IOSR Journal Of Humanities And Social Science (IOSR-JHSS)
Volume 29, Issue 6, Series 6 (June, 2024) 01-10
e-ISSN: 2279-0837, p-ISSN: 2279-0845.
www.iosrjournals.org

Influence Of Land-Use And Land-Cover Changes On Biodiversity Depletion Over Abia State, Nigeria From 1988 – 2018: A Geographical Information System Approach

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Abstract:
This study assessed the land-use/land-cover changes over Abia State from 1988 to 2018 with a view to ascertaining the changes that have taken place in the study area over the thirty-year period. The study employed Remote Sensing and Geographical Information System (GIS) platforms of Landsat Thematic Mapper (TM) of 1988, Landsat Thematic Mapper (TM) of 1998, Landsat Enhanced Thematic Mapper Plus (ETM+) of 2008 and Landsat8 (OLI) images of 2018 with spatial resolution of 30 metres. The satellite images were all geo-referenced. The Erdas Imagine 9.2 and Arc GIS 10.6 were the digital image-processing software types applied in processing and analyzing the images. The study area was categorized into four land use types; built-up areas, high vegetation density areas, moderate vegetation density areas and low vegetation density areas. A spatial analysis of the shape files shows that from 1988 to 2018 the annual change rate for the built-up areas was 2.57km^2 (0.05%), high vegetation density areas 31.02 km^2 (0.64%), areas of moderate vegetation density -5.99km^2 (-0.12%) while areas of low vegetation density had 28.40 km^2 (0.58%). It was also observed that areas of high vegetation density were the most adversely impacted by Land-Use Land Cover (LULC) changes. We therefore recommend the application of remotely sensed images and Geographic Information System (GIS) techniques to the bird's eye view capture and monitoring of rapid urban expansion which trigger unwholesome depletion of biodiversity in the area.
Keywords: *Abia State, Biodiversity Depletion, Geographical Information System, Land-Use/Land Cover Changes, Remote Sensing, Vegetation Density*

Date of Submission: 07-06-2024 Date of Acceptance: 17-06-2024

I. Introduction

Understanding the connections that exist between biodiversity and land-use is essential to comprehending the linkages that exist between humans and their surroundings (Haines-Young 2009). The most significant natural resource that has an impact on all facets of human existence is land, and the most crucial element in a natural ecosystem's operation is biodiversity. Obayelu (2014). According to Adedipe et al. (1991), land is typically understood to comprise not just the actual soil but also everything below and above it. Because of ongoing changes in land usage and land cover, the land has undergone significant alterations. According to Heistermann et al. (2006), land-use reflects the dynamic processes involving human activity and the biophysical features of the planet.

In the end, modifications to land uses and management—not just on a national and local level, but also on a global one—are the primary forces behind changes in biodiversity (Haines-Young 2009). Though humans have been modifying land to obtain food and other essentials for thousands of years, current rates, extents and intensities of land-use and land cover changes are far greater than ever in history, driving unprecedented changes in ecosystem and environmental processes (Erie, 2016). These changes encompass the greatest environmental concerns of human populations today, including climate change, biodiversity loss, and the pollution of soil, water and air.

Land-use and land-cover changes have emerged as a global phenomenon and perhaps the most significant regional anthropogenic disturbance in the environment, especially in the 20th century (Ademiluyi, *et al,* 2008). Consistent increasing demands for food and settlement due to increase in population growth and urbanization has led to natural vegetation such as forests and natural grassland, being replaced by agricultural land and artificial surfaces, thereby contributing to the increasing rate of land-use and land-cover changes (Jie, et.al, 2019) which results in biodiversity depletion and biodiversity loss.

Dramatic land-use and land-cover changes that would have taken centuries now take place within a few decades (Ademiluyi, *et al,* 2008). Land-use and land-cover change is necessary and essential for economic development and social progress.

The idea of land-use which simply means the conversion of a piece of land by humans usually with the intention to obtain products and benefits through using land resources aids the proper exploitation of the earth's resources and generation of benefits. Land-use and land-cover change, though beneficial, is arguably one of the most pervasive socioeconomic forces driving changes and degradation of ecosystems. Deforestation, urban development, agriculture, and other human activities are forms of land changes that have substantially altered the Earth's landscape. The untold plundering of the land affects important ecosystem processes and services, which invariably has wide range-cum- long-term consequences on biodiversity.

According to the Convention on Biological Diversity and the United Nations Environment Programme (1992), biodiversity, also known as biological diversity, is "the variability among living organisms from all sources including, among other things, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and ecosystems." There is evidence now that people have changed a sizable amount of the land area on Earth (Vitousek et al., 1997). Global land-use changes have resulted from rapidly growing human populations and rising agricultural operations (Cunningham et al., 2005).

