Application of Remote Sensing and GIS to Detect Land Use and Land Cover Changes in Jos East Local Government Area, Plateau State, Nigeria.

Wuyep Solomon Zitta1 Isha Azi Haggai1 Arin Hassan Buhari 1 Daloeng Hyacinth Madaki1
1 Department of Geography, Plateau State University, Bokkos, Nigeria

Corresponding author:
E-mail: wuyepsol@yahoo.com

ABSTRACT
This study examines the potentials of Remote Sensing techniques and GIS in land resources management with particular reference to detect land use and land cover changes in Jos East L.G.A, between 1995 to 2015. In this study, administrative maps, remotely sensed data (Landsat and Nigeriasat-1 satellite imageries) and GIS techniques were used in the image analysis. All these were done using Ilwis 3.3 Academic, ERDAS 9.3, IDRISI 17.0 and ArcGIS 10.1. Digital camera was also used for ground truthing. The results were presented using classified imageries. Between the years 1995 to 2015, there was consistent change in the land use land cover of Jos East with different LULC categories. Throughout the study years, vegetation was observed to have the highest percentage of the total land coverage with 57544.28 ha (63%) in 1995, decreasing to 50322.96 ha (50%) in 2005, and 34969.95 (39%) in the year 2015. While agricultural/farm land was gradually increasing throughout the study period with 21271.05 ha (23%) in 1995, 27017.37 ha (27%) in 2005 and 25406.19 ha (28%) in 2015. Findings also showed that build-up-areas/settlement development increased consistently from 1451.97ha (2%) in 1995, 3290.49 ha (3%) in 2005 to 5817.96 (6%) in 2015. It was concluded that agriculture in the study area is increasing while large areas of vegetation is drastically reducing and being converted to farmlands and settlements. It is recommended that government should put up a reliable land management system to ascertain the changes that are taking place in the study area at regular interval.

Keywords: Agriculture, Vegetation, Settlement, Remote sensing, Jos East, GIS

BACKGROUND
Urbanization and environmental activities have contributed to the modification of our environment [1]. Human activities have been recognized as a major factor shaping the biosphere [2-4]. Many urban areas have expanded in recent decades, increase in population and introduction of various forms of land use planning are the various issue threatening the environment today [5,6].

Cities are experiencing spatial expansion which is largely as a result of people moving to cities in search for better employment and opportunities [7]. This leads to an increase in size, well beyond the limits of most cities and the preference of living at the outskirts of the city with open spaces at reasonable distances from cities [8].

Knowledge about Land Use/Land Cover (LU/LC) has become significant to
overcome the problem of loss of productive ecosystems, biogeochemical cycles, loss of agricultural lands, deterioration of environmental quality, biodiversity, destruction of wetlands and loss of fish and wildlife habitat. The main reason behind the LU/LC changes includes rapid population growth, rural-urban migration, lack of valuation of ecological services, reclassification of rural areas as urban areas, ignorance of biophysical limitations, and use of ecologically incompatible technologies [2,7].

Rapid urbanization and sprawl in Nigeria have been affecting 400,000 hectares of vegetation annually [7]. There is hardly any vegetation that has not been affected by human activities of which the Jos East Local Government Area (LGA) is not an exception. Activities of man such as farming, logging, grazing, hunting, urbanization and other development activities induced by the rapidly increasing population have together reduced natural vegetation cover to patches on the surface of the earth [9, 10]. The spatial extent of urban development not only in Jos East LGA, but also in other areas in Nigeria that have undergone tremendous changes in the last 30 years.

Land use/land cover inform the type of human activities or natural cover present at a particular location [11]. In other words, land-use is the various ways which land is put to use depending on human needs. Also, land-cover describes the total physical land features (water bodies, soil, vegetation, rocks and so on) covering a particular land surface [1].

To justify this study, the use of Remote Sensing and GIS techniques to detect LULC in Jos East LGA has become imperative, hence, monitoring and documenting the changes. This is achieved through the following objectives: 1) assessing the land use/land cover pattern over a period of 20 years (1995-2015); and 2) determining the rate at which the land is undergoing changes. Findings would be of relevance to assist government identify and implement measures for effective control.

