Spatio-Temporal Dynamics of Landuse and Land Cover in Oil Producing Communities of Akwa Ibom State, Nigeria

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ABSTRACT: This study examines the spatiotemporal dynamics of land use and land cover (LULC) in selected oil-producing communities in Akwa Ibom State, Nigeria, to assess the impact of human activities on vegetation. Remotely sensed satellite imagery from Landsat-5, Landsat-7, and Landsat-8, acquired in 1986, 2003, 2016, and 2021, was utilized for land cover classification and trend analysis. The Normalized Difference Vegetation Index (NDVI) was applied to assess vegetation health, while the rate of land cover change was calculated using the FAO formula. The findings revealed a continuous decline in vegetation cover over the study period. In 1986, land cover distribution followed a decreasing trend: Secondary forest (38.77%) > Swamp area (24.93%) > Primary forest (22.54%) > Built-up area (6.11%) > Water bodies (5.70%) > Bare surface (1.96%). By 2003, the land cover proportions had shifted, with Primary forest experiencing the most significant reduction. In 2016, the decreasing order of land cover classes was Primary forest > Swamp forest > Built-up area > Secondary forest > Water bodies > Bare surface, indicating an expansion of built-up areas. Between 1986 and 2021, the overall LULC dynamics followed the trend: Primary forest (33.3%) > Secondary forest (26.8%) > Swamp forest (21.6%) > Built-up area (11.6%) > Water bodies (5.5%) > Bare surface (1.3%), with an overall change rate of 16.7%. The dominant decline in primary forest cover revealed the increasing influence of human activities as a key driver of land cover changes. Given these findings, nature-based solutions are recommended as a strategic approach to balancing human activities with ecological sustainability. Implementing sustainable forest management practices will be crucial in mitigating further deforestation and promoting environmental conservation in the region.
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1.1 Introduction

Worldwide, the coastal environment is a highly endowed region with natural resources that promote the livelihood of humans, plants and animals (Ubuoh *et al*., 2019; Essien *et al*., 2020). It is a dynamic area with physical processes that responds to coastal hazards and anthropogenic events associated with environmental degradation such as flooding, sea level rise, land subsidence, erosion and gas flaring (Oyegun and Ogoro, 2016; Ubuoh *et al* ., 2019). During the last few decades, the Niger Delta region, especially the coastal environment has been faced with an increase in its population and economic activities resulting in enormous benefits and processes not just to the region alone but to the adjacent states and the entire country (Essien *et al*., 2020). These benefits and processes have also created environmental changes to this region's oceans and coastline (Ekong, 2017; Georgia Tech, 2018). According to the United Nations (UN), over three (3) billion people depend on marine and coastline resources for livelihood and other human necessities. These resources also serve to regulate global climate and act as a sink for greenhouse gases and habitat for biodiversity (Ijiomah, 2018). However, due to the prevalent human activities and impacts globally, Coastal and Marine Socio-Ecological Systems (CMSES) have been seriously degraded by pollution, erosion, flooding, habitat destruction, exploitation, climate change etc. (Nahuelhaul *et al*., 2016), thus making the coastal and marine environments more vulnerable to natural hazards and thereby increasing the risk and resultant impact (Lozoya *et al*., 2014).

The processes and effects are very much the case in Nigeria with the rapid economic expansion in the Niger Delta. In Akwa Ibom State, noticeable changes and impacts of activities and processes on the region have been the loss of mangrove trees, erosion, oil spills and exploitation (Ubuoh and Ogbonna, 2018; Essien et al., 2020). The mangrove that once provided fuel and habitat is unable to oppose the pressure and toxicity levels of petroleum chemicals(Lugo *et al*., 2014). Oil spills, gas flaring, lumbering and other exploitation activities have created negative impacts on the vegetation cover (Yaw and Edmund, 2006).

According to IPCC, the change in Land use/Land cover represents one of the most important factors influencing terrestrial and aquatic ecosystems. Land use/land cover changes play a major role in global environmental changes, as they significantly change the boundary relationship between the Earth and the atmosphere. Natural and anthropogenic changes in land use affect many landscape features, and interact in a variety of ways - for example on the global carbon cycle - with the climate system (IPCC, 2000). Therefore, investigations of Land use/Land cover changes have become more and more imperative. Detecting change digitally will help in determining the changes that have occurred in land use and land cover with the help of geo-referenced multi-dimensional remotely sensed data (Coppin *et al*., 2004). This study aims at assessing and generating information for the changes occurring in the selected oil-producing communities in Akwa Ibom State in geospatial information systems and remote sensing to implement comprehensive strategic action plans for adaptively managing that would lead to sustainable forest ecosystem in the area since the impact is worsening and the speed of change is not easily known.

1.2 Materials and Methods

Study Area

Akwa Ibom State is situated in the Niger Delta region of Southern Nigeria. It lies between latitude $4^0$300N and $5^0$300N and longitudes $7^0$300E and $8^0$150E (Robert, 2015)[Fig1]. It is the topmost oil-producing state in the country. The state covers an area of about 8000sq.km. Mean annual rainfall over the area decreases gradually from about 4050mm near the coastal area to about 2100mm in the north (Aniekan and Okon, 2016). The mean annual temperature is 26.9°C. Relative humidity except for the short period of dry season remains at an average of 70% to 80% throughout the year. The area is noted for its wetlands, sandy coastal ridge barriers, brackish or saline mangroves, fresh and saltwater swamp forests as well as lowland rain forest. It is crossed by several rivers and streams. The area has very high agricultural potentials and is rich in crude oil, gas and many other natural resources (Ubuoh *et al*.,2020).

