Detecting the Rate of Urban Expansion and Changes in Landuse/Landcover in Umuahia North, Abia State, Nigeria

[1]Ogu, O.G., [1]Umezuruike, S.O. and [2]Peter, C.C.

[1]Department of Environmental Management &Toxicology, Michael Okpara University of Agriculture, Umudike, Nigeria

[2]Department of Environmental Resource Management, Abia State University, Uturu, Nigeria

Corresponding Author: Ogechi.godson@yahoo.com (+234 8067287071)

Abstract: Landuse/Land Cover change over time is a phenomenon occurring globally due to varied interests of the inhabitants in a particular area. Umuahia, the Abia State capital has witnessed remarkable expansion, growth and development since 1991. The general objective was to map the Landuse/Landcover and estimate the rate of urban expansion in Umuahia North between 1991 and 2015. Landsat satellite imageries of 1991 and 2015 of the study area were brought into GIS environment and processed using ENVI 4.5 and ILWIS 3.2 Academic image classification software. The study revealed significant changes in Landuse types over the study periods. It was observed that forest and vegetation depreciated substantially in total Landcover area loosing 30.30 KM^2 (1.21 Km^2 annually) and 28.80 Km^2 (1.15 Km^2 annually) respectively between 1991 and 2015. Built-up area experienced the highest rate of expansion gaining 50.0 Km^2 (2.0 Km^2 annually) over the study periods. These developments raise concerns given the high rates of deforestation, loss of cultivable land and urban expansion in the study area. Urban planning authorities and policy makers should develop policies that would curtail urban land consumption rate and conserve agricultural land at the peri-urban fringes of Umuahia North.

Key Words: GIS, Landuse/Landcover, Urban Expansion, Umuahia North

1.0 INTRODUCTION

Due to anthropogenic activities, the earth's surface is being significantly altered and man's presence on the earth and his use of land has had a profound effect upon the natural environment, thus resulting into an observable pattern in the land use/land cover over time (Lambin *et al*, 2003; Jiang *et al*, 2004; Asthana and Asthana, 2005; Zubair, 2006; Long *et al*, 2008). Urbanization is one of the several anthropogenic activities that impact on land use/land cover. Urban population has been growing more rapidly than rural population worldwide, particularly in developing countries (Lambin *et al*, 2003). According to the United Nations Population Division (2002), as at the year 2000, towns and cities sheltered nearly half of the world's population (over 2.9 billion people), the majority of which were in developing Countries. This has resulted in a high rate of urbanization. Ifatimehin and Musa (2008) revealed that, "with increase in urban population comes a whole spectrum of activities such as commercial, agricultural, transportation, industrial, recreational, residential, institutional, etc. These landuses exert pressure on the seemingly finite land resources in urban centres, thus, land is fast becoming a critical resource". Its demand is likely to continue growing, but maintaining the capacity to sustain that demand remains a fundamental issue of both academic and policy discourse.

Current information on Land Use and Land Cover forms necessary input in studies relating to urban planning. The need for Land Use/ Land Cover data has become in recent times increasingly important in national Urban Planning. Haphazard and uncontrolled developments lead to deteriorating environmental quality which constitutes a clog in Urban Planning and growth (Osborne *et al*, 2001). Land use/ land cover change over time is an inevitable phenomenon occurring globally due to both temporary and permanent interest of the inhabitants in a particular area (Adeniyi and Omojola, 1999). The phenomenon could be revealed either in a small or large scale but the most interesting and fundamental observation is that change occurs overtime in a particular place. Mengistu and Salami (2007) sees the phenomenon as being local and place specific, occurring incrementally in ways that often escape our attention. He also observed that humans have been altering Land-Cover since prehistory through the use of fire to flush out game and, since the advent of plants and animals domestication, through the clearance of patches of land for agriculture and livestock. Globally, it has been

observed that the impact of human activities on land has grown enormously, altering entire landscape, and ultimately impacting the earth's nutrient and hydrological cycles as well as climate.

