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Geospatial Assessment Of Land Use/Land Cover Change And Its Impact On Forest Cover In Owerri, Imo State, Nigeria

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ABSTRACT: Land use and land cover change (LULCC) is one of the principal environmental challenges in different parts of the globe. Consequently, this study evaluated LULCC in Owerri since the last 40years (1980-2020) and next 40years (2020 - 2060) using geospatial techniques. Primary and secondary data were employed for the study. Primary data were systematically collected using Geographical Positioning System; the secondary data (Satellite Imageries of 1980, 2000 and 2020) were acquired from United States Geological Survey (USGS). The imageries were processed, enhanced and classified into four LULC classes using supervised classification in Idrisi and ArcGis10.5. Result showed that forest land, built up, grass/agricultural land and water body were the four major LULC in the study area. Kappa coefficient values of 91%, 85% and 92% for 1980, 2000 and 2020 respectively shows strong accuracy of the classification. There were significant changes in area coverage of different LULC classes. Forest cover was on a continuous decrease while built up, grass land and water body were on a continuous increase. Within the period (1980 - 2020), 210.2km^2 of forest land cover was converted to other land use, while built up, grass land and water body gained 179.05km^2, 24.16km^2 and 7.02km^2 respectively from the original forest land cover. A similar trend of persistent forest reduction and built-up expansion were also predicted. Urbanization, human population explosion and high socio-economic activities were the major factors of LULCC in the area. Proper LULC planning and effective management are emphasised to ensure sustainable development in the area.
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INTRODUCTION

In the last decade, about 13 million hectares of forest cover had been lost each year to other land uses FAO (2010). This has contributed to vast array of environmental challenges ranging from global warming, flooding, loss of biodiversity, land degradation, air and water pollution. Due to the vital role forest vegetation plays to ensure ecosystem sustainability and services such as carbon sequestration to reduce atmospheric carbon concentration, soil enrichment, air and water purification and provision of habitats for many plants and animal species, loss of forest cover have environmental implications. Historically, land use/land cover change has been an old tradition practiced by man to get hold of the basic needs and resources for survival, but the rate has drastically increased due to human population explosion and high socio-economic demands. Ellis (2011) revealed that the populace and their activities on land are the major drivers of LULCC, and have modified most of the telluric biosphere into anthropogenic biomes, and consequently led to series of unhealthy ecological patterns and processes. It has momentous environmental penalties at local, regional and global scales for global biodiversity loss, distress in hydrological cycle, upsurge in soil erosion and sediment loads (Decried *et al*. 2004). Verburg *et al.* (2000) reported that LULCC has turned out to be one of the key factors of environmental susceptibility within the human environment system that directly affects the spatial range of ecosystems through deforestation, fragmentation etc. which consequently, affects the floristic, structural pattern and composition of a region and however decrease species richness and diversity worldwide (Iwara *et al,* 2012).

Seif and Mokaram (2012) have revealed that LULC assessment is an important means for sustainable land management, ecosystem sustainability and environmental planning, because it is comprehensive and critical in assessing the relationships and patterns of anthropogenic activities within a temporal scale. However, proper understanding of how anthropogenic activities affect land use patterns would proffer new scopes to policy making and public policy evaluation (Chakir and Parent, 2008). Therefore, the assessment of LULCC becomes imperative in order to better understand their impacts on forest degradation and the environmental implications.

Remote Sensing and GIS are principal tools for gathering precise and appropriate information on the spatial distribution of land cover/land use changes over large areas; it hasbeen an effective tool to study the changes in LULC across the world (Weng *et al.,* 2004; Chen *et al.* 2006). Consequently, this study utilized remote sensing and GIS technologies to ascertain the extent and rate of LULCC in Owerri for the past 40 years and next 40years. It revealed the trend of land use and land cover changes, the major drivers of the changes and the impacts on forest vegetations. It is hoped that the information will enhance knowledge on the environmental implications of anthropogenic activities andmanagement decisionson the land; thus, promoting sustainable land use management, environmental planning and policy implementation.

