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DETECTION AND ANALYSIS OF SPATIOTEMPORAL LANDUSE PATTERN FOR PROPOSED AKURE MILLENNIUM CITY .

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Abstract

The importance of landuse pattern in actualising and sustaining future cities in the ever dynamic environment cannot be overemphasised. Two very high resolution satellite images (Ikonos-0.8mand Quickbirds-0.6m)of Akure for the year 2006 and 2016 respectively acquired, process and subjected to segmentation algorithm of object oriented image analysis (OBIA) using the *Cognition* developer 64- 9.01 software. The segmentation result was exported to ArcGIS 10.3 software environment where each segments were assigned landuse types, using visual interpretation techniques. Eight landuse classes were extracted for the two years. The landuse classification was generated in maps. An accuracy assessment performed on the maps was 93.07% and 87.73% respectively. The result of the analysis showed that the 201.76km^2 total area mapped in 2006 has increased to 200.69 km^2 in 2016, open landuse had the highest coverage in 2006, followed by the residential landuse but in 2016 the reverse was the case. The study observed significant change in the landuse types as the open-space landuse and residential landuse type were the dominant landuse types in the study period while Commercial, Community & Public Institutions, Educational, Industrial and Recreational landuses were not too different in their use in the study period. The study recommended a close watch on unguided expansion and uncontrolled urbanisation which may defeat the actualisation and sustenance of the proposed millennial city in Akure.

Keywords: Landuse, Environment, segmentation, map, analysis, city, change

1.0 Introduction

The importance of landuse pattern in actualising and sustaining future cities in the ever dynamic environment cannot be overemphasised. The detection and analysis of pattern of landuse is an important requirement in landuse change detection for monitoring the dynamic environment. The urban environment is increasingly dynamic in spatial complexity and spectral heterogeneity. Land as an essential part of the environment has been the stage of the dynamism of the environment and the needs of man, the features and processes of the environment are the major actors. Of the dynamics of the environment both in space and time, the dynamics of landuse is major and pivotal (Oyinloye and Oloukoi, 2012) and has become a

phenomenon in global environmental change (Ademiluyi, Okude and Akanni, 2008; Pandit, 2011). The reason being that the land, its uses, the resultant changes and effects or impacts, has been dominant in the insatiable quest in man (Lambin et al., 2003). The effects of the use of land by man and the dynamics of the landuse is posing serious challenges on African cities like their other counterparts in the world, as these cities face challenges of population increase, advancement in technology, and many other factors of growth in their rapid, incessant and sporadic transformation (Briassoulis, 1999; Ademiluyi et al., 2008). Cities are the areas where the alteration of the environment is mostly evident. Observation, understanding and proper assessment of the pattern of the landuse will assist in the management of the environment and its natural resources. Such as proper decision and policy making that will prevent various decadence of the environment, that will result in an effective and adequate land use planning which will eventually bring about a secured land tenure. Changes in the environment are mostly studied in Remote Sensing through the landcover. These changes are mostly caused by the underlying landuse. An understanding of the underlying landuse transformations from a detailed and accurate mapping and analysis will help to curb hysterical expansion and the detriments to the environment, the ecosystem and the residents due to the management of the resultant effect. The use of very high resolution satellite images has become a major breakthrough in handling the detailed and accurate mapping of the spatially complex and heterogeneous urban environment, which has been beyond the handling of the low and medium resolution satellite images. The addition of the object oriented image analysis of these images has given Urban Satellite Remote Sensing a boost to providing reliable, detailed and accurate information about the urban environment through maps. These helps are germane to actualising and sustaining the millennium development city proposed for many potential cities in the developing countries.

