from[7].

Between 1986-1996

$$r = \frac{\ln\left(\frac{A_2}{A_1}\right)}{t}$$

Where:

r = rate of sprawl

A1 = area extent of urban sprawl the initial time (t1)
A2 = area extent of urban sprawl at later time (t2)
ln = natural log (2.71828).
t = t2- t1.

$$r = 2.71828 \quad \frac{(17{,}492.04)}{\frac{11{,}992.32}{10}}$$

$$r = 2.71828 \quad \frac{(1.4586)}{10}$$

$$r = 2.71828\ (0.146)$$

r= 0.397
r= 0.397 ×100
r= 39.7%
Between 2006- 2016

$$r = 2.71828 \quad \frac{(112{,}933.17)}{\frac{63{,}966.51}{10}}$$

$$r = 2.71828 \quad \frac{(1.7655)}{10}$$

$$r = 2.71828\ (0.17655)$$

r= 0.479
r= 0.479×100
r= 47.9%.

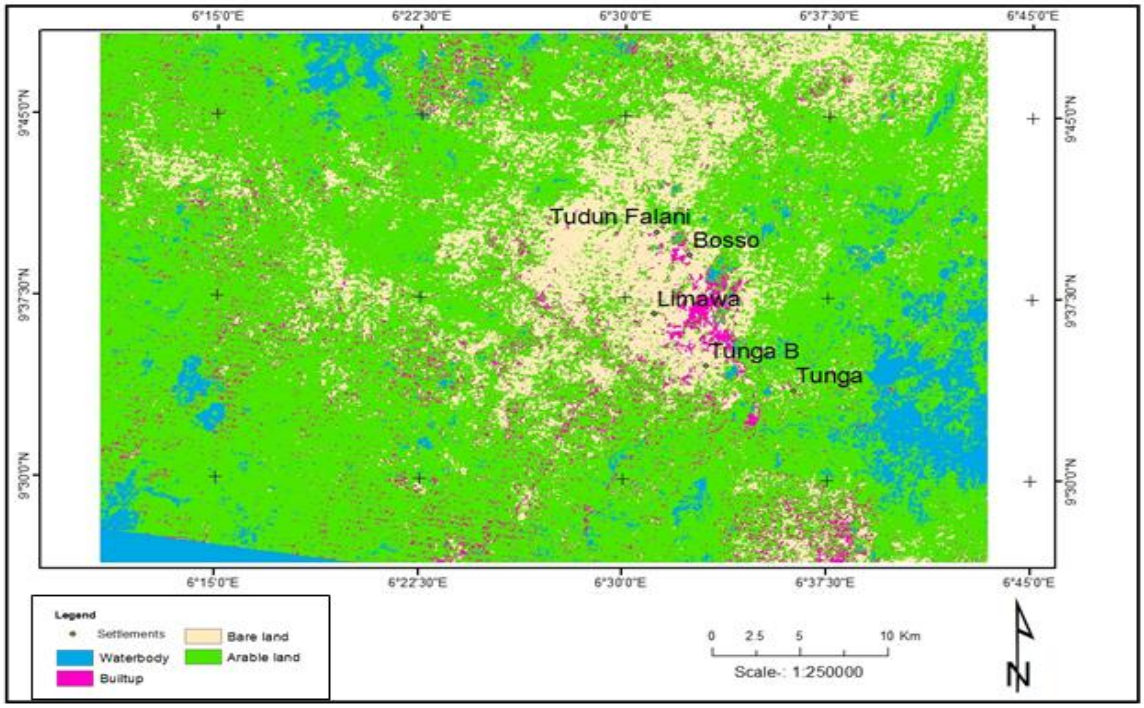

Fig.2: Land use and Land cover Map of Minna Town in 1986

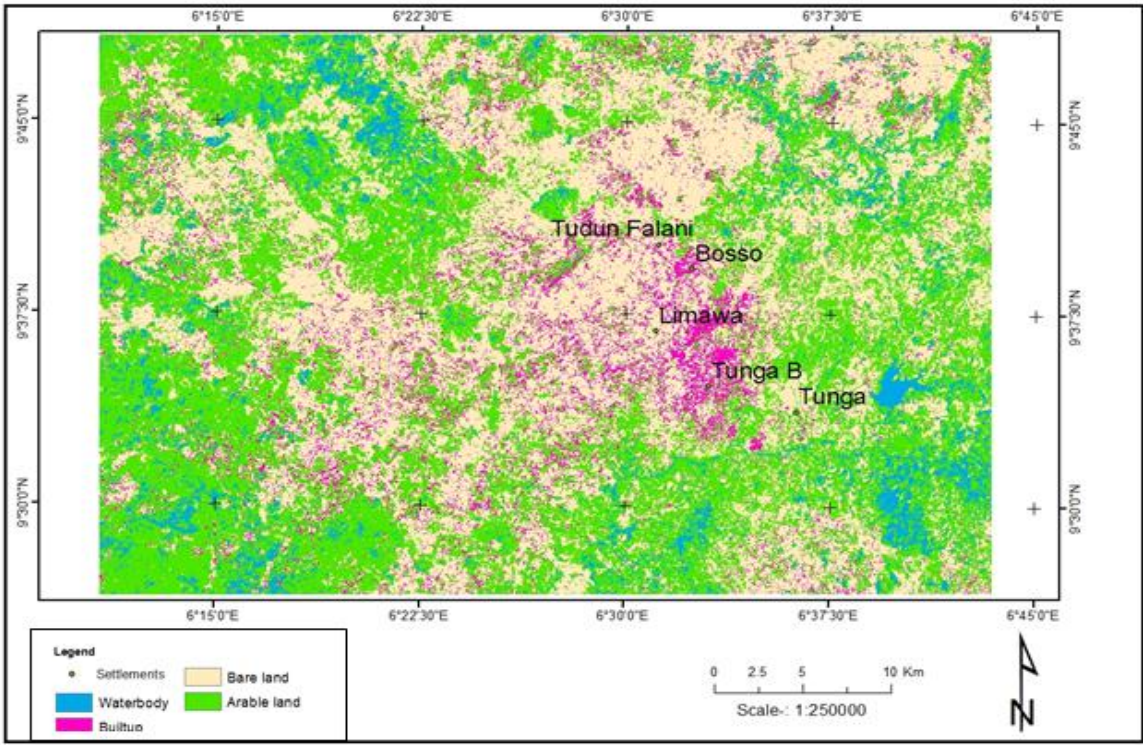

Fig.3: Landuse and LandCover Map of Minna Town in 1996

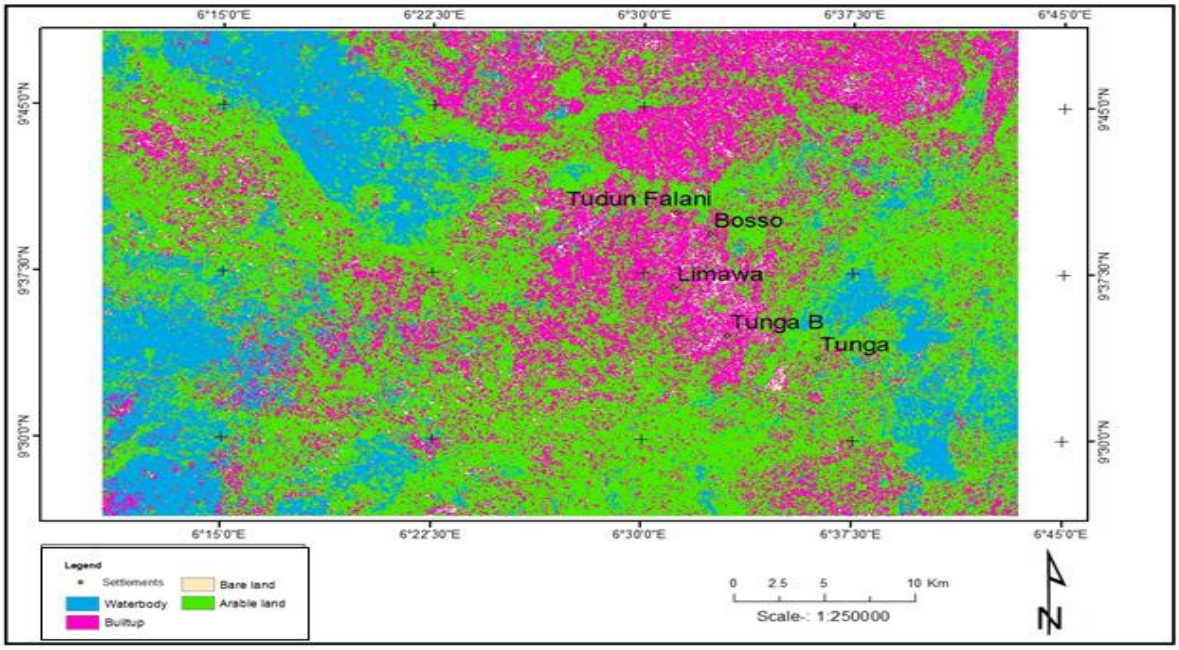

Fig.4: Landuse andLandcover Map of Minna Town in 2006

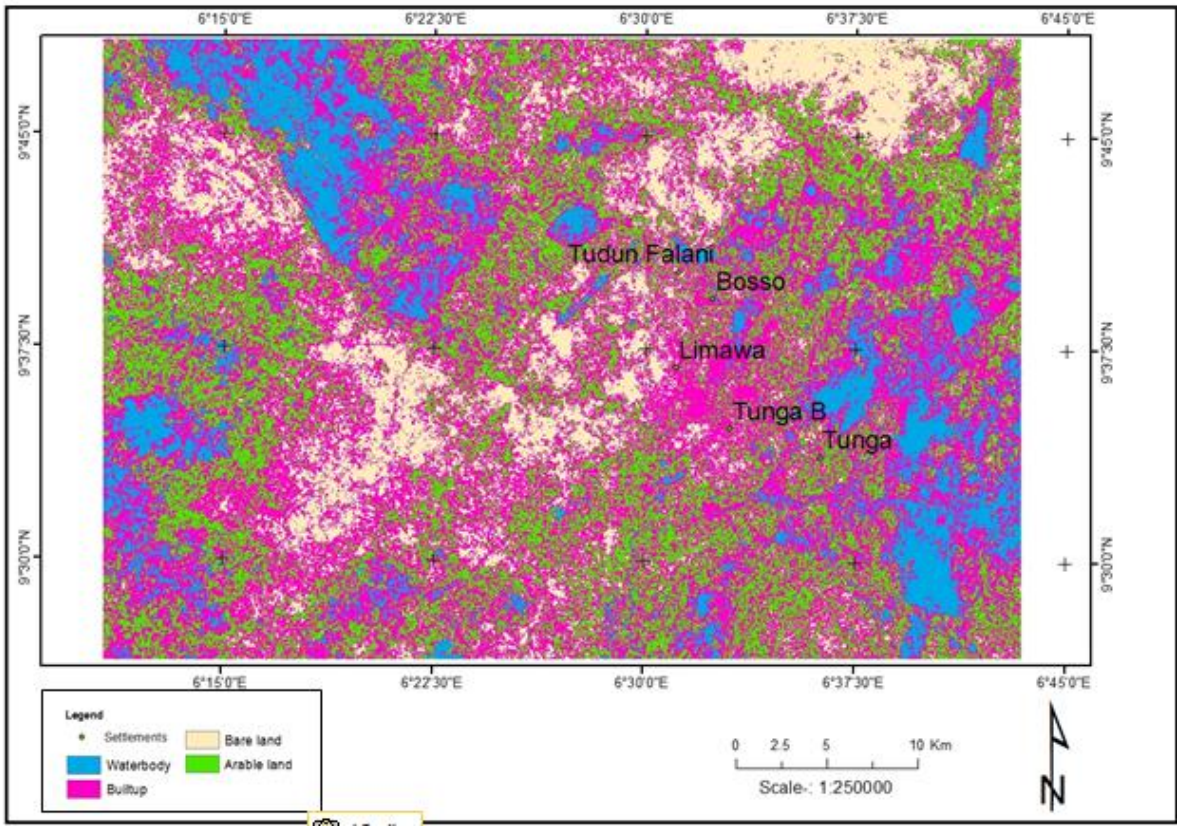

Fig.5: Landuse and Landcover Map of Minna Town in 2016

IV. CONCLUSION

From 1986 to 2016, GIS and remote sensing techniques were utilized to assess and determine urban expansion in the research region. Minna Metropolis is spreading, according to GIS study results from 1986, 1996, 2006, and 2016. The report suggests that strategies for sustainable urban planning and development be implemented in the region to prevent urban sprawl.

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