IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 13, Issue 3 Ser. II (March. 2019), PP 21-29
www.iosrjournals.org

Geospatial Modelling of Land Use/Land Cover Change Detection, Remotesensing and GIScienceapproach: Adamawa State University Mubi, Nigeria.

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Abstract:*This research focus on examining and analyzing the landuse/land cover change detection that occurred over Adamawa State University Mubi during the period between 2001 to 2014 by geospatial modeling approach. Thisresearch was able to detect and identified the land cover changes that occurred duringthe period of 13 years. The multi-temporal satellites images (MSS, TM, and ETM+) coveringthe study area between 2001, 2006, 2012 and 2014 were used as the primary data sourcesfor this research. The global mapper 13 software, Google Earth, and http://glovis.usgs.gov were used for image acquisition while the ArcGIS 10.1 software was used in thedata analysis such as the classification of the image, calculation of areas and visualizationof cartographic features. The study shows that the Agricultural land use reduced drastically due to increases in Residential land use and institutional land use in the study area. Thisis because of the increase in the institutional land use within the study area which attracts people to reside within the study area. The results further show a high level of accuracy for the selected images for the years 2001, 2006, 2012 and 2014, respectively. Italsoshows that the study area was once very rich in Agricultural land use or vegetation land cover consisting of grass, shrubs, and farmland as at 2001 which later reduced remarkably in 2012 and totally eliminated by 2014 due to changes in the land cover of the study area.*

Keywords:*Land use/Land cover, Change Detection, Remote Sensing, GIS, ASDSU.*

Date of Submission: 27-02-2019 Date of acceptance:13-03-2019

I. Introduction

Research has shown that land use/land cover has been changing from time to time due to human activities on it. Some of the changes are influenced by many factors such as cultural, agricultural, political, historical and economically at large scale. Landcover is referred to as natural vegetation, water bodies, rock/soil, artificial cover and others resulting due to land transformation. Since bothlanduse/landcover are closely related and are not mutually exclusive they are interchangeable as the former is inferred based on the land cover and on their contextual evidence. A serious problemformodeling urban land use/land cover change has been the lack of spatially detailed data (R. Manonmani et al 2010). The GIS and remote sensing have the potential to support such models, by providing data and analytical tools for the study of urban environments. Urban land cover types and their real distributions are fundamental data required for a wide range of studies in the physical and social science, as well as by municipalities for land planning purposes (Stefanov, 2001). The technologies of Geographical Information Systems (GIS) and Remote Sensing have been combined to detect and control urban encroachment in a way which is easier and faster than the traditional methods of surveying the urban environment (Da Costa,1999). However, many shifting land use patterns driven by a variety of social causes, result in land cover changes that affect biodiversity, water and radiation budgets, trace gas emissions and other processes that come together to affect climate and biosphere (Riebsame, et al. 1994).

Land use and land cover are distinct yet closely linked characteristics of the Earth's surface. The use to which we put land could be grazing, agriculture, urban development, logging, and mining among many others. While land cover categories could be cropland, forest, wetland, pasture, roads, urban areas among others. The term land cover originally refers to the kind and state of vegetation, such as forest or grass cover but it has broadened in subsequent usage to include other things such as human structures, soil type, biodiversity, surface, and groundwater (Meyer, 1995).

Land use and land cover are important components in understanding the interactions of the human activities with the environment and thus it is necessary to be able to simulate changes (Kuldeep and Kamlesh, 2011). Land use and land cover change have become a central component in current strategies for managing natural resources and monitoring environmental change (Kuldeep and Kamlesh, 2011).

Remote Sensing (RS) and Geographic Information System (GIS) are now providing new tools for advanced ecosystem management. The collection of remotely sensed data facilitates the synoptic analyses of Earth - system function, patterning, and change at local, regional and global scales over time; such data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of biological diversity (Wilkie and Finn,1996).

For this research, the landuse inventory and monitoring changes that cover Adamawa State University between the years 2001 to 2014 were analyzed and examined. Some changes that affect the agricultural or Vegetation, Residential, institutional and some other land use have been monitor and were exposed.

