Assessment of Land Use/Cover Change Using Remote Sensing and GIS Techniques: A Case of Osogbo and Its Peripheral Areas in Nigeria

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ABSTRACT: The importance of accurate and timely information describing the nature and extent of land resources and changes over time is increasing, especially in rapidly growing city areas. Landsat satellite imageries of three different time periods, i.e., Landsat Thematic Mapper (TM) of 1982, 2000 and 2018 were acquired by Global Land Cover Facility Site (GLCF) and earth explorer site, quantify the changes in the Osogbo and its peripheral areas from 1982 to 2018 over a period of 36 years. These data sets were imported in ArcGIS 10.3, ERDAS Imagine and IDRIS Selva, satellite image processing softwares to create a false colour composite (FCC), supervised classification methodology was employed using maximum likelihood technique. The images of the study area were categorized into four different classes namely Core-urban, Peri-urban, Vegetation, water body. The results indicate that during the last thirty-six (36) years, Core-Urban land and water body have been increased by 2.74% (38.20 km2) and 0.98% (13.69 km2) while Peri-Urban land, and vegetation cover have decreased by 0.35% (5.00 km2), and 3.36 % (46.87 km2), respectively. The results quantify the land cover change patterns in the city and its peripheral area and demonstrate the potential of multitemporal Landsat data to provide an accurate, economical means to map and analyse changes in land cover over time that can be used as inputs to land management and policy decisions.

Land use/cover is two separate terminologies which are often used interchangeably (Dimyati *et al*., 1996). Land over refers to the physical characteristics of earth's surface, captured in the distribution of vegetation, water, soil and other physical features of the land, including those created solely by human activities e.g., settlements. While land-use refers to the way in which land has been used by humans and their habitat, usually with accent on the functional role of land for economic activities. The land use/cover pattern of a region is an outcome of natural and socio-economic factors and their utilization by man in time and space. Information on land use/cover 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. This information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population. Land use affects land cover and changes in land cover affect land use. Changes in land cover by land use do not necessarily imply degradation of the land. However, many shifting land use patterns driven by a variety of social causes, result in land cover changes that affects biodiversity, water and radiation budgets, trace gas emissions and other processes that come together to affect climate and biosphere (Riebsame *et al*., 1994). Land use/cover change detection is very essential for better understanding of landscape dynamic during a known period of time having sustainable management. Land use/cover changes is a widespread and accelerating process, mainly driven by natural phenomena and anthropogenic activities, which in turn drive changes that would impact natural ecosystem (Ruiz-Luna and Berlanga-Robles, 2003; Turner and Ruscher, 2004). Understanding landscape patterns, changes and interactions between human activities and natural phenomenon are essential for proper land management and decision improvement. Today, earth resource satellites data are very applicable and useful for land use/cover change detection studies (Yuan *et al*., 2005; Brondizio *et al*., 1994). With the invent of remote sensing and Geographical Information System (GIS) techniques, land use/cover mapping has given a useful and detailed way to improve the selection of areas designed to agricultural, urban and/or industrial areas of a region (Selcuk *et al*., 2003). Application of

remotely sensed data made possible to study the changes in land cover in less time, at low cost and with better accuracy (Kachhwala, 1985) in association with GIS that provides suitable platform for data analysis, update and retrieval (Chilar, 2000). The advent of high spatial resolution satellite imagery and more advanced image processing and GIS technologies, has resulted in a switch to more routine and consistent monitoring and modelling of land use/land cover patterns. Remote-sensing has been widely used in updating land use/cover maps and land use/cover mapping has become one of the most important applications of remote sensing (Lo and Choi, 2004). Landsat-TM images represent valuable and continuous records of the earth's surface during the last 3 decades (USGS, 2014). Moreover, the entire Landsat archive is now available free-of-charge to the scientific public, which represents a wealth of information for identifying and monitoring changes in manmade and physical environments (Chander *et al*., 2009; El Bastawesy, 2014). Several studies acknowledged the importance of pre-processing (i.e., data selection, co-registration, radiometric calibration and normalization) in performing accurate and reliable change detection analysis (Jensen, 2005; Lu *et al*., 2004; Mas, 1999; Scheidt *et al*., 2008; El Bastawesy *et al*., 2013). Some research scholars have made extensive research on land use/land cover change detection using remotely sensed images. Daniel et al. (2002) have compared land use/ land cover change detection methods and made use of 5 methods, viz., traditional post-classification cross tabulation, cross correlation analysis, neural networks, knowledge-based expert systems and image segmentation and object-oriented classification. They observed that there are merits to each of the five methods examined and that, at the point of their research, no single approach can solve the land use change detection problem. Yuan *et al*. (2005)developed a methodology to map and monitor land cover change using multi-temporal Landsat TM data in the seven-county Twin Cities Metropolitan Area of Minnesota for 1986, 1991, 1998 and 2002. Their result showed that between 1986 and 2002 the amount of urban land increased from 23.7% to 32.8% of the total area, while rural cover types of agriculture, forest and wetland decreased from 69.6% to 60.5%. Adepoju *et al*. (2006) examined the land use/land cover changes that have taken place in Lagos for the last two decades due to the rapid urbanisation. A post-classification approach was adopted by Adepoju with a maximum likelihood classifier algorithm. El Gammal *et al*. (2010) have used several Landsat images of different time periods (1972, 1982, 1987, 2000, 2003 and 2008) and processed these images in ERDAS and ARC-GIS software to analyse the changes in the shores of the lake and in its water

