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Analysis of Urban Landuse Pattern and Spatial Changes in Nsukka, Enugu State, South-Eastern Nigeria

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ABSTRACT

There have been noticeable changes in urban land use development in Enugu State, Nigeria. These changes have been prominent in core urban areas of Enugu and Nsukka among others. These changes did not just occur in isolation; there are factors influencing such changes. In this study, remote sensing and geographic information system (GIS) were used to examine urban land use land cover change in Nsukka, Enugu State for 1986, 2006 and 2016 to predict future changes that are likely to take place. The study shows Nsukka Urban as being compacted with built-up area with negative implications like overcrowding and encroachments on land uses, especially, open spaces meant for recreational activities. Similarly, landmass reserved for agriculture and recreation has been steadily infringed. Therefore, effort should be made to check the rate of deforestation or at least moderate the rate at which urban forestry is fast being deforested using buffers. Otherwise, there will be a dearth of urban forestry in the next 20years.

KEY WORDS: Land cover, Landsat imagery, land use development, classified images, urban expansion.
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INTRODUCTION

According to Ejemevowi (2015), land use refers to the way human beings employ and exploit land cover for several purposes like farming, mining, housing, logging, and recreation and so on. Therefore, land use change is the exploitation of land cover through its conversion and modification over time primarily to meet human needs. Land use/cover changes associated with urbanization are important drivers of local geological, physical, hydrological, ecological, and climatic change.

In the tropics, conversion of forest/vegetative cover into cropland, pasture and more especially into a settlement or physical structures has risen drastically during the last decade and this land use issues emerged in the research arena some decades ago following evidence that climate was under the influence of land surface processes (Gehendra-kharel, 2010). Humans have been using land and its resources for centuries in pursuit of better lives in line with their needs. The way humans have used land and exploited its resources over time is a serious problem (Sunday and Umar, 2013) as it has altered land, the land use pattern and impacted negatively in the functioning of the ecosystem.

Rapid population growth and its associated urbanization processes are the main factors of change in land use in this recent time, with Nsukka Local Government Area (L.G.A) not being an exception. This has made it obvious as human population increases geometrically or exponentially, while the resources available to support the population tend to grow arithmetically (Ouedraogo et al., 2015). However, with the scientific breakthrough in the area of agricultural production, industrial manufacturing products, birth control as well as improved medical care which evolved in the late 19th century, this has helped man to meet up with the need of the growing population (Ogbonna, 2016; Ejemevovwi, 2015).

To this end, detailed information on existing land use patterns and changes is important in assisting state and local government legislators, urban managers and

environmental planners in decision making (Innocent and Joel, 2013). To this extent, Geographic Information System (GIS) and Remote Sensing (RS) as an integrated modern technology is used to examine the extent of land use/cover change (spatiotemporal analysis) from 1986-2016. Therefore, governments and planning agencies should acknowledge these changes immediately and incorporate the result into land use planning and decision-making process effectively and promptly (Gehendra-kharel, 2010).

Land cover/land use pattern is the physical state of the land surface which includes both natural amenities like crop lands, mountains, vegetation, soil type, biodiversity, water resources and human-made structures such as buildings, pavements among others (Meyer, 1995). Change in land cover usually happens in two ways - land cover conversion and land cover modification (Lambin, 2006). Land cover conversion is a change in the overall classification of land cover through a complete replacement of one type of land cover with another type due to change in urban extent, agricultural expansion or deforestation. Land cover modification is also another form of land use change which simply means a change in the character of land cover resulting from anthropogenic factor without undergoing an overall classification (Koji et al.,2014).

There are several causes of land use change of which understanding them will make important factor in land use decision-making process. Researchers and scholars have identified proximate and underlying causes of land use change to understand the land use decision-making process. The proximate causes of land use change involve a direct and immediate physical action on land cover at the local level, such as individual farms, households, or communities (Tamba and Simbay, 2012).

The underlying causes of land use change are the fundamental forces that alter one or more proximate causes and operate at a regional or even global level. Some of the identified causes of land use change as identified by Innocent and Joel (2013), are technological, economic, political, institutional, demographic and cultural. These underlying causes are also the causes of urbanization which in turn is the driver of land use change in the study area. There has always been an increase in the settlement and agricultural areas as a consequence of increasing population as contained in other land use land cover analysis and literature.