For thousands of years, people have been altering the land to get food, shelter, and other necessities of existence. According to Misana et al. (2003), the rates, extents, and intensities of these alterations are significantly higher now than they have ever been and are still unrecorded. A significant amount of land degradation and biodiversity loss result from the majority of development operations being carried out in many cases in an unplanned and disorganised manner. Currently, significant factors influencing environmental change include land-use change, as well as other environmental and socioeconomic processes occurring at various scales (urbanisation, tourism, pollution, climate change, etc.) (Chemini and Rizzoli, 2007). According to UNECOSOC (2008), cited in Obayelu (2014), land access and land usage are essential for the roughly 2.5 billion rural populations in developing nations that rely on agriculture, forestry, and forest products as their primary sources of income. Therefore, a comprehension of the connections between humans and their environment requires an awareness of the interconnections between land-use and biodiversity.

Planning for the sustainable management of biodiversity requires a thorough understanding of how land-use affects biodiversity decline. While in certain locations, maintaining particular patterns of biodiversity may depend on particular land uses or land management techniques. The biodiversity resources found in a region greatly influence the applications that can be made of it.

Human land-use and changes in land-use practices are the single most significant factor contributing to the decline in biodiversity (Catizzone et al., 1998). There are significant ramifications for biodiversity in the study area as a result of these changes in land-use and management.

It is on this premise that our study posits an analysis of changes in land-uses during the last 30 years. The findings from this study will provide decision support systems in areas of capturing and monitoring land-use scenarios. The dynamics in land-use monitoring resulting from the growing demand for land-use practices due to increasing population has often led to biodiversity depletion and ultimately species extinction. This forms the bedrock of this research which strives to fill the gaps in our knowledge of the relationship between land-use and biodiversity depletion. This is in order to increase the level of awareness of this aspect of environmental change which is currently abysmally low. In the same vein it serves to prevent the risks and losses of uncontrolled biodiversity loss. Policy makers need to be well informed about the drivers of biodiversity loss and the levels of loss.

This study focuses on the influence of land-use and land-cover changes (LULCC) on biodiversity depletion over Abia State, Southeastern Nigeria from 1988 - 2018. The vegetation type is rainforest, but has been largely degraded due to human activities like farming and agriculture giving rise to agriculturally induced soil erosion. Its floral composition derives from three major characteristic features: its extensive cultivation in the reduced rainforest; its being a natural transition zone between the savanna zone of northern Nigeria and the lowland rain forest zone in the south and consistent and seasonally rampant burning which edge out herbaceous species (Anyadike, 2002).

Regrettably, there has been a significant decline in biodiversity, which has lowered biomass productivity. The loss of biodiversity in the research area may be partly attributable to intensive LULCC, which is the cause of this trend. Khaya ivorensis, Melicia excela, Pentaclethra macrophylla, Elaeis guinensis, and Raphia vinifera are among the dominant plant species. Among the wildlife species are Cricetomys gambianus, Protoxerus strangei, Philantomba maxwelli, Hyena stirata, and Python sabae. The population, which was 2,154,083 in the 2006 census and is expected to reach 4,143,100 in 2022, is primarily rural (NPC, 2006).

Study Area

Abia state is located between latitudes 04° 45'N and 06° 07' N and longitudes 07° 00'E and 08° 10' E. It is bounded to the north by Enugu and Ebonyi states, northwest by Anambra state, to the west by Imo state, to the east by Akwa Ibom state and to the south by Rivers state. The location of the study is presented in Fig 1.

Abia state covers an area of about 4857.32 km^2**.** Abia State lies within the tropics. Owing to the fact that the area is in the equatorial zone (about 530km away), the solar radiation is high throughout the year. Even though radiation is high, the amounts are not the optimum possible in the area. This is as a result of short duration of sunshine which ranges from average of 5.3 hours in the southern part to 5.5 hours towards the northern end. The shorter hours of sunshine are following the dust haze during the dry season (Anyadike, 2002). The hottest months are from February to April (the dry season) with temperatures of over 27°C. The coolest month is August which is in the middle of the rainy season with temperatures of about 24°C (Ofomata, 2010).

