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Spatio-Temporal analysis of Land-Use and Land-Cover dynamics in Oghara, Delta State, Nigeria

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ABSTRACT

This study investigates the spatio-temporal dynamics in land use and land cover (LULC) in Oghara, Delta State, Nigeria between 1991 and 2019 using GIS and remote sensing technology. The study used Landsat 5 TM images for 1991 and Landsat 7 ETM+ images for 2002 and 2019. Land-use and land-cover change detection were done with the aid of ENVI software version 5.3 for image pre-processing, image classification, accuracy assessment, post-classification process, thematic change detection and statistical results and ArcGIS desktop version 10.3 (ESRI) for editing boundary of the study area, post-classification processes, map layout and visualization. The study revealed that continuous increase in human population and consequent spatio-physical development impact on land-use patterns and land-cover characteristics of the area between 1991 and 2019. The study covered 264.15Km^2. Built-up areas increased from 12.10 km^2 (4.585%) to 22.72 km^2 (8.60%), forested areas decreased from 142.49 km^2 (53.94%) to 81.30 km^2 (30.78%) and mangrove areas decreased from 51.27 km^2 (19.41%) to 48.56 km^2 (18.38%). Also, cultivated/grassland areas increased from 50.77 km^2 (19.22%) to 102.66 km^2 (38.86%) and areas covered by water bodies increased from 7.52 km^2 (2.85%) to 8.80 km^2 (3.33%), thus, indicating a high rate of deforestation and general land surface cover dynamics. The study recommends the establishment of forest reserves, enactment and enforcement of laws on forest protection and education of population on the importance of forests and sustainable use of forest resources.

Keywords: Delta State, Geographic Information System, land-cover, land-use, remote sensing.

1. INTRODUCTION

Human settlements, including urban centres are dynamic as they continue to experience increasing population and spatial growth: A process called urbanization (Nuissi and Siedentop, 2020). Urbanisation according to Igben, (2021) is manifested in increased heterogeneity of the population and economic activities as well as physical development of spaces for dwelling units and business ventures; thus, impacting on both land-use and land-cover of an area.

Therefore, Land-use and Land-cover change (LULC) is one of the consequences of human interactions with natural environment (Lambin et al., 2003; Lambin and Geist, 2006; Mucova et al., 2018; Dahal, 2021).

Though the terms land-use and land-cover (LULC) are commonly used mutually and sometimes synonymously, they are discrete in meaning. Land-cover simply refers to the physical and natural layer which covers the earth surface that has not been impacted by human activities. These include earth's surface natural cover such as deserts, water, vegetation and soil. By extension, land cover change denotes metamorphosis in the natural surface characteristics of the land while land-use is the type of human activity as it relates to the surface of the earth. Land-use change consists of human-induced modifications of the land surface (Zhang and Li, 2022).

Following from the above, Giridharan and Emmanuel, (2018) defined land-use and land-cover change as the modification of the surface features on the earth's landscape which can be distinguished by their surface features or appearance at different times. It is the spatial and temporal dynamics that occur in the natural surface of the earth crust mostly as a result of the activities of man such as urbanisation, industrialisation and agriculture. Prime among these three drivers of LULC change is urbanisation. However, natural phenomena such as earthquakes, water and wind erosion may cause changes in land cover change, unlike land-use change which is the consequence of human activities.

The United States Geological Survey (USGS) classification of land-use and land-cover change is widely used in most LULC studies. This classification identified different levels of land-use arranged in a hierarchical or nested order from level I to IV. Level I include broad land-use categories such as 'agriculture' or 'urban and built-up' areas. This level of classification is commonly used for regional and other large-scale applications. Within this level I category are a number of more detailed (level II) land-use and land-cover classes. For example, the 'urban and built-up' class includes 'residential,' 'commercial' and 'industrial' sub-classes. Furthermore, each of the level II classes contains detailed sub-divisions (La-Gro, 2005).

Most studies of land-use and land-cover changes in Nigeria are spatio-temporal in nature. Consequently, remote sensing and geographic information system (GIS) are major tools employed to monitor and obtain precise information about the spatial and temporal distribution of land-use and land-cover changes at local, national and regional scale (Enoguanbhor et al., 2019; Nkwunonwo, 2013; Owoeye and Ibitoye, 2016; Abiodun et al., 2011; Jaishi & Budhathoki, 2021; Otokiti et al., 2021; Mukhtar & Raphael, 2022). Bariweni and Andrew, (2017) study of land use and land cover changes in the Wilberforce Island using non-existent data with a view to determining rate of deforestation and changes in the vegetation cover for a 13 – year period showed that the main rationale for deforestation were logging, farming, building of houses and fuel wood fetching.