volume. Bhagawat (2011) presented the change analysis based on the statistics extracted from the four land use/land cover maps of the Kathmandu Metropolitan by using GIS. According to him, land use statistics and transition matrices are important information to analyse the changes of land use. El-Asmar *et al*. (2013)have applied remote sensing indices, i.e., normalized difference water index (NDWI) and the modified normalized difference water index (MNDWI) in the Burullus Lagoon, North of the Nile Delta, Egypt for quantifying the change in the water body area of the lagoon during 1973 to 2011.

However, Nigeria has been regarded as the most populous nation in Africa with a teaming population of over 130 million crowded over a land area of about 923,000 square kilometers. It has over a hundred cities with population that passes for urban centres. Nigerian cities Notably Lagos, Kano and Ibadan are among the first one hundred largest cities in the world (World Gazetteer, 2005), which translates into pressures on land and thus high urban dynamics. The pressures on land orchestrated by increased rate of urbanization brought with it intractable urban problems, such as poor environmental sanitation, pollution, crime, unemployment and overcrowding among others. Many writers confirmed that Nigerian urban centres are faced with rapid growth and development, which contribute to land use change. Though land use changes are indirect consequence of national economic growth, it is important to evaluate land use changes in the regional and the local context in order to assist in anticipating the impacts associated with change and contribute to an understanding of productive environmental sustainability (Laymon, 2003). Therefore, an attempt is made in this study to map out the status of land use/cover of Osogbo and its peripheral being at traditional city, in view to detect the land consumption rate and the changes that has taken place over the last 36 years with a view to project what may obtainable by year 2036 using geospatial techniques.

Study area: Osogbo is the capital city of Osun State, one of the thirty six states in Nigeria. It is located on latitude 7.7^{0}N and longitude 4.5^{0}E of Greenwich meridian with an average height of about 300m above the sea level. It was founded in the late 18th century and originated as a traditional as well as cultural town which derives its name from the proclamation by the goddess of Osun River. The town is known for very rich arts and cultural heritage (Adenike, and Akinola, 1991; Awe and Albert, 1995). Following the creation of Osun State in 1991, Osogbo assumed the status of a state capital. It has two local government areas, which are consisting of Osogbo and Olorunda with

surrounding local governments which are Egbedore, Ede North and South respectively. The population of Osogbo according to the 1991 census before it became a state capital was 189,733 and its total land area is about 2,875sq, km. (Afolabi, 2001). Over the years, Osogbo has witnessed tremendous growth, both spatially and in population. The establishment of a railway station is perhaps a major factor in the growth of Osogbo. Apart from the railway, postal and telecommunication, PHCN (now Ibadan Electricity Distribution Company) regional station, road network, agglomeration of heavy and many light industries, being the seat of government and the presence a good number of higher institutions, Osogbo thus became a major trading and distribution centre for people within and outside its immediate environment.In recent times, the location of Osogbo as a state capital, coupled with other factors mentioned above, has led to the influx of people from other towns and villages, thus giving it the status of a twin city, that is, a traditional as well as a modern city (Adenike and Akintola, 1991) and this account for the uncoordinated expansion of the city into its fringes which has posed serious consequences on land use planning and management. Below is the map showing the study area.
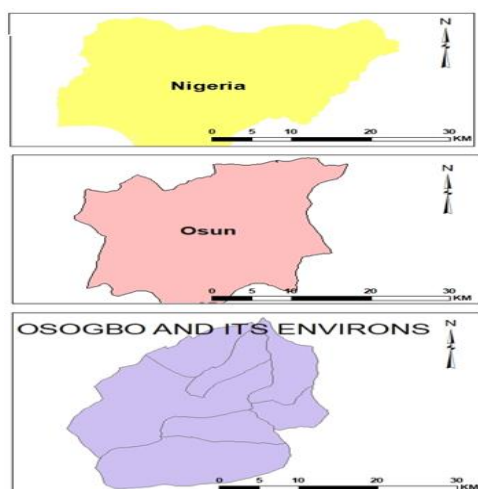
Fig 1: Map of Osun State showing the Seven Local Government Areas under study as Osogbo and its peripheral.

