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Analysis of land use and land cover change characteristics in Warri metropolis, Nigeria

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Abstract

This study is aimed at analyzing land use and land cover changes in Warri Metropolis between 1964 and 2014 and to project changes to the next 5years, 10years and 25years planning periods. Data used are aerial photographs, satellite images, topographical maps, and census data. Remotely sensed data (1964 and 2014) were interpreted, classified and overlaid in a GIS environment using Arc-GIS version 9.3 software. GIS-derived data were subjected to rigorous statistical analysis of ANOVA, New Ducan Multiple Range Test and Time Series Analysis. Results of GIS analysis indicated that built-up sprawled other categories. Built-up expanded from 8.36km^2in 1964 to 54.2km^2in 2014. Forest reduced from 52.23km^2 in 1964 to 22.23km^2 in 2014. Mangrove reduced from 63.79km^2 in 1964 to 29.6km^2 in 2014. Scattered cultivation reduced from 103.30km^2 in 1964 to 71.6km^2 in 2014. Water bodies increased from 16.46km^2 in 1964 to 22.04km^2 in 2014. Using Analysis of Variance (ANOVA) the model at $p<0.5$ indicated significant changes in land use and land cover. Duncan New Multiple Range Test compared the means and indicated significant differences in land use and land cover in decadal remotely-sensed data for the periods. This implies that there is a significant change in land use and land cover in Warri Metropolis between 1964 and 2014. Multiple Regression Model showed population growth, changes in built-up and forest explained changes in land use. Time Series Model indicated a calculated value of 4.985 which is higher than the critical table value = 1.6 at n-2 df. This implies that land use and land cover will change significantly in the near future (5 years, 10 years and 25 years planning periods). Markov Transition Estimator, forecasted agriculture will occupy 7,67km^2 (22.7%) of total land area in 5-years planning period, forest, 5, 141km^2 (15.4%) built-up area 12, 689km^2 (38%), water bodies 8,04km^2 (41%). In 2024, (10years planning period), agriculture is forecasted to occupy 6,498km^2 (19.4%) of total land area, forest 3,59km^2 (9.725%) built up area, 2,603km^2. In 25 years planning period, 1939, agriculture is forecasted at 5,842km^2 (1.75%), forest 2,561km^2 (7.6%), built up area 17,007km^2 (51%) and water bodies 7,908km^2 (23.6%) of total mapped area. Markov projection clearly indicates that built up area will grow increasingly at the expense of other categories. Based on the aforementioned, recommendations were proffered

Keywords: Characteristics; Landuse; Land Cover; Analysis; Warri Metropolis; Nigeria

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1. Introduction

The increase in population and human activities are exacerbating demand on land and soil resources for agriculture, forestry, pasture, urban and industrial uses. Nigeria is faced with a number of land related challenges, especially mono-cultural economy; over-dependence on crude oil resources, soil erosion, deforestation, loss of biodiversity, urban decay and congestion, desertification and drought, increasing prices of food and scarcity of land resources in the rural and urban areas. Rapid urbanization in the past decades in Nigeria has affected approximately 400,000 hectares of vegetative cover (Etim & Dukiya 2013).

Warri Metropolis has experienced unprecedented urbanization and sprawling pattern of development between 1964 and 2014. Consequently, resulting in the conversion of forests, wetlands, rubber plantations and fertile agricultural sites to a landscape of human settlements. Nigeria has lost over 580,841km^2, accounting for 63.83% of her fertile land resources to desertification in the fifteen northernmost states (Olagunju, 2014).This has resulted in massive north-south emigration of herdsmen, peasant farmers, and constant clashes with other Nigerians over land resources. Consequently, Land use and land cover change have become a major theme of research interest in the development process of Nigeria today (Abbas, Muazu & Ukoje, 2010).

Nigeria has over a hundred urban settlements including Warri Metropolis (Oluseyi, 2006), with the demand for land for public and private facilities derives ultimately from demographic factors. Nigeria has the smallest hectare of land per head when compared with some other African countries, although some European countries have lower values, their rate of population growth is lower than that of Nigeria (Adeniyi, 1979). The rapid growth of population coupled with industrial development leads to growth of many more central places which, in turn, require land for various purposes, such as agriculture, industrial, recreation and forestry. Since population growth and development are inevitable and the land area is fixed (Malthus, 1798; Waugh, 1995; Briggs, 1998; Lipsey & Chrystal, 2004; Wolfgram, 2005; Dao, 2012; Okwori, Ajegi, Ochinyabo & Abu, 2015), a judicious utilization of land is important in the planning of the nation's economy. A better knowledge of our natural resources is necessary for more effective and rationale management (Ndukwe, 1997). Ironically, man's demand for land resources is rapidly increasing at the very time when the supply per head is rapidly decreasing with the quality of some deteriorating. This singular situation calls for the wisest possible management. This requires accurate inventories taken periodically, using the best available global practices.

The literature shows that remote sensing techniques is technologically more efficient than ground based data gathering methods and has a number of benefits in gathering information that make it a good tool in environmental management and monitoring (Asinyanbola, 2014). These include: a capability for recording more permanently detected patterns, opportunity for objective analysis of observations to minimise personal peculiarities of observers, play back facility at different speeds, means of enhancing images to reveal or highlight selected phenomena, and the synoptic view advantages offered by raised platforms. Other advantages include, ability to record data on otherwise remote and inaccessible areas; ability to produce accurate data on extensive targets at desired time intervals and at comparatively lower cost compared to ground survey methods and capability to record data in multi-spectral form at different levels, at diverse spatial resolutions and scale. From the perspective of the developed world, remote sensing is a cost saving method of acquiring raw data to update available information, for the developing countries, especially those in Africa; it has provided an opportunity to obtain first generation information on various aspects of earth resources such as land use and land cover (Abiodun, 2000).

In Africa and other developing nations of the world, the application of remotely sensed data and analytical technique such as Geographical Informational Systems (GIS) is very critical for studies where extensive areas such as Warri Metropolis are involved. Large scale topographic maps of up to scale of 1:50,000 are not usually available for detailed mapping on ground or on the field (Kamusoko, Mundia & Murayama, 2011). In addition, there is paucity of simple physical data such as census data, socio-economic data, environmental and infrastructure data. The available basic data are usually not reliable and not usually up-to-date for modelling analysis. With the rapid changes in land use and land cover in Warri Metropolis (1964-2014), it has become necessary to use remote sensing technology as an essential tool in monitoring of the inaccessible and difficult tropical rain forest and swamp conditions. The remote and inaccessible nature of most tropical forest regions, especially parts of Warri Metropolis, where local communities are protesting environmental degradation and clamouring for control of their non-renewable oil and gas resources, limits the feasibility of ground based inventorying and monitoring methods. In such sensitive or "dangerous" areas, data is best acquired without physical touch or contact with the target or study area. Satellite remote sensing can also penetrate the thick tropical cloud-cover of Warri Metropolis and register clear images of terrain features.

Land use information is a vital tool for all urban development efforts. Changes in the use of land are to a large extent a reflection of how society responds to socio-economic, institutional, and management practices (Adeniyi, 1979). Yet, research reports relating to several urban areas in developing countries such as Warri Metropolis are replete with comments concerning the inadequacy of relevant land use information. Consequently, effective planning is rendered more difficult. The situation is compounded and partly caused by lack of appropriate methodology to acquire background information to aid town planners and policy makers in tackling complex land challenges (Adeniyi, 1979; Kamusoko, Mundia & Murayama, 2011; Asinyanbola, 2014).

The state of land use and land cover information in the Niger Delta, especially in Warri Metropolis is portrayed in Anderson's remark (1996), in a key note address in Port-Harcourt, Nigeria, to stakeholders and land users in the oil and gas sector based in the Niger Delta area of Nigeria, "We in Shell Petroleum Development Company, recognise the need for a more complete understanding of the environmental pressures on the Niger Delta. There is need to know more about population growth, migration, deforestation, farming, soil degradation, oil activities, road construction and other factors and how these affect the Niger Delta over time".

A number of studies emanating especially from United States America, Europe, China, India and more recently Africa and Nigeria in the past four decades have demonstrated that remote sensing data and GIS analysis have great potentials to provide a cost effective, timely, up-to-date and reliable information on land use and land cover changes (Adeniyi, 1980; Atubi, 2004; Cabral, 2008; Narayanan & Hanjagi, 2009; Ejemeyovwi, 2009, 2010; Eludoyin, Wokocha & Ayolagha, 2010; Tahir, Imam & Hussain, 2012; Ogunbadewa, 2012; Oriye, 2013; Ade, & Afolabi 2013; Monte & Farhan 2013).

