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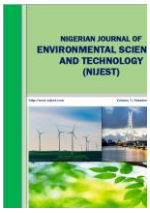

Mapping Land Accessibility for Crop Production in Insurgency Affected Areas: A Case Study of Madagali Local Government Area, Adamawa State Nigeria

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ABSTRACT

Accessibility to land for crop production is among the top priorities in the lives of peasant farmers in Nigeria. Land as a free gift of nature is useful for many purposes such as: Agricultural, Commercial, Recreation and so on. The study area in this research covered the vulnerable area invaded by the Boko Haram insurgency beginning from year 2014. Consequently, due to an appreciable and progressive level of improvement recorded, it is expected that faming activities will resume in full capacity. This study therefore utilized remote sensing and geospatial information system to investigate the available locations where practicing of planting varieties of crops can be presented to prospective farmers for easy and quick identification from maps visualization. The pre and post insurgency maps were produced to provide useful information to famers to take advantage of as a result of the about 10% increase in agricultural land use from 58% to 72% over the period of 8 years under consideration. These accessibility maps find application in the area of decision-making for by the stakeholders for the realization of sustainable development goal 2 zero hunger before the end of 2030.

Keywords: Land Mapping, Crop Production, Insurgency, Remote Sensing

1.0. Introduction

Post-insurgency in the northeastern part of Nigeria has led some inhabitants to retrace their way back to their ancestral homes and landed property. Repossessing their abandoned ancestral land and by extension, prospective land seekers for agricultural purposes can benefit from the tool of geospatial information systems and remote sensing (Jare and Bunu, 2021; Adelaja and George, 2019;). The creation of a database from appropriate imagery in a GIS environment has proven more efficient in land classification and historical changes that have occurred in a geographical location (Oymatov et al., 2023; García-Berná et al., 2020).

The land is one of the most cherished investments in Nigeria today. Much attention is given to adverse conditions that affect land either through manmade causes or natural phenomena. We witnessed the invasion of the Boko Haram insurgency in Madagali LGA precisely from August 2014. Residents of this study area fled to mountainous areas for settlement. In early 2017, military gains and improved security in parts of northeastern Nigeria have spurred a greater focus on conflict stabilization measures as the Lake Chad Basin Commission and the African Union Commission have adopted a regional stabilization strategy, which highlights short, medium, and long-term stabilization, resilience, and recovery needs (Brechenmacher, 2019).

In response, several donors (Non-Governmental organizations) including the UK Department for International Development (DFID), the European Union (EU), and the U.S. Department of State have funded "upstream conflict prevention" programs focused on strengthening dialogue and coordination between communities, local authorities, and security actors (Saskia et al, 2019). This improvement in the northeastern region and the land of Madagali LGA prompts the need to carry out this study of land accessibility mapping after the insurgency for improving crop production to reduce poverty, starvation, and in the nation's economic increase at large. Due to the improvement recorded this work shall identify with the aid of mapping accessible land areas where there is a need for more crop production to take place.

For sustainable land use, nowadays, the land use planning (LUP) approach requires more and more data integration, multi-disciplinary and complex analysis, and needs. Certainly, GIS, which has a strong capacity for data integration, analysis, and visualization, becomes the main tool to support LUP approaches, therefore, the application of GIS in LUP is well documented (Alshuwaikhat and Nassef, 1996, Ball, 2002), (Bojorquez-Tapia et al., 2001), (Brazier et al 1998). With the use of GIS and SRS, this study mapped the study area with identified improved land areas after the insurgency for more crop production. However, the people of the study area value the agricultural land on which their sources of livelihood dwells.

Agriculture is the art or science of cultivating the land including the harvesting of the crop, and the rearing and management of livestock (Dinaye, et al. 2023). The major economic activity of the study area is agriculture. Crop production is a branch of agriculture that deals with growing crops for use as food. In crop production, the major food crops grown in the study area are Maize, Sorghum (guinea corn), Groundnuts, Beans, rice, and Bambara-nut. The reasons why they engaged in food crop production are set according to their priority, of which the first is food for consumption, self-employment, wealth creation, and hereditary least. From food crop production, they can create wealth, be self-employed, and also helps in investing in other sectors such as their wards' education and trading (Vahyala, et al 2016). In general food crop production has led to an increase in the standard of living of the farmers of Madagali.

Although there is so much literature on the effect of the Boko Haram Insurgency in Madagali LGA Adamawa State Northeastern part of Nigeria, this study mapped land accessibility crop production. With the aid of GIS and SRS, it also mapped and identify vulnerable land areas during the insurgency, and improved accessible land areas after the insurgency where crop production can take place. The aim of this research will be achieved through practical field data acquisition for ground truthing to validate the classify the maps for their various uses while targeting the returning farmers, stakeholders, Adamawa State governmental agricultural agencies, and intended farmers who may have an interest within and outside the study locality.

2.0. Methodology

2.1 Description of the Study Area

The study area is Madagali Local Government North Senatorial Zone of Adamawa State in Northeastern part of Nigeria. Madagali LGA is located at coordinates (10°53'11.34", 13°37'46.88"E 10°53'2.25"N 13°37'58.64"E) of UTM zone 33N at an elevation of 506 meters above mean sea level. The study area is characterized by Sahel savannah having about 12,919 inhabitant and total area of 19,800 square kilometers. There are ten wards in the study area and all the wards had been recaptured from insurgency activities, these wards are; Hyambula, Madagali Wagga, Wula, Kirchinga, Sukur, Gulak, Babel, Duhu/Shuwa and Pallam. Figure 1 shows the map of Nigeria, Adamawa State, and the Local Government Area of Study.

