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# Spatio-Temporal Assessment of Urban Expansion on Agricultural Landuse in Mubi Town Adamawa State, Nigeria

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**Abstract**
This research examined the potentials of GIS and remote sensing techniques in spatio-temporal assessment of urban expansion on agricultural land-use in Mubi town, from 1987 to 2010 so as to detect the change that has taken place in this status between these periods. Attempt was also made to project the subsequent change for the next 10 years 2020. In achieving this, the satellite imageries were classified (supervised classification) into various land uses, database for the land uses were created and change detection using statistical graph was introduced. GIS Software such as ArcView3.2a, ILWIS 3.1, ArcGIS, and Idrisi, were used for spatial analysis. Primary data was also analyzed using simple statistical analysis. The result of the work shows a rapid expansion in built-up area between 2000 and 2010, while the period between 1987 and 2000 witness gradual expansion. It was also observed that change by 2020 may likely follow the trend in 1987 and 2000. Suggestions were therefore made at the end of this work for further planning and decision making at both state and local government levels.

*Key Words: Geographic Information System, spatio-temporal, land use, urban expansion*

## Introduction

In recent times, cities and towns in developing countries have been observed to experience unprecedented growth in size and number. It is estimated globally that more than five billion people will live in urban areas by 2025 and eighty percent of these are expected to live in cities in developing countries (ITC, 2005). Urban expansion is one of the important areas of man's interaction with his environment with great impact on the natural land cover. The rapid expansion of urban centers in developing countries has continued to pose great challenges to a broad range of experts. The multidisciplinary scope of urban expansion invokes interests from ecologists, planners, civil engineers, sociologists, administrators and policy makers for no other reason than to know how much expansion is taking place and how the effect of the expansion on land use /land cover can be reduced. Urban expansion simply serves as strong agent of land use/land cover change (LULCC). Accelerated Urban growth is usually associated with and driven by the population concentration in an area. The extent of urbanization or its growth drives the change in land use pattern (Gardon et al, 1992; Paul and Meyer, 2001; Weng, 2001). Urbanization in most countries has historically pushed all forms of agriculture out of the city and into the rural areas, considering it too dirty for the wealth and glory of the city.

Urban expansion may be regarded as the continuous increase in size or growth of an urban settlement in terms of population and physical development. Klosterman et al (2006) refers to urban sprawl as the areal expansion of urban concentrations beyond what they have been. Urban expansion involves the conversion of land Periphery to urban centers that has previously been used for non-urban uses to one or more urban uses (Northam, 1979). There are factors usually responsible for the expansion of urban areas, such as accessibility, economic activities, administration, and presence of social amenities, institutions, infrastructural facilities, and nature of soils, absence of disaster, relief and climate, among others. Such factors attract people from far and near into a particular city or town, most of which are likely to settle permanently. The history of Mubi being generally conducive environment, with peaceful atmosphere that favours economic and social activities, agricultural productivity, the administrative functions, political party secretariats, it has become one of the major commercial centers in as well as the largest urban area after Yola, the state capital of Adamawa State. Such activities and functions require other services like medical services, hotels, institutions of learning, security services, and office buildings, amongst others. As a result, more space of land would be required in order to satisfy these demands (Adesina 2005).

Urban expansion has both positive and negative effects on the urban and peri-urban dwellers. Lands are sold to meet other needs, establish business and build residential; on the other hand, there would be competitions. Accurate information on the extent of urban expansion and growth is of the great interest for the municipalities of growing urban and suburban areas for diverse purpose such as urban planning, water and land resources allocation etc. Recently, remote sensing has been used in combination with Geographic Information System (GIS) to assess land cover change more effectively than by remote sensing data alone. It has already proved useful in mapping urban areas, and as data source for the analysis and modeling of urban growth and land use/land cover change (Harris 2013).

The quest for food, shelter, clothing and other necessities of life by the alarming increase in human population in Mubi town possess great challenges on agricultural land uses (Appeaning 2009). There seems to be encroachment by other land uses such as residential, industrial, infrastructural, commercial, and recreational landuse into agricultural land use. High concentration of people tends to bring about land fragmentation which reduces the size of farmland and leads to low yield. This prompted the researcher to carry out the study in order to assess the impact of urban expansion on agricultural land use in Mubi using remote sensing and geographic information system. Although, many authors have addressed the issue of urban sprawl, urban expansion and their environmental consequences on land, human and non-human resources from different perspective, yet little or no much has been said about the rapid development of Mubi town at the detriment of agricultural land use which supply local food stuff, source of livelihood to both urban and peril-urban low income dwellers (Bashir 1999).

**Materials and methods**

A number of methods that differ in approach, accuracy, cost and duration have been developed to meet the demand for higher accuracy in assessing, monitoring and determining the extent of urban expansion. The overall methodological design for the study is shown in figure 1 below.