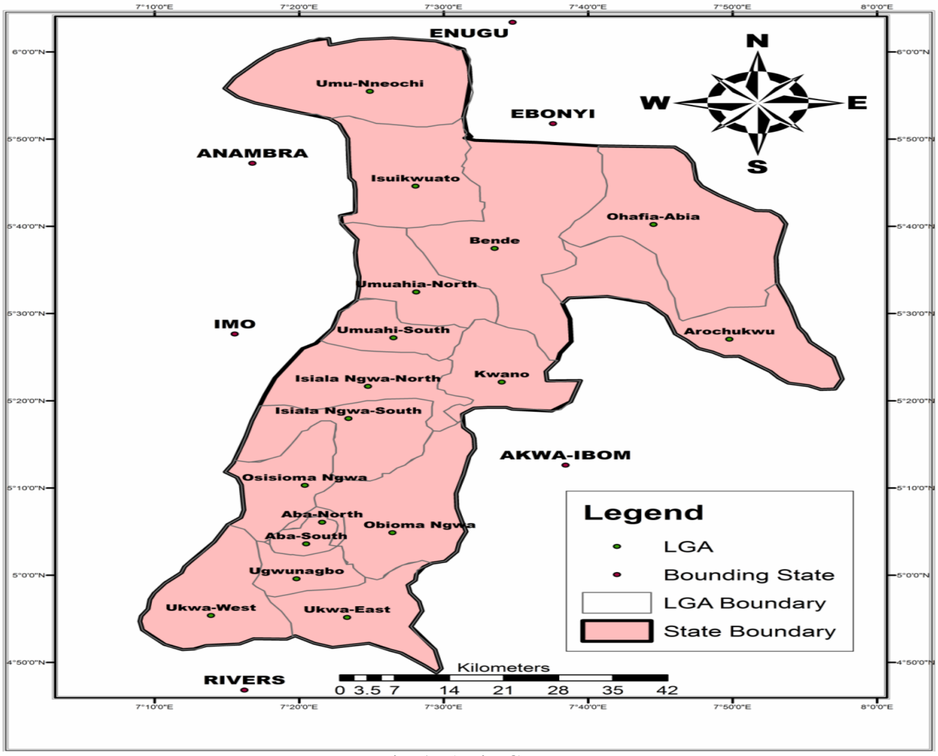

Fig.1. Abia State
Source: Adapted from Google Earth, 2019

In terms of rainfall, Abia state experiences two kinds of rainfall – convectional rainfall and rainfall associated with disturbances. Such disturbances include line squalls, isolated showers and thunderstorms. Convectional rainfall occurs from May to September, while disturbance rainfall comes at the beginning and end of the rainy season – March/April and October/November. The mean annual rainfall in the southern part is about 2,250 mm while it decreases to the north to 1,750 mm.

The area experiences two rainfall peaks which are in July and September/October. These peaks are separated by a short dry season, which occurs in August and is referred to as little dry season or August break. Generally, rainfall over the study area is controlled by the presence of moist tropical maritime air mass (mT) and the location of the inter-tropical discontinuity (ITD) (Ofomata, 2010). The study area used to experience rainfall evenly distributed within the rainy months and these together with high temperature regime of the study area encouraged the maintenance of climax vegetation. However, sequel to the drop in the amount of rainfall received in the area in the rainy months (July, September and October) in recent times; together with agricultural practices the vegetation has continued to retain the status of a lowland rain forest (Ofomata, 2010).

The relief of Abia State is characterized by plains and lowlands. The trend of the topography of the area is that of a gradual ascent which extends from the southern end (Aba) to the northern part (Okigwe). Hence this gradual ascent stems from plains from 50-100 metres above sea level (Aba) to plains from 100- 250 metres above sea level, stretching from Umuahia up to Okigwe. However, there are some parts of Okigwe, near Ihube that lie on plains from 200 metres to 350 metres above sea level (Anyadike, 2002). The relief and drainage of

Abia state is developed over relatively simple geological formations that range from the Asu- Cenomanian age (Lower Cretaceous) to recent alluvial deposits (Anyadike, 2002).

In terms of drainage, Abia State drainage system falls under one of the exoreic river systems. These are rivers that drain into the sea through other areas outside Igboland. They are grouped into three: the Niger system, the Cross River system and independent streams. The Niger with its tributaries and distributaries drains about 50 per cent of Igboland. The largest of the independent streams – that is those which reach the sea without joining one of the two large rivers is the Imo River. Quite unlike the other streams of the coastal plain which flow with general slope of the land in a southern direction, the Imo changes its direction and as a result, receives the Aba and Otamiri rivers as its major tributaries. Abia State is therefore dominated by the Imo River drainage system, with Imo River as the most important river in the state. The Imo drainage system has a total drainage area of about 8,288 square kilometers making it one of the largest independent streams in the area. (Anyadike, 2002). However, in the study area there are other smaller streams scattered across the state which join the Imo River at different points, which in turn empties into the Atlantic Ocean through the Niger Delta. The soils of Abia State fall into the category of ferrallitic soils. These are soils that are rich in free iron. They have low mineral content and are low in fertility. These ferrallitic soils are derived from sand, where they are further subdivided in line with their dominant colour. They are developed from various complexes of sandstones and shales where they occupy the well-drained sites. The soils of the study area are therefore made up of two subdivisions of the ferrallitic soils: yellowish – brown soil developed on loose sandy sediments in the southern part of the state like Aba and reddish – brown soils developed from sandstones and shales towards the northern part like Umuahia, Bende and Okigwe.