Rapid population growth and poverty are believed to be the main factors of change in land use in Southern Burkina Faso and it has experienced a rapid population growth due to massive peasants' migration from the north and central regions of the Country, exacerbated by decreasing rainfall and arable land in the area of origin. The population also exhibited positive growth as a result of both natural increase and migration of farmers. Change in land cover types correlated with population growth, which in turn was driven mainly by population growth which has a side-effect on environmental conditions in the area. Thus, there is an urgent need for agricultural intensification-related policy initiatives to discourage expansion of cultivated lands and its associated fragmentation of forested areas.

Remote sensing and Geographic Information System (GIS) help integrate natural, cultural, social and economic information to create a spatial information system on the available terrain resources. Satellite data are used to assess the rate of change in Land use / Land cover between 1996 and 2015 and also examines the extent to which images and GIS software effectively contribute to mapping land use/cover in the Niger Delta region. Five distinct units were identified in the classification of land use/land cover pattern categories which are: Farmland, Build up land, Wasteland, Forest land and Waterbodies.

Over the years, Nsukka as a Local Government Area (LGA), has undergone a series of land use developments, and as a result, land use changes have taken place particularly in the urban areas. The resources and environment of Nsukka urban centres are increasingly generally depleted due to the pressure from urbanization.

Nsukka as a Local Government Area is rapidly developing resulting from the high population, which is exacerbated with trade and commerce in addition to the location of the University of Nigeria, Nsukka. These have brought about the high rate of anthropogenic activities as they are in a quest to satisfy their unlimited need. For these reasons, built-up areas together with its land use tend developing towards the urban hinterlands.

This study aims to examine the land use pattern of Nsukka Local Government Area using Geographic Information System (GIS) and Remote Sensing as a tool. To achieve this aim,the specific objectives include to: to quantify land use pattern for 1986, 2006 and 2016 and to establish the trend in land use change from 1986 to 2016.

METHODOLOGY

The Study Area

Nsukka L.G.A is one of the seventeen Local Government Areas in Enugu State of Nigeria. It has a total area of 495.87 km² and lies between latitudes $6^0$42'36.278"N and $7^0$1'20.819"N and longitude $7^0$10'27.79"E and $7^0$34'21.44"E. It equally shares boundaries with Igbo-Etiti L.G.A to the South, Uzo-Uwani L.G.A to the West, Udenu L.G.A to the East and Igboeze-North L.G.A to the North, all in Enugu State, (Figures 1-3).

Nsukka is currently experiencing a high rate of urbanization, most especially in the urban centers like Odenigbo, Oba – Nsukka, Alu – Udele, part of Obukpa where University of Nigeria, Nsukka is located, Onuiyi, Barracks and Ogige market and its surrounding. This particular act of urbanization has resulted in an ad-hoc

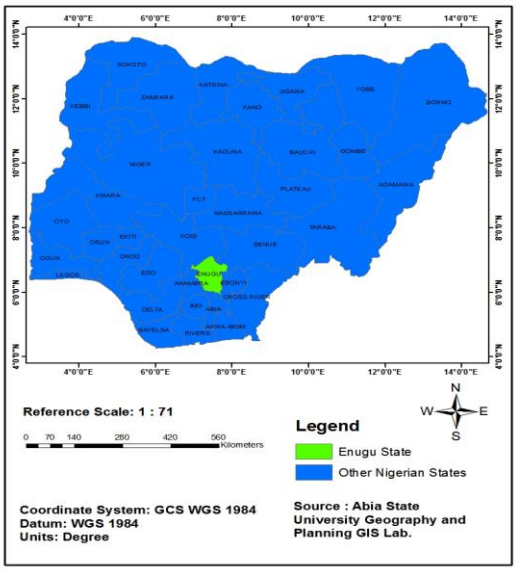

Figure 1. Location of of Enugu State, Nigeria.