Residential land-use characteristics were combined with some land uses aiming at institutional development and thus it is proposed for future land-use decisions to local authorities. Information on landuse/landcover in the form of maps and statistical data is very vital for spatial planning, management, and utilization of land for agriculture studies, economic production etc. Today, with the growing population pressure, Lowman-land ratio and increasing land degradation, the need for optimum utilization of land assumes much greater relevance.

II. Materials and Methods:

This part presents the materials and methods used in the study. It provides a general geographical description of the study area together with the methods of data collection and analysis.

Study Area:

The research work covers Adamawa State University in Mubi, Mubi North local government area of Adamawa state. Mubi metropolis is a geopolitical area comprising of two local government areas; Mubi North and Mubi South. The metropolis is located between latitudes 10◦ 05' and 10◦ 30'N of the equator and between longitude 13◦ 12' and 13◦ 19'E of the Greenwich meridian. The two Local government areas occupy a land area of 192,307 Km2 and support a total population of 260,009 people (National Population Census 2006). The area shares boundary with Maiha L.G.A in the South, Hong L.G.A in the West, Michika L.G.A and the Cameroon Republic in the East (Adebayo 2004) as shown in (Figure 1).

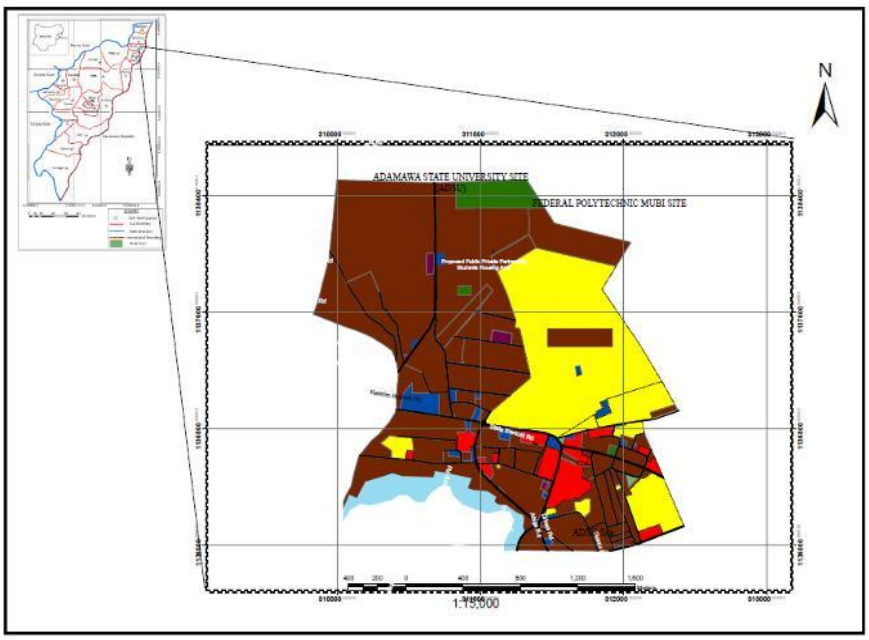

Figure: 1 Map of Adamawa state showing the Study Area.
Source: Geoinformatics Lab Fed. Poly. Mubi.

Methods of data collection:

The major sources of data for land use/land cover change of this research work depends solemnly on multi-temporal satellite images of 2001, 2006, 2012 and 2014 as presented in Figures 2A, 2B, 2C and 2D. Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) Landsat images of the study area for four Epochs; 2001, 2006 and 2012 and 2014 were obtained from Global Land Cover Facility (GLCF) an Earth Science Data Interface. The characteristics of images of the study area were presented in Table 1.

For high accuracy of interpretation, the analysis was done through an integrated coverage of Landsat satellite images (MSS, TM, and ETM+) and an improved and up-to-date high accuracy classification. These

images provide reliable and up to date information on land use and changes of land cover over both space and time which may lead to establishing a trend on land cover change. Field survey had been undertaken to check the accuracy of land cover classification and interpretation.

