ANALYSIS OF LAND USE/LAND COVER VARIATION IN OKIGWE AREA, IMO STATE FROM 2000 TO 2020 USING GIS TECHNIQUES

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ABSTRACT: Population growth and urbanisation implies that the earth surface continues to change in different forms. The study analysed land use/ land cover (LU/LC) variation in Okigwe local government area (LGA), Imo State, using Geographic Information System (GIS) and remote sensing techniques, to determine the extent of changes in forest, urban development, water body, grass land and agricultural land, from 2000 to 2020. Data collection for the study involved Landsat images collected over the same year period with five years interval. These imageries were processed using the image classification of LU/LC of the study area. The results show that there is steady decrease in vegetation, agriculture, and grassland from years 2000 to 2020. Study results for the year 2000 showed that forest, agricultural land, and grass land classes were 35%, 31% and 4%, respectively while urban area was 19% of land within the study area. In the year 2020, it was observed that forest, agricultural land, and grass land were reduced to 30%, 28% and 2%, respectively while urban area increased to 29%. Based on the study findings, reduction in all the classes within the two decades studied were because of urbanisation. Therefore, Okigwe LGA should be well-planned with respect to land use, in order to check urban sprawl.

Keywords: Land Use, Land Cover, Geographic Information System, Remote Sensing, Okigwe

INTRODUCTION

Changes in land use and land cover are mainly driven by spatiotemporal modifications which are as a result of natural forces and/or anthropogenic activities for socio-economic development. Therefore, land use/ land cover (LU/LC) changes in any geographical location are affected by physical factors like climate, geomorphology, terrain and relief (Yalew et al., 2016). Also, population dynamics with respect increment and reduction in the number of human beings in a given area goes a long way in determining changes in LU/LC. This implies that environmental, social and economic needs of an increasing human population will also increase, thereby exerting pressure on land and the resources contained therein (Emetumah, 2017; Ezedike et al., 2020). Changes in land use depends on what/how human beings do with land in over a given period of time. Human use of land for agriculture, deforestation and housing has pointedly expanded LU/LC (Njoku & Tenenbaum, 2022; Obiahu et al., 2021). Expansions in LU/LC have also affected natural processes like evapotranspiration, recharge of surface water systems and the underground aquifer. Also, studies have shown that significant modification in LU/LC have perniciously affected global climate change and frequency of natural disasters with dire socio-economic consequences in many parts of Africa (Hegazy & Kaloop, 2015; Sewnet, 2015; Tewabe

& Fentahun, 2020). Therefore, it is imperative that LU/LC modification is examined given its pertinent role in sustainable resource management, development planning, deforestation control, water resource utilization and land degradation mitigation.

In order to understand the rate of various environmental phenomena like vegetation depletion, expansion of urban areas, water bodies and agricultural activities in any geographical location, identifying changes in land use is very important in sustainable development (Nse et al., 2020). On that note, Geographic Information Systems (GIS) and remote sensing (RS) have been found very useful in spatiotemporally ascertaining the extent of modification in land use with a given area (Njoku & Tenenbaum, 2022; Obiahu et al., 2021; Tewabe & Fentahun, 2020). Furthermore, the iterative nature of data collected through remote sensing not only makes it easy to detect and quantify LU/LC patterns, but also significantly facilitates data processing, mapping and geo-referencing (Congalton & Green, 2019; Jensen, 1996).

