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Analysis of Land Use/Land Cover Changes to Monitor Urban Sprawl in Keffi-Nigeria

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Abstract: Unprecedented population growth couple with unplanned development activities has result in urbanization with haphazard housing arrangement. The aim of the study is to identify the manifestation of sprawl to access its magnitude and to deduce its potential effects on land resource. The method used for the study involved utilization of Remote Sensing imageries obtained from Landsat ETM and Nigeria Sat-1 which were used in an Ilwis 3.2a raster data environment to obtain quantitative data. The magnitude of sprawl was determined and the built-up themes were compared with the population data to observe the rate of growth. It was observed that while population is increasing by 25.15%, built-up areas are increasing by 96.18% which is almost 4 times the rate of population growth. The study concluded that sound land use planning has to be providing by the relevant planning authorities to monitor growth boundaries for urban sprawl in order to archive a sustainable city.

Key words: Sprawl, land cover change, digital image classification, GIS operation, Keffi, Nigeria

INTRODUCTION

Urbanization worldwide continues at a rapid rate and it is estimated by the United Nations Population Fund 1999 that by the year 2025, 80% of the world population would live in cities. Most major metropolitan area faces the growing problem of urban sprawl. Residential and commercial development is replacing underdeveloped lands at an unprecedented rate. These urban sprawl result in the lost of natural vegetation, open spaces and at most the productive agricultural lands while the move to suburbs have brought a lot of benefits to the average citizen, it has also caused numerous urban problems. Cities that were once compact now spread over the landscape, consuming open spaces and wasting resources. This pattern of urban growth is known as sprawl (Cunningham, 2003).

Activities in which man engage in such as clearing of forest (for cultivation, grazing of animals and construction purposes) has in so many ways tempered with the natural vegetation in the study area. The change usually graduate from nonurban to urban land uses if not checked would leads to the destruction of productive lands and the depletion of the forest reserve.

As land becomes increasingly important and competition among alternative use intensifies, shift in land use may be affected by further institutional and environmental constraint. Thus, it is imperative that planners and land use economics developed quantitative capabilities which can be implemented to evaluate the impact of alternative land use policies. The most important issue for the population is the threat to future production of food and other essentials by the transformation of productive lands to non productive uses such as conversion of agricultural land use to residential land use and the degradation of range land by overgrazing.

Available literature describing land use changes indicate that land resource economist and planners have not been concern with projecting future pattern of land use gotten from historical observations. However because of historical bias there has been concerted effort to developed analytical capabilities for use in evaluating the future implications of alternatively land use policies designed to alter trends in land use change in Keffi.

This study will attempt to answer the question: Has urban sprawl undergo a remarkable degree? Is there any significant manifestation of urban sprawl on the study area? This research is aimed at analyzing the spatial dimension of land use change to monitor urban sprawl in the study area. The main objective of the study is to determine the extent of urban sprawl that occurs in the study area (if any) between 1999 and 2007; asses the pattern of and magnitude of urban sprawl in Keffi and make suggestions on future physical planning in the study area.

The spatial patterns of urban sprawl over different time periods can be systematically mapped, monitored and accurately assessed from satellite data (remotely sensed data) along with conventional ground data (Lata *et al*., 2001). Mapping urban sprawl provides a picture of where this type of growth is occurring, helps to identify the environmental and natural resources threatened by such sprawls and to suggest the likely future directions and

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patterns of sprawling growth. Remote sensing and Geographic Information System (GIS) can be used separately or in combination for application in studies of urban sprawl. In the case of a combined application, an efficient even though, more complex approach is the integration of remote sensing data processing, GIS analyses, database manipulation and models into a single analyses system (Michael and Gabriela, 1996). Such an integrated analyses, monitoring and forecasting system based on GIS and database management system technologies requires an understanding of the problem and the application of available technologies. The integration of GIS and remote sensing with the aid of models and additional Database Management Systems (DBMS) is the technically most advanced and applicable approach today.