MATERIALS AND METHODS

Study Area

Owerri, the capital of Imo State, is in the south-east geopolitical zone of Nigeria. It comprises Owerri Municipal, Owerri North and Owerri West Local Government Areas. Its geographical location is between Latitudes 5°31’0’’N and 5°14’30’’N and Longitudes 6°54'30’’E and 7°11’0’’E in the Southern part of Imo State, with an estimated population of about 401,873 in the year 2006 and 516,610 in 2015 (National Population Commission, 2006). It covers approximately $551km^2$in landmass which cuts across Nwaorie and Otamiri rivers. According to Emeribeole *et al.* (2015) Owerri has two major climatic seasons: the dry season and the rainy season with mean temperature range between 24^0C to 34^0C and relative humidity of 70% in dry months and 90% in wet months. Owerri is the centre of commercial and industrial activities in Imo State, and thus experiences increased urbanization from surrounding rural communities and other states. Figure 1 is the map of the study area.

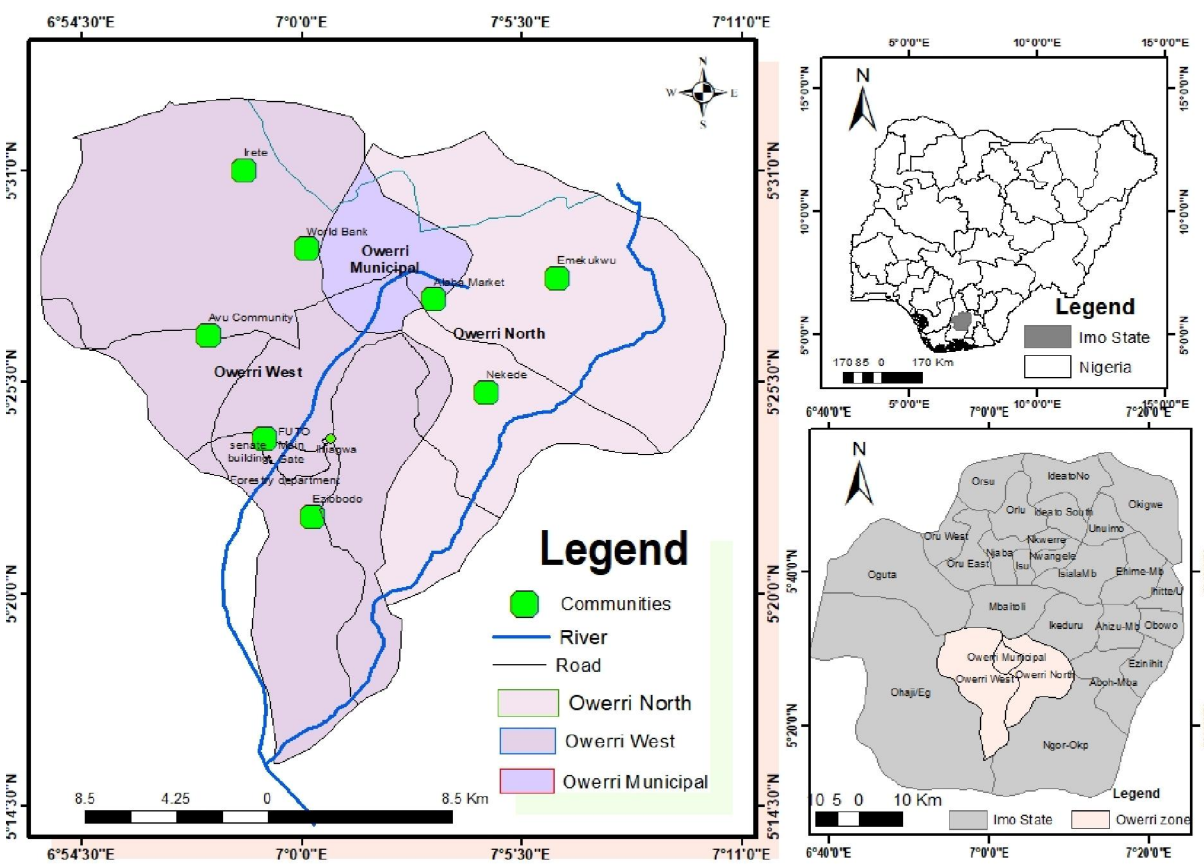


Figure 1: Map of the Study Area

Data Collection

The study employed both primary and secondary methods of data collection. Primary data (Ground truth coordinate points) were collected from the three local governments that make up Owerri, using Geographical Positioning System (GPS), while secondary data (Satellite Landsat Imageries<10% cloud cover) of one season and path 188 and row 56 were got from United States Geological Survey (USGS) in time series; 1980 Thematic Mapper (Tm), 2000 Enhanced Thematic Mapper (ETM) and 2020 Operational Land Imager (OLI) as shown in the table one below.

Table 1: Details of Landsat Imageries Dataset used

Year	Sensor	Scene ID	Path /Row	Date acquired	Resolution
1980	TM	P188r56_5dt19800218_z32_20.tif P188r56_5dt19800218_z32_30.tif P188r56_5dt19800218_z32_40.tif	188/56	18-02-1980	30m
2000	ETM	P188r56_7t20000207_z32_nn20.tif P188r56_7t20000207_z32_nn30.tif P188r56_7t20000207_z32_nn40.tif	188/56	7-02-2000	30m
2020	OLI	LC08_L2SP_188056_20200125_20200824_02_T1_SR_B3.TIF LC08_L2SP_188056_20200125_20200824_02_T1_SR_B4.TIF LC08_L2SP_188056_20200125_20200824_02_T1_SR_B5.TIF	188/56	05-02-2020	30m

Source: http:usgs.gloVis.gov/

Data Analysis

