FOREST ECOSYSTEM POTENTIALS IN NIGERIA: OPPORTUNITIES FOR GREEN ECONOMY IN THE 21ST CENTURY

EDITORS

B.O. AGBEJA, A. C. ADETOGUN, O.V. OYERINDE, J.A. OLUSOLA & O.S. OLANIRAN

Proceedings of The 3rd Commonwealth Forestry Association (CFA) Conference, Nigeria Chapter

Federal University of Technology Akure, Ondo State, Nigeria

2-3 December, 2020

Proudly Supported by the Federal University of Technology, Akure

Factors Influencing Spatio-Temporal Variation of Urban Green Space in Ado-Ekiti Metropolis

Alegbeleye. O. M. and Alo, A. A.

Department of Social and Environmental Forestry
University of Ibadan, Ibadan, Nigeria

**Correspondence: alegbeleyeokiki@gmail.com; akintundealodaniel@gmail.com*

Abstract

Geographic Information Systems (GIS) and Remote Sensing (RS) have proven to be an accurate means of determining Urban Green Space (UGS), extent and pattern of changes in land use land cover of a large area of land over time. However, there is dearth of information on spatial variation of UGS and its perceived factors in Ado-Ekiti. Therefore, this study adopted RS and GIS techniques to determine the factors responsible for the UGS changes in Ado-Ekiti metropolis. Map of Ado-Ekiti metropolis and Landsat imageries of 1987 (TM), 1998 (TM) and 2019 (OLI) were obtained. A set of 112 well-structured questionnaire was randomly administered to respondents in the study area. Map of Ado-Ekiti was georeferenced and digitized to obtain its shapefile. Landsat imageries were classified using the maximum likelihood algorithm of supervised classification in ArcGIS. The shapefile was superimposed on the classified imageries and clipped for determination of land use land cover sizes. The questionnaire were analyzed to determine the perceived factors responsible for the spatial variation in the UGS using logit regression model in STASTICA. Four land use land cover; Green spaces, Built-up area, water body and bare land, were identified in Ado-Ekiti metropolis. The UGS decreased from 76.1% in 1987 to 32.1% in 2019. In the same vein, water body reduced from 0.3% to 0.1% in 1987 to 2019 respectively. However, built up area and bare land increased from 20.3% and 7.5% to 54.6% and 13.2% in 1987 to 2019, respectively. Spatial and temporal variation in UGS was significantly influenced by population growth (103760.20 Odds-Ratio) and demand land for agriculture (15.53 Odds-Ratio) as represented with the equation FAUGS =-26.78+11.50(PG) - 20.20(Poverty) – 15.04(LLE) -12.59(DT) + 2.74(AGR). However, other factors, whose contributions were not significant include lack of law enforcement, demand for timber and poverty.

Keywords: Land use cover, urban green space, geographic information system (GIS), remote sensing (RS) and perceived factors,

INTRODUCTION

Urban greenspace is the publicly managed vegetative areas within an urban environment such as forested land, wilderness, street trees, parks, gardens, backyard gardens, geological formations, coastal areas and agricultural lands (McIntyre *et al*., 2000). There has been growing interest in green space research as it has a positive influence on human well-being and livelihood (Agbelade, *et al*., 2017). Urbanization is rapidly evolving throughout the world. It is an inevitable process that goes along with economic development and rapid population growth. According to UN, (2007), 70 percent of the global population will live in urban areas by 2050 as cities now house slightly more than half of the world's population. According to Rimal, (2011), when the residential and commercial land uses at the peripheral of metropolitan areas are converted to green environment, this is considered to be a sign of regional economic liveliness whose benefits are increasingly unbiased against ecosystem impacts. Urbanization processes in Ado-Ekiti metropolis is envolving and have generated some geomorphological impacts in the city. The increase in infrastructural development in this city has transformed the city and the land use pattern into a more vibrant urban settlement. The expansion of the city both demographically and spatially has

affected the plant biodiversity and the rapid population growths have impacted negatively on the plant conservation. The rate of these changes in green space is not well defined and documented which invariably will lead to poor urban green space management and environmental planning. Alo and Akindele (2011) reported that information in forestry sector was scares or where available, may not be up-to-date. Therefore, the status, extent and changes over time of UGS in Ado-Ekiti is not currently known. Although, previous study on land use land cover measurement in Ado-Ekiti metropolis focused on qualitative analysis, that is, changes in land use land cover changes in terms of spacing, increased pollution and waste generated (Oriye, 2013). However, there is limited information on the quantitative aspect of UGS in the study area. Therefore, this study aimed at determining the changes in the urban green space of the study area between 1987 and 2019 and the factors responsible for these changes.

