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SPATIO-TEMPORAL ANALYSIS OF LAND USE AND LAND COVER DYNAMICS IN A PART OF SOUTHERN NIGERIA

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ABSTRACT

Agriculture, industrialization, transportation, urbanization and other anthropogenic activities have impacted on the natural cover of the earth surface, hence the dual concepts of land use and land cover (LULC). This study analyses spatio-temporal dynamics in LULC in part of southern Nigeria (path 189 and row 056) between 2002 and 2023using satellite imageries: namely, Landsat Enhanced Thematic Mapper Plus ETM+ of 2023, 2014 and 2002. The classification of land coverwas done with the aid of ArcGIS.The study revealed spatial dynamics in LULC over the study period. The percentage of the study area under cultivation increased from 7.96% in 2002, 17.79% in 2014 to 30.67% in 2023. Also, built-up area increased from 4.36% in 2002, 8.29% in 2014 but decreased to 7.06% in 2023. While areas of dense forest were 34.59% in 2002, 21.42% in 2014 and 11.57% in 2023, bare surface was 4.94% in 2014, 1.19% in 2002 and 25.34% in 2023.Oil spill was 6.13% in 2002, 6.42% in 2014 and 2.07% in 2023. Secondary regrowth/Plantation was 0.19%, 4.22% and 5.53% in 2002, 2014 and 2023 respectively. Water bodieswere 3.37% (2002), 7.06% (2002) and 11.27% (2023). The study recommends enactment of an enabling law or enforcement of existing laws governing forest protection and raising awareness and education of inhabitants on the need to preserve the natural land cover.

Keywords: ArcGIS, Land Use, Land Cover, Satellite images, Nigeria

INTRODUCTION

The surface of the Earth comprises natural cover such as deserts, rocks, water, vegetation and soil, which constitute the land cover. Igben (2023) defines landcoveras the physical and natural layer which covers the Earth surface that has not been impacted by human activities. However, anthropogenicactivities, including agriculture, industrialization, transportation and urbanization have modified the natural land cover, hence, land-use and land-cover change (LULC) is one of the consequences of human interactions with natural environment (Cheruto et al.,2016;Lambin et al., 2003; Lambin and Geist, 2006; Mucova et al., 2018; Dahal, 2021). In line with the above, Giridharan and Emmanuel (2018) asserted that land-use and land-cover change is the modification of the surface features on the Earth's landscape, which can be distinguished by their surface features or appearance at different times. Furthermore, it refers to the spatial

andtemporal dynamics that occur in the natural surface of the earth crust mostly as a consequence of human activities. These dynamics affects certain continuous characteristics of the land, namely, vegetation, soils, and so on, (Patel et al., 2019). Prime among these activities or drivers of LULC change is urbanization, which is manifested in physical and spatial growth of settlements (Nuissi andSiedentop, 2020; Igben, 2023).

The United States Geological Survey (USGS) classified land-use and land-cover change 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).

The literature is replete with numerous studies on land use and land cover dynamics in Nigeria.Some of these studies focus on the causes and dimensions of LULC changes (Fabeku *et al*, 2018;Ogunjobi *et al*, 2018; Igun and Williams, 2018; Fashae *et al*.,2020; Dalil et al, 2016;Hundu et al, 2023; Igben, 2023; Uchegbulam and Ayolabi, 2013) while others such as Koko et al, 2021;Odiji *et al*, 2022; Okeleye *et al*, 2023) dwelled on the impact of land cover changeson the human population. For instance, Fabeku *et al* (2018) assessed land cover changes in Ibadan using index maps generated from Landsat Satellite data (TM1, ETM+ and OLI) of Ibadan. The result of the study indicated a notable increase in built-up areas from 5.64% of the total land cover area in 1984 to 14.05% in 2014.

Similarly, Igun and Williams (2018) study of land cover changes as a result of urban growth in Lagos, Nigeria between 2002 to 2013 revealed that there was urban increase in the area as follows: 3.35% (2,200.77 ha), 27.87% (13,681.35 ha) and 6.20% (3,284.01 ha) for highly dense area, moderately dense area and less dense area respectively. Also, Fashae *et al* (2020) study of land use and land cover changes in Ibadan and its environs showed an increase in urban cover from 341.72 km^2 in 1984 to 520.58km^2 in 2019.

