EXAMINING THE ROLE OF GEOSPATIAL TECHNOLOGY IN NATIONAL DEVELOPMENT THROUGH URBAN LAND USE MAPPING

by

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Abstract

Up to date maps are needed for many developmental purposes. Traditional methods are slow and cumbersome. Akure Urban needs up to date maps both for monitoring and control of development in form of planning, etc. The tools of geospatial technology are available to solve the problem. This paper examined the importance of geospatial technology in national development from the perspective of Urban Landuse Mapping. High-Resolution satellite imagery of Akure (Quickbird of 0.7m spatial resolution) was used to map the Akure urban environment for the years 2010 and 2016, and Differential Global Positioning System (DGPS) method to obtain adequate ground control points for the purpose of georeferencing the satellite images. The study area was classified into eight existing land use classes using the segmentation algorithm of object-based image analysis (OBIA) of the e-Cognition Developer 64 software. Through GPS waypoints ground truthing for accuracy assessment of the land use classes was performed. The landuse maps were produced and analysed with ArcGIS 10.3 version. The results showed Commercial, Community and Public Institutions, Educational, Industrial, Open, Organised Open, Recreational and Residential as the existing land use classes in the study area; and that the 2010 and 2016 landuse maps generated had accuracies of 87.73% and kappa values of 0.832 and 0.852 respectively thus judging them to be good for analysis; as well as having both intra- and inter- land use transformations existing between the two epochs. Residential land use was observed to have the highest positive transformation of 18.38% while the open lands and the organised open lands experienced a decreasing transformation of 10.66% and 0.16% respectively. The results were then used to discuss the role that geospatial technology plays in a nation's development. The research concluded on the inevitability of the integration of Remote Sensing techniques and the tool of Geographic Information System for landuse mapping as an invaluable tool in sustainable national development. The paper recommended the placement of geospatial technology as first priority before, during and after any developmental processes of a nation.

Keywords:Landuse, Mapping, National Development, geospatial technology, Urban Environment.

1.0 Introduction

The relationship between man and land in the development of nations is an inseparable germane concept that is as old as the existence of man himself. The land sourced and sustains the man. Man is the major actor in the maintenance of the land [7]. His presence and activities are one of the twain life-wire of the land, the other being the nature [4]. National development arises from various initiatives of man as he put the land into various uses. Land use transformations result in national developmental processes. [2] observed one of such processes as where various dimensions of a nation and development of individuals are reconstructed and developed, and foremost in the factors of every National development is a planned national economy. [9] pointed out that crucial to any meaningful national development of any nation is the knowledge, availability and proper administration of its geospatial data and information. Acquisition, transformation and presentation of geospatial data and information to be the mainstay of geospatial technology.

The concept of modern geospatial technology involves the combination of different methodologies to provide spatial information required for sustainable development [3]. The integration of Remote sensing methodologies and the tool of Geographic Information System has made geospatial technology a veritable tool in the mapping and analysis of the urban environment which is the emblem of national development and the reflectors of national transformation [7];[10]. An accurate and detailed mapping of a nation's land use gives a true interpretation of the causes of the transformation of its land cover which is tantamount to its developmental processes. The land cover is the representation of the natural endowment of the nation, while the land use reflects the state of human activity that modifies the natural endowment. While the land cover is captured by satellite sensors, land use is mostly inferred because they are the underlining factors responsible for land cover changes. Land use and Land cover transformation are interdependent and interwoven in their roles in the dynamics of the environment, hence the combined term land use land cover (LULC).

Urban features are unique in their characteristics in the face of sensor capturing. They are spatially complex and spectrally heterogeneous [15,12]. This is why the techniques of Satellite Remote Sensing has been preferred to traditional geospatial technology methods in capturing data and representing the urban environment [8,7]. The uniqueness of the urban environment has also affected the method of Satellite Remote Sensing data capturing and the methodology of processing its data for representation, presentation and utilization. The use of low and medium resolution satellite imagery and the pixel-based image analysis (PBIA) has been found to be inadequate for Urban Satellite Remote Sensing (USRS) [15]. Rather the use of high and very high-resolution satellite imagery has been advisedly preferred. This also has to go with the methodology of Object-based image analysis (OBIA) designed to handle the uniqueness of the urban satellite remote sensing that is beyond the reach of PBIA. Unlike PBIA that treats feature according to the similarity in the radiance value of their picture elements (pixel) with the inherent problem of pixel overlaps among others [5]. OBIA group pixels into representative shapes and sizes through the process of multi-resolution segmentation or segment mean shift. Multipurpose segmentation produces homogenous image objects by grouping pixels. It generates objects with different scales in an image simultaneously. These objects are more meaningful because they represent features in the image. The image segmentation process decomposes an image into a number of image objects so that the characteristics of the image objects within each region have high homogeneity and strong correlations in terms of shape, size, texture, colour, tone, etc. PBIA has much software designed for its operation, some which can perform OBIA to a limited extent such as ERDAS Imagine, IDRISSI, ENVI, ILWIS etc. *eCognition Developer* software is exceptionally designed to handle OBIA especially using a high-resolution image. eCognition Developer can also perform PBIA but it is mainly designed for OBIA. It offers image segmentation allowing extensive data fusion and supporting the integration of Remote Sensing and Geographic Information Systems. Its suitability for the analysis of very high-resolution satellite images gave it an edge over other Remote Sensing software in mapping the urban environment [5].

