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Research Paper

Land Use Land Cover Dynamics: Integrating GIS and Remotely Sensed Data to Support Land Use Planning In Minna Metropolis Nigeria

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ABSTRACT: *Rapid urbanization and changing land use patterns in Minna Metropolis are a result of rising population pressures on land, water, and the environment, particularly in the city's core. As a result, this study used Remote Sensing and Geographic Information System applications to track the dynamics of land use and land cover in Minna Metropolis. The study included pictures from the Landsat Thematic Mapper TM, Enhanced Thematic Mapper Plus (ETM+), and Operational Land Imager (OLI) for the years 1986, 1996, 2006, and 2016. The findings show that urban built-up land increased from (4.98%) in 1986 to (7.26%) in 1996, to (26.54%) in 2006, and (46.86%) in 2016, while arable land decreased from (70.94%) in 1986 to (42.60%) in 1996, increased to (52.35%) in 2006, but then decreased to (27.08%) in 2016.The study also showed that agricultural land (70.94%) predominated in the area in 1986, followed by bare land (43.45%), built-up area (26.54 %) in 2006, and (46.86%) in 2016. If the scenario is not adjusted, the analysis indicates that there will most likely be crowding in Minna. According to the report, a master plan should be developed to guide land acquisition in the study region.*

KEYWORDS: *Land use Planning, Dynamics, Remote Sensing, GIS, Minna*

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I. INTRODUCTION

Global urban growth/expansion continues to rapidly increase [1][2], causing significant impacts on land and environmental dynamics at the regional and local scales[3][4]. The associated land use/cover changes [5][6] pose a great challenge to environmental sustainability[7] and sustainable urban development [4]. In this context, environmental sustainability is defined as the condition that allows human society to meet their current needs without compromising the current and future health of natural ecosystems [8]. Sustainable urban development thereby relies on designing urban areas with consideration given to consumption (e.g., energy) and pollutions (e.g., waste, water, air, and soil) [9], together with social, economic, and cultural considerations of creating a functional urban environment for current and future generations.

Informed land use planning can help to improve environmental sustainability and urban growth. Land use planning that is uncoordinated, unenforced, or non-existent can lead to chaotic growth and excessive deterioration of the built and natural surroundings [10]. Rapid urbanization and the emergence of informal settlements in less developed nations (especially in Sub-Saharan Africa) provide a challenge to present attempts for sustainable land use planning[11]. Land use planning focuses on the spatiality and geographies of socioeconomic and ecological aspects to optimize the use of space while avoiding conflict [12]. [13]. Preparation (identifying the purpose and objectives), data gathering and analysis, plan creation, negotiation and decision-making, implementation, and monitoring and updating are all part of the applied land use planning process [13]. Land use planning processes, according to[14], can be carried out at several scales (e.g., urban, regional, national). Land use planning, on a regional scale, tries to resolve conflicts between national goals and local interests by balancing various purposes such as new communities, protected areas, intensive agriculture, and animal husbandry. Land use planning processes in less developed countries, such as Nigeria, are severely hampered by a lack of data [15][16]. This is also true in Minna, one of Sub-Saharan Africa's fastest-growing cities [17]. Geographic Information Systems (GIS) and remote sensing (RS) tools have yet to completely realize their potential in providing fresh insights into land use planning and urban development. While earlier research in less developed nations has effectively used GIS and RS tools and data to measure land use/cover change, the literature has yet to investigate how these approaches connect to land use planning. In Akure, Nigeria, [18] depict urban growth at the expense of vegetation. They proposed that the city's master plan be revised and that a comprehensive regional land use plan be produced to address urban expansion issues, but they did not undertake a comparison of planned and actual land cover. In Jos, Nigeria,[19] found that urban land increased while non-urban land decreased. They claim that urban development in Jos did not follow the city's latest master plan. Cities outside of Africa have seen similar consequences. [20], for example, reported an increase in urban growth and a decline in urban vegetation in three cities in Chile, implying that urban planning and design should be used to maintain vegetation.