Table 1. Characteristics of the acquired satellite images.

S/N	Image	Sensor	Resolution	Date of acquisition	Source	Band
1	Landsat 7 2014	ETM+	0x30m	1/11/2014	GLCF	7 band
2	Landsat 7 2012	ETM+	0x30m	28/02/2012	GLCF	7 band
3	Landsat 7 2006	ETM+	0x30m	13/12/2006	GLCF	7 band
4	Landsat 7 2001	TM	0x30m	31/12/2001	GLCF	7 band

Methods of Data Analysis:

To analyze and assess the changes in land cover the most dynamic parameters such as Residential land use, institutional land use, commercial land use, Public land use roads and water body, were examined. ArcGIS 10.2 has been used to Classify and analyze the data. Standardization procedures for land cover classification created by the Food and Agricultural Organization of United Nations (FAO) and Global Land cover (GLC) which is recognized by International Organization for Standardization (ISO) as the standard international approach was adopted. It considered the widely used texture, tone; color and reflectance of the land cover presented in the image. These include image interpretation and classification, field verification and finally data harmonization and finalization. High levels of overall accuracy assessment were obtained before proceedings for the analysis on the images of the years 2001, 2006, 2012 and 2014, respectively. The quantitative data obtained from the analysis of the maps in the form of descriptive statistics were presented informs of tables, graphs, and percentages. Detecting changes over time series of land use and land cover of Adamawa state university were exemplified in the form of maps or chart formats.

Software Used:

The following software was used basically for this research work viz;

- Global Mapper – this software was used for image acquisition from land Sat 7 source and subsequent processing and digitizing of land uses of the existing development on the image. It was also used for the creation and exporting of shapefiles to ArcGIS software.
- ArcGIS – This software was also used to complement the display and processing of the Data.
- Google Earth– was used basically for image comparison.
- Microsoft Excel was used in producing the bars, charts, and graphs.

Development of a Classification Scheme:

Based on the prior knowledge of the study area for over 15 years and a brief Reconnaissance survey with additional information from previous research in the study area, a classification scheme was developed for the study area as shown in table 1. The classification scheme developed gives a rather broad classification where the land use land cover was identified and detected by lines of polygons signifying different use and how those use changes over time.

Table 1: Land use land cover classification scheme

CODE	LAND USE/LAND COVER CATEGORIES
1	Commercial
2	Institutional
3	Public
4	Recreational
5	Residential
6	Vegetation
7	Water Body

Figure 2A: Image of ADSU Area in 2001
Source: Landsat 2001

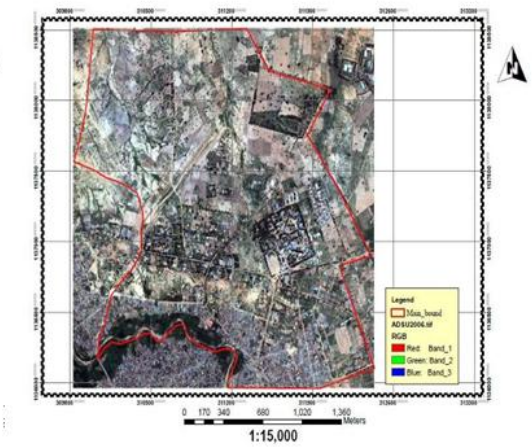

Figure 2B: Image of ADSU Area in 2006
Source: Landsat (2006)

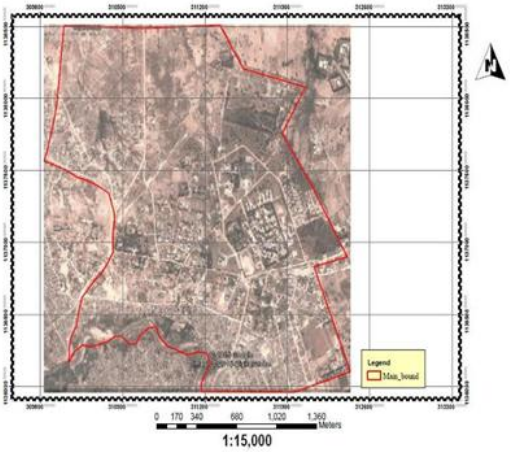

Figure 2C: Image of ADSU Area in2012
Source: Landsat (2012)