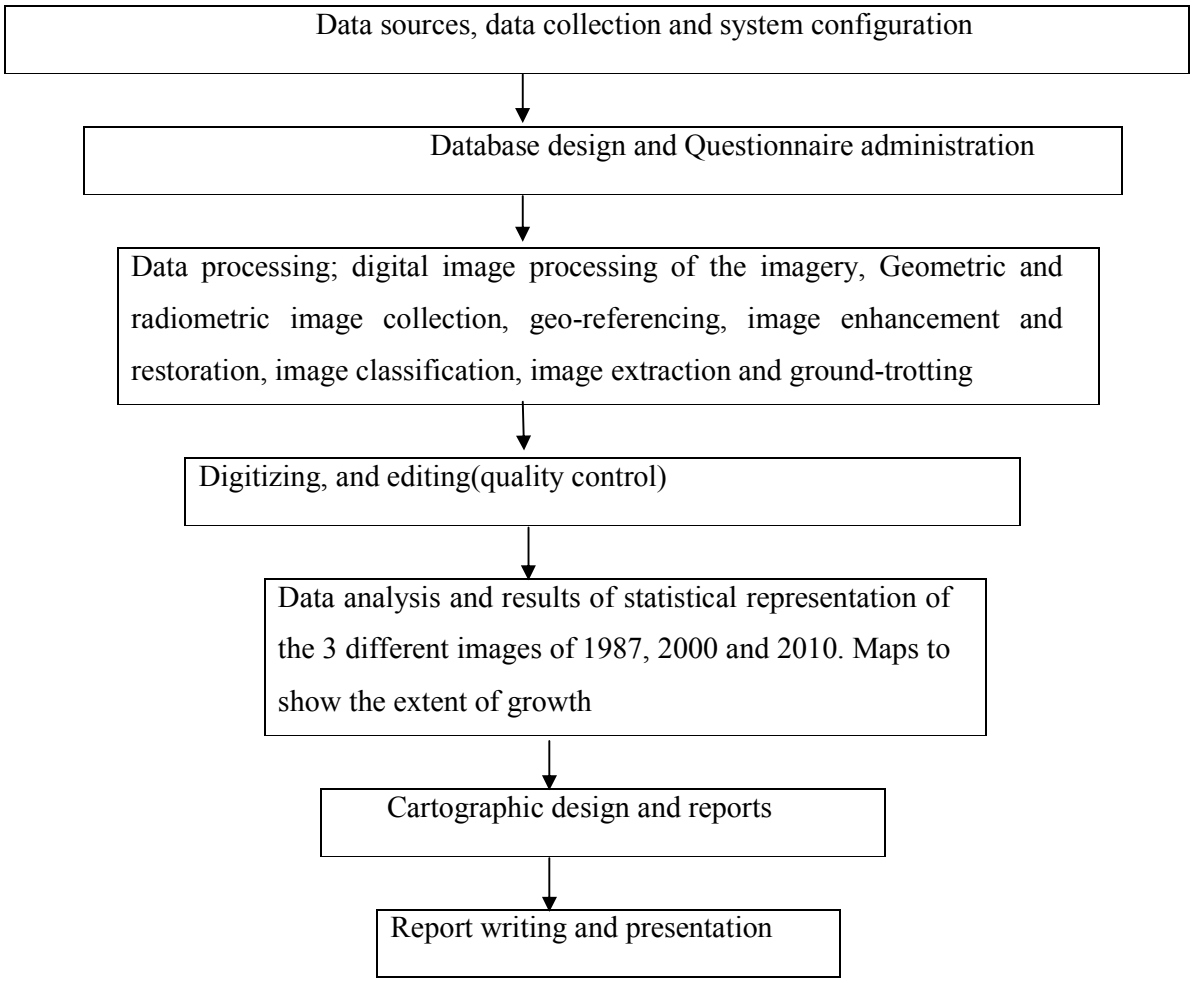


***Figure 1: Data acquisition procedure flow chart***

**Study area**

According to Adebayo (1999), Mubi town lies between latitude $9.30^0$ and $11^0$ North of the equator and longitude $13^020^{'}$ and $13^0$ 35' East of Greenwich meridian. Mubi metropolis comprises two Local Government Areas, namely; Mubi North and Mubi South local government areas. Mubi has a vast range of mountains which makes it unique with distant relief configuration along the eastern border with Cameroon. It is bounded in the north by Michika Local Government, in the west by Hong/Maiha Local Government Areas, to the south and east by the Republic of Cameroon. It has a land mass of 4738.77km2 and a population of 260,009 (NPC 2006). Mubi is on the high relief of Adamawa state with elevation ranging from 400 to 1500 meters above mean sea levels (Adebayo,

1997). The relief of Mubi is divided into two (2) zones. The highlands/mountain ranges and high plains. The highlands generally occupy the eastern part of the town. It stretches from north to south inform of chains of mountain ranges. The peaks of some of the mountain ranges vary from 1200 to 1500m while their bases vary from 800m to 900m. Prominent among these ranges are Gella, Vimtim, Mijilu, Mizza/Kirya and Duda ranges. The major drainage system in the study area is the River Yadzaram which takes its sources from the Gella hills.

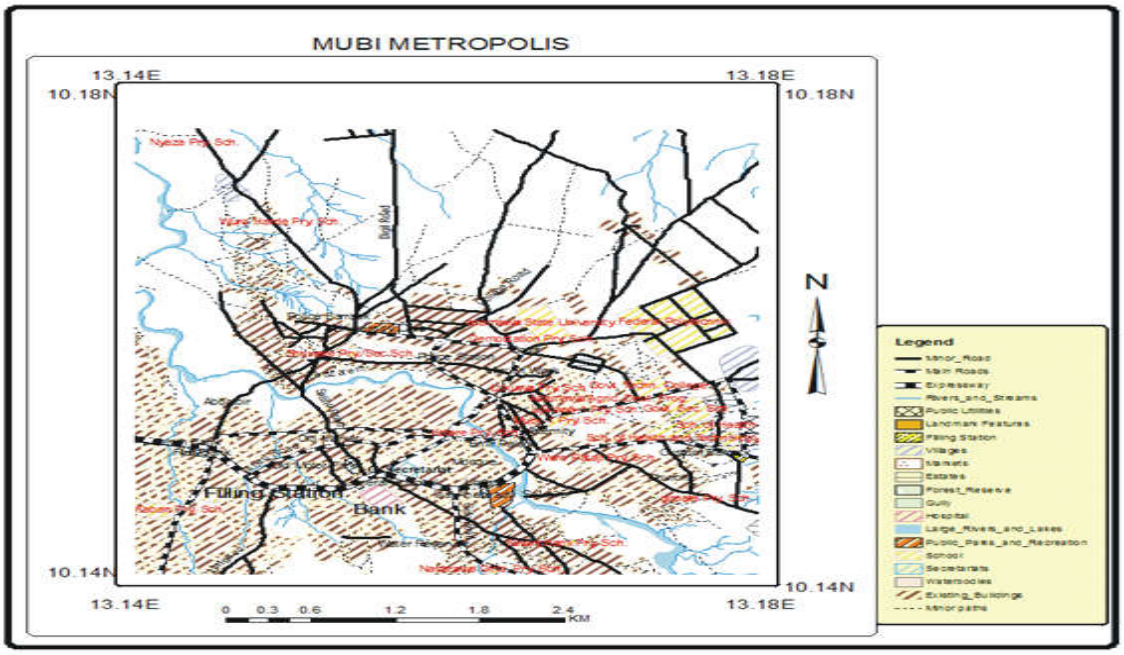


Fig.1 Study Area

**Data requirement**

**Primary data**: The primary data were collected through field observation with the use of Global Positioning System (GPS) to capture coordinates of the new development sites in the study area, (Barama, Gipalma, Tudun-wada, Sabon-Gari, Wuro-Harde, Dazala and Arhan-Kunu) which were integrated into GIS environment for further analysis. A set of questionnaires were administered on the residents of those locations, during which the pattern of urban expansion were observed. The questionnaires seek to find information on the factors that leads to rapid expansion, effects of the rapid expansion on agricultural landuse in particular, and other environmental resources in general. From the sampled size, the researcher selected six (6) villages systematically and drew 5 respondents from each village randomly (total of 30 respondents). A non-probability sampling technique was

adopted to administer the questionnaire in which a researcher decides whom to make part of his respondents.