The end-result of the geospatial technology process is the digital geospatial data and map, two things that are the life wire of national development. The geospatial data is an unlimited and unlimitable tool in the hand of Geo-scientist and Geo-modeller with the availability of the computer. There is virtually nothing in this age that the geodata cannot be used for as long as it is in the computer. The limitation depends on the field or discipline and the user. As long as it can be imagined it is possible. The map is a representation of the earth surface. Positions and locations of earth feature are transferred to a medium in a suitable coordinate system. The digital map is a computerised map. It is a dynamic representation of the earth in the computer. It is the map in motion. It is the map in soft copy. As the digital data, a digital map is an invaluable tool with unlimited and unlimitable utility. Maps are tools of national development as they serve as the bedrock of quality planning, policy and decision making. geospatial technology is the bedrock of national development. [6,7].

Akure is a fast growing and developing city. From an ancient town, it has developed over the years, capturing surrounding suburb (wards) into a city and yet evolving into a metropolis. From being administrative headquarter of a local government and the capital of Ondo state, its expansion has become so spread to two other local government areas that constitute the Akure kingdom of the ancient [11,14]. The development observed in Akure was made conspicuous through the change in its land cover that is a function of the transformation of the underlying land use [10]. It is geospatial technology techniques that are mostly used to measure and monitor these transformations [6,7]. It is on this premise that this study was carried out to map the urban land use of Akure to serve as tool for monitoring current development as well as planning and controlling future development in the area.

2.0 Material and Methods

Quickbird, high-resolution satellite imagery of Akure for two years, 2010 and 2016 were obtained for use in mapping the urban environment of Akure metropolis using combined techniques of Urban Satellite Remote Sensing and Geographical Information System (GIS). Differential Global Positioning System (DGPS) method was used to obtain adequate ground control points that were used to georeference the satellite images to correct for any geometric anomalies in the imagery. This is to relate map locations to earth surface locations by converting the image pixels in rows and columns to corresponding ground coordinates in Eastings and Northings. Coordinates of 16 Ground Control Points that were well-distributed and visible on the 2016 imagery were assigned on the imagery to perform map to image transformation (georeferencing) of the imagery. The coordinates of recognized points on the 2010 imagery were obtained from the previously georeferenced 2016 imagery to interactively perform an image to image transformation on the 2010 imagery using the 2nd Order polynomials.

Using the e-Cognition Developer 64 software, the segmentation algorithm of the Object Based Image Analysis (OBIA), the study area was classified into eight existing land use classes: Commercial, Community and Public Institutions, Educational, Industrial, Open, Organised Open, Recreational and Residential. GPS waypoints were used to perform ground truths for accuracy assessment of the land use classes. Land use maps for the two years were produced and analyzed with ArcGIS version 10.3 software (Figure 1a and Figure 1b). Underline resultant statistics of the land use classes and characteristics were also generated. The reliability of the maps was assessed through an accuracy assessment statistics. The maps and resultant statistics were thus subjected to analysis and used to discuss the role that geospatial technology plays in a nation's development.

3.0 Results and Discussion

The result from the accuracy assessment performed on both 2010 (Table 1) and 2016 (Table 2) land use maps, showed that the accuracy of the assessment was 87.73%; and kappa values, the measure of precision were 0.832 and 0.852 respectively, thus judging them to be of high accuracy and precision, and hence good for analysis.

