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Analysis of Land Use and Land Cover Change of Numan, Numan Local Government Area of Adamawa State

[1]Ogwu, Friday Adejoh, & Ogwuche, Victoria Ene[1]
[1]Department of Urban and Regional Planning, Modibbo Adama University of Technology, Yola
Jigawa State Urban Planning Board, Dutse
Email: fridayogwu@mautech.edu.ng

ABSTRACT
This paper examines the use of GIS and remote sensing in mapping land use/land cover of Numan between 1991 and 2019 so as to detect the changes that has been taken place in this status between these periods. Image processing and image classification in order to establish the land use and land cover changes in Numan within 1991 and 2019, Landsat images of the district were downloaded from the Earth Explorer a USGS resources as well as Google Earth image domain. The USGS data product is provided as image file and was processed using ArcMap as well as Excel. The period of land of LULC analysis covered roughly a period of twenty eight years, ranging from 1991 to 2019. As anticipated, the result showed an increase in urbanization while decrease in bare surface and vegetation cover. The use of satellite imagery has become one of the strongest tools for analyzing and interpreting the complex systems of the earth and the anthropogenic influences that continue to pressure the planets limited resources.
Keywords: *Land Use; Land Cover, and GIS and Remote sensing, Numan.*

INTRODUCTION

The entire world and particularly, the developing countries have witnessed exceptional changes in population size. This has been a major concern to government and policy makers because it has continued to strain the available resources and physical facilities. Likewise it poses problem in making adequate provision for requirements like infrastructures and the likes, most especially the newly developed areas in the city. There is a need for land use land cover change data so as to properly manage land. Furthermore, anthropogenic activities on the earth surface have also contributes to significant modifications, alterations and profound effects upon the environment thus resulting into an observable pattern of change in the land use land cover overtime. This process makes urbanization an essential building mass for prosperity, accounting for about 50-80% of National Gross Domestic product (GDP) of most countries (Alaci,2008). In fact, Fasote (2007) noted that the problem of chaotic and haphazard, uncontrolled development leads to deteriorating environmental quality which certainly takes place in the absence of any developmental measures. Land use/land cover change over time is an inevitable phenomenon occurring globally due to both temporary and permanent interest of inhabitants in a particular area (Elodoyin, 2010). The land use/land cover pattern of Numan is an outcome of natural and socio – economic factors and their utilization by man in time and space. Land is becoming a scarce resource due to enormous agricultural and demographic (population) pressure. Hence, information on land use/land cover and possibilities for their best use is essential for the selection, planning and implementation of land use patterns to meet the increasing demand for basic human needs and welfare. As a result, this information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population in Numan (Field Survey, 2019). One of the main prerequisites for better use of land is information on existing land use patterns and changes in land use through time. Many Federal agencies need current comprehensive inventories of existing activities on public lands combined with the existing and changing uses of adjoining private lands to improve the management of public land. Federal agencies also need land use data to assess the environmental impact resulting from the development of energy resources, to manage wildlife resources and minimize man-wildlife ecosystem conflicts, to make national summaries of land use patterns and changes for national policy formulation, and to prepare environmental impact statements and assess future impacts on environmental quality (Anderson, 1992). Viewing the Earth from space is now essential to the understanding of the influence of man's activities on his natural resource base over time. In situations of rapid and often unrecorded land use change, observations of the earth from space provide objective information of human utilization of the landscape. Over the past years, data from Earth sensing satellites has become vital in mapping the Earths features and infrastructures, managing natural resources and studying environmental change (Masta *et al.* 2010).

Aim and Objectives

The paper maps the land use land cover change of Numan area using GIS and remote sensing with the view of making physical planning recommendation towards improving physical growth management through the following objectives:

Creation of a Land Use/ Land Cover Classification Scheme (1991-2019)

Generation of statistical data on land consumption by settlement and reduction of vegetation areas as well as water body.

Assessing the Pattern of Land Use Land Cover Change of Numan.

Proffering planning recommendations for the management of land use/land cover in Numan.

Study Area

Numan is one of twenty-one Local Government of Adamawa State and is 62 Km away from Yola, the state capital. Numan is located in the Tropical region of Africa and lies between latitude 9°28′N and 9°27′N and longitude 12°28'E and12°20E of the equator. It has an estimated population 107,167 people. The major ethnic group includes Bachama, Bwanza, Bata, Balli, Hausa, Mayah, and Chobbo, etc. The three main administrative districts are Bachama, Bata, and Mbula each having a number of villages and hamlets. The settlement is influenced by the tropical maritime air mass which ushers in the raining season from April – October and the tropical continental air mass which brings the dry season, from November – March. Average annual rainfall is 947.6mm.

