Analysis of Landuse/Landcover Change in Damaturu Town of Yobe State, Nigeria

ABSTRACT

This study analysed landuse/landcover change of Damaturu town using remote sensing and GIS techniques. Information from field survey was used to complement the results of GIS analysis. Findings revealed that between 1986 and 1991, there were no significant landuse/landcover changes that have taken place in Damaturu town. After the creation of Yobe State in 1991, the policies of planning authorities played vital role in determining the urban landuse pattern which is described as bottleneck along the main roads and consequently the stratification of the lands within the town into high density, medium density, and low density areas within this period (1991-1999). During this period, Damaturu built-up area increased about four times. This significant increase led to corresponding increase in urban area which was responsible for significant decrease of bare surface and shrub land. In addition the large increase of cultivation by about 45Km^2 during that period cannot be unconnected with increased agriculture to meet the demand of the growing population. From 1999 to 2005, the built-up area of Damaturu increased by 7Km^2 while the urban area expanded by about 11Km^2. However, the reduction of bare surface by more than half is the most remarkable of all the landcover changes that have taken place within this period. The growth pattern within this period could be described as radial. Moreover, it was observed that the high density built-up spread out from core-traditional city centre to medium density areas. Within the period of 4 years (2005-2009), the expansion of built-up area of Damaturu was not as significant as the reduction of more than two-third of the wetland, and there was also significant reduction of shrub land. However, the reduction of bare surface during this period is insignificant as development of the town has been steady for quite sometimes. Damaturu areal extent increases geometrically while built-up areas and population increase arithmetically.

Keywords: [Landuse, landcover, change detection, Remote Sensing, GIS]

1. INTRODUCTION

The terms landuse and landcover are often used concurrently and sometimes interchangeably to describe landscape features of the Earth's surface. However, landcover denotes the physical features such on the Earth's surface, while landuse refers to the human activities associated with the landcover. The landuse/landcover (LULC) pattern of a region is determined by the natural and socioeconomic factors as well as their interactions in space over time.

Human activities have considerably changed the natural physical landscape of the Earth's surface resulting into characteristic pattern in the landuse and landcover over time. These changes continue as a result of continuous interaction between man and his environment for socioeconomic development. However, the magnitude of landuse and landcover change varies with time and space. Landuse and landcover change has become a central part in current strategies in natural resource management and environmental change monitoring.

This is because urbanisation has increased the exploitation of natural resources and has brought about changes in landuse and landcover patterns (Rimal, 2011) especially in developing countries of the world. These changes have both positive and negative impacts on the environment. Change detection analysis is required to ascertain the magnitude and pattern of the change for proper landuse development, planning and management.

Landuse/landcover change detection is the process of discovering differences in the pattern of landuse/landcover observed over time. Change detection is an essential process in monitoring and managing natural resources and urban development because it provides quantitative analysis of the spatial distribution of the features of interest. Landuse/landcover change detection involves not only detecting the changes but also the nature, extent and the spatial pattern of the change. There are several techniques of Remote Sensing (RS) and Geographic Information Systems (GIS) used for landuse change detection. These include Composite Image; Image Comparison; Comparison of the Classified Images; Combination of the Classified Images; Radar Classification (Belaid, 2003).

Landcover information is an important input parameter for a number of agricultural, hydrological and ecological models, which are essential tools for natural resources development, planning and management in a given area or region (Mishra et al). In order to provide necessary landcover information in modelling studies, knowledge on existing landuse/ landcover is required and the ability to monitor the dynamics of landuse resulting out of changing demands. However, it is difficult to acquire such comprehensive and accurate information in many areas that are large, inaccessible with difficult terrain based on ground observation and surveys. Therefore, satellite remote sensing is being used as a better alternative for detailed and comprehensive landcover studies (Mishra et al).

Zhou et al (2008) employed an object-based classification and post-classification change detection on multi-temporal high-spatial resolution aerial imagery to detect changes in the Gwynns Falls watershed from 1999 to 2004. The Gwynns Falls watershed includes portions of Baltimore City and Baltimore County in Maryland, USA. An object-based approach was first applied to implement the land cover classification separately for each of the two years. Following the classification, they conducted a comparison of two different landcover change detection methods: traditional (i.e., pixel-based) post-classification comparison and object-based post-classification comparison. The results of their analyses indicated that an object based approach provides a better means for change detection than a pixel based method because it provides an effective way to incorporate spatial information and expert knowledge into the change detection process. They reported that the overall accuracy of the change map produced by the object-based method was 90.0%, with Kappa statistic of 0.854, whereas the overall accuracy and Kappa statistic of that by the pixel-based method were 81.3% and 0.712, respectively.

Sreenivasulu and Bhaskar (2010) produced landuse/landcover maps of Devak catchment in Jammu District of India for the years 1958, 1979, 1990 and 1998 by image processing and visual interpretation technique from the analysis of Geocoded standard False Colour Composite (FCC) paper print data for the year 1990, digital data for the year 1998 and SOI topographic maps for the year 1958 and 1979. Their study found that during the period from 1979 – 98, about 76.0% area of the openscrub land has been replaced with forest and agriculture. While the agriculture which covered only an area of about 7.0% in 1958 has been increased to 14% in 1998. They discovered that the main river drainage covered an area of about 10 % of the total catchment.

