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Monitoring of Land Use/Land Cover Changes Using Remote Sensing Satellite Imageries in Dutse Urban Area, Jigawa State, Nigeria

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Abstract

The study examined land use/cover changes in the Dutse urban area, Jigawa State, Nigeria using remote sensing satellite imageries derived from Landsat satellite data. Different image processing techniques for analysing the images were utilised to detect land use/land cover changes in the period of study. The maximum likelihood classifier was used for the extraction of LULC classes over different periods of study. A land change modeler (LCM) was applied to detect the extent and magnitude of the land area of each class. The results revealed approximately 77.63 km^2 of built-up land during 1998, which increased to 120.30 km^2 in 2020; the rock outcrops area decreased from 85.48 km^2 in 1998 to 81.96 km^2 in 2020, the cultivable and uncultivable lands diminished from 334.83 km^2 to 295.68km^2 during 2020. A transition probability matrix results showed the area extent of rock outcrop, while presumptively, cultivable, and uncultivable land areaswould be taken over by built-up area with about 19.70% and 28.13% respectively. The built-up land has a probability as high as 52.18% to remain as built-up land in 2020. Landsat data provides desirable information regarding land use and land cover patterns of changes essentially useful to stakeholders, town planners, and other related fields concerning the spatial growth and expansion of urban areas.

Keywords: Landsat; urban; LULC; modeler; spatial, stakeholders

1. Introduction

Land cover is the layer of soil and biomass, including natural vegetation, crops, and human structures that cover the land surface. Land use refers to the purposes for which humans exploit the land cover (Fresco, 1994, as cited in Verburg, 2000). Land use refers to how humans and their habitat usethe land generally with an accentuation on the functional part of the land for viable economic activities (Rawat, 2015).

The continual nature of human activities, natural conditions, and development activities on earth aided in land use/land cover changes. Land use/cover changes are the major determinants of changes in our natural environment (Verburg et al., 2000). The changes give rise to deforestation, biodiversity loss, global warming, and an increase in the rate of flooding (Selçuk, 2008). Again, Riebsame et al., (1994), stressed, "Land use patterns, driven by a variety of social causes, affect land cover changes that affect biodiversity, water and radiation budgets, trace gas emissions and other processes that, cumulatively, affect global climate and biosphere." In light of this, land use/cover change discovery is very essential for a better understanding of landscape dynamics. Understanding terrain patterns, changes, and interactions that exist between human activities and natural phenomena is essentially very valuable to have proper planning and application of natural resources, their management, and decision-making enhancement (Mallupattu & Sreenivasula Reddy, 2013).

Studies have shown that land use and land cover change (LULC) with its impact on the surroundings is one of the growing focuses of global changes. In determining these global land use/cover changes, the application of satellite remote sensing imageries has proven a very veritably useful tool to derive accurate and timely information on the spatial distribution of land use/land cover changes over large and lower areas.

More importantly, the application of remote sensing and geographical information systems (GIS) in mapping land use/cover changes provides a useful and detailed way to improve the selection of areas designed for agricultural, urban, and industrial areas of a region (Selçuk et al., 2003, as cited in Rawat, 2015). It was also been confirmed that the application of remotely sensed and GIS techniques in the detection of land use/cover changes reduces time consumption, is cost-effective, and with better accuracy. "Studies conducted by Aldossary (2012), the paper demonstrates the use of remote sensing data to study urban expansion in Dubai and Las Vegas from 1984 to 2010 using Landsat images." The results showed a very detailed occurrence of changes in agricultural, urban, pasturage and forestry areas in the region over the designated period of the study. Moreover, Ayuyo and Sweta (2014) applied Landsat images to evaluate land cover and use changes from 1973 to the year 2010 in the Mau Complex in Kenya. The results obtained on the trends, rates, and magnitude of land cover and land use changes in the Mau forest complex over time proved that had occurred and resulted in the reduction of forest cover.

The main objective of this study is to identify, delineate, and quantify different land use/cover changes in Dutse urban area, Jigawa State, Nigeria using remote sensing satellite imageries derived from Landsat satellite data. Nonetheless, no adequate documented research work on the study area whilst using a remote sensing approach to give up-to-date, comprehensive information about the status and rate of urbanization occurring in the urban area.