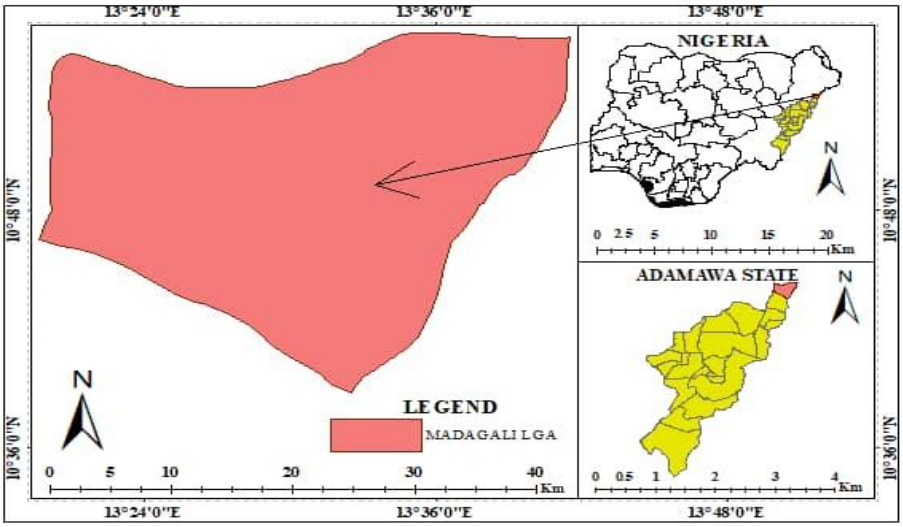

Figure 1: Map of the study area.

2.2 Materials

Land use land cover (LULG) was used in vegetation cover and other features, i.e the "brightness" and "color" of information contained in each pixel. The accuracy of the thematic map derived from Satellite Remote Sensing images was verified, field observation or ground truth. While the image classification was done using ArcGIS.

2.3 Methods

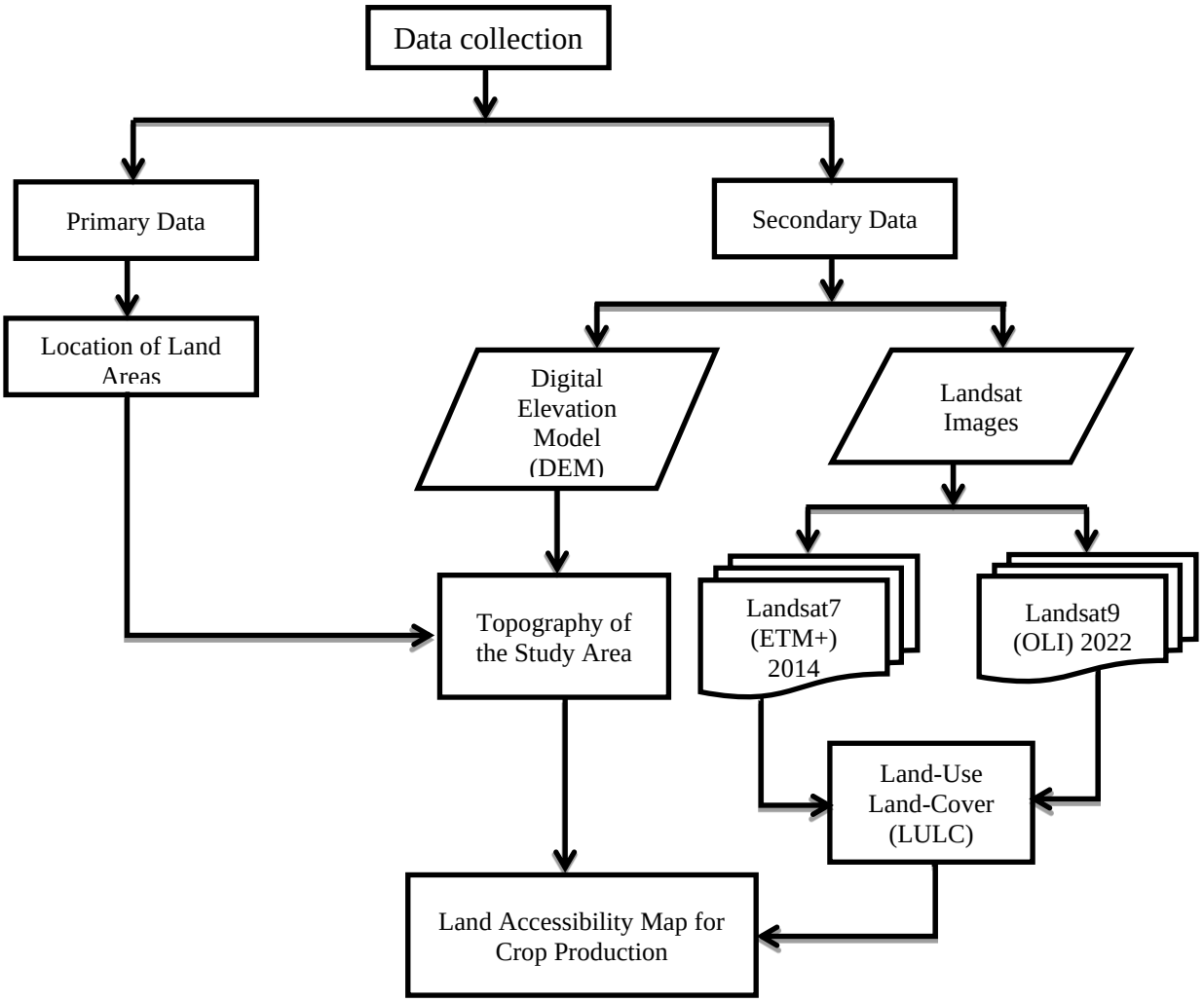

Figure 2. Flow diagram of the procedures

2.3.1 Description of Data and Sources

Primary and secondary data were used for the study, detailed information about the data sets and their sources are represented in Table 1 to 3.