Hundu et al (2021) study of the LULC in Katsina-Ala LGA of Benue State, 1990 and 2020 using Landsat TM (1990); Landsat ETM+ (2000, 2010); and Operational Land Imager (OLI) (2020) were used. Changes in land cover were measured using time series of remotely sensed data (Landsat TM, ETM and OLI). The study revealed that 43.25% of farm land cover was gained during the period 1990 to 2020 with an annual rate of change of 1.44%. Forest land cover was lost by -53.19% between 1990 and 2020 with an annual rate of change of -1.77%, built up area has increased by 9.20% with an annual rate of change of 0.31%.

Dalil et al (2016) study focused on change detection in Land use Land cover in Minna Nigeria. To analyze the change, Landsat ETM 1990, Landsat ETM 2000, Landsat ETM+ 2005 and Landsat ETM+ 2015 imagery covering the area between 1990 and 2015. The study revealed changes in land use land cover classes within the period (1990-2015); built-up area experienced rapid change with an increase of 38.66 km2, and a decrease of -5.32 km2 in vegetation. Decreases were also observed in farmland, water body and bare surface with -1.95 km2, -0.05 km2 and -32.78 km2 respectively.

Uchegbulam and Ayolabi (2013) study of land cover dynamics in part of the Niger Delta Region (NDR) as a measure of environmental degradation. The study, in addition to establishing the fact that the area was degraded, revealed that there was land cover dynamics manifested in the reduction of forest vegetation and increased built-up areas, from 42904.1ha in 1987 to 45423.8ha in 2002. Dense forest cover in 1987 was 1089702.2 ha and the built-up area was 42904.1 ha. Forest reduced to 987688.5ha 2002 and built-p area

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increased to 45423.4 ha. In addition, wetland covered an area of 275917.7 ha in 1987 but reduced to 130209.4 ha in 2004.

Igben (2023) investigated 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. Of the 264.15Km2 covered in the study, Built-up areas increased from 12.10 km2 (4.585%) to 22.72 km2 (8.60%), forested areas decreased from 142.49 km2 (53.94%) to 81.30 km2 (30.78%) and mangrove areas decreased from 51.27 km2 (19.41%) to 48.56 km2 (18.38%). Also, cultivated/grassland areas increased from 50.77 km2 (19.22%) to 102.66 km2 (38.86%) and areas covered by water bodies increased from 7.52 km2 (2.85%) to 8.80 km2 (3.33%), thus, indicating a high rate of deforestation and general land surface cover dynamics.

Igben and Efeturi (2022) utilized remotely-sensed data and GIS techniques to predict future spatial changes in rainforest vegetation in Oghara, Nigeria from 1991 to 2019 as a basis for predicting its future size in 2050. The study revealed that the size of forest cover decreased from 142.49km2 or 53.94% of the total area in 1991 to 81.30km2 or 30.78% in 2019 and predicted to further decrease to 60.52km^2 or 22.91 percent in 2050. Similar studies have been undertaken byOgunjobi, et al (2018) for Sokoto; Mukhtar& Raphael (2022) for Ede, State,Enoguanbhor et al., (2019) for Abujaand Olayiwola & Igbavboa (2014) for Benin City, and Wizor&Okugini (2020) for Kwale in Delta State, andNjike, Igbokwe & Orisakwe (2011) for Aba, Nigeria.

Although a number of studies have been done on LULC changes in Nigeria, most of them are localized and lack regional coverage. Instead they focus on single cities or settlements without covering land cover dynamics in neighbouring settlements which may impinge on the settlement under consideration. Hence, this study adopts a regional approach by considering dynamics in land use and land cover over several settlements using data generated from Satellite images. Therefore, the aim of this study is toanalysespatio-temporal dynamics in LULC in part of southern Nigeria (path 189 and row 056) between 2002 and 2023 using satellite images: namely, Landsat Enhanced Thematic Mapper Plus ETM+ of 2023, 2014 and 2002.

MATERIALS AND METHOD

Study Area

The area covered by the satellite images (path 189 and row 056) is situated insouthern Nigeria. Itcomprises parts of Bayelsa, Delta, Edo, and AnambraStates.Itlies roughly between Latitudes 5^0 and $7^0$45'N and Longitudes $5^0$45' and $7^0$35'E., over an area of about 32km^2. It is bordered in the north by the middle belt states of Kwara, Kogiand Benue. To the east are Enugu and Imo States and to the west is Ondo State. On its southern flank is the Atlantic Ocean, as shown in Figure 1.