**Secondary data:** the secondary data used include; topographical maps, land-use maps, population census figures. Three different Landsat images were used: Multi-spectral LANSAT TM 1987, LANSAT ETM 2000 and LETM 2010, downloaded from Global Land Cover Facility webside (http://glcfapp.umd.edu:8080/esdi/index.jjsp). Other secondary data used include information from journals, textbooks, paper/thesis, reports and other related sources.

**Software used includes;**

i. ArcView 3.2a ( for cartographic modeling)
ii. ILWIS 3.1 academy (for geo-referencing, and image processing)
iii. IDRISI Taiga (for change detection and prediction)
iv. Microsoft Word(for word processing)
v. Microsoft Excel ( for presentation of charts)
vi. Microsoft Office Access (for database management)
vii. ArcGIS (for cartographic modeling)

**Hardware component include:**

i. ADSU e-class laptop
ii. colour printer(for colour graphics)
iii. scanner( for data input)
iv. PC System
v. Hand held Germin GPS for data capturing/collection.

**Data processing**

Image acquired were digitally processed in the GIS environment using various Geographic Information System Software for georeferencing, image classification, generation of land use maps, change detection and other geospatial analysis.

**Geo-referencing**

The satellite imageries were geo-referenced in order to assign the "X" and "Y" coordinates following the conventional standard using ILWIS 3.2 academics. This followed after the extraction and thorough ground trothing are done.

**Digitizing and editing**

It is the process by which hard map is converted into digital format (Jack TD 2003). The method used in this work is on-screen digitizing in ArcGIS 9.2 GIS Soft Ware, after which editing was made for quality control.

