LAND USE CHANGES IN THE ADJOINING RURAL LAND OF MAIDUGURI BETWEEN 1961- 2002: TRENDS AND IMPLICATIONS IN ENVIRONMENTAL MANAGEMENT IN BORNO STATE, NIGERIA

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ABSTRACT

This study aimed at examining the trends in land use changes in Maiduguri urban area between 1961 and 2002 and the implications of these in environmental management. These were based on the use of GIS and Remote sensing techniques. Remote sensing data that were made available for this study include black and white aerial photographs of 1961 and 1972 at scale of 1:10,000 and 1:25,000 respectively and SPOT (panchromatic) at a scale of 1:40,000 with 10m resolution. These were interpreted to generate the land use maps for 1961 and 1972, and 1990. The land use map for 1990 on which the field observation of land use changes between 1990 and 2002 was used as the base data. The four land use maps were then digitalized and analyzed in a GIS environment using ILWIS 3.0 and ARCINFO 3.8. The total land area delimited in the study area within which changes were monitored over the period was 13,389 hectares. The study revealed among others that the land use changes trend in the city showed that Maiduguri grew at a fast rate. Consequently, it was concluded that such a high growth in a semi-arid environment where water supply is grossly inadequate, poses a lot of challenges in urban management. Therefore, there is a need to put in place procedures for regular acquisition of remotely sensed data that will make it possible to track the changes happening to land in the urban areas in Nigeria.

Keywords: *Land use, Change, Remote sensing, GIS, Maiduguri,*

INTRODUCTION

The goal of land use change analysis revolves around two central and interrelated issues, the drivers and impacts of the land use changes. The drivers of the change are the causes and processes that bring about the change while the impacts are the consequences of the change (Kates, Turner and Clark, 1990). In general, the study of impact of land use change has received more attention and publicity than the drivers simply because it is the impacts that are readily felt. In most cases, the drivers

are hardly appreciated. In the same vein, although there are environmental and socio-economic impacts of the change, one of the reasons for this is that the economic impacts are more subtle, long-term and subject to the influence of many more complex and less visible and verifiable factors than the environmental ones. However, the environmental and economic impacts are in many ways interrelated. The environmental impact may be viewed as causing the economic impacts, while the economic impacts accentuate the environmental, causing successive rounds of land use change. A very good illustration is the extraction of fuel wood by the peasants, which naturally degrades the vegetation cover. The degraded vegetation offers little or no opportunity for future extraction of fuel wood which further impoverishes the local people by forcing them to expend more energy and resources in going further and further into the forest in search for fuel wood, and causing even greater damage to the forest resources (Adesina and Amamoo1994; Warren et al 1991).

The environmental impacts of land use change are usually distinguished according to their spatial level i.e. global, regional and local. As regards to global environmental impacts of land use change and cover change, land use and cover are relatively new additions to the core concerns of global environmental change research (Meyer and Turner, 1996 Yemefack, 2005 and Tappan et al 2002 and 2004)). Land use/cover change impacts are basic to environmental changes as the local changes cumulatively affect the whole globe. This is what is obvious today as global change. Large-scale environmental phenomena like land degradation, desertification, biodiversity loss, habitat destruction and species transfer happen at local scales but they cumulatively manifest as regional and global changes.

Landuse changes cause a multitude of environmental impacts at the lower spatial levels in urban, suburban, rural and open space areas, which have been extensively documented (Salami 1995, Odeyemi 1999, Yuliang, et al 2004, Turner and Meyer 1994, Turner et al 1995, LUC 1988 , 1999). The impacts include changes in the hydrological balance of the area, increase in the risk of floods and landslides, air pollution and water pollution. The socio economic impacts of land use change are also significant and they give rise to serious concern at all spatial levels, for example, at the global level, socio-economic impacts concern issues of food security, water scarcity, population displacement and more generally the issue of human security and vulnerability to natural and technological hazards (Lonergan, 1988). The regional level socio-economic impacts of land use change are more variegated reflecting the variety of regional settings where these changes occur. The local level socio-economic impacts of land use change comprise similar concerns but they are restricted to the particular localities where these changes occur. A point that needs to be stressed in this is that usually all impacts of land use change are for some reasons. First, whether an impact is positive or negative depends on the spatial and temporal scale concerned. Second, human mitigating forces such as environmental and social regulation and policies, land restoration projects and similar actions may impede the negative influences of human driving forces and, thus, mitigate if not eliminate, the unwanted

consequences of land use change (Birassoulis 2001). The specific objectives of this study are to:

(i) Assess the trends and impact of land use changes in the study area over specified period;
(ii) Assess the implication of land use dynamics in Maiduguri region.

