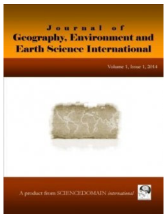

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Analysis of Land Use/Land Cover Transition in Warri Vegetation Zone of the Niger Delta Region Using Geospatial Techniques

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study analysed the land-use and land-cover transition of Warri vegetation zone of the Niger Delta Region over the last four decades using Landsat imageries of 1975, 1987 and 2015 with the aid of Remote Sensing (RS) techniques and Geographic Information System (GIS). The study area covered 187 km^2 and four land use/land cover types where analysed: Mangrove, non-mangrove, water body, and Urban area. The results show that as at 1975, out of the total area of 187 km^2, mangrove-covered 63.28 km^2 which was 33.8%, non-mangrove covered 87.01 km^2 which was 46.5%, water bodies covered 9.7 km^2 which was 5.2% and Urban settlements covered 27.01 km^2 which was 14.4%. By 2015, Mangrove covered 37.5 km^2 which was 20.1%, non-mangrove covered 45.7 km^2 which was 24.4%, water bodies covered 19 km^2 which was 10% and Urban settlements

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covered 84.7km^2 which were 45.3%. The results show a rapid and haphazard increase in urban areas, while a reduction in mangrove and non-mangrove vegetation. This is as a result of Urbanization, oil and gas exploration and other anthropogenic activities. Kappa coefficient was used to estimate the accuracy of the classification process and an average of 93% accuracy was recorded for the three years of study. The annual rate of change was calculated and used to project the likely state of land-use and land-cover in Warri metropolis by the year 2030 if current trends and practices are not hindered. The annual rate of change for mangrove was -0.64km^2 per annum and Non-mangrove was -1.03 km^2 per annum while Urban settlement experienced an increase and an annual rate of change of 1.44 km^2 per annum. The rate of vegetation loss over the past four decades and the annual rate of change is of notable concern and the need to implement conservation strategies, urban planning and sustainable development practices is paramount to prevent a complete loss of vegetation sometime in the future.

Keywords: Remote sensing; geographic information systems; urbanization; built-up; Kappa coefficient.

1. INTRODUCTION

The earth is equipped with an exceptional way of creating balance or maintaining equilibrium with the aid of biogeochemical cycles. Over the years, further studies and research has shown that very few landforms or landscapes across the globe still exists in its natural or pristine state. However, increase in human population, industrialization, urbanization and anthropogenic activities have intensified the pressure on natural resources and become a major driving force to the shift that Land-use and Land-Cover has experienced [1].

Awoniran et al., [2] elucidated that Land-use and Land-Cover change is a key area of study according to the International global environmental change research community, because it equips us with large volume of data on changes in carbon storage and sequestration by plants and it also opens up a new frontier into understanding the human dimension of environmental change. The Land-use and Land-Cover change detection research is a product of global determination to detect, predict, analyse and manage activities such as urbanization deforestation etc. that are ecologically damaging or alters Land-use.

There has a been a dynamic shift in population, rural-urban migration and socio-economic activities in the Niger Delta region which the Nigerian society has benefited immensely, since the commencement, exploitation and exploration of petroleum hydrocarbon [3]. The region is rich in Biodiversity and natural resources, and has become immensely important to the global community in regards to biodiversity conservation [4].

Warri Metropolis and surrounding communities have experienced an elevated degree of transition, urbanization, migration, expansion and developmental projects. These anthropogenic activities over time have brought about an upsurge in the rate at which land is converted or modified and also created a dynamic modification in the state of Land-use and Land-Cover. Petroleum hydrocarbon production activities in Delta state has made huge contributions to the foreign exchange revenue, created a significant economic landscape for Nigeria and also increased the degree of urbanization in Warri metropolis. Nevertheless, it also has its undesirable side and has prompted negative impacts to the environment in the region because of non-stop physical, environmental and socio-economic calamities that years or decades of little or no scrutiny and absence of effective assessment has caused [5,6]. However, there is little or no effort to assess the status, ascertain the rate of land consumption and also make an attempt to forecast some likely modifications that may happen in the future [3].

Most parts of the Niger Delta are unreachable due to the dense forest cover and challenging undulating terrain which impedes accessibility to some areas during ground surveys. Furthermore, the volatile nature of some communities can compromise the safety of indigenes and non-indigenes and prevent in-situ surveys. The use of Remote Sensing data in such situations offers countless advantages and provides information on dynamics and transition in Land-use and Land-Cover [7].

Vegetation whether Mangrove or Rainforests helps the earth with carbon sequestration which maintains the earth balance, serves as habitat for various biodiversity but the depletion of vegetation by urbanization, deforestation and oil spill pollution are key drivers to increasing climate change experienced on planet earth.

Continuous Geo-spatial studies of the transitions in Land-use and Land-Cover is very important especially as it relates to baseline assessment as an approach for advising in policy formulations concerning natural resources sector.

This study is restricted to assessing Warri metropolis Land-use and Land-Cover changes between 1975 – 2015. The area was carefully chosen based on dynamics, transitions and modifications that have occurred in the area since petroleum hydrocarbon production, deforestation and urbanization, hydrocarbon contamination and increased sabotage by militants.

It is very expedient for this study to be carried out in Warri metropolis to help identify the transition over the years, ascertain the state of vegetation especially the mangrove and rainforests and also plan for conservation strategies and sustainable development.