In addition, Balogun et al (2011) used multi-temporal remote sensing data and GIS techniques with field survey to detect the landuse and landcover change between 1986 and

2007 in Akure, a city in south-western Nigeria. The main objective of their approach was to examine the landuse landcover changes in city at different periods with a view to detect the present changes in the city and subsequently project the future changes in the area. They found significant changes in landuse and landcover of Akure through the different classification scheme and the findings of their study is presented as follows: arable land increased from about 29% to 41% and built-up/settlement from 10% to 35%; while bare-surface land decreased from 11% to 5% and dense forest from 49% to 15% respectively between 1986 and 2007. Results further revealed through projection that change by 2020 may likely follow the trend observed between 1986 and 2007.

Moreover, Abiodun et al (2011) used ETM LandSat imageries of (1984, 2001, and 2005), administrative map, and landuse map (2007) of Lagos State in southwestern Nigeria to determine different landuses in Lagos at different times. Change detection analysis was achieved by overlapping series of classified satellite imageries. The changes observed for each year were analysed in a GIS environment. The result showed a change of other landuse types to developed (built) land between 1984 and 2001. They also found that this pattern of change continued between 2001 and 2005.

Furthermore, Isma'il et al (2013) integrated LandSat TM of 1988, LandSat ETM imageries of 1999 and 2007 of Kazaure Local Government Area of Jigawa State in northwestern Nigeria into a GIS environment to analyse urban growth pattern of the area using post-classification change detection approach. The results of the change detection analysis were combined with information obtained on landuse change from field survey in the area. Findings revealed that population growth and expansion of economic activities have resulted into the expansion of the built-up area from about 12% in 1988 to close to 30% in 2007. In addition, the bare surface was found to have decreased tremendously over the years from 34% in the year 1988 to 4% in the year 2007.

Yobe is one of the states created in northeastern Nigeria in 1991, with the state capital located in Damaturu town. Since then, Damaturu has been experiencing rapid changes in the landuse/landcover types due to urban expansion and economic transformation in the town. These in addition to other factors influence the landuse/landcover change in the city. Therefore, there is the need to examine the trend and pattern of these changes for proper planning and development of the city. Daura et al (2006) studied the problems of Damaturu urban development focusing on the expansion of residential neighbourhoods. Besides, Mamudo (2009) appraised Damaturu development plan of 1992 with a focus on conformity analysis. His findings revealed specific problems of the development plan implementation, some of which are social, political, and economic. However, their studies did not examine the trend and pattern of landuse/landcover change in Damaturu since it was made the capital of Yobe State in1991. Hence, the focus of this study is to examine the dynamics of landuse/landcover change of Damaturu town from 1986 to 2009 using Remote Sensing and Geographic Information System techniques.

1.1 The Study Area

Damaturu is located between latitude 11^0 39' 30'' – 11^0 47' 00'' N and longitude 11^0 54' 00'' – 12^0 02' 00''E as shown in figure 1. The town has been the district headquarters of the then Borno province. It was later made the headquarters of Damaturu Local Government in 1976, and in 1991 it became the capital of Yobe State and headquarters of Damaturu Emirate in northeastern Nigeria. The town is on A3 highway and covers a land area of 206,241Km^2. Damaturu was founded in 1813 and it is multi-ethnic with the Fulani and Kanuri as the

dominant ethnic groups. Others are the Hausas, Karai-Karai, Bade and other minority tribes of the state. With the creation of Yobe state in 1991, a growing number of Igbo and Yoruba from southern Nigeria migrated there. Tivs and other southern tribes are also found as traders and public servants in Damaturu town.

According to the 1991 census of the National Population Commission, the population of Damaturu was 30,970. The population increased to 39,233 in the year 2000. It was estimated at 48,014persons according to 2006 census, and the population of Damaturu increased to 69,952 in 2010. The landuse and landcover of Damaturu consist of settlements, agricultural activities such as farming and animal rearing, and public structures such as schools, offices, road and markets etc. Being the administrative centre of the state, it is inhabited majorly by civil servants and traders.