DIMENSIONS OF URBAN CHANGES

The urban world is changing in three different and unconnected ways through urban growth, urbanization and the spread of urbanism. Urban growth occurs when the populations of town and cities rise. Urbanization refers to the increase in the proportion of the population that lives in towns and cities. Urbanism is the name which is commonly used to describe the social and behavioral aspects of urban livings, which are being extended across society as a whole as people adopt urban values, expectation and lifestyle (Clark, 1996). The switch in the location of population from rural to urban is presently quickest in many of the countries of Africa and Asia. Several areas are presently going through the social and economic crises, which have been promoting the process of urbanization (Gulgler, 1997). There is a general belief that the urban areas offer unlimited opportunities for making ends meet. When crops fail for example, the rural poor move to the cities.

The increased rate of urbanization in the developing countries is also strengthened by the activities of the multinationals that tend to concentrate their investments and manufacturing projects within urban areas. The rapid growth of many cities in Nigeria such as Lagos, Ibadan, Kano, Enugu and Maiduguri among others is associated with this. Also, urbanization can arise indirectly because of changes, which take place in agriculture when countries become absorbed within the global economy. A switch into commercial agriculture, growing crops such as exotic fruits, flowers and out-of-season vegetable for developed world can relieve labour demand in the rural areas and swell up the number of people living in the urban areas.

DESCRIPTION OF THE STUDY AREA

This study was carried in Maiduguri region lies between latitude $12^{o}50^{l}$ and $13^{o}40^{l}$ North and longitudes $11^{o}10^{l}$ and $11^{o}38^{l}$ east. It is located in the semi-arid region of the North Eastern Nigeria. It is the most important city in the North Eastern part of Nigeria and is the administrative headquarter of Borno State. The region is surrounded by Konduga local government area in the NW to SE and Maffa local government area to North East. Some of this local government have rural component. Five to six decades ago Maiduguri was only a small settlement whose western boundary was approximately the railway crossing at the Abaganaram Housing Estate and the railway staff quarters and station form the southern boundary (Akorede and Muhammad 2001), the other boundaries are situated by the sir Kashim Road to the north, Monday

market to the west, Bullabulin to the south and Gamboru ward bound Yerwa north respectively. Then the population was small and almost homogeneous with ethnic groups found being mainly Kanuri, Shua, and Hausa with few Ibo and Yoruba. Maiduguri today is a huge sprawling city occupying several thousands of hectares of land. Although some traditional areas can still be defined, over the past three to five decades, the city has changed both in ground plan and in detail. Urban land uses have increased due to primarily to the development of new housing estates and several non- residential facilities together with the expansion of transport network. Two factors are particularly important for this trend. The relative fragility of the physical environment as influenced by low annual rainfall and short rainy season has contributed to this overall change.

As the city grew in size, it has grown in population. The population has increased from 56,649 in 1952 to 156,000 in 1963, and 673,401 in 1991 and 811941 in 2006 (NPC 2006), and by 2010 the population of the city is estimated to be closed to 1.5 million. This region is consists of a vast open plain known to have developed on young sedimentary rock of the Chad formation consisting of loosed sand, gravels and clays. These sedimentary deposits are believed to have lain down during the quaternary period. The soil types are predominantly sandy at the surface and this may be the underlie problem of soil management in the region. It also has low organic matter contents and low weather able minerals, rapid oxidation of organic residue and frequent exposure of soils to seasonal burning characterize these soils. In some parts of the region there are juvenile halomorphic, vertisols, hydromorphic and alluvial soils corresponding to soil taxonomy order of Entisols, Aridosols, Vertisols, and Entisols or Vertisols respectively occur (Adeniyi and Amojola, 1999; Dami 2002).

The climate of Maiduguri area is the semi-arid type with wide seasonal and diurnal temperature ranges, a long dry season followed by a single wet season (Rim, 1991). Rainfall is less than 600mm per annum and is concentrated in only three to four summer months (June- September). The present available data on rainfall for the city are from 1979-1983 which include: 1979 (711.4mm), 1980 (622mm), 1981 (500.3mm), 1982 (423.4mm), 19983 (395.8mm). In 1983 was recorded as a drought year when crops could not mature before they perished and low yields were recorded that year. The vegetation types falls within the transition zones between the Sudan and Sahel ecological zones. The distribution and character of the vegetation like elsewhere, results from the interplay of climate, edaphic and biotic influence.