Similarly, Izah et al., (2018) present a land use change pattern analysis in the three geopolitical zones of southern Nigeria for 2000, 2005, 2010 and 2016 using Time Series Analysis. The results indicated significant dynamics in land use from 2000 to 2016 as it relates to the built-up land, forestland, farmland and mixed land in the study area. On the other hand, water body and rock outcrop land show less significant land use change. Other types of land use decreased as the built-up land increased. Furthermore, Haruna et al., (2019) conducted an assessment of land-use and vegetation cover in Kano metropolis from 1975-2015 using spatio-temporal tools.

In the same vein, Odjugo et al., (2015) analysis of the spatio-temporal pattern of growth in Benin City using Landsat of the US. Geological Survey (USGS) showed that the growth of Benin City is towards the east, south and North. In addition, the growth of Benin City towards the east, south and north and that the settlement expanded from 220km^2 in 1987 to 358km^2 in 2013, with an average annual growth rate of 1.5 percent. In a similar study, Olayiwola and Igbavboa, (2014) monitored the growth of Benin City between 1987 and 2008 with the aim of observing the trend of urban growth in Benin City vis-a-vis its consequence on the land use pattern. The study showed that urban growth in the city is directly affect by depletion in vegetation resources and pose a threat to the environment.

Abbas, (2012) attempted a comparison of the land use/land cover dynamics for 1986 and 2008. The data input used in the study were Landsat TM imagery of 1986 and Nigeriasat-1 imagery of 2008 and were analysed using ArcView GIS environment for geo-referencing and on-screen digitization of the needed layers. The land use-land cover layers for 1986 and 2008 were therefore generated. The magnitude, trend and annual rate of change analysis were generated from the land use-land covers for the years-1986 and 2008. The study showed that there was high rate of land use-land cover change leading to decimation of sources of livelihood and resettlement of the people.

In spite of the plethora of studies on land-use and land-cover changes in Nigeria, none has been done in the study area. In addition, the study area is experiencing rapid urbanisation and land-use and land-cover dynamics as a result of increasing physical development, which impacts on the socio-economic activities of the population. Therefore, there is the need to empirically assess the extent of land-use and land-cover dynamics. Consequently, this study aims to evaluate the land-use/land-cover changes in

Oghara, Delta State between 1991 and 2019. An understanding of land-use and land-cover change would provide comprehensive data to estimate and assess the past, current changes in the landscape particularly with a view to planning and sustainable development.

2. MATERIALS AND METHOD

Study Area

This study area, Oghara comprises twenty-settlements divided into two sub-groups: Namely, Ogharefe and Oghareki, in Ethiope West Local Government Area (LGA) of Delta State, Nigeria. The LGA is located in the southern part of Nigeria and lies within latitudes $5^0$54' 01'' N and 6^0 4' 25.00" N; and longitudes 5^0 36' 00" E and 5^0 46' 00.41"E, over an area of about 1,775 square kilometres. It is bordered by the River Ethiope and its adjoining tributary in the east and south respectively. To the north, it is bordered by the Osiomo/Ologbo River and to the southwest by Koko town in Warri North Local Government Area.

Oghara has a tropical climate characterized by uniformly high rainfall and temperature throughout the year. It is marked by two distinct seasons: The dry season and the rainy seasons. The dry season occurs between November and April, while the main rainy season begins in April till October. The dry season starts in November and ends in February. The average annual rainfall is high, about 266.5cm. Rainfall is heaviest in July and no month is completely rainless. January, which is the driest month, is characterized by rainfall of up to 2.5cm of rain in most years (Aweto and Igben, 2003). The period from December to February is usually marked by relatively cool, dry and dusty weather called the 'harmattan'.

Temperatures are generally high throughout the year, with a mean of between 24^0C (75.2^0F) and 27^0C (80.4^0F). There is no significant variation in diunal temperatures. There is, however, a slight seasonal variation averaging about 25^0C (82^0F) in the rainy season and 28^0C (82^0F) in the dry season. Relative humidity is normally over 90 percent in the early morning, but falls to between 60 and 80 percent in the afternoon (Udo, 1970).