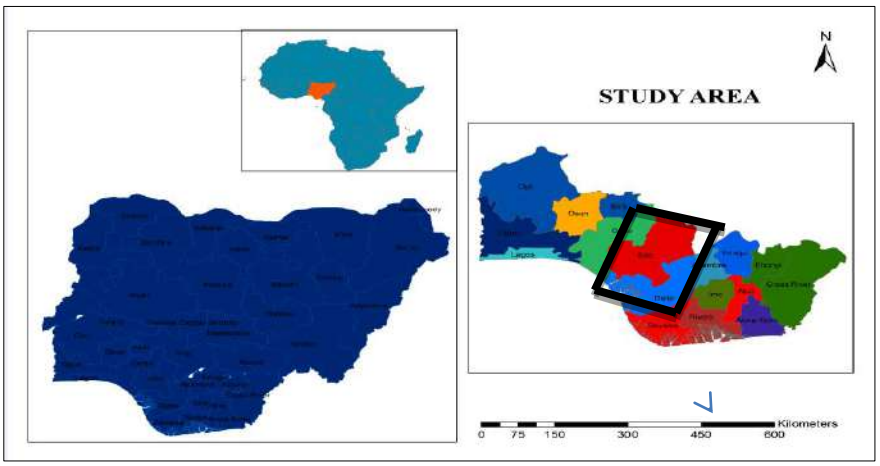

Figure 1: Study Area

The study area has a tropical climate and is characterized by uniformly high rainfall and temperature throughout the year. It experiences two distinct seasons: the dry and the rainy. While the dry season occurs between November and April, the rainy season begins in April till October. In the middle of the rain season, there is a brief spell of dryness in August which is commonly referred to as "August break". Consequently, two maxima of rainfall are recorded in the area. On the Koppen's climatic classification, the southern part of the study area belongsto Af category, while the northern part belongs to the Am category.

The wet season is experienced when the area is under the influence of the tropical maritime air mass, also known as the southwest wind. This air mass which originates from the Atlantic Oceanis moisture laden. The dry season is experienced when the area is under the influence of the dust-laden tropical continental air mass or the northeast wind.

The average annual rainfall is high, usually above 2,000mm (78.7in) with over 4,000mm (157.5in) received in the coastal Niger Delta areas. Rainfall is heaviest in July in the southern part of the area where no month is completely rainless. January, which is the driest month in this part, is characterized by rainfall of up to 2.5cm of rain in most years. The period from December to February is usually marked by relatively cool, dry and dusty weather called the 'harmattan'. The duration and severity of the harmattan vary from year to year and from the south to the northern part of the area (Aweto and Igben,2003).

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 between day and night 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 per cent in the early morning, but falls to between 60 and 80 per cent in the afternoon (Udo, 1978).

Furthermore, the area consists of three vegetation zones of mangroves, fresh water swamp forest and rainforest. The mangrove zones comprise muddy sheltered creeks, deltas, brackish and or strong tidal waters characterized by mangrove vegetation. The next zone is fresh water swamps, noted for floating grass, screw pine (*Pandanas candelebrum)* and raffia palm (*Raphia hookeri*) as the most common tree types. The rainforest comprises wet evergreen forest with trees at three layers. The first comprises mostly climbers; the second composes trees of between 2 to 10m tall, while the third layer comprises trees of over 10m tall. The rainforest and the fresh water swamps contain valuable trees such as mahogany (*Khaya Spp*), african walnut (*Lovoa trichilioides*), iroko (*Chlorophora excelsa*), abura (*Mitragyna ciliata*), sapele wood (*Entandrophragmacy lindricum*) and obeche (*Triplochitons cleroxylon*). The different ecological zones provide habitation for different species of plants, fishes, reptiles, mammals and minerals on which the population depend (Igben, 2012).

Data sets, Bands and Image Pre-Processing

Remotely sensed satellite images were obtained from the Global Land Cover Facility (GLCF) of (2023, 2014 and 2002) of path 189 and row 056 from the World Reference System (WRS-2).