The aim of the study is to detect, compare and analyse transitions in the Land-use and Land-cover of Warri metropolis over the past forty years.

1.1 The Objectives Include

1. Create a Land-use and Land-Cover classification scheme.
2. Analyse Land-use and Land-Cover changes from multi temporal data.
3. Assess the temporal variation of vegetation loss and mangrove depletion.
4. Evaluate the causes and impact of Land-use and Land-Cover change on Vegetation.

2. MATERIALS AND METHODS

2.1 Study Area

Warri in Delta Sate is one city in the Niger Delta region that has experienced urban-rural migration as far back as the 15th century, when the Portuguese missionaries came [8].

Warri metropolis is located between longitude 5^0 41′ 39.58″ E to longitude 5^0 50′ 11.42″ E and latitude 5^0 28′ 12.37″ N to latitude 5^0 33′ 25.35″ N. along the northern bank of Warri River about 48km upstream from the port of Forcados with an area of about 499.81km2 [9]. The study area is approximately 187 km2 comprising of four different LGA's namely Warri south, Warri southwest, Uvwie and Udu local government areas as shown in Fig. 1.

The 2006 population of Warri town (excluding the towns of Ekpan, Aladja and Ovwian) is approximately 303,417 [9].

2.2 Method of Data Collection and Data Description

2.2.1 Field observation and desk-based study

An initial survey to ascertain the study area in Niger Delta Region was done. Warri metropolis with its long history of oil and gas exploration and exploitation, urbanization and industrialization was the perfect fit to show Land-use and Land-Cover transition. Relevant data, literature and publications were consulted on biodiversity conservation, forest transition, Land-use and Land-cover modifications to help delineate the scope of study.

2.2.2 Satellite imageries and data acquisition

Geo-referenced, calibrated and ortho-rectified Satellite imageries and datasets were used for the investigations in this study and the change detections over four decades. This study made use Satellite datasets obtained from the archives of the United States Geological Survey (USGS) at www.earthexplorer.usgs.gov. Landsat images of 1975-Landsat 2 Multi-Spectral Scanner (MSS), 1987-Landsat 4 Thematic Mapper (TM) and 2015-Landsat 8 OLI/TIRS (Operational Land Imager/Thermal Infrared Sensor) of Warri metropolis were used.

2.2.3 Geometric correction

The geometric correction was done for Landsat image of 1975-Landsat 2 Multi-Spectral Scanner (MSS) to correct geometric distortions as a result of sensor-earth geometry variations, ensure accurate spatial reference or orientation with the other satellite images used for the study and also to ensure that the data obtained from Satellite imagery has accurate spatial assessment and measurement. The image which was in the Geographic Coordinate system (GCS) World

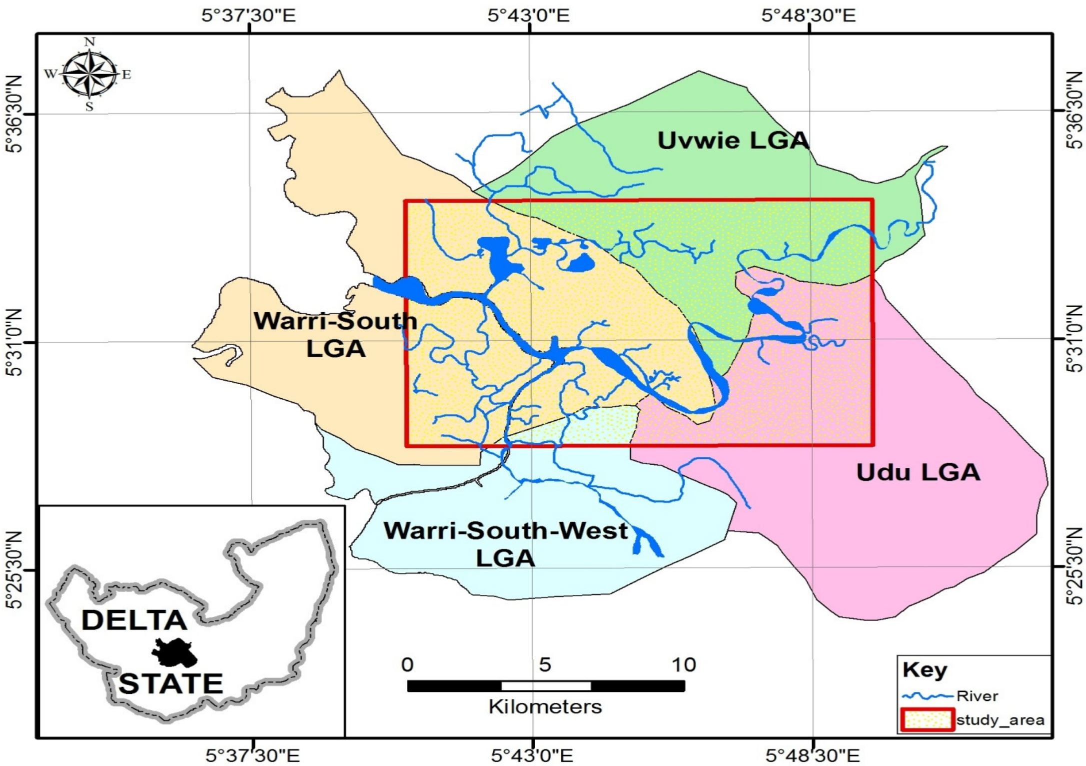

Fig. 1. Study Area
Source: Author's GIS analysis

Geodetic System (WGS) GCS-WGS 1984 was geometrically transformed in ARCGIS 10 to a projected coordinate system of the Universal Transverse Mercator (UTM) of zone 32 covering the study area. A polynomial geometric model in computer software ERDAS Imagine was used for geometric correction of the satellite imageries.

