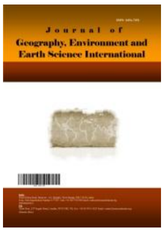

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Spatio-Temporal Changes of Land Use / Land Cover Classes in the Urban Wetland Area of Yenagoa Local Government Area of Bayelsa State, Nigeria

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Authors' contributions

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

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ABSTRACT

The study analyzes land use /land cover changes (LULC) using landsat5 TM, landsat 7 ETM and landsat OLI images of 1990,2000, 2010 and 2020.Through this study, the pattern of urban expansion for 30 years has been studied and changes in the distant future (30 years from now) have also been predicted. The satellite images covering the area were acquired and analyzed using ArcGIS10.3 and ENVI 5.0. A total area of 13741.4 hectares was delineated in the study area which is identified as Yenagoa's urban area. After processing the imagery, four land use/land cover LULC classes where developed, and the results shows that Built-up area continuously increased in land area from 1990 -2020 with total %change of 273.31%(4178.7Ha) and total annual rate of change of 25.33 ,Vegetation over have total %change of 38.55% (974.34Ha) and total annual rate of change of 3.85, wetland cover loss with total %Change of -61.96%(-5144.99Ha) and total annual rate of change of -6.19, and the water body have loss of total % of -2.16% (-8.05Ha) and total annual rate of change of -0.22. The study recommended that actual monitoring of wetland be employed using modern techniques such as GIS and Remote Sensing and also the

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traditional methods of conserving wetland ecosystem with appropriate wetland laws and legislation policies for sustainable management in conservation of wetland ecosystem.

Keywords: Global positioning system; satellite imagery; Google Earth; wetland; land use / land cover.

1. INTRODUCTION

Land use/ cover change is a key constituent of research in environmental sciences globally [1]. Technically, the concept of 'land use' is different from that of 'land cover'. 'Land use' is the purpose for which land is exploited by people; whereas, 'land cover' is the biophysical or inherent state of land above the lithosphere [2-3]. Scientist /environmentalist in the last decades have detected a trend of diminishing wetlands in terms of areal extent and health/quality, primarily linked to numerous anthropogenic interactions and indirect forces of the changing climate [4-5]. [4,6-11]. Explains that ecological fragmentation is often linked to human development in wetlands, generating a desire for management to establish a reasonable degree of land use that will generate a state of sustainability in these areas. The trend of wetland loss globally has reached an alarming trend as about 64% of global wetlands have been lost to development and other anthropogenic activities since 1990 [12]. The global distribution of wetlands today no longer reflects previous distributions as the ecological status of most wetlands have been distorted. Besides, poor planning and land uses do not encourage wetland preservation, rather they engender loss of wetland [13]. Olusola, [14] tried to distinguish between wetland degradation and wetland loss with the position that wetland loss is the outcome of converting wetland areas to non-wetland areas occasioned by human activities. These activities come in the form of dredging and boating, agriculture, industrial activities like mining, oil and gas exploration, lumbering, building of factories, construction of marinas and urbanization [15,16]. Urbanization remains a major threat to wetlands because as cities develop, rural areas in the urban fringes experience urban influences with an increased demand for land. Wetlands which serve as habitats to biodiversity is incrementally lost to urbanization and species become endangered and species that are foreign might be introduced into the environment [17].

It has been observed by most scholars that these wetlands have been degraded over time. Numerous factors have been identified to be responsible for the degradation of natural wetlands ecosystems in Nigeria especially in the Niger Delta region including Yenagoa L.G.A [18, Wali, et al., 2019b). The most important among them are, land demand by a large population, a lack of understanding of wetland values, misguided policies, lack of environmental laws and regulations, and water diversion needed because of rapid economic growth [19]. In 2011 UNEP's reports shows that wetlands around Ogoni land in the core Niger Delta communities are highly degraded and facing extinction [18] [20]. Wetlands are gradually becoming a threat to urban security in Yenagoa Local Government and its environ because the reclamation and degradations of these wetlands are done and controlled by rival urban gangs, community groups and forced economic migrants who see those wetlands are opportunity to expand their territories. Thus, residents and visitors alike thread with caution in most of those reclaimed and degraded wetland settlements [21].

GIS and remote sensing becomes a vital tool for the assessment of the status and well-being of wetlands [22] and in maintaining accurate records of the state of wetlands which is crucial in their preservation [23, 24, Anule et al., 2017; [11] Adeoye et at. [25] carried out a research on Geospatial Analysis of Wetland Areas in Lokoja, Kogi State, Nigeria. Their study was aim at measured the areal extent of wetland sites; analysed the spatial pattern of the ecosystem between 1986 and 2007 and identified the factors that are responsible for the changes in the size of wetlands in the study area. Topographical map of the study area was used as a guide to locate the wetland areas. A set of remotely sensed data (Landsat TM 1986, Landsat ETM+ 2001, Landsat ETM+ 2005 with 30m spatial resolution and SPOT-5, 2007 with 10m spatial resolution) were used to map and measure the areal extent and pattern of wetland areas. Dienye [26] carryout a research on geospatial mapping of wetlands in Eagle Island, Port Harcourt, Nigeria. The aim of her study was to produce maps of Eagle Island that depict the changes in the wetland areas and also show the flow patterns and bathymetric charts. The study made use of SPOT5 AND SENTINEL 2A satellite imageries for land-cover/landuse from 2005 to 2016 respectively. The satellite images covering of the study area were acquired and analysed using ArcGIS 10.3, and ENVI 5.0 software. The contour and vector map generated were done with surfer 10 software, and South Digital Echo sounder (SDE) 28s software was used to process bathymetric data acquired on the adjoining estuary , the total area analysed was 224.87hectares. Wizor &Wali [11] carried out a research on Geo-Spatial Analysis of Urban Wetlands Loss in Obio/Akpor Local Government Area of Rivers State, Nigeria. Their study aims to geo-spatially analyze urban wetland loss in Obio/Akpor Local Government Area (LGA), Rivers State, Nigeria. The study analyses land use /land cover changes (LULC) using Landsat7 UTM images of 2000, 2009 and 2018. The satellite images covering the area were acquired and analyzed using ArcGIS10.6. A total area of 25,773.39 sq km was delineated in their study area. After processing the imagery, five LULC classes where developed in ArcGIS environment, such as wetland, built-up area, vegetation, water bodies and bare surface. Their study shows that the urban land-use of Obio-Akpor LGA had changed dramatically during the period of 18 years. In 2000, wetlands occupied the second-lowest classes with 9.12% (2352.15 sq.km) of the total classes due to high level of urban development in the area while built-up areas occupied the third-highest classes with 17.62% (4543.83 sq.km) of the total classes.