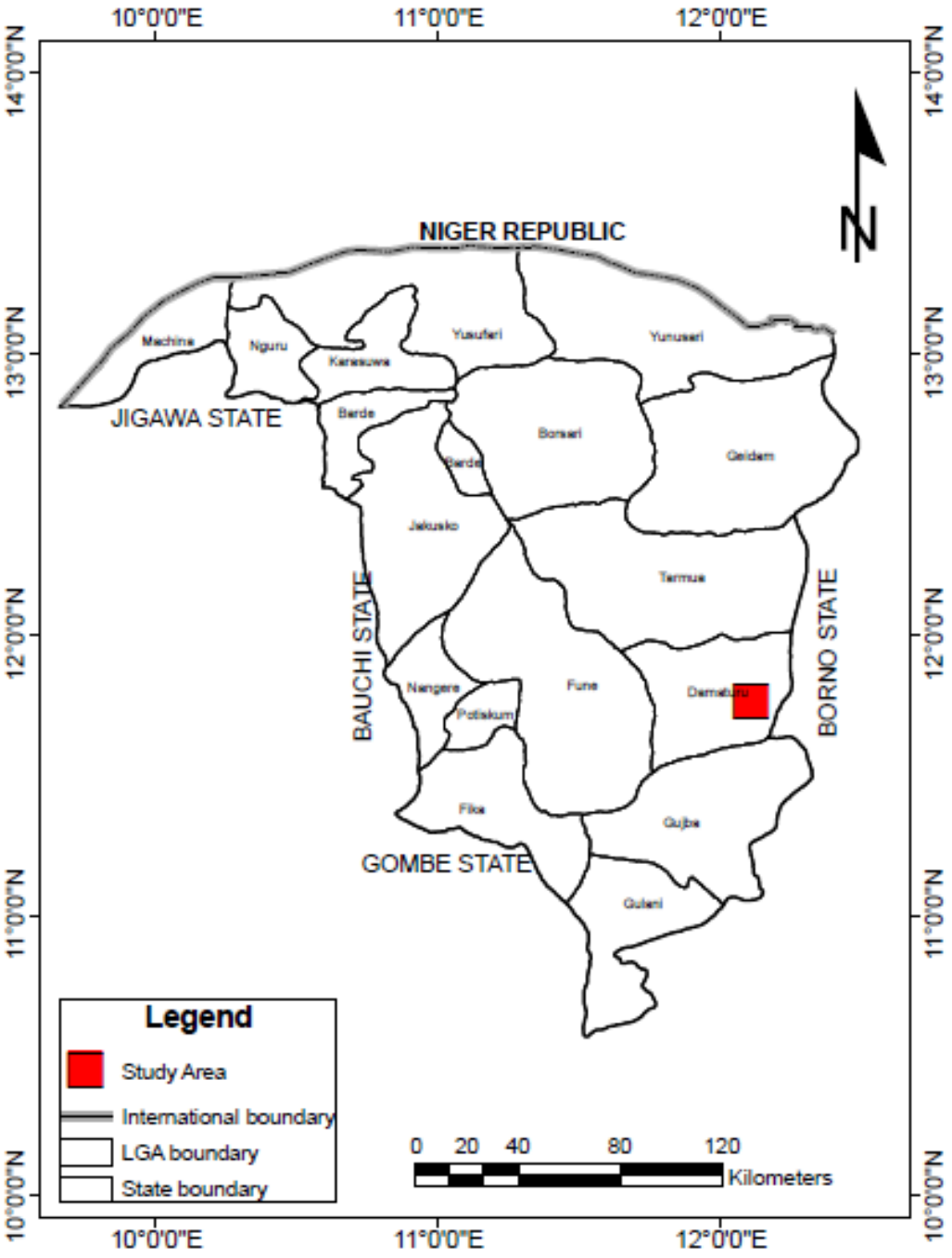

Figure 1: Yobe State Showing Damaturu
Source: Yobe State Ministry of Lands and Survey

2. METHODOLOGY

2.1 Types and sources of data

The primary data used for this study include four sets of satellite imageries, field survey, and information obtained from residents and key informants in the town. The satellite imageries

of Damaturu Township used are: LandSat Multispectral Scanner (MSS) – 1985, 1991, Landsat Enhanced Thematic Mapper (ETM) – 1999, and Nig-sat1 Enhanced Thematic Mapper (ETM) of 2009. All these imageries were obtained from National Centre for Remote Sensing in Jos, Nigeria. The images were resampled to 28.5m resolution and have band combinations in false colour of green, red and near infrared.

The response of the residents and key informants which included officials and traditional rulers was obtained through interviews. In selection of residential sampling units, the entire study area was divided in to three zones upon which 3 wards/layouts were selected from each zone based on simple random sampling method. Since the National Population Commission did not provide data at the level of wards/layouts, the house numbering by National Water Rehabilitation Project was used. Stratified sampling was employed by selecting housing estates, new private and traditional layouts. Then in selecting respondents from these sampling units, systematic sampling was employed, and the number of respondents selected from each sampled layouts was proportional to its size. The key informants included a total of 20 respondents from Ministry of Land and Survey. The selection of these respondents was through purposive sampling technique. The information obtained from these respondents includes evolution of settlements in the town, urban planning policies, the factors responsible for the spatial pattern of Damaturu urban growth and problems associated with the growth. The use of purposive, stratified and random sampling technique was employed because of the large size in the population of some of the wards and improper setting of houses especially in the inner city.

In addition, secondary data used for this study include Damaturu base map before the creation of Yobe State in 1991, Damaturu development plan of 1992, Damaturu SE topo-sheet, layout plans with a scale of 1:5000 and a reference ellipsoid of Clark 1880 and Universal Transverse Mercator (UTM) projection. These were obtained from Yobe State Ministry of Land and Survey. The population data of 1991, 1999, 2006, and 2011was obtained from National Population Commission, Yobe State Office, Damaturu. Other secondary data were sourced from journals and reports of Yobe State Ministries of Land and Survey, Works, and Housing Development.