Furthermore, Oghara lies in the lowland rainforest belt characterized by evergreen rainforest which contains valuable trees such as mahogany (*Khaya Spp*), African walnut (*Lovoa trichilioides*), iroko (*Chlorophora excelsa*), abura (*Mitragyna ciliata*), sapele wood (*Entandrophragma cylindricum*) and obeche (*Triplochiton scleroxylon*). However, there are mangrove and fresh water swamp forests along river basins. Associated with the mangrove forest are *Conocarpus erectus* and other woody species that grow at the edge of the swamps. The fresh water swamps contain floating grass, screw pine (*Pandanas candelebrum)* and raffia palm (*Raphia hookeri*) as the most common tree types (Igben, 2012).

The 2006 provisional national population census put the population of Oghara at 202,712 persons, made up of 102,750 males and 99,962 females (NPC, 2007). However, the population of the area is estimated to be over 300,000 persons in 2020 using the national growth rate of 3.0 percent. Facilities exist for primary and comprehensive health care in Oghara. There is also a tertiary health institution (Delta State University Teaching Hospital) at Oghara. Educational institutions cover the primary, secondary and tertiary levels, consisting of both private and public types.

One of the polytechnics in Delta state is located at Otefe-Oghara and a private university, Western Delta University is also located in the clan. In addition, the area is home to the Nigerian Navy Headquarters (Logistic Command) and a Squadron of the Nigerian Police (Mobil Unit). The East-West Road, which links the western part to the eastern part of the country, passes through the clan. Moreover, the clan is well connected with a network of roads. This couple with large expanse of fertile land for agricultural activities makes it very strategic for a lot of economic activities: Hence the high rate of urbanization.

Data Source and Acquisition

Landsat satellite imagery of the United States Geological Survey (USGS) was employed in this study. Images from Landsat 5-TM for the year 1991 and Landsat 7 ETM+ for the year 2002 and 2019 were used. The study area path and row scene (189/56) were obtained by a search function on the USGS website. This study accessed a 28-year temporal resolution period. In order to get quality images, all images downloaded had less than 10% land and scene cloud cover. Attempts were made to download images of same day in September across the years but the unavailability of quality images with less than 10% land and scene cloud cover necessitated the use of images of different days but within a week.

