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ANALYSIS OF THE SPATIO-TEMPORAL DYNAMICS OF MUBI AREA, ADAMAWA STATE, NIGERIA

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ABSTRACT

Advancement in technology has greatly facilitated the acquisition of data for all form of research. Recently, Remote Sensing and GIS have become a powerful technology for generating geo-spatial data about geographical features. In this research, Landsat satellite images were used to analyze the spatio-temporal dynamics of Mubi from 1988 to 2010. Idrisi Taiga software was used for classification and area calculation while Arcgis 9.3 was used for visualization. The study showed increase in Built-up area and decrease in Vegetation cover, bare surfaces, and Farmlands. The need for control measures on urban spread out onto agricultural lands is recommended among others.

KEYWORDS: Landuse/Landcover, Landsat, Idrisi Taiga, Classification.

INTRODUCTION

Urbanization is a global phenomenon and one of the most important reforming processes affecting both natural and human environment through many ecological and socio-economic processes (Mandelas, *et al.*, 2007). Currently, communities worldwide need spatial data to compensate for and adapt to the present urban growth while planning for expected future change and its impacts on infrastructure, as well as the surrounding environment. Rapid rates of urban land use change and rate of urbanization are now at the forefront of local political disputes (Goetz, *et al.*, 2003).

According to Meyer, (1995) every parcel of land on the Earth's surface is unique in the cover it possesses. 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 referred 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 ground water (Meyer, 1995). However, many shifting land use patterns driven by a variety of social causes, result in land cover changes that affects 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/land cover change is a key driver of global change (Vitousek, 1992) and has significant implications for many international policy issues (Nunes and Auge, 1999).To understand how landuse/landcover (LULC) change affects and interacts with global earth systems, information is needed on what changes occur, where and when they occur, the rates at which they occur, and the social and physical forces that drive those changes (Lambin, 1997). The information needs for such a synthesis are diverse. Remote sensing has an important contribution to make in documenting the actual change in land use/land cover on regional and global scales from the mid-1970s (Lambin *et al.*, 2003).

Land use/cover Change detection is very essential for better understanding of landscape dynamic within a known period of time for sustainable environmental management. Land use and land cover change has been recognized as an important driver of environmental change on all spatial and temporal scales (Tansey *and* Millington, 2006), as well as emerging as a key environmental issue on a regional scale.

Changes may involve the nature or intensity of change but may also include spatial (forest abatement at village level, or for a large-scale agro industrial plant), and time aspects. Land use/ Land cover changes also involve the modification, either directly, or indirect, of natural habitats and their impact on the ecology of an area (Rogan, 2004).

Studies have shown that only few landscapes on the Earth surface are still in their natural state (Singh, 1989). Due to anthropogenic activities, the Earth surface is being significantly altered in some manner and man's presence on the Earth and his use of land has had a profound effect upon the natural environment thus resulting into an observable pattern in the land use/land cover over time.

Arvind and Nathawat (2006) carried out a study on land use land cover mapping of Panchkula, Ambala and Yamunanger districts, Hangana State in India. They observed that the heterogeneous climate and physiographic conditions in these districts has resulted in the development of different land use land cover in these districts, an evaluation by digital analysis of satellite data indicates that majority of areas in these districts are used for agricultural purpose. An analysis of land use and land cover changes using the combination of Multispectral scanner (MSS) Landsat and land use map of Indonesia (Dimyati, 1995) reveals that land use land cover change were evaluated by using remote sensing to calculate the index of changes which was done by the superimposition of land use land cover images of 1972, 1984 and land use maps of 1990. This was done to analyze the pattern of change in the area, which was rather difficult with the traditional method of surveying as noted by Olorunfemi, (1983) when he was using aerial photographic approach to monitor urban land use in developing countries with Ilorin in Nigeria as the case study.

Mubi metropolis as a geo-political area is comprised 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 192,307Km2 and support a total population 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 Cameroon Republic in the East. Figure 1.

The growth of Mubi town is traced to the agricultural, administrative, and commercial functions it performs. By 1902, Mubi was a German base from where the neighbouring tribes (i.e Fali, Gude, Kilba, Higgi, Margi and Njanyi) of the region were subjugated. On 1st April 1960, Mubi was made Native Authority headquarters. The same year, July 1960, the town became provincial headquarters of the defunct Sardauna province. In 1967, Mubi was made L.G.A headquarters while in 1996, the town was splinted into Mubi-North and Mubi-South Local Government Areas. Currently, the town is the seat of Mubi Emirate Council and the headquarters of Adamawa-North Senatorial District.