Land use and Land cover alterations are effects of human social and economic intervention on the land cover in a landscape. Much has been written about the origin of land use and land cover alterations both in specific terms, such as the tropics, and in general terms (Fujita 1989, Fujita, Krugmam & Venables, 1999). Due to the complexity of the origin in landscape alterations over time, a commonly known difference is the proximate and ultimate causes (Geist & Lambin, 2001 and 2002). Causal explanation is given on the natural and social sciences. In the social sciences, focus is usually on the 'agent' or land manager Such agents are usually those concerned with the agricultural enterprise (Lynam, 2003) or those related to residential activities (Bockstael, 1996). Anthropologist, geographers, economist and sociologists usually consider the agent as the central theme of departure for evaluation. Econometricians and Chommitz & Gray, (1996), prefer explanations where behavioural objectives pursed such as profit maximization and minimization of risk. Ecologists, geologist are focused on ecological and edaphic factors in the human enterprise e.g. choice of location of natural reservations and agricultural activities (Huston, 1993). Ecological responses such as disturbance, growth of species and competition usually result in land use and land cover alterations either independently or in interaction with human activities. The proximate human origin of land use and land cover alterations is concerned with the behaviour and actions of individuals (Geist & Lambin, 2001 and 2002). Types of landscape alteration vary according to the characteristics of the agents that are active on the environment. In an extensive region with diversity, many agents may be active at different locations of the region making it difficult for a casual explanation due to the added complexity. According to Kaimowitz &Angelsen, (1998), landscape alterations can be explained by environmental changes, rapid population changes, technological development and institutional intervention (Walker, Perz, Caldas &Texeira da Silva, 2002). Primary scales and macro-scales are two processes at operation in landscape alterations; individuals seeking their objectives and the context of their decisions and actions. Such decisions are mostly processes as population growth and mobility, the climate and soil processes that constrain production on land resources, the evolution of commodity and labour markets, the continuing development of technological change, and actions of government bureaucrats to political pressure changes. Alterations in macro-scales are often the result of complex interaction of trans-national institutions, economic, political and social processes. It is these macro-scale processes and changes that are interpreted as ultimate causes in environmental change research.

In most of southern Nigeria, land allocation system is complex. Traditional rulers, chiefs, prominent families, powerful individuals, ethnic groups and the government own land. The traditional land tenure system in southern Nigeria is organised around customary laws where land is owned by the entire community rather than individuals. The customary land tenure system has its weakness because it cannot find solutions to challenges and constant crises arising from the distribution, allocation and utilization of land. As a response to these challenges and constant crises, Public cry, shortage of land for development resulting from the imperfections in the traditional land allocation mechanism, the Federal Government of Nigeria came up with the Land Use Decree of 1978 (Mabogunje, 2010). The Land use Decree established a uniform land allocation system for the entire country aimed at opening-up the land for rapid development by individuals, governments and institutions. Consequently, the Land use Decree of 1978, gave powers to the local government areas council and state governments under the executive governors to own and allocate all undeveloped plots of land resources in all states of Nigeria. This decree that has been operational for over three decades has not solved the challenges of land allocation in Nigeria. Land is still being owned by large prominent families and individuals. Traditional land allocation system remains an important mechanism for land resource allocation in the southern states of Nigeria especially Warri Metropolis. It is concerned with the whole system of how land is held by institutions, families, groups and individuals (Adeniyi, 1979).

Change detection is defined as the process of identifying the differences in the state of an object or phenomenon by observing it at different times (Singh, 1989). Essentially, it is concerned with the ability to quantify temporal effects using multi-temporal data sets. Many change detection procedures have been developed and used for various applications. There is post-classification comparison, image differencing, image rationing, image regression, principal component analysis, and so on. The important goal in change detection is to compare spatial representations of two points in time by controlling all variance occasioned by differences in variables of non-interest; variation in orbital and platform altitude and to measure change caused by differences in variables of interest.

In modern times, change detection relies primarily on two types of techniques. Image-to-Image comparison. Map-to-Map comparison involves the identification of differences between two maps of different dates. This type of comparison requires that the images from two different dates be classified by interest and then compared by an over-laid operation. In the past, before the evolution of remote-sensing techniques, the comparison was performed on a light table and was the only available spatially referenced land used and land cover change detection possible.

Numerous change detection procedures have been developed to evaluate changes inland use and land cover using satellite data (Coppin, Jointheere, Nackaerts, Muys, & Lambin, 2004; Lu, Mausel, Brondiozio, & Moran, 2004; Sing, 1989). Of these techniques, the pre-and post-classification comparisons have been most extensively used (Copin, Jonckheere, Nackaerts, Muys, Lambin., 2004; Singh, 1989). In the pre-classification proceures such as image differencing (Toll, Royal, & Davis, 1980), band rationing (Neloson, 1983), change vector analysis (Johnson & Kasischke, 1998), direct classification (Li & Yeh, 1980), vegetation index differencing (Townshend & Justice, 1995) and principle component analysis (Fung & Ledey, 1987; Hartter, Lucas, Gaughan, & Aranda, 2008) have evolved over the years (Hardin Jackson, Otterstrom., 2007; Jensen, 1996; Singh, 1989). The fundamental premise of these procedures is that changes in land cover and land use result in differences in the pixel reflectance values between the dates under review. While these techniques are effective for locating changes, however, they cannot identify the nature of identified changes (Ridd & Liu, 1998). Conversely, post-classification comparisons evaluate changes over time between independently classified land use and land cover data. In spite of the challenges associated with post-classification comparisons (Coppin Jonckheere, Nackaerts, Muys & Lambin, 2004; Singh, 1989), this method is the most widely used by analysts for identifying land use and land cover changes (Jensen, 1996), particularly in urban environments (Hardin Jackson, Otterstrom, 2007). However, one of the disadvantages associated with this method is that the degree of inaccuracy of the resultant land use and land cover change maps are determined by the accuracy of the individual map classifications. Consequently, meaning that such procedures are subject to error propagation. Nevertheless, post-classification techniques remains most useful in generating 'from-to-to' maps in change detection analysis. In addition, this procedure can be used with remotely sensed data acquired from sensors with different temporal, spectral and spatial resolutions (Alphan, 2003; Coppin Jonckheere, Nackaerts, Muys & Lambin, 2004).Change detection is used in many applications such as urban and regional planning, environmental management and forestry. Change detection an also provide information on resources at risk monitoring and evaluation.

Table 1. Land use and Land cover change Studies over the Years

Author	Title of Study	Data used	Result
Adeniyi, 1980	Land use change analysis using sequential aerial photography and computer techniques to monitor urban growth in Lagos Nigeria 1962 and 1974	Sequential black and white Aerial photographs, 1962 and 1964. Topographic maps.	Significant land use and land cover conversions registered ware indicated.
Adeniyi, 1995	Digital analysis of multi-temporal Landsat data for land use and land cover classification in semi-Arid area of Nigeria, Bakolori irrigation project area, Sokoto state Nigeria.	Landsat satellite data 1,2 and 3, X-band radar Mosaic Aerial photograph (black and white) photographic map	
Adeniyi, and Omojola 1999	Land use and land cover change evaluation in Sokoto Rima Basin of North-West Nigeria.	Aerial photograph 1962, aerial photograph 1977, Landsat (MSS) FCC and single band transparencies/enhanced sets (Goronyo sub-area), January 1986. Topographic map sheets, sheet 4, 10 and 23, 30.	Large scale conversion of agricultural land to urban uses.
Atubi, 2004	The application of remote sensing in monitoring urban land use dynamics in Victoria Island, Lagos Nigeria.	Aerial photographs of scale 1:40,000, 1983, 1988	It indicates an increase in structural development, in terms of roads, bridges, buildings, large scale conversion of sand filled areas into swamp, forest and vacant land to built-up areas'
Onosemuode, and Olanrewaju; 2007	Regression analysis and the use of spot remotely sensed data in monitoring environmental changes.	Black and white aerial photograph, SPOT multispectral (RGB) 231 imagery.	The change in the urban land use by the year 2006 from when I was last estimated in 1994 was predicted using the regression equation.
Bauer, Yuan, Sawaya, 2003.	Multi-temporal Landsat image classification and change analysis of land cover in the twin cities (Minnesota) metropolitan area USA.	Multi-temporal Landsat data 1986, 1991, 1998.	Unprecedented land use and land cover conversions most significantly from forest agriculture to urban uses