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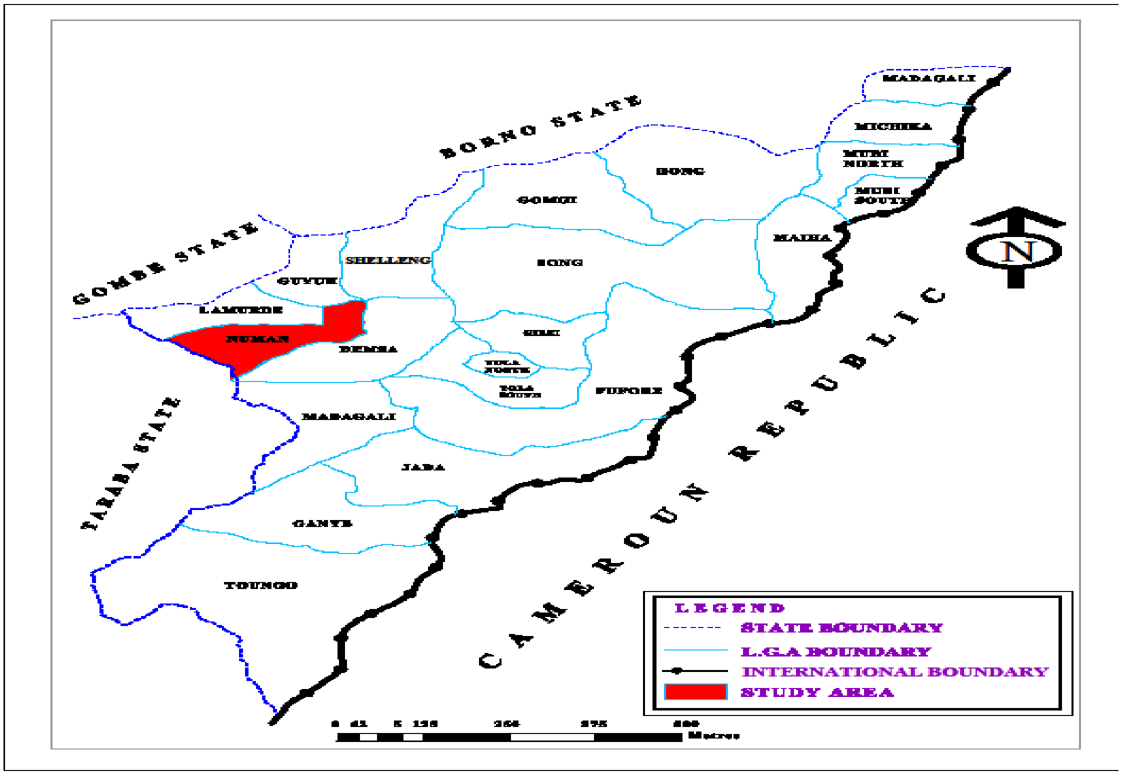

Fig. 1: Map of Adamawa Showing Numan

LITERATURE REVIEW

Land use/land cover changes play vital roles in global environmental change making it to contribute significantly to earth-atmospheric interactions and biodiversity loss, and it is a major factor in sustainable development and human responses to global change (United Nations Agenda 21, 2000). Changes due to human activities are often referred to as the terrestrial ecosystem and can be broadly divided into land cover and land use changes (Meyer and Turner, 1994) in Holman (2002) state that land cover denotes the physical state of the land including the quantity and type of surface vegetation, water, and earth materials. Land-Use change over time is an unavoidable phenomenon occurring globally due to both temporary and permanent interest of the inhabitants in a particular area. The phenomenon could be revealed either in a small or large scale but the most interesting and fundamental observation is that change occurs over time in a particular place (Eludoyin, 2010). Land-Use/Land-Cover changes are local and place specific, occurring rapidly in ways that often escape our attention (De-Sherbinin and Raustiala, 2002). Humans have been altering land use/Land-Cover since prehistory through the use of fire to flush out game and, since the advent of plant and animal domestication, through the clearance of patches of land for agriculture and livestock (De Sherbinin and Raustiala, 2002). In the past two centuries, the impact of human activities on the land has grown enormously, altering entire landscapes, and ultimately impacting the earth's nutrient as well as climate. The ability to forecast land