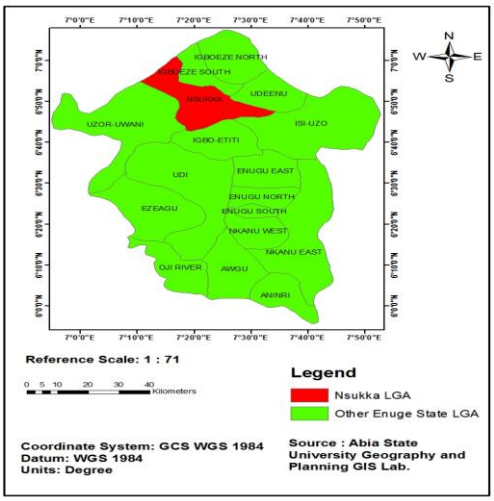

Figure 2. Location of Nsukka L.G.A., Enugu State.

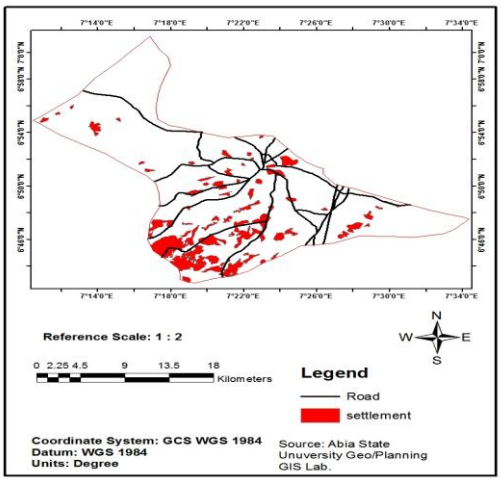

Figure 3: Map of Nsukka

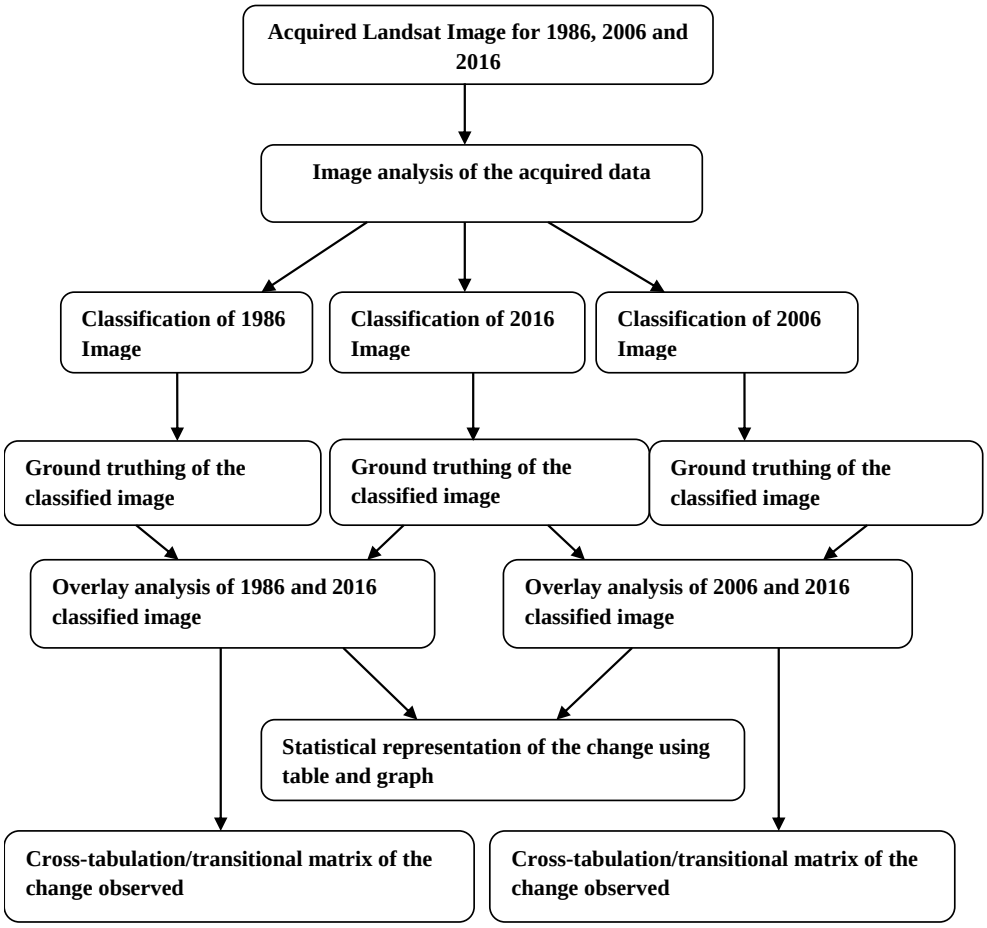

Figure 4: Land use/land cover change detection process.