According to Akinyemi and Isiugo-Abanihe (2014), the rate of urbanisation in Nigeria at 3.2 percent with expectations of having the highest contribution to the global urban population by the year 2030. Furthermore, increasing human population has resulted in substantial demand for natural resources, which increases land use and land cover change in many parts of Nigeria, especially in urban areas (Nwaogu et al., 2017). Therefore, it is not surprising that recent studies have been carried out in Nigeria on LU/LC modification and its relationship with relief system and surface temperature (Njoku & Tenenbaum, 2022), vegetation indices (Nse et al., 2020) () and urban expansion (Obiahu et al., 2021). The findings of these studies indicate that there are a lot of dynamism in LU/LC change across Nigeria, due to the different types of geographical characteristics attributable to variations in vegetative cover, agricultural practices, human settlements. However, the consistent factor in most studies on LU/LC change is the need to understand how human population growth (especially in urban areas) and its attendant appetite for natural resource depletion has modified the earth surface. Therefore, LU/LC studies are vital environmental management techniques that can facilitate sustainable development in Nigeria cities. Okigwe Local Government Area (LGA) is an important locality within Imo State, Nigeria because its metropolis is the third largest city in Imo State, after Owerri and Orlu. Growth in commercial activities involving trade in consumer goods and cattle has resulted in a growing population within Okigwe, with much of this growth driven by informal activities (Onyenechere et al., 2022). Furthermore, LU/LC changes have also been affected by increased farming activities, where natural forests and grasslands have made way for farmlands where cultivation of arable crops has taken over many land areas within Okigwe LGA. These commercial and agricultural activities have also affected LU/LC change due to increased demand for housing so as to accommodate a growing population within the area. Even though previous studies have looked at LU/LC changes in many parts of Nigeria and even Imo state, literature is lacking on LU/LC changes in Okigwe. This study therefore assesses LU/LC changes in Okigwe LGA Imo State between 2000 and 2020 by identifying and delineating LU/LC categories and pattern of land use change in the area, spatially estimating the extents of LU/LC changes between 2000 and 2020 and determining the extent of urban sprawl encroachment to agricultural farm land between 2000 and 2020. The timeframe between 2000 and 2020 was selected for the study because it marks the commencement of the present democratic dispensation in Nigeria which has resulted in tremendous changes in many aspects of life across the country.

MATERIALS AND METHODS

Study Area

Okigwe LGA is located between latitudes 5˚56'24"N to 5˚42'19"N and longitudes 7˚12'58"E to 7˚24'02"E (see Figure 1). It is bounded to the North by Orumba South LGA of Anambra State and UmuNneochi LGA of Abia State, to the East by Isuikwato LGA of Abia State and to the South by Umuahia North LGA of Abia State, while Onuimo and Ideato North LGAs both of Imo State forms the border to the west. Okigwe has grown into a major cattle transit town for the southeast and south sub regions of Nigeria. In 2006, Okigwe LGA has a population of 132,237 which is projected to have a population of 174,553 in 2021 and unevenly distributed over a total land area of 32,037.445 hectares. Okigwe LGA has five autonomous communities with different villages (in bracket) namely: Ikigwu, Otanzu-Amuro, Umulolo, Ihube and Otan-Chara. The Igbo language is widely spoken while Christianity is predominantly practiced in the area. Okigwe LGA has two major seasons which are the dry (between December and February) and the rainy (March to November) seasons. Topographically, relief in Okigwe LGA is relatively hilly and undulating.