These soils support agriculture with the production of subsistence crops and some *Theobroma cacao* (cocoa) grown on lower slopes within Umuahia area (Ofomata, 2010). This agricultural friendly soil makes room for more land-use changes in support of agricultural cultivation as local people keep on enchroaching on land for intensive agricultural cultivation. Following the fact that the soils support agriculture, while a majority of the people engage in it, there is the tendency that agricultural practices could influence changes in plant species diversity in the area, making room for plant species depletion due to over exploitation. This is more so as some farmers engage in continuous cropping. This in effect is capable of edging out some species in the face of bush burning. Some plants are cleared off the farmlands continuously at the expense of woody plant species diversity. On the other hand, if the soil is left undisturbed for a reasonable length of time it can support the growth of diverse woody plant species. (See Fig.2)

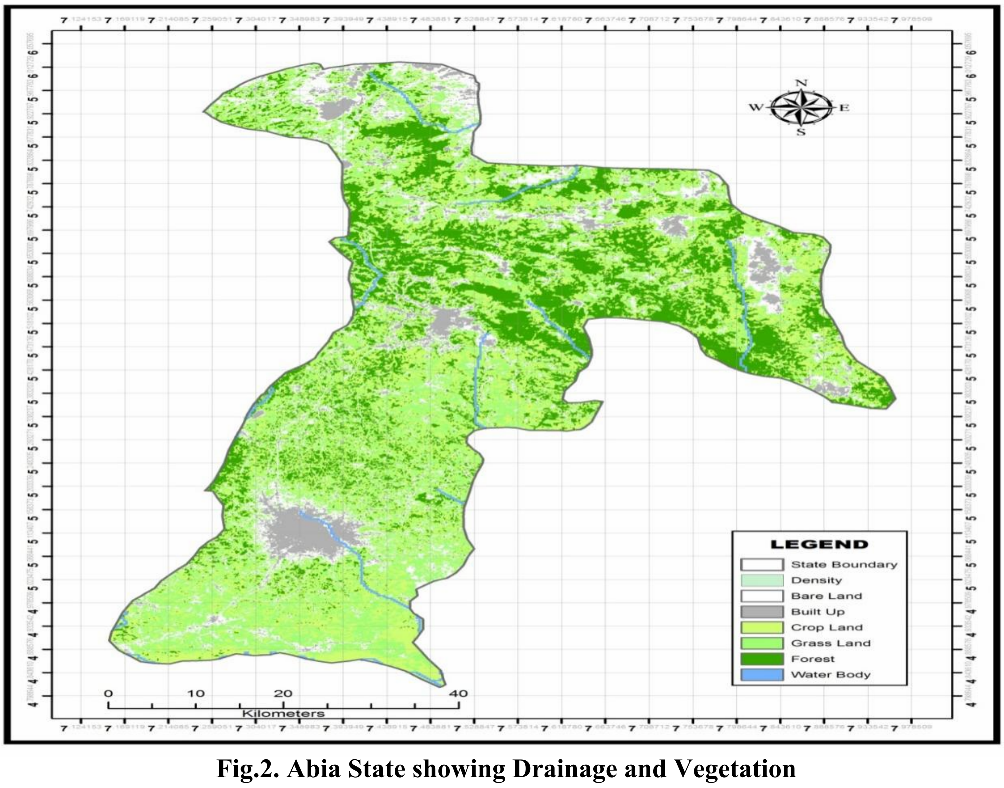

Fig.2. Abia State showing Drainage and Vegetation
Source: Adapted from Google Earth, 2019

Data collection

The Land-Use/Land-Cover change in the study area was assessed in order to ascertain the rate of loss of vegetation in general and woody plant species in particular. This was done using the satellite images of Abia State for 1988, 1998, 2008 and 2018. The data used for the Land-Use/ Land-Cover Change detection in this research were Landsat Thematic Mapper (TM) of 1988, Landsat Thematic Mapper (TM) of 1998, Landsat Enhanced Thematic Mapper Plus (ETM+) of 2008 and Landsat8 (OLI) images of 2018 all of which have Spatial Resolution of 30 metres. The LULC change maps for the four periods viv-a-viz 1988, 1998, 2008 and 2018 were attached.

The Satellite images were obtained from the United State Geological Survey (USGS) website. It is noteworthy that the above satellite images have been employed to source data for similar research by Matlhodi, Kenabatho, Parida, and Maphanyane, (2019).

Digital image-processing (Erdas Imagine 9.2) and GIS (Arc GIS 10.6) softwares were used in processing and analysing images as well as other geographic data acquired for the research. This was following the fact that remotely sensed data are not free from internal and external errors such as radiometric and geometric distortions. Since the data used were auto-rectified, geometric and radiometric corrections were not performed on the data used. However, the major image process task carried out was Geo-referenced.

In this case, the shape file datasets along with Topographic spatial datasets were all Geo-referenced, in other words Geo-rectified (registered) to a geographic coordinate system. The imagries were corrected to a common projection, Universal Traverse Mercator (UTM), once they were imported into the Erdas Imagine 9.2 environment. In contrast to the Geographic Coordinate System (latitude/longitude), which uses angular, non-decimal units for measurement, the UTM projection uses linear, decimal units, which makes it more dependable, according to Scott (1977). In order to link them with other pertinent and related maps that were used in this study, the analogue data set format was converted to a digital data set format. Geo-referencing which involves registering data to the real world was carried out by assigning location information to the data sets (images). This helped in defining the existence of those data sets in physical space as well as establishing their location in the real world.