The acquired lands at imageries were pre-processed for geometrical corrections. Image enhancement was carried out on the acquired imageries employing bands 4, 3, 2 for LANDSAT TM and ETM while bands 5, 4, 3 for LANDSAT OLI/TIRS to get false color composite according to (Bayes, 2012). This was necessary to enhance visualization and interpretability of the scenes for classification. The image bands were geometrically rectified to Geographic Coordinate System of the study area – WGS-84-UTM Zone 32N. The study area was then clipped out using administrative map of Nigeria containing Imo State and Local Government shape files in arc map.

The false color composite images were subjected to supervised classification with Maximum Likelihood Algorithm (MLA) to delineate the areas of Landsat images that denote thematic classes as given by maximal spectral heterogeneity (Makinde *et al.*, 2015). Hence, the land covers were classified into four land use classes: Built up, Forest cover, grass land and water body. Forest vegetation are the areas dominated by trees and shrubs; grass land are the areas dominated by grasses, including farm lands and gardens; water body are the areas occupied by streams, rivers, inland waters; while built-up areas are the areas occupied by built structures including residential, commercial, schools, churches, tarred roads and those land surface features devoid of any type of vegetation cover or structures including rocks. Four applications (ArcGis 10.5, Idris software, Excel and Microsoft word) were used in the study.

Confusion matrix was used for accuracy assessment of the classification procedure in accordance with the training samples and the ground truth points as a reference point. This approach has also been adopted effectively in similar studies by Ubaekwe and Engwoh (2020); Suratman and Surayahana (2012), Alatorre *et al.* (2011).

Area coverage of each LULC classes was populated in arcmap. Spatio-temporal changes in the classified LULC within the study periods were computed using the changes in the area in the different years according to (Suratman and Surayahana 2012, Ubaekwe and Engwoh 2020).

Land Change Modeling using Cellular Automata and Markov Chain algorithm in idrisi software was employed for prediction analysis (Souidi *et al*, 2019). Then land cover scenario for the year 2060 was modeled.