Thus this study focuses on analyzing the Spatio-Temporal Changes of Land Use /Land Cover Classes in the Urban Wetlands of Yenagoa local government area of Bayelsa State, Nigeria from 1990-2020 using satellite imaging, Geographic Information Systems (GIS) and remote sensing techniques to develop an inventoried map for an organized urban planning strategy for wetland loss.

2. MATERIALS AND METHODS

2.1 The Study Area

Yenagoa is headquarters of Yenagoa Local Government Area and the state capital of Bayelsa State (NDDC, 2006). Geographically, Yenagoa L.G.A lies within latitudes 4°49'N and 5°23'N and also within longitudes 6°10' E and 6°33'E (Fig. 1.). The city is located on the banks of Ekole Creek and Nun River; the latter being one of the major river courses making up the Niger Delta’s river.The study area features within the tropical monsoon climate of transitional zone of Koppen Af climatic types. The study area has a tropical rain forest climate characterized by two seasons, namely the wet or rainy season and the dry season. The rainy season lasts for about 7 months between April and October with an intervening dry period in August. The dry season lasts for about 4 months, between November and March. Amos et al., [27] emphasized that Yenagoa is located in a humid tropical wetland area with mean annual rainfall of about 2539 mm with an average mean temperature of 26.2°C. SPDC (2006) stated that ambient temperature of the study area ranges from 24.5°C to 32°C during wet and 25°C to 36°C during dry seasons. There are four broad ecological zones in the region defined by both relief and hydrological characteristics. The study area consists of alluvial deposits and an extensive, low-lying, typical deltaic plain with essentially flat topography which, in conjunction with the high annual rainfall, is responsible for the extremely poor drainage conditions and the widespread development of marshes and back swamps. This area is usually submerged during the wet season where flood waters range from 0.5 to 4 m deep [28]. There are a number of perennial streams, oxbow lakes and rivers in the area e.g. Kolo Creek, Epie Creek, Yenagoa and Nun river, etc. They all form a network which empties to the Atlantic Ocean through Nun River Estuary. These rivers are mostly turbid during the wet season possibly due to discharge of clay and silt [29].

3. METHODOLOGY

The study made use of primary data. The data were acquired using GPS to collect coordinates of the various urban wetlands in the study area. Imagery of the study area was also acquired from Google Earth, 2020 version to generate the land cover of the entire study area map. Sources of data in this study were acquired from a time series of landsat Thematic Mapper (TM) and Enhanced Thematic Mapper plus with Operational Land Imager (OLI) images and were used to derive land use and land cover maps of the study area. The data set include a notable period from 1990 to 2020. The raw satellite data was obtained from the archive of the United States Geological Survey and Earth Explorer. The maps were projected using Universal Transverse Mercator (UTM) and datum WGS 84 of zone 32. Both imageries were in the same coordinate system; UTM and datum WGS 84 of zone 32. The satellite imagery were re-sampled to spatial resolution of 30m x 30m using ArcGIS. However, image re-sampling process was necessary in other to have similar spatial resolutions (ground scale measurement) for all the imageries in the question. The colour composite of the study area was done using Idrisi Taiga from the raster processing tool by adding the four bands, band 1, 2, 3, and 4 from the landsat– TM, Landsat – ETM+ and Landsat – OLI into band combination dialogue box. Lastly the study adopted a cross-sectional research design method.

3.1 Methods of Data Analysis

Descriptive and Inferential statistics were employed in the study. The descriptive analysis involved the use of frequencies, percentages, chart, table and to calculate areas in hectares (Ha) of each epoch years and also to calculate the rate of change of the various land use and land cover classes as thus.

Change = Current Year – the Previous Year

$$\%\ \text{Change} = \frac{\text{Current Year} - \text{Previous Year x 100}}{\text{Previous Year x 1}} = \text{Trend}$$

$$\text{Annual Rate of Change} = \frac{\%\ \text{change x the number of years}}{100}$$

4. RESULTS

The results of the study showing the changes which has taken place over the 30 years period as deduced from the static distribution of land use/land cover for 1990, 2000, 2010 and 2020 are presented Figs 2, 3, 4 ,5 and 6 and in Table 1 and 2 respectively.