2.2.4 Layer stacking

With the aid of ERDAS Imagine 9.2 software, the different bands of the satellite images for each year of study were layer-stacked. This was done to ensure that the datasets were ready for additional processing and analysis. The different composite bands used in this study are;

i. Bands 7, 5 and 4 of the 1975 Landsat 2 MSS.
ii. 4, 3 and 2 of 1987 Landsat 4 TM.
iii. 4 and 3 of 2015 Landsat 8 OLI/TIRS.

2.2.5 Spectral enhancement

Spectral enhancement also known as image sharpening involves the modifying of values of pixels in a particular image to enhance or improve certain important features above others. It improves the overall quality of the image to aid human perception of the objects or phenomenon contained in the image. It helps to improve image resolution and enhance the quality of the satellite imageries to aid easy identification of pixels of mangrove and non-mangrove vegetation.

2.2.6 Clipping

This is also called sub-setting or delineating the Area of Interest (AOI). Warri metropolis which is the Area of Interest was delineated and identified by creating a polygon shape file for each year of study with the same spatial reference and was overlaid on the images in ArcGIS 10.2. This is illustrated in Fig. 2 to Fig. 4. Clipping helps to focus on the particular area of interest and ignore unnecessary information in the full satellite imageries.

2.3 Image Classification

The Maximum likelihood classification algorithm technique was used with the help of ERDAS Imagine 2014 to categorise and group image pixels into particular set of classes that represent a unique type of surface based on the values of intensity. Four classes were generated: mangrove, non-mangrove (this includes all other types of vegetation), built-up area (Urban) and water body.

2.4 Accuracy Assessment

Accuracy assessment is necessary in the processing and analysis of satellite images, as data gotten can serve as evidence for decision making and policy formulation [10].

The major reason for accuracy assessment is to evaluate the accuracy of the classification process. Kappa coefficient indexing statistics tool on ERDAS Imagine 2014, which has a scale measurement of -0.1 to 1 were used to determine the overall accuracy of the supervised classification.

2.5 Area Calculation

The total area of the study location for the clipped and analysed image were calculated in square kilometres (km) with the help of ERDAS Imagine 9 in other to quantify the size or spatial extent of changes that have occurred over time [11].

2.6 Change Detection

Land-use and Land-Cover data were compared and this helped to identify the change in area, percentage of change between 1975 and 2015 and the annual rate of change.

Change in Hectares = Area of later year – Area of former year

Trend (percentage change) =

$$\frac{\text{Observed Change}}{\text{Total Area}} \times 100$$

$$\text{Annual rate of change in km}^2 = \frac{A_2 - A_1}{t_2 - t_1}$$

Where A_2 is Area of later year
A_1 is Area of former or baseline year
t_2 is later year
t_1 is baseline or former year
[12,13]

The result of the annual rate of change was used to project until the year 2030 for Mangrove, Non-Mangrove and Urban settlements.

Microsoft Excel 2016 was used to calculate the percentage change, Annual rate of change in km^2 and projection of change by the year 2030.

3. RESULTS AND DISCUSSION

3.1 Clipping

The Area of Interest (AOI), which is Warri metropolis were delineated and identified by creating a polygon shape file in ArcGIS 10 for each year of study with the same spatial reference that was overlaid on the satellite images. Clipping helps to focus on the particular area of interest and ignore unnecessary information in the full satellite imageries. Figs. 2, 3 and 4 show the clipped area for this research.

3.2 Image Classification

With the aid of maximum likelihood classification technique, the Land-use and Land-Cover maps for the study area each year were created. Four Land-use and Land-Cover types were identified namely Mangrove, non-mangrove, water body and Built-up area.

The 1975 Landsat 2 Multi-spectral scanner (MSS) classification of Warri Metropolis as shown in Fig. 5 reveals that out of the total area of $187km^2$, mangrove covered $63.28km^2$ which is 33.8%, non-mangrove $87.01km^2$ which is 46.5%, water bodies $9.7km^2$ which is 5.2% and Urban settlements covered $27.01km^2$ which is 14.4%.

The 1987 Landsat 4 Thematic Mapper (TM) classification of Warri Metropolis in Fig. 6 shows us that out of the total area of $187km^2$, mangrove covered $54km^2$ which is 28.9%, non-mangrove $84km^2$ which is 44.9%, water bodies $8km^2$ which is 4.3% and Urban settlements covered $41km^2$ which is 21.9%.

The 2015 Landsat 8 OLI/TIRS supervised classification map of Warri Metropolis is shown in Fig. 7. The results show that out of the total area of $187km^2$, mangrove covered $37.5km^2$ which is 20.1%, non-mangrove $45.7km^2$ which is 24.4%, water bodies $19km^2$ which is 10% and Urban settlements covered $84.7km^2$ which is 45.3%.

3.3 Accuracy Assessment/ Validation of Classification

The accuracy assessment or validation of classification Analysis was done using Kappa statistics accuracy assessment. This is done to ensure precision and accuracy of pixel signatures assigned to a particular classification. Tables 2, 3 and 4 show the results of the accuracy assessment done with ERDAS Imagine 9 software. The error matrix shows an average accuracy of above 90% for the three years classified which helps validate the results for this study.