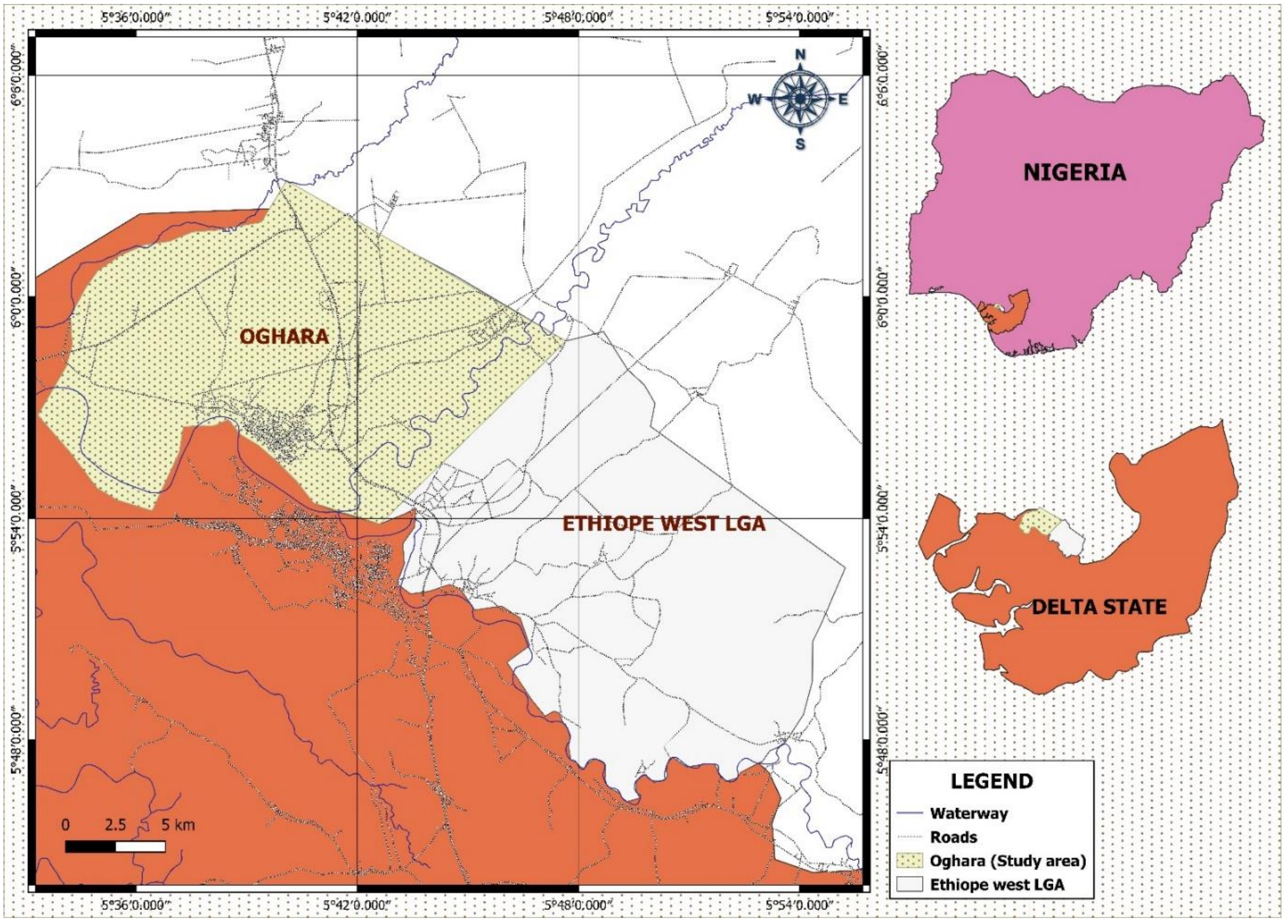

Figure 1 Map of Study Area
Source: Igben and Eregare, (2022)

Data Analysis

The software packages used for land-use/land-cover change detection study are: (i) ENVI software version 5.3 (Harris Geospatial Solutions, 2014) which was used for image pre-processing, image classification, accuracy assessment, post-classification process, thematic change detection and statistical results. (ii) ArcGIS desktop version 10.3 (ESRI) used for editing boundary of the study area, post-classification processes, map layout and visualization.

Land-Use and Land-Cover Analysis Process

Land-use and land-cover detection process in this study can be grouped into three main processes; namely, image pre-processing, image processing and post-classification comparison as in (Figure 2). Image pre-processing involves radiometric correction, geometric correction, scenes mosaic (Area with more than one scene) and masking study area. Image processing is the second stage which produces thematic classification maps of the three period images; this process consists of visual interpretation, training land-use/land-cover samples, maximum likelihood supervised classification and finally the accuracy assessment of the classified images. The last stage is the post-classification process which includes classification refinement, change detection analysis, change detection maps and statistical report.

Image pre-processing

Pre-processing of satellite images for change detection is very important (Andualem et al., 2018). It is an essential process to remove noise and increase the interpretability of image data; this process is necessary for time series analysis (Yichun et al., 2008). Satellite image processing composed of techniques and procedures which include radiometric and atmospheric correction; geometric correction and masking study area. Radiometric and atmospheric correction is used for scene illumination atmospheric conditions and correction for variations of the viewing geometry and instrument response characteristics to create a consistent and reliable image database. This study adopted pre-processing operations including radiometric and atmospheric correction and image enhancement and study area masking using ENVI 5.3 software.