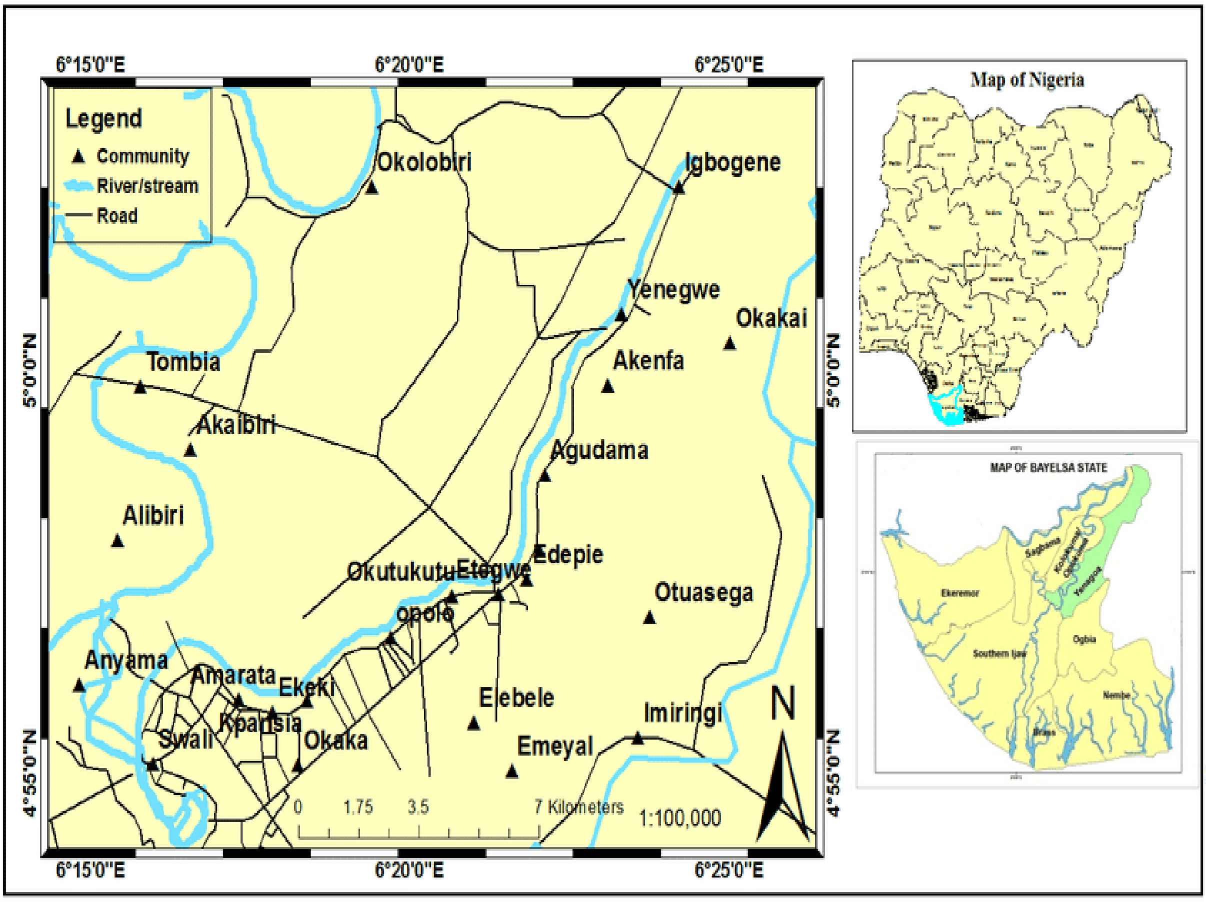

Fig. 1. Yenagoa Showing study Communities
(Source: Cartography and GIS Unit, Dept. of Geography and Env. Mgt. UNIPORT, 2021)

4.1 Classified land-use/land-cover Imagine for the Epochs of 1990 – 2020

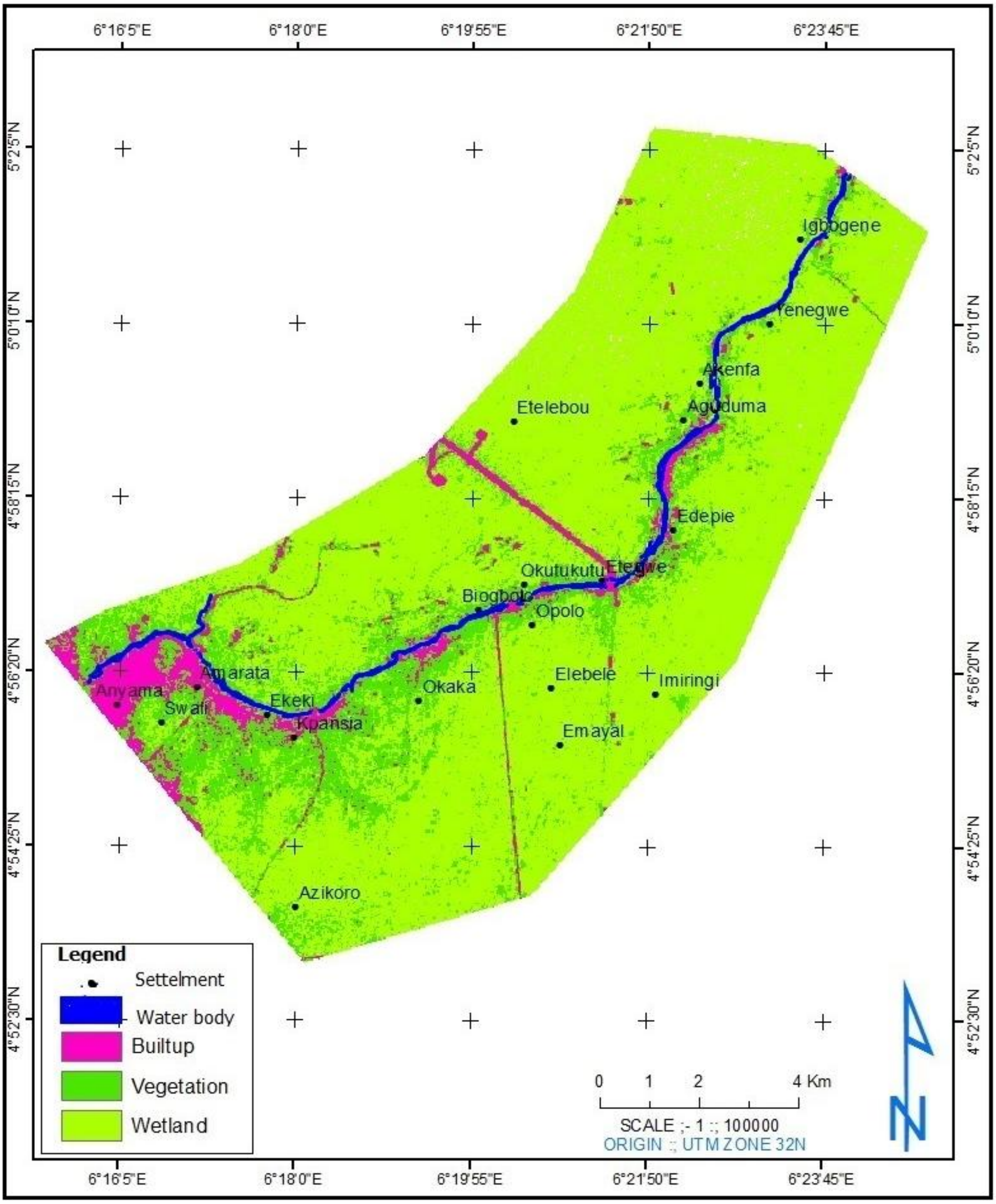

Fig. 2. Classified Landsat – OLI imagery of 1990 of the study area
(Source: Author's Field Work, 2021)