3.2 Digital image processing

Sub-set: Satellite imageries covering Damaturu township were extracted from the full scene of the images of 1986, 1999, 2005 and 2009.

Geometric rectifications: Geometric rectification is critical for producing spatially corrected maps of land use and assessment, through time. The 1986, 1999, 2005 Landsat images, and the 2009 Nig sat-1 were rectified and georeferenced to the UTM map projection (zone 32), Minna Nigeria horizontal datum, and Clark 1880 ellipsoid. As only some small part of Damaturu around Maisandari falls into zone 33, with only 2′ a degree.

3.3 Change detection

Image Classification scheme design: A supervised classification approach and maximum likelihood algorithm with a threshold of 50 and mahaloni respectively was used for landuse evaluation and mapping from Landsat data with spatial resolution of 30m. In order to detect landuse/landcover change of Damaturu town from 1986 to 2009, a modified version of supervised scheme was adopted to classify the images into five classes: the built-up, bare surface, cultivated land, wetland and shrubland. Then the image statistics was used to differentiate changes in landuse/landcover within the period of study. The change detection also used visual analysis which was combined with the information collected through field survey.

3. RESULTS AND DISCUSSION

The change detection analysis was divided into 3 periods based on available data and change scenarios. The first period took place 9 years after state creation which covered the period between 1986 and 1999; the second period examined the changes during 6 years of civilian administration which covered 1999 to 2005, while the third period covered the period between 2005 and 2009.

3.1 1st Period: Characteristics of Damaturu landuse/landcover during the military regime (1986-1999)

The first period took place before and after the creation of Yobe State which covered the period between 1986 and 1999. The landscape of Damaturu remained the same between 1986 and 1991 as there were no significant landuse/landcover changes that have taken place before the creation of Yobe State in 1991. This can be seen on the 1991 base map of Damaturu town in figure 2, and confirmed by responses from key informants and focus group discussions.

After the creation of Yobe State in 1991, the policies of planning authorities such as locating the government offices and housing estates at the outskirt of the town away from the city centre played vital role in determining the urban landuse pattern within this period (1991-1999). Another policy implication was variation in land values within Damaturu, and stratification of the lands within the town into high density area as in the core traditional settlement, medium density as in Sabon-Pagi and housing estates, and low density around the Government Reserve Area behind the government house. This can be seen in Figure 4. Meanwhile, the spatial growth pattern formed a bottleneck along the main roads within this period. Therefore, after 8 years of becoming a capital city, Damaturu built-up area increased about four times, from 3.06Km^2 in 1991 to 12.12Km^2 in 1999 as shown in table 1 and displayed in figures 3.1 and 3.2. This significant increase led to corresponding increase in urban area which was responsible for significant decrease of bare surface from about 81Km^2 to 62 Km^2 and shrub land from about 41Km^2 to 8 Km^2 as shown in table 1. In addition the large increase of cultivation by about 45Km^2 during that period cannot be unconnected with increased agriculture to meet the demand of the growing population. During this time, the landuse/landcover changed significantly, the significant increase in build-up density is attributed to massive construction of housing estate, development of empty lands, demographic change, as well as increased economic activities and other socio-cultural activities introduced into the town by immigrants as can be observed in figure 5.