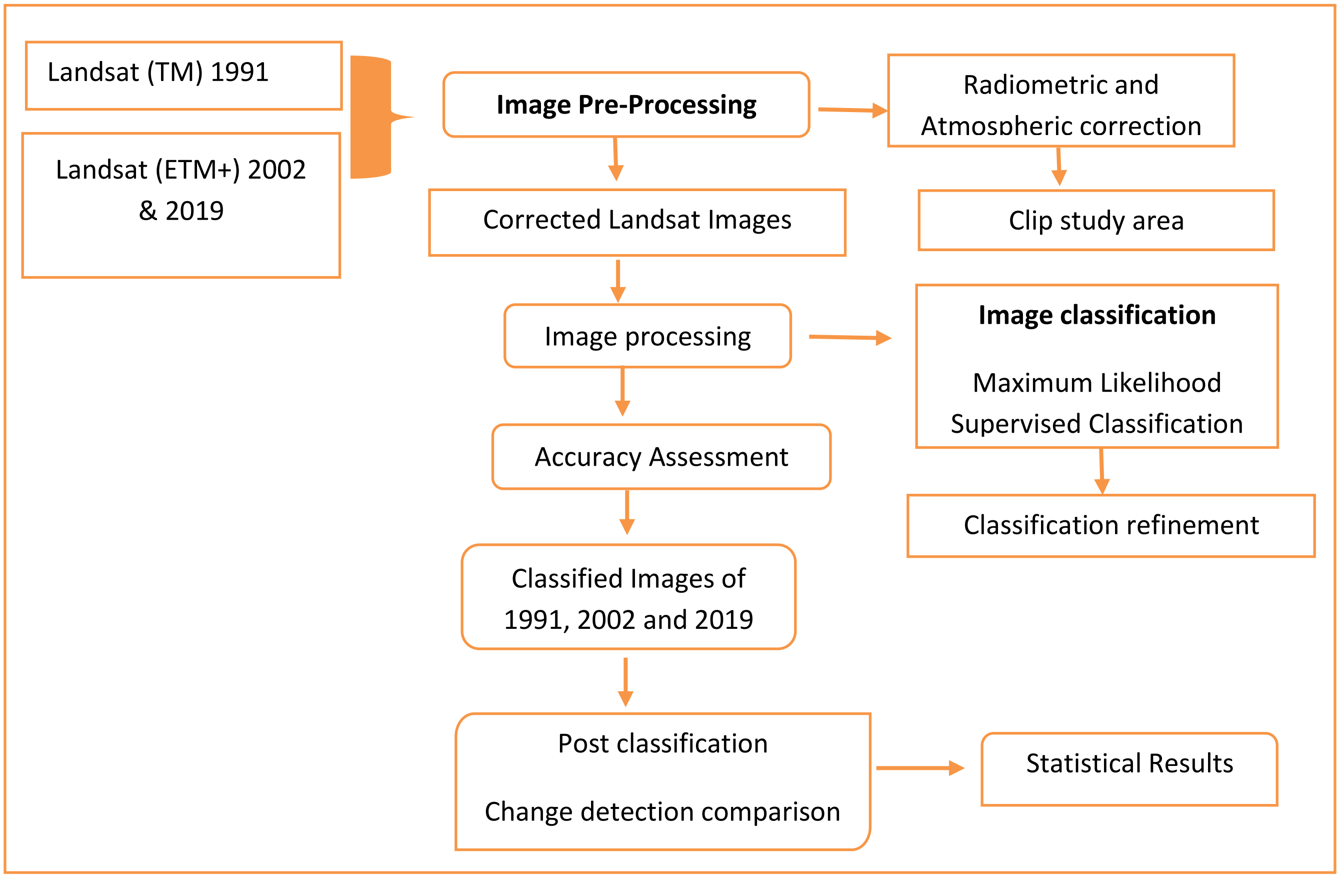

Figure 2 Schematic Representation of Procedure for Mapping Land Use-Land Cover Change and Detection
Source: Adapted from Igben and Eregare, (2022)

Image processing
In this study, Maximum likelihood supervised classification technique was used for the image classification of land use and land cover of Landsat images. In order to apply supervised classification method on Landsat images, five classes from the Anderson et al., (1983) level 1 classification were adopted namely built-up area, barren land, water bodies, mangrove, cultivated/grassland and forest land covers.

Image classification
For supervised classification, training signature samples were carefully collected. The study area was classified into five land-use/land-cover classes. The selected training samples were by the identification of land-use/land-cover classes from Landsat images. Multiple band combinations of Landsat images, in Figure 3, were used to aid the visual interpretation of land-use and land-cover classes from images and presented in (Table 1).

Accuracy Assessment
The accuracy assessment of the Landsat 1991, 2002 and 2019 images classification were carried out using the confusion matrix using ground truth samples from Google Earth. The confusion matrix shows the relationship between known reference data (ground truth data from high resolution image) and the corresponding land-use/land-cover classification map. The values in confusion matrix represent the count of pixel of each class which correctly classified in the right class. The result of an accuracy assessment typically provides users with an overall accuracy of the classification image and the accuracy for each class in the classification image. Maps used for land-use and land-cover analysis are produced with a high accuracy, at least above 85% as recommended by Manandhar et al., (2009). The accuracy of the analyses of this study for 1991, 2002 and 2019 were 91.35%, 89.77% and 90.08% respectively, which are all acceptable.