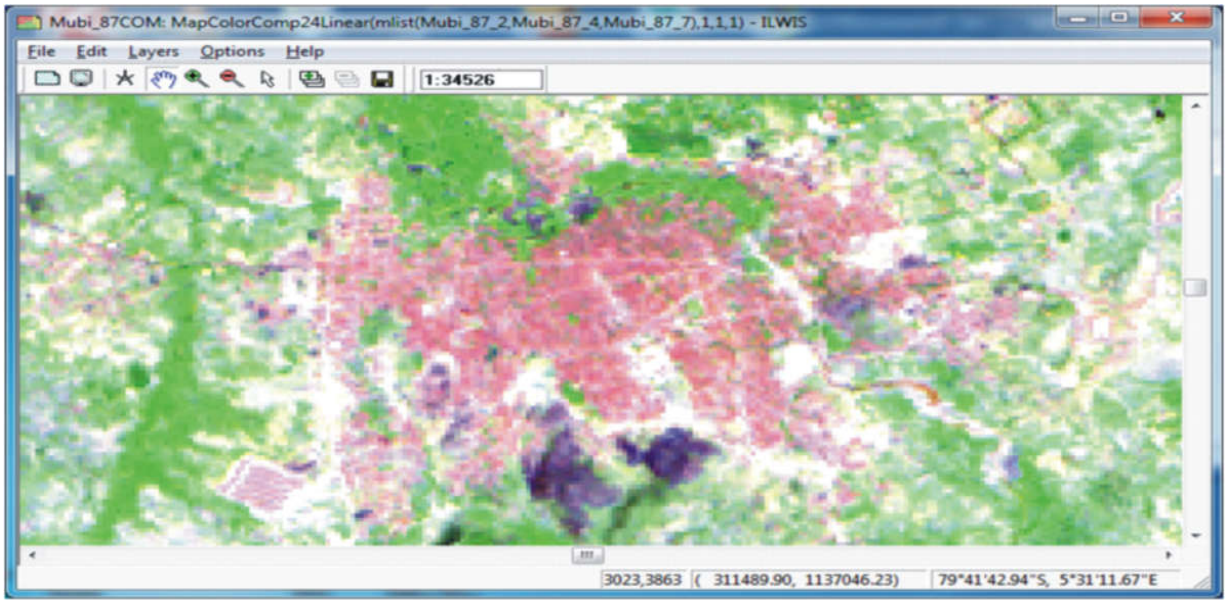


**Figure 2 Unclassified Mubi sub map 198**

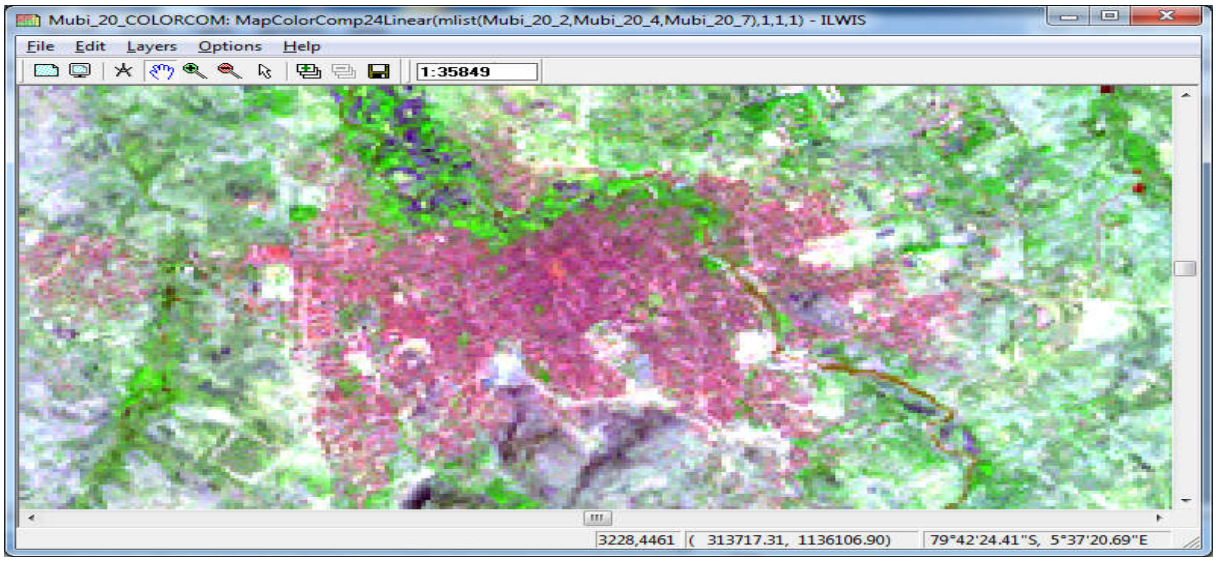


**Figure 3 Unclassified Mubi sub map 2000**

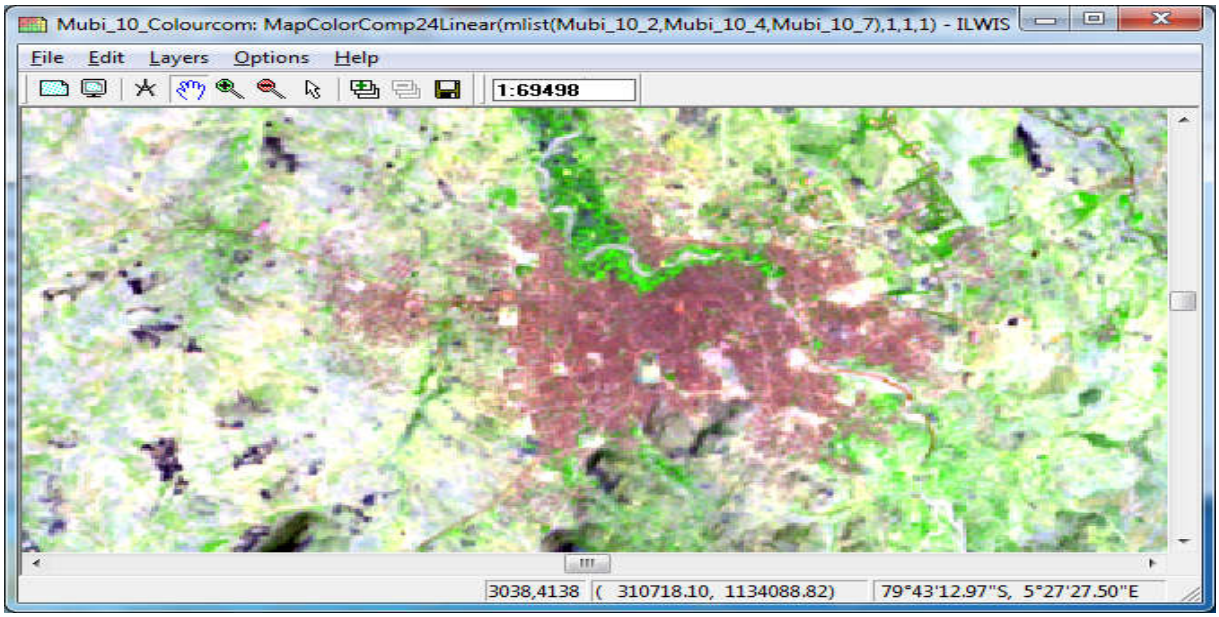


*Figure 4 Unclassified Mubi sub map 2010*

**Image classification**

The digital images were classified in order to assign pixels to classes to be mapped and to know the extent of change in the study area. Supervised classification was adopted where the process of using sample is known as identity. They were imported into ILWIS 3.1 for classification which included the following processes; creation of colour composite using three Bands (2, 4 and 7), sub-mapping of the image, and creating a map list, sample set and the domain. The land use was classified into five (5) domain classes, namely; bare surface, Built up areas, farmlands, vegetation and Rock outcrop. The reason for such classification is to avoid false identity of a particular landuse. And the data base of the landuses was created. Figure 3 shows a classified Landsat image of Mubi.

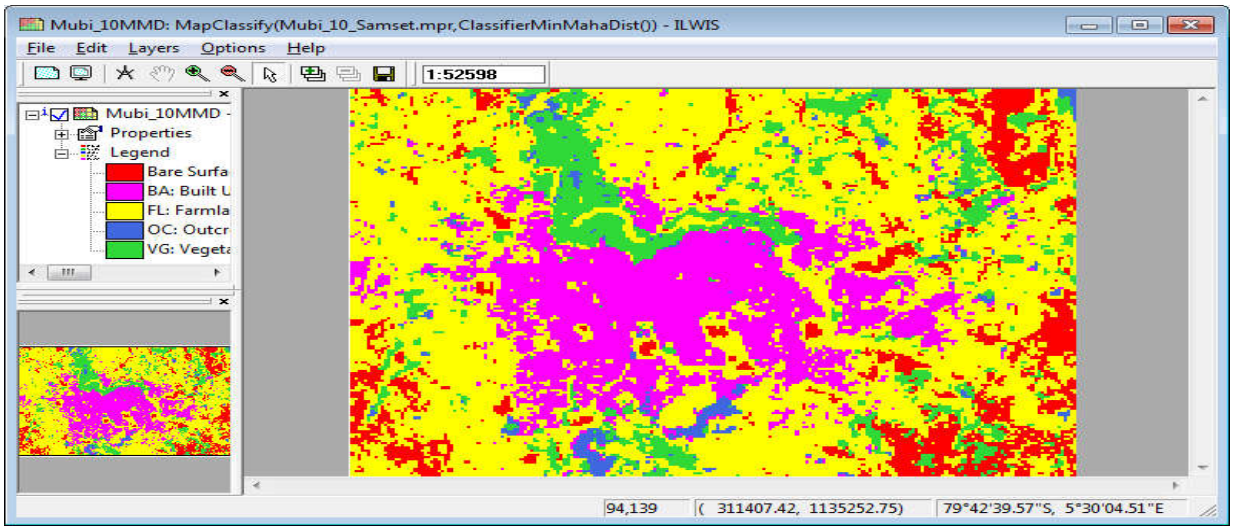


***Figure 5 Classified LANDSAT LETM***

**Techniques of analysis**

The techniques adopted for this study were GIS operations of change detection using statistical graph (histogram), and Querying analysis. The images of various land uses classified were analyzed and interpreted in order to arrive at the pattern of urban expansion. Simple descriptive statistical analysis was used to analyse the data generated from the questionnaires that were administered in identified areas of rapid expansion. The data captured through Global Positioning System (GPS) was used to generate contours of study area.