This study uses GIS and remote sensing data to look at the spatial trends of urban land cover dynamics in Nigeria's Minna Metropolis between 1986 and 2016, providing baseline data to help with informed land use planning. The study's goals were to: (i) visualize and quantify land use and land cover types for 1986, 1996, 2006, and 2016; and (ii) compute the land use and land cover types that change the most in the metropolis.

II. MATERIALS AND METHODS

Study area

The 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 with Paikoro 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[21]. Minna accommodates over seventy percent economic activities like shopping centers, hotels, neighborhood markets, shops, banks and street vendors among others [22](Figure 1)

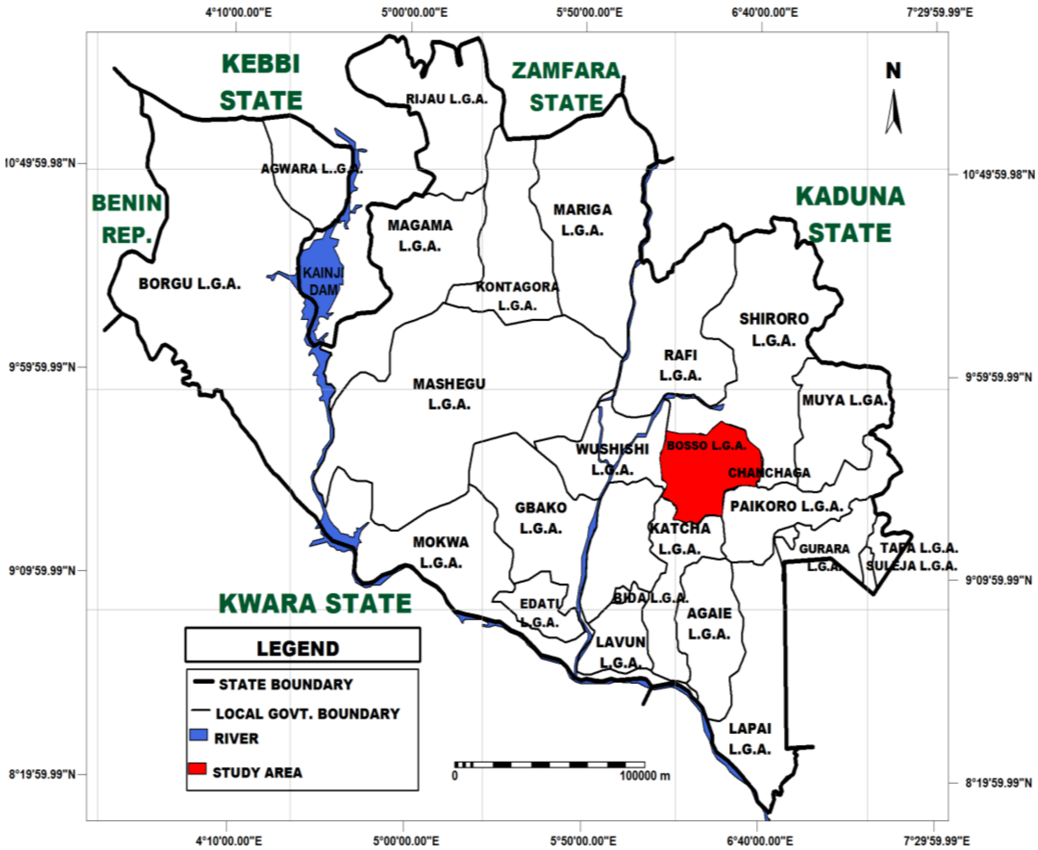

Figure 1: Niger State showing Minna
Source: Ministry of Land and Housing Minna, 2015

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

Image pre-processing involves removal or minimization of distortions introduced to satellite images due to sensor, solar, atmospheric and topographic effects. This is to enhance the quality and interpretability of the image components for remote sensing analysis[23].The study area was first clipped from the respective images and then orthorectified in order to correct distorted or degraded image data to its original scene. The pre-processing was done via image enhancement processes and the acquired images was geometrically and radiometrically rectified and restored using Arc GIS 10.1 and ERDAS Imagine 9.6 application software. The images was further enhanced to improve on its pictorial clarity and identification of homogenous image pixels of same land cover class.