2.0 Material and Methods

The two very high resolution satellite images (VHRSI) of Akure acquired for the study were Ikonos of 1m resolution of year 2006 and Quickbirds of 0.7m resolution of year 2016 respectively. The satellite images were subjected geo-rectification; landuse extraction using object-based imagery analysis and visual interpretation; landuse map statistical analysis and accuracy assessment. The Geo-referencing was done to convert the image pixels in rows and columns to corresponding ground coordinates in Eastings and Northings. Points used as controls were selected on the imagery of the study area. These points were visited with a differential GPS instrument and their coordinates were obtained. Sixty-five (65) of such points were obtained out of which sixteen (16) that adequately represent a good coverage of the image area (Ejikeme, 2016) were used for the geo-referencing.

This transformation of the 2 images were achieved through two approaches:

i. Image-to-Map rectification of 2016 Imagery
ii. Image-to-Image registration of 2006 Imagery.

With the availability of 16 GCPs that were well-distributed and visible on the 2016 imagery, the 2016 Imagery was georeferenced by assigning the coordinates of the surveyed points on the imagery. In the case of the 2006 Imagery, the coordinates of recognized points on the images were obtained from the previously georeferenced 2016 imagery interactively and transformed using the 2nd Order polynomials. The imageries were then rectified using 2nd order polynomials to 1m resolution in order to make them compatible in spatial resolution and to ensure equal and adequate comparison. It was ensured that the Root Mean Square value of the transformation was less than half of the size of the pixels. For landuse extraction, the multi-resolution segmentation approach as implemented in the software package was used to generate homogeneous image objects or segments on the basis of the spectral and contextual information using the parameters scale and colour. The highest value of scale 250 was used in order to differentiate segments with maximum standard deviation of

homogeneity. Also, the highest value of colour was used in order to place greater emphasis on colour in differentiating segments. The segmentation results were then exported to ArcGIS 10.3 software environment where each segment was assigned a landuse type by visual interpretation techniques after the segments were overlayed on the satellite image following the Anderson (1976) classification scheme (Jensen, 2004). Some of the techniques used include colour, shape, asymmetry, relative border, rectangular fit, size and texture. After the visual interpretation, the polygons were generalized to improve accuracy. Variables where derived from the attributes table of each landuse layer and results were presented in tables, bar graphs and maps.

The variables were described by the following formulae:

Total area (Ta) = Polygon geometry

Percentage (%) = $Ta/ \Sigma Ta_{t1..n} * 100$ Eq.1

Where t1 and t2 are the beginning and ending time of the landcover studies conducted.

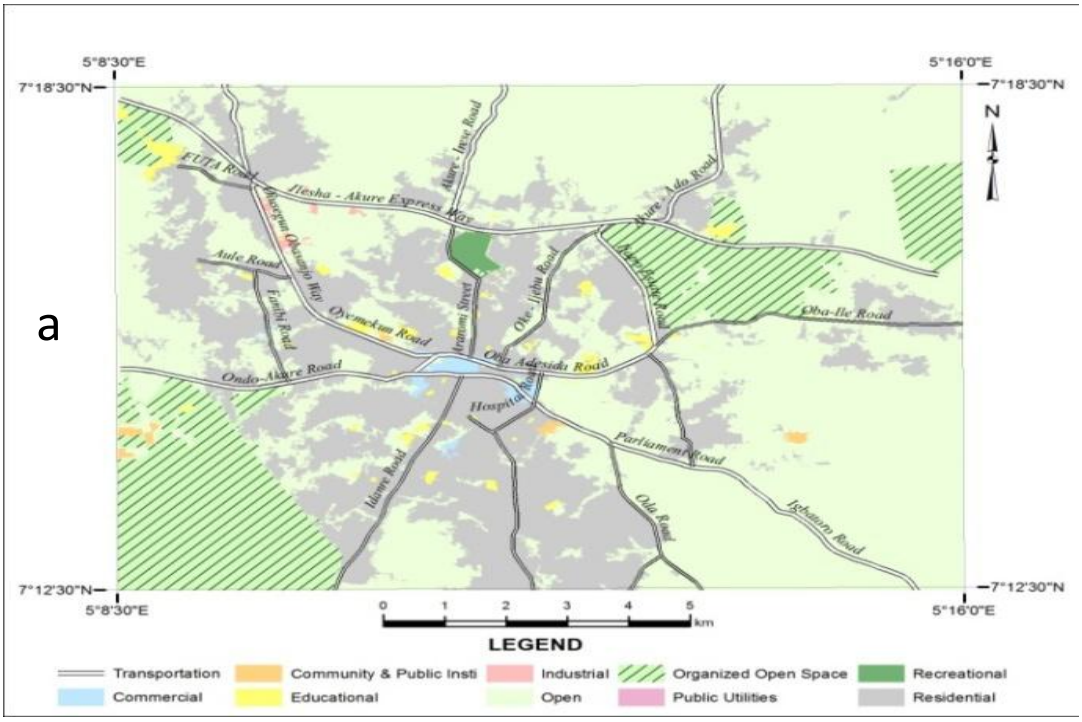
An accuracy assessment was performed as the final stage of the classification process. A random set of locations acquired during field survey on ground truth of the resultant landuse type was used. The resultant landuse maps were then compared with these field survey data to tabulate the relationship between true landuse classes and the classes as determined from ground truth. Errors of omission (Precision/Producer Accuracy) and errors of commission (User Accuracy) as well as the overall Accuracy and Kappa statistics were tabulated in a confusion matrix following the approach of Eastman (2012); Campbell and Wynne (2011) to ascertain the accuracy and precision of the landuse maps.