The original vegetation of the area consists mainly of low- growing shrubs, mostly Acacia spp, Anogneisus leiocarpus, Parkia biglobosa, Balanites alygptica, Piliostigma, Vitex doniana. Some of the dominant grass species includes Loudetia togoensis, and Axonopus compressus (Areola, 1978). Man has modified this largely fragile ecosystem; the most important factor of this change is agricultural activities and urbanization. Farming is also an important economic activity in the rural areas around the city. However, because of the limitations set by rainfall, farming activities is limited to only a part of the year. The most important crops grown during the short

wet season include millet, groundnut, beans, and animals. Animal rearing is also a conspicuous activity that becomes more and noticeable as one travels around and away from the city. Maiduguri area also falls within the Chad Basin relief region and is about 300m above sea level. The extensive plain land contains no predominant hills apart from a few sand dunes dating from a drier era and ridges, which constitute fossils shorelines from the Lake Chad was much larger.

METHODOLOGY

The sources of data used were based on map and non-map data. The map data used was the topographic map (Maiduguri NW sheets number 90) covering the city and its environ, while the non-map data sources were the remotely sensed imageries. They include, aerial photos for the year 1961 at the scale of 1:10,000, and for 1972 at the scale of 1:25,000; and SPOT images (pan) at the scale of 1:40,000. The aerial photographs were conventional black and white panchromatic images of 10m resolutions. The aerial photographs and SPOT images were interpreted using the analogue procedures. These were later converted to digital forms for computer-aided analysis. Although the aerial photographs and SPOT images were at different scales they were later geo-referenced on the same scale for Geographic Information System (GIS) analysis. For the situation as at 2002, ground survey method was adopted. The 1990 SPOT images were used as the base map, which was updated to obtain the 2002 ground situation.

Each set of aerial photographs for the different years were arranged in series of pairs, one after the other for stereoscopic vision under a mirror zoom stereoscope. The right hand photographs were covered with transparent overlay on which the details of the various land use or land covers were inserted with china graph pencils. The overlay was used for each set of overrun for the study area. The details of this interpretation were transferred unto a sheet of tracing paper for further analysis. The 1990 SPOT images were also interpreted based on an establishment of large number of image to ground concordances, using organized "ground truthing". On the bases of the recognition of classes of land uses/ cover were marked on overlay placed on the imagery with chinagraph pencil. These were then transferred onto the transparent tracing sheets to produce the land use map of the area for 1990. Land use classification scheme was done at two broad levels following the work of (Dami, 2002 and 2008; Adeniyi and Amojola, 1999) for similar locations in Nigeria. This was also at levels of urban and rural land uses.

After the interpretation of the images, geo-referencing and map transformation were done for each of the maps for the GIS analysis. The affine transformation procedure was employed which handle transformation of translation, scaling and rotation, which are essential requirements for computer visualization and manipulation of map data (ARCINFO software used, Dami, 2002). The interpreted map sheets were therefore digitalized, polygonized and rasterized using ILWIS 3.0 software for spatial analysis to be performed. The spatial analysis assesses the changes that have

taken place in the use to which parcel of land has been put over time. The digital procedure used with the aid of ILWIS software that can facilitate the computation and systematic assessment of changes that have taken place over time with respect to each of the land use type. To assess the trends, impacts and implication of land use changes, the following data were acquired (Luse61, Luse72, Luse90, Luse02 - Raster map of the urban land uses) to perform the spatial analysis (Dami, 2002).

RESULTS AND DISCUSSION

Table 1: Codes and class of land uses recognized in the study area

Code	***Description***
A1t0	Low density residential area with no tree cover
A1t1	Low density residential area with medium tree cover
A2t1	Medium density residential area with medium tree cover
A3t0	High density residential area with no tree cover
A3t1	High density residential area with medium tree cover
A3t2	High density residential area with high tree cover
Bt1	Commercial/Industrial area
Ct1	Industrial area
EC	Cemetery
EP	Playground
ES	Institution
Ft0	Farmland
F1t1	Farmland
Ft1	Farmland
Ft2	Farmland
R1	Tarred roads
R2	Untarred roads
River	River

Sources: Adapted from FORMECU (1996).