Land Use and Land Cover Change (LULCC) is a general term for the human modification of earth's terrestrial surface. The Land Use Land Cover Change alterations are generally caused by mismanagement of agricultural, urban, range and forest lands which leads to severe environmental problems (Seto *et al*, 2002). Though humans have been modifying land to obtain food and other essentials for thousands of years, current rates, extents and intensities of Land Use and Land Cover Change are far greater than ever in history, driving unprecedented changes in ecosystems and environmental processes at local, regional and global scale (Green, 1994). However, Braissoulis (2000) argued that land use changes such as urbanization tend to radiate out from existing areas of the same class and many models take advantage of this characteristic to make predictions of future change. Whichever is the case, the results of the pressure are numerous and they include intensified agriculture, decreasing amount of forestland, loss of biodiversity, intensified land degradation and soil erosion (Pellika *et al*, 2004). In a nutshell, Land Cover is continually transformed by Land Use changes, suggesting that Land Use is the cause of Land-Cover Change and the underlying driving forces remain economic, technological, institutional and demographic factors (Mengistu and Salami, 2007). In addition to being a driver of earth system processes affecting climate, the carbon cycle and the ecosystem, Land-Use and Land-Cover Change has a significant impact on the feedback of hydro climate process on the surface hydrology (Odunuga *et al*, 2007).

Often, improper landuse, especially at urban fringes, is causing various forms of environmental degradation. For sustainable utilization of the land ecosystems, it is essential to know the natural characteristics, extent and location, its quality, productivity, suitability and limitations of various lands (Nagamani and Ramachandran, 2003). The land use/land cover pattern of a region is an outcome of either one or a combination of natural and socio–economic factors (Anderson *et al*, 2001) and their utilization by man in time and space (Osborne *et al*, 201). Land is increasingly becoming a scarce resource due to immense pressure from anthropogenic activities. Therefore, information on land use changes and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. In situations of rapid and often unrecorded land use changes, observations of the earth from space provide objective information of human utilization of the landscape. Over the past years, data from earth sensing satellites has become vital in mapping the earth's features and infrastructures, managing natural resources and studying environmental change.

Remote Sensing (RS) and Geographic Information System (GIS) have been recognized as powerful and effective tools and widely applied in detecting the spatio-temporal dynamics of land use and land cover (Long *et al*, 2008), thus presenting new tools for advanced ecosystem management, agriculture and environments (Ray and Dadhwal, 2001; Jiang *et al*,2004; Kato and Yamaguchi, 2007). The collection of remotely sensed data facilitates the synoptic analyses of earth-system function, patterning, and change at local, regional and global scales over time. Such data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of biological diversity (Wilkie and Finn, 1996).This study investigates the rural-urban land use status of Umuahia urban and peri-urban area between 1991 and 2015, with a view to detecting the rate of rural land being converted to urban land use. Umuahia, the Abia State capital, has witnessed remarkable expansion, growth and developmental activities such as the construction of buildings and infrastructure as well as many other anthropogenic activities since 1991. This has, therefore, resulted in a sustained increase in urban land usage, modification and alterations of Umuahia and its environs over time. Although, studies relating to changes in landuse have been carried out within and around Umuahia (Okali *et al*, 2001; Onweremadu *et al*, 2007), the problem however, is that there has been very limited detailed and comprehensive attempts (as provided by Remote Sensing data and GIS tools) to evaluate this status as it changes over time with a view to detecting the rate of rural land loss and urban expansion. This is of particular concern to this study because the rural inhabitants depend largely on cultivation both for food supply as well as for income generation. The specific objective of this study was therefore to determine the rate of urban expansion and changes in landuse.

1.2. STUDY AREA

Umuahia, the Abia State capital, has witnessed remarkable expansion, growth and developmental activities such as the construction of buildings and infrastructure as well as

many other anthropogenic activities since 1991. This has therefore resulted in a sustained increase in urban land usage, modification and alterations of Umuahia and its environs over time. Umuahia is located along the rail road that lies between Port Harcourt to Umuahia's south and Enugu to its north. It has an area of 245 km² and a population of 220,660 at the 2006 census (Ukandu *et al*, 2011). Umuahia is well known as being an agricultural market center. It is also a railway collecting point for crops such as yams, cassava, corn (maize), citrus fruits, and palm oil and kernels. Umuahia is located in the south-eastern part of Nigeria. It lies between latitudes 5º 33′ 20′′ N and longitude 7º 28′ 52′′E. It is bounded to the north by Isuikwuato LGA, to the north-east by Bende LGA, to the south-east by Ikwuano LGA, to the south by Isiala-Ngwa North LGA and shares a common boundary with Imo state to the west. The study area is situated on the coastal plain geographical zone which is the greatest and largest of the geographical zones in South-Eastern Nigeria covering 27.5% of the area, close to the outcrops of sandstones and shale of the Bende-Ameki group of geological formations found to the east of the area. Located within the equatorial belt of Nigeria, the area is dominated by a tropical rainforest vegetation, and climate which is characterized by two distinct weather seasons: rainy and dry seasons. The area is characterized by a long dry season (November-March) and a longer rainy season (April-October). The mean annual rainfall is between 2,500mm to 3,100mm (Onyeka *et al*, 2008). The monthly mean temperature ranges from 25^{0}C to 32^{0}C, while mean relative humidity ranges from 60-90%. Highest and lowest monthly mean relative humidity is observed during rainy and dry seasons respectively.