Mubi is geographically well placed and functions not only as center of commerce in the region but also extends its sphere of influence to countries such as Cameroun, Central Africa Republic and Chad. Numerous banks, filling stations and hotels exist in the town to support the commercial activities. Another factor that led to growth of the town is rural-urban migration experienced from the surrounding villages. More over the town has become center of learning with numerous tertiary and secondary institutions established in the metropolis.

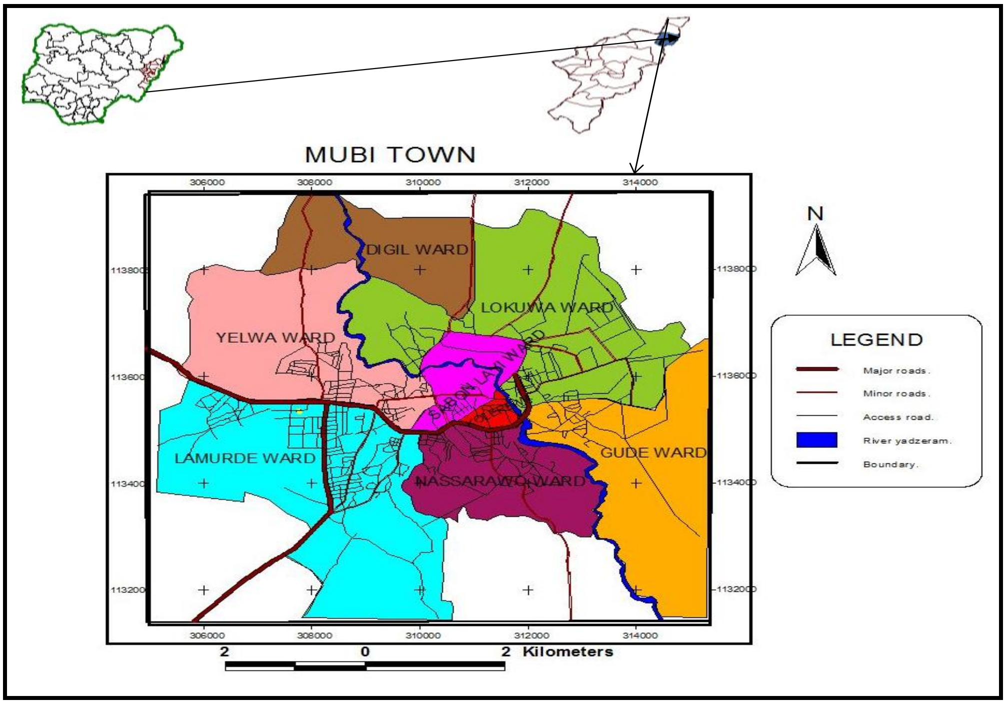

Figure 1: The Study Area
Source: GIS LAB., ADSU, MUBI

MATERIALS AND METHODS

The materials that were used for this study involve both primary and secondary data. The Primary data were collected through field observation and the use of GPS to collect the coordinates of features in the study area for ground truthing which was integrated into the GIS environment for error matrix in order to ascertain the accuracy level of the images classified according to number of classes under study such as Bare-surfaces, Built-up area, Vegetation and Rock-out crop and Farm land. The Secondary data used for this study included Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) Landsat images of the study area for three Epochs; 1988, 1999 and 2010. These were obtained from Global Land Cover Facility (GLCF) an Earth Science Data Interface. Table 1 shows characteristics the images used.

Hardware and Software

A HP 530 Laptop, HP colour printer and hand held GPS (Garmin 72) are the main hardware used for this study. The software used included GIS and non-GIS packages. IDRISI Taiga (GIS software) was used to manipulate and perform feature identification, recognition and classification. It was also used for calculation of area and statistical analysis. ARCGIS 9.3

was the other GIS software used for map visualization. The non-GIS Software used was Microsoft word 2007 for word processing.