Table 2: Mainland Uses in Maiduguri - 1961, 1972, 1990 and 2002

Main Land uses	1961		1972		1990		2002	
Code Description	ha	%	Ha	%	ha	%	Ha	%
High-Density Res	1338.25	81.09	2299.25	57.00	2271.75	32.61	2704.75	28.71
Institution	46.50	2.81	573.50	14.21	660.75	9.48	658.00	6.98
Commercial	106.00	6.42	211.75	5.24	530.75	7.62	458.00	4.86
Open Space	6.00	0.36	14.75	0.36	0.00	0.00	0.00	0.00
Medium density Res	29.75	1.80	22.50	0.55	899.00	12.90	1834.25	19.47
Low density Res	112.50	6.81	218.50	5.41	1899.25	27.26	3038.25	32.25
Cemetery	11.25	0.68	11.25	0.27	16.00	0.22	51.00	0.54
Airport	0.00	0.00	682.25	16.91	687.50	9.87	675.25	7.16
Total Urban	1650.25	100	4033.75	100	6965	100	9419.5	100
Urban	1650.25	12.32	033.75	30.12	6965	52.02	9419.5	70.35
River	189.75	1.41	212.50	1.58	203.50	1.51	214.00	1.59
Gandum Daji Forest Reserve	0.00	0.00	0.00	0.00	768.75	5.74	763.50	5.70
MNR Agric Exp Farm	0.00	0.00	175.00	1.30	175.00	1.30	256.25	1.91
Non-urban	11549.00	86.25	8967.75	66.97	5276.75	39.41	2736.25	20.43
Total study area	13389.00	100	13389.00	100	13389.00	100	13389.00	100

Sources: Adapted from Dami (2002)

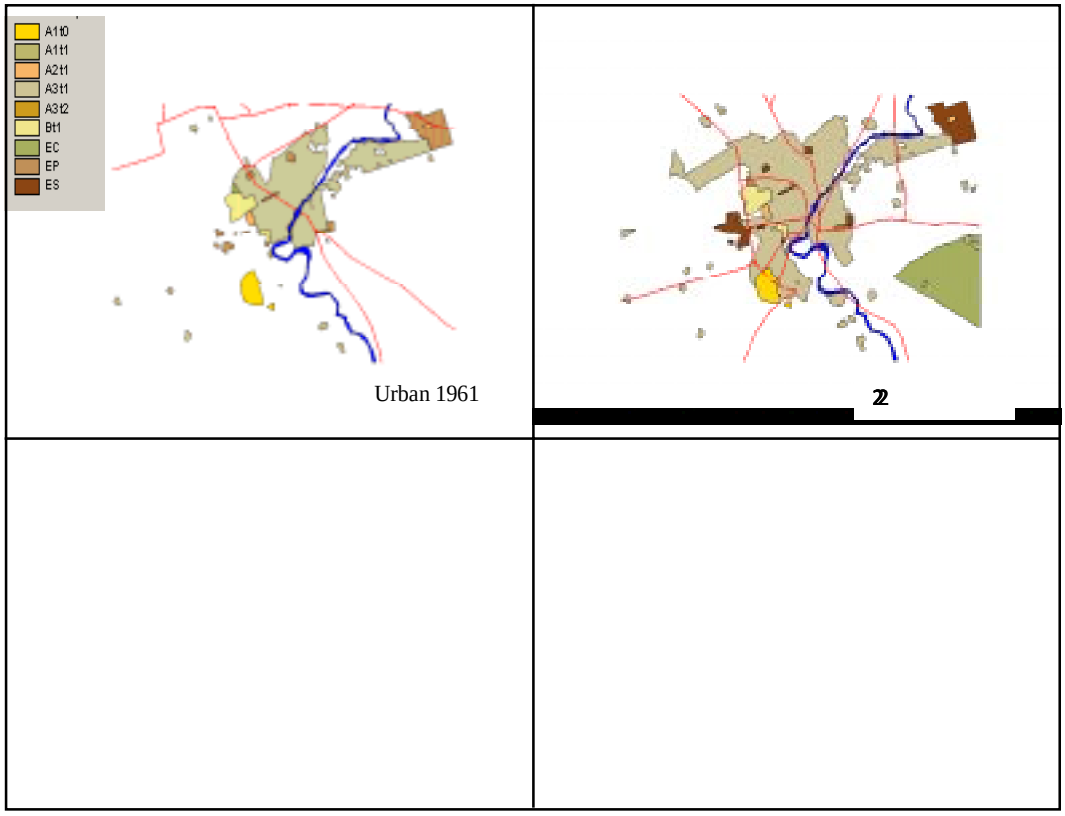
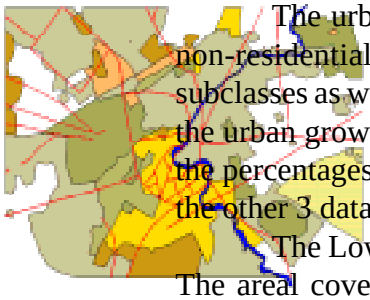


Figure 1: Maiduguri urban growth 1961 to 1972 to 1990 to 2002



The urban land use class consists of two main subclasses the built up and non-residential areas within it, while the rural land use classes consist of two subclasses as well, agriculture fields and rivers (table 1). The final output map shows the urban growth between 1961 to 1972 and 1990 to 2002 (figure1). In computing the percentages, a total area of 13,389, which is delimited for 1961, is the same for the other 3 data points.