3.0 Results

From the processes of segmentation and classification, eight landuse classes were adopted for the two years (2006 and 2016). These are Commercial, Community and Public Institutions, Educational, Industrial, Open, Organised Open, Recreational and Residential. The landuse classes and their components are shown in table 1. Consequently, Landuse pattern maps (Figure 1), the statistics of the individual landuse area and the percentage coverage for the two years 2006 and 2016 (Table 2) were generated.

Table 1: Landuse Classes and Components

S/N	Landuse Class	Component
1	Commercial	Markets, Shopping Malls, Motor Parks, Saw Mills, Local Shops, Banks
2	Community & Public Institutions	Health centre, Police Stations, Fire service centres , Churches, Mosques, City Centre, Government offices, Public Utilities (PHCN, Water board, Telecom, Water body, Refuse Dump)
3	Educational	Public and Private Pre-Primary and Primary Schools, Secondary and Post Secondary Schools, Tertiary Institutions.
4	Industrial	Industries: Employment area, Light Industrial area, Heavy Industrial area
5	Open Space	Undeveloped lands and vegetations, that is neither part of nor maintained by any organisation (every unurbanised areas).
6	Organized Open Space	Areas under acquisition but not yet utilized. Undeveloped lands and vegetations that are part of and maintained by an organisation.
7	Recreation	Passive Recreation, Active Recreation, Restaurant, Hotels, Motels, Sport Centres
8	Residential	All levels of housings.