Table 1: Data Description

PRIMARY DATA			
S/NO	**ITEM**	**DATA SOURCE**	**DATE**
1.	Spatial location of Land Areas	Handheld GPS	13th/12/2022
SECONDARY DATA			
2.	Digital Elevation Model (DEM) SRTM	USGS Earth Explorer	12th/10/2012
3.	Landsat Image	Landsat7 (ETM+) 2014	01/11/2014
4.	Landsat Image	Landsat8 (OLI) 2022	

Table 2: Landsat 7 (ETM+) Image Data

S/N	IMAGE I.D	BANDS	ACQUISITION DATE
1.	LE07_L1TP_185052_20141101_20200905_02_T1_B1	5,4,3	11 NOVEMBER, 2014
2.	LE07_L1TP_185052_20141101_20200905_02_T1_B2	5,4,3	11 NOVEMBER, 2014
3.	LE07_L1TP_185052_20141101_20200905_02_T1_B3	5,4,3	11 NOVEMBER, 2014
4.	LE07_L1TP_185052_20141101_20200905_02_T1_B4	5,4,3	11 NOVEMBER, 2014
5.	LE07_L1TP_185052_20141101_20200905_02_T1_B5	5,4,3	11 NOVEMBER, 2014
6.	LE07_L1TP_185052_20141101_20200905_02_T1_B6	5,4,3	11 NOVEMBER, 2014
7.	LE07_L1TP_185052_20141101_20200905_02_T1_B7	5,4,3	11 NOVEMBER, 2014
8.	LE07_L1TP_185052_20141101_20200905_02_T1_B8	5,4,3	11 NOVEMBER, 2014

Table 3: Landsat 9 (OLI) Image Data

S/N	IMAGE I.D	BANDS	ACQUISITION DATE
1.	LC09_L1TP_185053_20221107_20230323_02_T1_B1	7,5,4	07 NOVEMBER, 2022
2.	LC09_L1TP_185053_20221107_20230323_02_T1_B2	7,5,4	07 NOVEMBER, 2022
3.	LC09_L1TP_185053_20221107_20230323_02_T1_B3	7,5,4	07 NOVEMBER, 2022
4.	LC09_L1TP_185053_20221107_20230323_02_T1_B4	7,5,4	07 NOVEMBER, 2022
5.	LC09_L1TP_185053_20221107_20230323_02_T1_B5	7,5,4	07 NOVEMBER, 2022
6.	LC09_L1TP_185053_20221107_20230323_02_T1_B6	7,5,4	07 NOVEMBER, 2022
7.	LC09_L1TP_185053_20221107_20230323_02_T1_B7	7,5,4	07 NOVEMBER, 2022
8.	LC09_L1TP_185053_20221107_20230323_02_T1_B8	7,5,4	07 NOVEMBER, 2022
9.	LC09_L1TP_185053_20221107_20230323_02_T1_B9	7,5,4	07 NOVEMBER, 2022
10.	LC09_L1TP_185053_20221107_20230323_02_T1_B10	7,5,4	07 NOVEMBER, 2022
11.	LC09_L1TP_185053_20221107_20230323_02_T1_B11	7,5,4	07 NOVEMBER, 2022

Two set of Satellite data was collected and were used they include; Landsat 9 Operational Land Imager (OLI) satellite data and Shuttle Radar Topography Mission (SRTM). They were used to drive the surface Digital Elevation Model (EDM) of the study area. The elevation data collection is the Shuttle Rader Topography Mission (SRTM), it uses radar signals to collect the elevation of topography at 20m intervals. It was access online through earth explorer.

2.4 Data Presentation

Several maps were presented altogether. Satellite image Map, Elevation (contour) map, SRTM map LULC map, Vulnerability map during the insurgency and final map showing improve Areas after the insurgency. The result was presented in maps showing/identifying improved land areas were crop production is can take place.

3.0 Results and Discussion

3.1 Results

The following maps: the satellite image map of the study area, the hill shade map of the study area, the contour map, the classified contour map, elevation variability map from Shuttle Radar Topography Mission, the Land Use Land Cover Map (LULC 2014) of the Study Area, the Land Use Land Cover Map (LULC 2022) of the Study Area, and the Vulnerable map of the Study Area during the Insurgency as preliminary investigation maps for the study area from which deductions were made. Further explanations are made in the discussions. Figures 3 to 11 show these maps in succession.

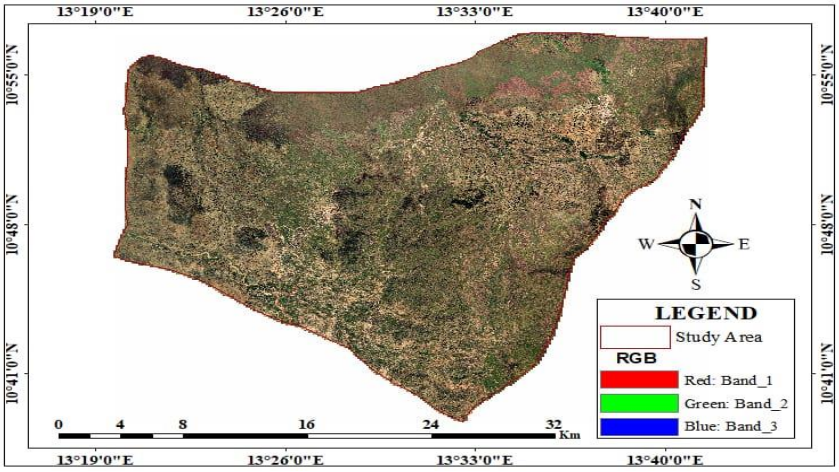

Figure 3. Satellite Image Map of the Study Area.