MATERIAL AND METHODS

Database preparation: Three data sets of Landsat Thematic Mapper at a resolution of 30m of 1982, 2000 and 2018 were used for land use/cover classification. The satellite data covering study area were obtained from global land cover facility (GLCF) http://glcfapp.glcf.umd.edu:8080/esdi/) and earth explorer site (http://earthexplorer.usgs.gov/). These data sets were imported in ArcGIS 10.3,ERDAS Imagine and IDRIS Selva, satellite image processing

softwares to create a false colour composite (FCC). The layer stack option in image interpreter tool box was used to generate FCCs for the study areas. The sub-setting of satellite images were performed for extracting study area from both images by taking geo-referenced out line boundary of Osogbo and its peripheral map as AOI (Area of Interest). For better classification results some indices such as normalized difference vegetation index (NDVI), normalized difference water index (NDWI) and normalized difference builtup index (NDBI) were also created to classify the Landsat images.

Land use/cover detection and analysis: To work out the land use/cover classification, supervised classification method with maximum likelihood algorithm was applied. The Maximum Likelihood algorithm assumes that the histograms of the bands of data have normal distributions. If this is not the case, you may have better results with the Parallelepiped or Minimum Distance Decision Rule, or by performing a first-pass Parallelepiped Classification. The Maximum Likelihood Decision rule is based on the probability that a pixel belongs to a particular class. It calculates the probability of a pixel being in a certain class and assigns it to the class with the highest probability.

RESULTS AND DISCUSSIONS

The results obtained through the analysis of multi-temporal satellite imageries were diagrammatically illustrated in Figs. 2–4and data are registered in Tables 1, 2 and 3 respectively. Fig. 2depicts spatial distributional pattern of land use/cover of Osogbo and its peripheral for the year 1982 while Fig. 3 for the year 2000 and Fig 4 show 2018. These data reveals that in 1982, about 74.78% (1040.89km2) area of Osogbo and its peripheral was under vegetation, 21.35% (297.21km2) under peri-Urban, 3.74 % (52.03 km2) under Core-Urban/ built _up Area, and 0.12% (1.68 km2) under water body. While in 2000 land categories was found about 79.17% (1101.90 km2) under vegetation, 30.17% (204.84 km2) under Peri-Urban land, 5.31% (73.84 km2) under Core-Urban/ built-up Area, and 0.81 % (11.23 km2) under water body. However, 2018 the area under these land categories was found about 71.42 % (994.02km2) under vegetation, 20.99 % (292.12km2) under Peri-Urban land, 6.48 % (90.23 km2) under Core-Urban/built up area, and 1.104 % (15.37 km2) under water body. For the projected LULC of Osogbo and its peripheral in the year 2036 as projected about 61.24 % (850.49 km2) under vegetation, 27.13 % (375.83 km2) under Peri-Urban land, 9.68 % (132.96 km2) under Core-Urban/ built-up Area, and 1.94 % (32.53 km2) under water body.
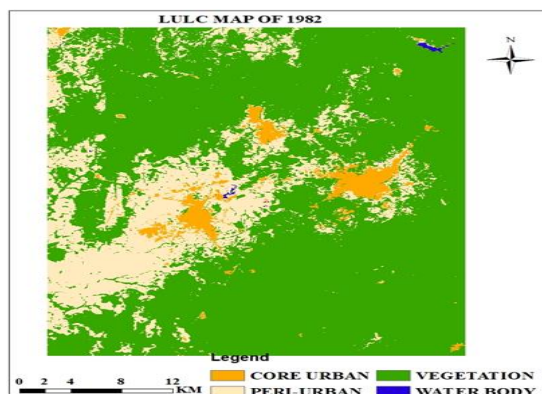
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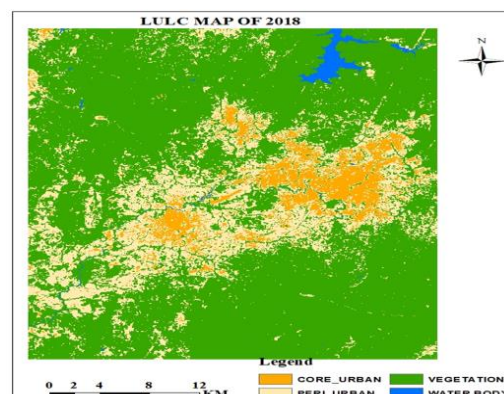Fig 2: Land use land covers classification 1982