Figure 2D: Image of ADSU Area in 2014
Source: Landsat (2014)

III. Results, Analysis and Discussion:

The main objective of this Research work forms the basis of all the analysis carried out in this section. The satellite images covering Adamawa state University (ADSU area) of 2001, 2006, 2012 and 2014 were manipulated in maps, charts, and statistical table formats. They include the static, change, projected and inventory land usesthe land cover of each class. The patterns and percentages in the selected parameters were presented hereafter.

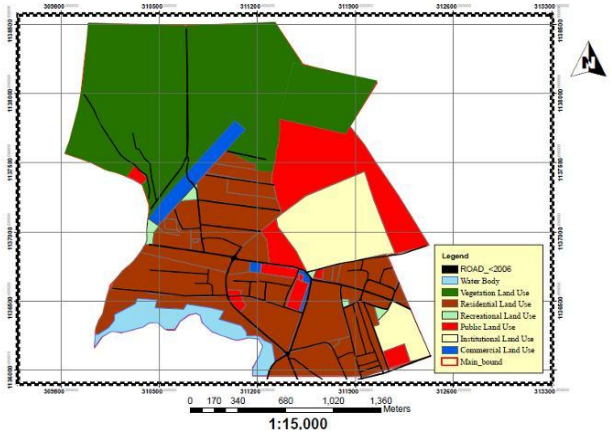

Figure 3: Digitized land use parametersof the ADSU Area in (2001)

Land Use /Land Cover Distribution 2001:

The static land use land cover distribution for 2001 study year as manipulated, calculated and derived from the Landsat satellite image of figure 2a using GIS software are presented in table 2 below.

LANDUSE/LAND COVER CATEGORIES	Year 2001		
	Area (Sq Km)	Area (%)	Cumulative %
Commercial	1.626	10.0	10
Institutional	1.503	9.2	19.2
Public	3.895	23.9	43.1
Recreational	1.721	10.6	53.6
Residential	3.674	22.5	76.2
Vegetation	3.167	19.4	95.6
Water Body	0.717	4.4	100.0

Table 2: Land cover change inventory of 2001

The land cover of the ADSU area shown by the Landsat image of 2001 has been manipulated in map format (Figure 3). It shows that the study area was once very rich in a high number of public land use and Residential land use, they cover 23.9% and 22.5% respectively of the study area as shown in Table 2. It also shows that 19.4% part of the study area were open or dense natural vegetation. Institutional land use only covers a small area, occupying only 9.2% of the study areas.