RESULTS

Land Use/Land Cover Classifications and Accuracy Assessments

The four major Land Use and Land Cover classes observed in the study area for the period of 1980, 2000, 2020 and 2060 are presented in Figure 2. In 1980, it can be observed that forest dominates the entire area, followed by the built up, patches of grasses and traces of water body. The same trend is observed in 2000, with slight increase in built up areas. In 2020 and 2060, built up dominates the area mostly in 2060 map, with patches of grass lands, water body and reduced forest lands. The accuracy assessment of the LULC classifications for the study periods are presented in table 1. The overall accuracy and Kappa Coefficient values were 94% and 91% for 1980, 89% and 85% for 2000 and 94% and 92% for 2020, respectively.

Area Coverage of different LULC classes

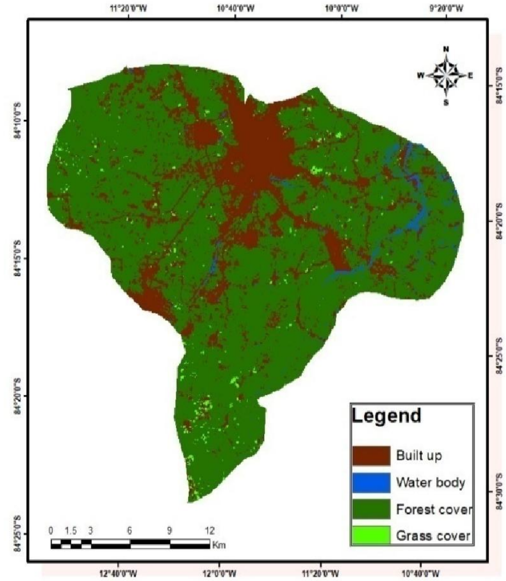
Figure 3 shows the area coverage of different LULC classes within the periods of 1980, 2000, 2020 and 2060. In 1980, built up area covered128.48km^2, forest land 402.06km^2, grass land 9.07km^2, water body 11.41km^2, and total land area of approximately 551km^2. In 2000, built up increased to 186.42km^2, forest land reduced to 327.34km^2, grass land and water body increased to 22.90km^2 and 14.39km^2, respectively whereas the total land area remained the same. In 2020, built up, grass land and water body hugely increased to 307.53km^2, 33.23km^2 and 18.43km^2 respectively with significant reduction in forest cover to 191.86km^2, while the total land area remained the same. In 2060 prediction, built up largely increased to 413.27km^2, forest land drastically reduced to 93.32km^2, grass land slightly reduced to 24.47km^2 with slight increase in water body to 19.95km^2 while the total land area remained the same.

Change Detection

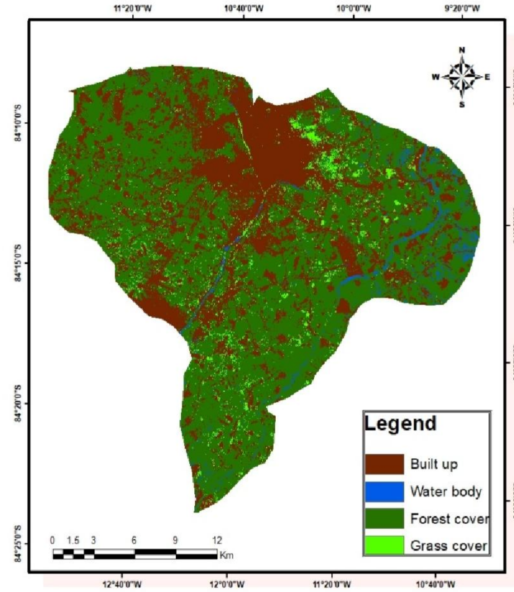
Table 2 shows the results of the changes observed in the different land use/land cover from 1980 to 2060. Between 1980 to 2000, built up areas gained or increased by 57.94km^2 at the percentage of 38.76%, forest land lost 74.72 km^2 to other land use land cover at the percentage of 49.99%, while grass land and water body gained 13.83 km^2 (9.25%) and 2.98 (1.99%) respectively. Between 2000 to 2020, built up areas gained 121.11km^2, (44.7%), forest land lost 135.48 km^2, (50%) while grass land and water body gained 10.33 km^2 (3.81%) and 4.04 km^2(1.49%) respectively. From 2020 to 2060, built up areas would be expected to gain 105.74 km^2, (49.28%), forest and grass lands to lose 98.54 km^2 (45.93%) and 8.76 km^2 (4.08%) respectively, while water body would gain 1.52 km^2, (0.71%). In other words, between 1980 to 2020, forest cover reduced from 402.06 km^2 total area to 191.86 km^2, and will decrease to 93.32 km^2 by the year 2060. There has been progression in built up from 128.48 km^2 in 1980 to 307.53 km^2 in 2020, and will increase to 413.27 km^2 by the year 2060.