engagement of men in different activities which has consequently given rise to different land use pattern in order to meet with the need of the growing population. The major challenges facing this area include traffic congestion, contiguous building, coupling with high population density, high rate of surface run-off, resulting in erosion as a result of paved surfaces which equally blocks the point of groundwater recharge.

Data Collection

The two Landsat 7 images of 1986 and 2006 and that of Landsat 8 of 2016 Enhance Thematic Mappar (ETM^{+}) on Path 188 and Row 055 were acquired during the same season to ensure uniform reflectance of geographic features in order to reduce error during image classification. Layer stacking of the different bands of the images of same spatial location was done using ERDA software; the images were geo-referenced using projected coordinate system (PCS), Universal Transverse Mercator (UTM) coordinate system, Datum World Geodetic surveyor (WGS) 1984; Northern hemisphere, Zone 32. This was done to ensure effective pixel to pixel registration between images which helps to represent the real world accurately and for efficient analysis during the overlay analysis. Re-sampling was done using the nearest neighbour algorithm to keep the original brightness values of image pixels unchanged using ArcGIS 10.1.

These images were classified into land use classes which are settlement, farmland, forest, bare surface using ArcGIS 10.1 software, which is dependent on the observable features. The unsupervised classification was carried out using an ISO-cluter algorithm to perform the classification on the images. Ground trothing (Figure 4) was carried out and google earth was also used for image verification. The unsupervised classification is used, instead of supervised classification, because it will effectively and accurately extract the data for effective analysis.

Data analysis

Morph-metric analysis technique, which involves space-time language and provides a work frame at which land use pattern can be examined; thus examining the land

Table 1: Areas of land use types for 1986.

Object ID	Identified land use pattern	Count (pixels)	Area Covered		
			Square meters (m^2)	Square kilometres (km^2)	Percentage (%)
1	Forest	151032	135928800	135.9288	27.412
2	Bare surface	196451	176805900	176.8059	35.655
3	Farm land	147454	132708600	132.7086	26.763
4	Settlement	56034	50430600	50.4306	10.170
	Total	550971	495873900	495.8739	100.000

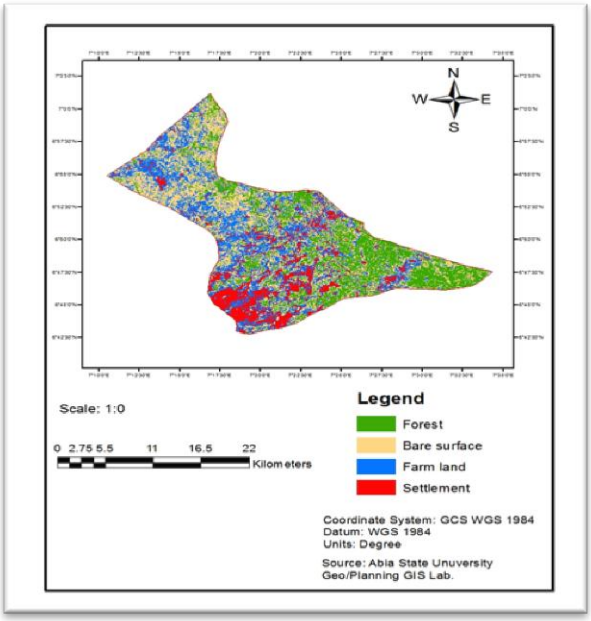

Figure 5: Classified Image of Nsukka, 1986.

use/cover changes that have occurred over a 30-year period in three epochs. A cross-tabulation matrix was used as a yardstick for the prediction of change if nothing is done to ameliorate human activities.