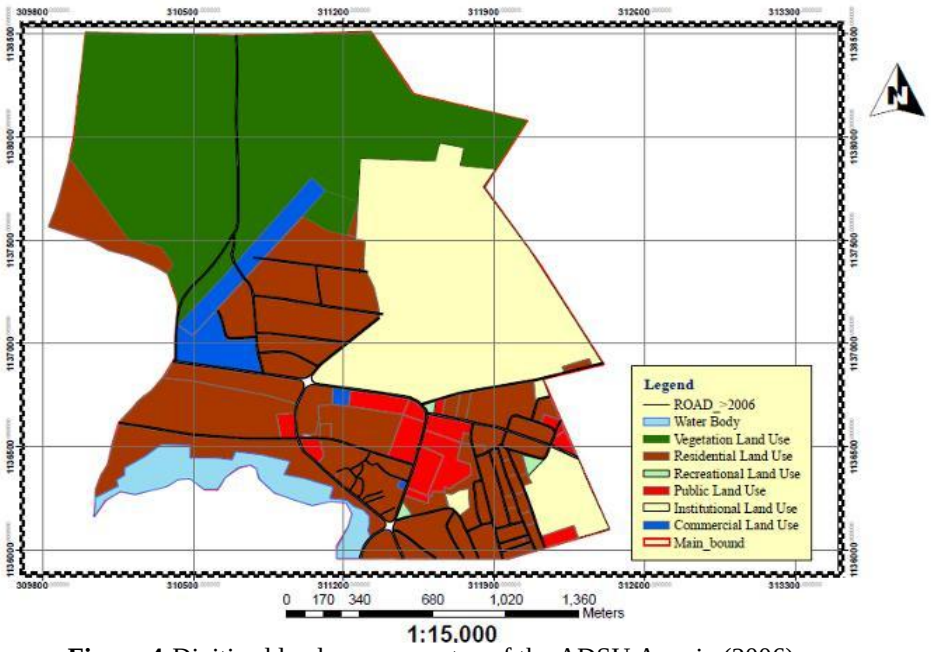

Figure 4: Digitized land use parametersof the ADSU Area in (2006)

Land Use /Land Cover Distribution 2006:

The static land use land cover distribution for 2006 study year as manipulated, calculated and derived from the Landsat satellite image of figure 2b using GIS software are presented in table 3 below.

Residential	4.914	34.1	74.1
Vegetation	3.020	21.0	95.0
Water Body	0.711	4.9	100.0

Table 3: Land cover change inventory of 2006

LANDUSE/LAND COVER CATEGORIES	Year 2006		
	Area (Sq Km)	Area (%)	Cumulative %
Commercial	1.629	11.3	11.3
Institutional	2.648	18.4	29.7
Public	1.071	7.4	37.1
Recreational	0.3993	2.8	39.9

The land cover of the ADSU area shown by the Landsat image of 2006 has been manipulated in map format (Figure 4). It shows that the study area was public land use decreases drastically from 23.9% to 7.4% and institutional land use increases from 9.2% to 18.4%. Residential land use increases from 22.5% to 34.1%, vegetation experience a little increase from 19.4% to 21.0% as shown in Table 3. It also shows that a decrease in public land use was due to the increase in the institutional land within the study area. Waterbody almost maintains its area with just a little variation.

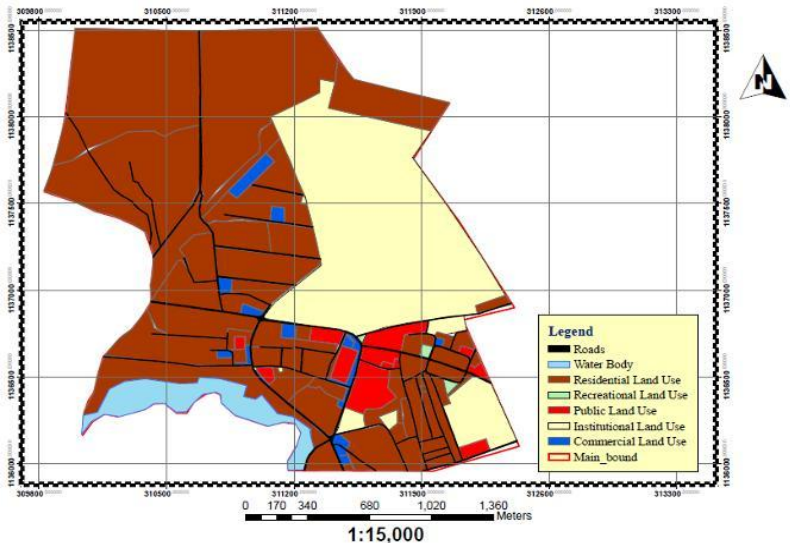

Figure 5: Digitized land use parametersof the ADSU Area in (2012)

Land Use /Land Cover Distribution 2012:

The static land use land cover distribution for 2012 study year as manipulated, calculated and derived from the Landsat satellite image of figure 2c using GIS software are presented in table 4 below.