METHODOLOGY

Study Area

Ado-Ekiti metropolis is located on latitudes 7° 35' and 7° 39' N of the Equator and Longitudes 5° 10' and 5° 19' E of the Greenwich Meridian. It is situated to the North of Ikere-Ekiti, West of Are-Ekiti and Afao-Ekiti, East of Iyin-Ekiti and Igede-Ekiti, and south of Iworoko-Ekiti (Figure 1). The low relief and gentle gradient characteristics of Ado-Ekiti favour agricultural and construction activities and make much of the metropolis susceptible to erosion and flood hazards during the rainy season (Awosusi and Jegede, 2013). Ado-Ekiti has a plan metric area of about 884km^2. Geologically, the region lies entirely within the pre-Cambrian basement complex rock group, which underlies much of Ekiti State (Awosusi and Jegede 2013). The temperature of this area is almost uniform throughout the year, with very little deviation from the mean annual temperature of 27°C. February and March are the hottest 28°C and 29° C respectively, while June with a temperature of 25°C is the coolest (Adebayo, 1993; Nwatu, 2018). The mean annual total rainfall is 1367 mm with a low co-efficient variation of about 10%. Rainfall is highly seasonal with well-marked wet and dry season. The wet season is between April to October, with a break in August.

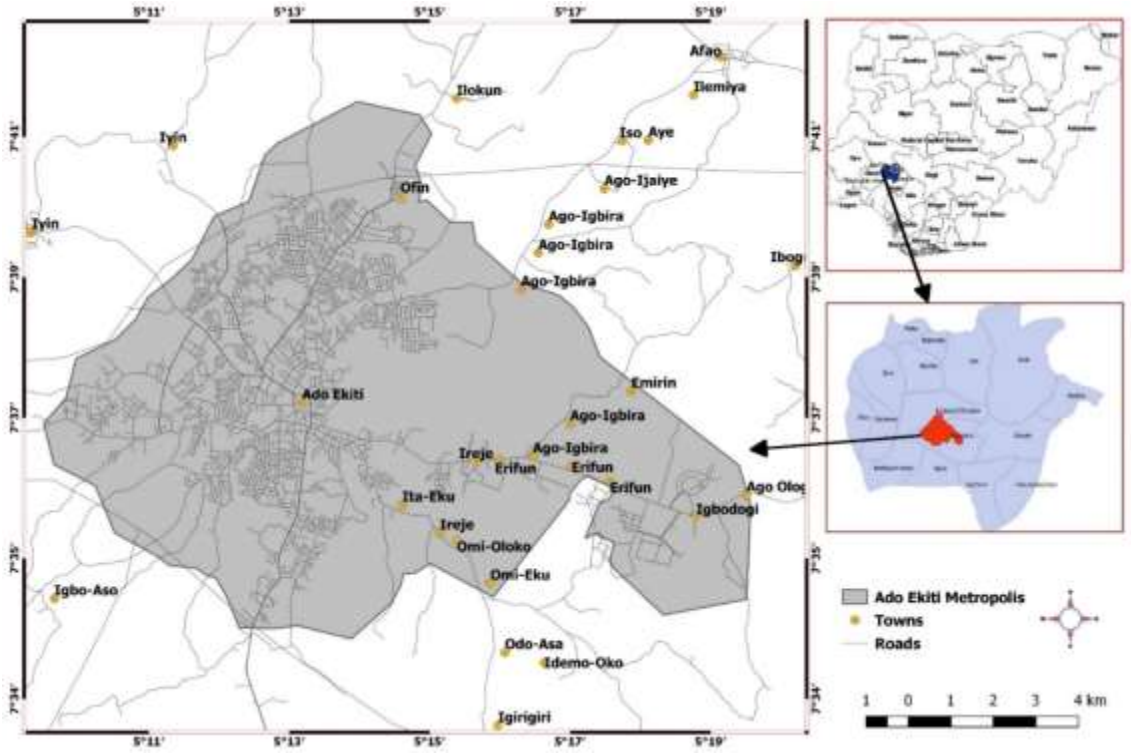

Figure 1: Ado-Ekiti metropolis

Source: Adapted from Abegunde et al., (2018)

