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Comparative Detection of Infrastructural Land Conversion Dynamics in a Nigerian City Using Space Technology *(Pp. 341-348)*

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Abstract
Land use and Land cover dynamics is a major feature of human presence and existence. In and around Owerri Metropolis, in Southeastern Nigeria, land conversion for infrastructural facilities is dominant. This study assesses the conversion rate and classes of land for infrastructure. Landsat TM 86 and ETM+ 2000 were used to detect and map the infrastructural LU/LC dynamics. The imageries were analyzed at the scales of 1:250,000 and 1:150,000. The result showed significant shifts in the aggregate conversion for infrastructures and vice versa, given varieties of forcing agents. Aggregate built up class went up from 438.04 sq. km to 543.88 sq. km between 1986 and 2000. Annual mean coverage rate is about 7.56 sq. km [5.8%] within the study period. The PAVM for the periods were presented as 15.7% and 10.8% respectively. This shows that Land use and Land cover were massively converted into and from infrastructural class.

Key words: land use, land cover, satellite imagery, infrastructure, land conversion.

Introduction

According to Cihlar and Jansen [2001], land cover [LC] and land use [LU] are concepts that define and describe terrestrial environment in natural and anthropogenic contexts. LC is largely of natural origin or is created by LU but, is characterized by the biophysical features of the terrestrial environment.

On the other hand, LU refers to the manner in which these biophysical assets are used by people [for details, see Cihlar and Jansen, 2001]. It is the employment of LC and management strategy used on a specific class by human agents for land managers [Baulies and Szejwach, 1997]. LC may be created by LU as defined by infrastructural facilities such as roads, buildings, etc. In this study, built environment is taken as being synonymous with infrastructural class.

Studies have revealed several concerns of LU and LC on the global environmental change, the issues involved in LU and LC conversions as all as its changes over time (Meyer and Turner, 1994). This conversions cause modifications, and on the aggregate, global change of diverse dimensions. Specifically, the conversions for and imposition of infrastructure influence, for example, influence the climate system of cities as opposed to hinterlands [Riebsame, Meyer and Turren, 1994 Veldkamp and Fresco, 1994]. Ojo [1986] and Walker and Steffen [1994] admitted that LU is the dominant forcing of global change, and observed regional variations and swings in the climate system in the past few years. The need to monitor and measure the rate of land conversions for infrastructure and vice versa is the essence of this paper. Moreover, since infrastructural LU is the result of interactions between society and the natural environment, knowledge of it is crucial for the study and improved understanding of human induced global changes. This may influence institutional responses to contemporary environmental change at all levels from local to global [Pritchard, et al, 1998 and Cihlar and Jansen, 2001]; the relevance of space technology for periodic LU and LC monitoring, change detection and mapping is highlighted.

Specifically, this paper examines the rate of land conversion to and from infrastructural LU between 1984 and 2000 in Owerri Metropolis using TM 86 and ETM+ 2000. This particularly, is as a result of the reasons presented above and to further evolve a systematic strategy for studies of LU and dependent processes. It was to identify the primary drivers of the intra-class

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dynamics during the periods in order to predict the extent and imposition of land conversions for infrastructure, and vice versa, in the future.

Study Area Description and Delimitation

The study area is Owerri metropolis and environs in Southeastern Nigeria. Owerri, a closely-settled built-up area is the administrative capital of Imo State in Eastern Nigeria is shown in Figure 1. The pre-1976 Owerri comprised largely pockets of rural settlements of predominantly subsistence farmers. It lies between latitude $5^o25^'$N and 5^o $34^'$ N and longitude $6^o7^'$E and $7^o06^'$E covering an area of approximately 5,792.72 km^2 and a population of 190, 575 people. The area is within the humid tropics and is characterized by high temperature and rainfall regimes with a mean maximum temperature of about 32^0C and a mean minimum of about 21^0C. Recent studies (e.g. Nnaji, 1998, 1999 and FGN, 2003) however reported declining trend in rainfall characterized by large spatial and temporal variations.

The area lies in the rainforest belt of Southeastern Nigeria characterized by low- land tropical rainforest, which has virtually given way to secondary forest re-growths of mostly tree crops and shrubs separated by crops at various stages of growth. In the area, vegetation plays the dual role of humus supply and protection of the soil from the ubiquitous soil leaching and erosion.

Owerri and environs are within the densely populated region of Southeastern Nigeria. The growth rate of the population growth, its size structure, density, spatial distribution and urbanization characteristics are critical factors of the environment likely to affect LU and LC dynamics. Being the administrative capital of Imo State, associated infrastructure, education opportunities and employment potentials, the city attracts growing migrants from distant and adjourning towns and villages. The emergence of small and medium sized agro-husbandry industries in the peripheral, semi-urban villages have attracted urban sprawl and rapid socio-economic activities. Hence, subsistence agriculture, petty trading, white collar jobs (paid employment), artisanship characterize and significantly influence the contemporary LU and LC patterns. This has exerted great pressure on the ecological resources, even without any eco-conservations efforts.