The study will extend to the entire Keffi land-use/land-cover and its environs. Time wise, it will study sprawl for a period of 8 years i.e., from 1999-2997. The study will attempt to monitor sprawl by utilizing only quantitative data gotten from land and population character and hence determine the relationship between the change in built-up area and population growth. The study has attempted to study sprawl manifestation using geospatial technologies (Remote sensing and GIS). It will exemplify data acquisition and analysis techniques utilizing quantitative data for use in the planning authorities if needed and will thus suggest a planning strategy and implication of sprawl within the study area.

Research hypothesis:

- H_o: There is no significant change in land-use/land-cover from 1999 and 2007
- H_1: There is a significant change in land-use/land-cover from 1999 and 2007

The study area: Keffi and its environs can be located within latitude 8°47'-8°55' and longitude 7°50'-7°55'. It is found within sheet 208 of the topographical sheet of Keffi North East. It is bounded by Karu to the West; Kokona to the East and Nasarawa local government area to the South. The area fall within the guinea savannah area of Central Nigeria (Hill and Rackham, 1974) characterized by tall trees and thick grasses, the vegetation is generally thicker on he hills and along the river channels they are denser during the wet season than the dry season. There is also a wide spread of vegetation degradation due to urban expansion.

The relief ranges from about 277 m towards the Northeast, to 340 m towards the Southeast. The general relief is a gentle slope with undulating isolated hills. There are also steep escarpments in the extreme Southwest.

The major rivers around this region is the Antau river which rises from the Kaduna hills/Jama'a platform and goes far south as Kogin Koto near Nasarawa local government area where it empties its content in River Benue. Minor streams also exist in isolated parts of the town. The area experiences two weather conditions in a year. It includes the warm rainy season which starts from the month of May and ends in October; the cold dry season begins in November and ends in February while the hot dry season starts in March and ends in April with a sunshine duration of 8-9 h day^{-1}. Hence, day time lents are on the average about 8.5 h for most of the dry season. In this region temperatures are generally high because it experience over headed sun twice every year.

Keffi lies within the basement complex of the North Central Nigeria where igneous rocks and metamorphic rocks of Precambrian age are found. These rocks consist of the pan African (older) granite, gneiss, biotite medium grain biotite granite and porphyroblastic biotite granite.

The gneiss rock outcrops are found occupying parts of the North Eastern portion and are known to be considerable weathered on hand spacemen which are medium grain with discontinuous alternation of light and dark minerals. Keffi urban centre is experiencing a nucleated growth. The settlement shows no pattern of growth and arrangement due to lack of proper planning. The settlements in this area are shown in the Table 1.

Table 1: Residential settlements in keffi

Settlement	Area comprises
Ungwwar Rimi	Ungwar Rimi, Kofar Masa, Makeran Baki, Ungwar Mada, 1 and 2, Ungwar Rama, Yankokara, ECWA Church and Kurmin Dauda
Gangaren Tudu	Gangaren Tudu, Ungwar Tiv, Ungwar Waje, Tudun Wada, Masallecin Idi, Keffi Air Strip and Keffi Local Government Housing Estate
GRA	Areas of Akwanga by Pass Road, Stretching from Turaki's house to Keffi hotel including Government Collage Keffi, FMC and Staff Quarters
Goriya	Kofar Goriya, Kofar Kokona, Gunduru, Makwalla, St. Peters Catholic Church and St. Williams and Baptist Primary School
Iya 1	Tsohon Kasuwa, Mayanka, Ungwar Kaura, Gindin Dutse, Ungwar Fadama, Lungu, Ungwar Tudu, Ungwar Majema, Ungwar Chadau, Cinema, Kofar Hausa, Ungwar Kaje and Tudun Amama
Iya 2	Congo, CRDP, Pyanku, Keffi University New Site, Gangaren Korofi, Ungwar Zamfarawa, NTA Junction and Imani Housing Estate
Keffi East Central	Area comprises from FMC Keffi, School of Health Technology, Gwaza hotel, Ungwar NEPA and Federal Government College Keffi
Lambaji	Lambaji, Marmara, Kauran Sarki, Makeran Fari, Gangaren Aboki, Tsohon Tasha and Makwalla
Tudun Kofa	Tudun Kofa, Ungwar Nufawa, Kadarko, Ungwar 'Yarbawa, Parts of Gangaren Karofi and the Emir's Palace and Gangaren Masaka,
Yara	Yara 1 (maji), Sabon Pegi, Sabon Layi, Ungwar Kutare, Keffi Stadium, Dadin Kowa and Keffi Central Market
Yelwa	Yelwa1 and 2, Yelwan Lamma, Zango, Ungwar Tofa, Yelwan Barau, Ketare, Tudun Ba'u, Government Day Secondary School Yelwa.
Keffi North Central	Areas stretching from Nagari Clinic, Low-Cost East, Local Government's Secretariat 1 and 2, Antau Bridge and Mobil Filing Station