**Result and discussion**

The objective of this study forms the basis of all the analysis carried out in this chapter. The results are presented in form of maps, charts and statistical tables.

**Demographic data of the respondents**

Table 1 Age structure of the respondents

| Age group | Frequency | Percentage (%) |
|---|---|---|
| 0 – 20 | 7 | 23.3 |
| 21- 40 | 22 | 73.3 |
| 41-60 | 1 | 3.3 |
| 61 and above | 0 | 0.0 |
| Total | 30 | 100 |

Source: Field work Sept. 2012

The table 1 show that greater percentages of the respondents (73.3%) are within the age group (21-40) these forms the population of working class.

Table 2 Duration of stay in Mubi

| Variable | Frequency | Percentage |
|---|---|---|
| Less than 2 years | 7 | 23.3 |
| 2-5 years | 3 | 10 |
| 6 years and above | 20 | 66.7 |
| Total | 30 | 100 |

Source: Field work Sept. 2012

The table 2 above shows the period of years of the respondents in Mubi town. It reveals that (66.7%) spent six years and above, (23.3%) less than two years, while (10%) spent between (2-5) years. This indicates that there was rapid growth within last ten years.

**Data on the trends of urban expansion**

Table 3 expansion of Mubi town was rapid in last 10 years

| Variable | Frequency | Percentage |
|---|---|---|
| Agreed | 13 | 43.3 |
| Strongly Agreed | 16 | 53.3 |
| Disagreed | 1 | 3.3 |
| Strongly Disagreed | 0 | 0 |
| Total | 30 | 100 |

Source: Field work Sept. 2012

The table 3 shows the rate of urban expansion within the last ten years, about (96.6%) either Agreed (43.3%) or strongly agreed (53.3%) while the remaining respondents disagreed. This reveals that the expansion was rapid, and indeed.

Table 4 Farm lands are been turned to residential

| Variable | Frequency | Percentage (%) |
|---|---|---|
| Agreed | 14 | 46.7 |
| Strongly Agreed | 16 | 53.3 |
| Disagreed | 0 | 0.0 |
| Strongly Disagreed | 0 | 0.0 |
| Total | 30 | 100 |

Source: Field work Sept. 2012

Table 4 shows the effects of urban expansion on agricultural landuse in Mubi, where about (100%) either agreed (46.7%) or strongly agreed (53.3%) while none of the respondents either Disagreed or strongly disagreed with the statement. It then means that the expansion of Mubi town is at the detriment of farmlands which is the agricultural landuse.

Table 5 Increase in human population is the increase demand for shelter

| Variables | Frequency | Percentage (%) |
|---|---|---|
| Agreed | 6 | 20 |
| Strongly Agreed | 23 | 76.7 |
| Disagreed | 1 | 3.3 |
| Strongly Disagreed | 0 | 0.0 |
| Total | 30 | 100 |

Source: Field work Sept. 2012

Table 5 shows that increase in human population is one of the major factors of urban expansion in Mubi town with about (96.7%) of the respondents either (20%) Agreed or (76.7%) Strongly disagreed, while the remaining respondents either (3.3%) or (0%) strongly disagreed. The increase in human population could be as a result of natural factor (Fertility) in addition to high rate of migration.

Table 6 Urban expansion promotes economic and social activities

| Variable | Frequency | Percentage (%) |
|---|---|---|
| Agreed | 9 | 30 |
| Strongly Agreed | 20 | 66.7 |
| Disagreed | 0 | 0.0 |
| Strongly Disagreed | 1 | 3.3 |
| Total | 30 | 100 |

Source: Field work Sept. 2012

Table 6 portrays positive effects of urban expansion in Mubi town with about (96.7%) of the respondents either (30%) agreed or (66.7%) strongly agreed, while the remaining either disagreed or strongly disagreed on the statement. This shows that urban expansion has its associated benefits to both urban and peri-urban dwellers of Mubi.

The result on table 7 shows the respondents' opinion on the effects of urban expansion on the quantity and quality of agricultural productivity. About (83.3%) either agreed (50%) or strongly agreed (33.3%) while the remaining either disagreed or strongly disagreed (17%).

Table 7 Urban expansion reduces quantity and quality of agricultural landuse

| Variable | Frequency | Percentage (%) |
|---|---|---|
| Agreed | 15 | 50 |
| Strongly Agreed | 10 | 33.3 |
| Disagreed | 5 | 16.7 |
| Strongly Disagreed | 0 | 0.0 |
| Total | 30 | 100 |

Source: Field work Sept. 2012

**Factors responsible for Urban Expansion in Mubi**

The study reveals that several factors led to the expansion of Mubi town. These includes; high rate of immigration, commercial activities, topography, weather and climate, surplus of agricultural produce, establishment of schools and colleges, new employment, transfer, administration and social services, amongst others. But the most important of these are the establishment of Adamawa State University, Mubi, up grading of the Federal Polytechnic, Mubi, College of Health Technology, Skill Acquisition Centre, Federal Road Safety Commission Training School, Mubi New Market and Cow Market.

Thus, the urban expansion followed the pattern of Multiple-Nuclei theory, advanced by Ullman (2014), which argues that there are distinctive districts where activities are concentrated. The recent developments are mostly concentrated around Adamawa State University, (students' villa) engulfing Sabon Gari, G.R.A, Garden City, Wuro Harde and State-Low cost. While the Federal Polytechnic which has upgraded, is densely surrounded by students' villa, engulfing areas like Barama, Gipalma and part of Tudun-Wada. Other factors earlier mentioned account for the remaining growth in different locations observed to be in concentric layers, following the concentric growth zone hypothesis. There are concentric zones in Mubi town which are determined by spatial competition: Central Business District(CBD); includes residential office, retail, and cultural center and usually is the center for transportation, Transition Zone (Dense settlements, with business and light manufacturing), Workmen's Zone of homes, Exclusively residential districts and Commuters' Zone. These and other silent factors led to the rapid expansion of Mubi town especially in the last ten- to- twelve years.