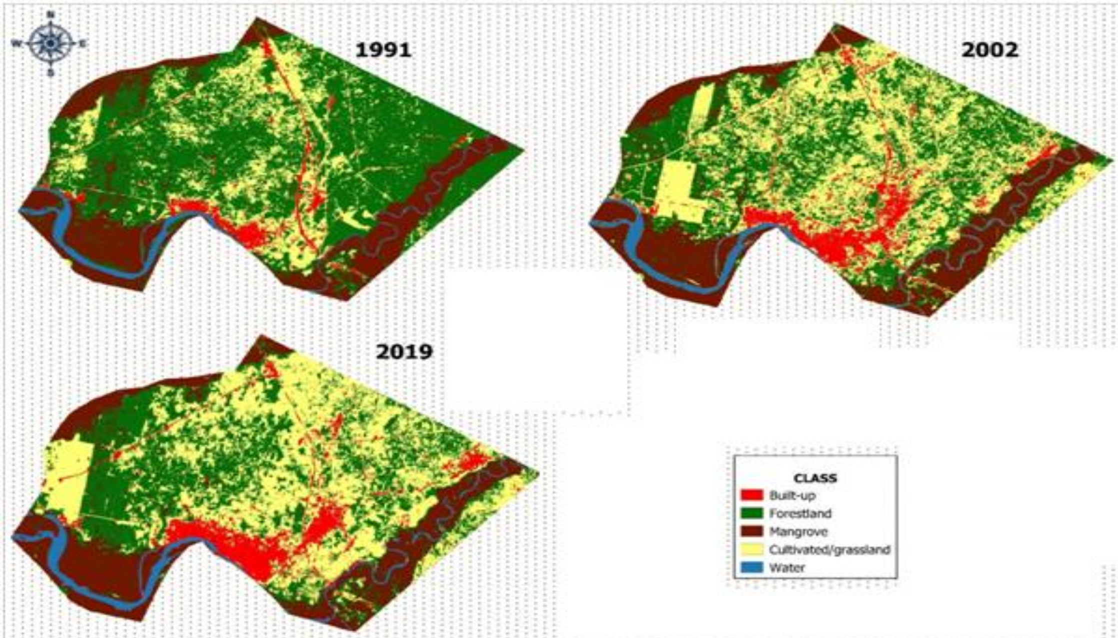

Figure 3 Land-Use and Land-Cover dynamics in Oghara (1991 – 2019)

Source: Images from Landsat 5-TM for 1991 and Landsat 7 ETM+ for 2002 and 2019

Table 1 Land-use and land-cover classification names, description and number of trained samples for each class of Landsat datasets

Class	Description	Number of samples (1991)	Number of samples (2002)	Numbers of samples (2019)
Built-up Area	A concrete structure such as residential, industrial, roads and other uses	40	41	42
Mangrove	Mangrove vegetation	25	22	22
Water Bodies	Reservoirs and rivers	30	32	32
Cultivated/grassland	Agriculture, grass vegetation and crop land	49	50	50
Forest land	Forest cover (trees)	50	53	53

Source: Landsat 1991, 2002 and 2019 Images of Oghara, Delta State

3. RESULTS AND DISCUSSION

The dynamics in land-cover during the period under consideration in Oghara, Delta State between 1991 and 2019 is in (Table 2). Of the total area of 264.15 Km^2 covered by the imageries, built-up areas increased from 12.10 km^2 (4.58%) to 22.72 km^2 (8.60%). Forested areas decreased from 142.49 km^2 (53.94%) to 81.30 km^2 (30.78%). While areas under mangrove vegetation decreased marginally from 51.27 km^2 (19.41%) to 48.56 km^2 (18.38%) between 1991 and 2019, cultivated and grassland areas increased from 50.77 km^2 (19.22%) to 102.66 km^2 (38.86%). Areas covered by water bodies increased from 7.52 km^2 (2.85%) to 8.80 km^2 (3.33%).