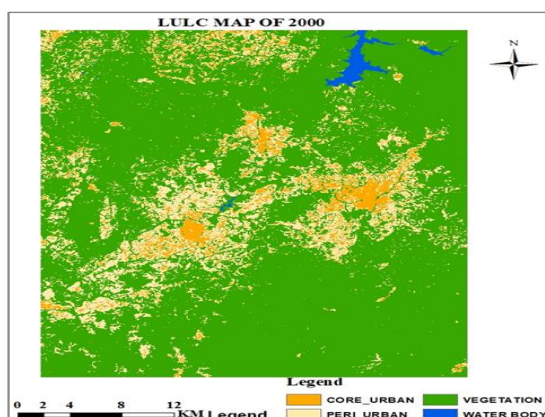Fig 4: Land use land covers classification 2018

Fig 3: Land use land covers classification 2000

Table 1: Showing the area covered by different land use classes in Osogbo and its peripheral region during the year 1982

Land use / land cover classes	KM²	%
Core-Urban	52.0326	3.73848
Peri-Urban	297.2052	21.35386
Vegetation	1040.8950	74.78713
Water Body	1.6776	0.12053
Total	**1391.8104**	**100**

Table 2: Showing the area covered by different land use classes in Osogbo and its peripheral region during the year 2000

Land use / land cover classes	KM²	%
Core-Urban	73.8414	5.30542
Peri-Urban	204.8424	14.71772
Vegetation	1101.8961	79.16999
Water Body	11.2302	0.80688
Total	1391.8104	**100**

Table 3: Showing the land use/land cover of the study area during the three observing years

1982		2000		2018		
Km²	%	Km²	%	Km²	%	Core-Urban
52.0326	3.73848	73.8414	5.30542	90.2295	6.48289	
297.2052	21.35386	204.8424	14.71772	292.1976	20.99407	Peri Urban
1040.8950	74.78713	1101.8961	79.16999	994.0167	71.41897	Vegetation
1.6776	0.12053	11.2302	0.80688	15.3666	1.10407	Water Body
1391.8104	100	1391.8104	100	1391.8104	100	Total

Land use/cover change: Data registered in Table 3 reveal that both increase and decrease changes occurred in the land use/cover pattern of Osogbo and its peripheral. During the last thirty six years the vegetation in the study area has increased from 1040.8950 km2 in 1982 to 1101.8961 km2 in 2000 which accounts for 4.38% increase, while 2018 there was a decrease 994.0167 km2 which amount to 7.75% decrease of the total study area this implies that desertification and deforestation processes may have occur during this period. Which means largely embodies the thinning out of the vegetation, decrease or destruction of perennial grass, and an increase and spreading of undesirable bush and woody species. The overall vegetation change has been ordinated into five broadly overlapping phases. These are primary degradation, denudation, revegetation, secondary degradation and a desertified phase.
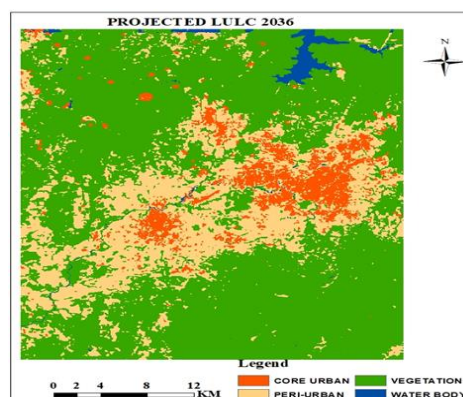

Fig 5: Land use land covers classification 2036

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Table 3: Showing the projected land use/land cover of the study area by year 2036

2036		
Km²	%	
132.9615	9.68312	Core-Urban
375.8256	27.13276	Peri Urban
850.4937	61.24701	Vegetation
32.5296	1.94820	Water Body
1391.8104	100	Total

The peri-urban has decreased from 297.2052 km2 in 1982 to 204.8424 km2 in 2000 which accounts for 6.63% while in 2018 it was 292.1976km2 which is an 6.27% increase compared with year 2000 result. The core-urban area has increased from 52.0326 km2 in 1982 to 73.8414 km2 in 2000 which accounts for 3.55% and year 2018 it also increases to 90.2295 km2 which amount to 1.17% increase. This maybe as a result of urbanization which account for population agglomeration and steady development over time. The water body of the study area has slightly increased from 1.6776 km2 in 1982 to 11.2302 km2 in 2000 which accounts for 0.68 %, while 2018 was 15.3666 km2 which accounts for 0.29 % increase.

Conclusion: The change pattern and temporal process in Osogbo and its environs does not conform to the popular land use theories; it comprises of urban core, surrounded by the high, medium and low-density areas. It is also obvious that the city is growing at such an alarming rate using up all the green and other forms of soft landscape in the city. Thus, the present study illustrates that remote sensing and GIS are important technologies for temporal analysis and quantification of spatial phenomena which is otherwise not possible to attempt through conventional mapping techniques.

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