Image Classification

Image classification is the process of organising feature pixels in an image into predefined groups (classes) on the basis of their spectral properties' similarity. The acquired and extracted data was processed using the supervised and unsupervised methods of advanced image classification techniques, namely Maximum Likelihood Classification (MLC) and Support Vector Machines (SVM) classifiers. Maximum Likelihood Classification classifies image pixels based on the highest probability of belonging to a particular class and minimizes misclassification errors by allowing variable weight specifications during the classification process. This approach was preferred for its enhanced accuracy, operational simplicity, easy applicability and performance. The sequence of operations to be followed will be identification and extraction training samples, extraction of signatures and classification of pixels into the land cover class.

Accuracy Assessment

It is the process of ascertaining the level of accuracy of classified land cover, land use features which serve as means of comparing the performance of several classification methods. In this study, this was achieved by assessing the overall, producer and user accuracies of the maps using the confusion matrix and kappa coefficient and was done in Arc GIS 10.1 software. The matrix table was then developed for each year; the confusion matrix and kappa coefficient were calculated as:

$$\text{User accuracy} = \frac{\text{Number of Correctly Classified Pixels in a Class}}{\text{Total Number of Pixels in a Class}} \quad \text{equation ----------- (1)}$$

$$\text{Producer's accuracy} = \frac{\text{Number of Correctly Classified Pixels in a Class}}{\text{Total Number of Pixels in all Classes}} \quad \text{equation -------- (2)}$$

$$\text{Overall accuracy} = \frac{\text{Total Number of all Correctly Classified Pixels}}{\text{Total Number of Pixels in all Classes}} \quad \text{equation ---------- (3)}$$

$$\text{Kappa Index of Agreement (KIA)} = \frac{N\Sigma^{n}_{i}=1\ mi1 - \Sigma^{n}_{i}=1(GiCi)}{N^{2}-\Sigma^{n}_{i}=1\ (GiCi)} \quad \text{equation --------------- (4)}$$

Where:
i=class number
N= total number of classified values compared to truth values
Mi, 1 = number of values belonging to the truth class i(also classified as class i)
Ci= total number of predicted values belonging to class i and
Gi= total number of truth values belonging to class 1.

Dynamics Detection

Change detection was carried out using the Post Classification Comparison (PCC) which is the most popular and most accurate dynamic detection approach. Post Classification Comparison describes the nature of changes between study epochs while minimizing the problem of radiometric calibration between images of different dates [24]. The proportion of each land use and land cover dynamic class was calculated for each year and the changes between the respective years was determined.

III. RESULTS AND DISCUSSIONS

TABLE 1 :Landuse / Landcover transformations from 1986- 2016 in km^2 and %

Category of LULC Class	Area Change Detection (1986 − 1996)		Area Change Detection (1996 − 2006)		Area Change Detection (2006 − 2016)	
	km^2	%	km^2	%	km^2	%
Waterbody	− 1,936.62	− 0.81	27,690.84	11.5	− 17,281.17	−7.18
Builtup	5,499.72	2.28	46,474.47	19.28	48,966.66	20.32
Bare land	64,738.71	26.87	−97,661.07	−40.53	29,230.47	12.13
Arableland	− 68,243.58	−27.94	23,495.76	9.75	−60,915.96	−25.24