For the period between 1991 and 2002, there was a remarkable increase of 87.77% in the size of built-up area. This increase is attributable to the spatial growth of the town between the periods of study. Oghara, being an oil-producing area and the headquarters of Ethiope West LGA attracted people in search of employment opportunities. The spatial growth and increased population also resulted in the establishment of primary health care centres, construction of roads and building of schools in the area: Hence, built-up areas increased from 12.10 km^2 in 1991 to 22.72 km^2 in 2002. This finding is in line with the study of Wizor and Okugini, (2020) which revealed that increases in built-up areas in Ukwuani LGA of Delta State due to oil exploration and subsequent increase in population and economic activities.

Table 2 Land-Use and Land-Cover in Oghara between 1991 and 2019

Classes	1991 (Km^2)	2002 (Km^2)	2019 (Km^2)
Built-up	12.10 (0.68%)	22.72 (1.28%)	22.84 (1.29%)
Forest	142.49 (8.02%)	88.32 (4.97%)	81.30 (4.57%)
Mangrove	51.27 (2.89%)	50.02 (4.38%)	48.56 (5.78%)
Cultivated/grassland	50.77 (19.22%)	95.67 (36.21%)	102.65 (38.86%)
Water	7.52 (0.42%)	7.44 (0.41%)	8.80 (0.68%)

Source: Landsat 1991, 2002 and 2019 Images of Oghara, Delta State

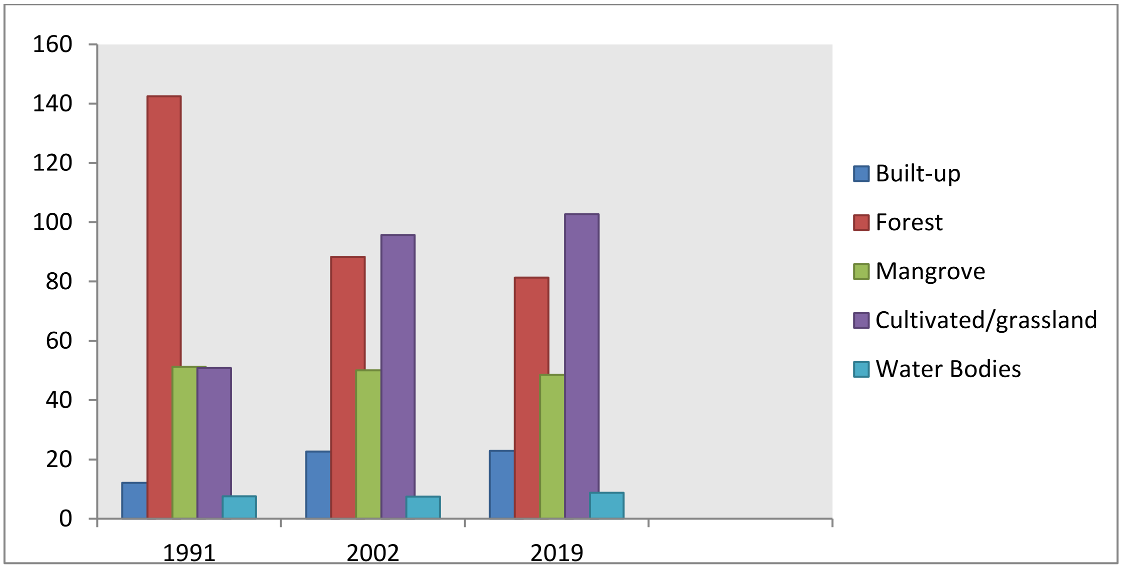

Figure 4 Land-Cover and Land-Use Change in Oghara between 1991 and 2019

However, there was slight increase in the size of built-up areas in Oghara with only 0.53% between 2002 to 2019. The only major driver of this increase during this period was the establishment of the Western Delta University in 2007. This finding is in line with Ejemeyovwi, (2015) study which showed that the establishment of the Delta State University Campus in Asaba caused an increase in built-up areas in Asaba, the capital of Delta State. Nevertheless, there was a massive reduction in the size of forested area in the study area between 1991 and 2002. Also, the period between 2002 and 2019 experienced a further decrease in forested areas to about 7.02 km^2 less than the 2002 value. Oghara area is an agrarian community which cultivates crops as rubber, cassava, palm trees, plantain, bananas, yam and vegetables.