Data Collection

Image acquisition and classification

Landsat imagery data were downloaded from USGS Earth Explorer. The Thematic Mapper (TM) imagery of 1984, 1998 and Operational Land Imager (OLI) imagery of 2019 were downloaded. The spatial resolution of landsat imageries is 30 m. They were used for image classification. Vector data used includes the shapefile of Ado-Ekiti metropolis, which was digitized. This study utilized Maximum Likelihood Classification Algorithm for the classification. The supervised classification method using the Maximum-Likelihood Classification (MLC) was used to classify the imageries into two land cover categories; Forested and Non-Forested (Built-up, Water and Bare surface) classes. Visualization and change detection maps were done using ArcGIS software.

Table 1. Satellite data

Satellite id	Year	Sensor id	Path/row	Spatial resolution
Landsat 5	1987, 1998	TM	190/55	30 m
Landsat 8	2019	OLI/TIRS	190/55	30 m

Table 2: Adopted modified version of the Anderson scheme of land use/cover classification.

LULC Categories	Description
Built-up area	Residential, commercial and services, transportation, communications, and utilities, industrial and commercial areas
Vegetation	Cropland, orchards, vineyards, nurseries, and confined feeding operations, plantation and mixed forest
Bare land	Sandy areas, barely exposed rock, transitional area and open land
Waterbody	Streams, lakes, and reservoirs

Source: Monica Cavinaw Geography, (2007)

Change Detection Analysis

It involved the comparison of independently classified images of different intervals. It aided in identifying the rate of change in percentage that has occurred within the selected years. To achieve this, the area in hectares and the percentage of each year was determined. This was calculated using the following equations:

$$\%\Delta \text{ in year} = \frac{Y_2 - Y_1}{Y_1} \times 100 \quad \text{..... (eq. 1)}$$

$$\text{Average Rate of Change} = \frac{Y_2 - Y_1}{T_2 - T_1} \quad \text{..... (eq. 2)}$$

$$\%\text{Average Rate of Change} = \frac{\text{Average Rate of Change } \left(\frac{\text{ha}}{\text{yr}}\right)}{\text{Years Difference}} \times 100 \quad \text{..... (eq. 3)}$$

Where: $Y_2 - Y_1$ is the observed change; $T_2 - T_1$ is the difference between the final period and the initial period; Y_2 is the ending year; Y_1 is the starting year

Accuracy assessment

To determine the level of error in the classification, an accuracy assessment was carried out. This involves comparing the classified and actual reference unit, an error matrix table was formed. According to Olofsson *et al.,* (2013), the matrix reveals errors of commission and omission. The User accuracy (Ua) and Producer accuracy (Pa) and overall statistics were calculated. To determine the accuracy of image classification, kappa statistics was used. It measures the agreement between the reality and the model predictions or to know if the error matrix values represent a result significantly better than random (Jensen 1996, Congalton 1991). It was computed using equation4.

$$k = \frac{N \sum_{i=I}^{r} x_{ii} \sum_{i=I}^{r} x_{ii} (x_{i+} x_{+i})}{N^2 - \sum_{i=I}^{R} (x_{i+} x_{+i})} \quad \text{..... (eqn.4)}$$

where N = total number of sites in the matrix; R = number of rows in the matrix; x_i = number in row i and column i; x_{+i} = total for row i; x_{i+} = total for column i; x_{ii} = total number in row i column i

UGS Perceived Factors

A total of 112 structured questionnaire was administered using simple randomization within the locals in the metropolis. These comprised 56 questionnaire each for households and the government officials in Ministries of Land and Housing Planning, Environment and Forestry. This was done to capture the views of both the elites that might be well informed with data and residence that might know the history of the metropolis. The retrieved questionnaire was coded and analyzed using Logit regression model in STATISTICA to determine the perceived factors that contributed significantly to the spatio-temporal variation in UGS in Ado-Ekiti metropolis.