2. Methodology

2.1Study Area

The Dutse urban area is located between Latitude 11°39′ 23″N to 11° 44′ 16″N and Longitude 09° 19′ 23″E to 09° 22′ 27″E, the capital headquarters of the state. Lies in the north-central part of the state (Figure 1). The study area consists of extensive areas of agricultural land, residential, shelterbelt reserves, and commercial and industrial sites. Characterized by out-cropped isolated generally flat-topped rock hills formed from the pre-Cambrian igneous rocks formation. Elevations in the study area range from 457 to 508 m as generated using elevation data from

NASA's 90m resolution SRTM data (www.floodmap.net). The study area has a hot semi-arid climate type (BSh) with dry and wet seasons, the temperature typically varies from 9.44°C to 41.66°C all year round and with an annual rainfall that ranges between 750-1000 mm (Hamidu et al., 2016). The structural characterization of the vegetation in the study area consists of an open wood savanna type with a variety of scattered trees in coexistence with different kinds of grass species.On the onset of rain, the grasses appear to be green, fresh, and blooming. While in the dry season, the grass withers and dies, though some of the plant species' roots remain alive and lie dormant. The most common types of trees and plant species in the area include Azadirachta indica (Neem), Baobab, Dum palm, Date palm, Guiera senegalensis, and Piliostigma thonningiia as well as Ficus glumosa, Eragrostis tremula, Pennisetum purpureum (elephant grass) to mention out of many.

However, as an administrative seat of the state and local government headquarters, Dutse has witnessed a very rapid urban growth leading to a dense concentration of mass people in the urban area therein increased in developing the land for residential and other purposes. The population of the Local Government area as recorded in 2006 population count was 251,135 with a projection increase to about 335,600 in 2016 (NBS, 2011). This therefore has influenced the pattern of human activities regarding to agricultural, commercial, and the mode of transportation systems invariably affecting the land use patterns of the study area.

2.2 Image Acquisition and Processing

In this study, Landsat TM and Landsat ETM+ (path 188, row 052) were used. The satellite imageries derived for the study area were downloaded from the USGS Earth Explorer (Figure 2). The imageries were imported into IDRISI Selva software version (17.02) for processing and then interpreted for the extraction of land cover/land use maps. However, in an attempt to determine the accurate geographical location for each land use and land cover class embraced in the classification system as well as for the creation of training sites and signature making. The study uses a field survey method to get the environmental characteristics of the study area by applying a Global Positioning System (GPS)device. Moreover,for better classification results,the optimum combination of bands out of all possible 3-band combinations was selected which greatly assisted in the creation of false color composite images. The optimum combination of three bands in a satellite image is the one with the highest amount of information (spatial-analyst.net) andis most appropriate in distinguishing land cover/ use image class categorization.

However,for images with striping lines and unwanted shade that significantly reduce the accuracy result of classification, destriping of Landsat ETM+ images by filteringtechnique was applied that take care of the resulting image striping problems. This facilitatesthe derivationof good quality and striping-free images used in this study.

2.3 Image classification

Diverse land use/cover types on an image can be differentiated using some image classification algorithms by considering their spectral features (Muazu, 2019). Inlight of this, the study applied a supervised classification method todetermineall pixels in the digital images into different land use/cover classesof the study area. The maximumlikelihood algorithm as the most common supervised classification algorithm was employed using IDRISI Selva (17.02) working environment. The maximum likelihood algorithm (MLA) is one of the most popular supervised classification methods used with remote sensing image data (& Kumar (2015) on land use/cover detection changes. This method facilitates comparing two images or images independently hence producing spectral classification results from different data sets with different dates to detect changes. The identified and classified land use/cover types in the study area include (i) Built-up lands (ii) Rock Outcrops and (iii) Cultivable and Uncultivable lands.

2.4 Change Detection

In the conduct of observing changes over the period selected for this study that is from 1998 to 2020 (22 years). The imageries downloadedwere inGeotiff compactedraster format suitable for variedkindsof applications. Imported through Geotiff to Idrisi conversion module essentially to be compatible with unique characteristics of IDRISI raster format.

Moreover,false colour composite images were created from the combination of uncorrelated bands (4, 3, and 2) whichopened up a better image classification composition. The composed images were subjected to image classification which was then used for the detection of changes in the designated period. The classification of the images centers around three classes namely built-up lands, rock outcrops, and cultivable and uncultivable lands. This enhances a good spectral response that facilitates in the detection of land use/cover types in the study area (Figure 3).