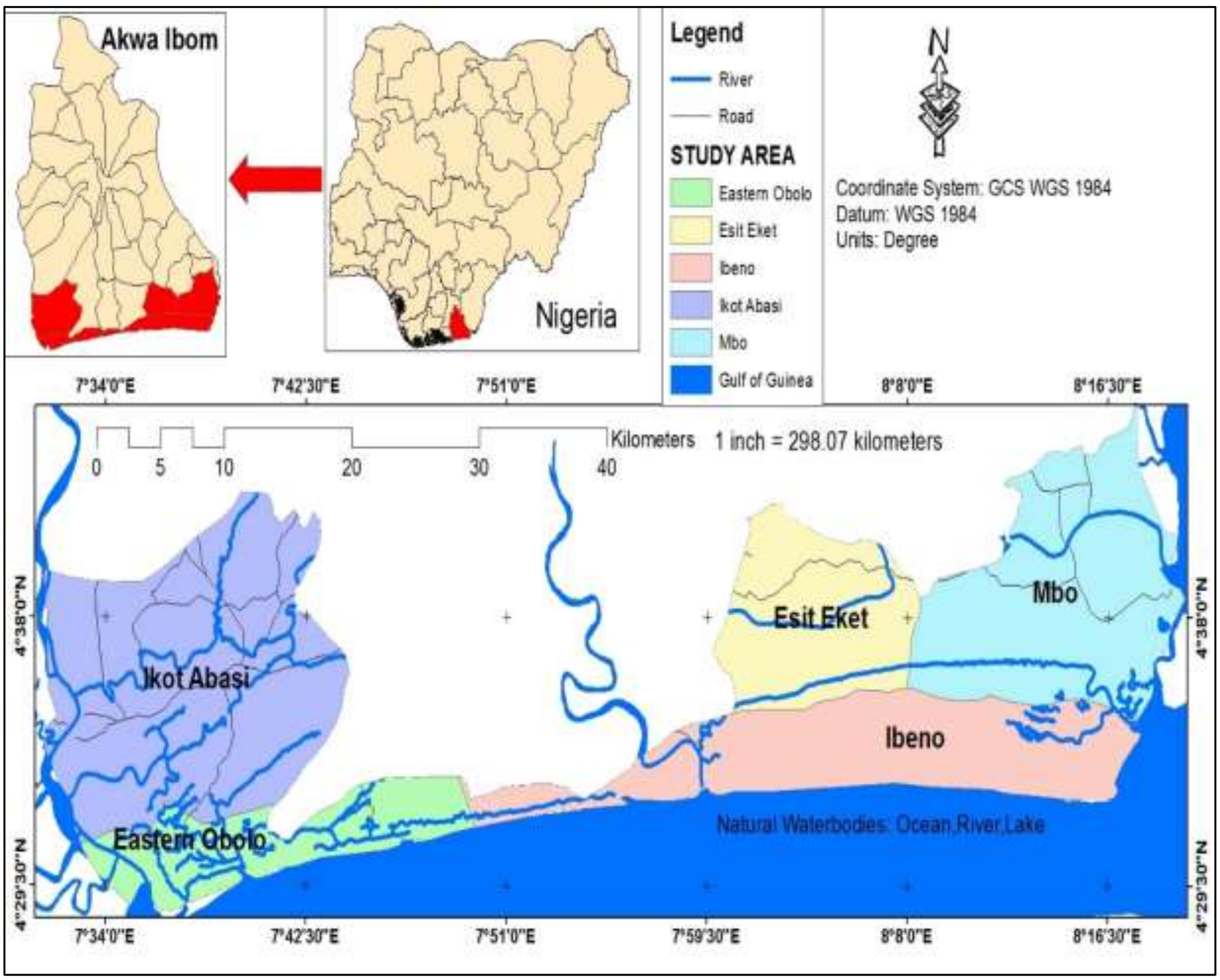


Figure 1: Map of the study are showing the selected LGAs.

1.3 Types of Data:.

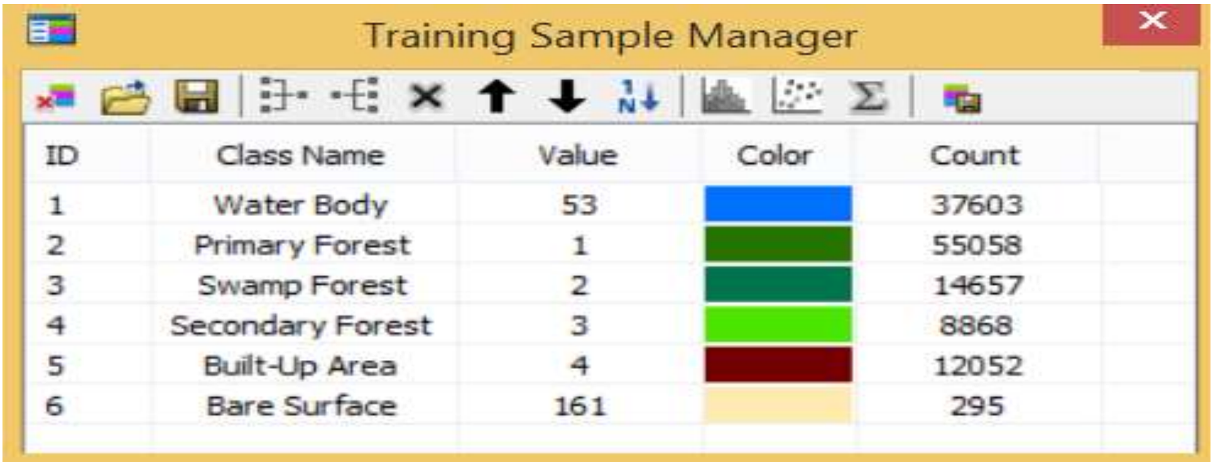
Remotely Sensed satellite imagery of Landsat Landsat-5, Landsat-7, and Landsat-8 images acquired on 1986, 2003 ,2016 and 2021 were used for the land use/land cover classification and change trend analysis.The three Landsat scenes (path 188/row 56 & 57 and path 187 row 57) that covers the study area were obtained from the United State Geological Surveys (USGS) with a resolution of 28.5m.These datasets were all acquired in the dry season in order to minimize seasonality variations. Landsat_8 comprising 11 Bands with a band list of 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11 with accompanied metadata was acquired from the U.S. Geologic Surveys with a Map Projection of UTM and the same Datum as WGS84. The Landsat-8 satellite data was acquired for both 2016 and 2021.