**Effects of Urban growth pattern on agricultural landuse**

The study reveals spatial pattern of urban growth and its effects on agricultural landuse. This is observed in the newly developed locations identified (SabonGari, WuroHarde, Barama, Gipalma,

Tudun-Wada, Lamurde, Arhan-Kunu and Dazala), where farmlands are been converted to building houses, schools, industries, construction of road networks. Other incompatible landuses such as volcanizer, mechanics, shoe maker, furniture workshop, corner shops, kiosk, car wash, drastically decreased agricultural landuse and consequently led to decline in agricultural productivity.

The fringe dwellers equally suffer from urban expansion at the receiving end. The decrease of farmlands portend serious challenges as many farmers whose farmland have been eaten up by urban expansion have to either relocate entirely to another rural area or change his means of livelihood. Such social perturbation increased their vulnerability to unsustainable livelihoods. The decline in agricultural productivity for urban development also means decrease in food production thereby causing serious threat to food insecurity (Tammi et al, 2011).

**Challenges of urban expansion in Mubi**

The tremendous improvement in social, economic, commercial, political, infrastructural, technological, industrial and cultural activities have made Mubi town to witness high rate of immigrations as well as a natural increase. As a result of influx of people into the town seeking for better living condition, new employment, higher education, business, transfer of service; consequently leading to high demand for accommodation, shortage of water supply, power supply, high house rent, high cost of land, traffic congestion, poor sanitation, environmental degradation, high rate of crime, increase in social vices, insecurity, inadequate food supply as against its high demand, unemployment and under employment, amongst others. These phenomena may likely leads to further encroachments into farmlands.

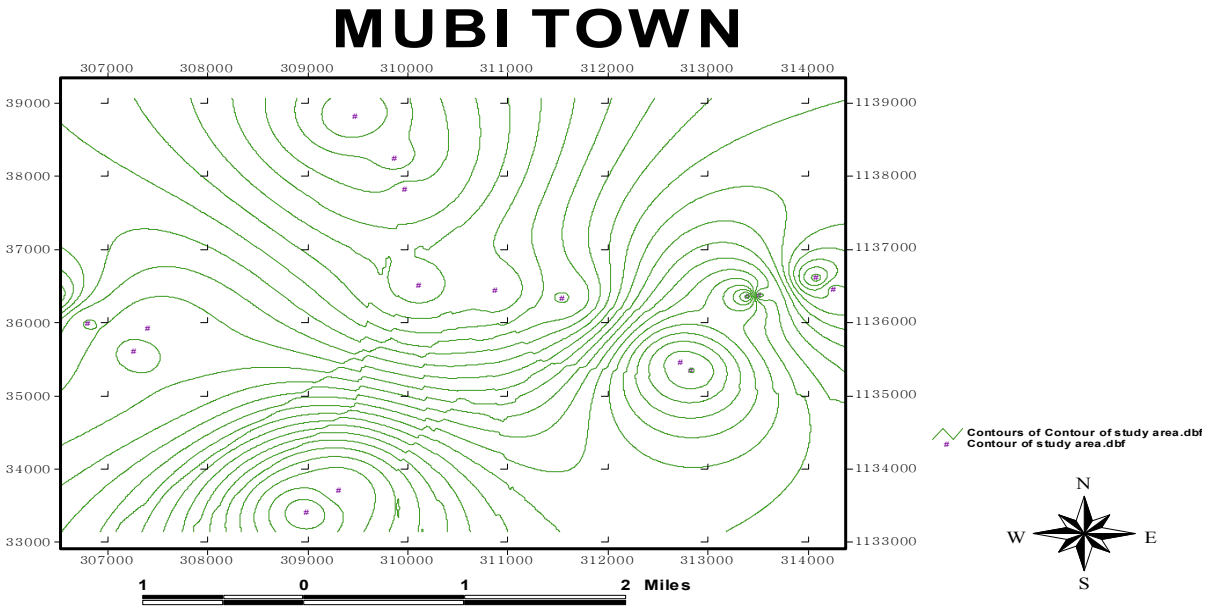


Figure 6 Contours of the study area (Source: Field Work 2012)

Figure 6 is the output of the data captured from selected locations where rapid developments are taking place and few points from the center of the town. It shows the contours of the study area.

**Image processing and analysis**

This aspect for the work portrays the results of the image processing which include; enhancement, transformation and classification of the Landsat imageries of Mubi for the three years (1987, 2000 and 2010). Three bands (2,4 and 7) were used in the processing, and supervised classification was adopted in order to arrive at a desired result. The land-uses are displayed along X-axis of the graph. The frequency of the occurrence of each of these values is shown on the Y-axis.