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use and land cover change and ultimately to predict the consequence of change will depend on our ability to understand the past, present and future state of land use and land cover change (Oyinloye and Kufoniyi 2011). This ability is enabled through the use of satellite images which provides valuable information for natural resources like land, water, forests, urban areas and infrastructure facilities such as road network, river network etc. GIS is a valuable tool to better manage, interpret and maintain resources. It is a proven decision support system employing land cover change maps among other data resources that are major products created from satellite images (Lambin, *et al.* 2007). Keeping track of change is important to our understanding of the earth as a system. Knowing about those changes is the first step towards understanding why and where they are happening. Change data can be used to update maps, and to estimate the rate of change in certain areas. Zhi-Yong Yin, *et al.* (2005) used image processing and analysis in a GIS environment to assess spatial change in urban land use patterns and population distribution. The unsupervised classification was used to classify the images into land use classes. Census polygon was constructed into various sets of units using census data in a GIS, and then comparison made with the classified image population in surface areas. In his studies carried out by 2004 in Shaoxing City in China, Zhi-Yong Yin uses satellite imageries for the year 1984, 1997, and 2000. One of the goals of the study was to produce a land use map of Shaoxing city and its surroundings; the result shows that there are undoubtedly a lot of changes that occurred between 1984 and 1997 when compared with those of 2000, due to the sufficient time gap. This paper observes that residential area development was mainly at the expense of agricultural land use.

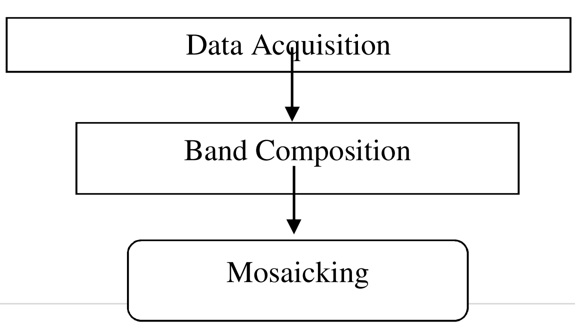
MATERIALS AND METHOD

Data was utilized from different sources for the purpose of this paper as shown in Table 1 below:

Table 1: Data Specification

S/N	Data Type and Date	Source	Data Format	Scale/Resolution
1	Thematic mapper TM 1991	http://earthexplorer.usgs.gov/	Raster	30x30m
2	Operational Land Imaginary OLI 2019	http://earthexplorer.usgs.gov/	Raster	30x30m

Source: Field Survey (2019).



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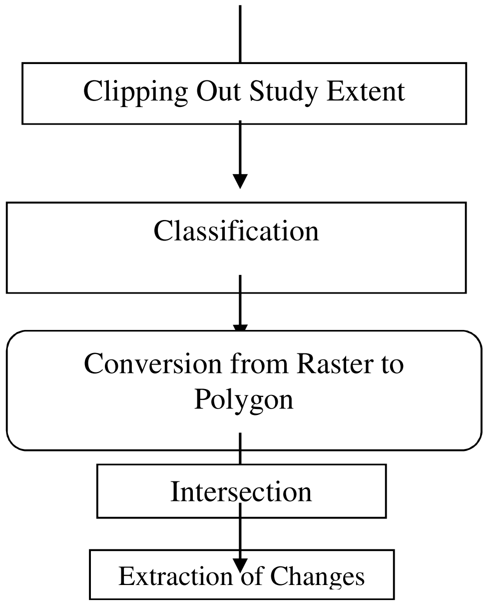