STUDY AREA AND METHODS

Study Area

Jos East Local Government Area (Figure 1) was created out of Jos-North L.G.A of Plateau state in December 1996. It has a land area of 2,540 km$^2$, and bounded by Jos-North L.G.A in the western part, Barkin-Ladi to the south-west and Mangu L.G.A in the southern area. The East and northern study area are bounded by Bauchi state. The climate is influenced by height above sea level and spatial position across the seasonal migration belt of the Inter-Tropical Discontinuity (ITD) [12]. Jos East falls within the wet and dry climatic type as a Tropical Rainy climate [13]. Mean annual rainfall is 1260 mm, and peaks between July and August; meanwhile, the mean annual temperature is about 22°C [13]. It consists of undulating plains of low relative relief to hill ranges on the plains. The study area falls within the Northern Guinea Savannah vegetation zone [12]. The estimated population of Jos East L.G.A in 2006 is 88,301 [14]. About eighty (80%) of this population is rural based. The remaining twenty (20) percent live in the semi-urban centres. Those in the rural areas engage in green economy as the main occupation while those in the semi-urban areas are either artisans or civil servants. The L.G.A is made up of six (6) districts namely; Fobur, Maigemu, Maijuju, Fursum, Federe and Shere [13].
Methods

Data types, sources, and collection techniques

The methodology adopted for this research is based on the use of remote sensing (satellite imagery) in a GIS environment to map, analyze and detect land use/land cover changes. Remote sensing and GIS have covered wide range of applications in the fields of agriculture, environments and integrated eco-environment assessment in assessing the pattern [15,16]. The sources of data for this research are categorized into primary and secondary sources. Primary sourced data were pictures captured directly from the field using a digital camera while the secondary data were satellite imageries from National Centre for Remote Sensing, Jos. The satellite imageries cover a time span of 20 years (1995–2015). The choice of this time span is to determine the changes that have occurred in the study.

In carrying out this study, the following software and instruments were used:

i) ILWIS 3.3 Academic and ERDAS 9.3 were used in classifying the three satellite imageries (Nigeria Sat-1, 2005 and 2015 Land Sat TM).

ii) ArcGIS 10.1 version was employed for the delineation of the study area from the map, clipping of the image to the study area and preparation of the image for analysis.

iii) IDRISI 17.0 for the cross tabulation

iv) Digital camera for the ground truth.

The band combinations used for the images are:

i) Near Infra-red - band 4

ii) Red – band 3

iii) Green – band 2

The reason for using these bands composition was for clear distinction of the boundaries. Due to involvement of multiple data sets, the study area was classified into five categories including: agricultural/farmland, bare surface/rock outcrop, built-up-area-settlement, water-bodies and Vegetation.

METHOD OF DATA ANALYSIS

The image analysis of this study was carried out using the ILWIS 3.3 Academic, ERDAS 9.3 and ArcGIS 10.1. The administrative boundary of the Jos East L.G.A was overlaid on each of the imageries using the ArcGIS 10.1. These were done so as to cut the imageries to the administrative boundary using the ArcGIS software. After sub-mapping the imageries into the administrative boundary of Jos East L.G.A, the three images of 1995, 2005 and 2015 were imported to ILWIS 3.3 environment. This was achieved in order to classify the imageries using the maximum classifier module of the ILWIS 3.3 software classification scheme. ERDAS 9.3 was also used to classify 2005 and 2015 imageries. The 2005 and 2015 image were captured during the dry season within the month of
February, making the areas exposed as bare surface while the 1995 image was captured in the rainy season.

The methods used to analyse the digital images are:

i) Enhancement of satellite imageries which includes the removal of cloud and haze through filtering.

ii) The satellite imageries were geo-referenced and orthorectified. The orthorectification took charge of corrections due to angle of inclination of the sensor and the curvature of the earth.

iii) Overlay operation.

iv) Maximum likelihood classification.

v) Calculation of the area in hectares (ha) of the resulting LU/LC types for each study year and subsequently comparing the results.

RESULTS
Detection of the Changes in the Land Use/Land Cover (LULC)

Vegetation comprising all lands with trees cover and grasses. As shown in Figure 2, the study area in 1995 recorded more of vegetation than other classes. Vegetation accounts for 57544.29 ha (62%). In Figure 3, 2005, vegetation occupied an area of 50322.96 ha, representing 50% of the total land cover of the study area. Figure 4 records consistent decline in vegetation over the 20 years period (1995-2015) as it occupies an area of 34969.95 ha (38%) in 2015.