3.4 Change Detection

This shows the rate of Land-use and Land-Cover transition over the past four decades in Warri Metropolis. The statistical Land-use and Land-Cover distribution derived from the imageries for each year of study is presented in Table 1.

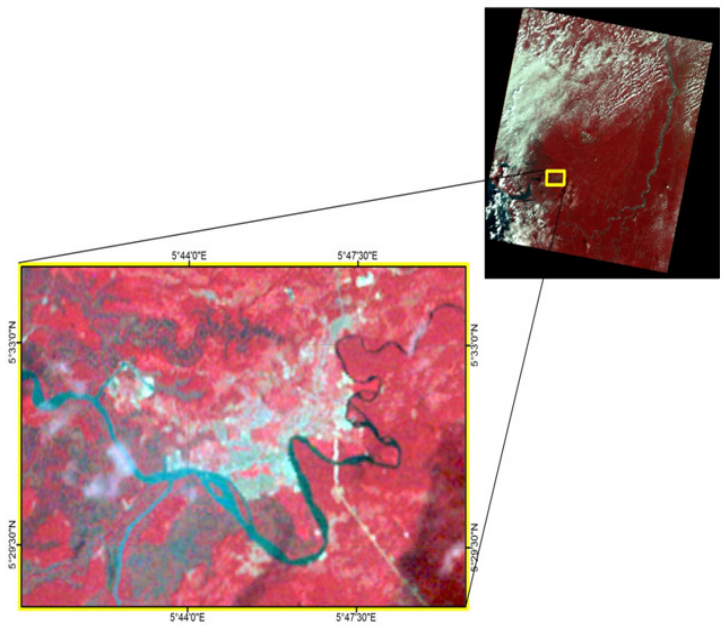

Fig. 2. Clipped 1975 (RGB-754) Landsat 2 MSS of the study area

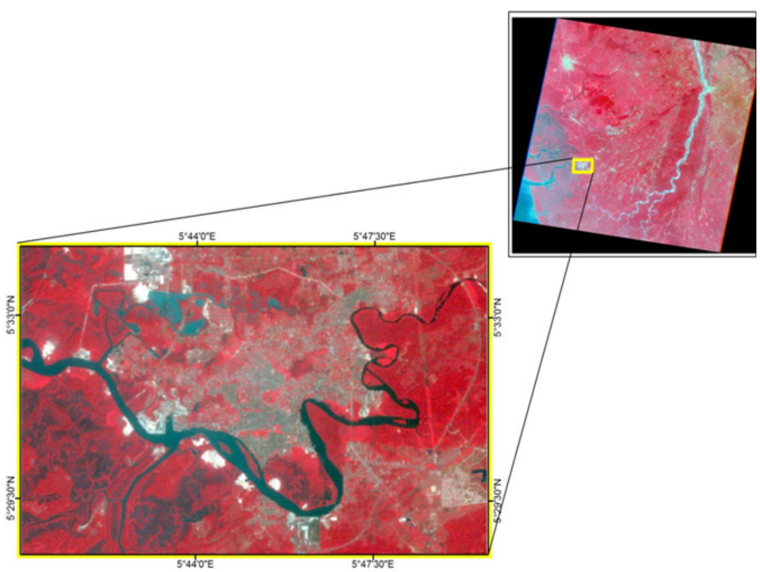

Fig. 3. Clipped 1987 (RGB-432) Landsat 4 TM of the study area

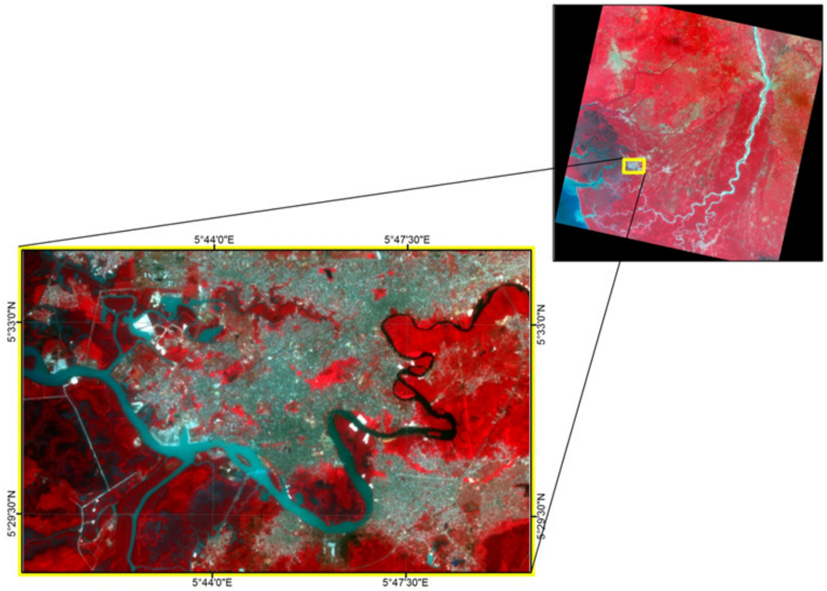

Fig. 4. Clipped 2015 (RGB-543) Landsat 8 OLI/TIRS of the study

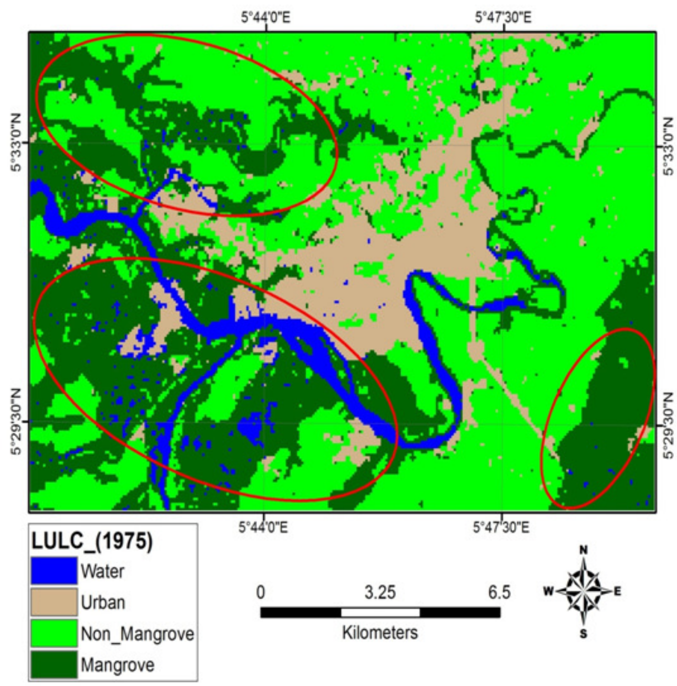

Fig. 5. Supervised classification of LU/LC 1975 Landsat 2 MSS

3.5 Projection Model

A simple projection model was used to predict the rate of change in km^2 using the annual rate of change. The annual rate of change or annual deforestation rate for mangrove between 1975-2015 was -0.64 km^2 per annum and Non-mangrove was -1.03 km^2 per annum. Urban settlement experienced an increase and an annual rate of change of 1.44 km^2 per annum.

The annual rate of change was used to project and the results show that by the year 2030, Mangrove will occupy just 27.83 km^2, Non-Mangrove 30.21 km^2 and finally Urban settlements will occupy 106.38 km^2 of the total 187 km^2 of the study area as shown in Table 5. Fig. 9 is a graphical representation of the projection model to the year 2030.

4. DISCUSSION

4.1 Land-use and Land-Cover Classes

The classification maps show the Land-use and Land-Cover of the study area over the past four decades (1975, 1987 and 2015). The 1975