Figure 2: Methodological Frame Work of the Paper

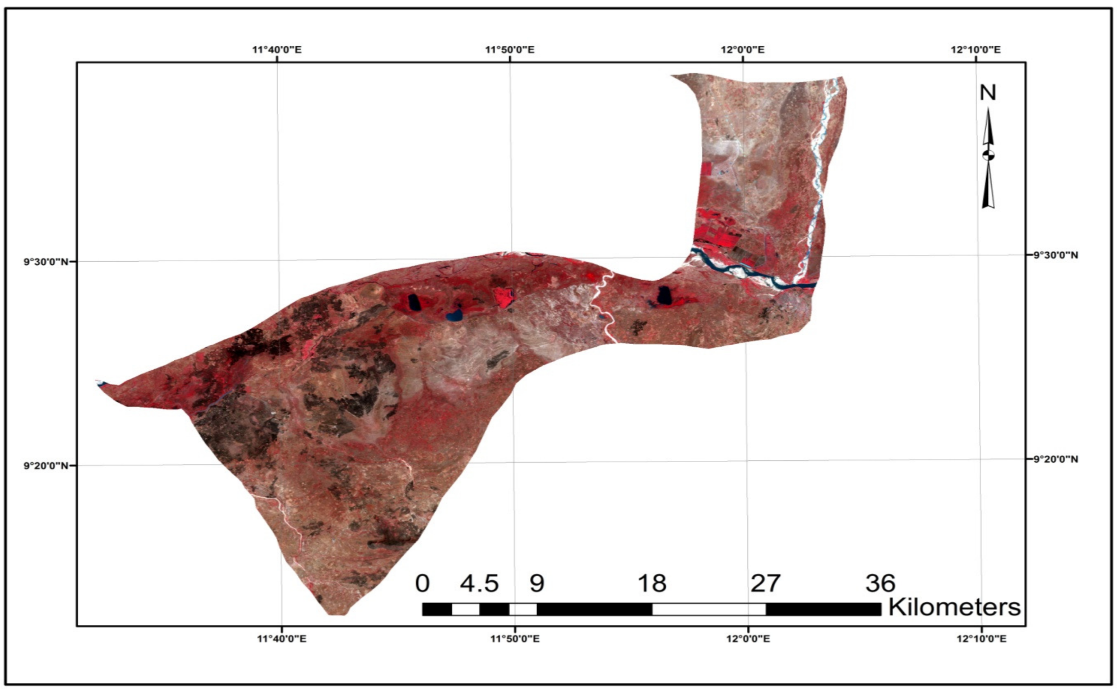

Figure 3: Land SAT TM (Thematic Mapper) 1991
Source: Earth Explorer, 2019

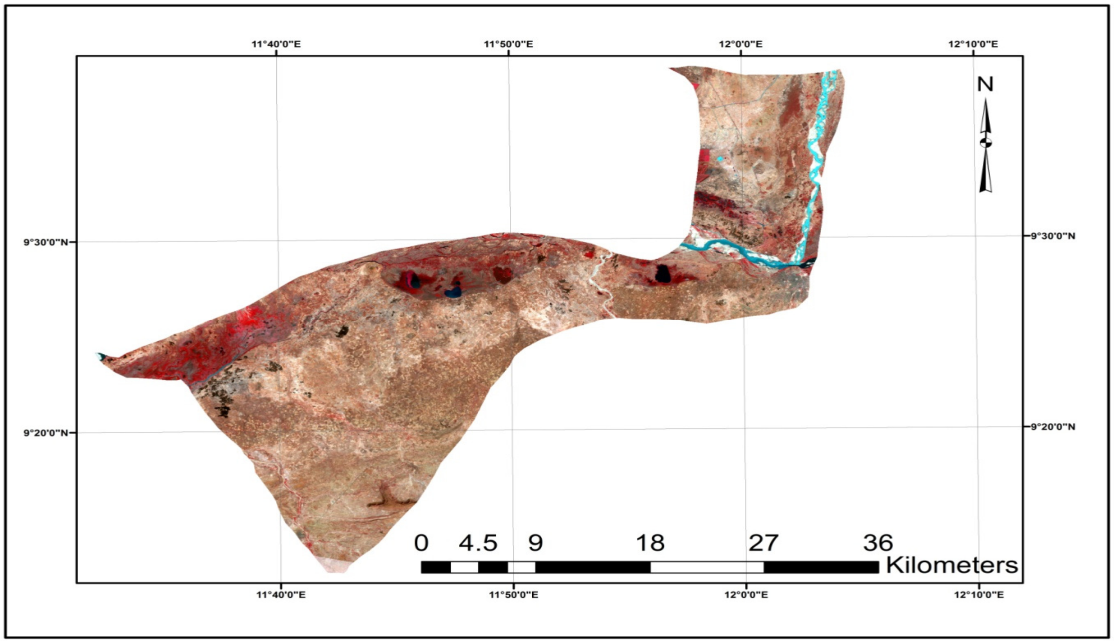

Figure 4: LandSAT OLI (Operational Land Imager) 2016
Source: Earth Explorer, 2017