LANDUSE/LAND COVER	Year 2012		
	Area	Area	Cumulative %
CATEGORIES	(Sq Km)	(%)	
Commercial	2.902	20.1	20.1
Institutional	2.992	20.7	40.7
Public	1.132	7.8	48.5
Recreational	0.1991	1.4	49.9
Residential	6.563	45.3	95.3
Vegetation	0	0.0	95.3
Water Body	0.684	4.7	100.0

Table 4: Land cover change inventory of 2012

The land cover of the ADSU area shown by the Landsat image of 2012 has been manipulated in map format (Figure 5). It shows that the study area experience a Rapid change in land use. The Commercial and institutional land use have 20.1% and 20.7% respectively, the Residential land use increases from 34.1% to

45.3%. The vegetation experience a total loss in land from 21.0% to 0.0% as shown in Table 4. Waterbody almost maintains its area with just a little variation from 4.9% to 4.7%.

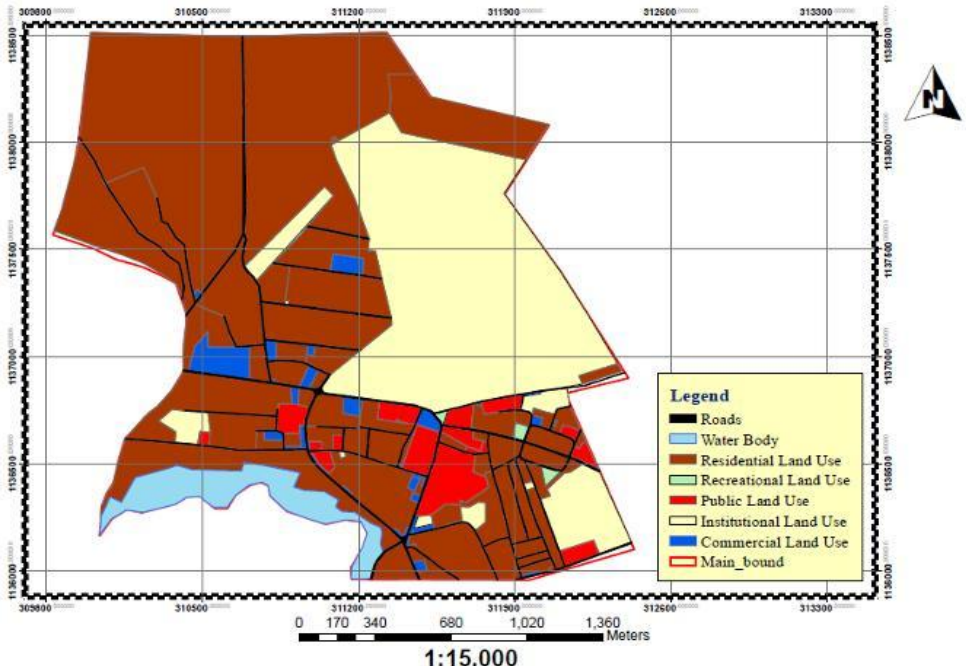

Figure 6: Digitized land use parameters of the ADSU Area in (2014)
Land Use /Land Cover Distribution 2014.

The static land use land cover distribution for 2014 study year as manipulated, calculated and derived from the Landsat satellite image of figure 2d using GIS software are presented in table 5 below.

LANDUSE/LAND COVER	Year 2014		
	Area	Area	Cumulative %
CATEGORIES	(Sq Km)	(%)	
Commercial	3.343	17.8	17.8
Institutional	4.357	23.3	41.1
Public	3.642	19.4	60.5
Recreational	0.2012	1.1	61.6
Residential	6.502	34.7	96.3
Vegetation	0	0.0	96.3
Water Body	0.693	3.7	100.0

Table 5: Land cover change inventory of 2014

General Inventory of change in land use/land Cover in ADSU Area

This study has shown that there is an absolute increase in the area covered by Residential with a maximum increase during the period 2001-2012 as shown in Tables 2 and 3 as well as in, Fig. 5, although it decreases in 20014 fig. 6 due to the introduction of institutional land use at the lower left Conner of the map. The figures showed a continuous decrease in the Vegetation area during the period 2001-2014. The reason that Residential land use increases with the increase in institutional land in the area are because more people are attracted to reside close to those institutions for easy access. All this increase is at the expense of the area covered by vegetation-land use which in general shows a continuous negative trend (decrease in the cover area) from 19.4 – 21 to 0 and 0 respectively. These results reflect a gloomy natural environmental condition which is caused mainly by Increase in population of the people eager to reside within the study area.