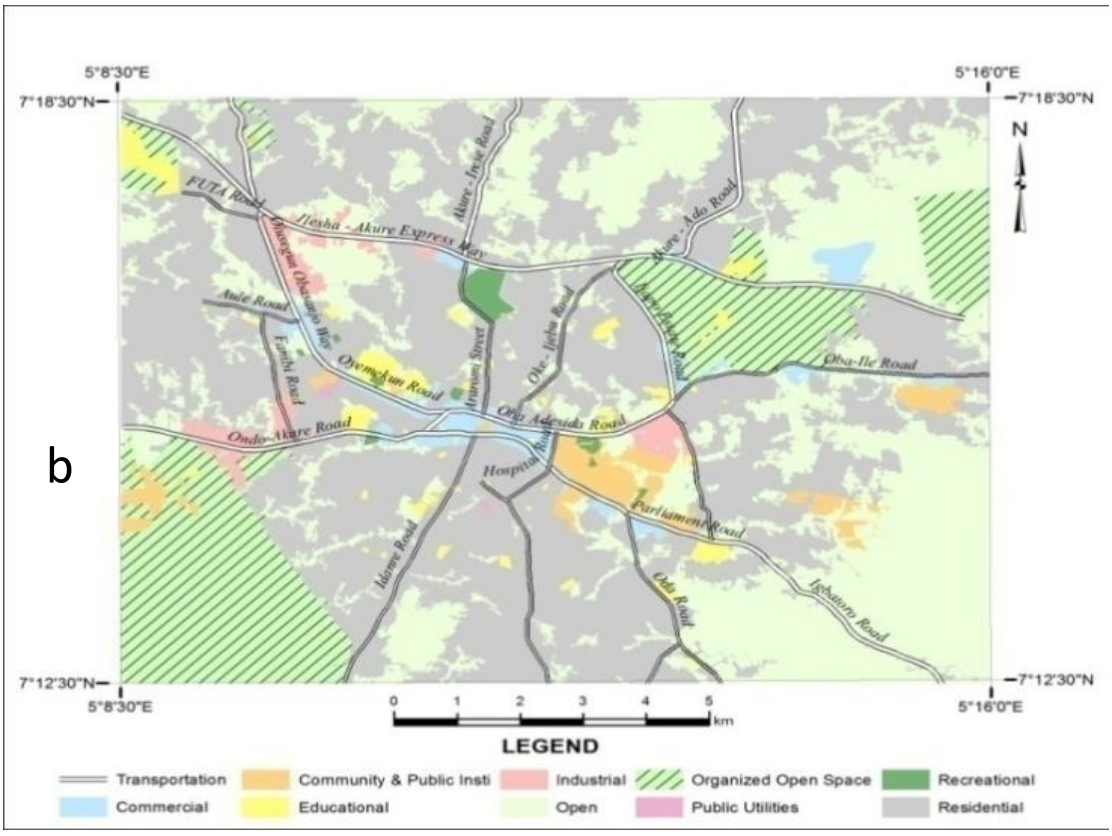


Figure : Landuse Pattern Maps for (a) 2006 (b) 2016

Table 5.1: Land use area statistics of the study area for year 2006 and 2016

Landuse	**2006**		**2016**		**Difference**		**Incr. Factor**
	T_a ()	**T_a%**	**T_a(km^2)**	**T_a%**	**T_a(km^2)**	**T_a%**	**2006x**
Commercial	0.93	0.46	3.86	1.92	2.93	1.46	4x
Community /Public Institution	0.44	0.22	3.83	1.91	3.39	1.69	9x
Educational	1.56	0.78	2.94	1.46	1.38	0.68	2x
Industrial	0.27	0.13	2.95	1.47	2.68	1.34	12x
Open	121.82	60.66	71.90	35.80	-49.92	-24.86	-2x
Organized Open Space	28.51	14.20	29.25	14.56	0.74	0.36	1x
Recreational	0.54	0.27	0.83	0.41	0.29	0.14	2x
Residential	47.69	23.75	89.13	44.38	41.44	20.63	2x
TOTAL	201.76	100.47	204.69	100.91	2.93	0.43	1x

4.0 Findings

The pattern of the landuse are evident both qualitatively (visual) from the maps (Figure 5.1) and the quantitatively (numerical) from the tables (Table 2). The maps depicts the identity, location and direction of the landuse types while the table and the Figure shows the areal extent of the landuse types for each year and their differences. Generally, from table 2, an increase in the total area in the two years was observed. This signified expansion in the study area as observed by Oyinloye, (2010) and Owoeye and Ibitoye, (2016) as always evident in the periphery of such large urban concentrations that are subject to urbanization and industrialization pressures and frequently result in losses of prime agricultural lands and tree cover. Along the columns, the Open landuse, Residential Landuse and Organised Open

landuse was observed to have the greatest areal coverage in that order. This signified the general trend in the development also evident in the study area. Everywhere was first an Open space (landcover) whether covered with vegetation or not. That is where development (landcover modification or conversion) commences. The first reflection in the development among others is the built up especially the residential landuse, which is always continous. The organised open landuse is always a fall out of the transformation of the built up landcover expressed through the residential landuse. Along the row, all the landuse type increased except the Open landuse and the Organised open landuse. These signified transformation in each landuse type which is evident in the urbanisation in the study area. These all confirm findings in literature that the study area has experienced transformation in underlying landuse that is evident in the landcover change, and that urbanisation has played a major role.