RESULTS AND DISCUSSION

The land use land cover map for Numan at 1991 is shown in Figure 5 and that of 2019 in Figure 6. A land use report containing the various land use types and their respective area in Hectares for the respective epoch that they cover. The percentage of coverage was also calculated to provide the percentage coverage of each of the land uses. The resultant table is termed Table 2. Graphs were also used to statistically show the land use land cover distribution in the area for 1991 and 2019. The graph for the land use land cover distribution at 1991 is shown in Figure 7 and that of 2019 in Figure 8. The land use land cover maps were then converted from raster to vector format in other to clearly show land use land cover changes in the area. The two land use maps were intersected together using a tool known as the "Intersect" Analysis Tool in ArcGIS Software. This tool merged the databases of the two land use maps showing clearly the areas with land use changes within this epoch. The resultant table is represented as Table 3. On this table, each land use class that was previously a different land use class was documented and unchanged land use classes were also identified. Finally, the "Pivot Table" data management tool on ArcGIS was used to create a change matrix from the change map which also shows land use land cover changes. The rows in the matrix shows the Area in Hectares of various land use classes as at 1991 while the columns represent the Area in Hectares of the various land use classes at 2019. The diagonal elements depict unchanged land use classes while other elements in the matrix show changes from one land use to the other. The resultant table is termed Table 4.