LAND COVER CHANGE DURING DIFFERENT PERIOD IN ADSU AREA								
Environmental Parameters	2001		2006		2012		2014	
	Area(Sqkm)	%	Area(Sqkm)	%	Area(Sqkm)	%	Area(Sqkm)	%
Commercial	1.626	10	1.629	11.3	2.902	20.1	3.343	17.8
Institutional	1.503	9.2	2.648	18.4	2.992	20.7	4.357	23.3
Public	3.895	23.9	1.071	7.4	1.132	7.8	3.642	19.4
Recreational	1.721	10.6	0.3993	2.8	0.1991	1.4	0.2012	1.1
Residential	3.674	22.5	4.914	34.1	6.563	45.3	6.502	34.7
Vegetation	3.167	19.4	3.02	21	0	0	0	0
Water Body	0.717	4.4	0.711	4.9	0.684	4.7	0.693	3.7

Table 6: General Land cover change inventory of ADSU Area (2001-2014).

Recreational	-1.3217	-7.8	-0.2002	-1.4	0.0021	-0.3	-1.5198	-9.5
Residential	1.24	11.6	1.649	11.2	-0.061	-10.6	2.828	12.2
Vegetation	-0.147	1.6	-3.02	-21	0	0	-3.167	-19.4
Water Body	-0.006	0.5	-0.027	-0.2	0.009	-1	-0.024	-0.7

PERCENTAGE OF LAND COVER CHANGE DURING DIFFERENT PERIOD IN ADSU AREA								
Environmental Parameters	2001-2006		2006-2012		2012-2014		2001-2014	
	Area(Sqkm)	%	Area(Sqkm)	%	Area(Sqkm)	%	Area(Sqkm)	%
Commercial	0.003	1.3	1.273	8.8	0.441	-2.3	1.717	7.8
Institutional	1.145	9.2	0.344	2.3	1.365	2.6	2.854	14.1
Public	-2.824	-16.5	0.061	0.4	2.51	11.6	-0.253	-4.5

.**Table 7:** General Percentage Land cover change inventory of ADSU Area (2001-2014)

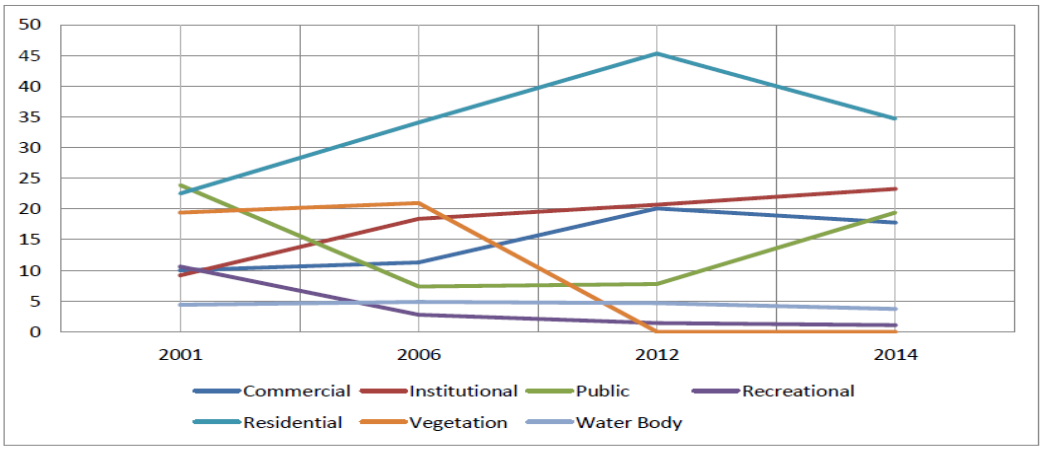

Figure 7: Land Cover Change in the measured parameters during Different time periods (2001-2014)