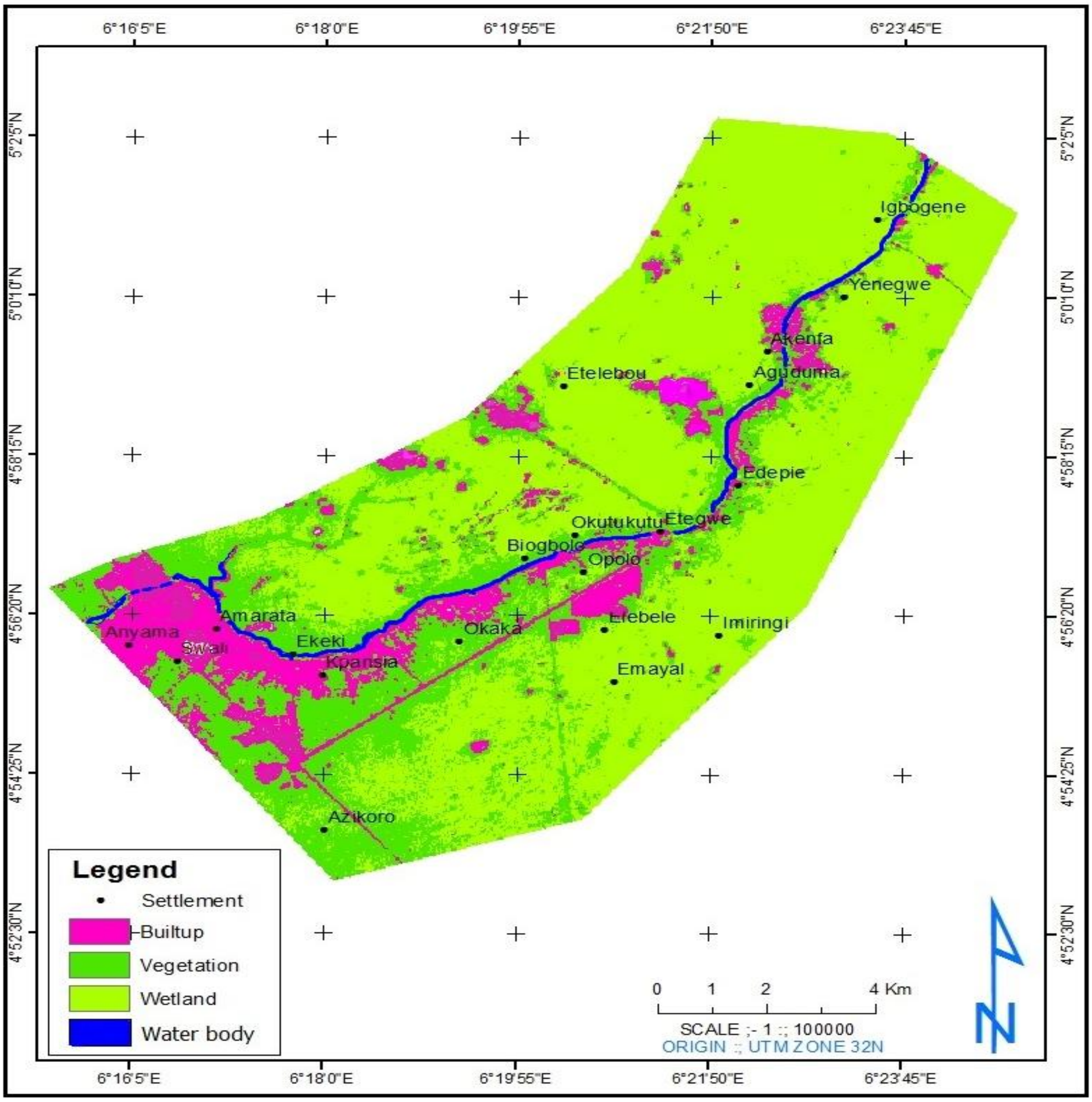

Fig. 3. Classified of Landsat – OLI imagery of 2000 of the study area
(Source: Author's Field Work, 2021)

4.2 Presentation of Classified Imagery Result

Table 1. Classification and distribution of Landuse/land cover in the study area from 1990-2020

Year	1990		2000		2010		2020	
Land Use /Land Cover classes	Area (Ha)	Area (%)	Area (Ha)	Area (%)	Area (Ha)	Area (%)	Area(Ha)	Area (%)
Built-up	806.67	5.87	1685.25	12.264	4076.93	29.669	4987.37	36.295
Vegetation	2693.43	19.601	3661.38	26.645	4282.65	31.166	3667.77	26.691
Wetland	9867.12	71.806	8028.63	58.427	5008.7	36.45	4722.13	34.364
Water body	374.16	2.723	366.12	2.664	373.1	2.715	364.11	2.650
Total	**13741.4**	**100**	**13741.4**	**100**	**13741.4**	**100**	**13741.4**	**100**

Source: (Author's Computation, 2021)