1.4 Image Processing And Data Preparation

Radiometric calibration and corrections is important component to the change detection (Caprioli et al., 2008), as it can eliminate or reduce image differences introduced as a result of changing atmospheric conditions. Hence, for the three set of images to be use together for change detection studies, necessary image processing was carefully carried out using ERDAS IMAGINE software. Atmospheric and radiometric correction was carried out followed by image-to-image geometric correction. The geometric correction was done by correcting Landsat 5-TM and Landsat 7 ETM+ images using the corrected image of Landsat 8-OLI that was already geometrically registered using ground control points. Thereafter, mosaicking, Subseting and Integration were done to generate/extract the spatial extent of the study area from three scenes of Landsat images.

1.5 Development of Image Classification Scheme and Image Analysis Using Remote Sensing and GIS

Development of the training site was established to define the supervised land cover classification scheme for the study area. This training sample for the signature of the supervised classification scheme includes the Bare Surface, Built-up area, Primary Forest, Secondary Forest, and water body. These are the identifiable land covers existing within the defined study area. The extracted Training sample shown in Plate 1 was used for this study.



Training Sample Manager

ID	Class Name	Value	Color	Count
1	Water Body	53		37603
2	Primary Forest	1		55058
3	Swamp Forest	2		14657
4	Secondary Forest	3		8868
5	Built-Up Area	4		12052
6	Bare Surface	161		295

Plate 1: Signature Training Scheme for Supervised Classification

The overall classification accuracy = No. of correct points/total number of points =268246/326280=82.2%

1.6 Determination of LULC Change rate

KAPPA analysis is a discrete multivariate technique used in accuracy assessments. KAPPA analysis yields a Khat statistic (an estimate of KAPPA) that is a measure of agreement or accuracy. For this land use land cover classification, the annual deforestation rate (r) is recommended because it is more intuitive than the formula used by FAO (q) (Ramesh *et al*., 1997). In some research results, the value of r is always higher than q. The difference in the value of both is lower than the value of the sampling error. The rate of change in annual forest cover (r, %/year) was calculated based on the initial forest cover area, with the formula as formulated by Ramesh *et al.* (1997), FAO(2005), Rijal *et al*., (2016), and expressed as :

$$Q = \left(\frac{A2}{A1}\right) \mathbf{X1(t2 - t1) - 1} \ \ldots \qquad (1)$$

Where Q is the deforestation rate

A1 = initial forest cover

A2 = final forest cover

t2 – t1 = difference in duration; 2020 -2000 = 20

Kappa Coefficients of the accuracy assessment were also generated to rate the entire classification's accuracy.

1.7 Tools for Data Analysis:

The tools used for the study analysis and computation include: Handheld Germin GPS used for accuracy in location during the survey, ArcMap 10.6, Microsoft Excel and Microsoft Word for the computation of the reports.

2.1 Results and Discussion

In this study, a total of 6 land covers were studied as described in the development of the training site, after the classification, various colours were assigned to the land covers to depict their real colour on the earth's surface. Thus; the Bare surface was represented with a Topaz-Sand colour, the Built-up cover was represented with Dark Umber, the Primary Forest was represented with a Fir green colour, Secondary Forest was represented with Quetzal green. The Swamp Forest cover was represented with a peacock green colour in the classification scheme and the water body was represented with Cretan blue (Fig. 2).

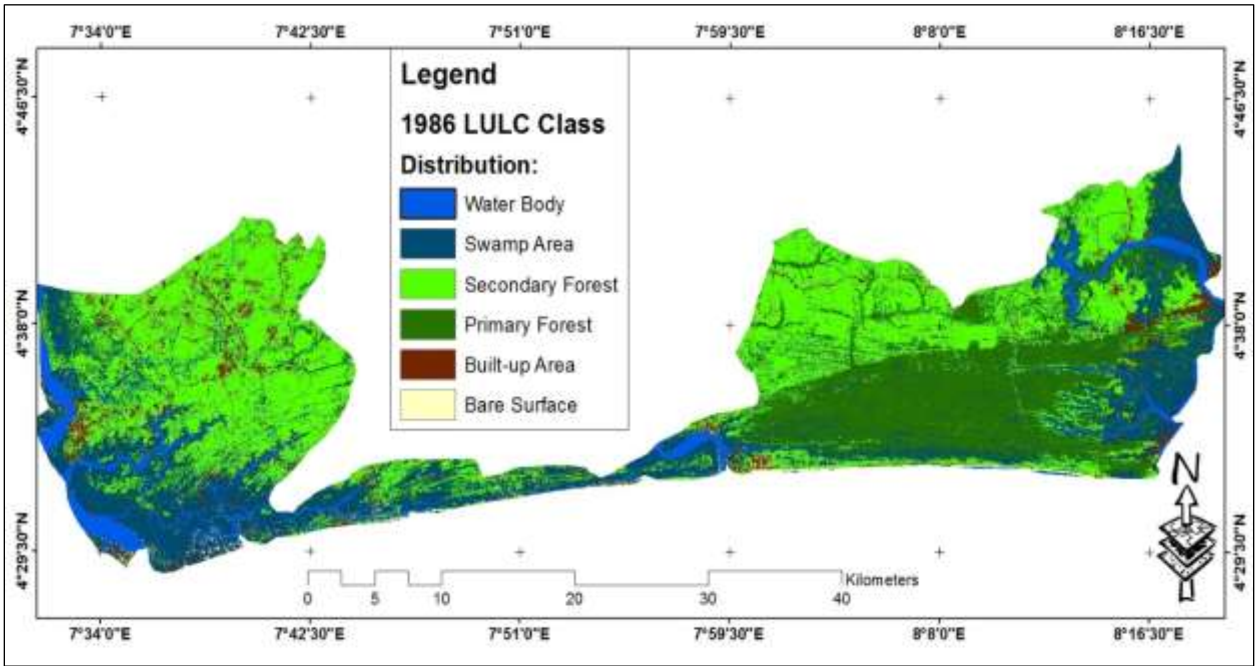


Figure 2: LULC Distribution Map in the Year 1986.