RESULTS AND DISCUSSION

Table 3 showed the land cover classified in the study area from 1984 to 2019. There was a significant loss in UGS in Ado-Ekiti from 76.1% in 1987 to 32.1% in 2019. This loss in UGS is gained by built-up area and bareland, which consequently increased from 20.3% and 7.5% in 1987 to 54.6% and 13.2% in 2019 respectively. The percentage change in the UGS in Ado Ekiti metropolis between 1998 (64.4%) and 2019 (32.1%) was more than changes recorded between 1987 (76.1%) and 1998 (64.4%). The high percentage change recorded between 1998 and 2019 could be as a result of the creation of Ekiti State in 1996 from the old Ondo State. As a result, there was rural-urban drift to Ado-Ekiti as the capital of Ekiti State, thereby increasing the social infrastructures and amenities in Ado-Ekiti. Therefore, increase in population growth within the metropolis led to increase in demand for land, for infrastructural developments and other human related activities which had effect on the green spaces in the study area. This is in line with the findings of Agboola (2019), that a considerable change in the pattern and process of land use in Ado-Ekiti metropolis had effect on it land cover. This is also corroborated by Kong and Nakagoshi (2005) and Anqi and Edwin (2019) that UGS reduction was influenced by urban sprawl, which also increase the population and consequently increased the built up area. In a similar finding, Alo and Aturamu (2014) argued that increase in infrastructure and population significantly reduces forestland. Our result indicated drastic reduction in UGS which is a threat to biodiversity conservation, increase in land surface temperature of the city and harsh climatic conditions.

Table 3: Land Cover Classification (1987, 1998 and 2019)

	1987		1998		2019	
Classes	Area (km²)	Area (%)	Area (km²)	Area (%)	Area (km²)	Area (%)
Green Spaces	89.7	76.1	75.8	64.4	37.8	32.1
Built-Up	20.3	17.2	34.8	29.5	64.3	54.6
Bare Soil	7.5	6.4	7.1	6.0	15.6	13.2
Water Body	0.3	0.3	0.1	0.1	0.1	0.1
Total	117.8	100	117.8	100	117.8	100

Land Use Land Cover Trend

Figure 2 showed the trend in the changes in the land use land cover of Ado-Ekiti metropolis between 1987 and 2019. It showed the rate at which each land cover changes over the years and the changes in the land cover for each year considered (Figure 3-5). Area covered by built up area increased from 1984 through 1998 to 2019. The changes in the land use is related to the discovery of Agboola (2019) that both in population size and spatial coverage, Ado-Ekiti has experienced continuous and unprecedented growth. And this can be attributed to factors such as rural-urban migration, residential development, economic growth and pattern of transportation routes.