Table 1: Characteristics of the acquired satellite images

S/N	Image	Sensor	Resolution	Date o f acquisition	Source Band
1	Landsat 7 2010	ETM+	30x30m	07/02/2010	GLCF 7 bands
2	Landsat 7 1999	ETM+	30x30m	10/12/199	GLCF 7 bands
3	Landsat 7 1988	TM	30x30m	07/11/1987	GLCF 7 bands

Radiometric correction

The Landsat scenes used in this research were radiometrically corrected so there is no need to repeat the process that may reduce the quality of the spectral data. By checking the header of Landsat imageries it was found that Lansat TM 1988 was acquired at 8-bit data where the Landsat ETM 2010 was captured as 16-bit data. For later processing Landsat ETM 2010 was synchronized to 8-bit data by rescaling the image. The spectral distribution of bands of Landsat ETM 2010 was normalized to Landsat TM 1988, which was chosen as a standard scene. The radiometric correction was conducted because it is impossible to obtain radiometric measurements for historical Landsat images. Images of the study area were then extracted from Landsat ETM+ 1999 and 2010, and Landsat TM 1988. All the images were sub-mapped using X and Y coordinate: Top left X=303851.47 and Y=1138946.14 Bottom Right X=318971.22 and Y=1130372.38 and the window extracts sub-image automatically from the original image. Colour composite was then performed for the purpose of enhancing the images, as it allow for simultaneously visualization of information from three separate bands of the images. Training sites were developed in Idrisi Taiga user interface with unique value to each of the classes (farmland, Bare surface, Built-up area, vegetation and Rock outcrop.) after which the images were classified using maximum likelihood classifier for each epoch (1988, 1999 and 2010) as shown in figure 2, 3 and 4 respectively.

RESULTS AND DISCUSSION

Land Use Land Cover Distribution

The classes for the land use land cover distribution for each study year as derived from the maps are presented on the Table 2.

This was achieved with the aid of statistical module of area calculation in Idrisi Taiga.

Table 2: Land Use Land Cover Distribution for Mubi Town (1988, 1999, 2010)

Landuse/land cover Categories	1988		1999		2010	
	Area (Ha.)	Area (%)	Area (Ha.)	Area (%)	Area (Ha.)	Area (%)
Built-up land	908.58	11.36	1094.34	13.68	2197.62	27.48
Bare surface	509.36	6.37	565.25	7.07	473.69	5.92
Vegetation	847.50	10.60	1276.53	15.96	363.26	4.55
Rock-out-crop	221.66	2.77	95.03	1.19	230.69	2.88
Farm land	5509.82	68.90	4965.77	62.10	4731.67	59.17
Total	7996.93	100	7996.93	100	7996.93	100

The results presented on Table 2 above represents the area of each land use land cover category for each study year. Built-up area in 1988 occupies 11.36% of the total land. Farmland has the highest area class with 68.90%, taking up more than half of the total area. This may be due to the fact that the town was in its traditional setting where farming seems to form the basis for living.

In 1999 Built-up area occupies 13.68% of the total land as results of increase in population. Farming activities seems to have reduced compared to 1988. This may be attributed to urban growth as more lands are used for building of houses, road construction and commercial activities there by occupying 62.10% of the total area of classes. The rock-outcrop occupies 1.19% which may be due to flattening of the rocks for housing and the bare surface covers 7.07% compared to 6.37% in 1988 possibly as a result of clearing of some vegetation and people buying lands for future development. Vegetation cover increased to15.96% as compared to 10.6% more than 1988 due to the fact that knowledge of gardening is becoming prominent as shown in Fig. 3.