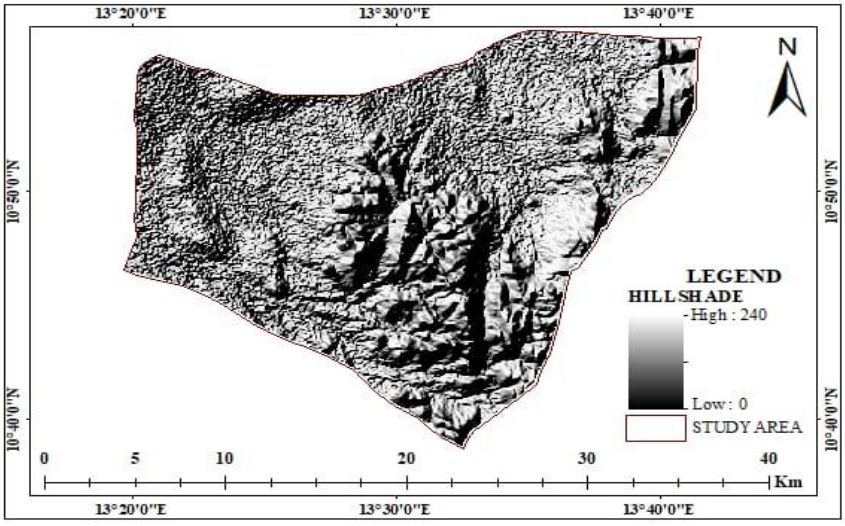

Figure 4. Hillshade Map of the Study Area.

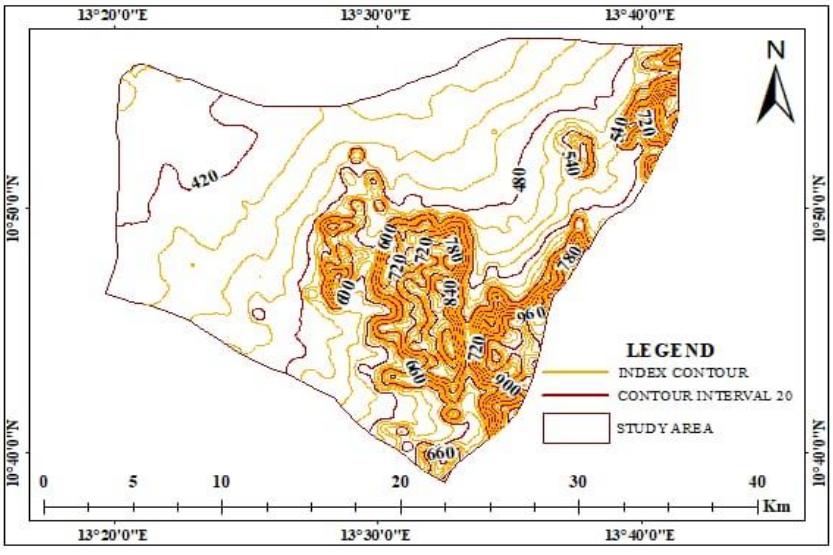

Figure 5. Contour Map (Elevation Model) of the Study Area.

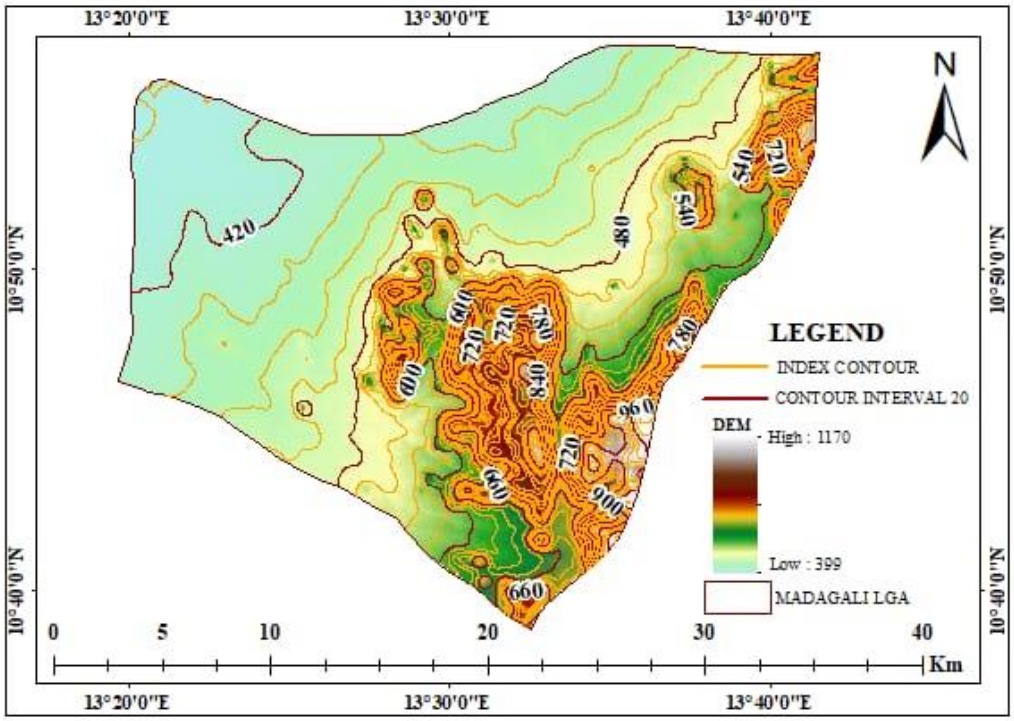

Figure 6. Classified Contour Map of the Study Area.