**LANDUSE MAP of MUBI 1987**

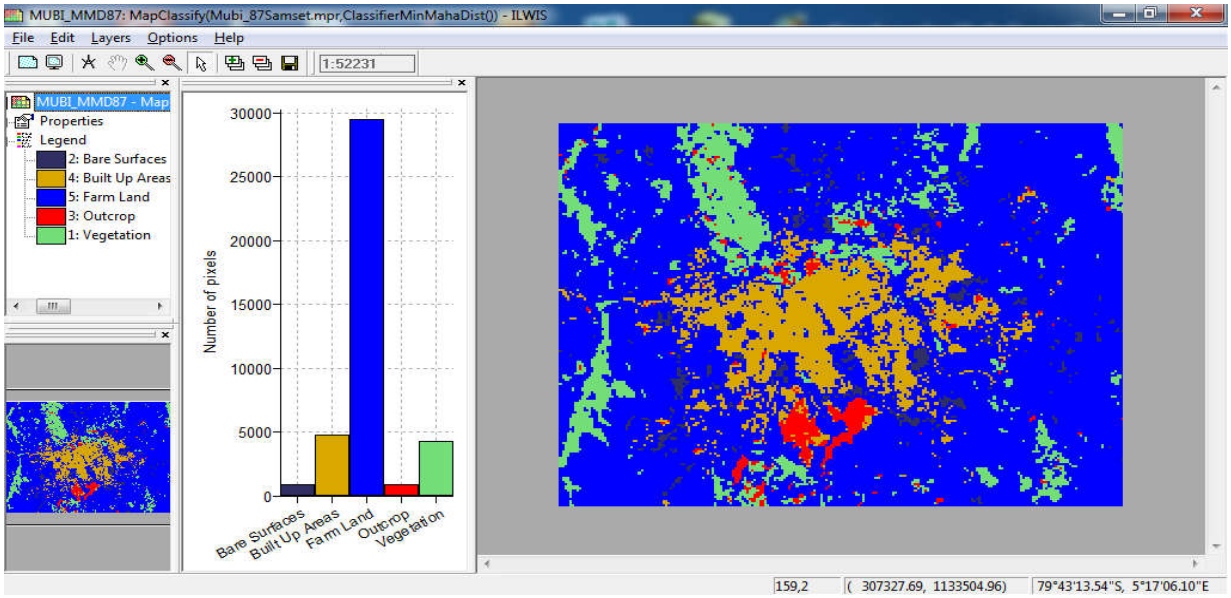


Figure 7: Mubi Land use Map final output 1987

Figure 7 **(**Mubi landuse 1987) satellite Imagery was classified into five land uses: vegetation, farmland, built-up area, outcrop and bare surface, using supervised classification with three bands (2, 4 and 7) that gave the desired colour. Having followed all processes involved, the result obtained revealed that vegetation covered approximately (4277m$^2$), farmland (29497m$^2$), built-up areas (4788m$^2$), Outcrop (896m2) respectively.

MUBI LANDUSE MAP 2000

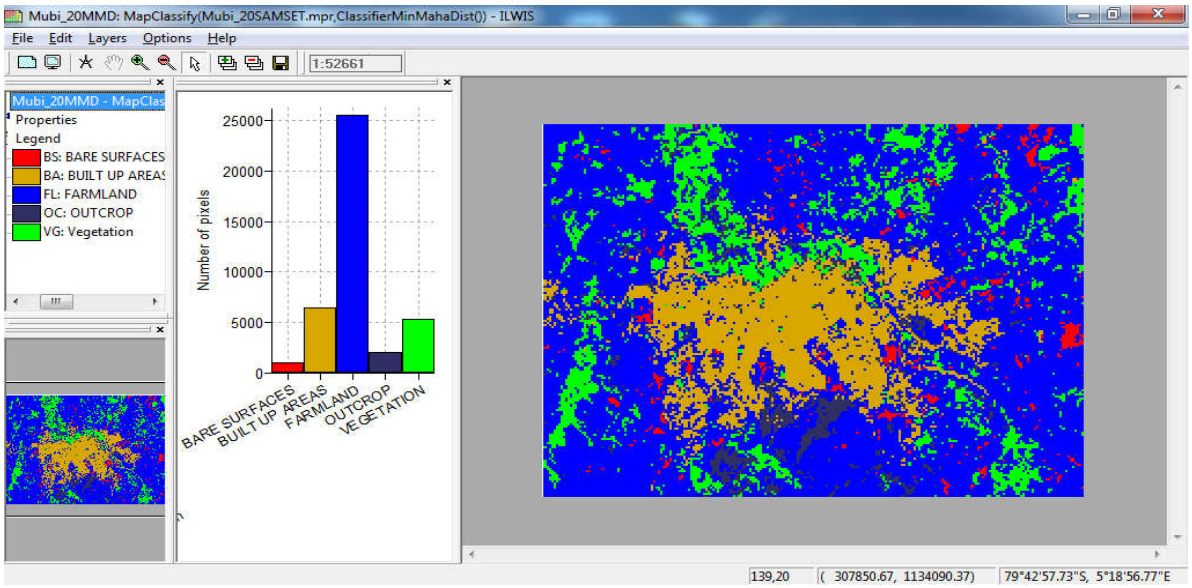


Figure 8: Mubi Landuse map 2000 Classified

Figure 8 is the result of classified landuse of Mubi 2000. The imagery was classified into five domain classes: vegetation, farmland, built-up area, outcrop and bare surface using three bands (2,4 and 7) and supervised classification was adopted in order to achieve maximum outcome. The histogram represents the values and areas covered by each land use: vegetation (5308$m^2$), farmland (25599$m^2$), built-up area (6461 $m^2$), outcrop (1992 $m^2$) and bare surface (947 $m^2$).

The result obtained shows the changes that took place between various land uses over space and time with more infancy on farmland and built-up area. Farmland in 1987 was approximately (29497$m^2$) and built-up areas covered (4788$m^2$) whereas in 2000, the same farmland was reduced to (25599 $m^2$) and built-up area (6461 $m^2$). This implies that there was decrease in farmland with increase in built-up area.