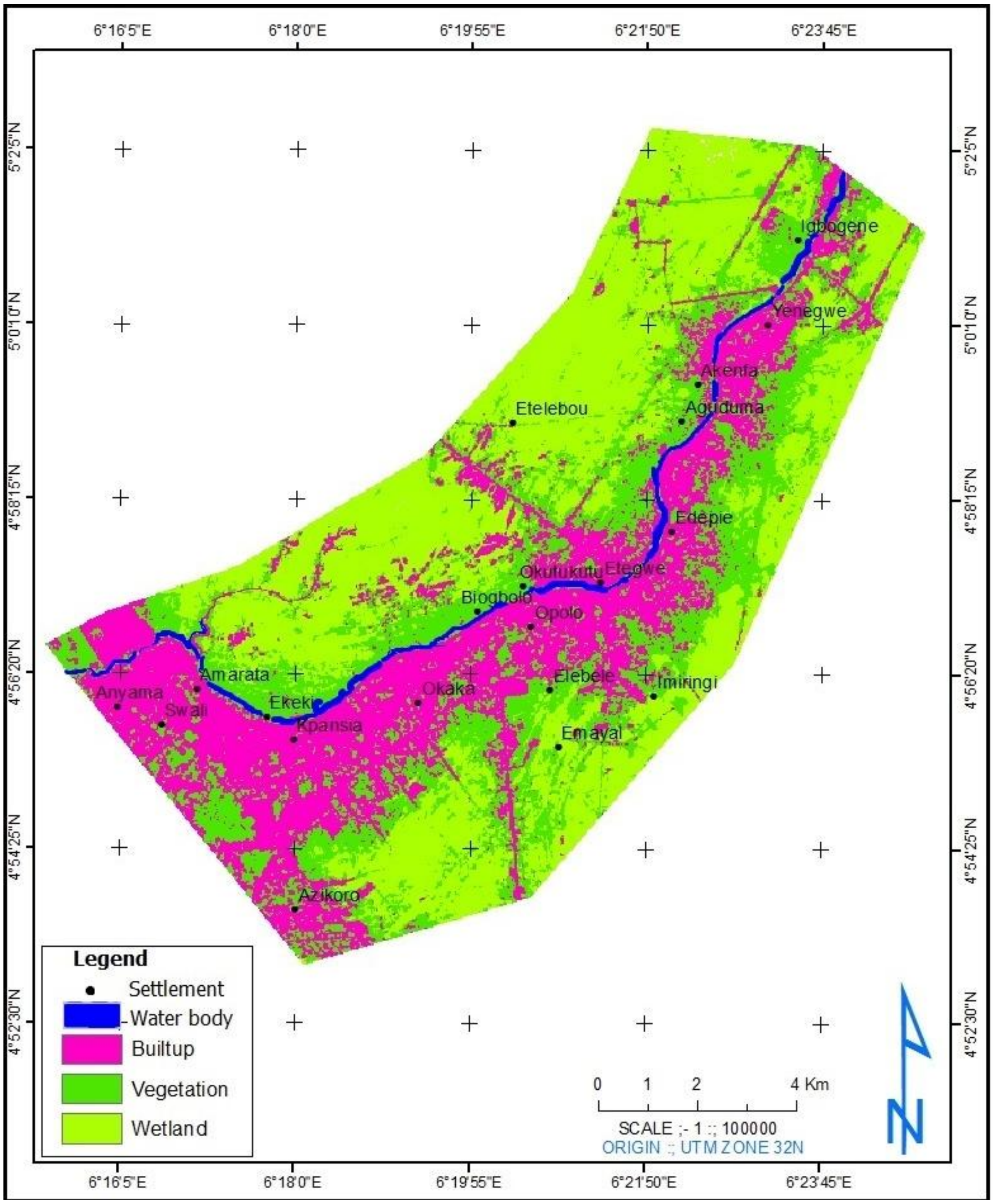

Fig. 4. Classified imagery of 2010 of the study area
(Source: Author's Field Work, 2021)

5. DISCUSSION

5.1 Classification and Distribution of Landuse/Land Cover in the Study Area from 1990- 2020

A review of the table 1 highlighted shows that in 1990, built up area occupied the third highest classes with 5.870% (806.67 Ha) of the total classes. This could be connected to low level of urban development, less pressure on wetlands, people having enough space to occupy and wetland being left alone. Wetlands ecosystem occupied 71.806% (9867.12 Ha) of the total classes. This may be the result of wetland being in an undisturbed nature without any conversion or alteration for use. The Vegetation cover occupied 19.601% (2693.43Ha) of the total Classes and water body occupied 2.723% (374.16 Ha) of the total class.

In 2000, built up area (urban land use) rose to 12.264% (1685.25 Ha) and maintained an increase in urban growth due to creation of Bayelsa state and also change from military to civilian rule (transitional period), constructions of many roads, empowerment by Government, and quest for white collar jobs. The wetlands maintain a small reduction of 58.427% (8028.63Ha). The vegetation cover occupied 26.645% (3661.38 Ha), this indicate that there was an increase in vegetation cover due to land reclamation from the wetland area. The water body occupied 2.664% (366.12 Ha); this shows a sharp reduction from the 1990.

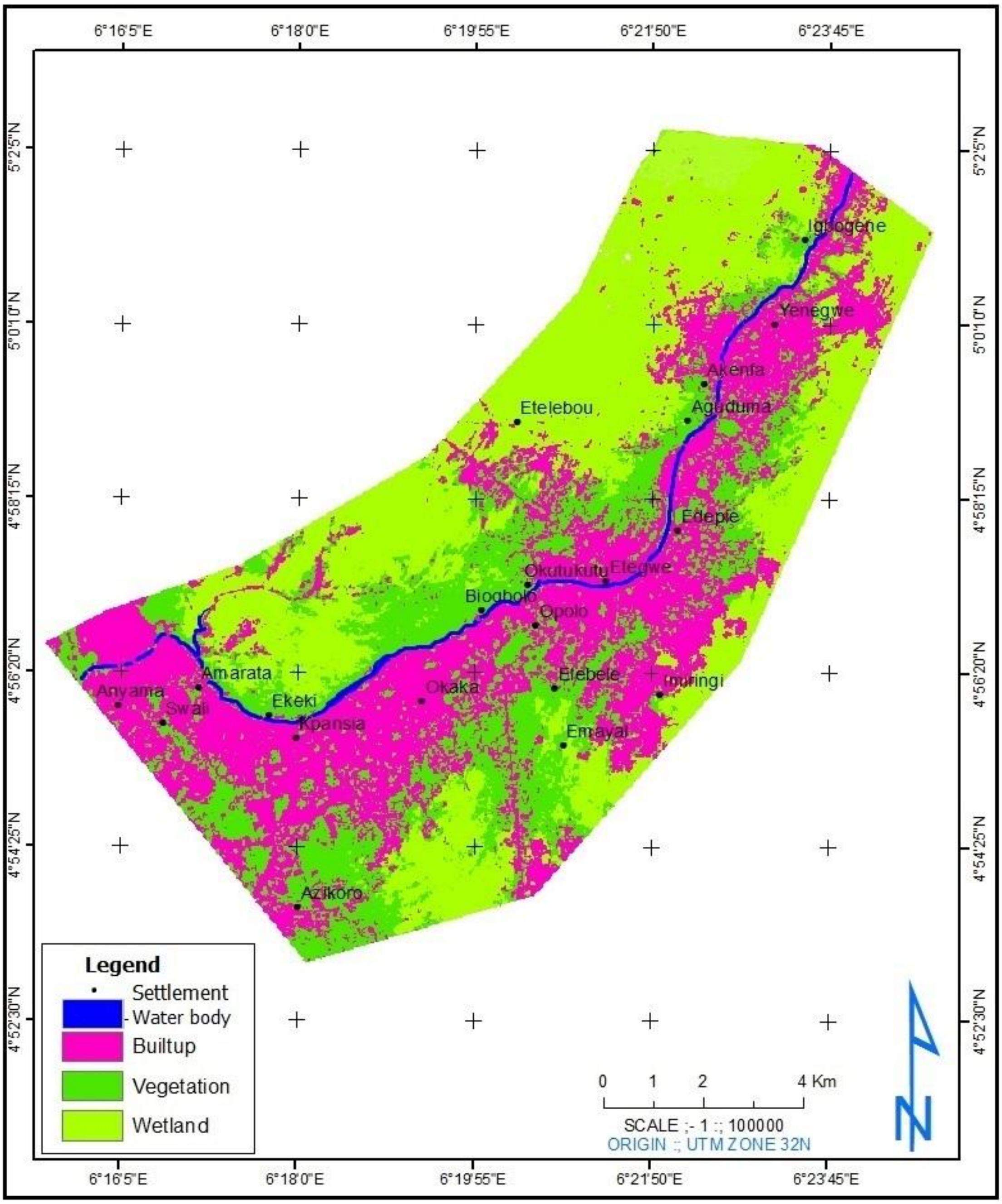

Fig. 5. Classified imagery of 2020 of the study area
(Source: Author's Field Work, 2021)