Rimal; 2005	Application of Remote Sensing and GIS, land use and land cover change in Kathmandu, Metropolitan city, Nepal.	Landsat images, Multi-spectral scanner satellite images, Landsat image 2, 1976, Landsat image 5 and Landsat 7, enhance thematic mapper, topographical map 1978.	Unprecedented land use land cover conversion where noted between 1976 and 2009. Most significant were from forest, open field and agriculture converted into urban uses
Phukan, Thakuriah and Saikia; 2013	Land use cover change detection using remote sensing and GIS techniques. A case study of Golaghat District of Assam, India.	Landsat ETM 1989, and IRS LISS 111 2009.	Result shows that change has occurred during 20 years of period of investigation
Ezemedo and Igbokwe, 2013.	Mapping and analysis of land use and land cover for sustainable development using high resolution satellite images and GIS.	IKONOS images, SPOT 5 and Topographical map.	Built up areas is increasing at an increasing rate, uncontrolled and uncoordinated growth, encroaching other land uses.
Maryna, 2002.	Land over change detection in northern Belarus	SPOT 3 and 5 images.	There was large scale land use and land cover conversion most significantly from forest and agriculture for land uses
Oyinloye and Kufoniyi, 2011.	Analysis of land use, land cover change and urban expansion in Akure, Nigeria.	Multi-temporal, multi-source satellite imageries of Landsat (MSS) images 1972, 1986 (TM) and Landsat enhanced thematic mapping (ETM) image of 2002.	Significant loss of open space, deforestation, colonization of adjacent farm land overcrowding, poor quality of housing, traffic congestion and poor standard of living
Hu, Liu, Hao and An; 2012.	Analysis of land use change characteristics based on remote sensing and GIS in the Jiuxiang River Watershed, China, between 2003 and 2009.	Quick bird images 2003 and 2009.	Significantly the area of farm land reduced in upstream, midstream, and downstream, while other land use increased with different degrees.
Narayanan, 2009.	Land use change in urban Bangalore using GIS and remote sensing	GIS and remote sensing	Drastic changes especially in terms of greenery loss and lake areas. There is a massive transformation of agriculture loss and considerable loss of lakes which have been attributed to the increase of concrete structures of this district
Ejemeyovvi, 2010. Ejemeyovwi and Gasu. 2010	Land use and land cover mapping, degradation and change detection in the Niger Delta environment using Delta State University, Abraka sites I, II, and III as case study. Change detection in land use and land cover mapping using remote sensing data and GIS (A case study of Aladja in the Niger Delta	Satellite spot images 2000 and 2009. Topomaps Landsat Imageries ILWIS GIS environmental spatial data base.	Significant land use and land cover conversions were revealed. Built up area gained while agricultural uses and forest cover lost. Extensive land use and land cover conversions registered from forest, Agriculture and open space to industrial residential uses

Ejemeyovwi, 2009	Land use and land cover mapping and land use pattern in Abraka	High spatial resolution remote sensing satellite spot image 2005. Topographic map and A Arcview 3.2 GIS software.	Extensive land use and land cover conversions from forest to residential, institutional and recreation, utilities etc.
Olomo, 2006	Classification of land use type in Abraka	Spot images 2006, satellite, quikbird images 2005.	High integrity Land use and land over map for study period 2005 was successfully produced.
Tini,Ohanna and Naphtali, 2011.	The use of remote sensing and GIS techniques for appraisal of spatial, growth in Mubi Metropolis, Adamawa State, Nigeria.	Mubi metropolitan map, quickbird satellite image, demographic data.	An unprecedented growth was registered, during the study period. This growth resulted in the land use conversion of forests, savannah grassland, into urban uses.
Mohan, 2005	Land use and Land Change Detection In The, National Region, Faridabad District Delhi, India.	Satellite remote sensing data	Remarkable conversion from forest to urban and agricultural land uses.
Kaba, 2011	Land use and land cover changes are ecological implication in Wuhan, China	Satellite remote sensing data	Significant change from forest to agriculture and residential, agriculture and urban uses.
Kudu; 2000	Detecting and quantifying land use and land cover changes in Eastern Mau between 1964 and 1987.	Air Photos and satellite, Spot images	Land use and land cover conversions, mainly from forest to agriculture and urban uses.
Yikalo,2010	Analysing and modelling of 1990 and of urban land cover change 2006 in Setubul and Sesiunta Portugal between 1990 and 2006	multi-spectral satellite images	Wood land, grassland, classes decreased for the period this shows that the natural equilibrium of the Sintra-Cascais municipalities is threatened by the strong construction pressure of the last thirty years.
Rimal, 2005	application of remote sensing and GIS, land use and land cover change in Kathmanda Metropolitan city, Nepal, 1976 to 2009	landsat image data 1976, MSS, 1986 TMc, 2001 ETM and 2009 ETM	growth is unprecedented most of the conversion is from forest to urban use
Albert Osei, Merem and Yaw and Twumasi, 2006	use of GIS and remote sensing technology as a decision support tool in land administration: The case of Lagos, Nigeria	Landsat images for 1984 and 2000, pair of images.	Significant land under water declined, agriculture and settlement increased significantly.
Huang, Liu, Luan, Jiang, Jumoing, and Hua;	Detection and prediction of land use change in Beijin based on remote sensing and GIS (1984-2005)	Landsat TM5 and SPT4	Land use and land cover transformations were revealed.
Dmitry, Varlyguin, Robb, Goetz, Stephen	Advances in land cover classification for applications research: a case study from the Mid-Atlantic Resac	Multi-temporal Landsat-7 ETM+ imagery, extensive field measurements, historically air photos.	Development of a variety of data set and techniques for board area land cover mapping efforts.
Abbas, Kim Muazu and Ukofe, (2008)	Mapping land use/land cover and change detection in Kafur Local government, Katsina,	Historical land use and land cover map (1995) and Google earth image (2008)	Dramatic changes in land use land cover changes revealed

	Nigeria (1995-2008) Using remote sensing and Geographical Information Systems.		for Kafur Local Government between 1995 and 2008
Prakasam, (2010)`	Land use and land cover change detection through remote sensing approaches: A case study of KodaikanalTaluk, Tamilnadu. International Journal of Geomatics and Geoscineces.	Satellite remote sensing imageries.	Large scale forest conversions to urban and agricultural uses.
Singh, (2011)	Forest Vegetation Analysis And Land cover Assessments In Tan Sub Watershed Of Hasdeo River Basin, Chhattisgarh, India.	Landsat remote sensing imageries,	Significant forest conversion to agricultural and urban uses
Ashraf M. D, Yasushi, Y (2009)	Land use and land cover change in greater Dhaka, Bangladesh between 1975-2003: Using remote sensing to promote sustainable urbanization.	Landsat Remote Sensing Imageries	Significant changes were indicated in built-up area and substantial reduction in the areal extent of water bodies.
Adeoye N.O (2012)	Spatio-Temporal Analysis Of Land Use/Cover Change Of Lokoja- A confluence town between 1986 and 2007	Landsat TM 1986, Landsat ETM+ 2011, Landsat ETM+ 2006 and SPOT 5, 2007.	Urbanization processes is mainly responsible for land use and land cover change.
Adeoye N.O and Ayeni B. (2011)	Assessment of deforestation, biodiversity loss and the associated factors: case study of Ijesa-Ekiti region of Southwestern Nigeria	SPOT XS 1986, SPOT XS 1994 Nigeriasat 1 2013.	Deforestation are a complex mix of anthropogenic factor, mainly conversion of forest resources to agricultural land use
Adoke A, (2013)	Trends in vegetation cover changes in Bonny area of Niger Delta, Nigeria between 1986 and 2007.	Landsat images 1986, 1998 and 2007.	Imbalances in the ecosystems and negative environmental quality and live ability.
Alaci, D.S.A, Amujabi F.A, Baba A.N and Daniel O. (2011)	Spatial growth assessment with remote sensing data for central Nigeria	Remotely sensed, Landsat TM,1987 and 2001.	Between 1986 and 32005 an increase of size of built up area.
Dinka M.O (2012)	Analysing decadal land use/cover dynamics of the lake Basaka catchment (Main Ethiopian Rift) using LANDSAT imagery and GIS lakes & Reservoirs: research and management	Landsat MSS, TM and ETM+ images and ERDAS imagine 9.1.	Drastic changed occurred in land use and land cover mostly in the form of deforestation, settlement and the irrigation system.