The bands (wavelengths) of electromagnetic wave utilized for the analysis were bands 1-5. ArcGIS 10.8 software was used for image processing and GIS analysis. Supervised maximum likelihood method of classification was adopted. The satellite images used are Landsat Enhanced Thematic Mapper Plus ETM+ of 2023, 2014 and 2002. They are 7 band images that have a spatial resolution of 28m. Visible radiation bands of 1, 2 and 3 of wavelengths range (0.4 μm – 0.7 μm), and bands 4 and 5 which are near infrared wavelength of range (0.7 μm – 1.1μm) were the acquired bands used for the analysis. Image filtering was done band by band using the algorithm AVG (Average) 3x3 based on matrix function. The characteristics of the

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satellite images used for the analysis are shown in Table 1.

Table 1: Satellite Images of 2023, 2014 and 2002 Characteristic. (GLCF: 2023, 2014 and 2002).

S/N	Date	Source	Satellite Type	Sensor	Path/Row	Band	Resolution	Noise
1	30/01/2023	GLCF	Landsat-7	Enhanced Thematic Mapper Plus (ETM +)	189/056	1-5	28m	2.06
2	28/01/2014	GLCF	Landsat-7	Enhanced Thematic Mapper Plus (ETM +)	189/056	1-5	28m	0
3	29/01/2002	GLCF	Landsat-7	Enhanced Thematic Mapper Plus (ETM +)	189/056	1-5	28m	0.48

Land Cover Classification

The area being a familiar terrain, supervised maximum likelihood classification algorithm was chosen. The training ground was the study area. Land cover classes were derived from the images after processing. Eight (8) land covers were identified and confirmed after ground truths. These include; cultivation, built-up area, dense forest, exposed soil and light forest. Others were oil spill, secondary regrowth and water bodies. Bands 3, 4 and 5 (B345) were used for the colour composite which gave the plants green colour vegetation.

RESULTS AND DISCUSSION

The satellite images for the three time period understudy is presented in Figures 2, 3, and 4. Results of analysis are presented as maps, tables, graphs and charts.

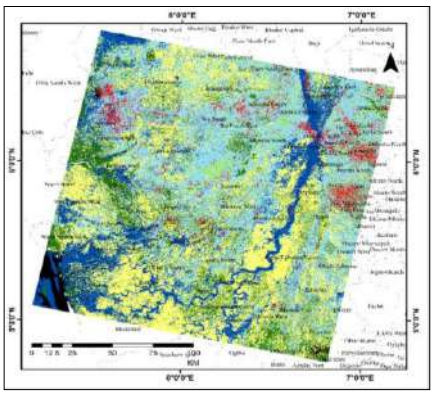

Figure 2: LULC of 2023

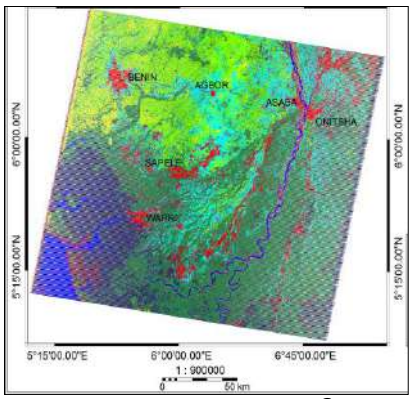

Figure 3: LULC of 2014

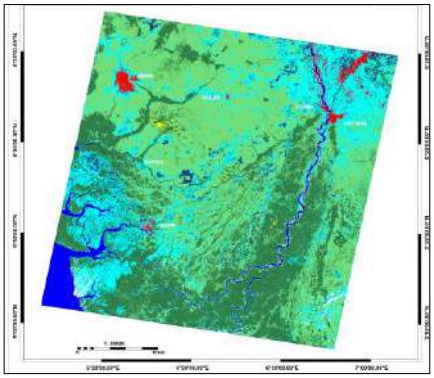

Figure 4: LULC of 2002.

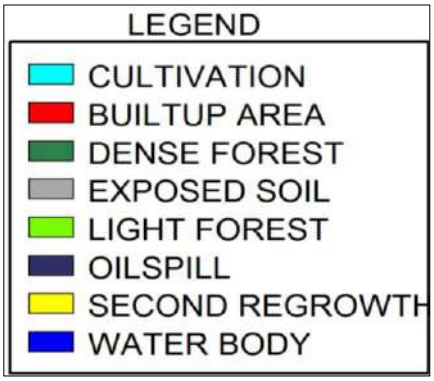

Table 2: The Land Use /Land Cover Statistics of 2023, 2014 and 2002.