**MUBI LAND USE 2010**

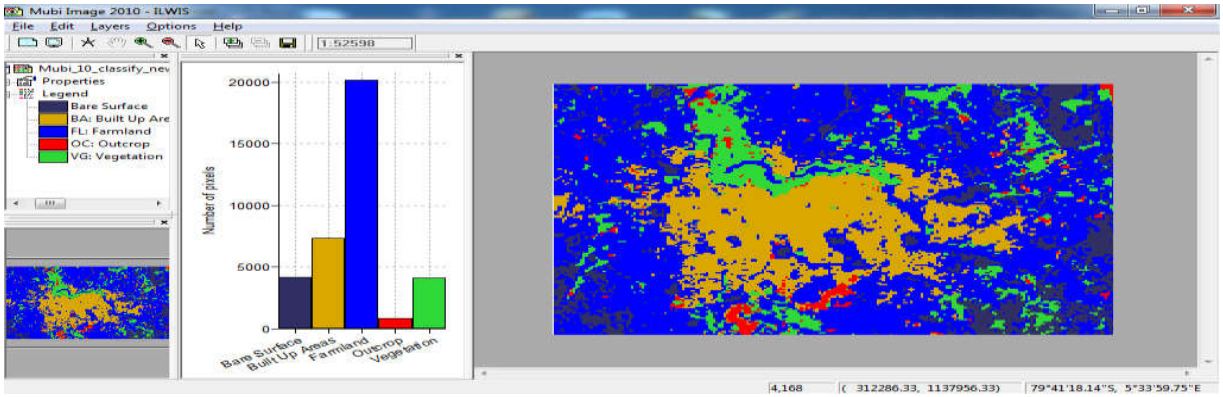


Figure 9: Mubi Landuse 2010 Classified

Figure 9 is the final output of classified landuse of Mubi town 2010. The land uses were classified into five domain classes namely; vegetation, farmland, built-up areas, outcrop and bare surface using three bands (2, 4 and 7), and supervised classification was adopted which gave the desired result. Besides, histogram was used to represent each land use with their respective area covered in square meters: vegetation (4100$m^2$), farmland (20184$m^2$), built up area (7306$m^2$) outcrop(801$m^2$) and bare surface (4182$m^2$). Comparing the results of the three satellite imageries (1987, 2000 and 2010) captured at interval of ten (10) years approximately, reveals that Farmland was (29497$m^2$), (25596$m^2$) and (20184 $m^2$) in 1987, 2000 and 2010 respectively. This shows a drastically decline of agricultural landuse with increase in other land uses, whereas built-up areas were (4788 $m^2$), (6461$m^2$) and (7306$m^2$) in 1987, 2000 and 2010 respectively. The results show that there was rapid increase in Built-up areas with decrease in farmland. The possible reasons for such trends in urban expansion over farmland are depicted in factors responsible for urban expansion.

**Projection of urban expansion in Mubi**

The projected population of Mubi town from 2000 to 2010 was 236,800. Using the straight method of population projection

Formula: $Pt = Po\ (1+r/100)^t$

Where

Pt = Future population (?)

Po = Current population (160,000)

1 = Constant

r = Population growth rate (2.5)

t = Period over which projection is made (10 years).

Therefore, $Pt = 160{,}000(1+2.5/100)^{10}$

$= 204813.527$

For this projection to be realistic, it suggested here that the state government should make a deliberate attempt to achieve this since it will lead to food security and environmental sustainability.

**Conclusion**

The identified factors attracting people to Mubi town include; Establishment of Adamawa State University, Mubi, concentration of higher institutions like Federal Polytechnic Mubi, College of Health Technology, Mubi, establishment private organizations, socio-economic activities such as trading, business, farming, Second major town in the state, New employment opportunity, transfer and retirement from work, Peace and stability, Natural population increase and surplus agricultural produce. Problems identified with urban expansion are decline of agricultural land use, most

farmlands have been turned to residential, displacement of many land owners, encroachment into Government Reserved Area (GRA), increase in land price and house rent, overstretch of available infrastructures and social amenities, emergence of criminal activities and social vices, land degradation and other related cases. However, the result of the work indicates that, there was rapid urban expansion between 2000 and 2010 than between 1987 and 2000. Although the growth started between 1987- 2000 within which the Adamawa state university was established in Mubi, but it became more pronounced and rapid between 2000- 2010, and by extension, to date. The Spatio-Temporal assessment of urban expansion using Geographic Information System (GIS) and Remote Sensing had been carried out in Mubi town taking into consideration the trends of urban expansion, the use of satellite imageries and other spatial data has revealed the potentials of the modern tools.

Urban expansion though desirable with attendant economic and social benefits to both urban and rural population, It requires systematic planning and continuous monitoring using Geographic Information System and Remote Sensing techniques. Thus, the new tools can help in controlling social, economic and environmental problems such as land pollution and degradation, encroachment, traffic congestion in our towns or cities. Lastly, in an attempt to ensure better urban growth, government have had adopted macroeconomic policies that are designed to mitigate magnitude of urban expansion to manageable levels. As a primary tool, a National Spatial Development plan could be established to address the mid-term and long-term local distribution of population; utilization of land; housing and transportation that favour decentralization of economic development and reduce too much pressure on agricultural land among urban and urban fringe dwellers.

**References**

Adebayo A.A. (2004), *Mubi region; A geographical synthesis paraclete publisher, Yola Nigeria.*

Adesina, F.A, (2005), Geo-information and natural resource exploitation in Africa; United Nations Economic and Social Council.

Appeaning A. K. (2009) *Measurement and Prediction of shore line change* in Accra, Ghana, Lambert Academic Publishing: Saarbrucken, Germany.

Bashir A. and Raji M.M (1999), *rural settlement of geography*. In Adebayo A.A. and tukur A. (leds) *adamawa state in maps*. Department of geography futy, yola pp100-103

Gardon N.D., McMaha, T.A. And Finlayson B.L. (1992), *stream Hydrology: An introduction for ecologists.*Joln Wiley and Sons Ltd. Baffins Lane, Chichester, West Susses, England.

Harris, P. M., and Ventura, S. J., (2013). The integration of geographic data with remotely sened imagery to improve classification in an urban area. *Photogrammetric Engineering and Remote Sensing,* 61, 993-998.

ICT. (2005). Education 2005-2006. International Institute for Geo-information Science and earth Observation, Enschede, the Netherlands. 28pp.

Klosterman, E.R., Lee, J., Selling, T.D. *Development of a Community Accessible Urban Sprawl Impact Assessment System in Northern Ohio, 15-County Region for the Impact Project;* Phase One Report; US EPA: Washington, DC,USA, 2006. Available online: http//gis.kent.edu/gis/emact/filelib/review. Pdf (accessed on 2/11/2010)

Mahesh K. J, Garg P.K. and Deepak K. (2008); *Monitoring and Modelling of urban sprawl using remote Sensin and GIS techniques*. Int. Journal of appl. Earth Observ.Geoinform. Vol. 10, 26-43.

Nehamenon (2004), *urban sprawl – A developing country approach*, A paper in the e-journal of the WSCSD Yele University, USA.

Paul, M.J., Meyer, J.L, (2001), *Streams in the urban landscape*. Ann Rev.Ecol. Syst. 32, 333 365.

Tammi et al(2011), *Effects of urban sprawl on livelihood of urban fringe dwellers in Mubi*, Adamawa state, being a paper presented at International Conference 28th -30th March, 2011 Obafemi Awolowo University, Ile-Ife Nigeria.

Turner, M. G., Wear, D.N. and Flamm, R.O. (1996). Land ownership and land cover change in the southern Appalacian highlands and the Olympic peninsula. *Ecol. Applic*6, 1150-1172.

Ullman. B.A., (2014). *Why should we be concerned about srawl?* The Environment Protection Agency, Available online www.epa.gov/region5/air/sue/sprawl/htm

Weng, Q. (2001), *Modelling urban growth effects on surface runoff with the integration of Remote Sensing and GIS.* Environ. Manag. 28(6), 737-748.