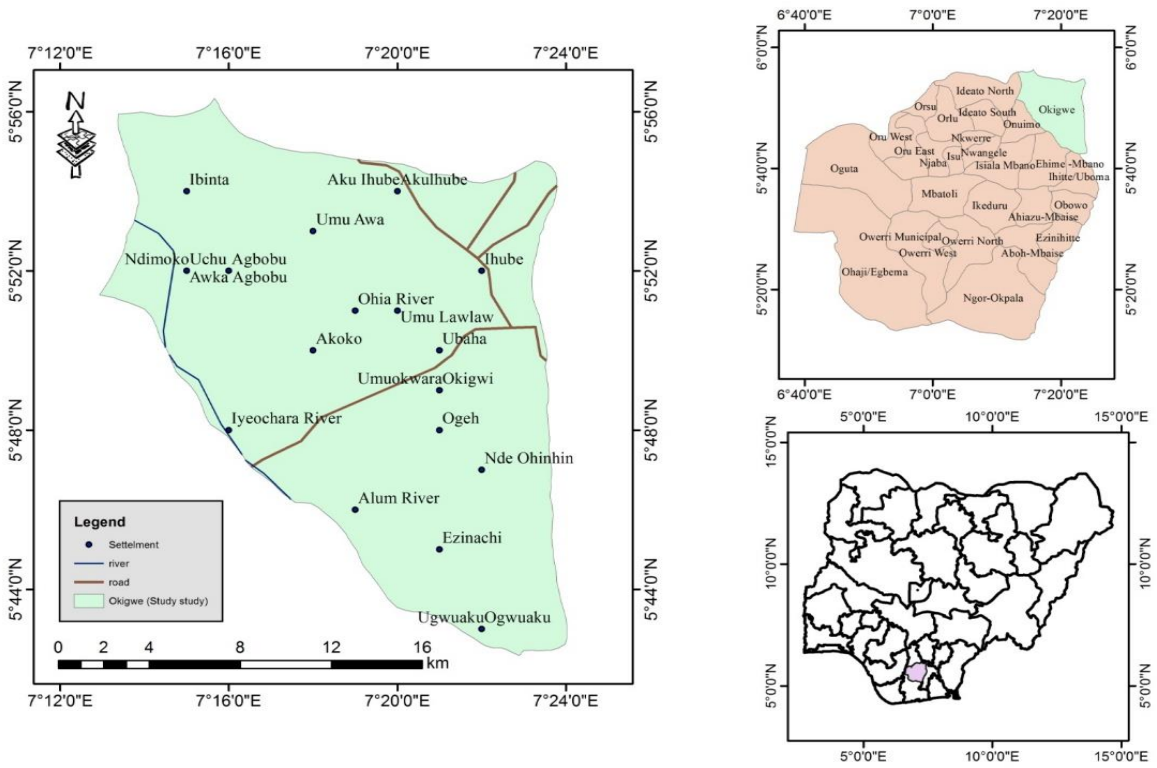


Figure 1. Map of the study area

Method of Data Acquisition an Analysis

Landsat Thematic Mapper at a resolution of 2017 with 30 meters resolution was used for land use/cover classification. The satellite data covering study area were obtained from earth explorer site (http://earthexplorer.usgs.gov/). The layer stack option in image interpreter tool box was used to generate face centered-cubic (FCC) for the study areas. The sub-setting of satellite images was

performed for extracting study area from both images by taking geo-referenced out polygon boundary of Okigwe which is the area of interest. All satellite data were studied by assigning per-pixel signatures and differentiating the area into five classes on the bases of the specific Digital Number (DN) value of different landscape elements. The delineated classes were: Forest, Urban Areas, Water Bodies, Grass Land, agriculture. For each of the predetermined land cover/use type, training samples were selected by delimiting polygons around representative sites. Spectral signatures for the respective land cover types derived from the satellite imagery were recorded by using the pixels enclosed by these polygons. After that maximum likelihood algorithm was used for supervised classification of the images. Due to unavailability of land sat satellite imagery in 1990 in the area, 2000 imagery were used for the analysis after data cleaning, all the 3 images of 2000, 2010 and 2020 were classified with supervised classification. This method was used because the authors are conversant with the area of study and also Google Earth assisted in assigning class and signature value to the images. The classes were grouped into five, namely: forest, urban area, water bodies, grassland and agriculture. This methodology was repeated in the five images representing 2000, 2005, 2010, 2015 and 2020.