An overlay analysis was carried out to quantify the observable change and generate a cross-tabulation (transitional matrix) which denotes what has changed to what over time in the study area. The cross-tabulation (transitional matrix) which are used for the analysis contains codes, such as grid-code, the based identified geographic features from which the change takes place (in the form of t_o), gridcode_1, means the identified geographic to which the based identified geographic features changed to (in the form of t_1) and the numerical values like meaning forest, bare surface, farmland, and settlement. These are dependent on the number of identified geographic features.

The result of the land use/land cover change as was analyzed using the unsupervised classification method on ArcGIS 10.1, on the selected epochs of 1986, 2006 and 2016, identified land use patterns during their image classification are settlement, bare surface, farmland and forest, of which these selected periods make it a spatiotemporal analysis. This change involves loss or gain of the area covered by the identified geographic features within the given extent of the study area. Figure 4 revealed that there are both positive/gain and negative/loss of identified geographic features in the course of the analysis.

RESULT

The classified image of 1986 as contained in Table 1 and Figure 5 shows that 27.4% of the study area is covered by forest, 35.7% is covered by bare surface, 26.8% is covered by farmland and 10.2% is covered by settlement. Showing that bare surface covers the largest portion and with settlement covering the least portion.

Table 2 showed the classified image of 2006 (Figure 6) and indicates that 29.8% of the study area is covered by forest, 37.2%% is covered by bare surface, 21.5% is

Table 2: Areas of land use types for 2006.

Object ID	Identified land use pattern	Count (pixels)	Area Covered		
			Square meters (m^2)	Square kilometres (km^2)	Percentage (%)
1	Forest	164096	147686400	147.686	29.78
2	Bare surface	204933	184439700	184.440	37.19
3	Farm land	118610	106749000	106.749	21.53
4	Settlement	63332	56998800	56.999	11.49
	Grand total	550971	495873900	495.874	100.00

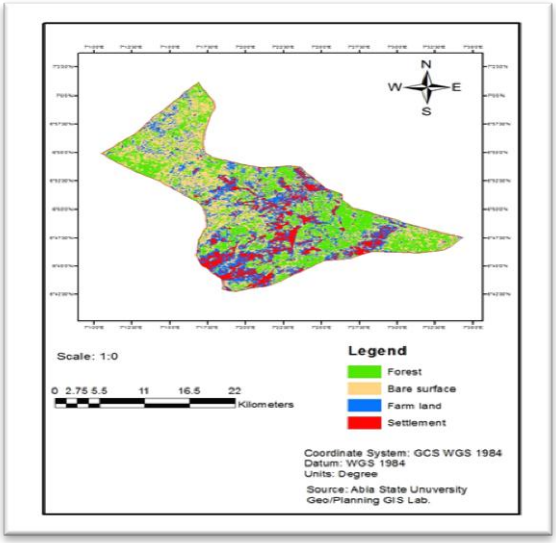

Figure 6: Classified image of Nsukka, 2006.

Table 3: Areas of land use types for 2016.

Object ID	Identified land use pattern	Count (pixels)	Area Covered		
			Square meters (m^2)	Square kilometres (km^2)	Percentage (%)
1	Forest	133267	119940300	119.940	24.188
2	Bare surface	185163	166646700	166.647	33.607
3	Farm land	161207	145086300	145.086	29.259
4	Settlement	71334	64200600	64.201	12.947
	Grand total	550971	495873900	495.874	100.000

covered by farmland and 11.5% is covered by settlement. This shows that forest and bare surface increased from 27.4% to 29.8% and 35.6% to 37.2%, farmland decrease from 26.8% to 21.5%,while settlement increased from 10.2% to 11.5% from 1986 to 2006.

Table 3 discloses the analysis of the classified image of 2016 (Figure 7), it interalia shows that 24.2% of the study area is covered by forest, 33.6% is covered by the bare surface, farmland covers 29.3% and 12.9% is covered by settlement. This shows that forest and bare surface decreased from 29.8% to 24.2% and 37.2% to 33.6% respectively, while farmland and settlement increased from 21.5% to 29.3% and 11.5% to 12.9% respectively from 2006 to 2016.

Table 4 reveals showed that from 1986 to 2016 periods, forest and bare surface decreased from 27.4% to 24.2% and 35.7% to 33.6%, respectively, while farmland and settlement increased from 26.8% to 29.3% and 10.2% to 12.9% respectively.