Thereafter, was sub-setting, a process which involves the extraction of an Area of Interest (AOI) from the main data. The subset Landsat images of the study area was obtained by masking the boundary of the study area with the main Landsat scene of Abia State concurrently using the clipping toolset in ArcGIS environment to subset the required data needed.

Further, the imageries were categorized into various classes while supervised classification technique was performed using maximum likelihood classification (MLC) algorithm. This technique enabled generation of training classes based on the actual land-use/land-cover themes present within the study area. This procedure helped in curtailing ambiguity that is associated with the unsupervised technique of image classification. The MLC is the most widely and commonly used with remotely sensed data, and is proven to yield the best classification results (Jensen, 1996). The attribute data and statistical data from the classification result were generated and used for post-classification comparison within the period

Based on remote sensed images and ground-truth from field work which substantiated the knowledge about the area, a classification scheme was generated after Anderson, Hardey, Roach and Witmer, (1976) and was adopted for this study.

II. Data Analysis

Assessment and examination of the loss of Wooded Plant Species (WPS) in Abia State through land-use /land-cover change detection

In this study area, the classification scheme produced four categories of land-use/land-cover types namely: Built-up land, High vegetation land, Moderate vegetation and low vegetation. See Table 1.

Table1: Land-use/Land-cover classification scheme of the Study Area

	Landcover/ Landuse Classes	Description
1	Built-up land	Land use for settlement and building of urban infrastructure such as schools, roads, etc.
2	High Vegetation	Natural forest.
3	Moderate vegetation	Land covered with natural vegetation such as grasses, shrubs.
4	Low vegetation	Agricultural land (grass like-plants) and other land cover

An accuracy assessment was performed on the classified imagery as recommended by Foody (2001). The assessment is very crucial for thematic mapping from remotely sensed techniques, and is known to mean the degree to which the derived image classification agrees with reality or conforms to the truth (Campbell, 1996). A total of 256 random points as recommended by Congalton (1991) captured at locations on the field were processed and exported to Erdas Imagine software. The points represent the various sample points obtained from the classified geo-referenced images to determine the degree of conformity with ground features.

Table 2 shows the attributes of the LULC changes from 1988 to 2008 while Table 3 presents the analysis of LULC changes in the study area from 1988 to 2018.

Table 2: LULC change (sq.km) in the Study Area from 1988 to 2018.

LULC	1988	1998	2008	2018
Built-up Areas	198.93	214.26	231.65	276.1
High Vegetation Areas	1866.04	1268.14	1200.7	1116.61
Moderate Vegetation Areas	2229.12	2191.46	2131.87	2049.36
Low Vegetation Areas	563.23	1183.46	1293.1	1415.25
Total	**4857.32**	**4857.32**	**4857.32**	**4857.32**

The LULC categories for the four years are presented in Fig, 3. The different rates and magnitude of changes for the years were calculated using the following equation:
.... (5)
Where D is the average annual rate of change (%), A1: average amount of land cover type at time (T1), A2: average amount of land cover type at time (T2).