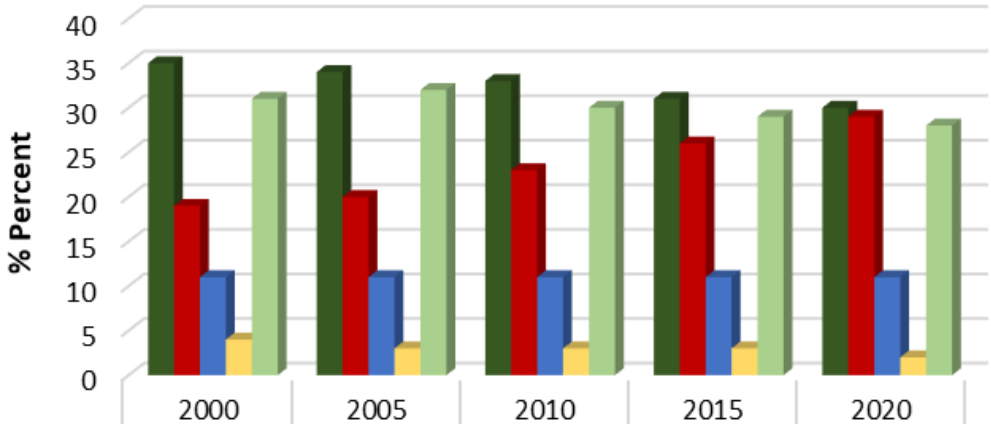
RESULTS AND DISCUSSION

The aim of the study is to assess LU/LC changes in Okigwe LGA, Imo State between 2000 and 2020 by identifying and delineating LU/LC categories and pattern of land use change in the area. Table 1 shows overall LU/LC detection for Okigwe in 2000, 2005, 2010, 2015 and 2020 which are presented in pixels and percentages.

Table 1. Overall land use and land cover detection for Okigwe in 2000, 2005, 2010, 2015 and 2020.

Year / Class	2000 (Pixel count [%])	2005 (Pixel count [%])	2010 (Pixel count [%])	2015 (Pixel count [%])	2020 (Pixel count [%])
Forest	125139 (35%)	121458 (34%)	116956 (33%)	112256 (31%)	106956 (30%)
Urban areas	68779 (19%)	70279 (20%)	80779 (23%)	86479 (26%)	101779 (29%)
Water bodies	40667 (11%)	40467 (11%)	40667 (11%)	40167 (11%)	39667 (11%)
Grass land	12563 (4%)	12363 (3%)	10563 (3%)	10160 (3%)	6563 (2%)
Agriculture	112574 (31%)	112974 (32%)	108576 (30%)	108276 (29%)	102576 (28%)
Total	357541 (100%)	357541 (100%)	357541 (100%)	357541 (100%)	357541 (100%)

Table 1 shows percentage LU/LC of Okigwe LGA from 2000 to 2020, for the five categories: forest, urban, water, grass land and agriculture. In the year 2000, it was observed that the highest LU/LC was forest which covered about 35% of the area, followed by agricultural land which covered about 31%.



	2000	2005	2010	2015	2020
Forest	35	34	33	31	30
Urban	19	20	23	26	29
Water	11	11	11	11	11
Grass Land	4	3	3	3	2
Agriculture	31	32	30	29	28

Figure 2. Percentage land cover/land cover of Okigwe in 2000, 2005, 2010, 2015 and 2020.

Meanwhile, Urban/built up places covered about 19% of the area while water bodies occupied 11% of the area. At 4%, grass land had the least percentage of the five LU/LC categories. This therefore means as at 2000, the area is dominated by greenery (forest, and agricultural land). In the year 2005, forest and agricultural land were also the highest LU/LC categories at 34% and 32%, respectively. This was followed by urban areas which slightly increased to 20% while water bodies remained the same at 11%. There was a slight reduction in grass land to 3%, indicating that these areas have been appropriated to other land uses. Majority of Okigwe LU/LC in 2010 was forest at 33%, followed by agricultural land at 30%. Also, water body and grass land areas remained the same at 11% and 3% respectively, while urban development increased to 23% of LU/LC. In 2015, forest cover and agricultural land in Okigwe reduced to 31% and 29%, respectively, while urban areas increased to 26% of LU/LC. Furthermore, grass land remained the same at 3% of LU/LC in Okigwe LGA. According to Figure 2, Okigwe LU/LC in the year 2020 shows that forest occupied 30% of the land use in the area, followed by urban development which occupied 29%. Whereas agricultural land occupied 28% of LU/LC in Okigwe LGA, grass land reduced to 2% of LU/LC; water body remained the same at 11% of LU/LC in Okigwe LGA. From this result, it can be deduced that Okigwe LGA has lost about 10% of forest, grass and agricultural land from 2000 to 2020. Furthermore, study results indicate that urban areas increased by about 10% between 2000 and 2020. This result aligns with the findings of Nse et al. (2020) on that urbanisation has significantly impact on land use and land cover in Nigeria. On that note, processed satellite images showing the classifications of various LU/LC features in the study area for 2000, 2005, 2010, 2015 and 2020 are shown in figures 3 to 7.