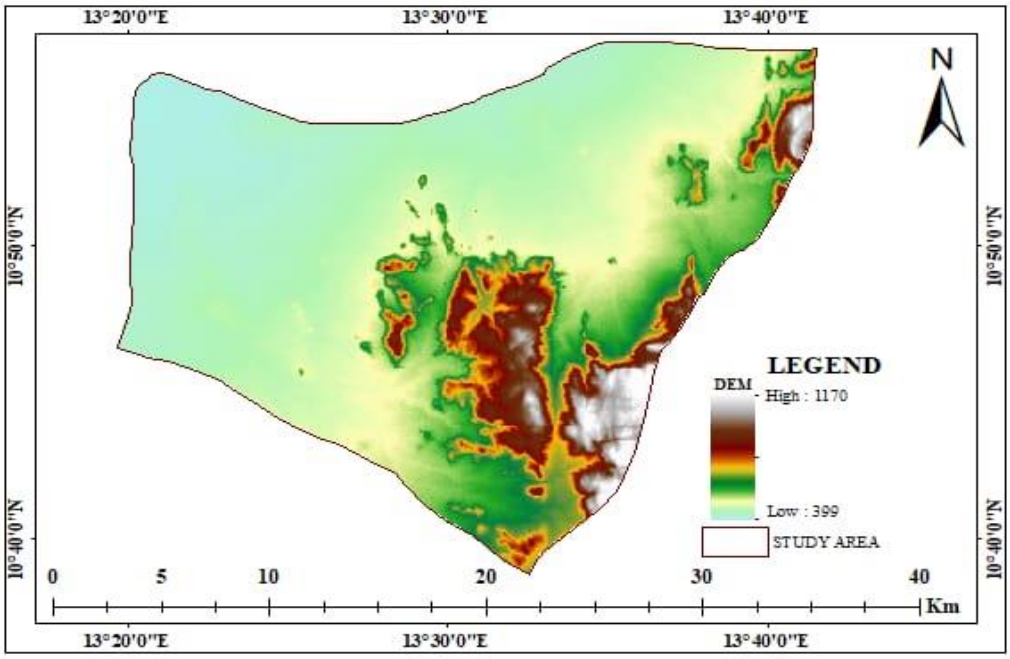

Figure 7. Shuttle Radar Topography Mission (SRTM) Map of the Study Area.

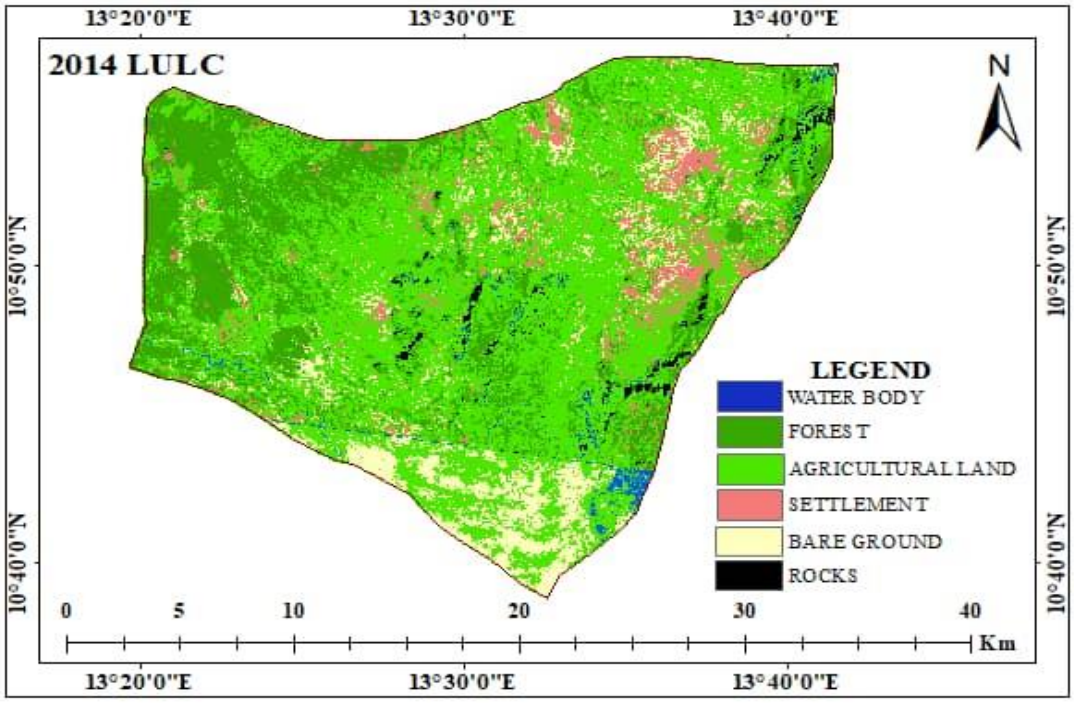

Figure 8. Land Use Land Cover Map (LULC 2014) of the Study Area.

