BUILT-UP AREA DYNAMICS IN "PRE- AND DURING BOKO HARAM CONFLICTS" IN MONGUNO LOCAL GOVERNMENT AREA OF BORNO STATE, NIGERIA

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ABSTRACT:

The Boko Haram insurgency has had a significant impact on the Monguno Local Government Area (LGA) in Borno State, Nigeria, for more than ten years. This study analysed how the Boko Haram insurgency affected the built-up areas of Monguno LGA. The focus of this study was to map, analyse, and detect the spectral and spatial changes of the earth's surface using remotely sensed images and geospatial techniques, focusing in particular on the built-up areas in the study area, in order to provide sufficient information on the status of built-up areas for effective planning and good governance. Employing a combination of the pixel-based Supervised Maximum Likelihood classification algorithm and the Object Based Image analysis, the study used Landsat 7 ETM+ satellite imageries for the years 2004 and 2007 and Landsat 8 OLT/TIRS imageries for the years 2014 and 2021 to determine the rate of change in the built-up areas over a period of seventeen (17) years (from 2004 to 2021). The classified Land Use and Land Cover (LULC) maps were grouped into four classes: water body, built-up areas, vegetation, and bare land, even though the study was more concerned about the changes in the built-up area. The results showed that from 2004, the built-up area occupied 0.12% with a total land area of 2.00km² and increased in 2007 by 0.21%. From 2007 to 2014 the built-up area was seen to have increased by 0.31% with a built-up area of 6.00km². Similarly, there was an increase in the built-up area from 0.31% in 2014 to 0.63% in 2021. Generally, the built-up area has increased by 0.51% from 2004-2021 and the largest percentage increase was noticed from 2014 to 2021 where there was an increase of 0.31% in the built-up area. This increase signifies that there has been an inflow of people into Monguno from neighbouring LGA. It was recommended that future research should incorporate other parameters such as population, literacy level, and socioeconomic well-being of the people.

1. INTRODUCTION

1.1 Background to the Study

Among the basic human needs, shelter plays a huge role in Human existence. Without shelter, man will end up in the bush like most other animals. However, Anthropogenic and natural activities have negative effects on our shelter and the environment in general. Humans influence can result in environmental changes through population increase, urbanization, and/or socioeconomic activities (Bala, 2022; Borak, *et al.*, 2000), leading to changes in the built-up environment.

The 'built-up environment' refers to the physical aspects of land covers that are built by humans. Remote sensing and GIS techniques enable observations, mapping out, and assessment of the level of human influence on the environment and its effects to a greater extent on the earth's surface resulting to changes known as the "land use and land cover" (LULC). The LULC deals with the human modification of the Earth's surface through factors such as local and proximate physical, socioeconomic, and demographic factors, as well as broader global and regional climatic forces of change (Grimm, *et al*., 2008). Therefore, these changes in LULC could also be examined in areas of conflicts by Boko Haram.

Boko Haram conflicts which started around 2009, resulted in the bombing, and burning of buildings; kidnapping and killing of people; leading to prominent changes in built-up areas particularly in Monguno L.G.A (Lanre, *et al*., 2015). These attacks carried out in Borno State have deterred the development of the Monguno LGA; leading to the displacement of over 30,000 indigenes in 2018, and also a set-back in the development of the areas.

Several studies have been carried out on the spatiotemporal changes in LULC locally and globally. These studies include Lu *et al*. (2004); Majumder (2010); Kaul & Sopan (2012); Sundarakumar *et al*. (2012); Yahaya (2015); Musa *et al*. (2016); Mohamed *et al*. (2020); Granville (2020); Aliyu *et al*. (2020); Alawamy *et al*. (2020); Alaigba *et al*. (2020); Aliyu *et al*. (2022); and Bala *et al*. (2022). There is a general perception of massive changes in the built-up but with a limited understanding of the difficult terrain of conflicts. However, from the reviewed literature, no comprehensive research on how the activities of Boko Haram have spatially affected the built-up areas and the extent of the changes they caused.

In this study, we used Remote Sensing and geospatial techniques to map out, analyse and detect the changes in the earth's surface especially in the built-up areas. The study is based on the changes that occurred between 2004 and 2021, with a view to planning the rehabilitation, reintegration, and resettlement of the displaced people in the area.