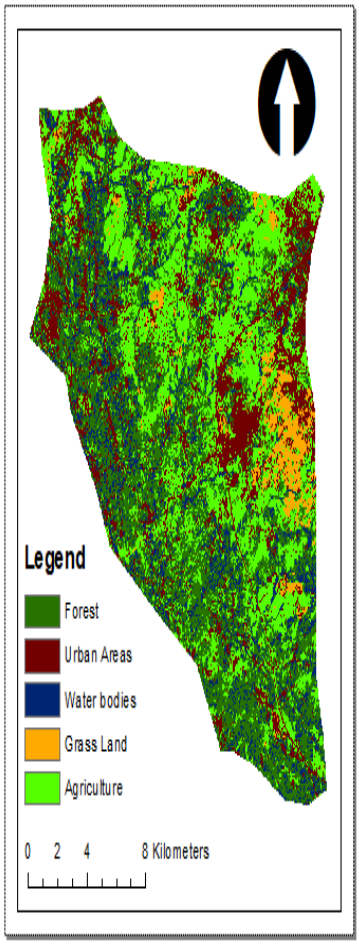


Figure 3. Land use and Land cover classification for Okigwe area in the year 2000.

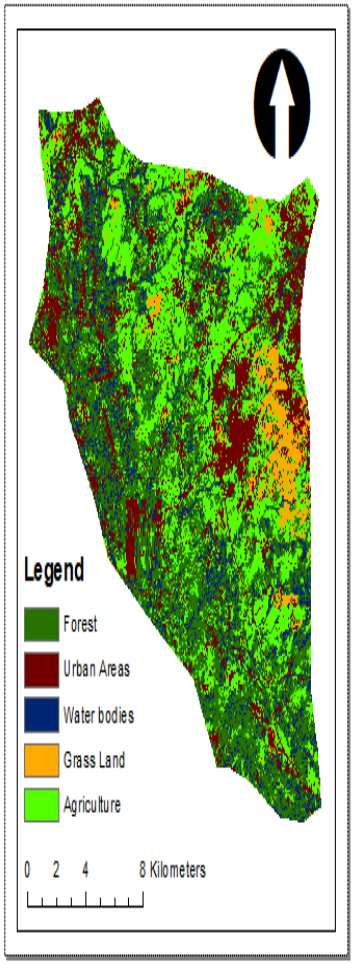


Figure 4. Land use and Land cover classification for Okigwe area in the year 2005.