1.3. MATERIALS AND METHODS

The main secondary data used for this study were a landuse map and a Landsat ETM+ satellite image of Umuahia North for 1991 and 2015, respectively. Raw Landsat satellite Imageries of ETM 30m by 30m resolution of 2 study periods (1991 and 2015) of the study area were obtained from Landsat Global Land Use/Land Cover facility and processed using ENVI 4.5 GIS software and ILWIS 3.2 Academic image classification Remote Sensing software. The political maps of Abia State and Umuahia North were also obtained. The remote sensing data were corrected for radiometric and geometric errors. The ILWIS 3.2 Academic GIS software was used in classifying the land use map imagery of the study area. Land use maps were generated from the classified images. Landuse/cover maps were generated from the classified images while the statistics generated were used as the basis producing the bar graphs and charts in the work.

1.4. RESULTS AND DISCUSSION

Results

The classification and quantification of the images of the study area (Umuahia North) was necessary in the detection of changes in the various LULC. Thus, the static LULC distributions for the study period (Table 1) were derived over the 2 study periods (1991 and 2015). From tables 1 and 2, it was discovered that as at 1991, Forest constituted the largest LU category in the study area occupying an area of 151.20 Km2 (representing 61.89%) of the total LC of the study area, with water body being the least occurring LC type (2.50 Km² or 1.02% of total LC area). The other LU categories which include Built-up area, farmland, vegetation and open space occupied 11.40 Km² (4.67%), 10.10 km² (4.13%), 66.60 Km² (27.26%) and 2.60 Km² (1.06%) respectively.

Tables 1 and 2 indicate that for the study period 2015, there were significant increases in built-up area, farmland, and open space LU categories; while vegetation, forest and water body declined substantially over the 25 year period (1991-2015). Tables 1 and 2 revealed that forest experienced the highest rate of decline in total LC area losing 30.30Km² (1.21 Km² annually) between 1991 and 2015. Similarly, vegetation also lost 28.8Km² (1.15 Km² annually) over the study period. This reduction in forest and vegetation LC could be attributed to the rate of expansion of built-up area as observed. Conversely, built-up area experienced the highest rate of expansion gaining 50.0Km² (2.0Km² annually) between 1991 and 2015, while farmland gained 8.4Km² (0.34 Km² annually) and open space gained 0.8Km2 (0.03 Km² annually) over the same period.

Table 1: Landuse/Landcover Distribution of Umuahia North in 1991 and 2015

LU/LC Type	1991 Area (KM²)	1991 Area (%)	2015 Area (KM²)	2015 (Area %)

Built-up Area	11.40	4.67	61.40	25.13
Farmland	10.10	4.13	18.40	7.53
Vegetation	66.60	27.26	38.40	15.72
Open Space	2.60	1.06	3.40	1.39
Forest	151.20	61.89	120.90	49.49
Water body	2.50	1.02	1.80	0.74
Total	244.30	100	244.30	100

Table 2: Gain and Loss in LULC of Umuahia North between 1991 and 2015 (KM^2)

LULC Type	Total Gain	Annual Gain	Total Loss	Annual Loss
Built-up Area	50.00	2.00	-	-
Farmland	8.40	0.34		
Vegetation	-	-	28.80	1.15
Open Space	0.80	0.03		
Forest	-	-	30.30	1.21
Water body	-	-	0.60	0.02