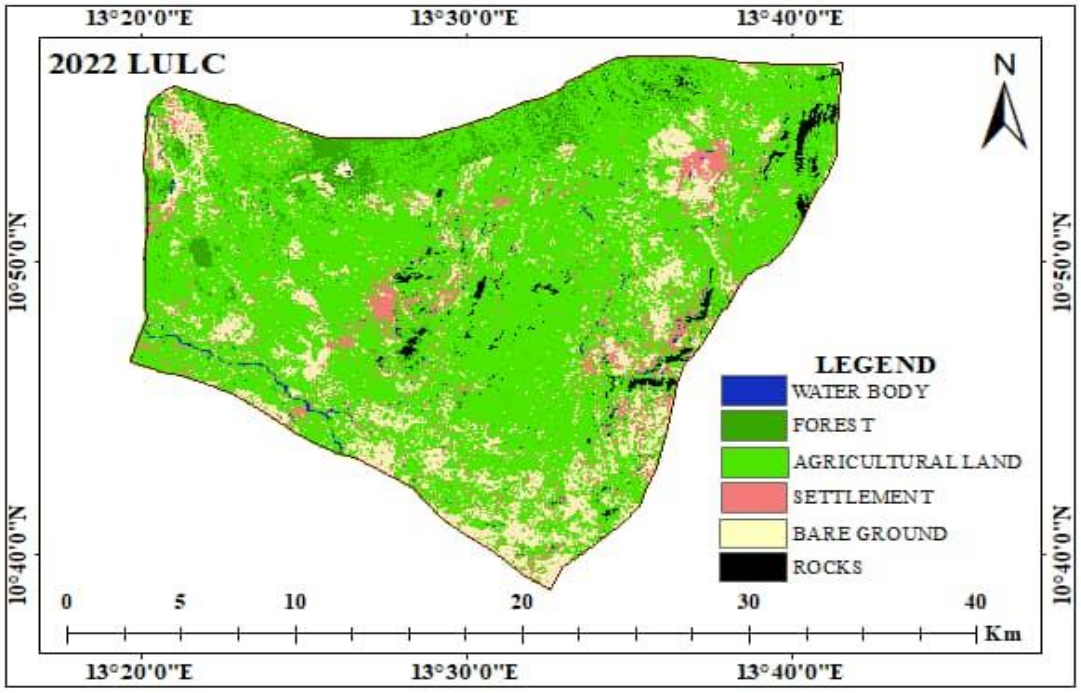

Figure 9. Land Use Land Cover Map (LULC 2022) of the Study Area.

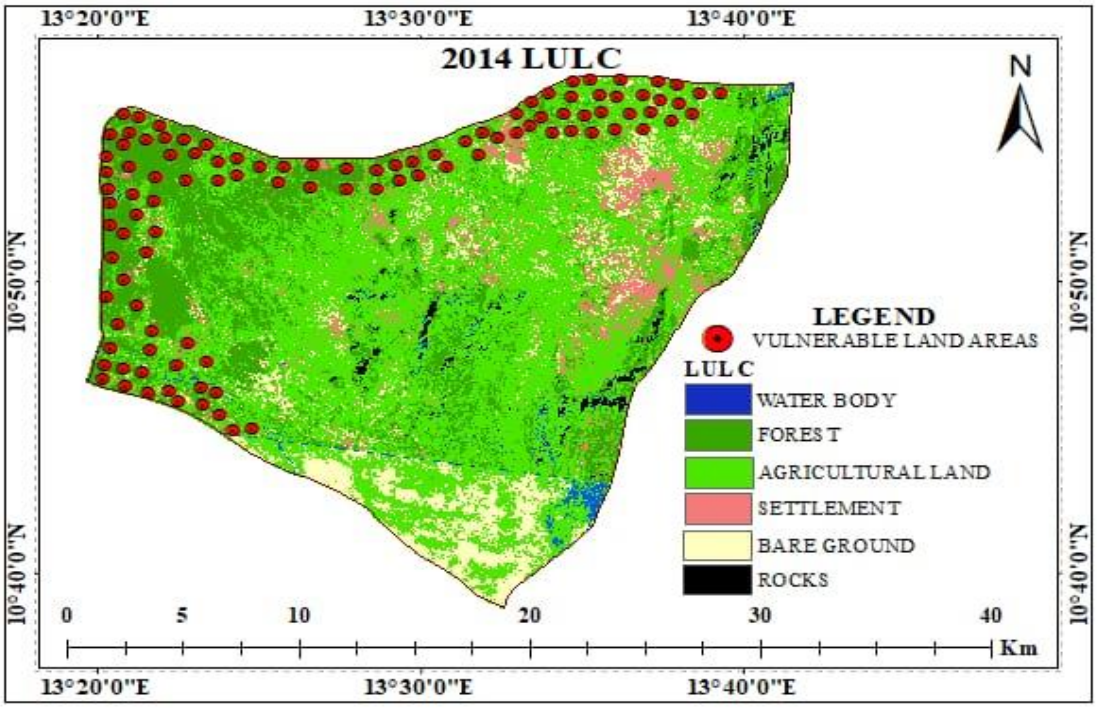

Figure 10. Vulnerable map of the Study Area during the Insurgency.