Source: Field work, (2014)

Most commonly used remote sensing and GIS software, is ILWIS followed by ArcGIS 9, ArcView 3, IDRISI, ERDA IMAGINE, ArcGIS 10, and ENVI (Asiyanbola, 2014). Remotely sensed images were from diverse sources, prominent among which are: global land cover facility (GLCF) of University of Maryland, Maryland, USA, Google Earth, Nigeria's newly established National Space Research and Development Agency (NASRDA) Abuja, , and National Centre for Remote Sensing (NCRS) Jos, Nigeria in that order.

1.1. Study area

The study area was identified as Warri Metropolis. Warri Metropolis is situated on the bank of Warri River, one of the busiest river in Nigeria. The area is located on latitudes 5^0 27′ N to 5^0 37′ N and longitudes 5^0 40′ E to 5^0 50′E (figure 1). It consists of Uvwie, Warri South,Warri south west, and Udu local government areas of Delta State Nigeria. It is made up of urban settlements such as Warri, Olumaro, Effurun, Enerhen, Ogbe-Ijaw, Ekpan, Alaka, Ugborikoko, Gbolokposo, Okere, Ajamimogha, Ugbuwunagweh, Ubeji, Ogunu, Aladja, Obodo, Orere, Ijala, Pessu Town, Ode-Itsekiri, and rural communities of Ajatitor, Edgeba, Ifie, Ugboroke, Okugburhe, Ekete etc.

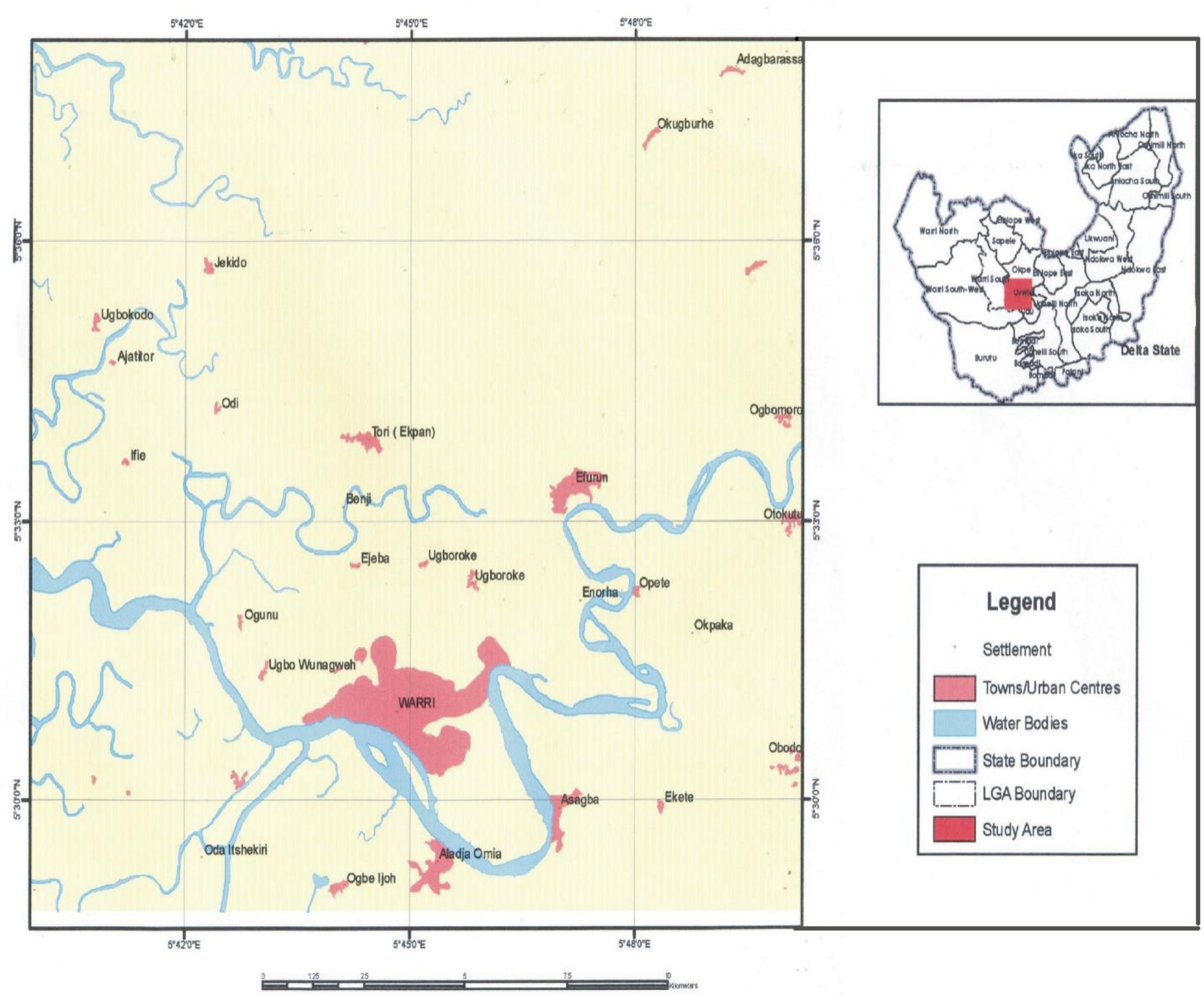

Figure 1. Base map and location of Warri Metropolis (Delta State, Nigeria) (Source: Topographic map sheets, Warri 309 SE, and Burutu 318NE 1964)

As shown in figure 1, the area includes a diversity of land use and land cover types, interspersed with many wetlands, rivers and streams transacted by the Warri River. High and low density development characterizes the central portion with many urban settlements. Several rural land uses, including agricultural fields, secondary vegetation, wetlands and forests, are dispersed across the surrounding landscape. The diversity of land use and land cover types, and the unprecedented urbanization between 1964 and 2014 presents an appropriate scope for land use and land cover change analysis over a period.

Warri Metropolis as defined in the current study covers an extensive area of 334.79 km^2. There has been a large scale land use and land cover change in Warri Metropolis over a period of time since the colonial period but never as fast as between 1964 and 2014. Land use and land cover changes in Warri Metropolis (1964-2014) is a response to rapid population growth, economic prosperity; following the Oil boom of 1970s, rural/urban drift, urban-urban drift, unprecedented urbanization, industrialization and globalization (coming of multi-national companies and inflow of foreign capital).

2. Research method

This study adopted the empirical design, thus primary and secondary data were used in the current study. Primary data such as aerial photographs (1:25,000, 1963-4) and satellite images (SPOT XS satellite images, spatial resolution-3bands, temporal resolution-18days) were acquired from the. Office of the Surveyor General of the Federation, Abuja, and Daimler Geographic's archives, Lagos, respectively. Secondary data such as topographic maps (Warri 309SE & Burutu 318NE, 1:50,000, 1964) were acquired from the office of the Surveyor General of the Federation Abuja. Census data of Warri Metropolis (1964 to 2014) were acquired from the archives of Nigeria Population Commission, Warri.

The two primary data sources used in this study were acquired from two different remote sensing satellite systems, which have different spatial resolutions. The SPOT XS has spatial resolution of 10m by 10m, while aerial photographs are of 1:25,000scale. Due to the different spatial resolutions of the images, the classification scheme developed, which has two levels, had the scales harmonized in order to compensate for moderate resolution of the aerial-photographs.

The purposive sampling technique was adopted in this study. A base map was generated from 1964 topographic map sheets, Warri 309 South East, and Burutu 318 North East. Aerial photographs of 1964 and satellite imagery for the year 2014 respectively were consulted for this study. The survey method was ''Wall to Wall'' coverage or mapping. Information were derived through space and aerial observations. The entire study area as defined, in figure 1, latitude 5^0 27' N to 5^0 37' N and longitudes 5^0 40' E to 5^0 50 E was enumerated, rather than a sampled area; this is a standard practice in remote sensing investigations.

Two base maps were generated from the scanned topographic map of (Warri 309SE & Burutu 318NE, 1: 50,000, 1964) for 1964 (T1) and 2014 (T2). The base maps were used to aid the interpretation of terrain features on the remotely-sensed data; scanned aerial photographs of 1964 and satellite images of 2014. Topographic maps are ideal and compensate inadequacies in the aerial photographs (Patrono, 1996).

The standard image processing technique of image interpretation, information extraction, layer tracking, geometric correction, geo-referencing and change detection were performed on the decadal images (1964, 1974, 1984, 1994, 2004 and 2014). The rationale for using these dates stem from the fact that it was within this period that Warri Metropolis experienced oil boom in which it became the focus of oil and gas fields' development and unprecedented economic activities.