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1.2 Study Area

The study area (in Figure 1), Monguno L.G.A. is located in Borno State, the North-Eastern part of Nigeria. It lies between Latitudes 12º16′05″N and 12º41′10″N of the Equator and Longitudes 13º18′00″E and 13º48′15″E of the Greenwich Meridian. The land area is about 1,913 km², and about 133km from Maiduguri, the State capital.

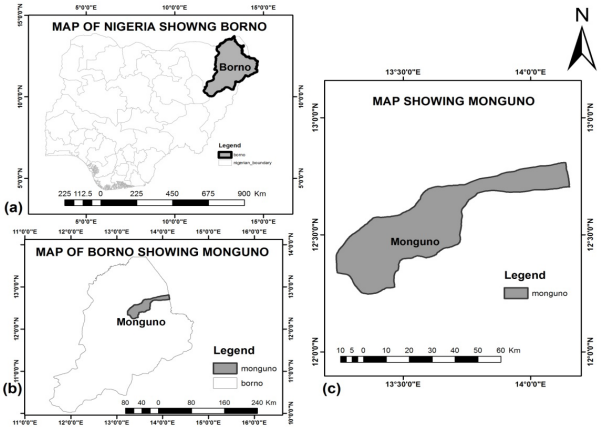

Figure 1. Locational maps: (a) Nigeria showing Borno State. (b) Borno State showing Monguno L.G.A. (c) Monguno L.G.A. (Study area).

2. MATERIALS AND METHODS

2.1 Data collection

The satellite datasets of Landsat 7 and 8 (Table 1) were downloaded from United State Geological Survey Agency (USGS) via Earth Explorer with a cloud cover of <10% and a resolution of 30x30m. Similarly, Figure 2 is a workflow of all the stages followed in executing this study.

S/N	Landsat satellites	Date of Acquisition	Purpose
1	Landsat 7 ETM+	06/01/2004	For detection of changes in built-up areas
2	Landsat 7 ETM+	30/01/2007	For detection of changes in built-up areas
3	Landsat 8 OLI/TIRS	25/01/2014	For detection of changes in built-up areas
4	Landsat 8 OLI/TIRS	28/01/2021	For detection of changes in built-up areas

Table 1. The characteristics of datasets used (Source: USGS)

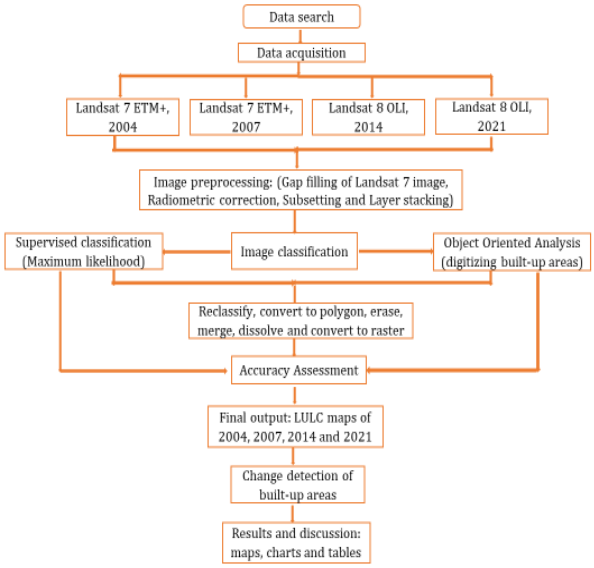

Figure 2. Methodology workflow diagram

2.2 Image pre-processing

The satellite images' visual interpretations were enhanced through image preprocessing. Gap filling of Landsat 7 images for 2007 was carried out to replace those missing stripes so that the image can be used. This was achieved using QGIS software in Figure 3.

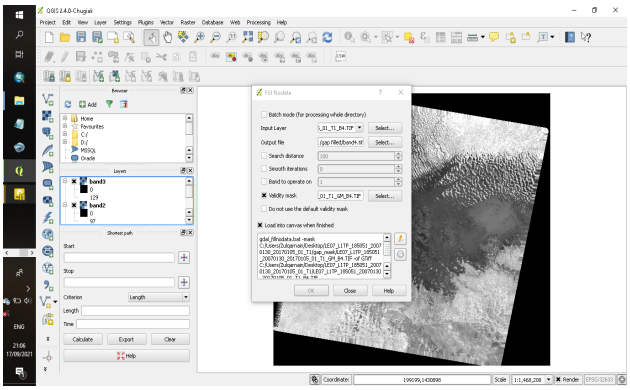

Figure 3. Gap filling of Landsat 7 ETM+ for 2007.