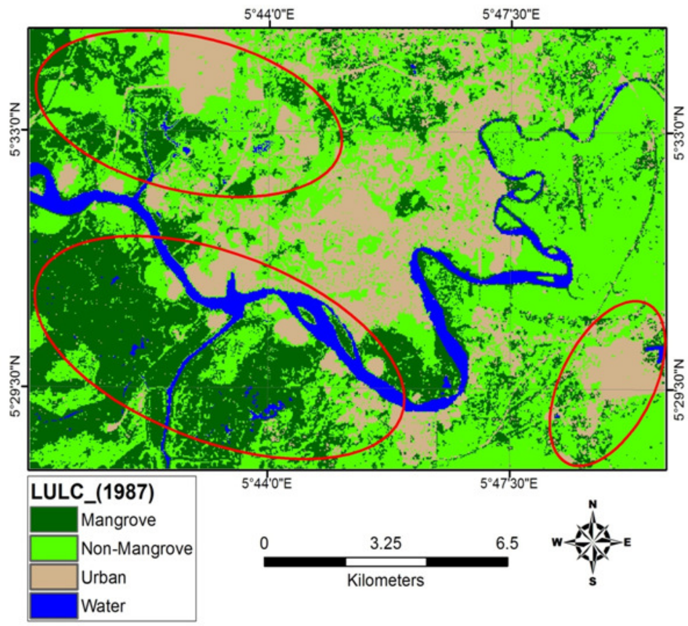

Fig. 6. Supervised classification of LU/LC 1987 Landsat 4

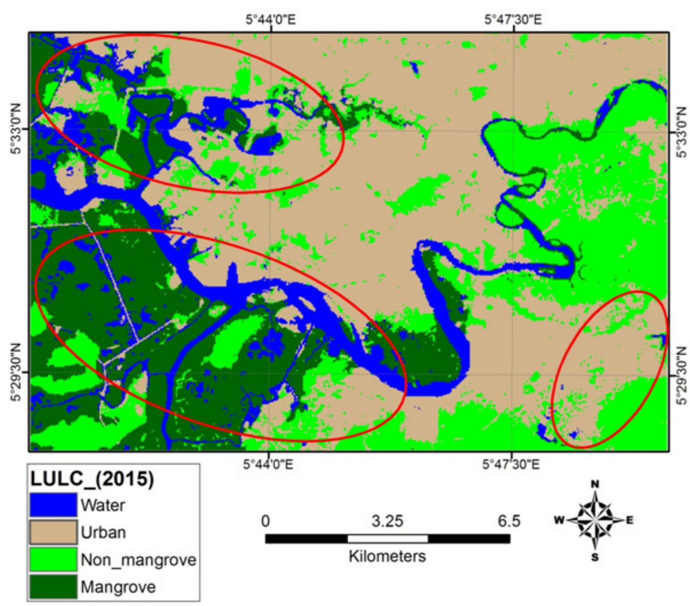

Fig. 7. Supervised classification of LU/LC 2015 Landsat 8 OLI/TIRS

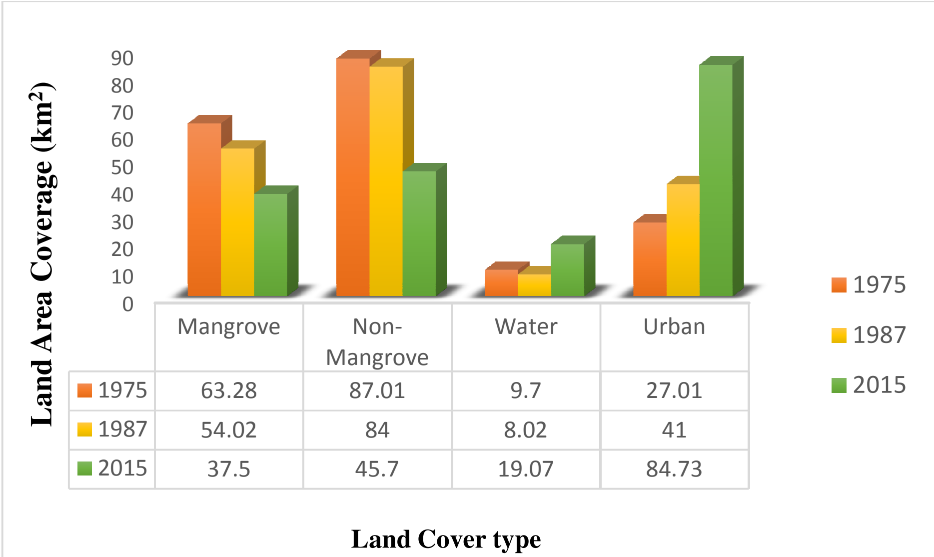

Fig. 8. Pattern of land-cover transition in Warri metropolis

Table 1. Land-use and land-Cover distribution of Warri Metropolis

Land-use/Land-Cover	1975		1987		2015	
	Area (km^2)	Percentage (%)	Area (km^2)	Percentage (%)	Area (km^2)	Percentage (%)
Mangrove	63.28	33.84	54.02	28.88	37.5	20.05
Non-Mangrove	87.01	46.53	84	44.91	45.7	24.44
Water	9.7	5.19	8.02	4.29	19.07	10.20
Urban	27.01	14.44	41	21.92	84.73	45.31
Total	187	100	187.04	100	187	100

Landsat 2 Multi-spectral scanner (MSS) classification of Warri Metropolis in Fig. 5 serves as a baseline map and point of reference to show the transitions that have occurred. The classification shows that out of the total area of 187km^2, mangrove covered 63.28 km^2 which is 33.8%, non-mangrove 87.01 km^2 which is 46.5%, water bodies 9.7 km^2 which is 5.2% and Urban settlements covered 27.01 km^2 which is 14.4%. This shows that the Mangrove and Non-Mangrove Vegetation occupied a greater area of the total study area as at that time due to dependence on agriculture and minimal urbanization. The Mangrove and Non-Mangrove vegetation served as a major means of livelihood for the people as intense oil and gas production has not fully started as that time.

By 1987, Warri Metropolis started experiencing some mild level of urbanization and industrialization since the inception of oil and gas activities. Although the Mangrove and Non-Mangrove vegetation still occupied a larger area of total study area as at this time. Out of the total area of 187km^2, mangrove