Land Use /Land Cover	**Percentage**		
	2023	**2014**	**2002**
Cultivation	30.67	17.79	7.96
Built-up area	7.06	8.29	4.36
Dense forest	11.57	21.42	34.59
Exposed soil/gallery forest	25.34	4.94	1.19
Light forest	6.50	29.95	41.74
Oil spill/Noise	2.07	6.42	6.13
Secondary regrowth/Plantation	5.53	4.22	0.19
Water bodies	11.27	7.06	3.37

The trend in LULC changes for the period under study is graphically represented in Figure 5 below.

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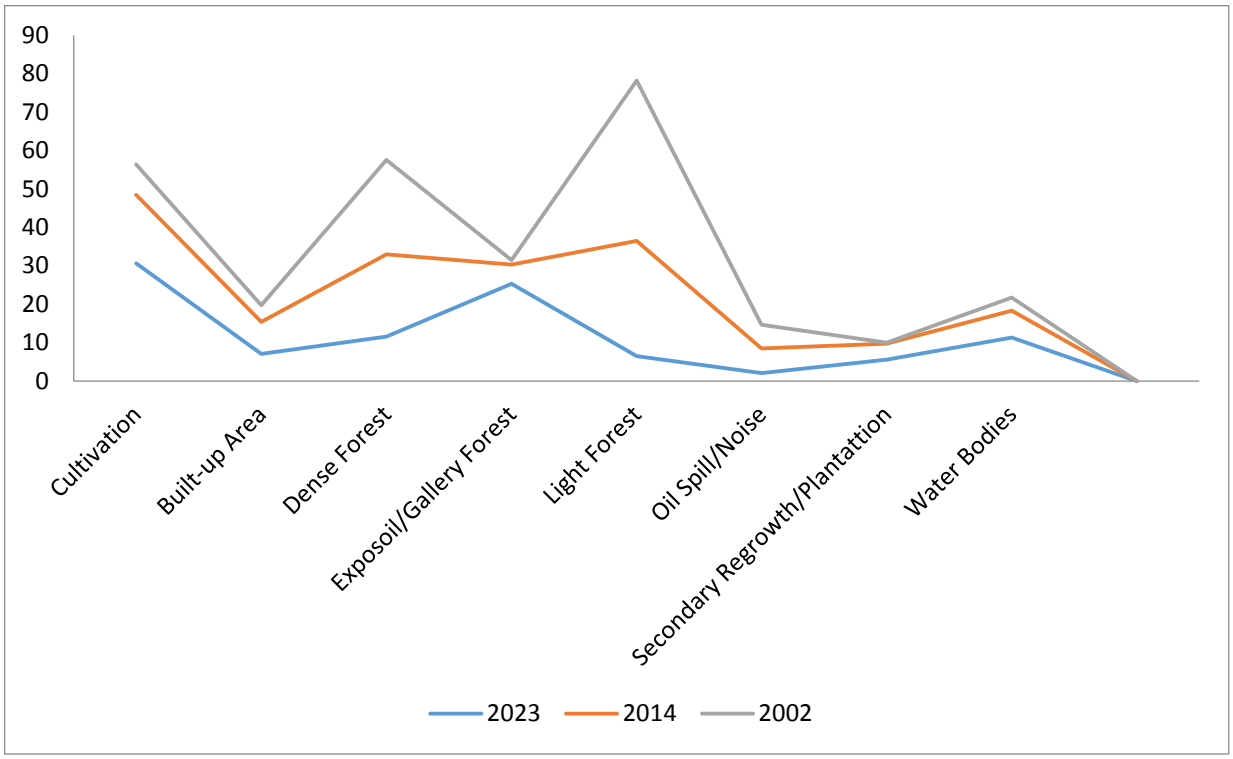

Figure 5: Land Use Dynamics between 2002 -2023

The percentage of the study area under cultivation for 2002, 2014 and 2023 are 7.96%, 17.79% and 30.67% respectively. The statistics shows that there was continual increment in cultivation over the period. This is as a result of agricultural activities in the area as more people, organizations and governments are going into agricultural cultivation. Also, there is increase in government-private partnership in agriculture in recent years. This finding is in agreement 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/Effurn metropolis, Delta State, Nigeria. This view is corroborated by Fabiyi, (2011) who highlighted these factors among those contributing to loss of forest and vegetation in parts of the Niger Delta.