Abubakar (2010)

MATERIALS AND METHODS

Base line data collection: The data collection was carried out in two phases which involves primary and secondary data collection the nature of these data and there sources is shown in the Table 2.

The topographical sheet of 1:50,000 used has the following features:

- Land use/build up areas
- Drainage and water bodies
- Contours and slopes
- Road and rail network

Ground-truthing was carried out which involves pre-field work/data collection and field investigation of the study area. Ground-truthing provides a first hand data to create an anchor point in the image classification to avoid passing out wrong information.

Development of land use/land cover classification scheme: The United States Geological Survey (USGS, 1987) classification scheme level 1 was used to classified land cover types. The six resultant land use/land cover classification used are: bare surface, built-up areas, cultivated lands, vegetation, rock out crops and wetlands.

Digital image processing and image interpretation: Image processing is carried out in other to remove the visible systematic error in the image data and to improve their detection and interpretability. This process is carried out digitally by the process called image enhancement, image classification and feature extraction integration. The image enhancement is done to render the image data more effective for subsequent interpretation by increasing the visual distinction between features of interest. In the image classification, unsupervised classification approach was carried out to partition the feature by method of cluster analysis and aggregating them into their natural cluster groupings or spectral signatures. By applying feature extraction, output is gotten through the selection of features of interest. The aim is to extract quantitative features from remotely sensed imageries.

Table 2: Primary and secondary data collection details used for the study

Nature of data	Study area (Keffi)	Data source (s)
Primary	Topographical sheet No. 208 of Keffi N E	Ministry of Lands Survey and Town Planning Lafia Nasarawa state at scale 1:50,000
Primary	Satellite remote sensing imageries. Nig sat dated 11/10/2007. Land sat ETM dated 17/12/1999	National Center for Remote Sensing Jos Plateau State at scale 1:100,000
Secondary	Population data from census abstract for 1999 and 2006 including projections for 1996	National Population Commission Lafia Nasarawa state
Secondary data	Topographic survey maps of Keffi	Federal Ministry of Lands survey and town planning Keffi

Digital image analysis procedure: Land use/land cover was mapped primarily with land sat and Nigeria Sat-1 imageries of Keffi 1999 and 2007, respectively by a variety of analytical procedure including statistical methods and human interpretation. All mapping is done on an ILWIS 3.2a environment raster format. The raster format preserve the attribute integrity of the land use layer and is simpler to edit than complex vector polygon coverage.

The raster pixels are assigned to a domain of land use classes according to the classification scheme chosen above. The domain of land use classes were assigned according to the various spectral signatures each of them portrays. A sample set was created several times to confirm the spectral signatures each of them portrays for every land use/land cover under classification.

Hypothesis testing and statistical predictive modeling of urban sprawl in keffi: Statistical Package for Social Sciences (SPSS) software was used in order to test urban sprawl in Keffi. The estimated percentage of land-use/land-cover (dependant variable) of 1999 and 2007 and the population figures for these years (independent variable) were subjected to linear regression analysis using the backward elimination procedure.

Determination of magnitude of change and percentage change: The magnitude of change is the degree of expansion or reduction in the land use/land cover sizes. A negative value will represent a decreasing land use/land cover sizes while a positive value will indicate an increasing land use/land cover. The magnitude of change (M) is calculated by the equation:

$$M = B - A$$

Percentage change (P) is calculated as:

$$P = \frac{B - A}{A} \times 100\%$$

Where:

M = The magnitude of change
P = The percentage change
B = The base year (2007)
A = The referenced year (1999)

The computer based analytical tools used include: 14 inches monitor; GIS PC ILWIS 3.2a software; 40 GB Ram; Microsoft excel; HP Laser jet 2100 printer; 700 Mb Cd Rom for the transfer of images and optical data.