The level of land use and land cover conversions over the period 1986-2016 has been shown in Table 4.2. The results clearly show a consistent increase in the built -up land uses and corresponding decrease in the arable lands. The urban built-up land use increased from (4.98%) in 1986, to (7.26%) in 1996, to (26.54%) in 2006 and (46.86%) in 2016. On the contrary, the arable land decrease from (70.94%) in 1986 to (42.60%) in 1996, increased to (52.35%) in 2006 but later decreased to (27.08%) in 2016. The water bodies decreased from (7.49%) in 1986 to (6.68%) in 1999, but increased from (6.68%) in 1999 to (18.18%) in 2006 and decrease from (18.18%) in 2006 (11.00%) in 2016. The bare land increased from(16.59%) in 1986 to (43.46%) in 1999 but drastically decreased from (43.46%) in 1999 to (2.93%) in 2006 and gradually increased from(2.93%) in 2006 to(15.06%) in 2016. In general, throughout the period (1986 – 2016) the urban built up land uses increase extensively to engulf most of arable lands. However, during the period (1999-2006), the encroachment of urban/built up land uses was higher over bare lands than on arable lands. In particular, during the period of 1986 to 2016 a high percentage of agricultural lands and bare lands were converted to urban areas. This indicates that urbanization was taking place at a very fast rate, and taking over.

TABLE 2: Result of Minna Landuse and Landcover Classification Statistics for 1986, 1999, 2006 and 2016

Category of LULC Class	1986 Area		1996 Area		2006 Area		2016 Area	
	km^2	%	km^2	%	km^2	%	km^2	%
Waterbody	18,046.08	7.49	16,109.46	6.68	43,800.30	18.18	26,519.13	11.00
Builtup	11,992.32	4.98	17,492.04	7.26	63,966.51	26.54	112,933.17	46.86
Bare land	39,991.68	16.59	104,730.39	43.46	7,069.32	2.93	36,299.79	15.06
Arableland	170,922.24	70.94	102, 678.66	42.60	126,174.42	52.35	65,258.46	27.08
Total	**240,952.32**	**100**	**241,010.55**	**100**	**241,010.55**	**100**	**241,010.55**	**100**

According to Table 2, the land use and land cover type that predominated in the area in 1986 was arable land (70.94 %), bare land (43.4 %), built up area (26.54 %), and built up area (26.54 %) in 2006, and (46.86 %) in 2016. This clearly shows that in 2006 and 2016, the agricultural land that comprised arable land and barren land (in 1986 and 1996, respectively) was transformed to built-up areas. This is also an indicator of the area's urbanization or expansion.