Table 3: Landuse transformation and increment from 2006-2016

Landuse Type	Comm -ercial	Community & Pub. Inst	Educational	Indust-rial	Open	Org Open	Recreati-onal	Resident-ial
ΔT_a (%)	1.46%	1.69%	0.68%	1.34%	-24.86%	0.36%	0.14%	0.43%
Increament factor (2006x)	4x	9x	2x	11x	-2x	1x	2x	1x

Specifically, between the study year (2006-2016), as shown in table 3, the commercial landuse has increased by 1.46% in area and four times the area in the year 2006. This is observed in the maps spreading along the major roads and from the core of the town in agreement with Hurd's star theory (Imimole, 2005) that a city grows from its centre along its major transportation arteries. The community and Public Institution landuse has increased by 1.69% and nine times the area of 2006, educational landuse increased by 0.68% and twice the area in 2006, Industrial landuse has increased by 1.34% and eleven times the area of

2006. Open landuse on the other hand has reduced by 24.86% and twice the area of 2006, Organised open increased by 0.36% and one time the area of 2006, Recreation increased by 0.14% and twice the size of 2006, while Residential increased by 0.43% and one time the area in 2006. All these are pointing to a rapid growth of the study area into the proposed millennium development city (Adeoye, 2016). Urbanisation is fast taking place, the green area is fast depleting. The worrisome thing is that the observation of Oyinloye (2010), Olajuyigbe *et al*,. (2015), Owoeye and Ibitoye (2016), Ogunlade and Enisan (2016), Ogunlade (2018) that the spatiotemporal transformation in the city is uncontrolled and unguided is still an evident problem threatening the smooth actualisation of the proposed future city.

5.0 Conclusions

The study has revealed that Akure like all other emerging cities in Africa and the World at large is undergoing sporadic, incessant and fast transformation, that is fuelled by urbanisation factors (Ogunlade, 2018). These transformation are the effects of the use of land by man and the dynamics of the landuse. The dynamics of the landuse and its impacts are posing serious threats to this emerging city because cities are the areas where the alteration of the environment is mostly evident. All factors of growth are at play as evident in the transformation of the various landuse classes towards the emergence of the proposed millennium city in not too distant a future. The threat to the actualisation and sustenance of this future city is that the haphazard way in which the transformation is taking place. These threats are on the increase as the use of land is inevitably intensified to meet up with the challenges of population increase, advancement in technology, and many other factors of growth (Gupta, 1988 cited in Oyinloye, 2010).

6.0 Recommendations

Proper management of resources is a necessary step to actualising a durable and veritable future city. The landuse patterns as has properly assessed will help in proper decision and policy making that will prevent inadequate planned and unplanned landuse and unsecured tenure system, which has been the bane of ancient cities like Akure, and has led 'overtime to the development of different forms and grades of slum in and around urban core area'. Hysterical urban expansion of Akure and its environ as observed by Owoeye (2016) and Oyinloye (2010) is inevitable without an understanding of the underlying landuse transformations. Landuse maps serves as a base map for many urban renewal projects, planning schemes and other relevant urban landuse planning (Imimole, 2005). Landuse data remain an invaluable tool for planners and decision makers, and all that are concerned with land resources management (Imimole, 2005; Rolf, 2001). Poor database and data management is a problem in Nigeria, and this has affected effective planning and management of the rural and the urban environment. Oyinloye (2010) observed that Akure has not had a good master plan. This study is hereby recommending a close watch on unguided expansion and uncontrolled urbanisation which may defeat the actualisation and sustenance of the proposed millennial city in Akure. This close watch will be easily and adequately achieved through regular, frequently updated accurate and detailed landuse mapping, and the development and maintenance of a good database system.

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