covered 54km^2 which is 28.9%, non-mangrove 84km^2 which is 44.9%, water bodies 8km^2 which is 4.3% and Urban settlements increased from 14.4% as at 1975 to 21.9%. The result shows an increase in urban settlement and a decrease or degradation in Mangrove and Non-Mangrove vegetation due to deforestation for lumbering and construction of Urban settlement.

The 2015 Landsat 8 OLI/TIRS supervised classification of Warri Metropolis shows a clear picture of how much urbanization has taken place with the increase in urban settlements. It also exposes the rate of deforestation of Mangrove and Non-Mangrove vegetation. As at December 2015, findings of this study reveals that mangrove covered 37.5 km^2 which is 20.1%, non-mangrove 45.7 km^2 which is 24.4%, water bodies 19 km^2 which is 10% and Urban settlements covered 84.7km^2 which is 45.3%. this shows the sporadic rate and haphazard nature of the increase in urban settlement in Warri metropolis.

Table 2. Accuracy assessment of LU/LC classification of Warri Metropolis (2015)

Error matrix (2015)	Mangrove	Non-mangrove	Water	Urban	Row total	User accuracy	Kappa
Mangrove	51	1	1	2	55	92.73%	0.91
Non-mangrove	2	57	0	2	61	91.94%	0.89
Water	1	0	25	2	28	89.29%	0.88
Urban	0	4	1	105	110	95.45%	0.93
Column total	54	62	27	111	254		
Producer's accuracy	94.44%	91.94%	92.59%	94.59%			
Overall accuracy	93.36%						

Table 3. Accuracy assessment of LU/LC classification of Warri Metropolis (1987)

Error matrix (1987)	Mangrove	Non-mangrove	Water	Urban	Row total	User accuracy	Kappa
Mangrove	56	1	0	9	66	80%	0.76
Non-mangrove	0	115	0	1	116	99.14%	0.98
Water	0	0	21	0	21	100.00%	1
Urban	0	3	0	48	51	94.12%	0.92
Column total	56	119	21	58	254		
Producer's accuracy	100.00%	96.64%	100.00%	82.00%			
Overall accuracy	93.36%						