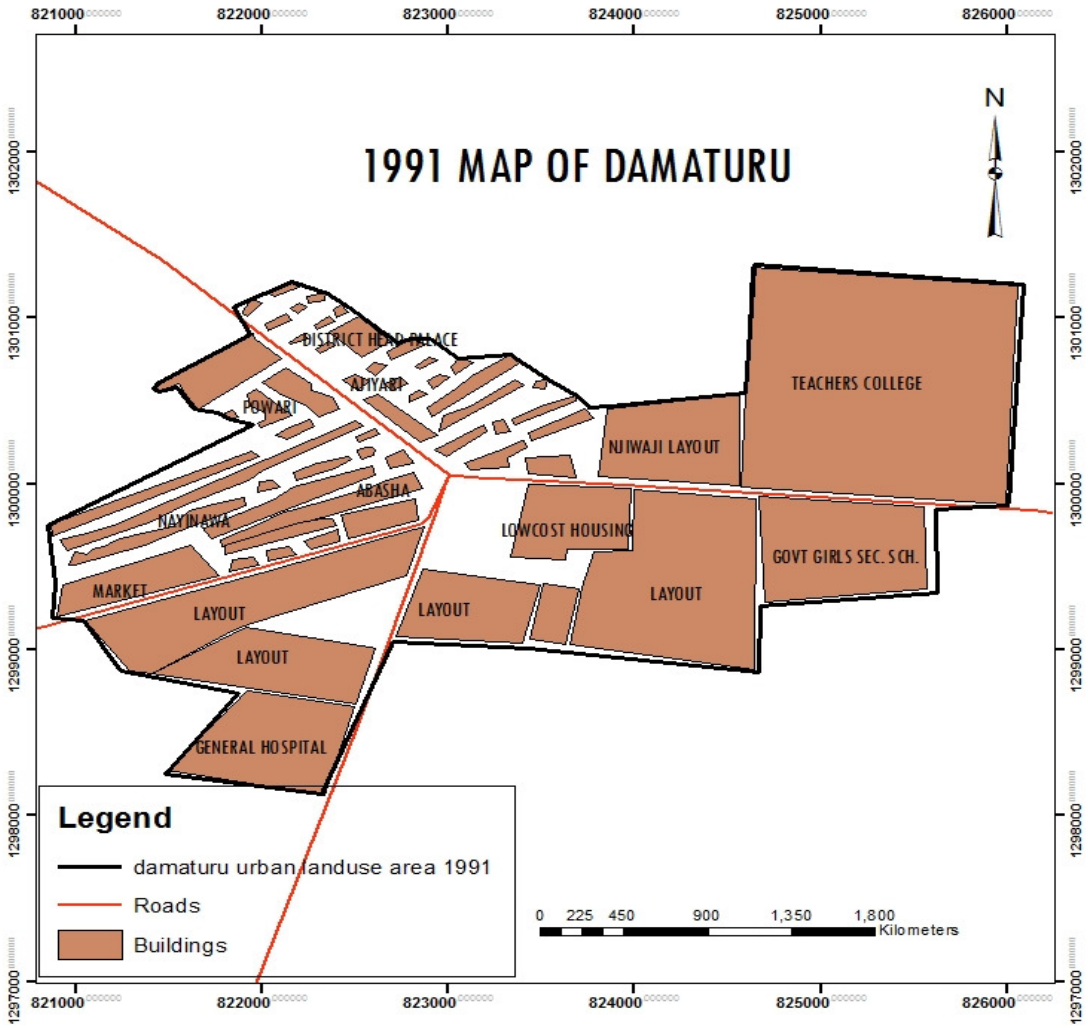

Figure 2: Damaturu before State Creation
Source: Yobe State Ministry of Land and Survey.

3.2 2nd Period: Damaturu landuse/landcover change during the civilian administration (1999-2005)

The second period which covered 1999 to 2005 analysed the changes that took place during the civilian administration. As it can be seen in table 1 and figure 5, the built-up area of Damaturu increased from 12.12Km^2 – 19. 02 Km^2, depicting an increase of about 7Km^2 of the built-up density; while the urban area expanded from 21.95Km^2 – 33.32Km^2 depicting an expansion of about 11Km^2 within this period. The expansion can be seen in figures 3.2, 3.3 and 5. The wide variation between the urban area extent and built-up density within this period is attributed to increase in urban sprawl. The growth pattern within this period could be regarded as radial around the 1999 urban growth, and the growth was attracted by the only housing estate (Sani Daura) which also represents high density area in the town. Other high density areas that developed later include Waziri Ibrahim and Ali Marami Housing Estates as shown in figure 4. Furthermore, it can be observed from figure 3.3 of the 2005

Damaturu map that the high density built-up spread out from core-traditional city centre to medium density areas shown in 1999 map around Gwonge, Injiwaji layout and around Nayi-Nawa and Damaturu Sunday Market. Besides, it can be seen from table 1 that the reduction of bare surface by more than half is the most remarkable of all the landcover changes that have taken place within this period, while the increase in shrub land is also remarkable.