Table 1:Accuracy Assessment Table for the year 2010

ACCURACY ASSESSMENT FOR 2010 LANDUSE MAP

Land Use	COM	INST	EDU	IND	OP	ORG	RECR	RES	Classification Overall	Producer Accuracy
Commercial	20		2	2	1	-	-	4	29	68.97
Community & P	-	10	-	-	-	-	-	2	12	83.33
Educational	-	1	24	-	-	-	-	2	27	88.89
Industrial	-	-	-	6	-	-	-	4	10	60.00
Open	-	-	-	-	147	5	-	-	152	96.71
Organized OS	-	-	-	-	5	32	-	-	37	86.49
Recreational	-	-	-	-	-	-	5	-	5	100.00
Residential	4	2	2	-	10	-	-	85	103	82.52
Truth Overall	24	13	28	8	163	37	5	97	375	-
User Accuracy	83.33	76.82	85.71	75	90.18	86.49	100.00	87.63	80.51	-
Overall accuracy	**87.73**									
Kappa	**0.832**									

Table 2:Accuracy Assessment Table for the year 2016

ACCURACY ASSESSMENT FOR 2016 LANDUSE MAP

Land Use	COM	INST	EDU	IND	OP	ORG	RECR	RES	Classification Overall	Producer Accuracy
Commercial	35	1	1	3	-	-	-	10	50	70.00
Community & P	-	21	2	-	-	-	-	4	27	77.78
Educational	-	2	37	-	-	-	-	4	43	86.05
Industrial	-	-	-	24	-	-	-	4	29	82.76
Open	-	-	-	-	70	-	4	-	74	94.60
Organized OS	-	-	-	-	5	38	-	-	43	88.37
Recreational	-	-	-	-	-	-	9	-	9	100.00
Residential	5	-	-	-	75	-	-	95	100	95.00
Truth Overall	40	24	40	27	163	38	13	118	375	-
User Accuracy	87.50	87.50	92.50	88.80	91.89	93.33	100.00	69.23	80.51	-
Overall accuracy	**87.73**									
Kappa	**0.852**									

Figures 1a and 1b show the land use maps of the study area for the two years while table 3 shows the land use area statistics. The land use maps and the land use area statistics table is a reflection of the transformations in the study area between the study year 2010 and 2016.

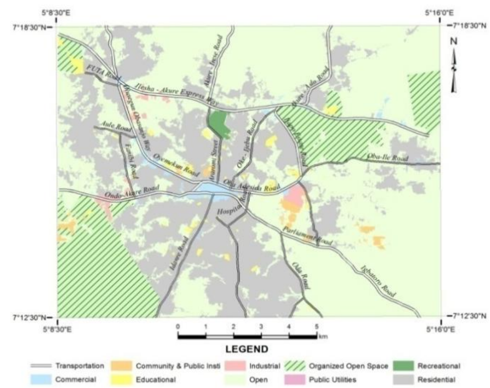

Figure 1a: 2010 Landuse Map

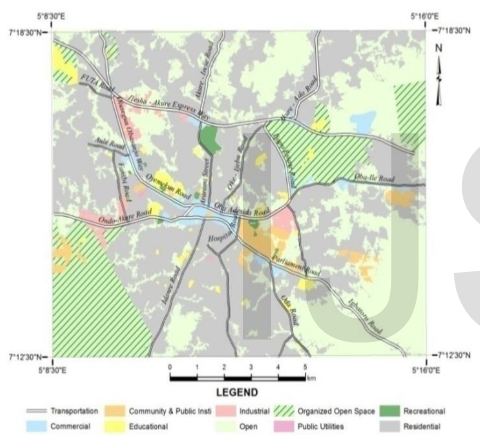

Figure 1b: 2016 Landuse Map

Table 3: 2010 and 2016Landuse area statistics

Land Use	2010		2016	
	T_a (km^2)	T_a (%)	T_a (km^2)	T_a (%)
Commercial	2.33	1.16	3.86	1.92
Community & PI	1.33	0.61	3.83	1.91
Educational	1.99	0.99	2.94	1.46
Industrial	1.35	0.67	2.95	1.47
Open	113.87	56.46	71.90	35.80
Organised Open	29.56	14.72	29.25	14.56
Recreational	0.61	0.30	0.83	0.41
Residential	52.22	26.00	89.13	44.38
TOTAL	203.1	100.9	204.69	100.91

The maps revealed a bi-temporal dynamics in the land use classes between the two years. These dynamics are quantitatively interpreted in the land use statistics table 1. From the duo, it is observed that all the land-use classes experienced an increasing transformation (Figure 2a). Residential land use (all levels of housing) was observed to have the highest positive transformation of 18.38%.