Agricultural land under cultivation used for paddy and other crops production. This accounts for 21271.05 ha (23%) in 1995 (Figure 2). Farmland occupying 27017.37 ha (27%), this with an increase of 4% in 2005 (Figure 3). By 2015 farmlands accounts for 25406.19 ha (28%) and Figure 4. Bare surface/rock outcrop (Human induced barren lands) accounted for 9936 ha (11%) in 1995 Figure 2. Bare surface/rock outcrop occupying 18435.69 (18%) as seen in 2005 (Figure 3) while bare surface/ rock outcrop occupied 24245.1 ha (27%) in 2015 (Figure 4).

Built-up areas (Land allocated to residential and others) in Figure 2, accounts for 1451.97 ha (2%) in 1995, while the LULC change detection for the study area in 2005 as seen in Figure 3 derived image revealing 3290.49 ha. There is a significant increase of 1% in settlement development from 2% in 1995 to 3% in 2005 as seen in plate 2 (farmland to settlement). Figure 4 occupies 5817.96 ha (6%) in 2015.

Water bodies (Land covered by water like rivers, streams and lakes as well as man-made ponds mining ponds and road construction ponds are mostly seen only in the rainy seasons around Kerker, Furaka, and Rizek villages. Water body was very high having 608.85 ha, 2% in 1995 (Figure 2). Water body accounts for 1198.08 (1%) while the areas that were not classified had 1%. The 2005 image (Figure 2) was not very clear because of the season the image was captured, this made some of the areas in the image unclassified as water body occupies 373.23 ha (1%) in 2015 (Figure 4).

DISCUSSION

The study reveals that land use/land cover distribution of the study area in 1995 corresponds with the low population of the area as at that time of this study. The settlement had only 2% while farmland occupied about 23% of the total land coverage. It also showed that, the major occupation of the people is agriculture. This activity is seen around Fobur and Maijuju districts. It can clearly be seen that there is an increase in settlement around the study area hence, population increase. The study area witnessed large amount of agriculture land converted into settlements (see plate 2) and other urban development activities. Urban expansion appears to have direct
effects on the available agricultural land in and around the urban area which in turn affects food security. These have tremendous effects such as reduced food production, low agricultural produce, and ecological degradation, environmental and socioeconomic challenge [12]. The result further shows that there is an increase in economic activities of the people which is mostly farming. People had to clear the vegetation purposely for agriculture (see plate 1); clearing of vegetation for farming purposes. In Fobur district for example, about 10 hectares of land belonging to an individual was cleared for tomatoes farm and many hectares were also cleared in Sabon Gari, Kerker, Nabatong and Naton for vegetable cultivation; cucumber, tomatoes as seen during the ground truthing.

The study also reveals that water bodies and forested areas decreased due to gradual conversion of water spread areas and forested area to built-up area as the population increased significantly during the past decades. This finding is in line with the result of Gete and Hurni [17] in Dembecha area, North western Ethiopia who found out that the expansion of cultivated land took place at the expense of forest land between 1957 and 1982. Similarly, studies have revealed that the expansion of agricultural land has been at the expense of lands with natural vegetation cover [18-22].
CONCLUSION AND RECOMMENDATIONS

The aim of this study was the application of remote sensing data and GIS to detect land use and land cover changes in Jos East LGA. From the findings, there are changes in land use/land cover that has taken place in Jos East L.G.A. Vegetation was observed to have the highest percentage of the total land coverage in 1995 but decreased during the study period (1995-2015). Also, agricultural/farm land, settlement development increased consistently in size from 1995 to 2015. It is concluded that agriculture is increasing while large areas of vegetation is drastically reducing and converted to farmlands and settlements. Remote Sensing techniques and GIS have important roles in the linkage and analysis of the data, in particular for detection (direct or indirect), extrapolation and interpretation, area calculation and monitoring of changes. The use of remotely sensed data has been proved to be a good choice for detecting and monitoring land use transformation even in a short time series.

It is recommended that government should put up a reliable land management policy in form of restrictions on premature conversion of agricultural land, controlling vegetation from further reduction. Also, government should take into cognizance of land use/land cover at a regular interval to ascertain the changes that are taking place in the study area.

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Arin, H.B. and Daloeng, H.M. wrote the abstract, conclusion, recommendations and critiquing this paper.

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**CONFLICT OF INTEREST**
The authors declare no conflict of interest in the research they have undertaken.

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