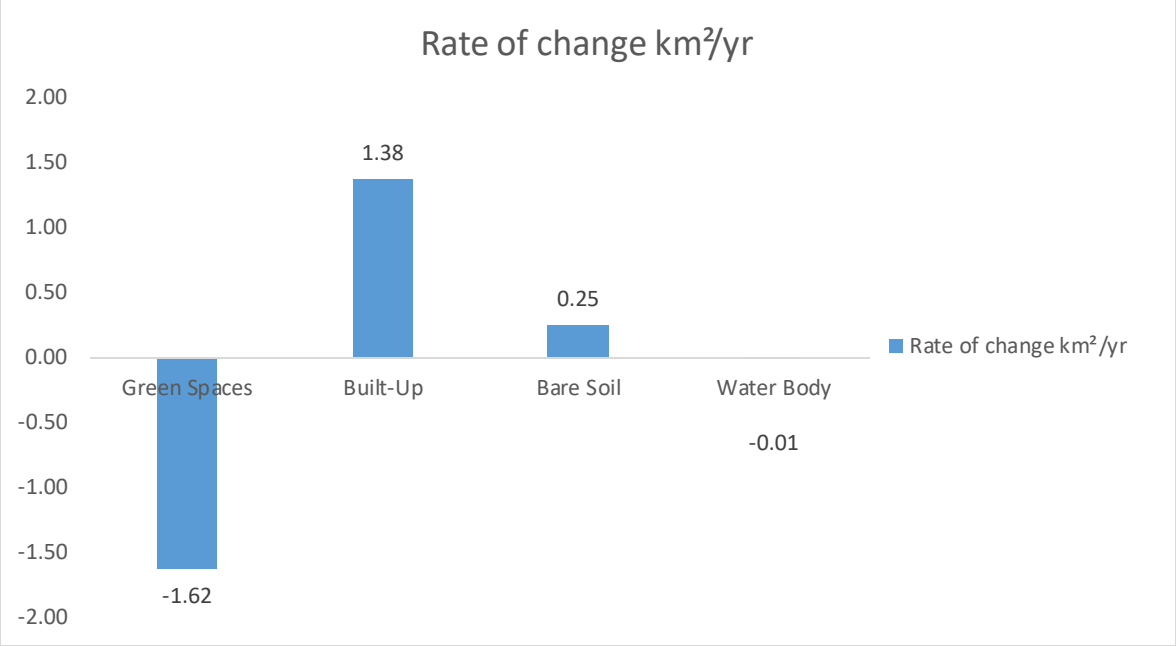

Figure 2. Land Cover trend between 1987 and 2019

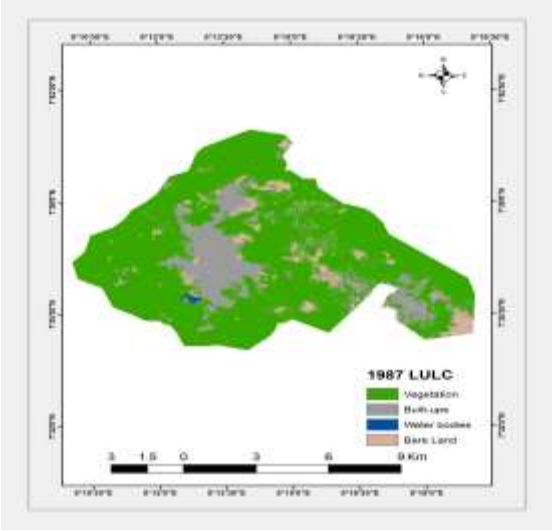

Figure 3: 2019 Land cover changes for year 1987

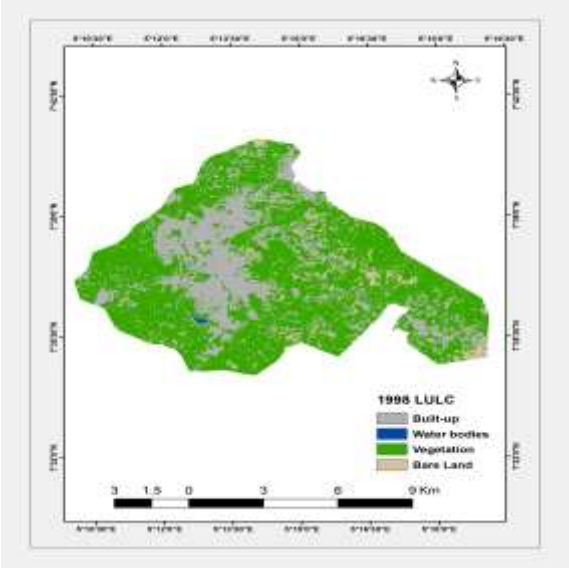

Figure 4: 2019 Land cover changes for year 1998

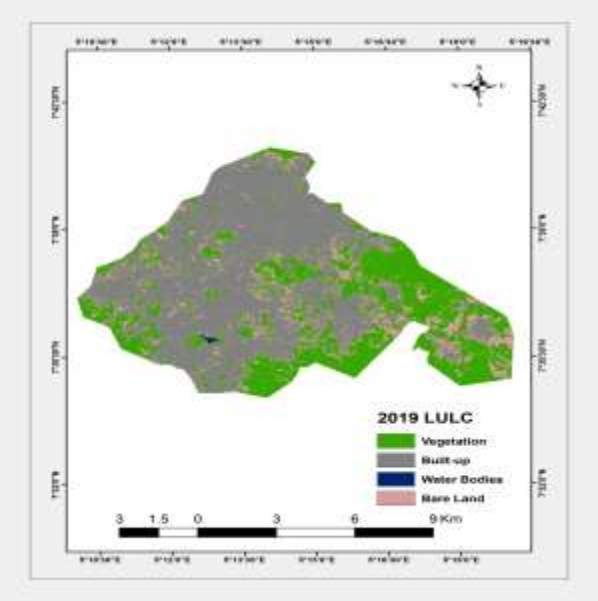

Figure 5: 2019 Land cover changes for year 2019

Image Accuracy Assessment

The accuracy assessment gives user's accuracy (Ua), producer's accuracy (Pa), Kappa statistics (k) and overall accuracy for the years considered for the land use land cover trend analysis. Table 4 indicates classification accuracy for user's accuracy (Ua), and that producer's accuracy (Pa) was greater than 50%. The kappa statistics that show the level of accuracy for 1987, 1998 and 2019 were 0.87, 0.79 and 0.85 respectively. The overall accuracy for 1987, 1998 and 2019 were 78.1%, 88.75% and 91.3% respectively.

Table 4: 1987, 1998 and 2019 Error matrix

LULC	1987	1998	2019
	Pa Ua	***Pa, Ua***	***Pa, Ua***
Green spaces	85, 77.3	81.8, 85	90.9, 100
Built-up	75, 88.2	100, 85	83.3, 100
Bare Surface	68.2, 75	88.9, 80	93.3, 70
Water body	85, 73.9	87, 100	100, 95
Kappa statistics	0.87	0.79	0.85
Overall accuracy	78.1%	88.75%	91.3%

Factors Influencing Urban Green Space Dynamics

Table 6 shows the logit regression determine the most significant factor affecting urban green space dynamics. Population Growth had the highest (103760.20) odds-ratio. This was followed by agriculture (15.53), while Poverty, Lack of law enforcement and Demand for Timber had 0.00 odds-ratio. The model indicated that, Population growth contributed significantly to change in the UGS in the study area. This was followed by quest for agricultural for food production. However, the contributions of other factors were not significant to the saptio-temporal variation of UGS in Ado-Ekiti. The model is represented with equation (1).