Statistical noise and atmospheric extinction affecting image brightness values was removed using Radiometric correction (Figure 4). Equation (1) was used in the raster calculator of ArcGIS to apply the corrections on the images.

$$L_\lambda = ((lmax_\lambda - (lmin_\lambda)) \div (Qcalmax - Qcalmin)) \times (('image' - 1) + (lmin_\lambda)) \quad (1)$$

where $Lmax_\lambda$ = Radiance maximum band
$Lmin_\lambda$ = Radiance minimum band
$Qcalmax$ = Quantize maximum band
$Qcalmin$ = Quantize minimum band

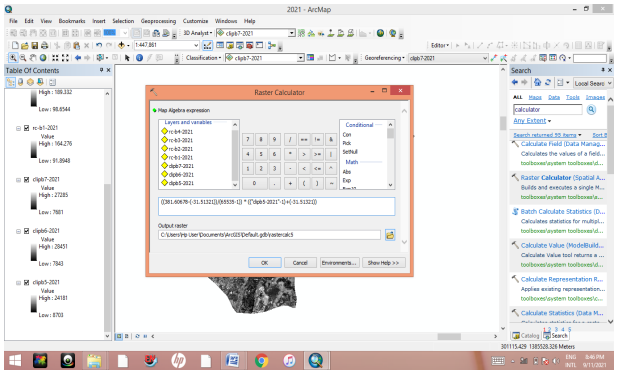

Figure 4. Radiometric correction of the datasets

A scene of Landsat with paths 185, row 51 covered the study area and beyond, therefore, the study area was clipped using the administrative boundary shapefile of Monguno L.G.A. For both the Landsat 7, ETM+, and Landsat 8, OLI/TIRS, bands 1,2,3,4,5,6, and 7 were layer stacked in ArcGIS.

2.3 Image classification

Maximum Likelihood Supervised classification which is a pixel-based classification was conducted on all the epochs using four land cover classes of waterbody, vegetation, bare land, and built-up areas. However, pixel-based classification tends to encounter spectral signature mixture, thereby misclassifying the land covers (e.g. bare land misclassified as built-up areas and vice versa) and resulting in an error of commission (Aliyu, *et al.* 2023). The emphasis of this research was on built-up areas dynamics; therefore, Object-oriented image analysis was utilised.

By contrasting each ground truth pixel's location and class with their corresponding values in the classified image (represented by the rows), the classification accuracy was determined. The overall classification accuracy (calculated as the sum of diagonal elements divided by the grand total) was 84.00%, 96.5%, 74.5%, and 80%, for 2004, 2007, 2014, and 2021, respectively.

3. RESULTS AND DISCUSSION

3.1 Change Detection

The results of classifications performed over the study area are displayed in Figures 5,6,7 and 8. The Figures highlight the changes in the area over 17 years study period (2004, 2007, 2014, and 2021).

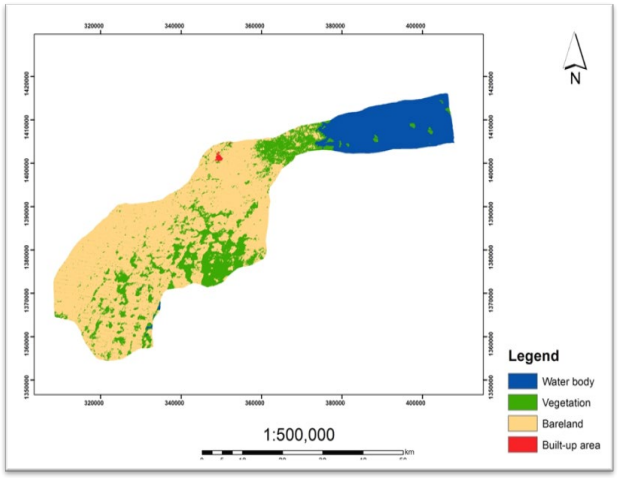

Figure 5. Classified image of the study area for the year 2004

In 2004, which is the pre-conflicts era, the built-up area occupies 0.12% with a total land area of 2km². The built-up areas are clustered in the Monguno town with few settlements outside the town. In 2007, which is also the Boko Haram pre-conflict era, the results show built-up increased from 0.12% to 0.21% with 4km² in area size. The increase showed that the growth occurred on all the axis but the southwestern part of Monguno LGA had more growth.