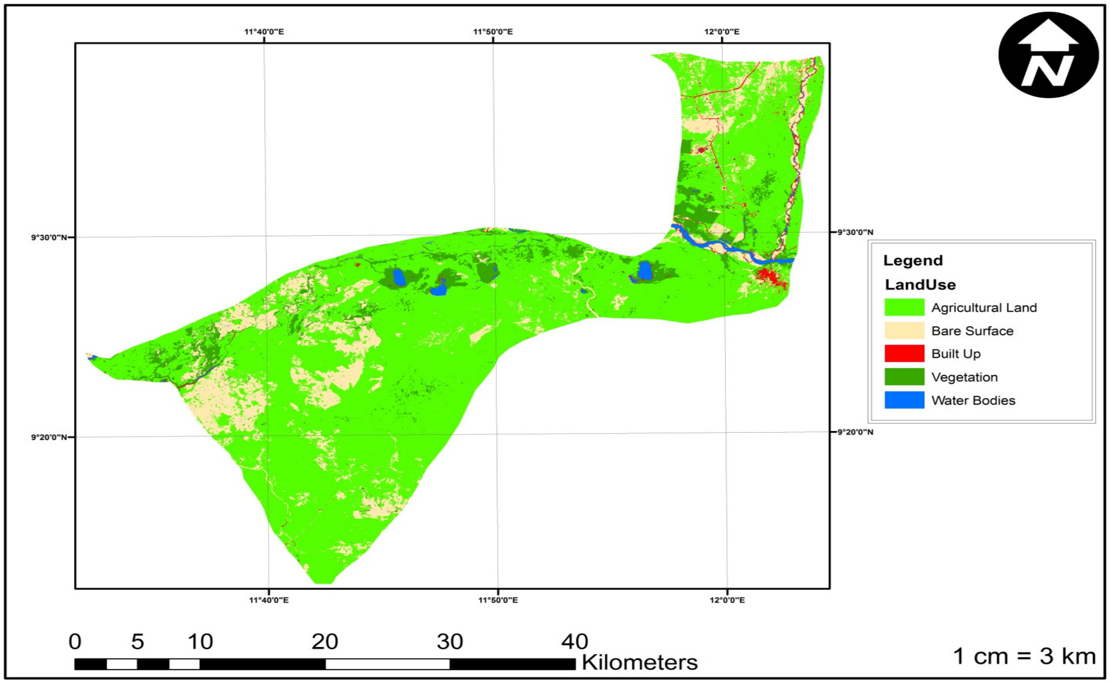

Figure 5: Land Use Land Cover Map at 1991

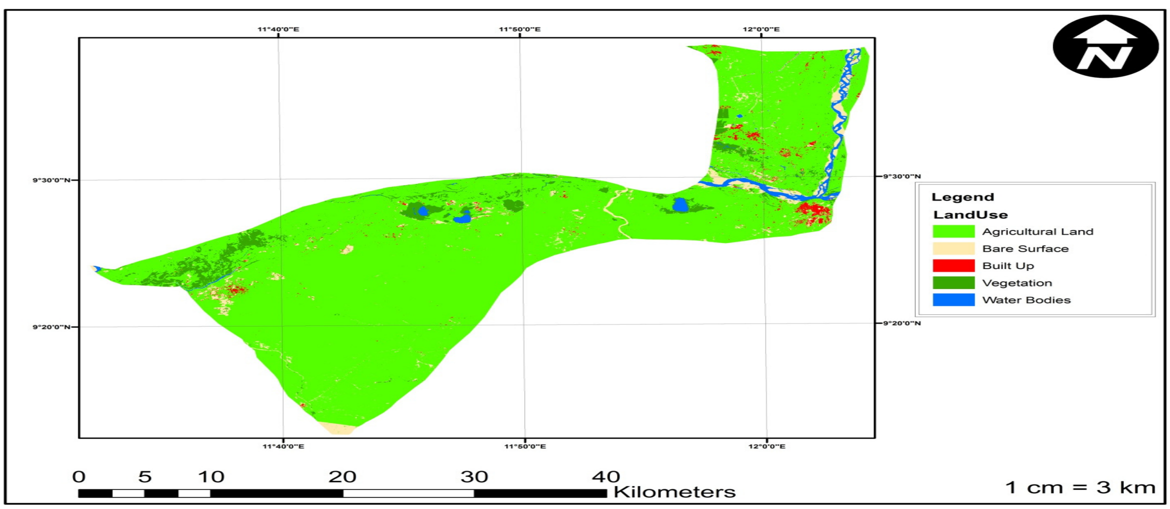

Figure 6: Land Use Land Cover map at 2019

	1991		2016	
Land Use	Area in Hectares	Percentage (%)	Area in Hectares	Percentage (%)
Bare Surface	13263.10	14.67	3589.33	3.97
Agricultural Land	67966.40	75.17	79774.20	88.22
Built Up	970.22	1.07	1172.97	1.30

Vegetation	7182.59	7.94	4214.68	4.66
Water Bodies	1039.74	1.15	1670.87	1.85
TOTAL	90422.05	100	90422.05	100

Table 2: Land Use Report for 1991 and 2019.