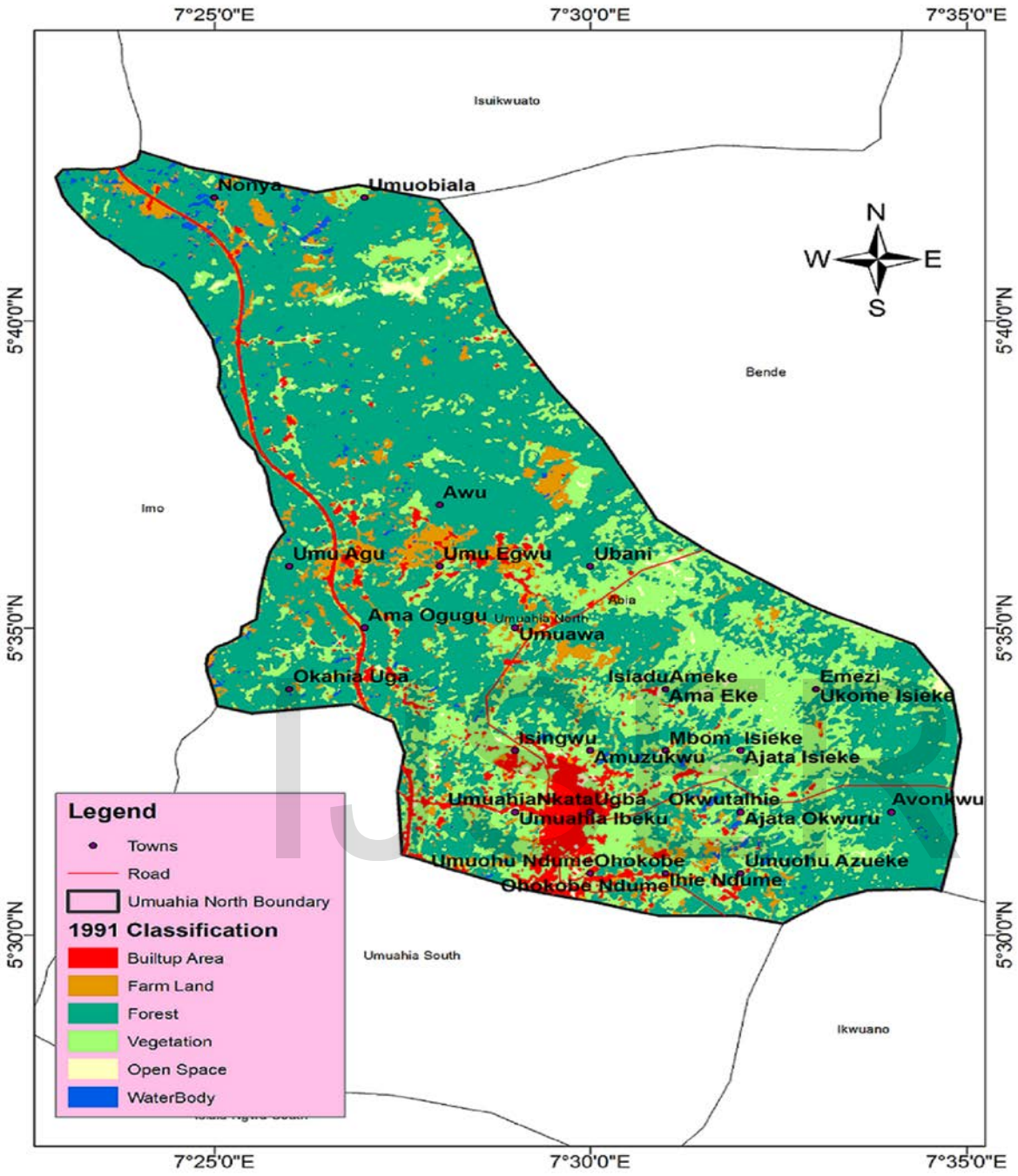

Figure 1: LULC Map of Umuahia North in 1991

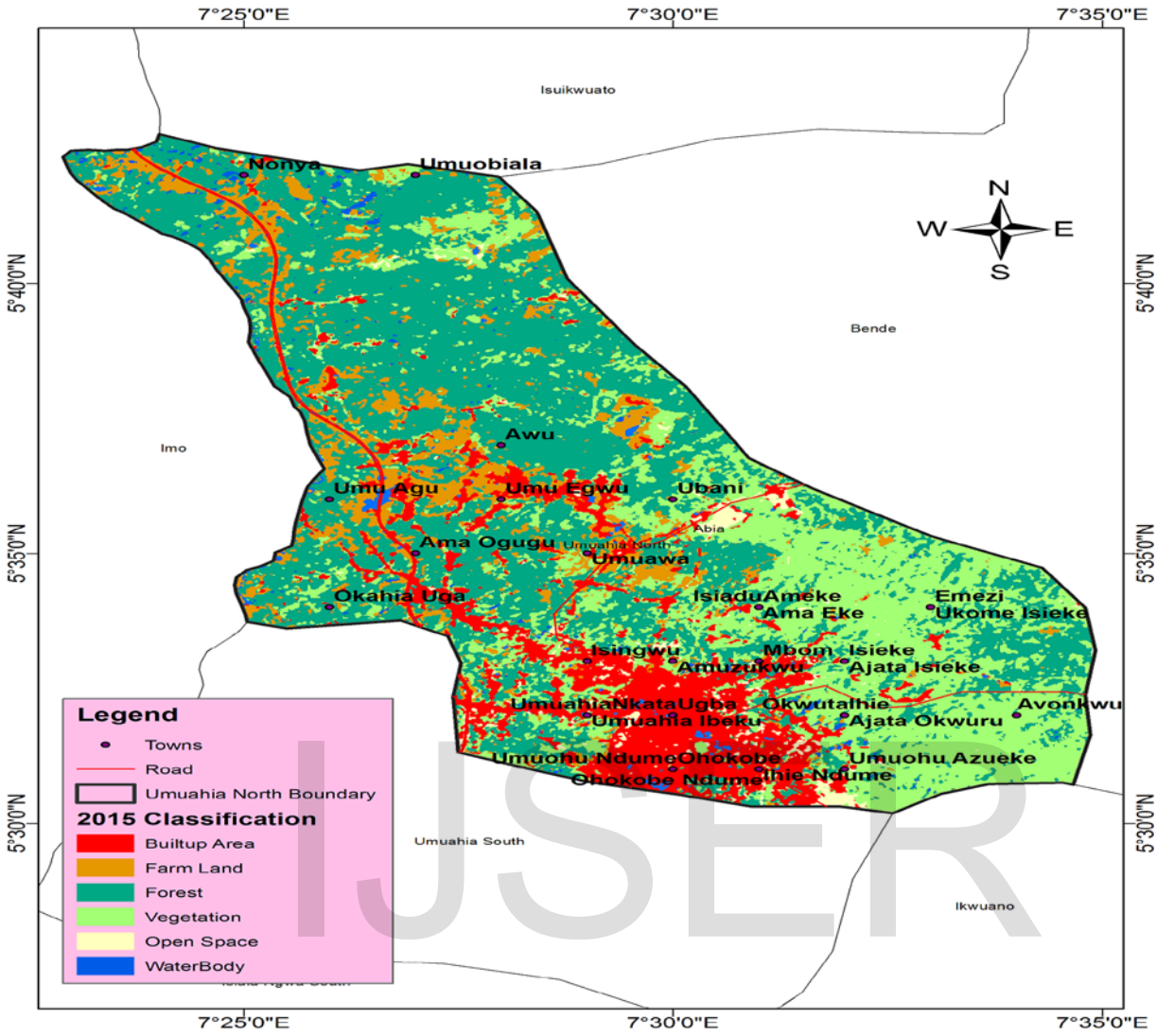

Figure 2: LULC Map of Umuahia North in 2015

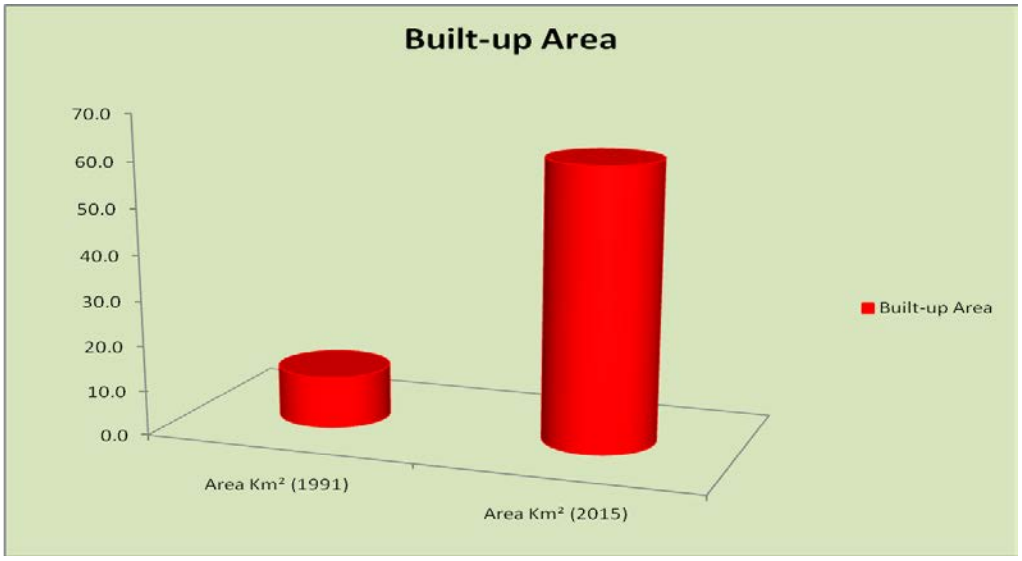

Figure 3: Rate of Urban Expansion; 1991 and 2015

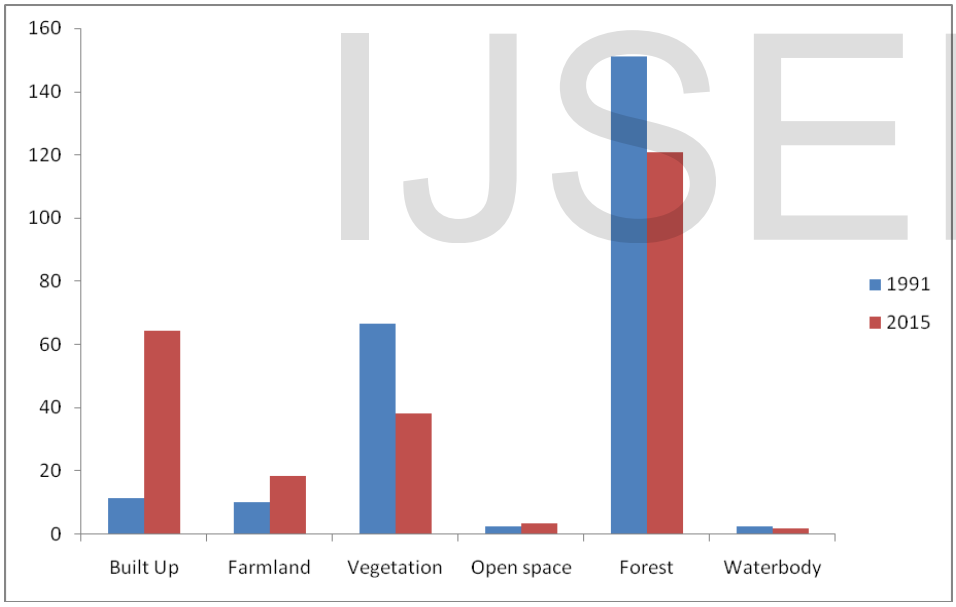

Figure 4: Graphical Distribution of LULC of Umuahia North in 1991 and 2015

Discussion

Before 1991, Umuahia could boast of a few industrial and educational institutions such as the Golden Guinea Breweries, Modern Ceramics industries and the Umuahia Central Market as well as small scale and cottage industries. Another key historic monument present at Umuahia was the War Museum. Educational Institutes included the research Institutes at Umudike and the University. Others included the General and Specialist Hospitals found located at Umuahia before 1991. These institutions placed Umuahia in the position to play the role of a central place to surrounding Communities. Umuahia peri-urban and surrounding rural areas had abundant cultivable land, green areas, economic trees and large expanse of forested areas. According to Okali *et al* (2001), the basic economic activities that were prevalent during the period under discourse were commercial activities within the Umuahia urban area and agricultural activities at the peri-urban fringes of Umuahia. These economic activities were centered at the Umuahia main market and included trading in goods which were mostly imported. The agricultural products in the area included maize, citrus, vegetables, pineapples, plantains and bananas, oil palm and raphia palms. This explains why the findings of this study (as shown in tables 1 and 2 and fig. 1) show less built-up area as at 1991. The findings conform to those discovered by Okali *et al* (2001) and Ifatimehin *et al* (2006) in Aba Urban and peri-urban area, as well as Lokoja urban and peri-urban area respectively.