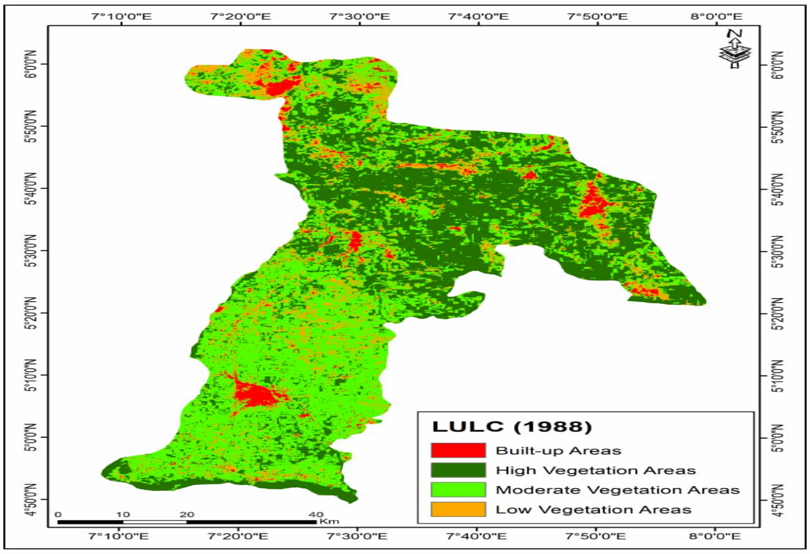

Fig. 3a: LULC Category of the Study Area for 1988

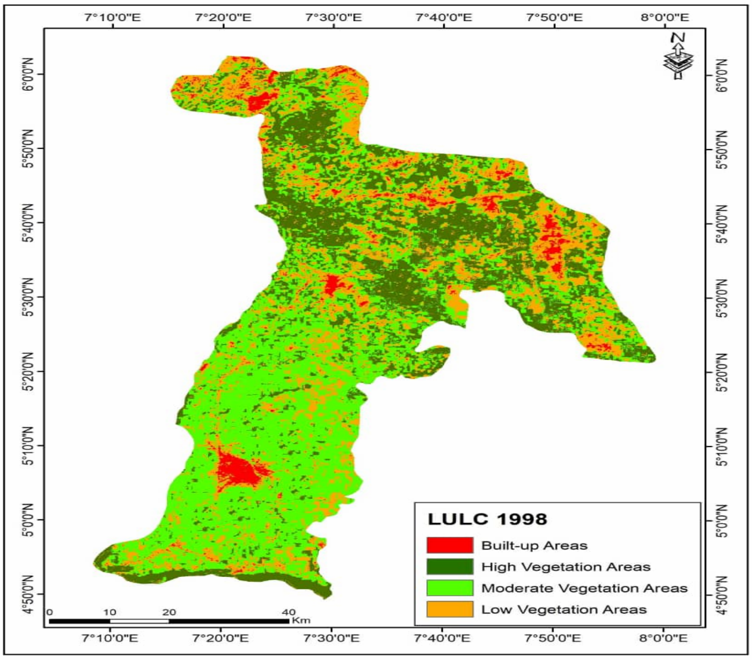

Fig. 3b: LULC Category of the Study Area for 1998

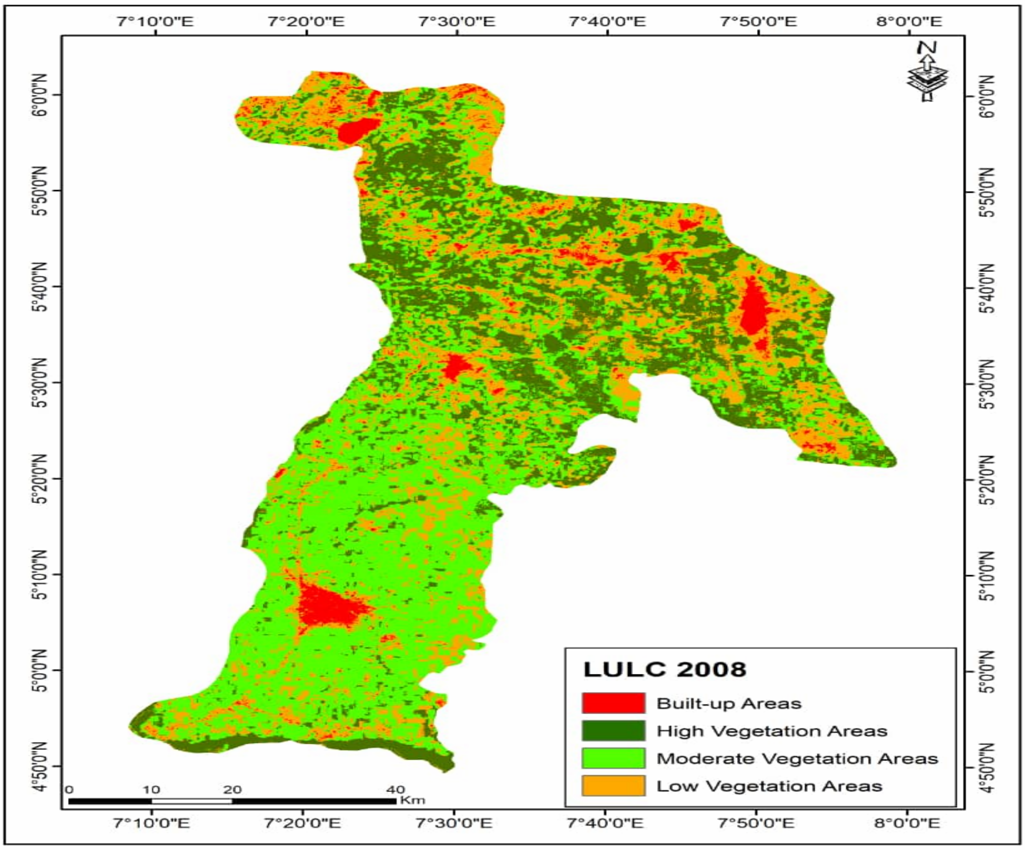

Fig.3c: LULC Category of the Study Area for 2008

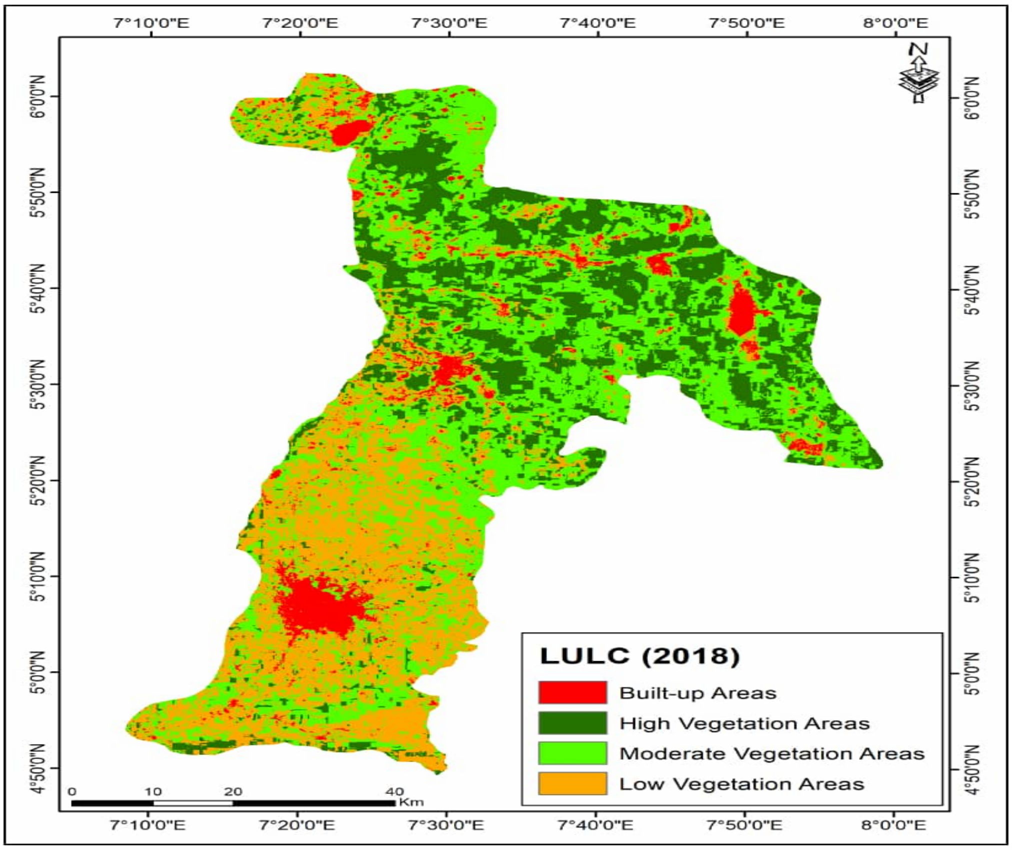

Fig.3d: LULC Category of the Study Area for 2018

III. Results

The LULC changes in the study area from 1988 to 2018 area presented on Table 3.
Table 3: LULC change in the Study Area from 1988 to 2018.

Table: 3 1988 -1998 Land-Use/Land-Cover Change Dynamics

LULC Type	Area (Km²) 1988	Area (%)	Area (Km²) 1998	Area (%)	Area (Km²)	Area (%)	Annual Change Rate in Km²	%
BUA.	198.93	4.10	214.26	4.41	15.33	0.31	1.53	0.03
HVA	1866.04	38.42	1268.14	26.11	-597.90	-12.31	-59.80	-1.23
MVA	2229.12	45.90	2191.46	45.12	-37.66	-0.78	-3.77	-0.08
LVA	563.23	11.60	1183.46	24.36	620.23	12.76	62.02	5.70