Measuring the magnitude of urban sprawl: To understand the complexity of a dynamic phenomenon such as sprawl, land use change analysis was carried out. The urban sprawl over a period of 8 years was determined by computing the areas of all the land use and comparing it with the built up theme. Urban density was calculated for the built up area to quantify the sprawl in the area. The Urban Density (UD) is calculated by the equation:

$$U = \frac{\text{Population}}{\text{Built} - \text{up area}}$$

A decreasing urban density will indicate a disperse settlement.

Built-up areas and population as indicators of urban sprawl: The percentage or proportion of the total population in a region to the total built-up of the region is a measure of quantifying sprawl. It can be safely considered that developed areas have greater proportions of impervious surfaces i.e., the built-up areas as compared to the lesser-developed areas. Further more, the population in the region also influences sprawl. The proportion of the total population in a region to the total built-up of the region is a measure of quantifying sprawl. Sprawl may be said to have occur when the rate at which land is converted to developed or urban land uses exceeds the rate of population growth (USGS, 1987).

Considering the built-up area as a potential and fairly accurate parameter of urban sprawl has resulted in making considerable deductions on this phenomenon. Since, the sprawl is characterized by an increase in the built-up area along the urban and rural fringe this attribute gives considerable information for understanding the behavior of such sprawls. This is also influenced by parameters such as population density and population growth rate.

RESULTS AND DISCUSSION

Preamble: The land use and land cover data gotten from the remotely sensed imagery were subjected to various GIS operations. The estimates of the analysis show six categories or land use and land cover types. The result of the analysis has revealed an uncontrollable urbanization and the absence of land use planning regulations. The categories of land use/land cover from the estimates and its associated change from 1999-2007 is shown in Table 3.

Table 3: Land use /land cover estimates of Keffi and its environs using GIS and remote sensing data from 1999-2007

Land use/land cover categories	Land sat ETM 1999		Nigeria Sat-1 2007	
	Area km^2	Percentage	Area km^2	Percentage
Bare surface	8.09	5.61	4.70	3.28
Built-up area	13.38	9.59	26.25	18.30
Cultivated lands	90.87	63.06	85.84	59.72
Rock out crops	3.08	2.14	3.57	2.49
Vegetation	16.92	11.75	10.53	7.34
Wetlands	11.59	8.05	12.60	8.78
Total	143.93	100.00	143.49	100.00

National Center for Remote Sensing and GIS Jos/Field work 2009

Interpretation of results and the spatiotemporal variation of land use/land cover in keffi and environs

Bare surface: They include: foot paths, foot ball fields play ground and other open spaces that plant cover could not grow on. Bare surfaces witness a decrease within the study period it covers an area of 8.09 km^2 (5.61%) in 1999 and decrease to 4.70 km^2 (3.28%) in 2007.

Built-up areas: From the estimates, urban land use (built-up areas) occupy an area of 13.38 km (9.59%) in 1999 and witness an increase to 26.25 km (18.3%) in 2007. These figure reveal a general change in magnitude of 96.18% from 1999-2007.

Cultivated lands: The cultivated lands witness a decrease of 5.03 km^2 within the period of 1999 and 2007. This result implies that the level of crop cultivation is decreasing while urban land use is virtually on an increase, meaning that lands meant for crop cultivation are giving way to urban land use. These cultivated lands occupy an area of 90.87 km^2 in 1999 and decrease to 85.84 km^2 in 2007.

Rock outcrop: Rock bodies are relatively stable probably due to vegetation growth on rock bodies and crop cultivation on rock surfaces. The rock outcrop occupy about 3.8 km^2 (2.14%) from the 1999 estimates and 3.57 km^2 in 2007.

Vegetation: Vegetation experienced a great decrease due to the increasing demand for fuel wood and the rapidly expanding human population and urban land use which is growing in expense of the vegetal land cover. Vegetation is estimated to cover an area of 16.92 km^2 (11.75%) in 1999 and decrease to 10.53 km^2 (7.34%) in 2007.