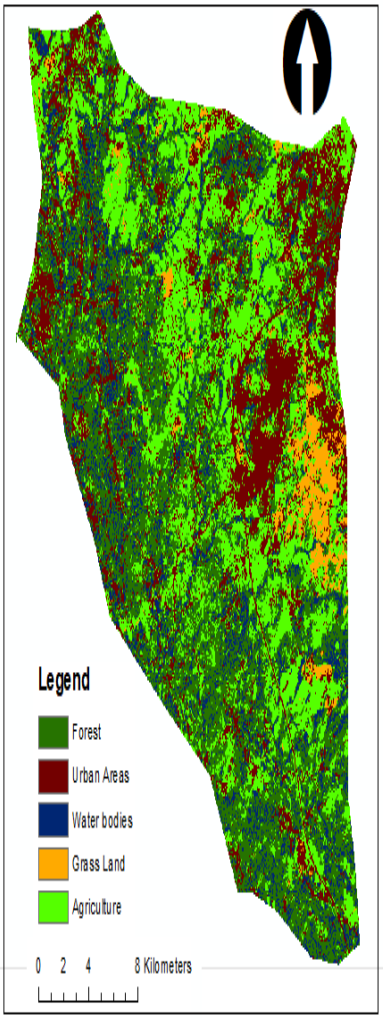


Figure 5. Land use and Land cover classification for Okigwe area in the year 2010.

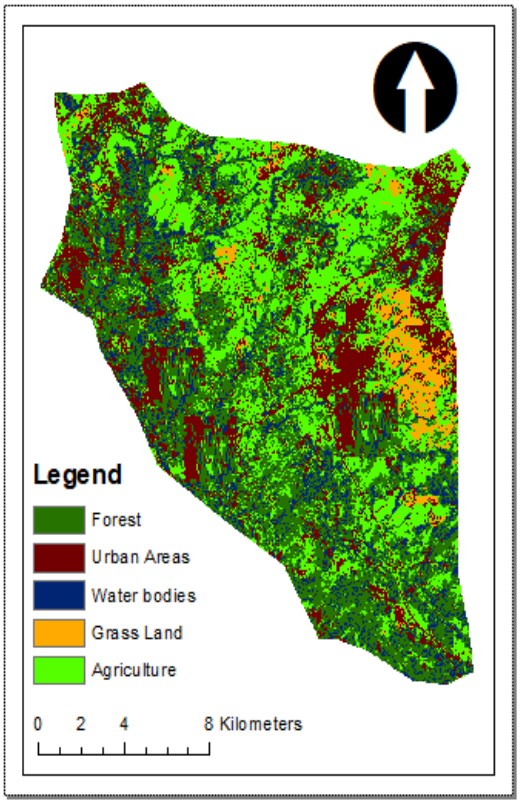


Figure 6. Land use and Land cover classification for Okigwe area in the year 2015.

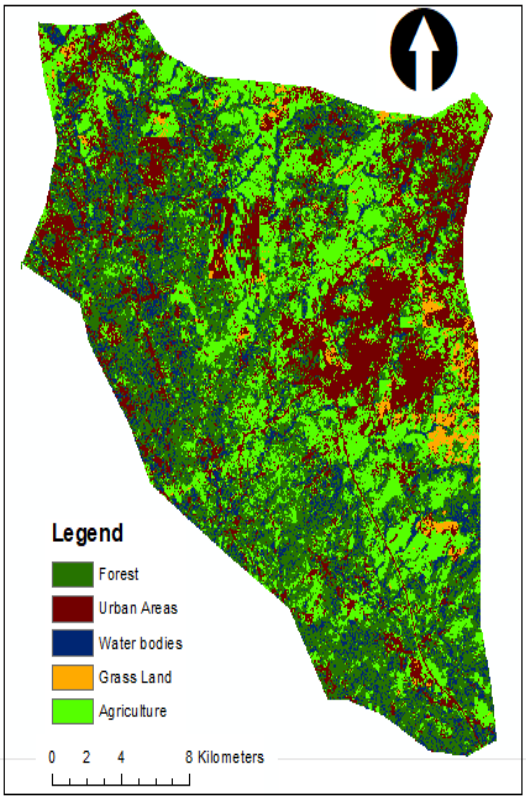


Figure 7. Land use and Land cover classification for Okigwe area in the year 2020.