TOTAL	4857.32	100.0	4857.32	100.0	-	-	-	-

Table 4 1998 to 2008 Land-Use/Land-Cover Change Dynamics

LULC Type	Area (Km²)1998	Area (%)	Area (Km²) 2008	Area (%)	Area (Km²)	Area (%)	Annual Change Rate in Km²	%
BUA.	214.26	4.41	231.65	4.77	17.39	0.36	1.74	0.04
HVA	1268.14	26.11	1200.7	24.72	-67.44	-1.39	-6.74	-0.14
MVA	2191.46	45.12	2131.87	43.89	-77.59	-1.23	-7.76	-0.12
LVA	1183.46	24.36	1293.1	26.62	109.64	2.26	10.96	0.22
TOTAL	4857.32	100.0	4857.32	100.0	-	-	-	-

Table 5; 2008 to 2018 Land-Use/Land-Cover Change Dynamics

LULC Type	Area (Km²) 2008	Area (%)	Area (Km²) 2018	Area (%)	Area (Km²)	Area (%)	Annual Change Rate in Km²	%
BUA.	231.65	4.77	276.1	5.68	44.45	0.92	4.45	0.09
HVA	1200.7	24.72	1116.61	22.99	-84.09	-1.73	-8.41	-0.17
MVA	2131.87	43.89	2049.36	42.19	-8.25	-0.17	-0.83	-0.02
LVA	1293.1	26.62	1415.23	29.14	122.13	2.51	12.21	0.25
TOTAL	4857.32	100.0	4857.32	100.0	-	-	-	-