Table 2. Coordinates of Randomly Selected Ground Control Points and Ground Truths

LOCATION ₦:	LOCATIONS	GPS CO-ORDINATES
1	Osubi Airport Roundabout	005^0 49' E 05^0 35'N
2	Ogbolo Okposo Market Junction	005^0 48'E 05^0 33'N
3	Federal Government College, House of Assembly Roundabout	005^0 43'E 05^0 31'N
4	Okere Warri/Sapele Road Junction	005^0 44'E 05^0 30'N
5	Site of Agbasa Juju shrine (edge of the entrance)	005^{0}45'E 05^{0}33'N
6	Site of Effurun Juju shrine (edge of the entrance)	005^{0}47'E 05^0 33'N
7	Site of Okere Juju shrine (edge of the entrance)	005^{0}44'E 05^{0}31' N
8	Erejuwa road junction, Warri/Sapele road.	005^{0}45'E 05^{0}30'N
9	Hunssey College, main field edge	005^{0}44'E 05^{0}31'N

Source: Authors Field work (2014)

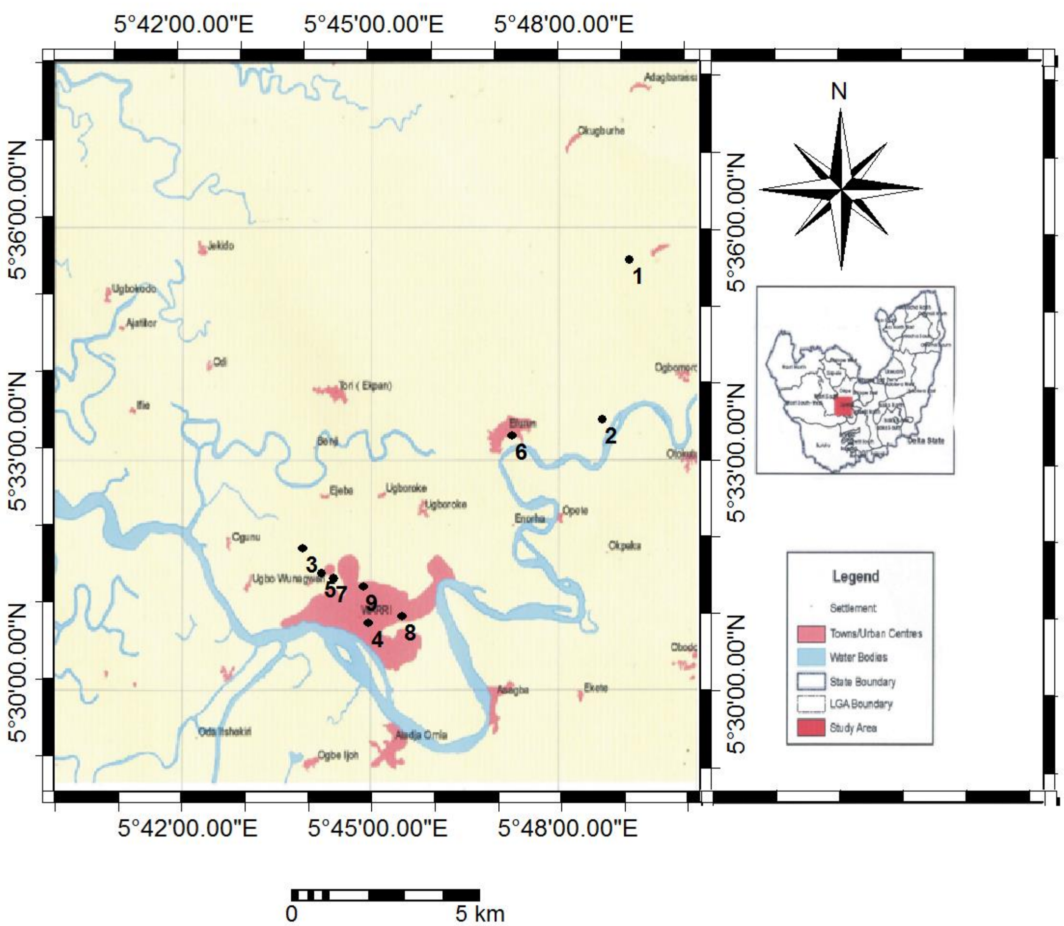

Figure 2. Coordinates of Randomly Selected Ground Controls Points and Ground Truths (Source: Field work, 2014)

Interpretation tasks include adoption of Anderson (1976) classification scheme with some modifications to suit the objectives of the current study and the data available, pattern recognition, enumeration, measurement and delineation into areas of similar photo-generic characteristics. Interpretation strategies adopted in this study include direct interpretation, inferential interpretation, probabilistic and deterministic interpretations.

Field survey was performed throughout the study area using global positioning system (GPS), with GPS receiver, Germin, GPS Map 76 C5X. (Seetable 3.2 and fig 3.2). This survey was performed in order to obtain accurate location point data, included in the classification scheme, creation of training sets, signature development, to obtain ground control point for ground truth sampling and to confirm results obtained during the categorization of the different land use and land cover types. The field survey also helped to raise the local reference level of the analyst which further aided interpretation of image features. An important purpose for the field survey is to investigate and confirm that the current study was actually executed within the study area as defined in fig 1; Base Map and location of Warri Metropolis, Delta State. Nigeria, latitude 5^0 27’ N to 5^0 37’ N and longitudes 5^0 40’ E to 5^0 50’E.

It was observed and noted, that all selected ground control points and ground truths, spatially captured on figure 3.2 below, are within the defined study area, latitudes 5^0 27’N to 5^0 37’N and longitudes 5^0 40E to 5^0 50’E, as the goals of the field checking and completion were achieved.

3. Discussion of results

The first stage involved in GIS analysis is the scanning and exportation of topographical maps, aerial photographs and digital satellite data into GIS environment empowered with spatial analysis tool and software, ArcGIS, version 9.3. The maps were plan metrically registered to meet accepted standards in remote sensing and GIS. Consequently, four control points were collected from each of the maps making a total of twelve points in degrees and minutes and converted to decimal degrees for registration of maps to real coordinate system, based on ArcView image analysis extension (see Table 3 below).

Table 3. Control Points for Maps Registration

Tic id	X coordinate (Longitude)	Y coordinate (latitude)	Map Sheet No
1	5.7500	5.7500	309 SE
2	6.0000	5.7500	309 SE
3	6.0000	5.5000	309 SE
4	5.7500	5.5000	309 SE
1	5.7500	5.5000	318 NE
2	6.0000	5.5000	318 NE
3	6.0000	5.2500	318 NE
4	5.7500	5.2500	318 NE

Source: Field work and GIS Analysis (2014)

Furthermore, known points were collected from maps for geo-referencing the aerial photographs. In addition, on the digitized aerial photographs, four points each were randomly selected and taken as ground control points (GCP), and used for the geo-rectification. The satellite image that was already geo-referenced was used to geo-reference the aerial photographs. This was done so that the data extracted from both satellite and digitized aerial photographs and digitized topographic map data can overlay properly and fit for further analysis. The root square error for the registration is less than 0.03 or 3%, to indicate a very high level of accuracy in the co-registration of digital image maps of 1964 and 2014. The different classes of land cover and land use were extracted from digitized aerial photographic and satellite images for the two years using on-screen digitizing. However, the digital maps were projected to UTM-31 so that areas (sizes) can be generated and computed for different categories of land use and landcover. The projection parameters are shown in Table 4 below.

Table 4. UTM Zone 31 Projection Parameters

Parameter	**Value**
Category	UTM-31 (1983)
Projection	Transverse Mercator
Central Median	-117
Reference Latitude	0.0
Scale Factor	0.9996
False Easting	500000

Source: Field work and GIS Analysis, (2014)

Remotely sensed data were analysed using ArcGIS spatial analysis tool and software version 9.3. At the image extraction, classification and change detection stage, a head-on-screen digitizing method was adopted for delineation and classification of extracted features. The cleaning, editing and topology building was carried out using ArcGIS version 9.3 software extension. Two maps were generated for 1964 and 2014 and compared and a post-classification overlaid operation was performed to generate the change map as shown on figure.3, 1964, land use and land cover map, figure. 4, 2014, land use and land cover map and figure. 5, change map for Spatio-temporal characteristics of land use and land coverof Warri metropolis between 1964 and 2014). The post-classification overlaid operation used in this study was adopted from Lilles & Kiefer (2000), Ezeomedo & Igbokwe (2013).