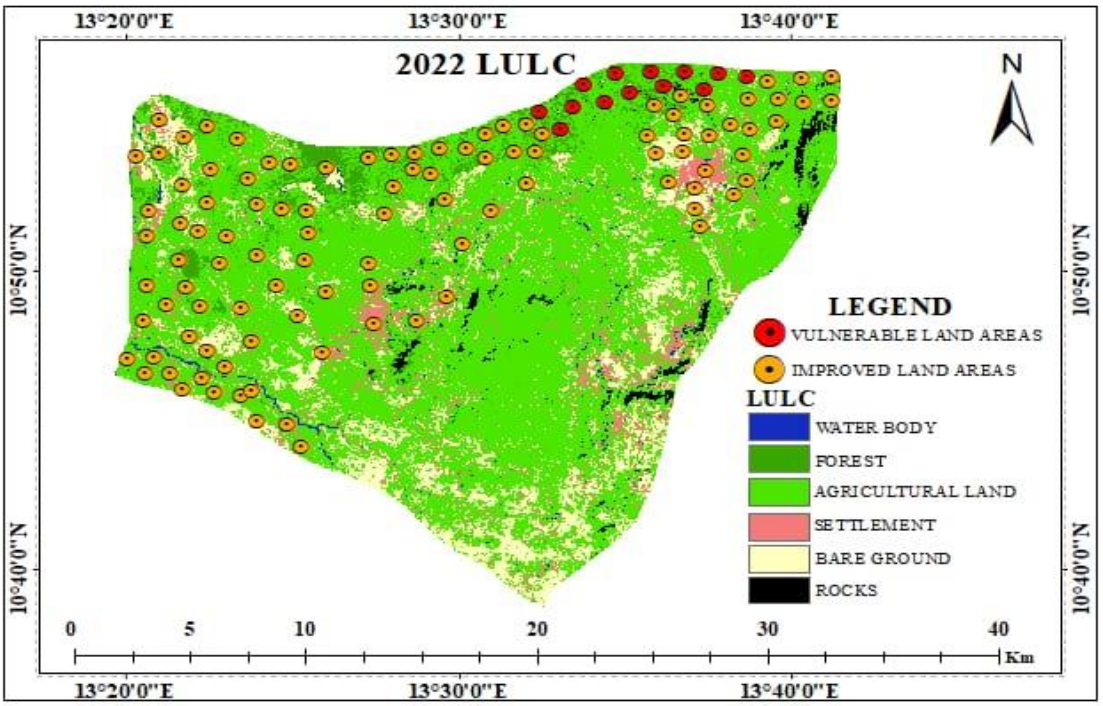

Figure 11. Improved/Accessible map of the Study Area after the Insurgency.

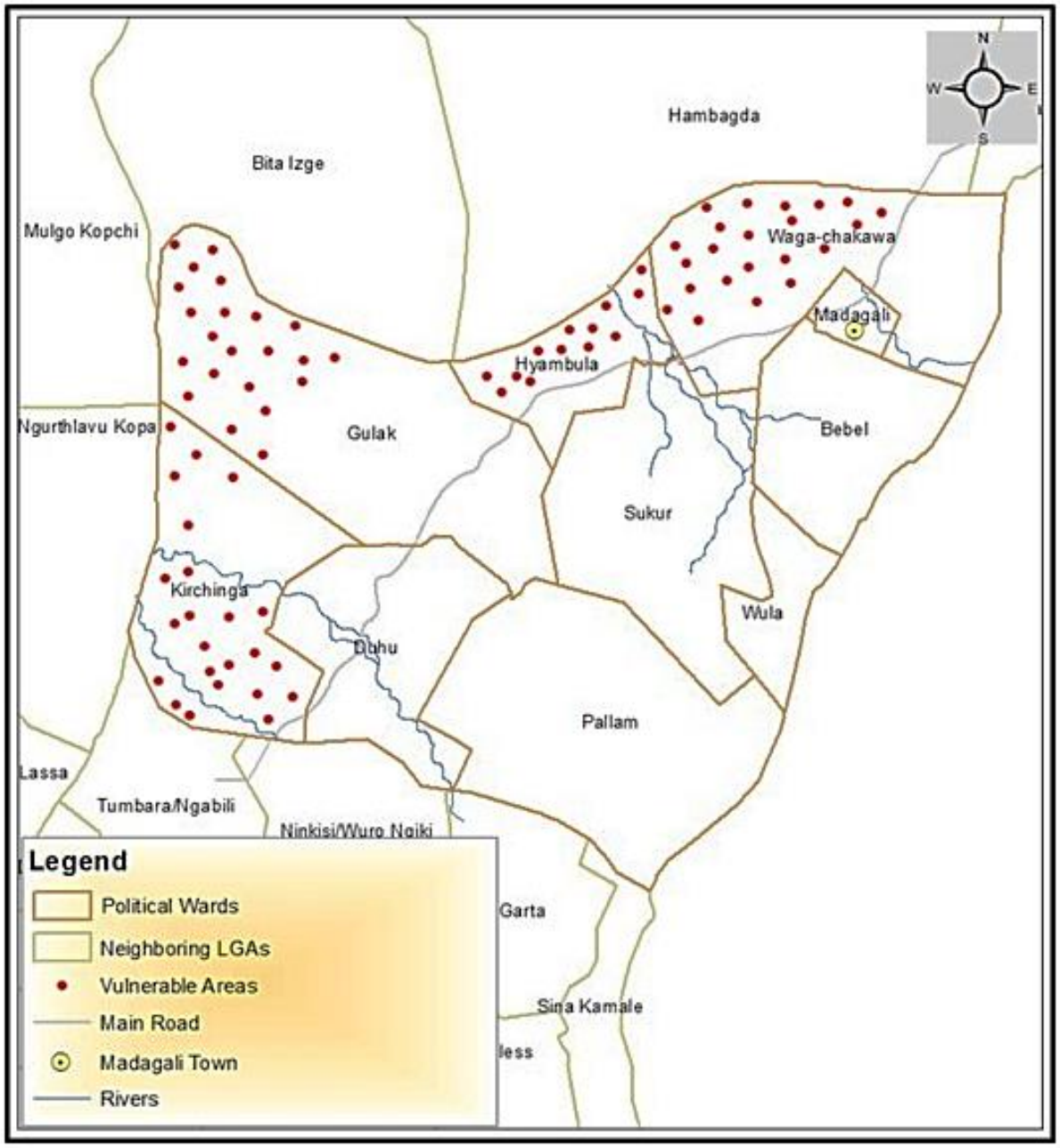

Figure 12. Wards Map Showing Vulnerable Land Areas during the Insurgency.

The Figure 12 is the insurgency vulnerability map of the study area. The red symbols on the map shows the inaccessible land areas during the insurgency. The areas are less with mountainous hills that can be suitable for crop production but full of threat of the insurgency. In Figure 12, the map shows four (4) vulnerable wards with red color symbols, the wards are; Waga, Hyambula, Gulak and Kirchinga.