The study utilises a land change modeler (LCM) that is, to uncover the change dynamics in each of the specified class categories within the period of study (1998 to 2020). The LCM allows for specifying the essential components associated with the land cover change analysis of the study area. In this regard, two land cover maps (classified image maps- 1998 and 2020) were used as the basis for understanding the nature of change in the study area. However, this facilitates the rapid assessment of change that contributes significantly to understanding the progression of gains and losses, net change, persistence, and spatial trend of changes both in maps and graphical illustrations of changes in the length of the specified period of the study. The Markovian module was also utilized for change prediction analysis. This gives out the probability and the expectation of changes to occur from each land cover type to each other land cover type over the specified number ofperiods.

3. Results and Discussion

The results obtained from the use of multi-temporal imagery data of Landsat TM and ETM+ reveal the dynamic changes occurring in the patterns of land use/cover in the study area. Results inferthat inthe specified period (1998-2020), the land use/cover classes were likely to turn into built-up areas. As evident from Figure (3), there has been a noticeable gain/increase in the built-up land area with associated losses/decrease in the area of rock outcrops, and cultivable and uncultivable land areas. Although an approximated 77.63 km^2 of land area was built-up lands during 1998, the area extent had increased to 120.30 km^2in 2020. Conversely, the area of rock outcrops (rocky hillocks) decreased from 85.48 km^2 in 1998 to 81.96 km^2in 2020. Similarly, the area of cultivable and uncultivable lands diminishedfrom 334.83 km^2 to 295.68 km^2in 2020.

The attributable factors perceived towards changes in land use and land cover were that of sectoral urban development programs initiated by the state, whichresulted in the expansion of the built-up land areas. Thus, being the administrative headquarters of the state, and the range of economic activities, have led to an increased density of populations in the urban area which therefore increases the pressure on demand for residential houses and administrative offices by the state, local government, and other parastatals. Similarly, this has led to the development or conversion more of cultivable and uncultivable lands in the outskirts of the urban area where population density is low and cheaper land. However, the conversion may affect the sustainability of cultivable land areas in the long term. Similarly, quarrying activities haveopened up accessible land for construction thatpromotes the rate of built-up land area.

In the context of determining the transitional probability area matrix of the variables used in the study area, the Markovian transition matrix was applied. The transition areas matrix is a text file that records the number of pixels that are expected to change from each land cover type to each other land cover type over the specified number of time units (Eastman, 2012). Row categories from Table (1) represent land use land cover classes in 1998, whereas column categories represent 2020 classes. From the observed trends (Table 1), there is a high probability of other classes transitioning into built-upareas, the area extent of rock outcrops (rocky hillocks), cultivable and uncultivable were likely to be taken over by the built-up area with about 19.70% and 28.13% respectively. The built-up land area has a probability as high as 52.18% to remain as built-up land in 2020, which signifies stability. Chances of the probability of change from built-up land areas to rock outcrops, cultivable and uncultivable land areas remain insignificantly very low with about 0.07% and 3.58% respectively.

The study also adopts the spatial trend of change simply to understand the systematic variations of the occurrence of changes over the given period of study. Figure 4revealed a cubic spatial trend of change, which represents gradual trends in the surface over the area illustrating the spatial trend pattern of change in land use/cover classes.The redder colours and higher numbers indicatethe intensity of changes, whilst the lower numbers, darker green to blue colours were indicating less intense changes. Thus, approximately along the southern edges running down to the centre and slightly away from the centre, there was a gradual pattern of change with increasing values. Revealing a gradual transition of cultivable and uncultivable land areas to built-up land areas. While moving down north, the reddish colour is slowing down indicating a low amount of changes from built-up lands. Along the southwestern part, lower numbers, darker green to blue colours were increasing towards the edges thus, indicating less amount of transition from rock outcrops to cultivable and uncultivable land areas. Meanwhile, this has proved the centrifugal growth and expansion of the Dutse urban area with an enormous conversion of more cultivable and uncultivable land into built-up lands.

The illustration given on the spatial trend of change (Figure 4) showsthat theconversion of cultivable and other land use patterns is perhaps a continual process,and attributableto the unprecedented growth of the human population and economic activities. These activities increase the demand for an expansion of the land area for residential and other dwelling activities.