Two map analysis were carried out within the GIS environment. These include the generation of areal statistics of the classes of land resources generated from digitizing and image interpretation, and the overlay operation for change detection. The first analysis is to obtain the post classification comparison of the land resources categories derived from the areal analysis used to generate the change maps, while the second analysis is to determine the location, areal extent or magnitude of land use and land cover change. The two map analysis above is consistent with the objectives of this study: inventory of land use and land cover for 1964 and 2014 and the determination of the location and magnitude of land use and land cover changes in Warri Metropolis (1964-2014).

The different maps generated were then prepared for cartographic production. The cartographic production of land cover and land use inventory maps were composed using spatial analysis tool and software Arc GIS 9.3.The thematic map production facilities were employed with appropriate symbols and patterns to create land use and land covermaps. The hard copy map products were finally printed using the Hewlett-Packard LaserJet printer, M1132MFP on A4 papers and are presented in Figures 3, 4 and 5.

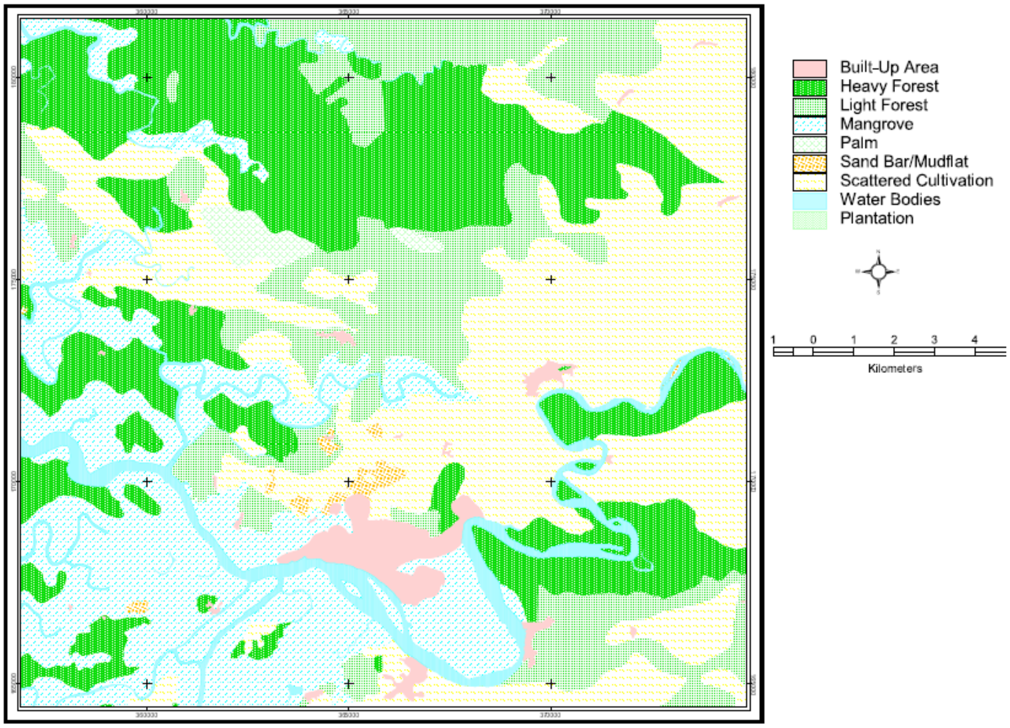

Figure 3. Static Characteristics of the Land use and Land cover of Warri Metropolis for 1964 (Source: Fieldwork and GIS Analysis, 2014)

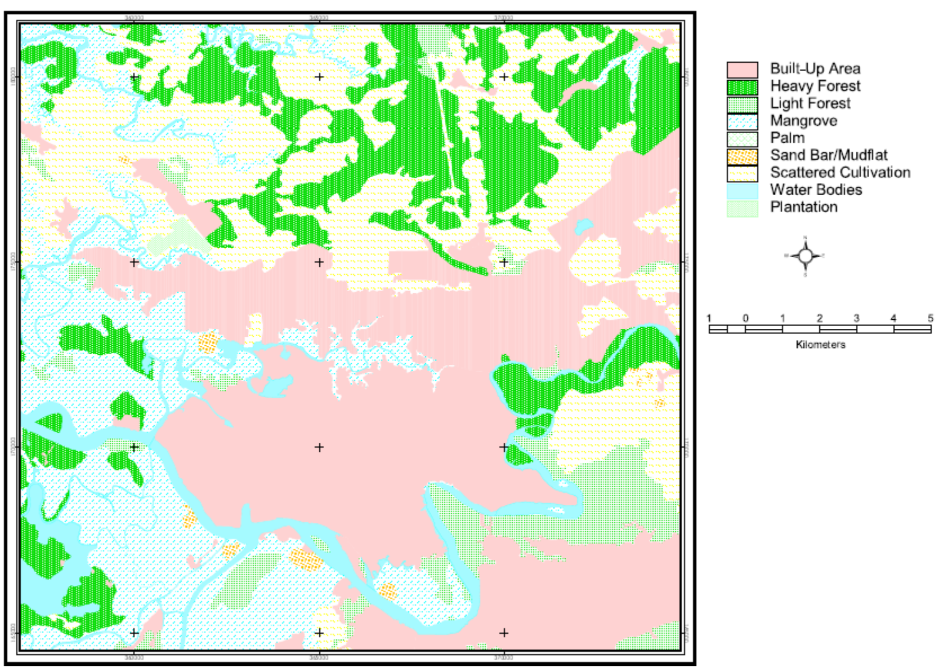

Figure 4. Static Characteristics of the Land use and Land cover of Warri Metropolis for 2014 (Source: Fieldwork and GIS Analysis, 2014)

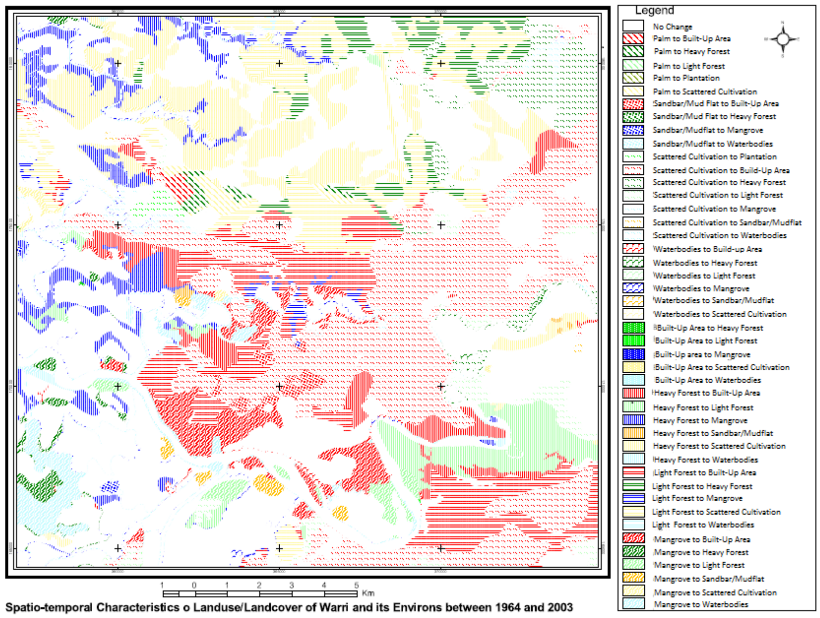

Figure 5. Spatio-temporal characteristics of Land use and Land cover of Warri Metropolis (1964 and 2014) (Source: field work and GIS Analysis, 2014)

Table 5. Statistics of Land use and Land cover for Warri Metropolisin 1964

Land use and Land cover Class	Frequency	Area (M²)	Area (ha)	Area (km²)	Percent
Built-Up Area	36	8,364,809.68	836.48	8.36	2.50
Heavy Forest	32	85,979,364.74	8,597.94	85.98	25.68
Light Forest	16	52,231,246.90	5,223.12	52.23	15.60
Mangrove	33	63,794,491.36	6,379.45	63.79	19.06
Palm	2	3,036,968.56	303.70	3.04	0.91
Sand / Mud	11	1,630,405.24	163.04	1.63	0.49
Scattered Cultivation	17	103,302,848.07	10,330.28	103.30	30.86
Water Bodies	20	16,450,152.59	1,645.02	16.45	4.91
Total (1964)		334,790,287.14	33,479.03	334.79	100.00