The entire study area was approximately 102,703.08 hectares of land. The results from the land use and land cover map of 1986 are displayed in Figure 2, and was discovered that the largest cover was the Secondary Forest which occupied 39,813.08 hectares which constituted 39%. The swamp forest and riparian vegetation occupied about 25,600.17 that constituted 25% and the primary forest cover occupied 23,148 hectares constituted 23%, the built-up area occupied approximately 6,274 hectares constituting 6%, water body occupied about 5,856 hectares having 5.7%, and the bare surface occupied 2,011.54 hectares constituting 2% of the entire area, respectively. In 1986, LuLc dynamics were in decreasing order of Secondary forest (38.77%) >Swamp area (24.93%) >Primary forest (22.54%) > Built-up (6.11%) > Water bodies (5.70%) > bare surface (1.96%), with secondary surface as dominance.

Table: 1: 1986 LULC Distribution of the Study Area

LULC Class	Pixel Count	Area (M^2)	Area (Ha.)	Percentage Area Cover
Bare Surface	24,765.00	20,115,371.25	2,011.54	1.96
Built-up Area	77,244.00	62,741,439.00	6,274.14	6.11
Primary Forest	284,987.00	231,480,690.75	23,148.07	22.54
Secondary Forest	490,158.00	398,130,835.50	39,813.08	38.77
Swamp Area	315,176.00	256,001,706.00	25,600.17	24.93
Water Body	72,097.00	58,560,788.25	5,856.08	5.70
Total	**1,264,427.00**	**1,027,030,830.75**	**102,703.08**	**100.00**

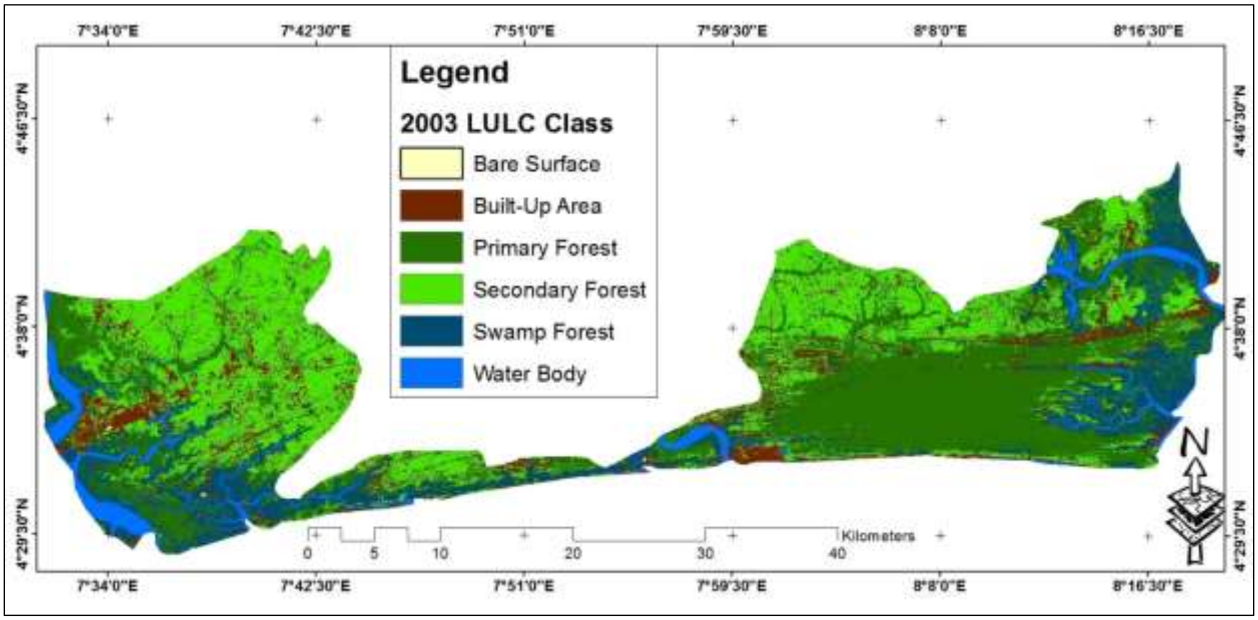


Figure 3: LULC Distribution Map in the Year 2003.

Table 2: 2003 LULC Distribution of the Study Area

LULC Class	Pixel Count	Area (M^2)	Area (Ha.)	Percentage Area Cover
Bare Surface	877.00	789,300.00	78.93	0.08
Built-Up Area	130,860.00	117,774,000.00	11,777.40	11.47
Primary Forest	416,167.00	374,550,300.00	37,455.03	36.47
Secondary Forest	360,398.00	324,358,200.00	32,435.82	31.58
Swamp Forest	171,547.00	154,392,300.00	15,439.23	15.03
Water Body	61,296.00	55,166,400.00	5,516.64	5.37
Total	**1,141,145.00**	**1,027,030,500.00**	**102,703.05**	**100.00**

The land use land cover map of 2003 revealed that primary forest occupied approximately 37,455 hectares, constituting 36.5 %, secondary forest occupied 32,435.8 hectares with 31.6 %, swamp forest occupied 15,439.2 hectares, with 15.3 %, bare surface occupied 78.93 hectares that constituted 1.3%, built-up area occupied approximately 11,777.4 hectares of 11.5% and water body occupied about 5,516.6 hectares that constituted 5.37% of the total area, respectively.