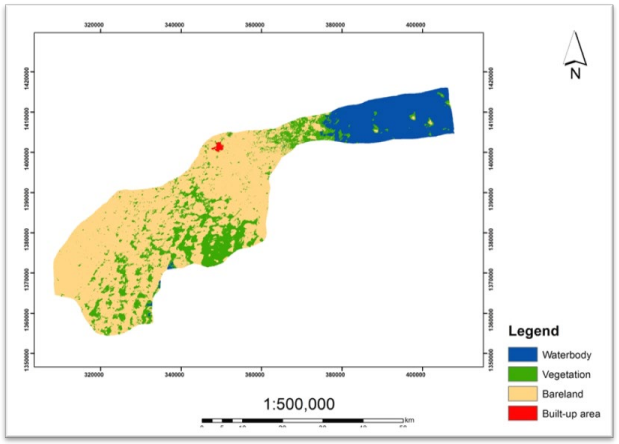

Figure 6. Classified image of the study area for the year 2007

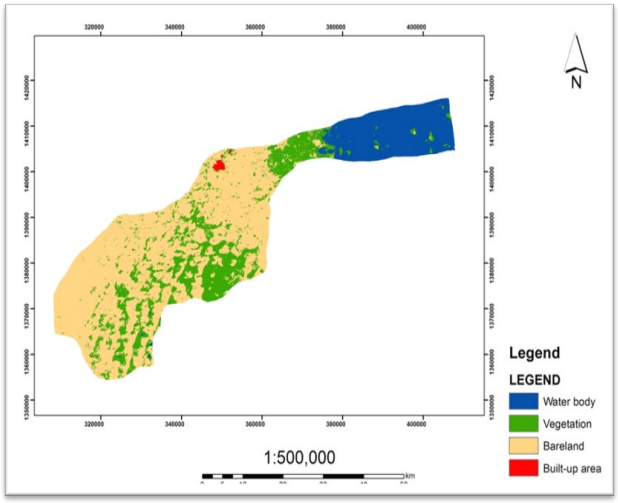

Figure 7. Classified image of the study area for the year 2014

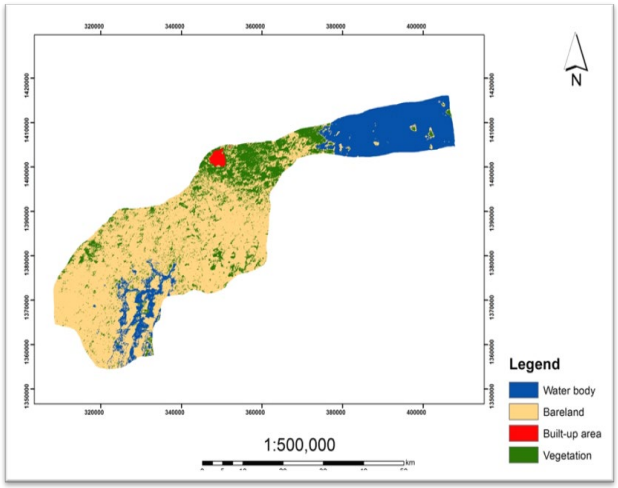

Figure 8. Classified image of the study area for the year 2021

In 2014, despite the fact that there was an insurgency in the area, there was still an increase in the percentage of built-up areas. The built-up was seen to increase from 0.21% (in 2007) to 0.31% (in 2014), with a total area of 6km². In 2021, the built-up area was also found to increase to 0.63% from 0.31% with a total land area of 12km².

Class name	2004		2007		2014		2021	
	Area (km²)	(%)	Area (km²)	(%)	Area (km²)	(%)	Area (km²)	(%)
Water body	326	17.17	309	16.26	316	16.58	403	21.21
Vegetation	369	19.44	359	18.89	415	21.78	300	15.78
Bare land	1201	63.27	1228	64.63	1168	61.31	1185	62.36
Built-up area	2.00	0.12	4.00	0.21	6.00	0.31	12.00	0.63

Table 2. Classified area for the various years

LULC	Change in Area(km²) (2004-2007)	Change in Area(km²) (2007-2014)	Change in Area(km²) (2014-2021)
Water body	17	-7	-87
Vegetation	10	-56	115
Bare land	-27	60	-17
Built-up area	-2	-2	-6

Table 3. Gain and loss between the years under study (km²)