Source: Fieldwork and GIS Analysis (2014)

Table 6. Statistics of Land use andLand cover for Warri Metropolis in 2014

Land use andLand cover Class	Frequency	Area (M²)	Area (ha)	Area (km²)	Percent
Built-Up Area	25	102,740,472.52	10,274.05	102.74	30.69
Heavy Forest	51	54,281,728.26	5,428.17	54.28	16.21
Light Forest	30	22,229,053.25	2,222.91	22.23	6.64
Mangrove	82	59,727,828.19	5,972.78	59.73	17.84
Plantation	1	852,279.69	85.23	0.85	0.25
Sand / Mud	11	1,459,111.59	145.91	1.46	0.44
Scattered Cultivation	33	71,464,452.15	7,146.45	71.46	21.35
Water Bodies	30	22,044,698.61	2,204.47	22.04	6.58
Total (2014)		334,799,624.26	33,479.96	334.80	100.00

Source: Fieldwork and GIS Analysis (2014)

Table 7. Statistics for Land use and Land cover Change Matrix between 1964 and 2014in Warri Metropolis

LULC (2014)	Built-Up Area	Heavy Forest	Light Forest	Mangrove	Palms	Plantation	Sand / Mud	Scattered Cultivation	Water Bodies	LULC Sum (1964)	LULC Loss (Ha)	Percent Loss in 1964 (%)
LULC (1964)												
Built-Up Area	824.57	3.03	0.72	2.86	0.00	0.00	0.00	3.59	1.72	836.49	11.9	1.43
Heavy Forest	798.17	3,394.74	914.30	1,085.77	0.00	0.00	21.04	2,212.49	171.32	8,597.83	5203.1	60.52
Light Forest	2,205.24	729.43	416.41	170.27	0.00	0.00		1,665.09	36.69	5,223.13	4806.7	92.03
Mangrove	818.66	210.18	220.46	4,210.47	0.00	0.00	99.17	120.73	699.63	6,379.30	2168.8	34.00
Palms	59.52	95.39	0.08	0.00	0.00	0.40	0.00	148.31		303.70	303.3	99.87
Plantation						0.00						
Sand / Mud	135.09	5.52		19.16	0.00	0.00	0.00		3.27	163.04	163.0	100.00
Scattered Cultivation	5,361.62	911.38	644.73	272.32	0.00	84.83	25.60	2,988.56	41.05	10,330.09	7341.5	71.07
Water Bodies	70.98	78.15	25.95	211.74		0.00	0.10	7.31	1,250.74	1,644.97	394.2	23.97
LULC (2014)	10,273.85	5,427.82	2,222.65	5,972.59	0.00	85.23	145.91	7,146.08	2,204.42	33,478.55		
LULC Gain (Ha)	9,449.28	2,033.08	1,806.24	1,762.12	0.00	85.23	145.91	4,157.52	953.68			
Percent Gain in 2014 (%)	91.97	37.46	81.27	29.50	0.00	100.00	100.00	58.18	43.26			

Source: Fieldwork and GIS Analysis (2014)

One of the major result of topographical map overlay is the generation of two dimensional matrix within the GIS environment, (Adeniyi & Omojola 1999). The matrix show the nature of the land use and land cover changes for the two given sets of years (1964 and 2014), thereby, accomplishing the objectives of this study. For example change assessment between years 1964 and 2014 as shown in Table 7, contains 8 land use and land cover themes for each of the years. However, the change analysis reveals 64 (8x8) classes of land use and land cover changes all grouped under areas of decreasing changes, increasing changes and, areas without changes. The second major product within the GIS environment from this matrix is the location specific mapping of the total changes. However, since generating the entire 64 changes will be cartographically crowded and meaningless, the area considered to be of significant implications for land resource management were selectively mapped.

Statistical techniques such as Analysis of Variance (ANOVA), Duncan New Multiple Range (DNMRT), Multiple Regression Models, and, Time Series Analysis have been adopted to test hypotheses 1,2and 3 for detailed explanation of land use and land cover dynamics in Warri Metropolis (1964-2014). However, to abstain if there is any significant change in landuse and land cover characteristics in Warri metropolis between 1964 and 2014, One-way analysis of variance (ANOVA) statistical techniques was used to determine how significantly variable data from remotely-sensed images within and between the study years (1964-2014). The ANOVA technique applied was adopted from Atubi, (2015). The goal was to test if data collected from 1964, 1974, 1984, 1994, 2004 and 2014 remotely sensed images were equal in sample means or otherwise.

Table 8. ANOVA Table

	Sum of squares	**Df**	**Mean square**	**F**	**Sig.**
Between groups	773236.979	5	154647.396	3.3331	.013
Within groups	1949668.434	42	46420.677		
Total	2722905.412	47			

Source: Researchers Computation (2014)

In table 8 above, the model shows significance at P<0.05. This implies that there is a significant changes in Land use and land cover types between1964 and 2014.

However, New Duncan Multiple Range Test (DNMRT) below was used to compare the means, to ascertain whether they were significantly different (Atubi, 2015).

Table 9. Summary for Duncan New Multiple Range Test (DNMRT)

Identifiers

Duncan[a]

		Subset for alpha =0.05		
Land use change characteristics	**N**	**1**	**2**	**3**
1964.	8	11.6700		
1974.	8	41.8487	41.8487	
1984.	8	149.6250	149.6250	
1994.	8	156.3725	156.3725	
2004.	8		255.1713	255.1713
2014.	8			387.6250
Sig.		.229	.076	.226

Means for groups in homogenous subsets are displayed
a. Uses harmonic mean sample size = 8.000.
Source: Researchers computation (2014)

From table 9 above, there seem to be a systematic change in LULC types since 1964. However, while the change from 1964 to 1994 was gradual, the era 2004 to 2014 shows some rapidity in the change characteristics. Factors for this rapid change in LULC types is explained in the regression model below (see Table 9). Duncan New Multiple Range Test (DNMRT) shows that there were differences in the LULC of decadal remotely sensed data, 1964, 1974, 1984, 1994, 2004 and 2014.

Again, the multiple regression model was used to ascertain if landuse and land cover change between 1964 and 2014 are significantly dependent on population growth, change in the area extent of built – up area and change in the areal extent of forested area.

From table 10, it is clear that population growth, change in the areal extent of forested area and change in the areal extent of built-up area sufficiently explain the change detected in land use and land cover of Warri Metropolis (1964-2014). This is because the model shared an overall correlation of r. 99.5, this is a strong correlation. However, the coefficient of determination shows that 99% of the LULC detected can be explained by population growth, changes in the areal extent of forested area and changes in areal extent of built up area, leaving the other1% unexplained to other land use and land cover change factors such as change in water bodies etc. Furthermore, the model is significant at p>0.05. This implies that LULC is significantly dependent on Population growth, changes in areal extent of Forested area, and changes in areal extent of built-up area. The null hypothesis is rejected and the alternative hypothesis is accepted which states that "Land use and Land cover change between 1964 and 2014 in Warri Metropolis is significantly dependent on Population growth, changes in the areal extent of the built-up, and changes in areal extent Forested area".

Table 10. Model Summary (Multiple Regression Analysis)

Mode	R	R square	Adjusted R square	Std. error of the estimate	Change Statistics				
					R square change	F change	Df1	Df2	Sig. F change
1	.995[a]	.990	.989	2.36076	.990	1531.470	3	47	.000

a. Predictors: (Constant), Population growth, Forested area change, Built up area change
Source: Researchers computation (2014)

An attempt was made to project land use and land cover changes in Warri Metropolis beginning from 2014, as base year to the next 5 years (2019), 10 years (2024), and 25 years (2039), planning periods. The probability of land use and land cover change from one type to the other in the next 5years, 10years and 25years, were determined by employing geo-spatial tool and GIS software, the Markovian Transition Estimator (MTE), from IDRISI Andes. (Jahan, 1986; Muller and Middleton, 1994; Rimal 2005; Oluseyi, 2006; Wu, 2006; Huang, Liu, Luan, Jiang, 2008; Rimal, (2011). In the current study Markovian Transition Estimator, an application of land use and land cover change detection analysis, projects future possible land use and land cover change based on the rate of the past changes and present (see Table 11: land use and land cover change matrix, 1964-2014, Warri Metropolis) and projects from the present matrix of 2014 and outputs.