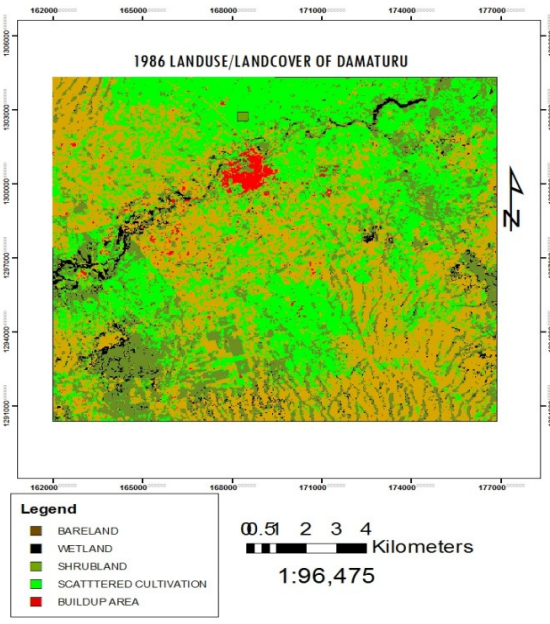

Figure: 3.1 1986 LULC of Damaturu

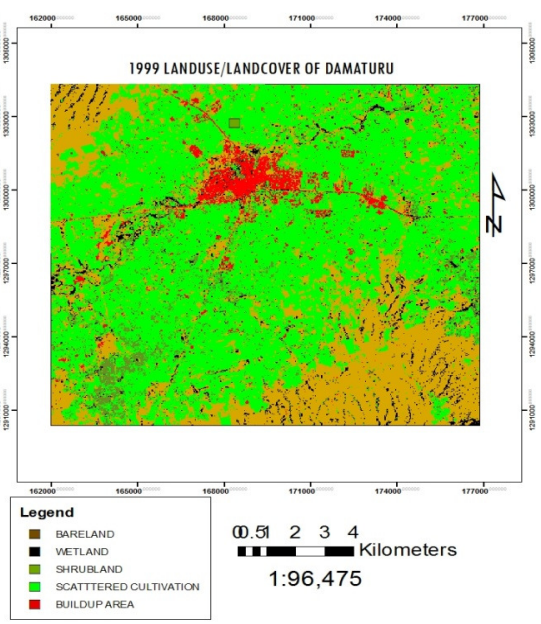

Figure: 3.2 1999 LULC of Damaturu

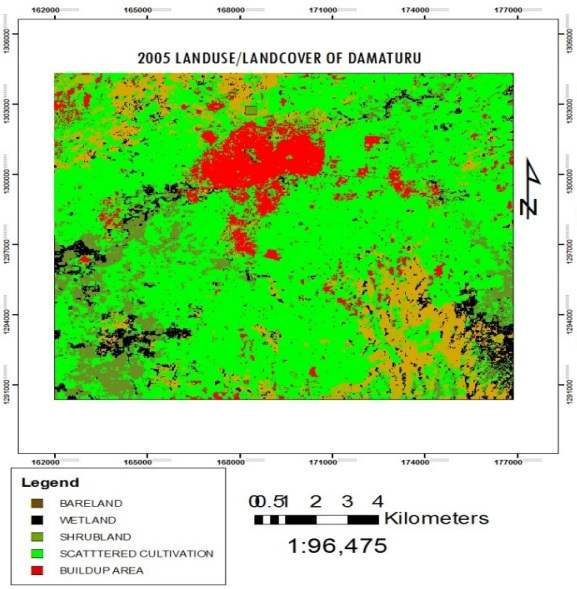

Figure: 3.3 2005 LULC of Damaturu

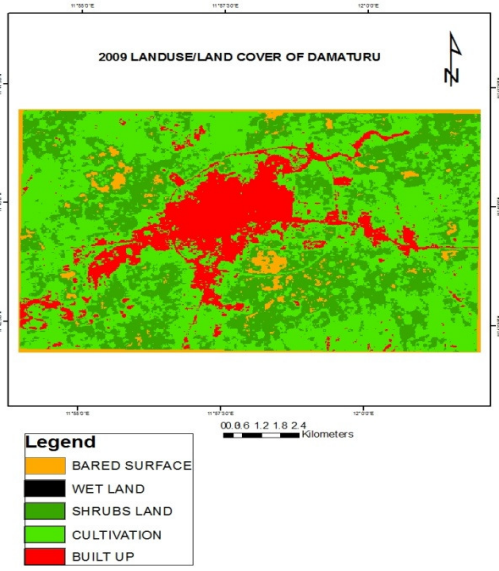

Figure: 3.4 2009 LULC of Damaturu

255 **Table 1 Damaturu Landuse/Landcover change from 1991-2009**

Years / Classes (Km^2)	1991	1999	2005	2009
Built-up	3.06	12.12	19.02	23.42
Bare surface	81.47	62.11	25.35	23.13
Urban area	4.99	21.95	33.32	54.37
Wetland	4.56	6.65	11.02	4.05
Cultivation	75.98	120.92	132.75	131.63
Shrub land	41.63	7.95	18.56	14.21