3.1 Land Use Land Cover Change Prediction Analysis

The study utilises CA_MARKOV in IDRISI Selvafor land cover prediction over time from past changes. In its predictive procedure, it adds an element of spatial contiguity as well as knowledge of the likely spatial distribution of transitions to Markov chain analysis (Eastman, 2012). The prediction of LULC changes from 2020 to 2040 (20 years) in the study area was conducted. The prediction map revealed decreasing trends of land area for Rock outcrops of about 79.77 km^2, cultivable and uncultivable land areas of 273.73km^2, and an accelerated increase of land area to built-up lands of approximately 144.42 km^2. This, however, would provide a very sound knowledge for future and proper sustainable planning and management of potentially available resources.

4. Conclusion

The study has generated a wider perception and understanding of the potential importance of using Landsat data in obtaining desirable information about land use and land cover pattern of changes occurring over a specified period. Hence, there is a very impendingneed to utilised high-resolution imagery data for this kind of study because of their capability to detect the very minimal temporal amount of changes occurring on the surfaces. The adaptation of the land change modeler (LCM) in the study has greatly enhanced the quantitative view of the spatial expansion of built-up areas. Subsequently encroaching into other categories of land use and land cover classes in the span period of study. This has led to the decrease and disruptions of ecological land. It’s of paramount importance to accomplish diverse land use planning in the context of sustainable environmental and management planning that could explore more froma qualitative perspective perfecting very realistic possibilities. The projected land cover in the study area for approximately twenty years however, melted to develop an integrated approach that could place sufficient focus on incorporating human behaviour, political economics, and other social benefits by stakeholders, town planners, and other related fields that concern in the growth and expansion of urban areas.

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Conflict of Interest

The authors declare no conflict of interest in the conduct of this study.

REFERENCES

Aldossary, A. *Analysis of Urban Change Detection Techniques in Desert Cities Using Remote Sensing* (Master's thesis), California State University, Northridge,2012. http://scholarworks.csun.edu/handle/10211.2/1043

Ayuyo, I. O. and Sweta, L. Land Cover and Land Use Mapping and Change Detection of Mau Complex in Kenya Using Geospatial Technology. International Journal of Science and Research (IJSR), 3 (3), 767-778, 2014.

Eastman, J.R. IDRISI Guide to GIS and Image Processing Accessed in IDRISI Selva 17. Clark University, Worcester, 182-185, 2009.

Hamidu, H., Falalu, B.H., Abdullahi, I.M., Kwaya, M.Y. and Arabi, A.S. Groundwater Chemistry, Storage and Dynamics in Parts of Jigawa Central, Northwestern Nigeria. Bayero Journal of Pure and Applied Sciences, 10(1): 138-147, 2016.

https://www.floodmap.net/Elevation/ElevationMap/?gi=2344245(Accessed on 5/16/2023).

http://spatial-analyst.net/ILWIS/htm/ilwisapp/optimum_index_factor_functionality_algorithm. (Accessed on 02/02/2023).

Mallupattu, P.K. and Sreenivasula Reddy, J.R. Analysis of Land Use/Land Cover Changes Using Remote Sensing Data and GIS at an Urban Area, Tirupati, India.*The Scientific World Journal*, Article ID 268623, 1-6, 2013.
https://doi.org/10.1155/2013/268623

Muazu, A. *Soil Salinity Risk Assessment and Mapping in Jibia Irrigation Project Site, Katsina State, Nigeria, Using Remote Sensing Data* [Unpublished doctoral dissertation]. University of Bakht Alruda, Deweim, Sudan, 2019.

National Bureau of Statistics - Nigeria. 2006 Annual Collaborative Survey of Socio-Economic Activities in Nigeria. Final Statistical Report Volume I, 2011. Available at:
https://www.nigerianstat.gov.ng/nada/index.php/catalog/central/about

Rawat, J.S. and Kumar, M. Monitoring land use/cover change using remote sensing and GIS techniques: A case study of Hawalbagh block, district Almora, Uttarakhand, India. *The Egyptian Journal of Remote Sensing and Space Science*, 18 (1), 77-84, 2015. Retrieved from:
https://www.sciencedirect.com/science/article/pii/S1110982315000034

Riebsame, W.E., Meyer, W.B. & Turner, B.L. Modeling land use and cover as part of global environmental change. *Climatic Change* **28**, 45–64, 1994.
https://doi.org/10.1007/BF01094100.

Verburg, P.H., Y. Chen, W. Soepboer, A. Veldkamp. GIS-based modeling of Human-environment interactions for natural resource management: applications in Asia. In: 4th International Conference on Integrating GIS and Environmental Modeling(GIS/EM4): Problems, Prospects, and Research Needs. Banff, Alberta,Canada, pp1-13, 2000.