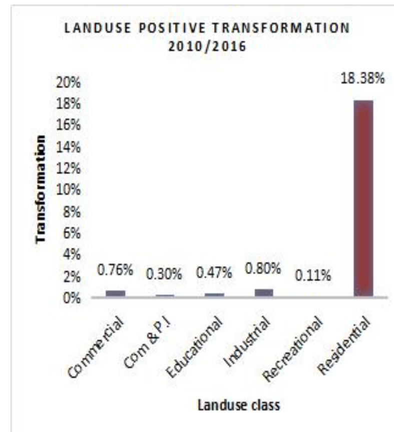

Figure 2a: Landuse Positive Transformation

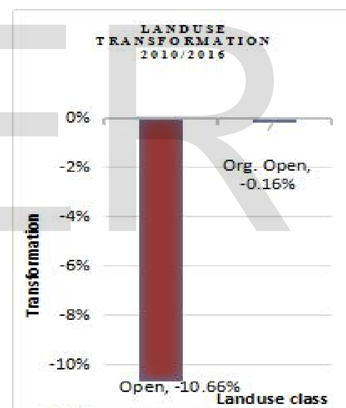

Figure 2b: Landuse Positive Transformation

Residential land use (all levels of housing) was observed to have the highest positive transformation of 18.38%. The open lands (undeveloped lands and vegetation, that is neither part of nor maintained by any organization, every un-urbanised areas) and the organised open lands (areas under acquisition but not yet utilized, undeveloped lands and vegetation that are part of and maintained by an organisation) experienced a decreasing transformation (Figure 2b) of 10.66% and 0.16% respectively.

3.1 Physical development in the study area within the study years

As observed by [13], [14], [9], [10] there was a great physical development in the study area between the year 2010 and year 2016 through the positive transformation in the built-up landcover. A physical observation made on the study area also confirmed the researcher's observation and further ascertained from the information provided in the land use maps (Figure 1a and 1b) and geospatial data generated (Table 3, Figures 2a and 2b).

Findings showed that from the core to the suburb of the study area, there was physical development resulting from the transformation of the land use classes. Examples are: the establishment of Akure shopping mall, the Dome event hall, Orange FM broadcasting station, Akure Stadium, Democracy Park, and AutoMart centre, NEPA and Isikan markets, Abattoirs, various Health centre like Mother and Child hospital; various Motor parks and Mega-Schools; various infrastructural development in all the higher institutions of learning Also, the dualisation of Arakale, Oba-Ile and Ondo roads; construction of Street Lights at Oyemekun road, to mention but a few.

The development has a resultant effect (as expected) on the open land use and the organised open land use classes. For instance, bushes were cleared for the construction of buildings and other infrastructures in the study area. This inter- and intra- land use transformations is the indicator of the development in the study area which is a prototype of national development.

3.1 The role of geospatial technology in national development

The capacity of a country to raise the standard of living of its residence by providing individuals with basic livelihood requirements is national development [2]. This is indexed through: development of rural areas, increasing agricultural outputs, enlargement of economic knowledge, growth in urban areas and poverty eradication. Acquisition, transformation, presentation and proper management of geospatial data is the designate of geospatial technology, mapping is most times the process and maps are the end product. Maps reveal the geographic position, location and spatial relationship of earth features. These revelations are assets for decision and policy making, and national planning. Geoinformation and earth observation data and information are the tools for planners, policy makers, engineers, scientists, technologist etc. for the processes of national development such as decision support system, expert system, web-Geographic Information System and ontology as observed by [3], [7], [6]. Urban Satellite Remote Sensing used in mapping the land use of Akure has made geoinformation and earth observation data available for the development of an integral part of the nation Nigeria [10]. The land use maps generated from the study is a tool to assist planners, the government, individuals and various organization in the understanding of the nature, pattern and trend of the land use for quality decisions [1]. The analysis provided is an eye-opener and 'a catalyst' for investors, land users and speculators and all land-use stakeholders. The spatiotemporal dynamics of the urban environment revealed in the research is a material for environmental impact assessment (EIA), urban land use change detection, climate change studies. It will help in the full-growth and expansion of industries, agriculture, education, social, religious and cultural institutions. All these enables the nation provide basic livelihood requirements to raise the standard of living of its residence which will be evidenced in the development of rural areas, increased agricultural outputs, enlargement of economic knowledge, growth in urban areas and poverty eradication.

Conclusion

The research has revealed mapping as an invaluable tool through which geospatial technology can enhance national development. Maps and geospatial data produced through the mapping are tools in the hand of decision and policy makers in all ramifications and at all levels of national development. The assertion that geospatial technology is the bedrock of all meaningful and sustainable development has been shown in the research. The use of Remote Sensing technology and the tools of Geographical Information System in effective mapping of the study area's urban dynamics provided a strong reason that there can be no sustainable national development in the absence of proper mapping, and that the enhancement of national development is made easy through geospatial technology techniques. Through the urban satellite mapping conducted in the study area, it was revealed that the transformation of the land use classes observed were the indicators of the development. The maps and numerical data generated assisted in the interpretation and proper insightful analysis of these transformations from the perspectives of national development. This helped to x-ray the role of geospatial technology in national development.