Table 2 shows the extent of change that occurred in the LU/LC of Okigwe LGA within the two decades studied. As observed in the table, there is a decrease in forest cover which lost about 5%. Urban area increased from 19% in 2000 to 29% in 2020, implying that urban have an increment of about 10%. The water bodies remained the same in the two decades. While grass land areas lost about 2% of land cover, agricultural land also lost about 3% in two decades studied. Forest which covered about 35% of Okigwe's LU/LC in the year 2000 was reduced by 4% in 2020. This finding can be attributed to urban Sprawl in the area because some forested land may have been cleared in order to erect buildings.

Table 2. Percentage changes in Land use land cover for Okigwe from 2000 to 2020.

Year / Class	% Change (2000-2005)	% Change (2005-2010)	% Change (2010-2015)	% Change (2015-2020)	Total % change (2000-2020)
Forest	-1	-1	-2	-1	-5
Urban areas	1	3	3	3	10
Water bodies	0	0	0	0	0
Grass land	-1	0	0	-1	-2
Agriculture	1	-2	-1	-1	-3

Furthermore, it was noted that there was no change in the water body in the area within the two decades of the research. The study area also lost about 2% of natural grass land. As at the year 2000, the grass land covered about 4% of the study area which reduced to 2% within two decades. There is no doubt that urban sprawl causes the demolition of vegetation and other natural cover (Hegazy & Kaloop, 2015; Njoku & Tenenbaum, 2022; Tewabe & Fentahun, 2020). In terms of agricultural land, the study area had 31% of LU/LC in the year 2000. The study identified that within two decades, agricultural land reduced by 3% in 2020. Previous LU/LC studies have attributed reduction in agricultural land to urbanisation (Obiahu et al., 2021; Sewnet, 2015). Many farm lands may have been converted to commercial and residential use. Urban sprawl spreads along with different factors of development significantly reduce agricultural activities because many perceive urbanisation as a precursor to better job opportunities. Therefore, farm lands can be sold to developers who erected structures for companies and banks that have used the lands for residential and commercial purposes. In this study, it was observed that urban areas increased from 19% to 29% within two decades (2000 to 2020). This is as a result of increasing need for residential, commercial and industrial buildings, transportation infrastructure, among others uses. This result is similar to the findings of Mallupattu and Sreenivasula Reddy (2013), whose comparison of LU/LC in 1976 and 2003 showed significant increase in built-up areas from 5.91km² in 1976 to 18.34km² in 2003, a net increase of 12.44 km².

The study is not without limitations. Quantitative data from respondents in the study area may have provided more insight into the specifics of how urbanisation has affected LU/LC changes in Okigwe LGA. Furthermore, annual or bi-annual satellite imageries of the study area, covering the

two decades studied may have clearly shown the exact period when LU/LC changes begin manifesting in Okigwe LGA.

Conclusion/Recommendations

The study has analysed LU/LC changes in Okigwe LGA by applying GIS and remote sensing techniques. The study has evaluated changes in forest, urban development, water body, grass land and agricultural land, from 2000 to 2020, ascertaining that forest, agricultural land, and grass land have reduced by 5%, 3% and 2%, respectively while urban area has increased by about 10% within the two decades studied. Therefore, reduction in all the classes within the two decades studied were because of urbanisation which has increased significantly. The present study has significant practical implications for relevant stakeholders, The study results have filled the gap with respect to paucity of information on how LU/LC in Okigwe LGA has been affected by the passage of time. This information is important because knowing how land-use and vegetation cover in Okigwe LGA has metamorphosed over the years will help planners, researchers and all other stakeholders in making valid decisions thereby fostering sustainable development in the study area. Based on the study findings, it is recommended that adequate considerations be made with respect to land use planning in Okigwe LGA. This will go a long way in fostering ecosystem balance through sustainable resource preservation and conservation. Also, further research is needed in linking population and urban sprawl to LU/LC changes in the study area. This will add to the body of knowledge defining how demography affects urbanisation and changes in LU/LC in the study area.