Wet lands/water bodies: These wetlands occupy an area of 11.59 km^2 (8.05%) in 1999 and 12.60 km^2 (8.78%) in 2007 as seen from the estimates. Figure 1 and 2 shows a relatively stable area but increase by about 1.1 km^2 from 1999-2007. These wetlands contribute generally to agricultural cultivation especially in areas that are permanently wet.

Rates of growth and magnitude of sprawl in Keffi and environs from 1999-2007: The rates of growth of urban land use and its development in Keffi and environs by far

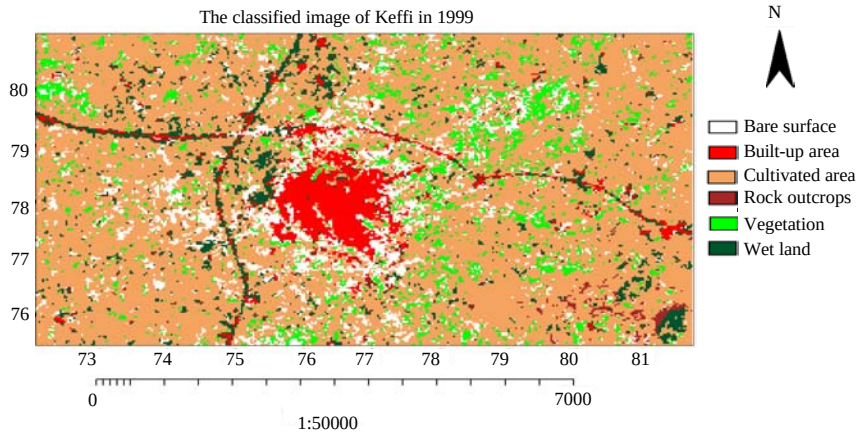

Fig. 1: Classified image of Keffi in 1999

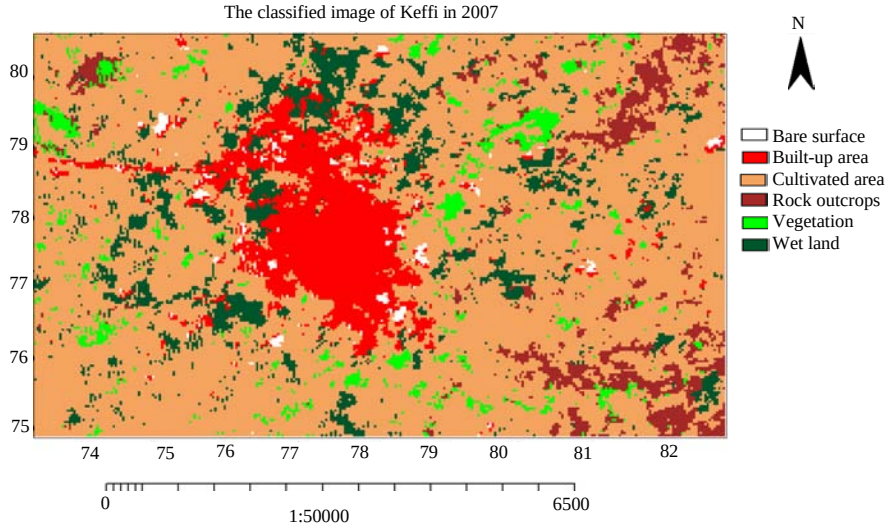

Fig. 2: Classified image of Keffi in 2007

outplace population growth. This implies that the land is consumed at an excessive rate and probably unnecessary amount as well.

Between 1999 and 2007, population grew by 25.5% (extracted from National Population Commission, Lafia) while the amount of developed land grew by 95.18% nearly 4 times the rate of population growth thus, indicating sprawling urban area. This implies that the per capital consumption of land has increase markedly over 8 years of the study period. The per capital consumption of land refers to the utilization of all the urban land uses ranging from commercial, educational/ institutional, recreational establishment alongside with residential establishment per person. Since, most of these initiatives pave way for the creation of jobs and subsequently help in earning livelihood. The development of land is seen as a direct consequence of these and hence one can conclude that the per capital land consumption is inclusive of all the associated lands development.