Table 1: Accuracy assessment of the classification

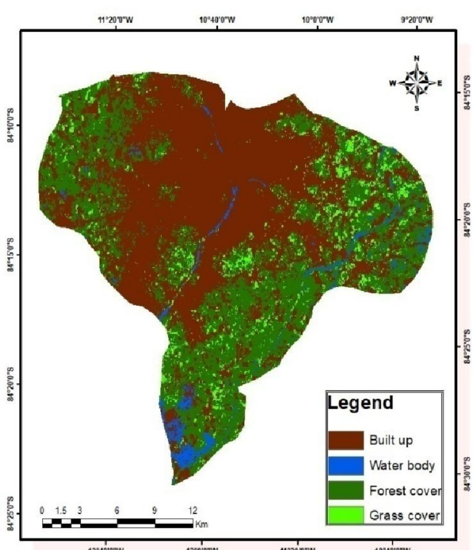
LULC Classes	**1980 PA**	**1980 UA**	**2000 PA**	**2000 UA**	**2020 PA**	**2020 UA**
Forest	0.88	0.90	0.92	0.75	0.94	0.92
Grass	0.90	0.98	0.94	0.69	0.96	0.94
Water	**1.00**	0.98	0.74	0.80	0.94	0.98
Built up	0.96	0.89	0.94	0.88	0.92	0.92
Over all accuracy	**0.94**		**0.89**		**0.94**	
P(r)	0.25		0.25		0.25	
Kappa Coefficient	0.91		0.85		0.92	
Kappa (%)	**91**		**85**		**92**	



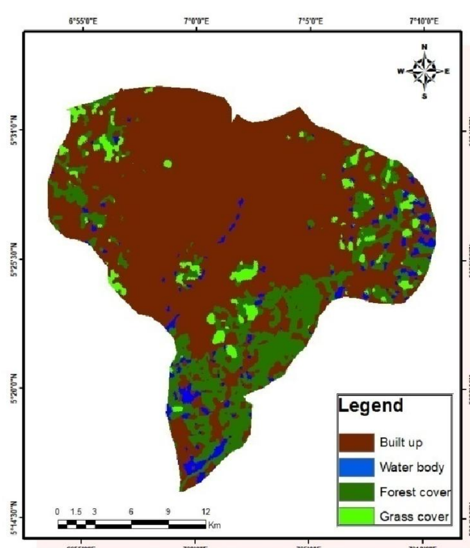
Owerri 1980



Owerri 2000



Owerri 2020



Owerri 2060

Figure 2: LULC Classification of 1980, 2000, 2020 and 2060 prediction
Where PA= Producer's Accuracy, UA= User's Accuracy