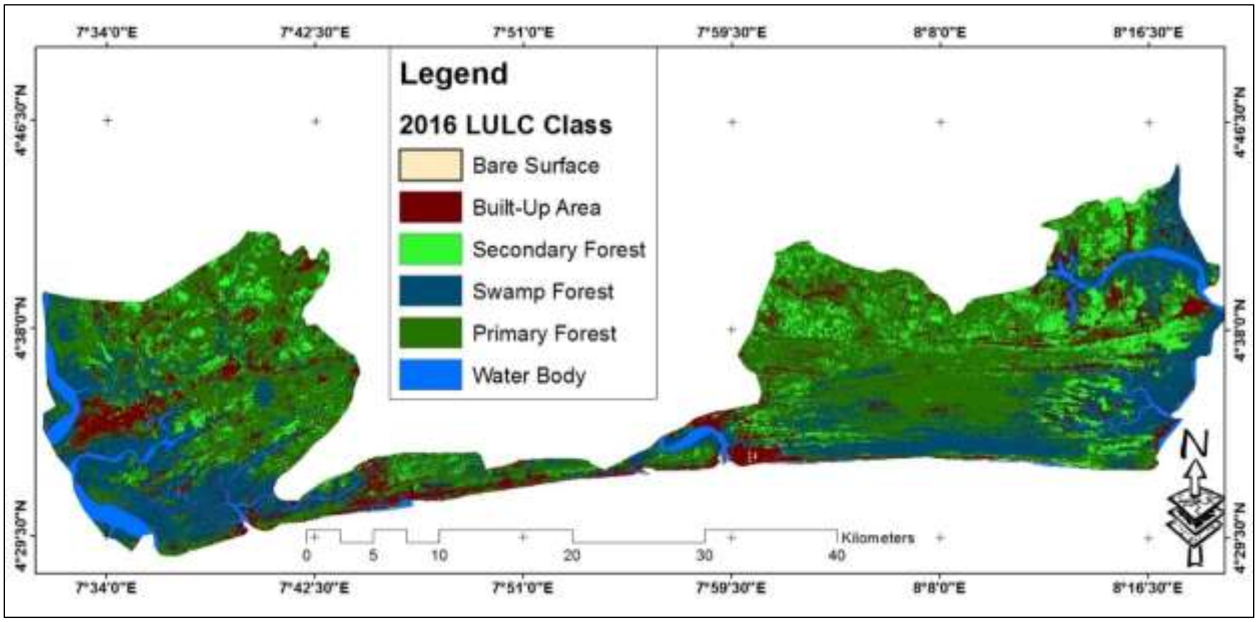


Figure 3: LULC Distribution Map in the Year 2016.

Table: 3: 2016 LULC Distribution of the Study Area

LULC Class	Pixel Count	Area (M^2)	Area (Ha.)	Percentage Area Cover
Bare Surface	2,648.00	2,383,200.00	238.32	0.23
Built-Up Area	139,077.00	125,169,300.00	12,516.93	12.19
Primary Forest	555,835.00	500,251,500.00	50,025.15	48.71
Secondary Forest	125,312.00	112,780,800.00	11,278.08	10.98
Swamp Forest	259,282.00	233,353,800.00	23,335.38	22.72
Water Body	58,991.00	53,091,900.00	5,309.19	5.17
Total	**1,141,145.00**	**1,027,030,500.00**	**102,703.05**	**100.00**

During 2016, the result of LULC indicated that primary forest covered approximately 50,025.2 hectares that constituted 48.7 % , swamp forest covered 23,335.4 hectares, with 22.7 % , built-up covered approximately 12,516.9 hectares of 12.2 % , secondary forest covered 11,278.1 (5.2 %), and bare surface is the least of all the land cover with a total of 238.3 hectares (0.23%) of the total land area. The distribution was in decreasing order of Primary forest >Swamp forest > Built-up area> Secondary forest > Water body > bare surface, with primary forest as dominance.

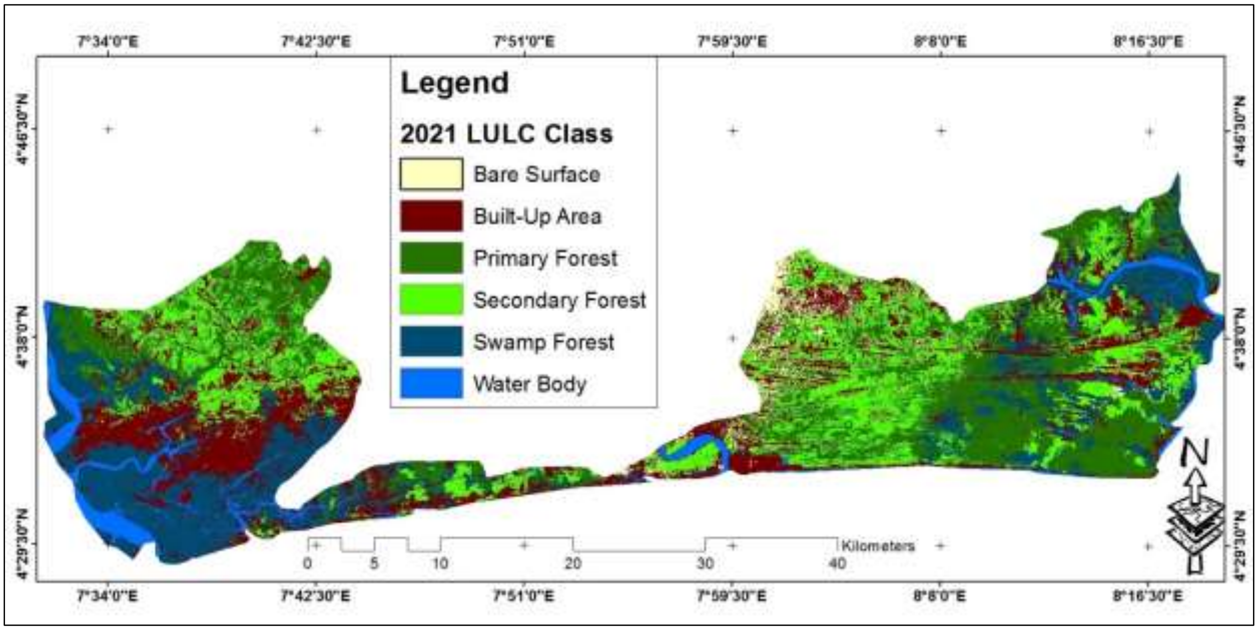


Figure 5: LULC Distribution Map in the Year 2021.

Table: 4: 2021 LULC Distribution of the Study Area.