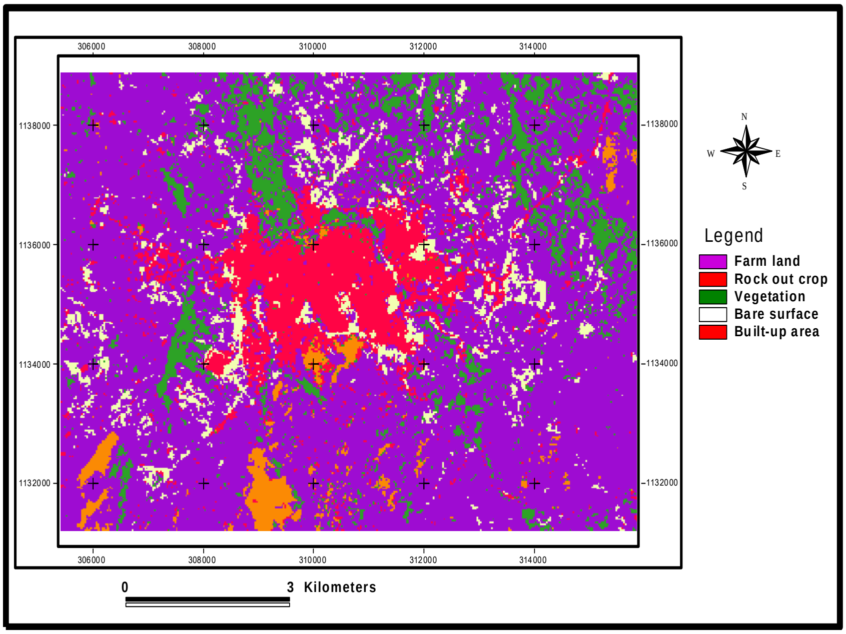

Figure 2: Classified Lansat TM of Mubi 1988

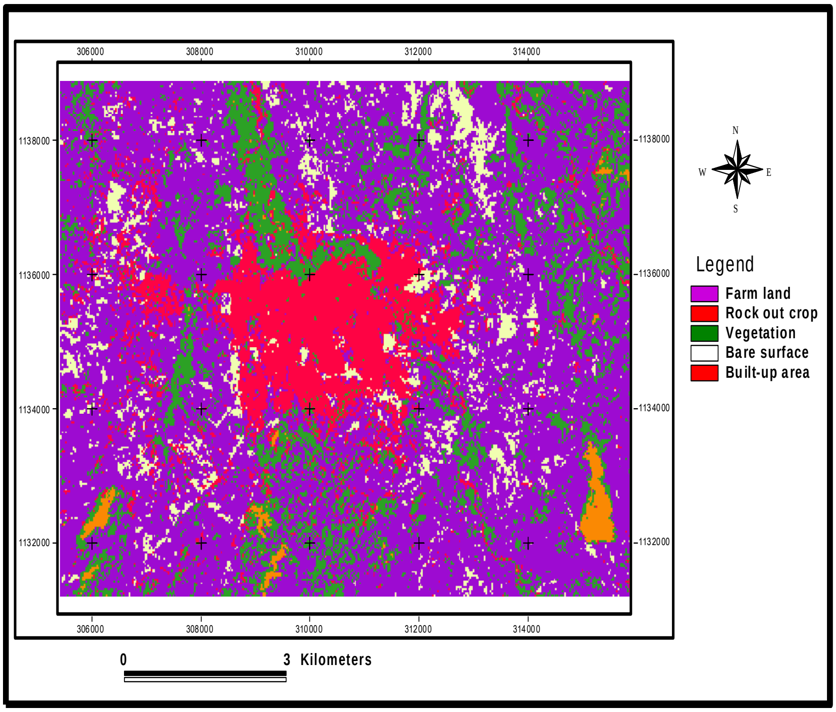

Figure 3: Classified Lansat ETM+ of Mubi 1999

By 2010, built up area has increased by 27.48%. This is probably based on many factors such as Establishment of Adamawa State University, concentration of schools, availability of social amenities, good security, better climatic condition and fertile land. Farmlands reduced to 59.17%. The main reason for the reduction of the farmlands was development associated with urbanization, where structures were raised for housing and commercial activities. Bare surfaces decreased to 5.92% due to its conversion to other land uses such as built-up area. Rock outcrop increased to 2.88% owing to continual denudation processes such erosion and mass movement. Vegetation decreased to 4.55% increasing anthropogenic activities such as farming, and expansion of built-up area as shown in Fig. 4.