Also, built-up area was4.36% in 2002, increased to 8.29% in 2014 and slightly decreased to 7.06% in 2023. The significant increment recorded between 2002 and 2014, a period of 12 years was as result of rapid population growth which gave rise to increased economic activities in the area. However, the slight decrease between 2014 and 2023, a period of 9 years was as a result of other land use taking the place of built-up area. This finding is in line with Wizor and Okugini, (2020) study which revealed that increases in built-up areas in Ukwuani LGA of Delta State was due to increase in population and economic activities as a result of petroleum exploitation. It wsalso in tandem with Igun and Williams (2018) and Fashae *et al* (2020) studies of land cover changes due to urban growth in Lagos and Ibadan respectively.

In contrast, areas of dense forest reduced throughout the period under study. It was 34.59%, 21.42% and 11.57% in 2002, 2014 and 2023 respectively. This is understandable because more trees were being felled for logging, cultivation taking the place of dense forest and expansion of residential and industrial layouts. This increase is in tandem Atubi et al. (2018) study which indicated that conversion of land for agricultural and other developmental use contributed to the land-cover changes in Warri/Effurun 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.

Bare surfaces, burrow pits/excavated land, submerged area, and de-vegetated areas were classified as exposed soil. Gallery forest and exposed soil are grouped together in 2023 image, and has a percentage of 25.34%. The high value is attributed to the merging of exposed soil and forest along the banks of water body (gallery forest) in the area. Exposed soil recorded 4.94% and 1.19% in 2014 and 2002 respectively. The decrease between 2002 and 2014 was as a result of increase in road construction and other anthropogenic factors in the area. This development is in line with Uchegbulam and Ayolabi (2013) study of land cover dynamics in part of the Niger Delta Region (NDR) and Igben (2023) study of Oghara in Delta State, Nigeria.

Light forest had 41.74%, 29.95% and 6.50% in 2002, 2014 and 2023 respectively. These can also be attributed to growth in population; light forest gave way for construction sites. Certain cultivation may have been captured as light forest, therefore, after each harvest; there is a decrease in the statistics. The sharp decrease between 2014 and 2023 may be that part of light forest may also have been captured as gallery forest.

Oil spill recorded 6.13% in 2002, 6.42% in 2014 and 2.07% in 2023. The spills are caused by artisanal refineries in the creeks, pipeline vandalization, equipment failure and accidents. Since the introduction of the Presidential Amnesty Programme (PAP), there has been a decrease in oil spillage especially in the Niger Delta region. However, there are still pockets of illegal refineries and other vandalization activities that account for the low percentage recorded in 2023.

Secondary regrowth/Plantation maintained a gradual increase during the period. This was as a result of campaigns in tree planting and increase in palm and rubber plantations in the region. 0.19%, 4.22% and 5.53% were recorded in 2002, 2014 and 2023 respectively.

The increase in dredging activities, overflow of rivers due to climate change and flooding in the region, led to the gradual increase in water body coverage as it recorded 3.37%, 7.06% and 11.27% in 2002, 2014 and 2023 respectively. This finding is in line with Igben (2014) study on proliferation of inland sand dredging activities in the Niger Delta, Nigeria.

CONCLUSION

This study focused on spatio-temporal analysis of land-use and land-cover changes in part of southern Nigeria between 2002 and 2023 from Landsat Enhanced Thematic Mapper Plus ETM+ (path 189 and row 056). Land use and land cover classification of land was done with the aid of ArcGIS 10.8 software. The study revealed spatial dynamics in LULC over the study period. The percentage of the study area under cultivation for 2002, 2014 and 2023 were 7.96%, 17.79% and 30.67% respectively. Also, built-up area was 4.36% in 2002, 8.29% in 2014 and 7.06% in 2023, while areas of dense forest were 34.59%, 21.42% and 11.57% in 2002, 2014 and 2023respectively.Bare surface was 4.94% in 2014, 1.19% in 2002 and 25.34% in 2023. Oil spill was 6.13% in 2002, 6.42% in 2014 and 2.07% in 2023. Secondary regrowth/Plantation was 0.19%, 4.22% and 5.53% in 2002, 2014 and 2023 respectively. Water bodies were 3.37%, 7.06% and 11.27% in 2002, 2014 and 2023 respectively.

Consequently, the study recommends enactment or enforcement of laws governing forest protection and raising awareness of inhabitants of the area of the need to preserve the natural land cover. In addition, the population should be educated on the importance of forests and the need to conserve forest resources.

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