The use forested lands for agricultural activities is a major driver of deforestation in the study area. Other drivers of deforestation in the area include harvesting of fuel wood and clearing of land for urban infrastructural development. This development is in tandem with a study by Atubi et al., (2018) which showed that conversion of land for agricultural and other developmental use contributed to the land-cover changes in Warri metropolis, Delta State, Nigeria. This view is corroborated by Fabiyi, (2011) who highlighted the factors among those contributing to loss of forest and vegetation in parts of the Niger Delta.

For the period under consideration, the areas covered by mangroves experienced the least reduction with 1.25 km^2 between 1991 and 2002 and 1.46 km^2 between 2002 and 2019 for a total reduction of 5.29% from the 1991 value. This is due to the presence of other tree species in the area which serve as source of raw materials for fuel wood, construction materials, medicinal extracts.

The use of those other tree species such as mahogany (*Khaya Spp*), African walnut (*Lovoa trichilioides*), iroko (*Chlorophora excelsa*), abura (*Mitragyna ciliata*), sapele wood (*Entandrophragma cylindricum*) and obeche (*Triplochiton scleroxylon*) for the uses listed above decreased the dependence on mangrove trees resulting in low rate of cutting down these trees and is reflected in the little changes detected in the size of the mangrove areas during the period under consideration. This finding is supported by Eleanya et al., (2015) study which revealed that harvesting of appropriate trees within the mangrove biome for intended uses was preferred to cutting down mangroves in some parts of the Niger Delta.

Furthermore, there was a marked increase in the area under cultivation and grassland in the study area. Between 1991 and 2002, these areas increased by 44.90 km^2. This increase correlates with the period of increased influx of people into Oghara community in search of new opportunities for a better life. The increase in population was followed by an increase in agricultural activities which involved cutting down trees and bush-burning to convert land for agricultural purposes, this led to Oghara being a predominantly agrarian society. This result is in agreement with Bariweni and Andrew, (2017) study which showed that conversion of land for agricultural purposes directly increased cultivated/grassland areas in Wilberforce Island in Bayelsa State, Nigeria.

Between 2002 and 2019, the cultivated/grassland areas increased by 6.99 km^2. This increase is much less than that between 1991 and 2002 and can be attributed to reduced interest in agricultural activities among the population, migration of a large portion of the population and oil contamination of potential agricultural lands. This view approximates the result of Ikehi et al., (2014) study which highlighted these factors as among those that affect agriculture in the Niger Delta region.

Similarly, the area covered by water decreased by 0.08 km^2 between 2002 and 2019. However, it increased by 1.36 km^2; with a net increase of 17.02% between 2002 and 2019. The result of this study contradicts that of Wizor and Okugini, (2020) which indicated decreases in areas covered by water in a study in Ukwuani LGA of Delta State, Nigeria. Similarly, Ejemeyovwi, (2015) study in Asaba showed no changes in areas covered by water bodies between 1991 and 2015.

4. CONCLUSION

This study is on spatio-temporal analysis of land-use and land-cover dynamics in Oghara in Ethiope West Local Government Area of Delta State, Nigeria between 1991 and 2019 using GIS and remote sensing technology. The study used Landsat 5 TM images for 1991 and Landsat 7 ETM+ images for 2002 and 2019. Land-use and land-cover change detection were done with the aid of ENVI software version 5.3 for image pre-processing, image classification, accuracy assessment, post-classification process, thematic change detection and statistical results and ArcGIS desktop version 10.3 (ESRI) for editing boundary of the study area, post-classification processes, map layout and visualization.

The study revealed that there were changes in land-use and land-cover in the area which was hitherto dominated by forest vegetation. Specifically, there were increases in built-up, cultivated/grassland and areas covered by water bodies, while forested and mangroves areas decreased in size during the period understudy; thus, indicating that continuous increase in human population and consequent spatio-physical development impact on land-use patterns and land-cover characteristics of the area between 1991 and 2019. Following from the above, the study recommends establishment of forest reserves, enactment and proper enforcement of laws governing forest use and protection. In addition, the population should be educated on the importance of forests and the need to conserve forest resources.

Informed consent

Not applicable.

Ethical approval

Not applicable.

Conflicts of interests

The authors declare that there are no conflicts of interests.

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The study has not received any external funding.

Data and materials availability

All data associated with this study are present in the paper.

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