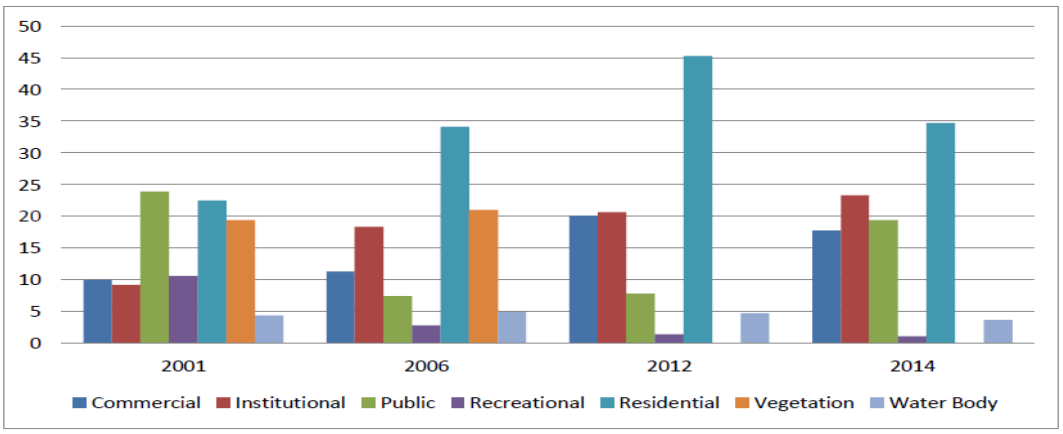

Figure 8: Percentage Land Cover Change in the measured parameters during Different time periods (2001-2014)

IV. Recommendations

Thegeospatial modeling of land use/land cover was found to be more effective in the inventory and analysis of data. Therefore, it was recommended that the urban and regional planning of Mubi L.G.A. Adamawa State Should follow/checkmate and control the usage of land in the study area especially the residential land use since development is been carried out on daily bases and best practice is needed. In order to implement the overall land use/land changes, it is recommended special consideration should be given to all the changes especially the drastic and total loss in the vegetation land use to minimize the effect of global warming and impact of climate change to the research area.

An integrated assessment of land use/land cover change mapping and spatial and temporal modeling works should be done through the application of GIS and remote sensing and the use of cellular Automata/Markov Chain. Finally, we will like to recommend that the management should stick to proper land utilization so that the new developments should not be placed or concentrated on one side of the institution.

V. Summary and Conclusion:

In this research work, an investigation was made to detect the possible land use and land cover that occurred within the period of 13 years by accurately capturing seven (7) classes of land use from Landsat imagery. This study haspointed out one of the significances and capability of GIS and Remote Sensing in capturing spatial-temporal data. The change in land use and land cover in ADSU area between 2001 to 2014 can be explained by the complete or total loss in vegetation-land use due to increase in institutional land use area and residential surrounding it. The expansion of institution creates competition over the natural resources of the land mass by the residential land use within the study area which will make the study area more vulnerable to heat during the hot season. The minimum change was observed in water body which was almost insignificant because there was no case of flooding in the study area and the river is located at the lower bottom of the study area which gives a maximum change of 0.5% in 2006 and a minimum of -0.7% in 2014. The residential area expanded rapidly in the last 11 years from 22.5% in 2001 to 45.3 in 2012 and then it falls a little to 34.7 within two years i.e. 2014. The total difference in the area was -1.9107 Km^2 2001 to2006, +0.0798Km^2 from 2006 to 2012, +4.2661Km^2 from 2012 to 2014 and 2.4352 from 2001 to 2014 respectively.

Acknowledgment

We thank the anonymous reviewers for their constructive comments and suggestions.

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Aminu Abdulwahab. " Geospatial Modelling Of Land Use/Land Cover Change Detection, a Remotesensing and Giscienceapproach: Adamawa State University Mubi, Nigeria.." IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT) 13.3(2019): 21-29.