LULC Class	Pixel Count	Area (M^2)	Area (Ha.)	Percentage Area Cover
Bare Surface	34,161.00	30,744,900.00	3,074.49	2.99
Built-Up Area	187,384.00	168,645,600.00	16,864.56	16.42
Primary Forest	292,202.00	262,981,800.00	26,298.18	25.61
Secondary Forest	293,008.00	263,707,200.00	26,370.72	25.68
Swamp Forest	269,860.00	242,874,000.00	24,287.40	23.65
Water Body	64,530.00	58,077,000.00	5,807.70	5.65
Total	**1,141,145.00**	**1,027,030,500.00**	**102,703.05**	**100.00**

Table 4 and Figure 5 summarized the LULC distribution during 2021, primary and secondary forests recorded 26,298.18 and 26,370.72 hectares constituted 25.6 and 25.7 %, respectively. Swamp forest covered 24,287.4 hectares (23.7%), built-up area recorded 16,864.56 hectares (16.4%), water body covered 5,807.7 hectares and constituted about 5.7% and bare surface occupied about 3,074.5 hectares of 3% of the entire area. The distribution of LULC distribution in 2021 was in decreasing order Secondary forest > Primary forest > Swamp forest > Built-up area > Water body > Bare surface, with secondary as dominance forest.

2.2 Change Detection of Land Use Land Cover during 1986 to 2021.

This section revealed the changes in the study area's land uses and land covers. The land covers that have been reduced from their original area distribution and those that have gained land cover due to human growth and development activities and seasonal climatic changes. Table 5 elaborates on the aforementioned changes, which can also be visualized in Figure 6 for only the changes observed in the built-up surface and forest vegetation. Because of their high-temperature retention rates, built-up surfaces and rock outcrops are the most significant cover that correlates with rising global warming effects (Ukaegbu, *et al.*, 2017).

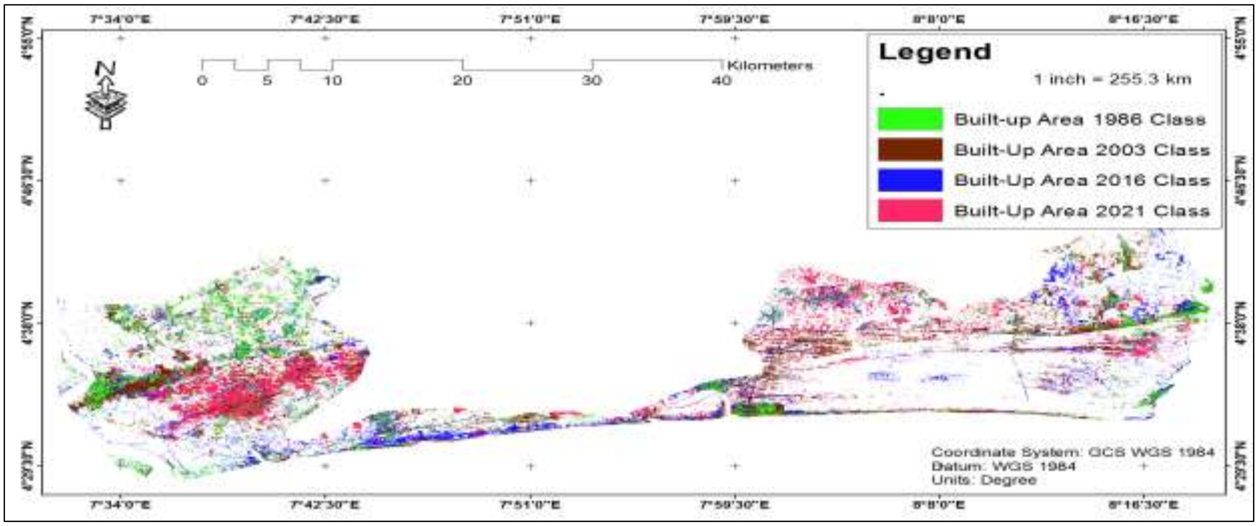


Fig 6. Change Detection of Land use land cover from 1986 to 2021

In the year 1986, the Built-up surface recorded about 6,274.14 hectares of land cover which constituted about 6.1% of the entire cover that year. In 2003 from the change detection analysis, the built-up surface gained about 5503.26 Hectares. At the same time, Primary forests from 1986 to 2003 increased the vegetative cover by about 14306.96 Hectares. While Secondary and swamp forest covers mapped for this research lost about 7,377.26 and 10,160.94 hectares respectively.

Only Primary Vegetation lost the cover to Built-up areas, Secondary forests, and Swamp forests between 2016 and 2021, comprising approximately 23,726.97 hectares of land area. According to Figure 6, which depicts the LULC change detection map, it was recorded as approximately 24673.68 Hectares gained from the previously classified LLULC in the 1990 class, representing a 3.36 per cent increase from the overall land use and land cover classification. Finally, this huge increase witnessed in the LULC Change detection analysis was attributed to the over-exploitation of the study area through several ongoing anthropogenic activities. The study has also shown that the built-up cover has increased constantly through the years of studies.

Table: 5: LULC change distribution in the study Area across the years.

LULC Class	Bare Surface	Built-Up Area	Primary Forest	Secondary Forest	Swamp Forest	Water Body
LULC Class 1986	2011.54	6274.14	23148.07	39813.08	25600.17	5856.08
LULC Class 2003	78.93	11777.4	37455.03	32435.82	15439.23	5516.64
Change 2003-1986	-1932.61	5503.26	14306.96	-7377.26	-10160.94	-339.44
LULC Class 2016	238.32	12516.93	50025.15	11278.08	23335.38	5309.19
Change 2016-2003	159.39	739.53	12570.12	-21157.74	7896.15	-207.45
LULC Class 2021	3074.49	16864.56	26298.18	26370.72	24287.40	5807.70
Change 2021-2016	2836.17	4347.63	-23726.97	15092.64	952.02	498.51