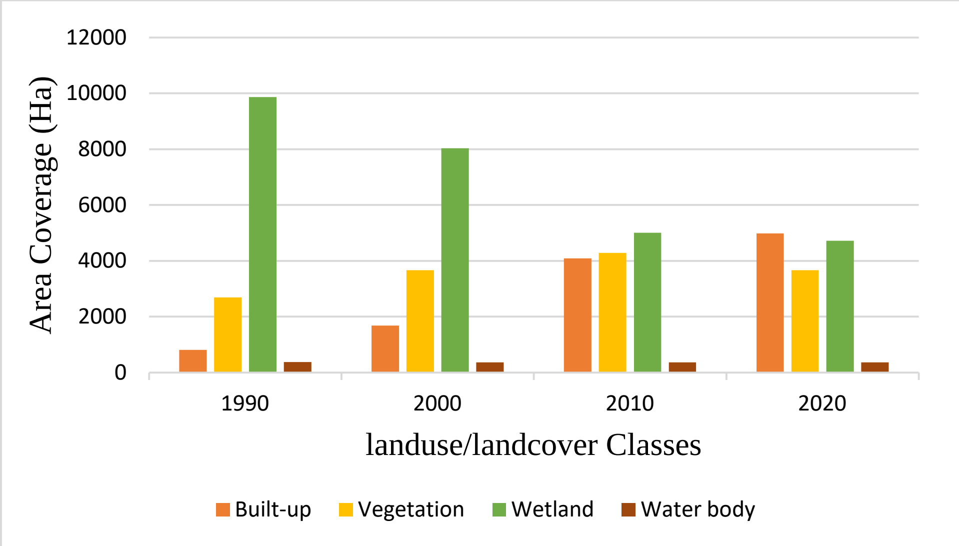

Fig. 6. Graphical representation of landusse/landcover against Area Coverage

The Table 1 highlighted indicates that in the year 2010 built up area (urban land use) occupied 29.669% (4987.37Ha) of the total class with a high increase. The wetlands occupied 36.45% (5008.70Ha) which indicates that there is pressure on wetland use such as plant products harvested from fuel wood, urban agriculture, sand dredging, sanitation, water pollution and industrial activities from oil companies within the metropolis. The vegetation cover occupied 31.166% (4282.65 Ha) of the total class with reduction from 2000. The water body occupied 2.715% (373.1Ha), this is indicate that percentage change value increases from 2000.

The year 2020 witnessed an expansion of cities in terms of developmental activities in all facets. Here, built up area increase over the year. The pattern of land cover distribution in 2020 indicated that built-up areas were occupied by the development in the Yenagoa local government area, as there was not enough space for development in the Yenagoa metropolis. The built-up occupied 36.294% (4987.37Ha) of the total land area. Degradation of wetland becomes very high. The Table 1 shows that wetlands occupied 34.36% (4722.13Ha). This is to say that there is a reduction in the size of both wetlands ecosystem due to rapid conversion of wetlands for housing development and excessive urban sprawl and its associated problems of inefficient use of land, urban space and the development of shanty towns/slums. The vegetation cover occupied 26.69% (3667.77 Ha); this shows a clear indication that there is a reduction in Area percentage when compared with the year 2010. This is due to an increased in the built-up area. The water body occupied 2.650% (364.11Ha); this shows that it still maintains slight difference in percentage with year 2010. Fig. 6 shows the statically model of land use/land cover as against area Coverage.

Urban land use and other activities have put pressure on wetland in the study area. Urban growth and encroachment to the wetland due to high population and the suitability of the areas for infrastructural development has increased stress to the wetland in the study area. For instance, the population of the yenagoa's urban area has increased rapidly over the years. As a result of urban growth, areas that were known as wetlands (see Figs 2 - 5) have been converted into built-up areas and areas for other infrastructures.

5.2 Changes in Classification and Distribution of Land Use/Land Cover in the Study Area from 1990- 2020

Table 2 shows information on the overall land use and land cover change between 1990 -2000, 2000-2010, and 2010 -2020 based on the land use and land cover maps as shown in figures 2-5. Both the absolute percentage increments between the two years and relative percentage increment from 2000 were also calculated. Negative symbols in the statistics indicated a loss in the class [30,31].

Table 2. Changes in Classification and Distribution of Land use/land cover in the Study Area for 1990- 2020

Landuse/ Landcover category	1990 (Ha)	2000 (Ha)	Change (Ha)	% Change	Annual Rate Of Change	2000 (Ha)	2010 (Ha)	Change (Ha)	% Change	Annual Rate Of Change	2010 (Ha)	2020 (Ha)	Change (Ha)	% Change	Annual rate of change	Total Change	Total % change	Total rate of change
Built-up	806.67	1685.25	878.58	108.91	10.891	1685.25	4083.93	2398.68	142.33	14.23	4083.93	4985.37	901.44	22.07	0.21	4178.7	273.31	25.33
Vegetation	2693.43	3661.38	967.95	35.94	3.594	3661.38	4282.65	621.27	16.97	1.7	4282.65	3667.77	-614.88	-14.4	-1.44	974.34	38.55	3.85
Wetland	9867.12	8028.63	-1838.49	-18.63	-1.863	8028.63	5008.7	-3019.93	-37.61	-3.76	5008.7	4722.13	-286.57	-5.72	-0.57	-5144.99	-61.96	-6.19
Water body	374.16	366.12	-8.04	-2.15	-0.215	366.12	366.1	-0.02	-0.01	0	366.1	366.11	0.01	0	0	-8.05	-2.16	-0.22

Source: (Author's Computation, 2021)

The results from Table 2 revealed that from 1990 -2000 the Built-up area has change in area covered to be 878.58Ha with a percentage change of 108.91%over an annual rate of change over 10years period to be 10.89, this shows that there is an increase in built-up area due to growth in population. Vegetation cover experienced increased in the study area from 35.94% (967.95 Ha) of the total land from1990-2000 with annual rate of change of 3.594. Other class such as wetlands reduced in the study area from -18.63% (-1838.49 Ha) of to the total land from 1990-2000 with an annual rate of change of -1.863. The analysis shows that water body also reduced in the study area from -2.15% (-8.04 Ha) of the total land area from 1990-2000 with annual rate of change of -0.215. This is as a result of increase in other class of landuse/ landcover.