The proportion of the total population to the total built-up in Keffi is 5,644 persons km^{-2} in 1999 which decrease to 3,611 in 2007. Since, urban sprawl is indicated by a low density urbanizing area, the reduction of the urban density makes sprawl to be a reality and not a mere mirage of phenomenon.

Implication of sprawl in Keffi and environs: From the estimates shown in Table 4 and 5, respectively the built-up areas is on an increase, the ratio of the population to the percentage built-up has also decrease remarkably in Keffi. This is evidence that urban growth is increasingly dispersed and that urban land use is changing at an unnecessary amount as a result of

Table 4: Magnitude and percentage change in land use/land cover

Land use/ land cover	Area km^2 (A) 1999	Area km^2 (B) 2007	Magnitude of change M = B-A	Percentage change P = B - A/A×100%
Bare surface	8.09	4.70	-3.39	-41.90
Built-up areas	13.38	26.25	12.87	96.18
Cultivated lands	90.58	85.84	-5.84	-5.54
Rock outcrops	3.08	3.57	0.49	15.91
Vegetation	16.92	10.57	-6.39	-37.77
Wetlands	11.59	12.60	1.10	8.71

Table 5: Built-up areas, population and urban density

	Built-up area km^2		Population		Urban density	
Segment	1999	2007	1999	2007	1999	2007
Keffi town	13.38	26.25	75,523	94,791	5,644	3,611

population increase. When ever this land is altered by urban growth, additional modification will be required to accommodate the change and the demand for infrastructure and basic services of housing has increase as new houses are constructed, schools/educational institution and other municipal services such as roads are created to improve the efficiency of land development, land is continually lost as a result of these housing development leading to urban growth. The pattern of these housing development and growth are observed to be dispersed, probably motivated to a significant degree by the desire of people to move close to their occupational activities since most of the residents are farmers.

Among the land use and land cover changes as seen; bare surface, cultivated lands and vegetation are affected by sprawl in Keffi. Most of this expansion of development has come in expense of the cultivated and vegetal land cover. The cultivated and vegetal land cover has become prime target for urban sprawl. Should these cultivated and vegetal land cover be depleting at rates of this nature in a community with occupation largely agrarian, there is a great threat to farmers' productivity and income. This nature of land use change is evidence of lack of proper land use planning strategy in Keffi and the negligence of the planning authorities to implement and enforce a sound land use planning policies in Keffi.

Analysis of the relationships between the urban sprawl and increase in population increases in Keffi: The values obtained from the backward elimination procedure was as the object of interpretation. The observed relationships between the two variables yielded a regression (r) value of 0.956 (approximately 0.96) to show that there is strong perfect association between the two variables at 0.001 level of significance. Hence, 96% of urban sprawl in Keffi is explained by population increases. Similarly, the coefficient of determination R^2 (Adj) value of 0.945 further confirms the relationships that 94.5% of the total sprawl is accounted for by population increases. This means that the residual part of the equation is explain by other insignificant variable such as road construction and installation of mast for mobile telecommunication among others. The F (calculated) for this relationship is 87.398 at a significant level of 0.001. This is however, checked against F (tabulated) and yielded a table value of 17.543 at 5% points of F-distribution. This result refutes to confirm the null hypothesis which states that there is no significant change in land-use/land-cover from 1999 and 2007.

CONCLUSION

Urban sprawl has been detrimental to Keffi and its inhabitants. It results to the loss of viable cultivated land resources and vegetative lands within the 8 years period of study. This sprawl results in a more widespread pattern of growth in an uncoordinated manner and resulting to haphazard housing development. This urban growth has been identified to be a direct response of the unprecedented increase in population putting pressure on all the available land resource. Therefore as Keffi grows sustainable planning programmes should be put in place so as not to temper with the productive land surfaces. The plan must be effective to maintain a balanced ecological, social and economic system. The local government council should institute monitoring and control measures/team to ensure effective compliance with planning law in order to address sprawl issues.

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