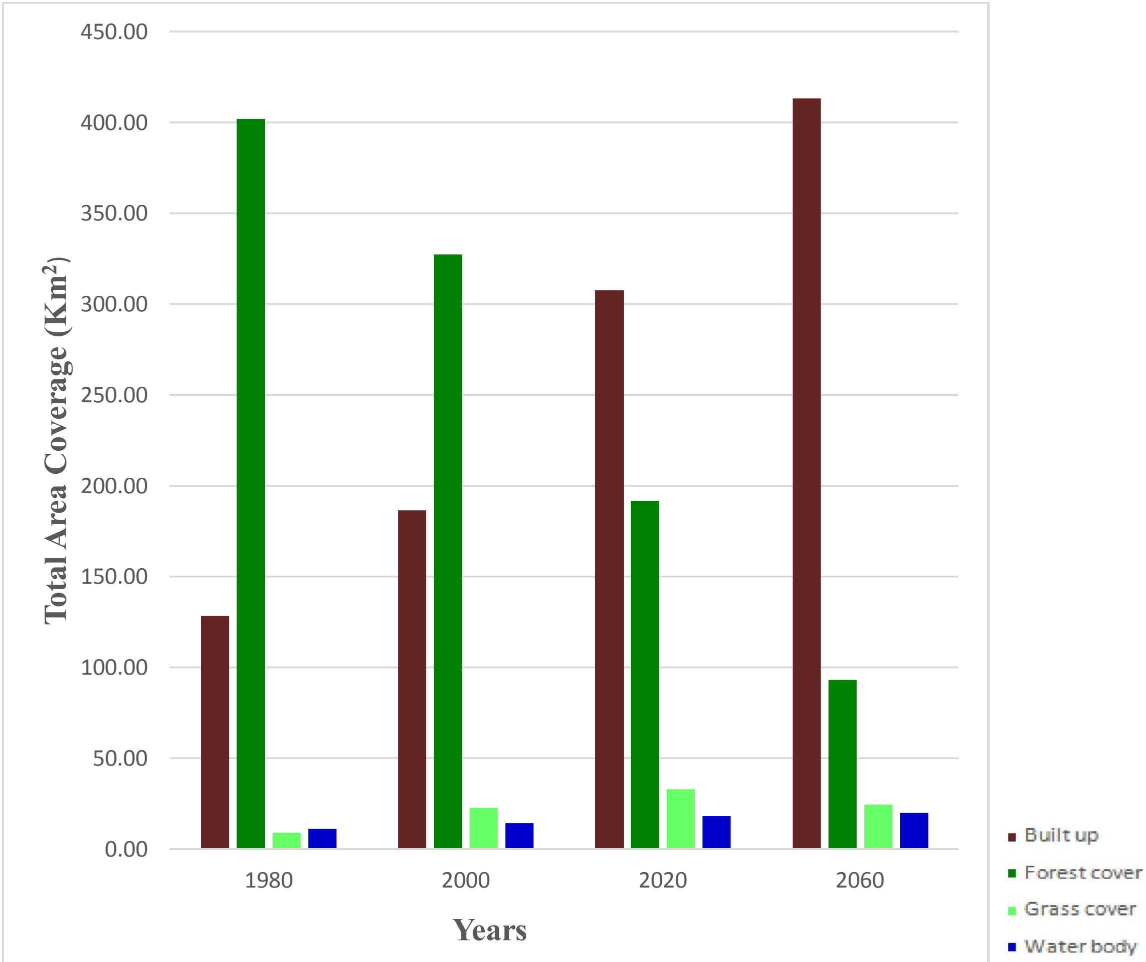


Figure 3: Area Coverage of Different LULC Classes of 1980, 2000, 2020 & 2060

Table 2: LULC Change (Km^2) Detection

Lulc Classes	**1980-2000**	**% Change**	**Remark**	**2000-2020**	**% Change**	**Remark**	**2020-2060**	**% Change**	**Remark**
Built-up	57.94	38.76	**Gain**	121.11	44.70	**Gain**	105.74	49.28	**Gain**
Forest Cover	-74.72	50.00	**Loss**	-135.48	49.98	**Loss**	-98.54	45.93	**Loss**
Grass Cover	13.83	9.25	**Gain**	10.33	3.81	**Gain**	-8.76	4.08	**Loss**
Water Body	2.98	1.99	**Gain**	4.04	1.49	**Gain**	1.52	0.71	**Gain**

DISCUSSION

The results of the accuracy assessment of the classifications indicated strong classification performance. According to Jensen (2005) and Lilles *et al*. (2004), Kappa values greater than 80% indicate strong classification performance, Kappa values between 40 and 80% indicate good classification performance and Kappa values of less than 40% indicate poor classification performance.