The result in Table 5 shows the observed changes in the bare surface area cover and water bodies are quite negligible and their percentage difference is not significant. There were trends in major forest loss (Table 5). Primary forest cover increased from 1986 to 2016 and was observed to be exploited from 2016 to 2021. Both Secondary and Swamp Forest cover was lost from 1986 to 2003, the loss of vegetation only continued for secondary forests while swamp and riparian forests gained cover from 2003 to 2021. In general, while there were massive fluctuations in the LULC, it was observed that Built-up area covers gradually increased and this would be attributed to projected population growth by the National Population Commission

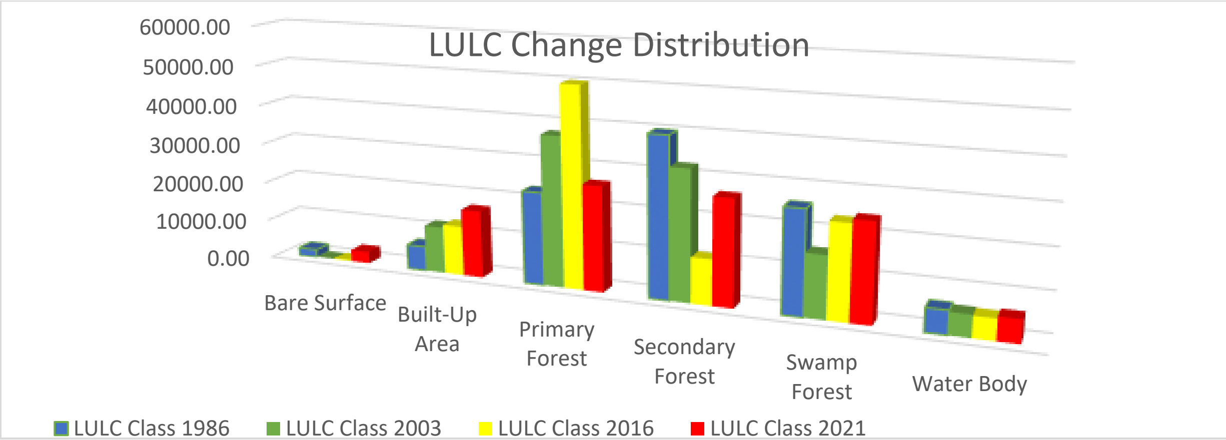


Figure 7: Trends of LULC Change Detected.

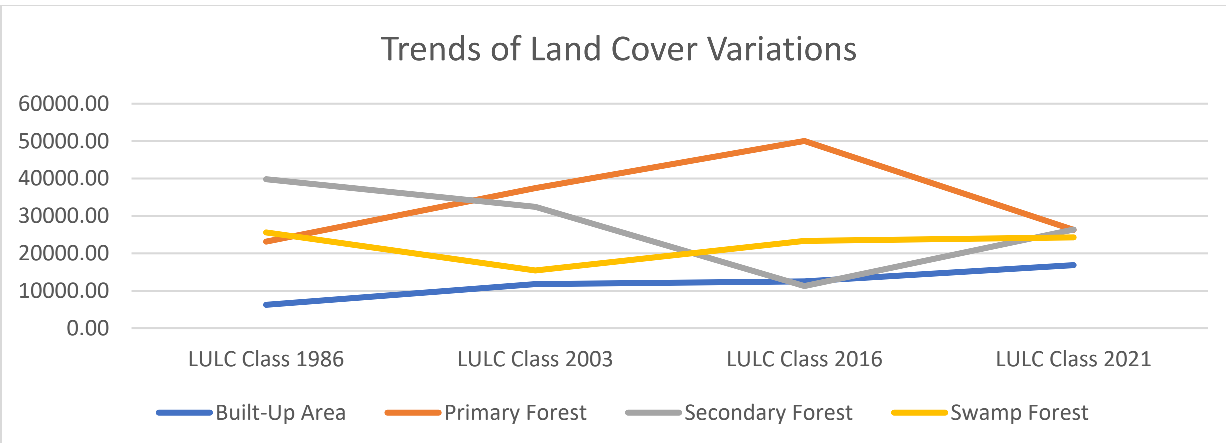


Figure 8: Trends of Land Cover Variation

Table 7: Change Rate of LULC in the selected oil-producing communities between 1986 -2021

LULC Class	1986	2003	2016	2021	Mean
Bare Surface	1.96	0.08	0.23	2.99	1.32
Built-up Area	6.11	11.47	12.19	16.42	11.55
Primary Forest	22.54	36.47	48.71	25.61	33.33
Secondary Forest	38.77	31.58	10.98	25.68	26.75
Swamp Area	24.93	15.03	22.72	23.65	21.58
Water Body	5.70	5.37	5.17	5.65	5.47
Total	**100.00**	100.00	100.00	**100.00**	**100**

Table 7 summarises the change rate of LULC in the selected oil-producing communities in Akwa Ibom State between 1986 -2021.

For bare surface, change rate of LULC ranged between 0.08 -2.99%, with 2003 recording the least change rate, while the highest was 2021 with a mean value of 1.32%, Built-up area ranged from 6.11-16.41%, with 1986 having the lowest rate and 2021 that recorded the highest rate with the mean value of 11.55%, primary forest ranged from 22.54-48.71%, with 1986 having the lowest rate and 2016 having the highest with the mean rate of 33.33%, Secondary forest ranged from 10.98-38.77%, with 2016 having the lowest rate and 1986 with the highest with the mean rate of 26.75%, swamp area ranged from 15.03 -24.93%, with 2003 < 1986 as highest rate with the mean value of 21.58% and water body ranged from 5.17- 5.70 with 2016 <1986 as the highest rate having the mean of 5.47%.

2.3 Discussion

In 1986, LuLc dynamics were in decreasing order of Secondary forest >Swamp >Primary > Built up > Water bodies > bare surface, with secondary surface as dominant. A secondary forest is a forest or woodland area which has regenerated through largely natural processes after human-caused disturbances, such as timber harvest or agriculture clearing, or equivalently disruptive natural phenomena (Ubuoh et al., 2020). This result is in tandem with the finding of Ogunleye *et al*.(2004) who reported that farming activities in the reserve have resulted in large hectares of impoverished secondary forest, bare and degraded lands, grasslands and plantation of exotic species. About 25 plants useful to the respondents have also been lost due to farming activities (Ogunleye *et al.*, 2004).