However, within 2000- 2010 as shown from the Table 2, the classes such as built-up area continued increases because of the urbanization due to creation of more jobs opportunities both in government, oil companies and commercial sectors. The built-up increased in the study area from 142.33% (2398.68Ha) of the total land area from 2000-2010 with annual rate of 14.23. The vegetation cover continued increasing due to land reclamation as shown from the Table 2, the increase in the study area from 16.97% (621.27Ha) of the total land area from 2000-2010 with annual rate of 1.7. The wetland area experienced reduction in area covered. The analysis shows that from the study area, the percentage change in wetland -37.61% (-3019.93 Ha) of the total land 2000-2010 with annual rate of change of -3.76. This result is as in increase in land use of other classes such as the built-up area and the vegetation cover. The analysis shows that there is no much reduction in water body. The water body change is very low in the study area from -0.01% (-0.02 Ha) of the total land area from 2000- 2010 with an annual rate of change of 0.00.

Within 2010 -2020, there was a tremendous change in the classes. The built-up area experienced sharp growth in the land area, and its changes over this period in the study area was 901.44Ha, a percentage change of 22.07% with annual rate of change of 0.21. This shows practical increment in built-up area. The vegetation cover reduces in the study area from-14.4%(-614.88 Ha) of the total land area from 2010-2020 with annual rate of change of -1.44. The wetlands area kept reduces in land area of-286.57Ha and percentage change of -5.72% with an annual rate of change of -0.57. Water body also maintained the slow rate of increase in the study area from 0.00 % (0.01Ha) of the total land area from 2010-2020 with an annual rate of change of 0.00.

In summary, no other land use classes experience this magnitude of change except built up and wetland. This extensive growth creates difficulties in the lack of adequate infrastructure and creates various negative environmental impacts. Some of the changes are the loss of biodiversity and valuable vegetation, including agricultural land. For instance, the conversion of vegetation land and wetland area into urban use increased the total impervious cover of the city while the conversion of marginal areas like flood plains and river corridors contributes to the reduction in channel carrying capacity of the creeks; this is reflected in the channel in ability to accommodate peak surface runoff which leads to the catastrophic floods experienced in the area [30].

The total percentage change and total annual rate of change for the whole trend is given below:

Built-Up	273.31%	and	25.33
Vegetation	38.55%	and	3.85
Wetland	-61.96%	and	-6.19
Water body	-2.16%	and	-0.22

6. CONCLUSION AND RECOMMENDATIONS

This study was designed to demonstrate the capacity of GIS and remote sensing in capturing, retrieving and analysing spatio-temporal data. An attempt was made in this study to develop a spatial data base on land use/land cover change, with an emphasis on land use classes, assess the ecological and socio-economic effects of wetland use, to map wetlands in Yenagoa's urban area between 1990 to 2020, and to explore the causes of degradation of the wetlands. A comprehensive land use/ land cover map was developed for four epochs for a period of 30 years. The major conclusion and recommendations are as thus:

In 1990, built up area employed the third uppermost classes with 5.870% (806.67 Ha) of the total classes. This might be linked to low level of urban development, less pressure on wetlands, people having enough space to occupy and wetland in predestined time. Wetlands secured up to 71.806% (9867.12 Ha) of the total classes. This may be the result of wetland being in its natural state without any conversion or alteration for use. The Vegetation cover occupied 19.601% (2693.43Ha) of the total Classes and water body occupied 2.723% (374.16 Ha) of the total class.

Within 2000, built- up area escalation to 12.264% (1685.25 Ha) .Wetland ecosystem maintain a small reduction of 58.427% (8028.63Ha). The vegetation cover occupied 26.645% (3661.38 Ha), this point out that there was an upsurge in vegetation cover due to land reclamation from the wetland area. The water body occupied 2.664% (366.12 Ha.

In the past 20 years built - up area occupied 29.669% (4987.37Ha) of the total class. Wetland occupied 36.45% (5008.70Ha) which indicates that there is pressure on wetland use such as plant products harvested from fuel wood, urban agriculture, sand dredging, sanitation, water pollution and industrial activities from oil companies within the metropolis. The vegetation cover occupied 31.166% (4282.65 Ha) of the total class with reduction from 2000. The water body occupied 2.715% (373.1Ha), this is indicate that percentage change value increases from 2000.

The year 2020 witnessed an expansion of cities in terms of developmental activities in all facets. Here, built up area increase over the year. The pattern of land cover distribution in 2020 indicated that built-up areas were occupied by the development in the Yenagoa local government area, as there was not enough space for development in the Yenagoa metropolis. The built-up occupied 36.294% (4987.37Ha) of the total land area. Degradation of wetland becomes very high with wetlands occupied 34.36% (4722.13Ha). The vegetation cover occupied 26.69% (3667.77 Ha); this shows a clear indication that there is a reduction in area proportion when compared with the year 2010. This is due to an increased in the built-up area. The water body occupied 2.650% (364.11Ha); this shows that it still retains small difference in portion within 2010. The study recommended that actual monitoring of wetland be employed using modern techniques such as GIS and Remote Sensing and also the traditional methods of conserving wetland ecosystem with appropriate wetland laws and legislation policies for sustainable management in conservation of wetland ecosystem.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Essien E, Cyrus S. Detection of urban development in Uyo Nigeria using remote sensing Landsc Ecol. 2019;8: 102
2. Lambin EF, Turner BL, Geist HJ, Agbola SB, Angelsen A, Bruce JW, Coomes OT, et al. 'The causes of land-use and land-cover change: Moving beyond the myths', Glob. Environ. Change. 2003;11:261–269.
3. Tariku Z, Vanum G, Yechale K, Abren G. Geospatial Analysis of Wetland Land Use/Land Cover Dynamics On Lake Abaya-Chamo, Southern Rift-Valley of Ethiopia. Research Square; 2020.
4. Eppink EV, van den Bergh JCJM, Rietveld P. Modelling Biodiversity and Land Use: Urban Growth, Agriculture and Nature in a Wetland Area. Ecological Economics. 2004;51:201-216.
5. Hartig T, Evans GW, Jamner LD, Davis DS, Garling T. Tracking restoration in natural and urban field settings. Journal of Environmental Psychology. 2003;23:109–123.
6. Ujoh F. Estimating Urban Agricultural Land Loss in Makurdi, Nigeria, Using Remote Sensing and GIS Techniques. Unpublished M.Sc Dissertation, Department of Geographyand Environmental Manag-ement, University of Abuja, Nigeria; 2009.
7. Ujoh F, Eneche PSU. Ecological Assessment of Infrastructure Development in Kaduna State, Nigeria. Geospatial Information Science (GSIS) Journal (article under review); 2017.
8. Anule P, UJoh F. Geospatial analysis of wetlands degradation In Makurdi, Nigeria.