FAUGS =-26.78+11.50(PG) - 20.20(Poverty) – 15.04(LLE) - 12.59(DT) + 2.74(AD)..... (equation 1)

n = 112, Final loss=1.90

Odds ratio (unit change): Constant (-26.7658); PG (103760.2); POVERTY (0.00); LLE (0.00); DT (0.00); AD (15.53).

Where FAUGS = Factors Affecting UGS

LLE = Lack of Law enforcement

PG = Population Growth;

DT = Demand for Timber;

AD: = Agricultural Demand

UGS: Urban Green Space

Table 5. Increase in Population

	Frequency	Percentage (%)
Increase in Population		
Yes	95	84.8
No	17	15.2
Total	**112**	**100.0**
Change in LULC		
Yes	98	87.5
No	14	12.5
Total	**112**	**100.0**

Table 6. Logistic binary nature of perceived factors that influenced urban green space dynamics

Dependent Variable (LULC): Perceived factors that influence UGS (Presence = 1; Absence = 0		
Independent Variables	**Coefficient**	**Odds-ratio**
Whether the presence of PG influence the change in UGS	11.50	103760.20*
Whether the presence of Poverty influence the change in UGS	-20.20	0.00
Whether the presence of LLE influence the change in UGS	-15.04	0.00
Whether the presence of DT influence the change in UGS	-12.59	0.00
Whether the presence of AD influence the change in UGS	2.74	15.53*
Model χ^2 (df = 6) = 2.68		

* = significant ns = Not significant

PG: Population Growth; LLE: Lack of Law enforcement; DT: Demand for Timber; AD: Agricultural Demand; UGS: Urban Green Space **χ^2 = Chi-sqaure**

Based on the model fitted to discover the most significant factors affecting the change in urban green space, out of the factors: poverty, population growth, lack of law enforcement and demand for timber and agriculture, increase in population due to rural-to-urban migration and increase in birth rate was the factor with highest level of significance followed by agricultural demand for food security. This implies that increase in a unit level of significance of these factors will have effect on the land use land cover of the study area.