$$\% = \frac{\text{Each Land Use}}{\text{Total Land Use}} \text{X} 100$$

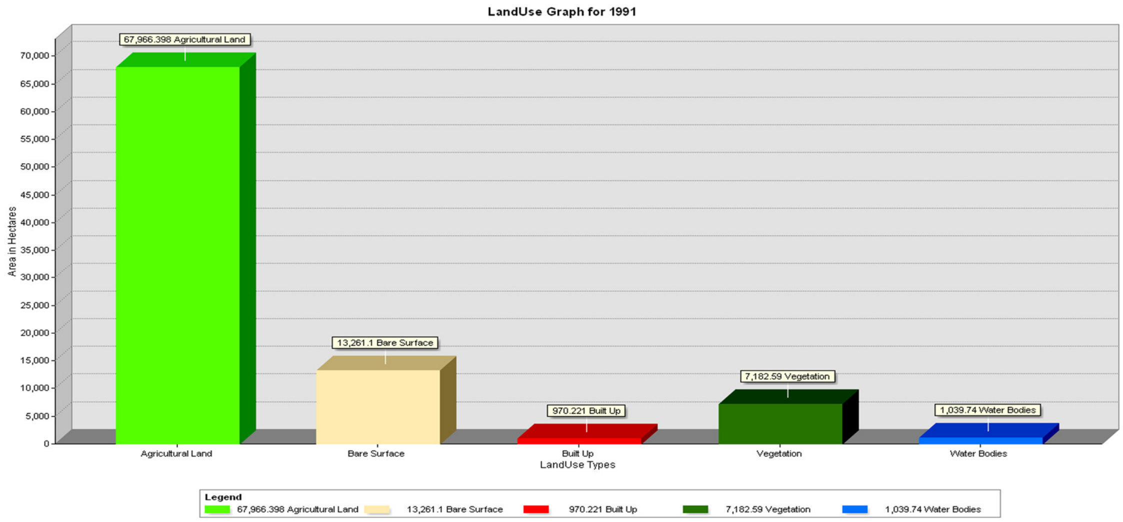

Figure 7: Graph showing Land Use Distribution at 1991

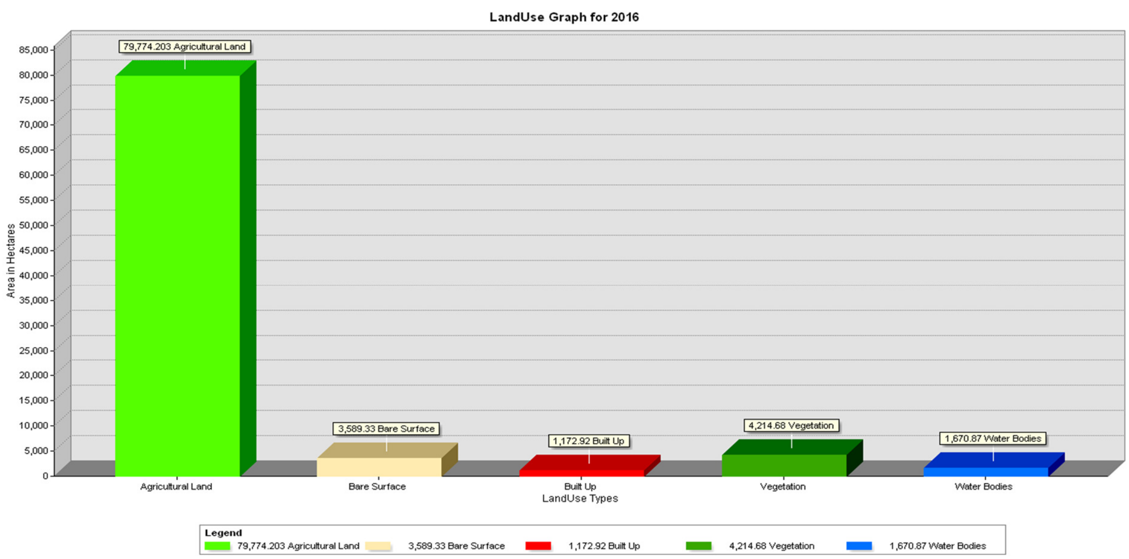

Figure 8: Graph Showing Land Use Distribution at 2019

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Table

change_map

FID	Shape *	FID_Classi	ID	GRIDCODE	Area_Ha	LandUse_91	FID_Clas_1	ID_1	GRIDCODE_1	Area_ha_1	LandUse_16	Change	Area
0	Polygon	0	1	2	13261.1	Bare Surface	0	1	5	79774.2	Agricultural Land	Bare Surface to Agricultural Lan	10733.9
1	Polygon	0	1	2	13261.1	Bare Surface	1	2	1	1172.92	Built Up	Bare Surface to Built Up	238.68
2	Polygon	0	1	2	13261.1	Bare Surface	2	9	2	3589.33	Bare Surface	Bare Surface Unchanged	1289.19
3	Polygon	0	1	2	13261.1	Bare Surface	3	18	4	4214.68	Vegetation	Bare Surface to Vegetation	566.242
4	Polygon	0	1	2	13261.1	Bare Surface	4	135	3	1670.87	Water Bodies	Bare Surface to Water Bodies	428.154
5	Polygon	1	2	5	67966.4	Agricultural Land	0	1	5	79774.2	Agricultural Land	Agricultural Land Unchanged	64056.7
6	Polygon	1	2	5	67966.4	Agricultural Land	1	2	1	1172.92	Built Up	Agricultural Land to Built Up	648.487
7	Polygon	1	2	5	67966.4	Agricultural Land	2	9	2	3589.33	Bare Surface	Agricultural Land to Bare Surfac	1592.79
8	Polygon	1	2	5	67966.4	Agricultural Land	3	18	4	4214.68	Vegetation	Agricultural Land to Vegetation	1328.06
9	Polygon	1	2	5	67966.4	Agricultural Land	4	135	3	1670.87	Water Bodies	Agricultural Land to Water Bodi	323.159
10	Polygon	2	7	1	970.221	Built Up	0	1	5	79774.2	Agricultural Land	Built Up to Agricultural Land	333.918
11	Polygon	2	7	1	970.221	Built Up	1	2	1	1172.92	Built Up	Built Up Unchanged	170.556
12	Polygon	2	7	1	970.221	Built Up	2	9	2	3589.33	Bare Surface	Built Up to Bare Surface	239.217
13	Polygon	2	7	1	970.221	Built Up	3	18	4	4214.68	Vegetation	Built Up to Vegetation	60.2662
14	Polygon	2	7	1	970.221	Built Up	4	135	3	1670.87	Water Bodies	Built Up to Water Bodies	165.943
15	Polygon	3	11	4	7182.59	Vegetation	0	1	5	79774.2	Agricultural Land	Vegetation to Agricultural Land	4548.61
16	Polygon	3	11	4	7182.59	Vegetation	1	2	1	1172.92	Built Up	Vegetation to Built Up	106.82
17	Polygon	3	11	4	7182.59	Vegetation	2	9	2	3589.33	Bare Surface	Vegetation to Bare Surface	247.463
18	Polygon	3	11	4	7182.59	Vegetation	3	18	4	4214.68	Vegetation	Vegetation Unchanged	2112.49
19	Polygon	3	11	4	7182.59	Vegetation	4	135	3	1670.87	Water Bodies	Vegetation to Water Bodies	163.878
20	Polygon	4	12	3	1039.74	Water Bodies	0	1	5	79774.2	Agricultural Land	Water Bodies to Agricultural La	79.1534
21	Polygon	4	12	3	1039.74	Water Bodies	1	2	1	1172.92	Built Up	Water Bodies to Built Up	7.59578
22	Polygon	4	12	3	1039.74	Water Bodies	2	9	2	3589.33	Bare Surface	Water Bodies to Bare Surface	218.773
23	Polygon	4	12	3	1039.74	Water Bodies	3	18	4	4214.68	Vegetation	Water Bodies to Vegetation	144.624
24	Polygon	4	12	3	1039.74	Water Bodies	4	135	3	1670.87	Water Bodies	Water Bodies Unchanged	589.243