LULC	Change in Area (%) (2004-2007)	Change in Area (%) (2007-2014)	Change in Area (%) (2014-2021)
Water body	0.91	-0.32	4.63
Vegetation	0.5	-2.98	6
Bare land	-1.36	3	1.05
Built-up area	0.09	0.1	0.32

Table 4. Gain and loss between the years under study (%)

3.2 The spatial extent of the land use/land cover changes

Figures 9 to 13 show graphical representations of the various land cover classes, in which the x-axis represents the land covers, whereas the y-axis represents the total area against each of the land covers. From the Figures, it was evident that bare land occupied the highest area of land covers for all the years. Similarly, built-up areas have the lowest total area for all the years. This is evident in comparison to the 1,913 km² total area of the study area.

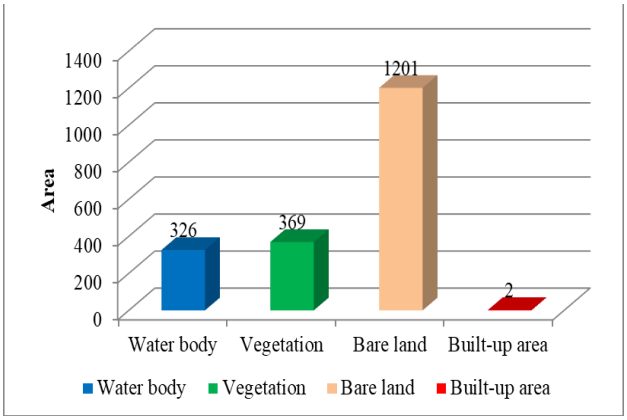

Figure 9. Distribution of the classified areas (km²) of 2004

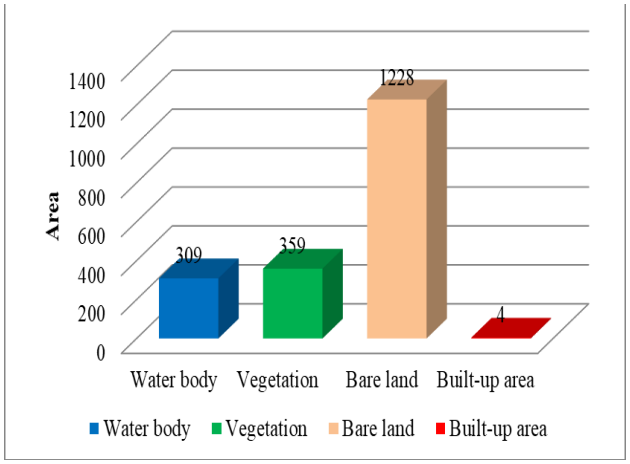

Figure 10. Distribution of the classified areas (km²) of the 2007

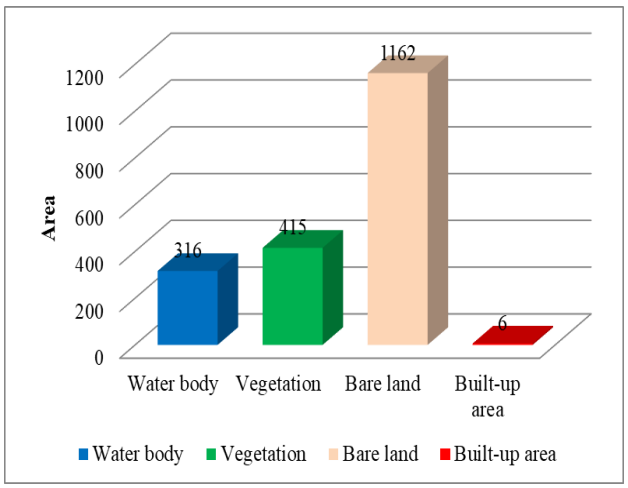

Figure 11. Distribution of the classified areas (km²) of 2014

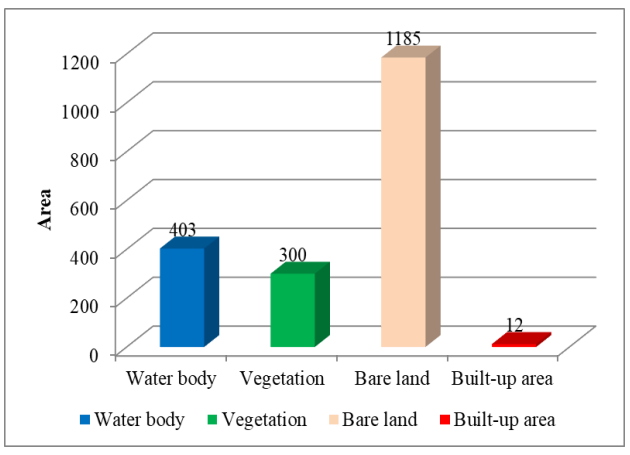

Figure 12. Distribution of the classified areas (km²) of 2021

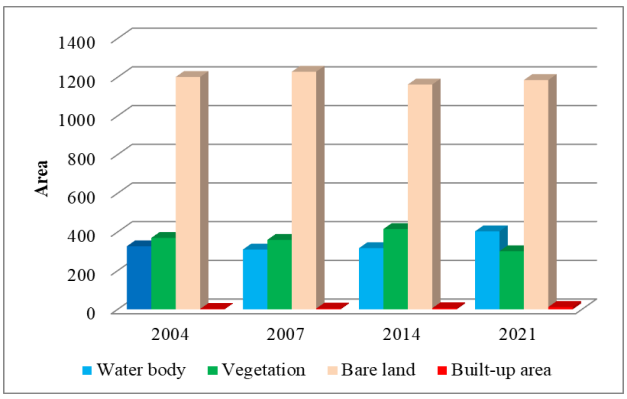

Figure 13. Spatiotemporal pattern of the classified areas (km²) for a period of 17 years (2004-2021)

3.3 Dynamics in Built-up areas

The spatiotemporal pattern of the built-up area in Figure 14 shows a steady increase over the period of the study.

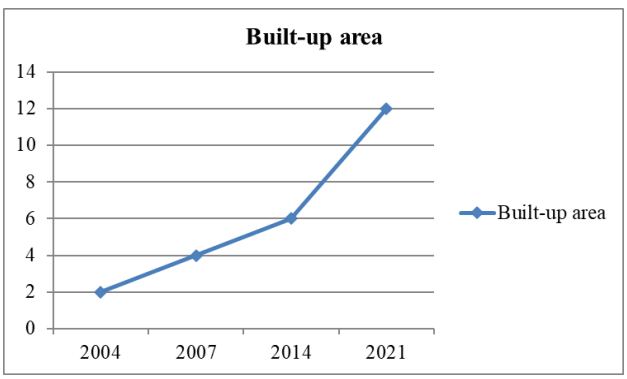

Figure 14. Spatiotemporal changes in built-up areas (km²) for a period of 17 years (2004-2021)

3.4 Discussion

The study identified the Spatio-temporal changes in LULC (in Table 2, 3 and 4), and particularly of the built-up areas in Monguno LGA from 2004 to 2021, with a clustered increase in Monguno town.