The Low-density residential areas have shown the most spectacular growth. The areal coverage went from less than 7% (112.5 hectares) in 1961 to 32.25% (3038.25 hectares) in 2002. This trend is expected. Low-density residential area implies low population-land ratio occupancy. As demands for such accommodation facility increases, the area of land use for the purpose normally increases. The demand for this type of accommodation is influenced by two factors:

i. Improved well being which makes more people to be able to pay for the accommodation
ii. Expansion in senior government functionaries who normally will be accommodated in such areas.

The key findings of this land use changes can be summarized as follows:

i. Urban land uses in the Maiduguri region have expanded enormously from just about 1650 hectares in 1961 to 9419 hectares in 2002.

ii. Following from (i) above, close to 1000 km^2 of rural land had succumbed to urbanization over the 41 year period.
iii. The residential areas have contributed most to the expansion of urban land uses. By 2002, they account for a little more than 80% of the land uses in the city.
iv. Open spaces, which hitherto were found in the city, had virtually disappeared by 2002. They have been taken over by other land uses which is a reflection of poor town planning management in the city.
v. Commercial activities have expectedly expanded. The areas so designated have increased by more than 4 times since 1961.
vi. The most significant areal expansion of urban land uses occurred between 1961 and 1972 when it increased by 144.43%. In fillings appeared to have become more important from 1972 upward.
vii. The analysis of the finer changes taking place revealed important changes. For example, it shows that some residential areas have converted to commercial areas.

Two main factors have been identified as responsible for the changes. These are:
i. Population growth and the attendant need for accommodation. The population of the city was less than 160,000 in 1961 but by project are close to 1 million by 2002. This is an increase of more than 6 folds.
ii. Poor implementation Town Planning Regulations. This gave room for unbridled growth of many of the land use types.

The implication of the land use changes in the study area shows that
i Maiduguri is changing very rapidly. The estimate of 2002 based on urban land use in 1990 gives an average growth rate of 204.44ha per annum. However, it can be observed that between 2005 and to date has doubled its previous rate which we do not have quantitative data to support. However, this is enormous, in arid areas like Maiduguri where water is in short supply. Government must be conscious of this enormous growth and so pursue programmes that will help manage the city region sustainably.
ii The pattern of growth of high-density residential area is worrisome. This growth is in part, traceable to poor implementation of town planning regulations. Also, the housing infrastructures are largely unorganized. The single unit houses compacted together is the dominant features of the high-density residential areas. A more organized estate development will be needed to emphasize vertical as opposed to lateral development in the city. There is also a need for government to have adequate information about the design of urban Maiduguri and to pursue the implementation of the design.
iii The conversion of rural land to urban use in the region is very fast, and poses real threat to crop husbandry and livestock keeping in the immediate rural

space adjoining the city. By the estimate made in this study the urban area of Maiduguri is presently close to 1400km2. This is an enormous space, which requires considerable import of food from the immediate rural areas to sustain itself. The urban area therefore needs to be monitored and managed in such a way that it is not allowed to continue to sprawl into the valuable rural land.

CONCLUSION

This study has demonstrated the versatility of GIS as a means of conducting environmental studies particularly land use. The study however, has been most constrained by the availability of remotely sensed data. There is a need to put in place procedures for regular acquisition of remotely sensed data that will make it possible to track the changes happening to land in the urban areas in Nigeria. This could be in the form of empowering the appropriate hands of the government to acquire the capability and capacity for the acquisition and use of remotely sensed data. The recent effort made by Federal Government to launch her two satellites systems (Nigersat2 and Nigersatx) is one of the best things that have ever happened in recent time in Nigeria, although the data is still not available for public domain which would have helped this work to be reviewed. However, this development will still enable Nigerian researchers to have access to real time data on the Nigerian environment. The remotely sensed data are usually of different capability. Thus, even when Nigerian is able to produce her own images there will be a need to interact with other producers of remotely sensed products to make up for inadequacies of the system on ground. The mechanism for this must be worked out to ensure that adequate monitoring and management of the urban land in the country can be done from time to time.

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