Verburg, P. H., de Groot, W. T. and Veldkamp, A. J. Methodology for Multi-Scale Land-Use Change Modelling: Concepts and Challenges. In Dolman, A. J. Verhagen, A. Rovers, C. A (Ed), Global Environmental Change and Land Use. Springer, 2003.

Figure 1: Satellite imagery of Dutse urban area extracted from Google Earth.

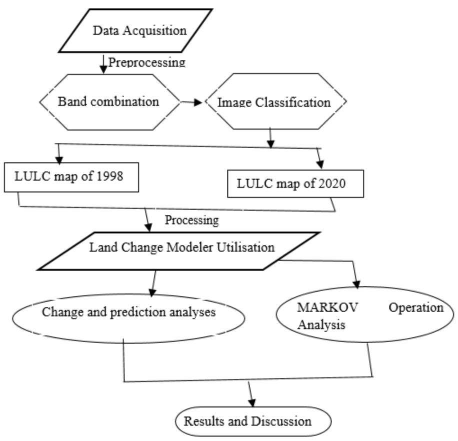

Figure 2. Flow chart illustrating the procedure taken to produce LULC maps of the study area

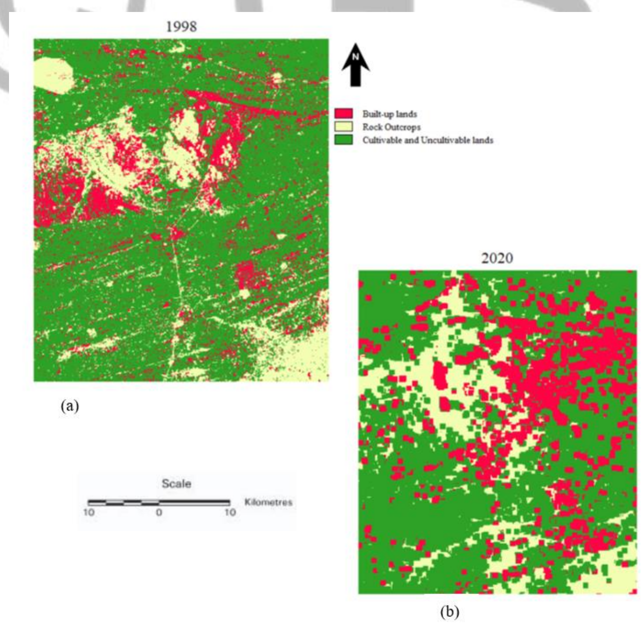

Figure 3. Land use/cover change and urban growth of Dutse Urban area: (a) 1998; (b) 2020

Table 1. Transition matrix of land use/land cover (LULC) of the study area

Classes	*Built-Up Lands*	*Rock Outcrops*	*Cultivable and Uncultivable Lands*
Built-up Lands	0.9222	0.0004	0.0774
Rock Outcrops	0.3481	0.5543	0.0976

Cultivable and Uncultivable Lands		0.0206	0.4822

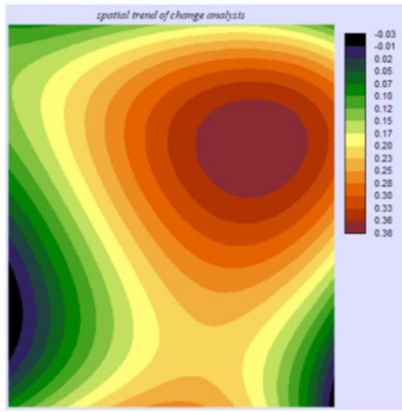

Figure 4. The cubic spatial trend of change analysis of the study area

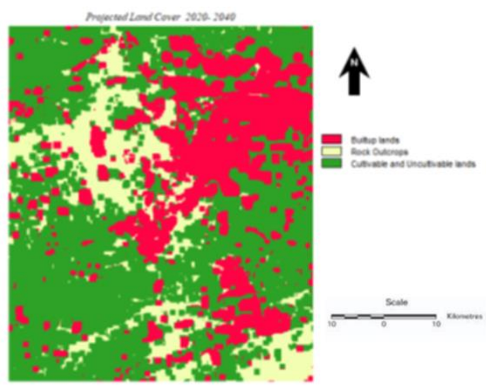

Figure 5. Land cover change prediction of the study area 2020-2040