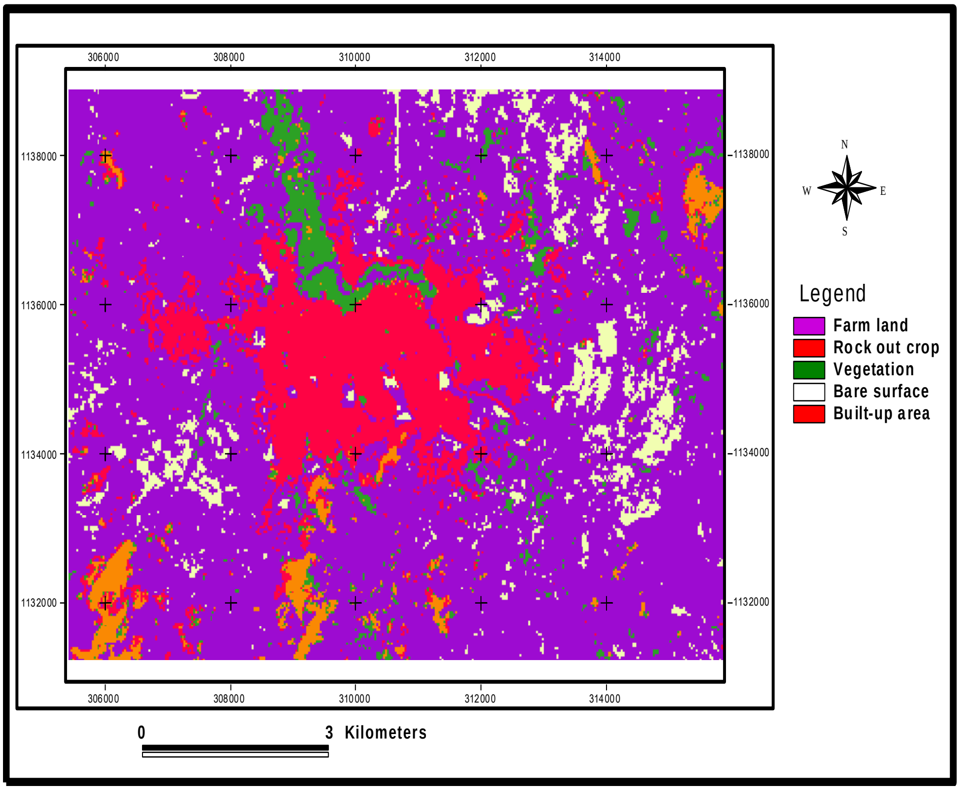

Figure 4: Classified Lansat ETM+ of Mubi 2010

Table 3: Land Use Land Cover Change: Trend, Rate and Magnitude

LANDUSE/LAND COVER CATEGORIES	1988 – 1999		1999 – 2010	
	AREA (Ha.)	PERCENTAGE CHANGE	AREA (Ha.)	PERCENTAGE CHANGE
BUILT-UP AREA	185.76	2.32	1103.28	13.8
BARE SURFACE	55.88	0.7	-91.56	-1.5
VEGETATION	429.03	5.36	-913.27	-11.41
ROCK-OUT-CROP	-126.63	-1.58	135.66	1.6
FARM LAND	-544.05	-6.8	-234.10	-2.93

From table 3, Built-up land increased by 2.32% while both vegetation and bare surface both increased by 5.36% and 0.7% respectively. There seems to be a negative change i.e. a reduction in farm land between 1988 and 1999. This may not be unconnected to the change in the economic base of the town from farming to business and other white collar jobs as a result of the creation of Mubi south Local Government in 1992. The period between 1999 and 2010 witnessed an increase in the rate at which the physical expansion of the city was going compare to 1988 and 1999. For instance, the built-up area increased by 13.8% as against the 2.32% increase between 1988 and 1999. This is connected to immigration and urbanization of the town. Also, there was a general decrease of 2.93% in farmlands owing to their conversion to housing plots, roads construction, institutional building, markets, facilities, utilities and services structures. Bare surfaces decreased by 1.5% as a result of it being converted to other uses. Vegetation witnessed reduction of 11.41%. This is connected to the anthropogenic activities such road construction, farming and building.

Consequences of Land cover changes

Since the study showed rapid increase in built-up areas at the expense of other landuses/landcover, Mubi is likely to be congested in the near future. This situation will pose negative implications in the area because of the associated problems of crowdedness such as crime and easy spread of communicable diseases. The gradual decrease in farmlands and vegetation may result to food insecurity.

CONCLUSION

This research work demonstrates the ability of GIS and Remote Sensing in capturing spatial-temporal data. Attempt was made to capture as accurate as possible five land use land cover classes as they change through time. The five classes were distinctly produced for each study year but with more emphasis on built-up land as it is a combination of anthropogenic activities that make up this class; and indeed, it is one that affects the other classes. However, the result of the work shows a rapid growth in built-up are between 1988 and 2010.

It is recommended that there should be a control measure on urban spreading out to agricultural land as this will have serious repercussions on food production. An integrated assessment of land use/land cover change mapping and spatial and temporal modeling works should be done. The task has to integrate remote sensing, spatial metric tools and socio-economic data to manage urban growth and expanding impervious surfaces.

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