Built-up was 0.12% in 2004; in 2007, it increased by 0.09%, bringing the total to 0.21%; in 2014, a rise of 0.10% was noted; and in 2021, a rise of 0.32% was also noted.

The findings showed that even though the studied area had experienced an insurgency, there was still a higher percentage of built-up area. This may not be unconnected with the internally displaced people (IDP) camps that were established in Monguno LGA to provide shelter for the indigenes.

The findings of this study can be contrasted with those of Bala *et al*. (2022), who discovered a comparable rise in built-up areas in the Gwoza LGA for the years 2005, 2009, 2014, and 2021, with the peak of the rise coming from 2014 to 2021. In a similar vein, Aliyu *et al.* (2022) discovered positive growth in Konduga's built-up regions for the years 2006, 2011, 2016, and 2021. Their findings showed that in 2006, built-up areas occupied an area of 52.59 km² (0.89%), 81.30 km² (1.39%) in

2011, 118.99 km² (2.06%) in 2016, and 129.49 km² (2.27%) in 2021.

3.5 Conclusion

The insecurity in Monguno LGA has destroyed homes and displaced many residents. However, the findings of this study showed that built-up areas actually increased during the study period despite the insurgency.

3.6 Recommendations

Future research should incorporate other parameters such as population, literacy level, and socioeconomic well-being because these could have been major causes of the Boko haram conflicts.

Also, the Monguno L.G.A.'s social and economic activities suffered setbacks as a result of the Boko Haram insurgency that took place there, thus concerned authorities should concentrate on restoring and rehabilitating these activities, and of course, provide a more secure environment for businesses to flourish.

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