Table 4. Accuracy assessment of LU/LC classification of Warri Metropolis (1975)

Error matrix (1975)	Mangrove	Non-mangrove	Water	Urban	Row total	User accuracy	Kappa
Mangrove	76	3	1	4	84	86.05%	0.80
Non-Mangrove	0	117	1	1	119	98.32%	0.97
Water	0	0	14	0	14	100%	1
Urban	0	0	0	37	37	100%	1
Column Total	76	120	16	42	254		
Producer's accuracy	100%	97.50%	87.50%	88.10%			
Overall accuracy	94.53%						

Table 5. Annual rate of change and 2030 projection

LU/LC	1975 km^2	1987 km^2	2015 km^2	1975-2015 area change km^2	Annual rate of change km^2	2030 km^2
Mangrove	63.28	54.02	37.5	-25.78	-0.64	27.83
Non-Mangrove	87.01	84	45.7	-41.31	-1.03	30.21
Urban	27.01	41	84.73	57.72	1.44	106.38

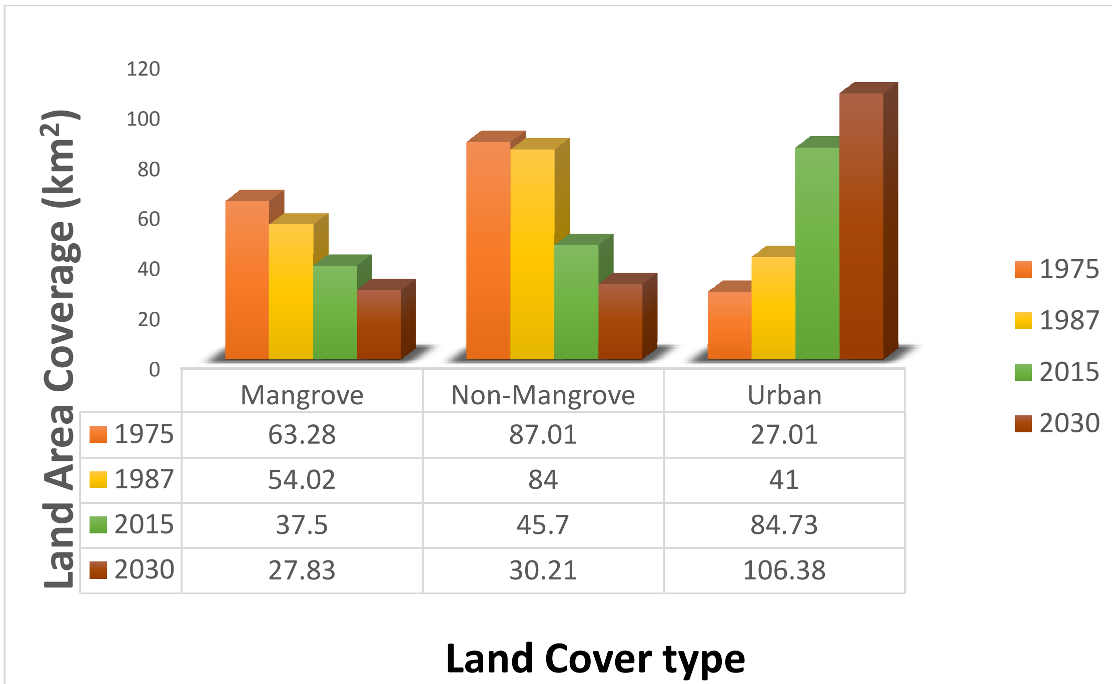

Fig. 9. Projected land-use and land-cover change as at 2030

4.2 Land-use and Land-Cover Transition

Table 5 presents an analysis of the past four decades showing a severe change in the normal progression of urbanization. The results revealed that the Urban areas had a 7.5% increase between 1975 and 1987 but between 1987 and 2015 it rapidly increased to 23.4% which can be attributed to the increase of oil and gas production, industrialization that ultimately leads to urbanization. This agrees with Gobo et al., [9] who in a similar study of the Warri metropolis using Landsat images of 1987, 2002 and 2007 experienced an overall increase in urban settlement or built up area and a reduction in mangrove forest, other vegetation and water bodies as there were converted by Man into residential and commercial uses.

Twamasi and Merem [3] also showed the nature of forest transition in Niger Delta region with increase in forest or vegetation fragmentation and increase in urban settlements which is similar to the prevalent situation found in Warri Meteropolis.

Between 1987 and 2015, there was an increase in water bodies from 8.02 km to 19.07 km which could be because of the increasing climate change issues which has led to sea level rise and inundation of some coastal lands as earlier established by Nicholls [14] and Brown, et al. [15] in their studies.

Fig. 8 is a graphical representation that clearly shows the trend and transition that Warri metropolis has experienced. The rate of degradation of vegetation especially the non-mangrove vegetation was evident in this study over the past 40 years at a constant and steady rate which raises an alarm that if nothing is done with the present percentage rate of change by 2055 we won't have any non-mangrove vegetation in the Warri metropolis. It can be stated that the rate of urbanization is directly proportional to reduction in vegetative cover in Warri Metropolis. These results confirm Madu's [16] findings that the higher the increase in population density and more urban population, the greater the negative environmental impact.