5.0 Recommendation

[2] observed the matter of national development to be one that concerns and affects the totality of the nation and the people in it as a whole; including'full-growth and expansion of industries, agriculture, education, social, religious and cultural institutions'. [8] affirmed that achieving a national development begins from an understanding and proper management of the geospatial data and information of the nation, which is the basis of sound planning, decision and policy

making, and the sustenance of developmental processes. Therefore the designate of geospatial technology is germane at every phase of all development of a nation. Map revision and update; and spatiotemporal change detection are important geospatial technology tasks that ensure a continuous intimation with the geospatial data and information of the nation, without which the process of national development can slow down or halt. It is thus recommended that placement of geospatial technology is a must before, during and after any developmental processes of any nation for sustainable development. Regular revision (say every 5 years) of national maps should be performed to ensure that master plans of cities as well as other developmental plans are being followed.

References

[1]McCoy, R.M. (2005): Field Methods In Remote Sensing. The Guilford, New York

[2]Bhawna B. (2018): National Development: Meaning and Problems.YOURARTICLELIBRARY. www.yourarticlelibrary.com/society/national-development-meaning-and-problems/76824. Retrieved on 20th January 2018

[3]Gottfried K. (2003): Geoinformation Remote Sensing, Photogrammetry and Geographic Information Systems. Taylor & Francis, New York.

[4]Briassoullis H. (1999): Analysis of Land Use Change: Theoretical andModelling Approaches – The Web Book of Regional Science, Regional Research Institute, West Virginia University, USA.

[5] eCognition Developer 64 Version 9. Trimble Inc. http://www.ecognition.com/

[6]Ghilani, C.D., Wolf, P.R. (2013): Elementary geospatial technology: An Introduction To Geomatics. (13th ed.). Pearson Education, New Jersey.

[7]Gomarasca,M.A. (2009): Basics of Geomatics. DOI 10.1007/978-1-4020-9014-1_1, 1C. Springer Science+Business Media B.V. 2009

[8]Harold, M., Scepan, J., Müller, A., Günther, S. (2002): Object-oriented mapping and analysis of urban land use/cover using IKONOS data. Proceedings of 22ndEARSEL Symposium "*Geoinformation for European-wide integration*", Prague, June 2002

[9]Ogunlade, S. & Enisan, G. (2016): Mapping and Analysis of Urban Land Use and Land Cover in Akure, Nigeria. In Ebohon, O.J., Ayeni, D. A, Egbu, C. O, and Omole, F. K. Procs. of the Joint International Conference (JIC) on 21st Century Human Habitat: Issues, Sustainability and Development, 21-24 March 2016, Akure, Nigeria, page number 965-971

[10]Ogunlade, S.O (2018): Mapping and Analysis of Spatio-temporal Landuse Dynamics of Akure and Environs, Ondo State Nigeria. Dissertation, Nnamdi Azikiwe University Awka, Anambra State, Nigeria

[11]Oyinloye, M.A. (2010): Spatial Analysis of Urban Growth in Akure, Nigeria. Desertation, Federal University of Technology Akure, Ondo State, Nigeria.

[12]Oyinloye, M.A. (2013) Geospatial Analysis of Urban Growth – The case of Akure, Nigeria. *American Journal of Social Issues and Humanities*, *3*(4):200-212

[13]Oyinloye, M. A., Kufoniyi, O. (2011) Analysis of Landuse, Landcover Change and Urban Expansion in Akure, Nigeria. *Journal of Innovative Research in Engineering and Sciences 2*(4). ISSN: 2141-8225. Retrieved from http://www.grpjournal.org. on September 2017

[14]Owoeye, J.O., Ibitoye, O.A. (2016) Analysis of Akure Urban Landuse Change Detection from Remote Imagery Perspective. *Urban Studies Research. Article ID:4673019:1-9*; Hindawi Publishing Corporation.

[15]Xiaoxiao, L., Guofan, S. (2014) Object-Based Land-Cover Mapping with High-Resolution Aerial Photography at a County Scale in the Midwestern USA. Remote Sensing ISSN 2072-4292. Remote Sens. 2014, 6,

1137211390; DOI:10.3390/rs61111372.