Methodology

Data used for the study were Landsat Thematic Mapper [TM] of 1986 and Enhanced Thematic Mapper plus [ETM+] of 2000 satellite imageries. These data were used for built LU and LC classification and statistical change analysis of static features captured by the imageries. The LU and LC classes were identified through a combination of their image characteristics, previous LU and LC patterns as well as previous potential changes, since the trend, regularity and patterns were identified for the conversion process.

Image classification was achieved through preparation of a confusion matrix. Through this process the built class of Owerri and environs was evolved to include 2 classes and 6 sub- classes and were numerically coded as presented on Table 1.

The Percentage Absolute Variation of Mapping [PAVM] was calculated to determine the degree of variance and ability of the imageries to map the built features. This involved determination of the change in areas between the LUs in 2000 from their coverage in 1986 and the conversion of the LU class to another between 1986 and 2000. A zero value implies that no change existed between the features on the data sets while the value of 100% means that LU classes were completely transformed in one of two data sets.

Results and Discussion

The infrastructural environment was identified and delineated on TM 86 and ETM+ 2000. There were also observed varying degrees of spectral signatures on the generated imageries and variations in the settlement class.

Land areas and features were assigned different spectral signatures to represent changes from one sub class to another. The coverage of infrastructural LU and LC in 1986 rose from 438.04km^2 to 543.88km^2 in 2000. This showed that about 105.84 sq. km [80.5%] increase in infrastructural LU covered the area between 1986 and 2000 while annual mean coverage is about 7.56 sq. km or about 5.8% increase annually within the study period.

Compared with other LUs, the conversion of forest class to the infrastructural class was about 42.79 km^2. This is due mainly to urbanization and land development as a result of population increases and provision of infrastructural development for the almost two decades.

Summary of the Land Use and Land Cover change analysis between the periods, 1986 and 2000 is presented on Table 2.

There were conversions between 5 classes. For example, there were areas which appeared on TM 86 as forest vegetation and on ETM+ 2000 as infrastructural. This conversion from forest vegetation to infrastructural represents about 42.79sqkm. The summary of changes on the infrastructural class is presented on Table 3.

Bare/eroded surfaces conversions to the built up class were mainly observed around the New Owerri Layout and the Amakohia Uratta area to be about 20.35km^2. This is as a result of urbanization and provision of physical infrastructures for the rising population. The cultivation to the built up class represents 150.78km

The comparison of the differences between the areas covered by the built class in relation to other classes is presented on Table 4. The strength of differences of the classes is shown using the Percentage Absolute Variation of Mapping (PAVM). The values show that there was an overall change of about 26.9% between the data sets.

Conclusions

The results of the comparative study revealed significant increase in infrastructural development between the two periods. The imageries proved useful and reliable in the mapping of infrastructural class. The bare/eroded surfaces class gave the highest PAVM value of 65.7%. This suggests that the LU and LC underwent massive land physical development due mainly to the rising spate of urbanization around Owerri and environs. This corresponds with the high percentage value [80.5%] obtained through comparison of change in the built of between 1986 and 2000 using the two data sets.

Given the above results, it is imperative to monitor and inventory the key drivers of infrastructural LU and LC change. Specifically, urban LU and LC are expected to be more rapid in recent times, given the rising population and the need to provide adequate and functional infrastructural facilities in Owerri and its environs.

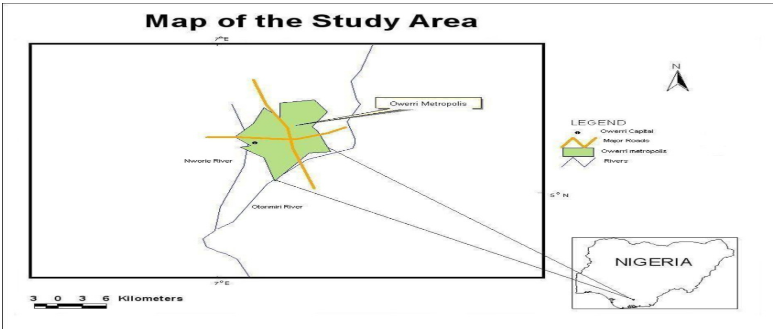

Figure 1: A map of Owerri showing its location in Nigeria [inset].