CONCLUSION

There were variation in urban green space in Ado-Ekiti between 1984 and 2019 with a significant decrease over the years. However, the built up area and bareland have taken over the loss by urban green space. Two factors that

contributed significantly to the spatio-temporal variation in urban green space in the study area were population as a result of urban sprawl, and agricultural demand for food security.

REFERENCES

Abegunde, S., Bola, D. and Idowu, A. (2018). Assessment of Heavy Metals Distribution and Contamination in Atmospheric Dust from Major Roads in Ado-Ekiti, Ekiti State using Pollution Indices.

Agbelade, A. D., Onyekwelu, J. C. and Oyun, M. B. (2017). Tree Species Richness, Diversity, and Vegetation Index for Federal Capital Territory, Abuja, Nigeria. *International Journal of Forestry Research*. Pp. 12.

Agboola, Olugbenga. (2019). 11 Agboola The Spatio Temporal Pattern.

Alo, A. A. and Aturamu, (2014). Spatial Distribution of Colleges of Education and Effects on the Forest Ecosystem: A Case Study of College of Education Ikere, Nigeria. *International Journal of Research in Agricultural Sciences* Vol. 1. No. 6. 379-384.

Alo, A. A. and Akindele, S. O. (2011): Contribution of forestry towards the attainment of the millennium development goals in Nigeria. Forestry in the context of the Millennium Development Goals.

Anqi, W. and Edwin, C. (2019). Institutional factors affecting urban green space provision – from a local government revenue perspective. *Journal of Environmental Planning and Management*. Vol. 62, (13). Pp 2313-2329

Awosusi, O. O., and Jegede, A. O. (2013). Challenges of Sustainability and Urban Development: A Case of Ado-Ekiti, Ekiti State, Nigeria, *www.todayscience.org/ier I, Vol. 1, Issue 1, 2013*.

Congalton R. G (1991) A review of assessing the accuracy of classifications of remotely sensed data. Remote Sens Environ 37:35– 46. *https ://doi.org/10.1016/00344 257(91)90048 –B*

Jensen J. R. (1996). Introductory digital image processing: a remote sensing perspective, 3rd edn. Pearson Prentice Hall, Upper Saddle River

Kong, F. and Nakagoshi, N. (2005). Changes of Urban Green Spaces and Their Driving Forces: a Case Study of Jinan City, *China. J. Int. Dev. Cooperat*. 11.

McIntyre, N. E., Knowles-Yánez, K., & Hope, D. (2000). Urban ecology as an interdisciplinary field: Differences in the use of urban between the social and natural sciences. *Urban Ecosystems*, 4(1), 5– 24

Nwatu J. U., (2018). Spatial analysis of urban green space dynamics in Ibadan metropolis, Ibadan, Nigeria. M. Sc. Project in the Department of Social and Environmental Forestry, University of Ibadan, Nigeria. Pp86.

Olofsson P, Foody GM, Herold M, Stehman S, Woodcock CE, Wulder M (2013). Good practices for assessing accuracy and estimating area of land change. Remote Sens Environ. *https ://doi. org/10.1016/j.rse.2014.02.015*

Oriye, O (2013). Urban Expansion and Urban Land Use in Ado-Ekiti metropolis, Nigeria, Federal University of Technology, Akure, Nigeria. *American Journal of Research Communication*, 1(2);

Owolabi, J. T., (2016). Trend Analysis of Rainfall and Temperature, in Ado-Ekiti, Ekiti State, Nigeria. *IIARD International Journal of Geography and Environmental Management*. Vol. 2 No.2. PP 16-30.

Rimal B (2011). Application of Remote Sensing and GIS, Land Use/Land Cover Change in Kathmandu Metropolitan City, Nepal. *Journal Theor. Appl. Info. Tech.;* 23(2): 80-86.

UN, "World Urbanization Prospects (2007). The 2007 Revision", NY, United Nations, 2007, *http://esa.un.org/unup/*