International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLII-2/W7, 2017 ISPRS Geospatial Week Wuhan, China; 2017.
9. Wali E, Phil-Eze PO, Nwankwoala HO. Saltwater- Freshwater wetland ecosystem and urban land use change in Port Harcourt metropolis, Nigeria. Earth Sciences Malaysia. 2018a;2 (1) 01-07. DOI:http://doi.org/10.26480/esmy/.01.2018.01.07
10. Wali E, Phil-Eze PO, Nwankwoala HO, Bosco-Abiahu Lilian C, Emelu, Victoria O. Analysis of Land use and Land Cover Changes in the Wetland Ecosystem of Port-Harcourt Metropolis, Nigeria. International Journal of Ground Sediment and Water. 2019b;09:503-524. DOI: 10. 5281/Zenodo.347888
11. Wizor CH, Wali E. Geo-Spatial Analysis of Urban Wetlands Loss in Obio/Akpor Local Government Area of Rivers State, Nigeria. Asian Journal of Geographical Research. 2020;3(1):35-48. Article no.AJGR.54603
12. Nedelciu CE, Siuta M. Report on Socio–Economic Benefits of Wetland Restoration in Central and Eastern Europe. Budapest: CEEweb for Biodiversity; 2016.
13. Junk WJ, An Shuqing, Finlayson CM Current State of Knowledge Regarding the World's Wetlands and their Future under Global Climate Change: A Synthesis. Aquatic Sciences. 2013;75:151–167.
14. Olusola AM, Muyideen AA, Ogungbemi OA. An Assessment of Wetland Loss in Lagos Metropolis, Nigeria. Developing Country Studies. 2016;1–7.
15. Turner MH, Gannon R. Major Causes of Wetland Loss and Degradation. Retrieved from Wetlands Loss and Degradation; 2017.
16. Olalekan A, Gordon M. The Niger Delta Wetlands: Threat to Ecosystem Services, their importance to dependent communities and possible management measures. International Journal of Biodiversity Science, Ecosystem Services and Management. 2011;7(1):50-60. http://dx. DOI. org/10.1080/ 21513732.2011.603138.
17. Hardman S. How does urbanization affect biodiversity? Retrieved from Ecological Blog;b 2011.
18. UNEP. Environmental assessment of Ogoni land, 1–262. United National Environmental Programme (UNEP): Nairobi; 2011.
19. Ohimain EL, Imoobe TOT, Benka-Coker. Impact of dredging on zooplankton communities of Warri Rivers, Niger –Delta. African Journal of Environmental Pollution and Health. 2002;1:37-45.
20. Wali E, Nwankwoala HO, Ocheje JF, Chinedu JO. Oil Spill Incidents and Wetlands Loss in Niger Delta: Implication for Sustainable Development Goals. Published in International Journal of Environment and Pollution Research. January by European Centre for Research Training and Development UK. 2019a;7 (1):1-20. Available:www.eajournals.org
21. Dapa N, Brown I (2020): The boom, the blunder and the brunt of Wetlands conversion and Urbanization in Port Harcourt Municipality. Int J Hydro. 2020; 4(5):243–252. DOI: 10.15406/ijh.2020.04.00251
22. Cook BI, Miller RL, Seager R. Amplification of the North American "Dust Bowl" drought through human induced land degradation. Proc. Natl. Acad. Sci. 2009;106:4997-5001.
23. Klemas V. Remote sensing of Wetland: Case Studies Comparing Practical Techniques". Journal of Coastal Research. 2011;27 (3):418-427.
24. Roberston HV. Wetland reserves in New Zealand: the status of protected areas between 1990 and 2013. New Zealand Journal of Ecology. 2016;40(1):1-11
25. Adeoye NO, Orimoogunje OO, Yusuf MJ. Geospatial Analysis of Wetland Areas in Lokoja, Kogi State, Nigeria. Ife Research Publications in Geography, [S.l.]. 2016;10: 114-124. ISSN 2636-5243. Available:https://irpg.oauife.edu.ng/index.php/irpg/article/view/36
26. Dienye, Amina Samuel. Geospatial Mapping of Wetlands in Eagle Island, Port Harcourt, Nigera". Department of Surveying and Geomatics, Rivers state University. (Un publish); 2019.
27. Amos-Tautau BMW, Onigbinde AO, Ere D. Assessment of some heavy metals and physicochemical properties in surface soils of municipal open waste dumpsite in Yenagoa, Nigeria. African Journal of Environmental Science and Technology. 2014;8(1): 41-47.

28. Akpokodje EG. A method of reducing the cement content of two stabilized Niger Delta soils. Q J Eng Geol London. 1986;19:359–363.
29. Amadi PA, Ofoegbu CO, Morrison T. Hydrogeochemical assessment of groundwater quality in parts of the Niger Delta, Nigeria. Environ Geol Water Sci. 1987;14:195–202.
30. Oludare H, Adedeja, Opeyemi O, Tope Ajayi, Olukemi L. Abegunde. Assessing and predicting changes in the status of Gambari forest reserve, Nigeria using remote sensing and GIS techniques". Journal of Geographic information system. 2015;7:301-318.
31. Wali E, Phil-Eze PO, Nwankwoala HO. Forecasting the future pattern of land use and land cover change in the wetland ecosystem of the Port Harcourt metropolis. International Journal of Emerging Engineering Research and Technology. Sryahwa Publications. 2018b; 6(2):1-7.

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