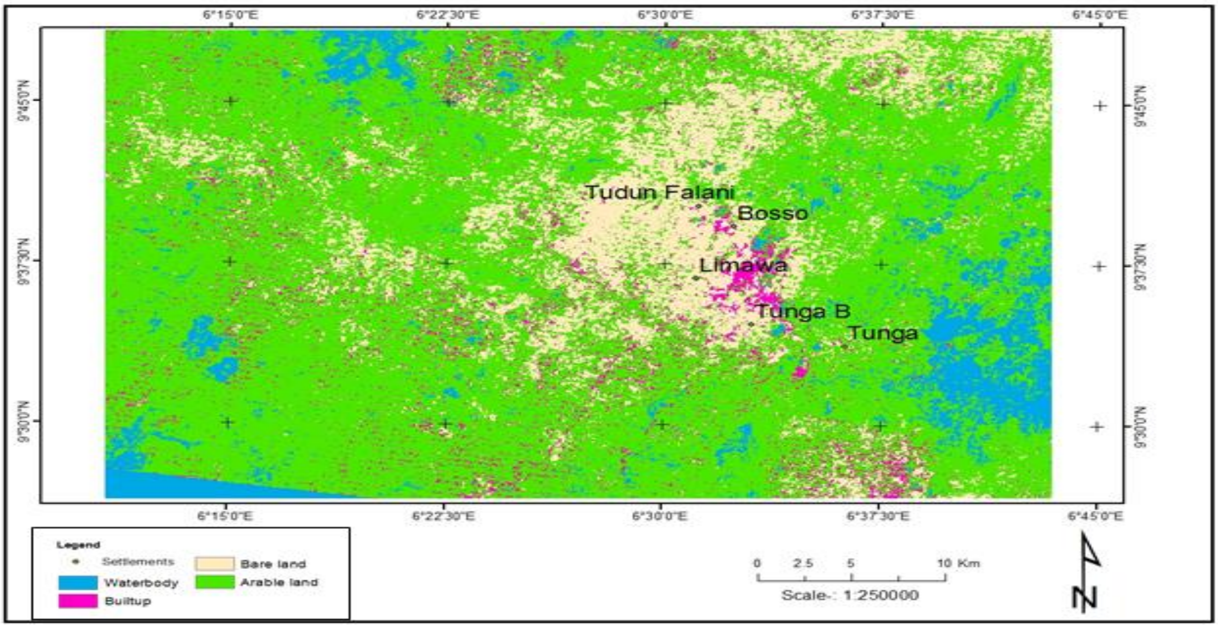

Fig.2: Land use and Land cover Map of Minna Town in 1986

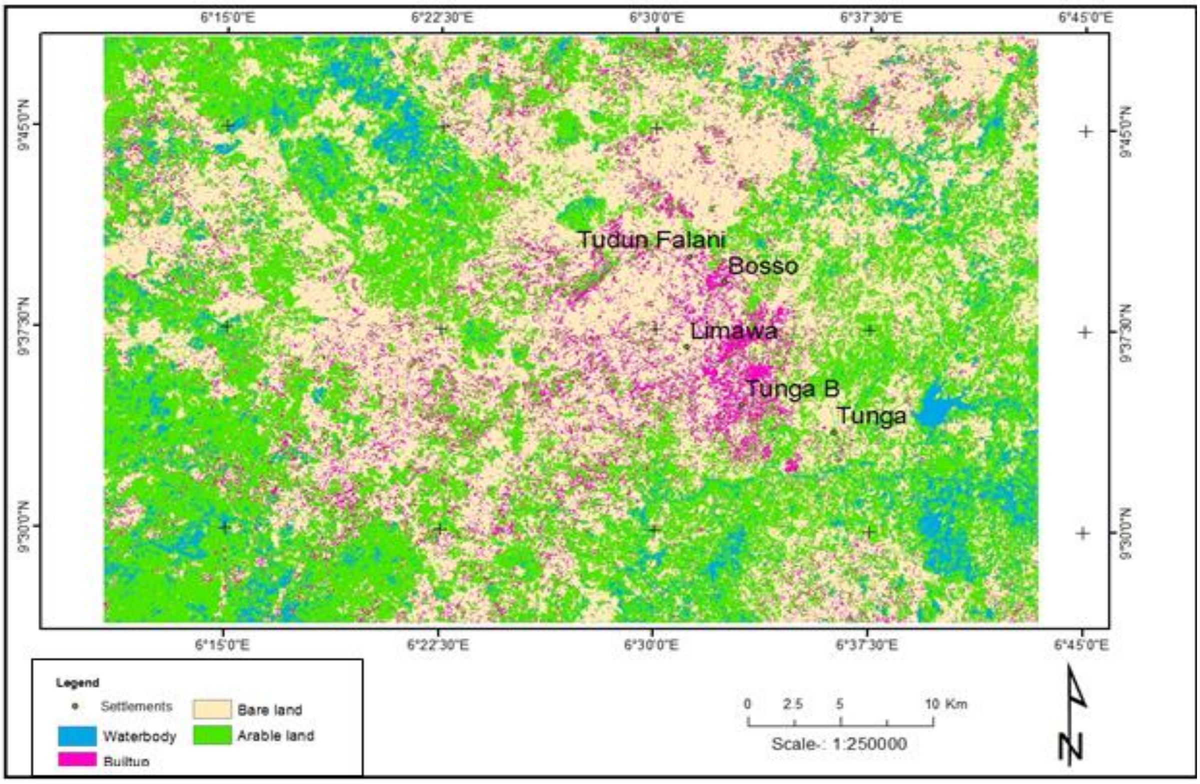

Fig.3: Landuse and LandCover Map of Minna Town in 1996

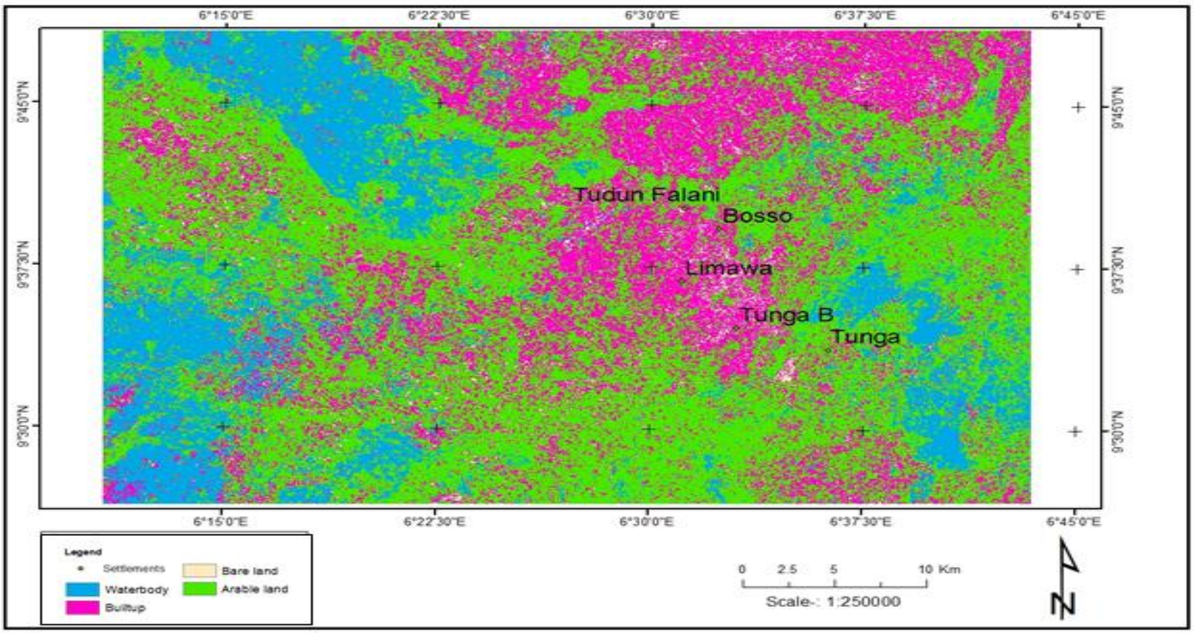

Fig.4: Landuse andLandcover Map of Minna Town in 2006

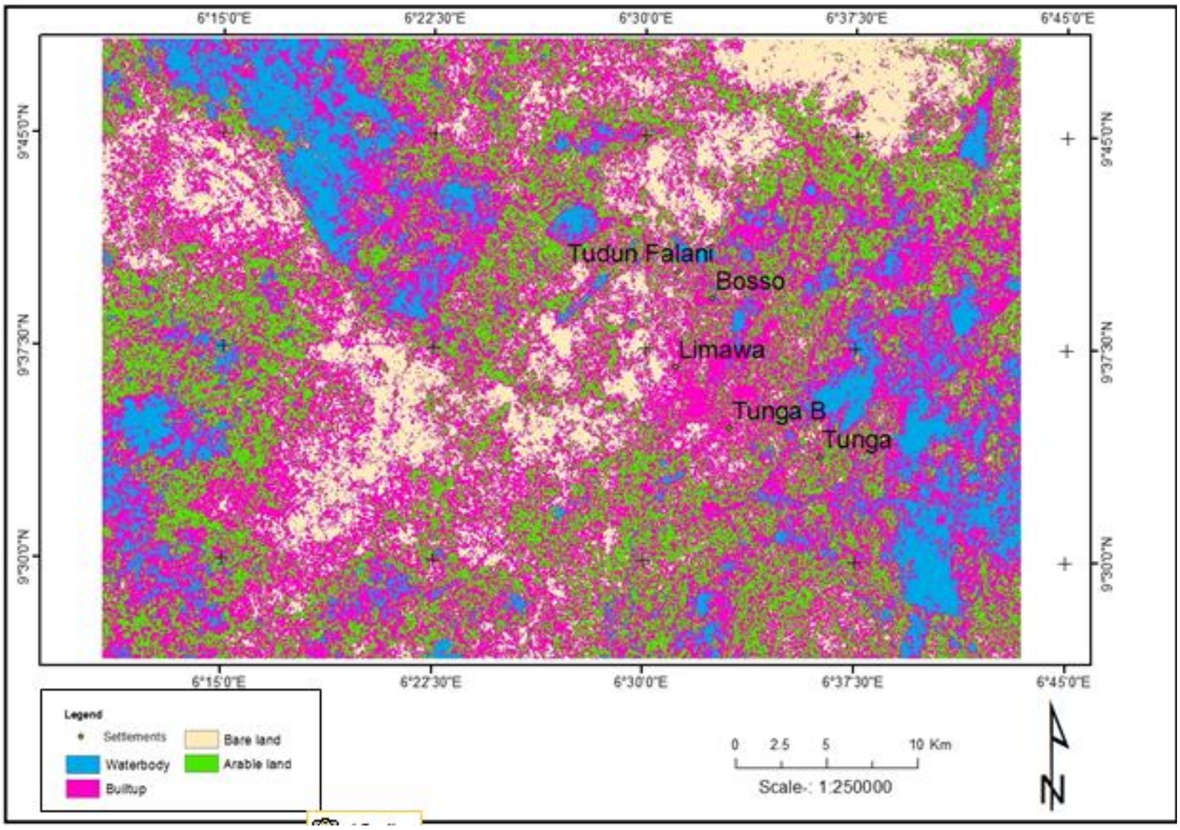

Fig.5: Landuse and Landcover Map of Minna Town in 2016

IV. CONCLUSION

This study showed how GIS and remote sensing could be used to capture spatial-temporal data for land use and land cover change analysis. If the scenario remains the same, there would most likely be crowding in Minna. Because of the associated difficulties of crowdedness, such