From 1991 Umuahia assumed the status of a State Capital. This is represented in the classified satellite imagery of Umuahia North in 2015 where there were very significant changes in the LULC with the built-up area appreciating from 11.40Km^2 to 61.40Km^2. Conversely, forest landcover lost significantly between 1991 and 2015 (from 151.20Km^2 to 120.90 Km^2), while farmland appreciated from 10.10Km^2 to 18.40 Km^2 as a result of forest landcover being converted to agricultural land and built-up area. This period coincides with the period when political and developmental activities became very active in Umuahia. For example, it is within this period that the Third Republic came into life along with the large population that is attracted to the State's seat of government through elected officials (State House of Assembly members, and other political appointees along with their families, aides and cohorts). The government was also responsible for the provision of infrastructure that encouraged the establishment of several manufacturing industries around and close to Umuahia. It was also after 1991 that Telecommunication operators were given license to operate in Nigeria. The combination of these factors favoured and encouraged agglomeration, high population increase and rapid urbanization of the study area. This is due to the fact that Umuahia urban provides opportunities for better and improved living conditions than those available at the rural communities that make up the study area. Again, the revelation that there has been encroachment on rural and agricultural land use by urban landuse in Umuahia is in agreement with the observations of Okali *et al*, (2001) and Ifatimehin *et al*, (2006).

1.5. Conclusion

Through the use of remote sensing data and GIS techniques, significant progress in the quantification, estimation and understanding of LULC changes in tropical regions have been achieved in recent times. Anthropogenic activities have been identified to be the major cause of changes that strongly interact with natural environmental variability, and therefore result in severe damage to the environment and ecology of regions where landuse is not well planned. In most cases, LU change is driven by synergetic factor combinations of resource scarcity leading to an increase in the pressure of production on resources, changing opportunities created by markets, policy intervention, loss of adaptive capacity, and changes in social organization and attitudes. Forest and water body declined substantially over the 25 year period (1991-2015). Forest experienced the highest rate of decline in total LC area losing 30.30Km^2 (1.21 Km^2 annually) between 1991 and 2015. Similarly, vegetation also lost 28.8Km^2 (1.15 Km^2 annually) over the study period. Built-up area experienced the highest rate of expansion gaining 50.0Km^2 (2.0Km^2 annually) between 1991 and 2015, while farmland gained 8.4Km^2 (0.34 Km^2 annually) and open space gained 0.8Km^2 (0.03 Km^2 annually) over the same period. The study therefore recommends:

1. Landuse planning should be instituted and implemented in Umuahia urban and its environs to ensure that rural landuse is sustainable.

2. Awareness campaign should be embarked upon and pursued with a view to ensuring that the inhabitants of the study area understand the negative effects and consequences that are associated with poor landuse consumption and planning.

3. Deliberate efforts such as declaration, reservation and preservation of the ecologically fragile forest regions should be instituted and logically pursued by government.

4. Government at all levels should enforce and insist on town planning as a matter of utmost importance in Umuahia Urban and its environs,

while providing an enabling environment for builders to erect structures accordingly.

References

Adeniyi, P.O, and Omojola, A. (1999). Land-Use Land-Cover change evaluation in Sokoto - Rima Basin of North Western Nigeria based on Archival of the Environment (AARSE) on Geoinformation Technology Applications for Resource and Environmental Management in *Africa, pp. 143-172.*

Anderson, J.R., Hardy, E.E., Roach, J.T, and. Witmer, R.E. (2001). A Land-Use and Land-Cover Classification System for use with Remote Sensor Data. Geological Survey Professional Paper 964 and a revision of the Land-Use classification system as presented in U.S. *Geological Survey Circular 671: 662-673*

Asthana, D.K and Asthana, M (2005) Environment: Problems and Solutions. New Delhi, S. Chand & Co.pp, 99

Braissoulis, H. (2000). Sustainable Development and the informal sector: An uneasy relationship. *Journal of Environmental Development, 8(3): 213-237.*

Green, T. (1994). Using Remote Sensing to Detect and Monitor Land-cover and Land-use Change. *Photogrammetric Engineering and Remote Sensing, 60 (3):331-337.*

Ifatimehin, O.O. and Musa, S.D. (2008). Application of Geoinformatic Technology in Evaluating Urban Agriculture and Urban poverty in Lokoja. *Nigeria Journal of Geography and Environment, 1:21-23.*

Ifatimehin, O.O. and Ufuah, M.E. (2006). Estimation of Urban Expansion and Agricultural Land Loss in Lokoja Using Remote Sensing and GIS Techniques. *The Zaria Geographer, 3:7*