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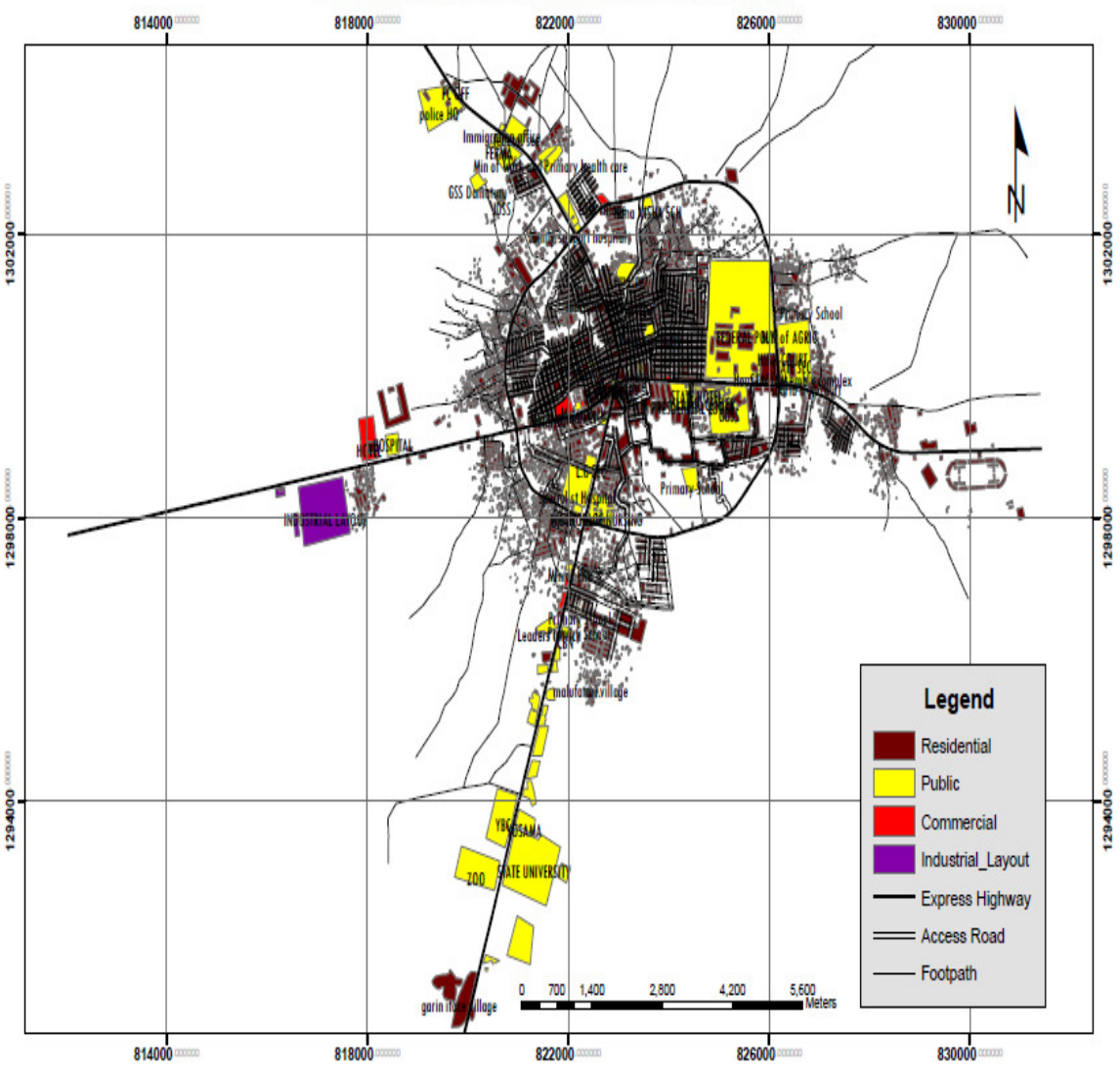

Figure 4 Damaturu urban landuse
Source: Google Earth Image

3.3 3rd Period: Current trend in Damaturu landuse/landcover change (2005-2009)

Within the period of 4 years (2005-2009), the built-up area of Damaturu expanded from 19.02 Km^2 – 23.42Km^2, and the urban area expanded from 33.32Km^2 – 54.37 Km^2 as shown in table 1 and visualised in figures 3.3, 3.4 and 5. This indicates a great variation between the rates of increase in urban area and built-up density, as the urban area extent was expanding at 4.8 times more than the built-up area as shown in figure 5. This tremendous expansion of built-p is responsible for the significant reduction of more than two-third of Damaturu wetland and significant reduction of shrub land. However, the reduction of bare surface during this period is insignificant as development of the town has been steady for quite sometimes.