as crime and disease spread, this condition will have negative consequences in the area. According to the study, land acquisition is increasing as arable land is converted to bare land and then to built-up areas, hence a master plan is needed to guide land acquisition in the study area.

REFERENCES

[1]. Nor, A.N.M.; Corstannje, R.; Harris, J.A.; Brewer, T. (2017). Impact of rapid urban expansion on green space structure. Ecol. Indic. 2017, 81, 274–284.

[2]. Angel, S.; Parent, J.; Civco, D.L.; Blei, A.; Potere, D. (2011). The dimensions of global urban expansion: Estimates and projections for all countries, 2000–2050. Prog. Plan. 2011, 75, 53–107.

[3]. Vasenev, V.I.; Stoorvogal, J.J.; Leemans, R.; Valentini, R.; Hajiaghayeva, R.A. (2018). Projection of urban expansion and related changes in soil carbon stocks in the Moscow Region. J. Clean. Prod. 2018, 170, 902–914.

[4]. Tiitu, M. (2018). Expansion of the built-up areas in Finnish city regions—The approach of travel-related urban zones. Appl. Geogr. 2018, 101, 1–13.

[5]. Akpu, B.; Tanko, A.I.; Jeb, D.N.; Dogo, B. (2017). Geospatial Analysis of Urban Expansion and Its Impact on Vegetation Cover in Kaduna Metropolis, Nigeria. AJEE 2017, 3, 31149.

[6]. Barrera, F.D.L.; Henríquez, C. (2017). Vegetation cover change in growing urban agglomerations in Chile. Ecol. Indic. 2017, 81, 265–273.