It was observed that the areas covered by forest vegetation were on a continuous decrease while built-up areas were on a continuous increase. Forest land cover was the major land cover in 1980, but gradually reduced as a result of human induced factors, while built ups continued to increase and gradually became the major land cover in 2020 and will continue to dominate the area by the year 2060. This is in line with the findings of Ukaegbu *et al.* (2017) and Emereibeole *et al*. (2015) in the same study area, Ubaekwe and Engwoh 2020 in Ikorodu, Lagos State, and Prakasam (2010) in Kodaikanaltaluk, Tamil Nadu. The continuous decrease and increase in forest cover and built up, respectively could be linked to many factors such as human population explosion, urbanization, industrialization, uncontrolled anthropogenic activities, as well as poor environmental management practices, weak environmental policies and poor policy implementations. Obviously, increase in human population directly increases the demands for more lands for settlements, increases the commercial activities and will gradually result to industrialization, rapid infrastructural development and urbanization. Increase in human population could also increase the levels of anthropogenic activities in the area such as deforestation, intensive farming, sand mining etc. This is similar to the report of Adeola *et al*. (2004), Madulu (2004), Ubaekwe and Engwoh 2020, that rapid human population growth is one of the major causes of forest degradation especially in a developing country like Nigeria where economic growth is seen as the only measure of development. In other words, the large expanse of forest land cover observed in 1980 could be attributed to low human population, poor infrastructural development and less socio-economic activities in the study area. Evidently, forest land cover suffers in the face of industrialization, urbanization, human population increase and infrastructural development; due to the fact that Governments and some individuals are more interested in the immediate economic growth, hence pay little attention to the environmental services that forest vegetations provide. This could be linked to many environmental crises facing us today among which are flooding, loss of biodiversity, land degradation, water and air pollutions, and climate change. This supports the report of Ukaegbu *et al.* (2017), who revealed that Owerri is experiencing increase in land surface temperature as a result of forest conversion, and thus recommended greening of entire city of Owerri and its environs. Grass lands and water bodies are also on the increase within the study periods. These could also be linked to human factors mentioned above.

The result of the prediction analysis has shown a similar trend of persistent forest reduction and built-up expansion. If the trend continues, by the year 2060 forest vegetation cover would be drastically reduced to 16.94% and grass lands 4.44%, while built ups will massively increase to 75% with slight increase in water body (3.62%). These will consequently double the environmental crisis already existing in the study area. Furthermore, it was observed that grass land which comprises of sparse vegetation, farm lands and grasses will lose 8.76km^2 to other land use land cover by the year 2060. This could be an indication that by the year 2060, some areas of farm lands and grass lands like fields will be converted to built-ups, and consequently reduced the available land for agriculture and thus the number of farmers in the study area. This probably would lead to shortage of food production and thus hunger and high cost of food stuffs may be inevitable in the study area by the year 2060.

CONCLUSSION AND RECOMMENDATIONS

This research work has successfully identified, examined and simulated future land use/land cover trends in Owerri, Imo State using Satellite data from 1980 to 2060. The study has shown the efficiency of GIS and Remote Sensing in capturing spatio-temporal data for various LULC assessments. Between 1980 and 2020, there were significant changes in land use/land cover. Forest cover was on a continuous decrease while built up, grass land and water body were on a continuous increase. Within the period (1980 - 2020), 210.2km^2 of forest land cover was lost or converted to other land use, while built up, grass land and water body gained 179.05 km^2, 24.16 km^2 and 7.02 km^2 respectively from the original forest land cover. The trend continued in the prediction (2020 - 2060) suggesting that in the nearest future, the remaining forest vegetation would be gradually be wiped out with grave environmental consequences.

In view of the observed trend in LULCC, concept of sustainable development which includes the environmental, social, economic and institutional dimensions should be adopted in the study area. Environmental Impact Assessment (EIA) should be carried out before any major industrial project is situated in the area. Policy makers should certify that the existing/future polices with regard to environmental degradation is implemented to the letter while also ensuring that land use/land cover mapping is done on a regular basis. The need for tree planting and increased awareness on the impacts of forest conversion/deforestation on our environment and general wellbeing is emphasized.

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