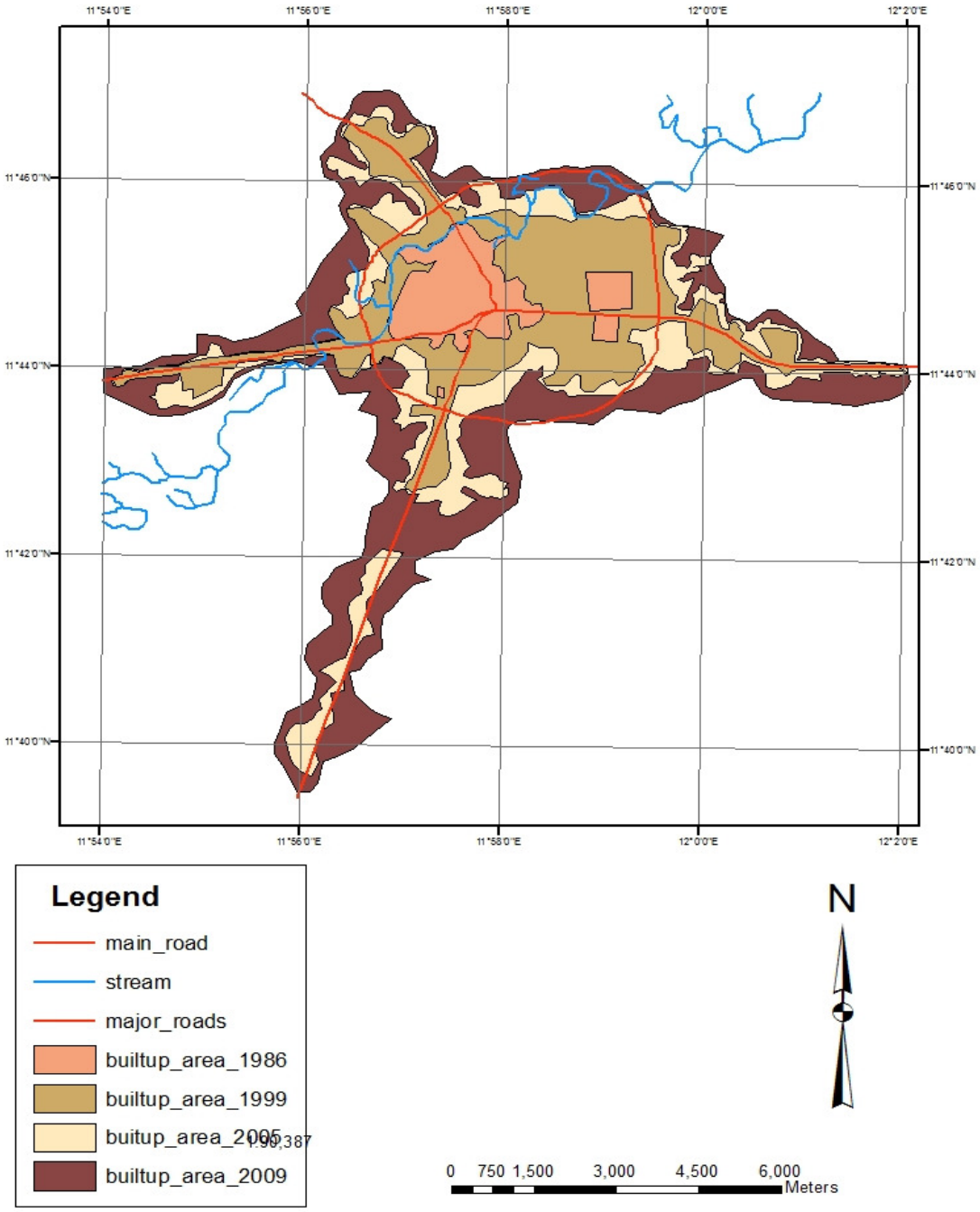

Figure 5 Damaturu Landuse Landcover Changes

4. CONCLUSION

This study analysed landuse/landcover change of Damaturu town using remote sensing and GIS techniques. Information from field survey was used to complement the results of GIS analysis. Findings of this study revealed that Damaturu town remained almost the same

between 1986 and 1991 as there were no significant landuse/landcover changes that have taken place. After the creation of Yobe State in 1991, the policies of planning authorities such as locating the government offices and housing estates at the outskirt of the town away from the city centre played vital role in determining the urban landuse pattern which was described as bottleneck along the main roads within this period (1991-1999). Another policy implication was variation in land values within Damaturu, and stratification of the lands within the town into high density, medium density, and low density areas. Therefore, after 8 years of becoming a capital city, Damaturu built-up area increased about four times, from 3.06Km^2 in 1991 to 12.12Km^2 in 1999. This significant increase led to corresponding increase in urban area which was responsible for significant decrease of bare surface from about 81Km^2 to 62 Km^2 and shrub land from about 41Km^2 to 8 Km^2. In addition the large increase of cultivation by about 45Km^2 during that period cannot be unconnected with increased agriculture to meet the demand of the growing population.

Moreover, after the creation of Yobe State in 1991and during the military regime, before the development of the town fully started, the population density of Damaturu town was 6,206.41 persons per Km^2. In 1999 when government offices, residential areas and recreation parks were fully developed and provided for the population, the population density decreased to 1,733.895 persons per Km^2.

In addition, it was found that from 1999 to 2005, the built-up area of Damaturu increased from 12.12Km^2 – 19. 02 Km^2, depicting an increase of about 7Km^2 of the built-up density; while the urban area expanded from 95Km^2 – 33.32Km^2 depicting an expansion of about 11Km^2 within this period. The wide variation between the urban area extent and built-up density within this period is attributed to increase in urban sprawl. The growth pattern within this period could be regarded as radial, and the growth was attracted by the only housing estate (Sani Daura) which also represents high density area in the town. Furthermore, it can be observed that the high density built-up spread out from core-traditional city centre to medium density areas. Besides, the reduction of bare surface by more than half is the most remarkable of all the landcover changes that have taken place within this period, while the increase in shrub land is also remarkable.

Within the period of 4 years (2005-2009), the built-up area of Damaturu expanded from 19.02 Km^2 – 23.42Km^2, and the urban area expanded from 33.32Km^2 – 54.37 Km^2. This indicates a great variation between the rates of increase in urban area and built-up density. This tremendous expansion of built-p is responsible for the significant reduction of more than two-third of Damaturu wetland and significant reduction of shrub land. However, the reduction of bare surface during this period is insignificant as development of the town has been steady for quite sometimes.

Damaturu areal extent increases geometrically while built-up areas and population increase arithmetically; also the rate of built-up expansion is far greater than the rate of population growth. This is as a result of improved living standard, as most of migrant to Damaturu residents after becoming the state capital are high and medium income civil servants. The spatial dimension of Damaturu town increases the travelling distance, as proximity to place of work is determining the people choice of place of residence, as some residents travelled over 13km to their various place of work.

COMPETING INTERESTS

: “Authors have declared that no competing interests exist.”.

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