Table 6: 1988 to 2018 Land-Use/Land-Cover Change Dynamics

LULC Type	Area (Km²)1988	Area (%)	Area (Km²) 2018	Area (%)	Area (Km²)	Area (%)	Annual Change Rate in Km²	%
BUA.	198.93	4.10	276.1	5.68	77.17	1.59	2.57	0.05
HVA	1866.04	38.42	1116.61	22.99	930.57	19.16	31.00	0.64
MVA	2229.12	45.90	2049.36	42.19	-179.76	-3.70	-5.99	-0.12
LVA	563.23	11.60	1415.23	29.14	852.00	17.54	28.40	0.58
TOTAL	4857.32	100.0	4857.32	100.0	-	-	-	-

IV. Discussion

LULC Change Detection in the study area from 1988 to 2018

The LULC Change results were analyzed after Matlhodi, Kenabatho, Parida, and Maphanyane (2019). Table 3 shows that moderate vegetation areas and high vegetation areas were the most dominant LULCC categories in 1988 and 1998 while moderate vegetation areas and low vegetation areas dominated the area in 2008 and 2018. In 1988 built-up areas covered 198.93km² (4.10%) while high vegetation areas covered 1866.04 km² (38.42%). Area of moderate vegetation covered an area of 2229.12 km² representing 45.90% of the total area whereas area of low vegetation density covered an area of 563.23 km² (11.60%). In 1998, built-up areas covered 214.26km² (4.41%) as high vegetation area covered 1268.14 km² (26.11 %). In addition, areas of moderate vegetation density and areas of low vegetation density covered 2191.46 km² (45.12%) and 1183.46 km² (24.36%) in the same year (1998) respectively. However, in 2008 and 2018, built-up areas covered an area of about 231.65km² (4.77%) and 276.1(5.68%), high vegetation area category covered an area of 1200.7km² (24.72%) and 1116.61 km² (22.99%); moderate vegetation areas category had 2131.87km² (43.89%) and 2049.36km² (42.19%) while the low vegetation areas covered 1293.1km² (26.62%) and 1415.23 km² (29.14%) in that order.

Generally, there is an underlying trend in the LULCC change in the 30-year change period across the four LULC categories. From Table 3, it could be seen that built-up areas steadily increased from 1988 to 2018.

During the period under review, the areas described as high vegetation Areas (HVA) and moderate vegetation areas (MVA) decreased steadily from 1988 to 2018. Also, there was a remarkable increase in the areal extent observed in the low vegetation areas (LVA) category. The land area covered by low vegetation areas category steadily increased from 1988 to 2018 whereas the reverse was the case with high vegetation and moderate vegetation areas categories of the LULC change. In other words, while there was a decreasing trend in HVA and MVA there was an increasing trend in built-up areas (BUA). This means that while there was an increase in the areal extent of built-up areas, there was also a proportionate increase in the rate of vegetation loss over the years. The same applies to high vegetation and moderate vegetation area categories. Given a significant decrease in the area covered by high and moderate vegetation from 1988 to 2018, it was observed that there was an increase in the level of vegetation depletion over the period. The overall effect of these dynamics in the LULC change in the study area is underscored by the fact that we noted generally the decimation of vegetation and particularly the depletion of woody plant species (WPS). These changes could be attributed to increase in population of the study area through migration or by birth. The birth rate of the study population is 3.9% quite high.

Evaluation of the annual rate of change in the thirty-year change set period

The annual change rates for all the LULC change categories were computed. It was observed that 1988 to 1998 change period witnessed the highest annual changes among the LULC change categories. High vegetation areas (HVA) and moderate vegetation areas (MVA) categories decreased annually at rates of 59.80 km^2 (1.23%) and 3.77 km^2 (0.08%) in that order. However, low vegetation areas (LVA) and built-up areas (BUA) categories increased significantly at rates of 62.02 km^2 (5.70%) and 1.53km^2 (0.03%) respectively. This is because the low vegetation area (LVA) and built-up areas (BUA) are areas within the urban areas and are variously attractive to migrants due to availability of livelihood potentials which necessitates increase in land for building purposes.

V. Conclusion

Unchecked population growth leads generally to bioresources depletion as a result of land-use/land-cover changes being expressed in Abia state. We therefore conclude that the overall implication of the annual change rates is that if there is no control in urban expansion and human activities in the area, there will be a wanton depletion of many plant species in the study area in the nearest future. This could lead to an irreversible species loss if not total extinction of most exotic woody plant species in the study area. This is more so as most of these species have been Red - listed in Nigeria by IUCN as threatened (Borokini, 2014). The significant increase in the LULC changes in the various categories of land-use types has been noted by Lopez (2001), who reported that settlements in developing countries are, at present, growing five times faster than those in developed countries as a result of population explosion. To avert a possible irreversible species depletion in the study area, we recommend that Government through its relevant ministries should take proactive steps to ensure controlled urban expansion and human activities and combat over exploitation of resources through proper population control measures.

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