[7]. Nwokoro, I.I.; Dekolo, S.O. (2012). Land use change and environmental sustainability: The case of Lagos Metropolis.In Sustainable City VII: Urban Regeneration and Sustainability; Pacetti, M., Passerini, G., Brebbia, C.A., Latini, G., Eds.; WIT Press: Southampton, UK, 2012; Volume 155, pp. 157–167.

[8]. Morelli, J. (2011). Environmental Sustainability: A Definition for Environmental Professionals. J. Environ. Sustain.2011, 1, 19–27.

[9]. Abdullahi, S.; Pradhan, B. (2017). Sustainable Urban Development. In Spatial Modeling and Assessment of Urban Form Analysis of Urban Growth: From Sprawl to Compact Using Geospatial Data, 1st ed.; Pradhan, B., Ed.; Springer International Publishing AG: Basel, Switzerland, 2017; pp. 17–34. ISBN 978-3-319-54216-4.

[10]. Yin, J. (2017). Urban Planning for Dummies, 3rd ed.; John Wiley & Sons Canada Ltd.: Mississauga, ON, Canada, 2012.

[11]. UN-Habitat. State of the World's Cities (2010/2011): Bridging the Urban Divide; Earthscan Publishing for a Sustainable Future: London, UK, 2008.

[12]. Phillips, P.M.; João, E. Land use planning and the ecosystem approach: An evaluation of case study planning frameworks against the Malawi Principles. Land Use Policy 2017, 68, 460–480.

[13]. BMZ. Land Use Planning (2012): Concept, Tools and Applications; GIZ: Eschborn, Germany, 2012.

[14]. Metternicht, G. (2017). Global Land Outlook Working Paper: Land Use Planning; UNCCD (United Nations Convention to Combat Desertification): Sydney, Australia, 2017.

[15]. Schug, F.; Okujeni, A.; Hauer, J.; Hostert, P.; Nielsen, J.O.; van der Linden, S.F. (2018). Mapping pattern of urban development in Ouagadougou, Burkina Faso, using machine learning regression modeling with bi-seasonal Landsat time series. Remote Sens. Environ. 2018, 210, 217–228.

[16]. Potts, D. (2012). Challenging the Myths of Urban Dynamics in Sub-Saharan Africa: The Evidence from Nigeria.World Dev. 2012, 40, 1382–1393.

[17]. Africa in Focus Figures of the Week (2018): Africa is Home to the 10 Fastest Growing Cities in the World. Available online: https//www.brookings.edu/blog/Africa-in-focus/2018/10/05/figure-of the- week-Africa-is-home-to fastest-growing-cities in the world/ (accessed on 5th October 2020).

[18]. Owoeye, J.O.; Ibitoye, O.A. (2016). Analysis of Akure Urban Land Use Change Detection from Remote Imagery Perspective. Urban Stud. Res. 2016, 4673019.

[19]. Adzandeh, E.A; and Fabiyi, O.O (2016). Spatio-temporal Pattern of Urban Growth in Jos Metropolis, Nigeria. Remote Sens.Appl.Soc.Environ.; 4,44-54.

[20]. Henríquez, C. (2017). Vegetation cover change in growing urban agglomerations in Chile. Ecol. Indic. 2017, 81, 265–273. `

[21]. Development Action Plan (DAP) for Niger State, Minna, 2007

[22]. Sanusi, Y.A. (2006). An Assessment of the Spatial Relationship between Poverty and Environmental Quality in Minna Metropolis (Unpublished PhD Thesis) submitted to Geography Department of Federal University of Technology, Minna.

[23]. Sowmya, D.R.; Deepa, S.P.; and Venugopal, K.R. (2017). Remote sensing satellite image processing techniques for image classification: A comprehensive survey. International Journal of Computer Applications, 161 (11), 24-37. https://doi.org/10.5120/ijca2017913306.

[24]. Weng, Q. (2012). Remote Sensing of Impervious Surfaces in the Urban Areas: Requirements, Methods, and Trends. Remote Sens. Environ, 117, 34–49.