4.3 Projection Model

The annual rate of change or annual deforestation rate for mangrove between 1975-2015 as shown in Table 5 was -0.64km^2 per annum and Non-mangrove was -1.03km^2 per annum. This result is similar to the findings of FAO [17] that also recorded a high rate of deforestation especially in tropical regions around the world. This result means that by 2030 only about 30% of the total study area will be covered with vegetation which is a serious threat to the biodiversity that thrives in the area.

Urban settlement experienced an increase and an annual rate of change of 1.44 km^2 per annum. This means that by the year 2030 built up areas will occupy 106.38 km^2 of the total 187 km^2 of the study area which is about 58% of the total study area. If the transition is not monitored and sustainable development plans not implemented serious environmental (flooding), social (Crime, slums) and health (Epidemics) issues will arise in Warri metropolis.

4.4 Effects of Urbanization

Urbanization is the concentration of population as a result of movement and redistribution [18]. In this study movement and redistribution refers to relocation of human population, industries, resources in a particular area or landscape.t the conversion of other Land-cover types to built-up area or urban settlement creates an imbalance in the ecosystem thereby inhibiting the ecosystem goods and services provided by the other Land-use and Land-Cover types. The results show an increase in built-up or urban settlement in Warri south, Uvwie and Udu local government areas. Part of Warri South local government area still has a significant amount of mangrove and non-mangrove vegetation. The reason for this situation is not different from what Gobo et al., [9], who attributed the increase in flooding of Warri metropolis as a result of Land-use and Land-Cover changes, which often result to the conversion of forest areas into urban use. This process modifies wetlands and mudflats and increases the area covered by impervious materials that reduces the channel carrying capacity of the waterbodies.

5. IMPLICATIONS OF FINDINGS OF STUDY

The results show the alarming rate of deforestation in Warri metropolis because of anthropogenic activities mainly urbanization, industrialization and oil pollution. The results also projected what Warri metropolis will look like by the year 2030 if the degree of change continues without proper and effective planning and management. The effect of vegetation loss and rapid haphazard urbanization is too glaring and cannot be sidelined. The following are the implications of the findings of this study.

5.1 Vegetation Loss and Climate Change

The loss of vegetation in Warri metropolis is a direct precursor to the loss of Biodiversity in that area. As earlier noted, The Niger delta is an ecologically important region in the world, as many rare species of the world biodiversity especially fauna habits in the mangrove and freshwater swamps. Therefore, the Endangered species found in this region might have actually gone into extinction as a result of alteration of their habitat and poaching.

Carbon is a major greenhouse gas and one of the drivers of climate change. Forests serve as a major sink for carbon and aids carbon sequestration. Deforestation and loss of vegetative cover has two major effects.

i. Increase in the amount of atmospheric carbon when the trees are cut down and burnt or used.
ii. Decrease in carbon sinks due to loss of vegetation.

These two effects of deforestation and carbon emissions are part of the major causes of climate change around the world. The loss of vegetation in Warri metropolis is a micro representation of what is happening around the Niger delta and the world at large.

5.1.1 Socio-economic consequences on livelihood, traditions and cultural dilution

In as much as urbanization enhances the standard of living, the major livelihood of the peasant farmers, fishermen and the local populace has been hindered by the loss of vegetation. The local populace with little or no education will not be privileged to get white collar jobs as a result of industrialization and urbanization, as they depend greatly on nature for a means of living. The destruction of vegetation and other natural resources as a result of urbanization and industrialization has led to the advent of militancy and other social vices in Warri metropolis and the Niger delta environment.

The loss of vegetation because of urbanization and other anthropogenic factors has led to cultural dilution as a result of migration and integration of diverse culture. Vegetation which serve as sacred totems, Religion or land marks have been degraded thereby erasing some traditions and foundations of the local populace.

5.1.2 Overcrowding/Slum development and flooding

The sporadic rate and haphazard nature of Urbanization in Warri metropolis has created a lot of urban slum, which is similar to the findings of Gobo et al. [9]. Slum development coupled with unemployment rates has created an increase in crime, prostitution and other social vices. The issue of Overcrowded apartments and building can lead to serious epidemic that has adverse effects on humans.

The construction of buildings on flood plains or wet lands, poor construction of roads without drainages and the unhealthy habit of dumping of refuse into gutters and drainages has given rise to a lot of urban flooding in Warri metropolis in recent years. This has serious health issues for both human and aquatic life as all surface run-off ends up in the water bodies.

6. CONCLUSION

This study shows the importance and efficiency of Geo-spatial techniques (Remote sensing and GIS) in capturing, manipulating and analysing spatio-temporal data. The results indicated that the use of supervised classification delivered satisfactory results in terms of distinguishing Built-up areas, Water bodies, Mangrove and Non-mangrove vegetation. The results propose that vegetation will convert to built-up or urban settlements because of rapid and haphazard urbanization, which will turn out to be the key feature of Land-use and Land-Cover changes in the future.

The study therefore recommends the following actions to improve conservation or sustainable urbanization in Warri metropolis:

1. A well planned and effective conservation strategy e.g. Biodiversity Action Plan (BAP) especially for Warri South local government area that still has a considerable amount of mangrove forest.
2. Adoption of an appropriate urban planning and zoning with impact studies and scenarios, in order to protect vegetation from urbanization encroachment.

3. Continuous Geospatial survey and monitoring my academicians, state and federal ministries.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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