Table 1: Land use and Land cover classification scheme for Owerri metropolis and environs

LU/LC Class	Numeric Code	Feature name [sub class]
Built/Infrastructure	11	Villages
	12	Urban areas
	121	Mixed traditional areas
	122	Mixed modern areas
	123	Commercial areas
	124	Industrial areas
	125	Open spaces and recreational areas
	126	Institutional areas
	127	Transportation
	128	Vacant lands

Table 2: Summary of the LU and LC change analysis between the periods 1986 and 2000

LU / LC Classes	TM 86 [Classified]	ETM+ 2000 [Classified]	Area in Km^2
Vegetation Δ Forest Vegetation	Forest Vegetation	Forest Vegetation	1097.46
Vegetation Δ Built-up	Forest Vegetation	Built-up	42.79
Vegetation Δ Water body	Forest Vegetation	Water Body	0.63
Vegetation Δ Cultivation	Forest Vegetation	Cultivation	290.38
Built-up Δ Forest Vegetation	Built-up	Forest Vegetation	15.29
Built-up Δ Built-up	Built-up	Built-up	331.15
Built-up Δ Water Body	Built-up	Water Body	0.56
Built-up Δ Cultivation	Built-up	Cultivation	91.04
Eroded Surface Δ Forest Vegetation	Bare/Eroded Surface	Forest Vegetation	0.02

Eroded Surface Δ Built-up	Bare Eroded Surface	Built-up	20.35
Eroded Δ Cultivation	Bare Eroded Surface	Cultivation	1.58
Water Body Δ Forest Vegetation	Water Body	Forest Vegetation	3.19
Water Body Δ Built-up	Water Body	Built-up	3.35
Water Body Δ Water Body	Water Body	Water Body	1.49
Water Body Δ Cultivation	Water Body	Cultivation	1.50
Cultivation Δ Forest Vegetation	Cultivation	Forest Vegetation	444.32
Cultivation Δ Built-up	Cultivation	Built-up	150.78
Cultivation Δ Water body	Cultivation	Water Body	0.95
Cultivation Δ Cultivation	Cultivation	Cultivation	295.89
Δ = changed to		Total Area	2792.72

Table 3: Summary of the changes on the infrastructural class, 1986 and 2000

LU and LC Classes	TM 86 [Classified]	ETM+ 2000 [Classified]	Area in km2
Built up Δ Forest Vegetation	Built up	Forest Vegetation	15.29
Built up Δ Built up	Built up	Built up	331.15
Built up Δ Water body	Built up	Water body	0.56
Built up Δ Cultivation	Built up	Cultivation	91.04
Δ = Changed to		Total	438.04

Table 4: PAVM of the Land Use and Land Cover Classes, 1986 and 2000.

LU / LC Classes [TM 86]	Area in km^2	% intra class	LU / LC Classes [ETM+ 2000]	Area in km^2	% intra class	PAVM
Bare/ Eroded surfaces	21.96	0.8	Bare/Eroded surfaces	4.54	0.2	65.7
Cultivation	891.94	31.9	Cultivation	680.4	24.4	13.5
Forest Vegetation	1431.25	51.2	Forest vegetation	1560.28	55.9	4.3
Built-up	438.04	15.7	Built-up	543.88	19.5	10.8
Water body	9.53	0.3	Water body	3.62	0.1	44.9

References

Baulies, X and G. Szejwach, [eds.] [1997]: Survey of needs, gaps and priorities on data for Land use/ land cover change research. *Report presented at the LUCC data requirement workshop,* 11 – 14 November, Barcelona

Cihlar J and L J M Jansen [2001]: From land cover to land use: A methodology for efficient Land use Mapping over large areas, *Professional Geographer* 53 [2], pp 275 – 289, Association of American Geographers.

Federal Government of Nigeria, [2003]: *First National Communication on Climate Change* (Final Draft), Federal Ministry of Environment, Abuja.

Njoku, J. D. [1992]: "*A Multi – band Assessment of SPOT Imaging System for Land and Land Cover Mapping of Northwestern Nigeria*". Unpublished MSc Thesis. Dept of Geography and Planning, University of Lagos, Akoka, Lagos.

Nnaji, A. O. [1998]: Climate Forcing, Precipitation Variability and Rainfall Forecasting Models for Northern Nigeria. *Proceedings of the 94th Annual Conference of Association of American Geographers*. Boston Massachusetts. March 26th- 29th

Nnaji, A. O. [1999]: *Climate Variation in the Sub – Saharan Region of West Africa: A Study of Rainfall Variability in Northern Nigeria*," unpublished PhD Dissertation, Department of Geography, University of Florida, Gainesville.182pp.

Ojo, S. O. [1986]: *The Climatic Drama.* Inaugural Lecture Delivered at The University of Lagos, University of Lagos Press. Lagos.

Pritchard, L., Jr, J. Colding, F. Berkes, U. Svedin and C. Folkes [1998]: The problem of fit between ecosystems and institutions . *IHDP working paper* No.2 Bonn, Germany. International Human Dimension Programme on Global Environmental Change

Riebsame W E, W B Meyer and B L Turner, II [1994]: Modeling land use and land cover as part of global environmental Change. *Climate Change* 28: 45 – 64

Veldkamp, A and L O Fresco [1996]: CLUE: A model to study the conversion of land use and its effects, *Ecological Modeling* 85:253 – 270.

Walker, B and W. Steffen [eds.] [1997]: The terrestrial biosphere and global change : Implications for natural and managed ecosystems. *A synthesis of GCTE and related research, IGBP Science*. Stockholm International Geosphere - Biophere Programme