Table 11 (a,b, c, d and e) indicates area matrixes for 2019, 2024, 2029, 2034 & 2039, 5years, 10years, 15years, 20years, 25years planning periods. In 2019, Agricultural land use is projected to occupy a total area of 7,607Km^2 that is 22.7% of the total land area of 334,79km^2 that is in 5 year planning period. Forest is projected at 5, 141km^2 (15.4%), Built-Up area 12, 689km^2(38%) and Water bodies, 8,041km^2 (41%).In 2024 (10-year planning period), Agriculture is projected to occupy 6,498km^2 (19.4%) of the total land area, Forest 3, 259km^2(9.72%), Built-up area 15,553km^2 (46.4%), Water bodies, 8,167km^2(24.39%). In 2029 (20years planning period), Agriculture is projected to occupy a space of 5, 965km^2 (17.81%), Forest is projected to occupy 2,695km^2 (8.05%), Built-up area is projected at 16,803km^2 (50.18), Water bodies 8015km^2 (23%). In 2039 (25 years planning period, Agriculture is projected to occupy 5,842km^2 (1.75%), Forest 2,561km^2 (7.6%), Built-up area 17,007km^2(51%), water bodies 7,908km^2 (23.6%) of the total mapped area of Warri Metropolis.

Consistent with Houet & Hubert-Moy, (2006), the modelling and projection of land cover change in Warri Metropolis in the next 5years, 10years and 25years planning periods, beginning from 2014 has been very important in the assessment of future environmental impacts. Simulation of man-induced land use and land cover changes following different scenarios or time series has revealed strategic policies that should be modified to improve environmental aspects in the area of urban sprawl, unplanned growth, so prevalent in

Warri Metropolis. There is also need to preserve the natural ecosystem under threat of uncontrolled growth. In addition, the current projections should be considered as a continuous exercise in foresight to anticipate future urban challenges and provide solutions to them in advance. Urban planners should have a proactive response to urban challenges. They should be prepared and equipped with up-to-date and reliable information and modern geospatial technologies for response optimization to many existing and future complex land challenges.

Table 11 (a-e). Transition areas matrixes, in km^2, land use and land cover projection, Warri Metropolis 2019, 2024, 2029, 2034 & 2039 (5years, 10years, 15years, 20years & 25years planning periods)

(a) 2019 (5years planning period)

Agriculture	**2394.87km²**	**740.88km²**	**2722.56km²**	**1748.37km²**	**7606.55km²**
Forest	1526.60	125.91	1251.28	1104.12	5141.88
Metropolis built-up	1991.78	360.0	8124.72	221.55	12688.9
Water bodies	584.48	897.96	3455.46	3103.01	8,041.19
Total area(km^2) land use and land cover 334.7km^2					
2024 (10 year planning period)					

(b)

Agriculture	1522.29	622.40	2773.13	1580.42	6498.0
Forest	829.22	518.33	1130.21	781.99	3259.7
Metropolis built-up	2603.53	738.68	9017.13	3193.74	155.53
Water bodies	1009.86	815.26	3082.97	2459.11	8167.10
Total area(km^2) land use and land cover 334,78Km^2					
(c) 2029 (15 year planning period)					
Agriculture	1198.60	503.30	2769.75	1457.58	5964.9
Forest	592.93	243.67	1115.54	663.24	2694.67
Metropolis built-up	2874.19	1148.89	9208.00	3714.23	16803.44
Water bodies	114.88	719.49	3961.0	2120.06	8015.26
Total area(km^2) land use and land cover 334,88km^2					
(d) 2034 (20 year planning period)					
Agriculture	1098.91	503.30	2851.65	1426.90	5880.6
Forest	483.44	243.67	1104.0	596.17	2427.2
Metropolis built-up	2946.02	1148.89	9054.79	3904.74	17054.2
Water bodies	1313.35	665.47	3996.37	1980.12	7955.11
Total area(km^2) land use and land cover 334.50km^2					
(e) 2039(25 year planning period)					
Agriculture	1055.93	480.28	2898.90	1446.80	5841.72
Forest	480.88	230.68	1226.27	623.54	2561.33
Metropolis built-up	2954.77	12180.03	8871.90	3962.42	17006.83
Water bodies	1353.69	635.44	4002.89	1916.21	7907.98
Total area(km^2) land use and land cover 334.46km^2					

Source: Field Work andMarkov Transition Estimators, (MTE) output (2014)

4. Policy implications

There is need for the establishment of a National Land use mapping programme to cover the entire land space of Nigeria and the establishment of wetlands of international importance (Ramsar site) in Warri Metropolis and other wetlands of Nigeria.

There is need to control sprawling Warri Metropolis through growth policies by legislative means. A regional development planning policy, directed towards aggressive development of infrastructural facilities such as roads, schools and electricity in the surrounding rural and urban settlements will discourage further sprawl. Public sector and private sector partnership to create housing schemes, particularly for the poor should be encouraged. The concept of new city planning should be adopted in developing small urban centres around Warri Metropolis. Consequently, this will absorb the excess population and reduce the spatial expansion of the metropolis to adjoining agricultural and other vegetated land uses and land cover.

Experiences show that communities are often the most negatively affected in land challenges confronting Warri Metropolis and other expanding urban regions. This is evident with the pace at which the rapid expansion of Warri Metropolis into adjoining rural communities has affected the land base of many communities over the years. Since rural communities are much closer to these challenges, efficient land management under the current circumstance demands more active roles for local communities in matters associated with land administration and management. This can be achieved through the provision of technical assistance that gives local community organizations real involvement in planning and implementation of new land programs adjacent to the communities.

For many years, land resources managers in Nigeria operated a conservative system in land allocation under which land is invested with the executive. This made the reformation of land information system difficult. Insufficient attention was not paid to a periodic geo-spatial inventory and evaluation of scarce land resources for policy and sustainable development with the latest advances in management information systems. Considering the defects in policy, unreliability of land information system, land management continue to face improper management. There is need to strengthen the policy by laying emphasis on periodic geospatial Inventory and continuous monitory of land resources for possible changes therein.

In recent times, the United Nations through document, Agenda 21, reiterated the importance of geospatial information system for planning and development in developing countries. However, the resources to achieve geospatial information as suggested in Agenda 21 of the United Nations has not fully been factored in the administrative framework of land administration and management in Warri Metropolis and other parts of Nigeria.

Considering the rapid urbanization of Warri Metropolis and other urban regions of Nigeria, the design of a regional land information system along the lines of Agenda 21 is urgently needed. Monitoring the spatial extent of change and keeping tract of land use trends in Warri Metropolis must be the major aim of the proposed Regional Land Information System. This will not only go a long way in sustaining an effective land management, but it will augment the decision support systems guiding land management with the latest advances in geo-spatial information technologies.

To facilitate urban land use planning, there is need to have access to up-to-date data, with administrative and geospatial characteristics. The data should be accessible through a standardized web services, providing up-to-date data from the source. Good land use decision can be taken only with reliable and up-to-date data. However, this data or information is not owned by a single organization, rather it is distributed with different organizations or institutions across the country. Therefore, organizing access to this data through a nationwide data infrastructure is inevitable. In this way, the gap between supply (data) and demand (usage) could be bridge or at least reduce substantially. The municipality of Almere in Netherlands is one of the best examples in land use planning (Aranya et al., 2003).

5. Conclusion

This study has detected, identified and defined the major land use and land cover categories or types in Warri Metropolis (1964-2014), as built up area, heavy forest, light forest, mangrove, palm area, sand/mud, scattered cultivation and water bodies. In addition, the current study has demonstrated beyond reasonable doubt that remotely sensed data, GIS analysis in conjunction with field data, have great potentials to provide a cost effective, objective, reliable and timely information on land use and land cover changes in urban regions of the Niger Delta area of Nigeria.

Effective planning is rendered difficult in Warri Metropolis owing to a lack of current land use and land cover information and the means of acquiring such information. The research methods adopted in this study and the results obtained is a strong evidence that the use of historical aerial photographic and satellite data in conjunction with field data can provide the best means of acquiring land information vital for the monitoring urban growth. It is suggested that more studies relating to urban growth using remotely-sensed data should be undertaken by researchers. Considering the extensive territorial spread of Nigeria, her ecological diversity, large population size, it is very clear that traditional methods of field investigation and inventorying cannot provide appropriate data base. Satellite remote sensing can bridge this gap. Since Warri Metropolis is deficient in up-to-date and reliable land use information, the GIS generated maps in the current study can be used as part of its database for land use planning consequently closing the land use data gap of Warri Metropolis. Paucity of current and reliable land use data is the major research problem of the current study.

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