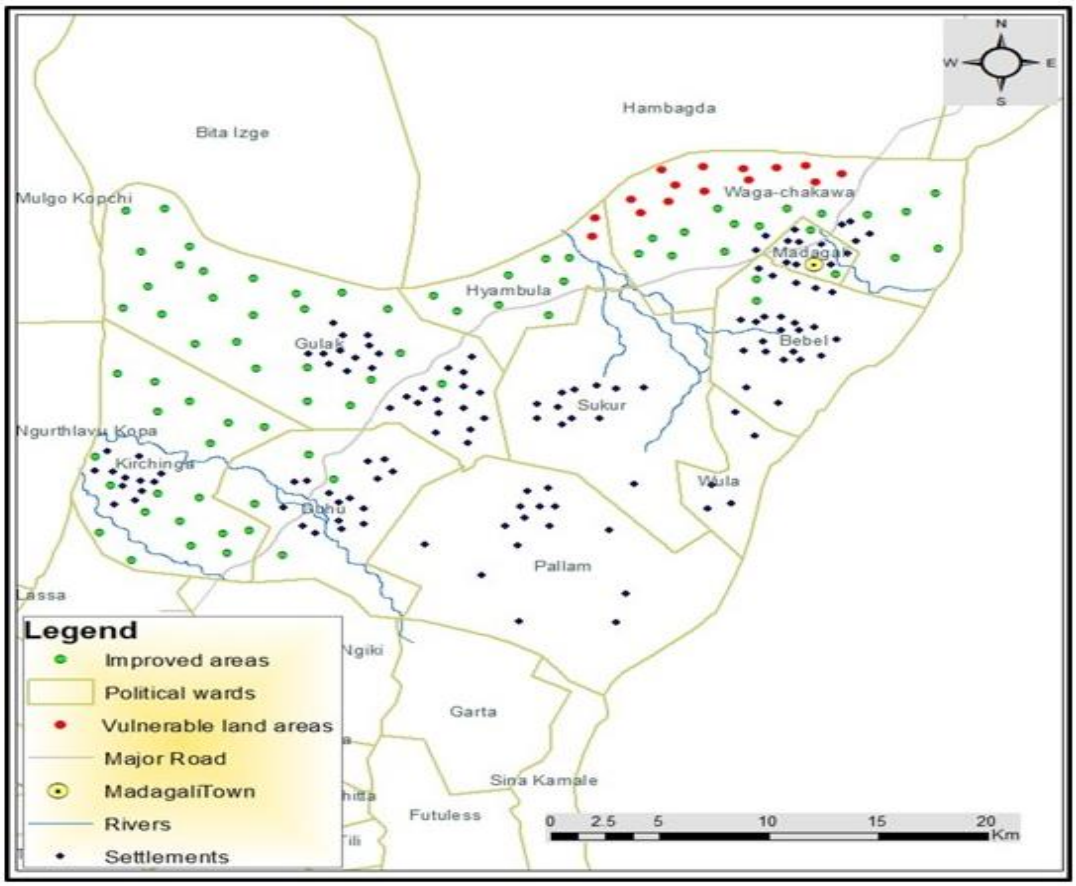

Figure 13. Ward Map Showing Accessible Land Areas after the Insurgency for Crop Production.

The Figure 13 is the final map of the study. The green symbols on the map shows the improved and accessible land areas after the insurgency while the black color Symbols signifies human settlement. The identified improved land areas are more with mountainous hills that makes production of crops more easy and suitable. Figure 13 map shows land areas with the ten (10) political wards of the study area. Figure 13 map is the final map showing the aim of the study by identifying land areas with Green colors, it symbolizes were improvement had been recorded after the insurgency for crop production, only one ward has a skirmish threat called Waga-Chakawa ward as identified on the map and the black color symbols signifies human settlement. The improvement in agricultural land opened for accessibility from 2014 to 2022 can be seen in Tables 3 and 4 in terms of the percentages (58% to 72%).

Table 3: Result of LULC of Landsat7 (ETM+) 2014 in Percentage

S/NO.	NAME	AREA (ha)	PERCENTAGE %
1.	WATER BODY	866.2150282	1%
2.	FOREST	19199.44859	24%
3.	AGRICULTURAL LAND	47185.34951	58%
4.	SETTLEMENTS	5035.88207	6%
5.	BARE GROUND	8278.811624	10%
6.	ROCKS	931.6135028	1%
7.	**Grand Total**	**81497.32032**	**100%**

Table 4: Result of LULC of Landsat 9 (OLI) 2022 in Percentage

S/NO.	CLASSES	AREA (ha)	PERCENTAGE %
1.	WATER BODY	590.3060274	1%
2.	FOREST	4033.451845	5%
3.	AGRICULTURAL LAND	59088.71688	72%
4.	SETTLEMENT	4653.549873	6%
5.	BARE GROUND	11940.10555	15%
6.	ROCKS	1174.599427	1%
7.	**Grand Total**	**81480.7296**	**100%**

Tables 3 and 4 show the percentage of six land use types considered in this work and their percentages which have that some land use classes have gained while some have losses in their original capacity of 2014. There is no doubt that more accessibility of land areas for crop production plays a vital role for source of livelihood.

4.0. Conclusions

This research has mapped out accessible land areas after the insurgency for the use of crop production in Madagali LGA. As identified in Figure 13, the map will serve as an interface for conveying suitable information that will aid easy accessibility for farmers and agricultural extension workers among other advantages it seeks to more available land areas. Conveying this information with the use of this map reduces the complexity of gaining access to such land areas and give farmers access to derive information suitable for crop production. This has also showed that Boko Haram insurgency within this area had been degraded. The method implemented in this study recommends the use of GIS as evidence in land area location processes above the speculative of other method and the risk attached. The study was initially designed such that accessibility of land areas for crops production could be determined on map platform so that users will be able to dynamically choose locations within the area of Madagali LGA they wish to utilize for crop production. The following are therefore recommended based on the findings:

i. There is need for more attention for reconstruction of the route destroyed during the insurgency that can make people easily convey their goods and services.
ii. Adamawa State government should look into the area of study to see how investment in agriculture can boost internally generated revenue for the state.

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