Jiang, D., Yang, X.H., Nicholas, C. and Wang, N.B. (2004). An Artificial Neural Network Model for Estimating Crop Yield Using Remotely Sensed Information. *International Journal of Remote Sensing 25 (9): 1723-1732*

Kato, S. and Yamaguchi, Y. (2007). Estimation of Storage Heat Flux in an Urban Area Using ASTER Data. *Remote Sensing of Environment 110 (1): 1-17*

Lambin, E.F., Geist, J.H. and Lepers. E. (2003). Dynamics of Landuse and Landcover in Tropical Regions. *Annual Review of Environmental Resources, 28:205-241.*

Long, H., Wu, X., Wang, W. and Dong, G. (2008). Analysis of Urban-Rural Land-Use Change During 1995-2006 and Its Policy Dimensional Driving Forces in Chongqing, China. *Sensors, 8: 681-699*

Mengistu, D.A. and Salami, A.T. (2007). Application of Remote Sensing and GIS in Landuse/Landcover Mapping and change Detection in a part of South-Western Nigeria. *African Journal of Environmental Science and Technology 1(5):099- 109.*

Nagamani, K and Ramachandran, S. (2003). Landuse/Landcover in Pondicherry Using Remote Sensing and GIS". In: Bunch, M.J., Suresh, V.M. and Kumaran, T.V. (eds). *Proceedings of the 3rd International Conference on Environment and Health, Chennai, India. 15-17.*

Odunuga, S, and Oyebande, L. (2007). Change detection and hydrological implication in the Lower Ogun flood plain, South West Nigeria, International Association of Hydrological Sciences Symposium on Remote Sensing for Environmental Monitoring and Change Detection. *Perugia, ITALIE, 316: 91-99*

Okali, D., Okpara, E. and Olawoye, J. (2001). Rural-Urban Interactions and Livelihood Strategies: The Case of Aba and its Region, South-Eastern Nigeria. Human Settlements Programme, *International Institute for Environment and Development. Available online at* http://www.iied.org/

Onweremadu, E.U., Osuji, G.E., Eshett, E.T., Okpara, C.C. and Ibeawuchi, I.I. (2007). Characterization of Soil properties of Owner Managed Farms of Abia and Imo States, for Sustainable Crop Production in Southeastern Nigeria. *Journal of American Science, 3 (1):2007.*

Onyeka, T.J., Owolade, O.F., Ogunjobi, A.A., Dixon, A.G.O., Okecghukwu, R., Bandyopadhyay, R. and Bamkefa, B. (2008). Prevalence and Severity of Bacterial Blight and Anthracnose Diseases of Cassava in different Agro-Ecological Zones of Nigeria. *African Journal of Agricultural Research, 3 (4): 297-304.*

Osborne, P., Alonso, J. and Bryant, R. (2001). Modelling Landscape-scale Habitat use using GIS and Remote Sensing: A case study with great Bustards. *Journal of Applied Ecology 38:458-471.*

Pellikka, P., Clark, B., Hurskainen, P., Keskinen, A., Lanne, M., Masalin, K., Nyman- Ghezelbash, P, and Sirviö, T. (2004). Land use change monitoring applying geographic information systems in the Taita Hills. Proceedings of the 5th AARSE conference (African Association of Remote Sensing of the Environment), Nairobi, Kenya. In print.

Ray, S.S. and Dadhwal, V.K. (2001). Estimation of Crop Evapotranspiration of Irrigation Command Area Using Remote Sensing and GIS. *Agricultural Water Management, 49 (3):239-249.*

Seto, K.C., Woodcock, C.E., Song, C., Huang, X., Lu, J, and Kaufmann, R.K (2002). Monitoring Land-Use Change in the Pearl River Delta Using Landsat TM. *International Journal of Remote Sensing, 23 (10):1985-2004.*

Ukandu, J. S., Udom, G. J. and Nwankwoala, H.O. (2011). Aspects of the Hydrogeology of Umuahia South Local Government Area, Abia State, Nigeria. *E3 Journal of Environmental Research and Management 2(2):014-026.*

Wilkie, D.S. and Finn, J.T. (1996) Remote Sensing Imagery for Natural Resources Monitoring. Columbia University Press, New York. p. 295.

Zubair, O. (2006). Change Detection in Landuse and Landcover of Ilorin and its Environs Using Remote Sensing and GIS, 1972-2005.An Unpublished M.Sc Dissertation, Department of Geography, University of Ibadan, Nigeria.