DISCUSSIONS

From the image classification analysis of 1986, forest

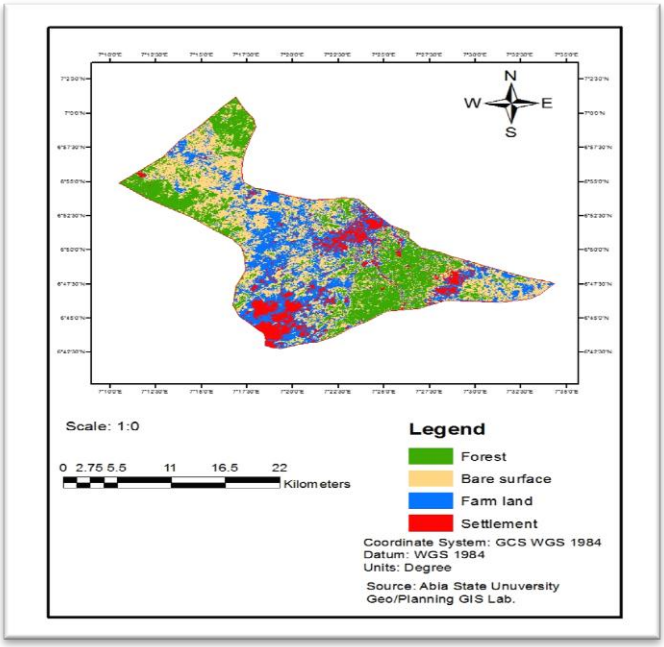

Figure 7: Classified Image of Nsukka, 2016.

Table 4: Area covered by land use patterns for 1986, 2006 and 2016.

		Area covered					
	Identified	1986		2006		2016	
Object ID	Land use Pattern	km^2	%	km^2	%	km^2	%
1	Forest	135.929	27.412	147.686	29.783	119.940	24.188
2	Bare surface	176.806	35.655	184.440	37.195	166.647	33.607
3	Farm land	132.709	26.763	106.749	21.527	145.086	29.259
4	Settlement	50.431	10.170	56.999	11.495	64.201	12.947
	Grand total	495.874	100.00	495.874	100.00	495.874	100.00

covers 135.9km^2, bare-surface covers 176.8km^2, farm-land covers 132.7km^2 and settlement covers 50.4km^2 of 4955.9km^2 of the study area. For the 2006 classified image, forest covers 147.7km^2, bare-surface covers 184.4km^2, farmland covers 106.7km^2 and settlement covers 57km^2 of 4955.9km^2 of the study area. For the image classification analysis of 2016, forest covers 119.9km^2, bare-surface covers 166.6km^2, farmland covers 145.1km^2 and settlement covers 64.2km^2 of 4955.9km^2 of the study area.

From the period of 1986 to 2006, it was observed that there is a loss of 25.96km^2 of the area covered by farmland, which is 5.24% of the total area covered by the study area. From 2006 to 2016, there is a loss of 27.75km^2 of area covered by forest and 17.79km^2 of the area covered by bare surface which account for 5.6% and 3.59% loss of the study area respectively, while from 1986 to 2016 which covers a period of 30 years, there is a loss of 15.99km^2 of area covered by forest and 10.16km^2 of area covered by bare surface which accounts for 3.22% and 2.05% of the total area covered by the study area respectively.

From 1986 to 2006, it was equally observed that there is a gain of 11.76km^2 of area covered by forest, which is 2.37% of the total area covered by the study area. In the area of bare surface, it gained an area of 7.63km^2,which is 1.54% of the study area. During this same period also, there is a gain of 6.568km^2 area of settlement which is 1.33% of the area covered by the study area. For the period of 2006 to 2016, there is a gain of 38.33km^2 of area covered by farmland and 7.2km^2 gain of the area covered by the settlement which account for 7.73% and 1.45% gain of the total area covered by the study area respectively, while from 1986 to 2016 which covers a period of 30 years, there is a gain of 12.38km^2 of area covered by bare surface and 13.77km^2 of area covered by settlement which accounts for 2.5% and 2.78% of the total area covered by the study area respectively.