REFERENCES

Akinyemi, A. I., & Isiugo-Abanihe, U. C. (2014). Demographic dynamics and development in Nigeria: Issues and perspectives. *African Population Studies, 27*(2), 239–248. https://doi.org/10.11564/27-2-471

Congalton, R. G., & Green, K. (2019). *Assessing the accuracy of remotely sensed data: principles and practices*. Boca Raton: CRC press.

Emetumah, F. (2017). Modern Perspectives on Environmentalism: Ecocentrism and Technocentrism in the Nigerian Context. *Asian Research Journal of Arts & Social Sciences*, *2*(4), 1–9. https://doi.org/10.9734/arjass/2017/32821

Ezedike, C., Ohazurike, E., Emetumah, F. C., & Ajaegbu, O. O. (2020). Health-seeking behavior and waste management practices among women in major urban markets in Owerri, Nigeria. *AIMS Public Health, 7*(1), 169–187. https://doi.org/10.3934/publichealth.2020015

Hegazy, I. R., & Kaloop, M. R. (2015). Monitoring urban growth and land use change detection with GIS and remote sensing techniques in Daqahlia governorate Egypt. *International Journal of Sustainable Built Environment, 4*(1), 117–124. https://doi.org/10.1016/j.ijsbe.2015.02.005

Jensen, J. R. (1996). *Introductory digital image processing: a remote sensing perspective.* (Issue

Ed. 2). New Jersey: Prentice-Hall Inc.

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

Njoku, E. A., & Tenenbaum, D. E. (2022). Quantitative assessment of the relationship between land use/land cover (LULC), topographic elevation and land surface temperature (LST) in Ilorin, Nigeria. *Remote Sensing Applications: Society and Environment*, *27*, 1-18. https://doi.org/https://doi.org/10.1016/j.rsase.2022.100780

Nse, O. U., Okolie, C. J., & Nse, V. O. (2020). Dynamics of land cover, land surface temperature and NDVI in Uyo City, Nigeria. *Scientific African*, *10*, 1-23. https://doi.org/https://doi.org/10.1016/j.sciaf.2020.e00599

Nwaogu, C., Okeke, O. J., Fadipe, O. O., Bashiru, K. A., & Pechanec, V. (2017). *Is Nigeria losing its natural vegetation and landscape? Assessing the landuse-landcover change trajectories and effects in Onitsha using remote sensing and GIS*. *9*(1), 707–718. https://doi.org/doi:10.1515/geo-2017-0053

Obiahu, O. H., Yan, Z., & Uchenna, U. B. (2021). Spatiotemporal analysis of land use land cover changes and built-up expansion projection in predominantly dystric nitosol of Ebonyi state, Southeastern, Nigeria. *Environmental Challenges*, *4*, 1-10. https://doi.org/https://doi.org/10.1016/j.envc.2021.100145

Onyenechere, E. C., Asikogu, L. O., Chikwendu, L., Emetumah, F. C., Onyegiri, I., Ukanwa, O. E., Nkwo, J. C., Nwokocha, R. K., & Onyeneke, C. C. (2022). Occupational Health and Safety Conditions of Informal Sector Workers in Three Nigerian Cities. *Afrika Focus*, *35*(2), 318–342. https://doi.org/https://doi.org/10.1163/2031356X-35020006

Sewnet, A. (2015). Land use/cover change at Infraz Watershed, Northwestren Ethiopia. *Journal of Landscape Ecology(Czech Republic)*, *8*(1), 69–83. https://doi.org/10.1515/jlecol-2015-0005

Tewabe, D., & Fentahun, T. (2020). Assessing land use and land cover change detection using remote sensing in the Lake Tana Basin, Northwest Ethiopia. *Cogent Environmental Science*, *6*(1), 1-11. https://doi.org/10.1080/23311843.2020.1778998

Yalew, S. G., Van Griensven, A., Mul, M. L., & van der Zaag, P. (2016). Land suitability analysis for agriculture in the Abbay basin using remote sensing, GIS and AHP techniques. *Modeling Earth Systems and Environment*, *2*(2), 1–14.