(0 out of 25 Selected)

change_map

Table 3: Change Table for the Study Area

Table

Change_Matrix

OBJECTID *	LandUse_91	Agricultural Land	Bare Surface	Built Up	Vegetation	Water Bodies
1	Agricultural Land	64056.7	1592.79	648.487	1328.06	323.159
2	Bare Surface	10733.9	1289.19	238.68	566.242	428.154
3	Built Up	333.918	239.217	170.556	60.2662	165.943
4	Vegetation	4548.61	247.463	106.82	2112.49	163.878
5	Water Bodies	79.1534	218.773	7.59578	144.624	589.243

(0 out of 5 Selected)

Change_Matrix

Table 4: Change Matrix

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From the table all the land use changes in column are the changes that occurs in 1991 while those in the rows shows the various changes that occurs in 2019.

DISCUSSION

The results presented above clearly show variety of changes on the land use of Numan. A lot really changed from 1991 to 2019 in the area which can be seen on Table 4. From the table, the lowest change that occurred was the 7.60 Hectares of land converted from water body to settlement which is majorly the less likely change to observe unless in the case of creating an island, beach, etc. In the case of Numan, a good number of the settlers are predominantly Fishermen and farmers so they likely will settle around water bodies so when these water bodies reduce or dry up, they may likely extend their buildings hence the 7.60 Hectare change from water body to building. The highest change that occurred was observed to be the 10733.90 Hectare change from bare surface to agricultural land. This is a positive change because it shows an increase in agricultural land which definitely yields an increase in agricultural production. In every land use change, if there is an increase in built up, to create a balance, an increase in agricultural land will do much good. Another change noticed from the table, is the 4548.61 Hectare change from vegetation to agricultural land. This change depicts deforestation and desert encroachment which may have been caused by felling down of trees to either use them for agricultural land or to use for firewood. Deforestation occurs when trees are been cut down without being replaced which can be vividly observed in Numan. Other changes can be observed from the change matrix represented as Table 4 which shows the various land use changes for this project.

CONCLUSION

Land use and land cover of Numan shows vegetation, build-up area, bare soil as well as water body. In the case of Numan, a good number of the settlers are predominantly Fishermen and farmers so they likely will settle around water bodies so when these water bodies reduce or dry up, they tends to extend their buildings, hence 7.60 Hectare change from water body to built-up areas. One of the positive changes that occurred was that 10733.90 hectare change from bare surface to agricultural land. In every land use change, if there is an increase in built up, to create a balance, an increase in agricultural land will do much good. About 4548.61 hectares change from vegetation to agricultural land. These changes depict deforestation and desert encroachment which may have been caused by felling down of trees to either use them for agricultural land or to use for firewood. Agriculture and vegetation dominated land use/land cover for the area studied at an approximate of 85% while Built-up, water body and bare surface covers the remaining 15% before 1991 the major farming activity in Numan was fishing and subsistence farming mainly in the communal as well as intensive commercial farming mainly for those who are high income earners, Vegetation type in the area is mainly savannah grassland with scattered tree. Finally, mapping and monitoring of urban land use growth is possible and very swift using remote sensing and GIS because of its cost effectiveness, reliability, its ability to produce high quality maps at any scale, store and maintain a large quantity of geographically related information, allows users to perform complex analysis by linking data layers and overlaying different datasets to get a spatial perspectives which gives the Town Planning Authority ease in the mapping and monitoring urban spatial growth at cheaper rate and effective manner.

RECOMMENDATIONS

The Paper Recommends that:

In the cause of design and implementation of land use, state governments are encourage to pay attention to entrenching new settlers. The control department on urban development should put more effort so as to control and limit sprawl development at its pace, and thus justifying the reason for such land use layout. Non-governmental organizations (NGOs) and community base organizations (CBOs) should also show their effort in the improvement and the development of the town by maintaining the right of way, providing opportunities for unemployed people in the community to get something to feed themselves through the utilization of their water body and land resources. An integrated assessment of land use/land cover change mapping and spatial and temporal modeling work should be done.

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