From the analysis, it was discovered that there is rapid increase in urban built-up areas explained in buildings projects that resulted in a decrease in forest land, agricultural land and open space. This is attributed to the anthropogenic activities of farming, bush burning, grazing among others. This demonstrates that remote sensed

data and GIS-based approach is found to be timely and cost-effective than the conventional method of analysis, classification of land use pattern effective for planning and management (Ogonna and Mba, 2017).

There is a positive change in the area covered by the settlement. Statistical analysis of this study revealed that settlement formerly occupied a proportion of 10.17% in 1986 and increased to 11.5% and 12.95% in 2006 and 2016 respectively. This is a clear indication of increase in population and infrastructure development in the study area.

This increasing settlement alongside with population growth of the study area revealed by the Nigerian population census of 1991 and 2006 has it that the population of Nsukka L.G.A as well as that of the projected population for 2016 which are 220,411, 309,448 and 394,948 respectively, are in positive correlation with the increasing area of settlement which is 50.43km^2, 57km^2 and 64.2km^2 over the selected epochs respectively as well. With the high rate of economic, religious and educational activities, it has become more obvious that the increase in population has brought about an increase in settlement and other infrastructural development in Nsukka L.G.A. to meet up with the religious, economic and residential need of the people.

Bare surface from the study result recorded both positive and negative change over the epochs under study, as it covers 35.66% in 1986 but increased to 37.2% in 2006 and then decrease to 33.61% in 2016. This can be attributed to human activities, which include, overgrazing, indiscriminate bush burning, firewood extraction and most importantly as identified from the study area that part of Nsukka L.G.A, especially Edemani-Nsukka which are characterised by stony and rock-out-crop resulting to low vegetative cover. Although, it was observed that recent development showed that the roofing of houses was done with white aluminum roofing sheet which has a conflicting spectral signature with this class that serves as a major limitation during image classification.

The forest increases and decreases over the selected epochs in the study area. From the study result, in the year 1986, the total area covered by forest was 135.93km^2, in 1986 and 147.69km^2 in 2006, which shows an increase of 2.37% in the area covered by forest, but in the year 2016, the area covered by forest decreases to 119.94km^2 which shows a decrease of 5.6%. Farmland was also another area which shows a decrease and later on the increase in the area covered. In the year 1986, the total area covered by farmland was 132.71km^2, in 2006, it covers an area of 106.5km^2, which shows a decrease of 5.24% in the area covered by farmland but in the year 2016, the area covered by farmland then increased to 145.09km^2 which shows an increase of 7.73%.

This was due to settlement increase over the selected epochs, as a result of population growth and the quest for man to meet up with its need as well as the increasing demand from the population has led man to explore and exploit resources within his environment to meet up with this demand without concern of the effect of his anthropogenic action on the environment. This has resulted in the change of different land use pattern into other ones, most especially from forest and bare surface to settlement and farmland in recent time.

Conclusion and Recommendation

This study demonstrates the usefulness of satellite data for the preparation of accurate and up-to-date land-use/cover maps, depicting existing land classes for analysing their change pattern for Nsukka L.G.A., by utilizing digital image processing techniques. Result of classification clearly shows a constant positive increase in settlement, with a balanced fluctuation among farmland, forest and bare surface. The result of this study is expected to be useful for formulating meaningful plans and policies to achieve balanced and sustainable development in the study area.

It is on this note that we should employ the sustainable use of land in planning to meet with the need of the present generation without compromising the need of the future generation. If humans fail to live in harmony with nature, catastrophe is inevitable.

For effective development, the following recommendations are to be adopted.

1. Effort should be made to check the rate of deforestation or at least moderate the rate at which urban forestry is fast being depleted using buffers. Excessive lumbering activities and use of firewood for fuel should be highly regulated to achieve a healthy environment.

2.The government should make laws and policies that will prohibit the indiscriminate and non-conservative action of man to the environment in other to create a healthier and livable environment. Likewise, some of the agricultural practices should be ameliorated, like the slash and burn, continuous cropping, overgrazing among others.

3. Education and creation of public awareness will help greatly in understanding the effect of anthropogenic action and as such change their perception and manner towards the environment as this will bring a positive change in our behavior towards the environment.

4.The use of Remote Sensing and Geographic Information System for effective monitoring of changes in the environment for more pragmatic land use management

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