In 2003, the LULC was in decreasing distribution order of: Primary forest > Secondary forest > Swamp forest > Built-up area >Water body > bare surface, with the primary forest as the dominant forest. The Food and Agriculture Organization of the United Nations defines primary forests as naturally regenerated forests of native tree species where there are no visible indications of human activity and the ecological processes are not significantly disturbed. This suggests that the forest area was intact with little or no interference by anthropogenic activities like oil and gas in the study area (Essien et al.,2020; Ubuoh et al., 2021).

In 2016, LULC distribution was in decreasing order of Primary forest >Swamp forest > Built-up area> Secondary forest > Water body > bare surface, with primary forest as dominant. This suggests that the forest area was intact with little or no interference from rural farmers and other human activities. This result is variant from the finding of Etekpe (2005) who noted that: "Apart from the loss of farms, oil spills have led to extensive deforestation with no adequate replanting practices that compounded land use degradation and led to a loss of soil fertility and consequently erosion of the topsoil.

The distribution of LULC distribution in 2021 was in decreasing order Secondary forest > Primary forest > Swamp forest > Built-up area > Water body > Bare surface, with secondary as dominance forest. This result is in tandem with the finding of Ogunleye *et al*.(2004) who reported that farming activities in the reserve have resulted in large hectares of impoverished secondary forest, bare and degraded lands, grasslands and plantation of exotic species. About 25 plants useful to the respondents have also been lost due to farming activities (Ogunleye *et al.*, 2004). It is further reported that anthropogenic Activities in oil-producing communities have simply altered the natural process combined, thus destroying the natural ecosystems supporting biodiversity (Chijioke *et al*., 2018).

From the results, the percentage change of bare surface between 1986 -2003 was about 1.9% showing a decreased in bare surface, 2003- 2016 was about 0.2% and between 2016-2021 was about 2.8%, which were highly insignificant, respectively. The percentage decrease in bare surface observed in this study is in tandem with the finding of Essien *et al.*. (2020), who reported a reduction in the area coverage of bare land between 1986 and 2003, in oil-producing area of Akwa Ibom State. They further explained that bare land has experienced dramatic deductions over time, due to continuous agricultural activities, development and urbanization (Essien *et al.*, 2020). On the issue of built-up area, the rate of percentage change in the entire study area between 1986-2003 recorded about 5.4%, 2003-2016 recorded 0.72%, and 2016-2021 with 4.23% respectively, indicating an increasing rate in construction works, resulting in the removal of vegetative growths for development, which is consistent with the findings of Essien et al (2020), Ubuoh *et al*. (2020) who reported about the systematic and progressive increase in the area coverage of Built Up in Southeastern Nigeria. This finding agreed with Dewan and Yamaguchi (2009) who monitored land use and land cover changes in Dhaka metropolitan, Bangladesh and observed an increase in built-up area land use due to an increase in population. The same trend in the rate of changes in LULC in the area of primary and secondary forest dynamics, swamp and water body changes, indicated negative changes in the study area. Furthermore, Uzonu (2018) opined that forest size has the greatest size in earlier years than bare land and green areas.

The rate of percentage changes in primary and secondary forests, Iberedem et al (2021), observed that changes in the different classes of land cover in Ikot Abasi were due to urban/settlement expansion, industrial development and sand mining. Butler (2019) asserted that forest loss is a result of urban and residential area growth, hence the consumption of building materials and agriculture etc. by rural and urban dwellers. In line with the result, it has been reported that, in densely populated areas, agriculture and urbanization have been the main causes of the disappearance of forests (Stehlik *et al*., 2007; Van Calster *et al*., 2008; Rejmánek, 2018). Ikot Abasi, home to Africa's largest Aluminum Smelter Company of Nigeria (ALSCON), has witnessed unregulated sand mining which has devastated the land cover where large quantities of sand were mined to build industries and estates located in the area, and there is commercial sand mining still going on today unabated. Accordingly, illegal oil refining in the area has led to the large-scale cutting down of mangrove trees for the burning of oil. Also, the illegal oil business has resulted to oil spilled on the surface, mangrove/forested areas, rivers, streams and lakes with attendant degradation of the land cover (Iberedem *et al*., 2021). These changes could be as a result of natural events such as weather, flooding, fire, climate fluctuations, and ecosystem dynamics which may initiate modifications upon land cover (Zubair, 2006). However, globally, land cover today is altered principally by direct human use such as agriculture and livestock raising, forest harvesting and management, and urban and suburban construction and development. Incidental impacts on land cover from other human activities on the forest could also be by acid rain from fossil fuel combustion, oil exploration (Zubair, 2006), and burying of oil and gas pipeline fragments or destroying the rich biodiversity ecosystems. Apart from the reduction in habitat area (forest area), clearing of pipeline tracks delineates natural populations, which might in turn distort breeding (Nenibarini, 2004).

Above all, between1986-2021, the rates of LULUC dynamics were in decreasing order Primary forest (33.3%) > Secondary forest (26.8%) > Swamp forest (21.6%)> Built up area (11.6%) > Water body (5.5%) > Bare surface (1.3%), having an overall change rate of 16.7%, with primary forest with dominance change rate, which indicated human activities as the major factors of land cover changes. The change rate of the present study is greater than the rate of change resulting in deforestation in Enugu being 4.2% (Uzonu et al., 2024), caused by multiple factors and humans in nature.

2.4 Conclusion

This study has revealed that land cover has significantly changed in nature, rate, direction, location and area between 1986 and 2021 in the oil-producing communities in Akwa Ibom State. Another land-use has taken the place of forests in the area, leading to land degradation Also land cover change is recognized as an important driver of environmental change on all spatial and temporal scales, and has become one of the major issues for environmental change monitoring and natural resource management, hence nature-based solutions(NBS). Based on the findings, it is suggested that physical planning measures should be in place to minimize the impact of human activities, especially oil and gas through re-vegetation and establishment and enforcement of environmental Standards to checkmating human activities capable of destroying forests in the area.

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