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Assessment of Landscape Change on Settlement, Water and Landcover Resources in Rivers State, Nigeria

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Abstract: Landscape change has become a major issue of concern in a fast growing global community where issues of space, water and food must be adequately addressed. This paper used satellite images of TM 1986, ETM 2008, ETM 2016 and ETM 2018 for the study of landscape changes in Port Harcourt region for four interval years. Supervised image classification through maximum likelihood classifier algorithm was used. The classified images were put into post-classification comparison analysis to identify the trajectory of land use/land cover changes through time. Six land use/land cover classes of farmland, settlement, swamp, water body, virgin forest and secondary forest were analyzed. Results revealed that between 1986 and 2016, settlement increased in size in the study area from 14.26 % to 56.90 %. Conversely, swamp and farmland recorded negative growths, whereas swamp decreased from 32.49 % to 5.73 %, farmland decreased from 30.68 % to 3.88 % within the same period. However, secondary forest showed a consistent positive growth from 10.66 % to 30.39 % throughout the study period (1986 to 2018). The study proposes a proper policy guideline and implementation for sustainable land use as these could enhance maintenance of natural hydrological cycle and retention of land cover for ecosystem needs and services.
[Emejuru, S. A. and Bakpo, M. T. **Assessment of Landscape Change on Settlement, Water and Land cover Resources in Rivers State, Nigeria.** *J Am Sci* 2019;15(7):70-77]. ISSN 1545-1003 (print); ISSN 2375-7264 (online). http://www.jofamericanscience.org. 8. doi:10.7537/marsjas150719.08.

Keywords: Virgin forests, secondary forests, landscape, post-classification, ecosystem.

1. Introduction

Food and water are two main essential components in the sustenance of life. Thus, the availability of these necessities has become a global concern to mankind especially in a rapidly expanding world population. This population must need water and food to survive. Water resources of a country represent a vital component of its national assets.

Properly managed water resources are a critical segment for all forms of life, food production, economic growth, poverty reduction and general wellbeing. The livelihoods of the rural dwellers are associated with land cover and water resources services. The surface and ground water resources of a country play a major role in agriculture, industrial activities, forestry, fisheries, hydropower generation and recreational activities. In all these, drinking water, agriculture and fisheries are critical to the rural dweller for his sustenance. Anthropogenic activities are major challenges in impacting the hydrological cycle and by extension the land cover as well as the climate.

Assessing the impacts of human activities on hydrological and land cover environments is becoming a global research interest area (Abam 2001; Abate 2011). In Rivers State, the water and landcover resources needs have been that of clean and healthy drinking water as well as the ability to preserve the natural land cover resources from pollution and total disappearance from the surface. Thus, to conserve the hitherto green infrastructure and the increasing fragile ecosystem against high population pressure as well as the emergence of squatter settlements is becoming a major challenge to urban planners, and regional governments. The Port Harcourt capital city of Rivers State had witnessed a dramatic change in its landscape in the last forty (40) years, due mainly to increase in urban population (NPC 1991; 2003).

The resultant effect of this is the population spillover into adjourning local government areas north and north-east of Port Harcourt City, and they include Obio/Akpor, Ikwerre, Emohua, Etche, Oyigbo and Eleme local government areas (LGAs). This has again led to a rapidly changing landscape (landcover and landuse) in these local government areas, as the migrant population scramble for accommodation within the available landscape.

Hence, most of the hitherto serene small settlements have become centres bustling with human beings and activities with different types of construction facilities. As a consequence, this has led to major environmental challenges such as vegetation/biodiversity degradation, solid waste and water pollution, proliferation of slums, over-exploitation of natural resources and abuse of physical planning laws and regulations. Bakpo and Solomon

(2018) had earlier reported the effectual relationship between soil and vegetation in oil and gas polluted environment as revealed by regression analysis.

According to Doygun and Alphan (2006), regardless of the regional economic importance, urban growth particularly the expansion of residential and commercial land use towards the periphery of urban areas, has an impact on the ecosystem. It is of consequence to note that topographic features such as terrain shape and water sheds within urban areas have important influence on water cycle, the natural filtering capacity of river systems, sustenance of critical habitats, forest cover and storm management (Meyer; Paul and Taulbee, 2005). This research is aimed at establishing to what extent the settlements; water and land cover resources have changed in Port Harcourt region between 1986 and 2018 and identify the direction and magnitude of the change.

2. Materials and Methods

2.1 Study Area

The study was conducted in the Southern most fringes of the tropical rain forest belt of Nigeria. The area lies within the geographical co-ordinates of 4º46[1]- 5º17 N latitude and 6º40[1]– 7º05[1] E longitude. It is situated on the eastern flank (precisely covering the LGA's of Obio/Akpor, Ikwerre, Emohua and Etche region of the upper Niger Delta Basin of Rivers State (Fig. 1).

The land form/topography is coastal plains, almost featureless. The region is generally flat except at some interfluve areas where the river channels cause the dissection of the almost monotonous plain. The highest elevation is not more than 25m amsl (Ede 2015). The geology is relatively young and composed of sedimentary rocks made up of sandstones, shales and clays of cretaceous and tertiary ages (Ofomata, 1975). The climate is the tropical wet climate (Koppen's 'Af' classification).

It is characterized by heavy rainfall (with only 2 – 3 months of moderate rainfall) and high temperature (23ºC – 34ºC) accompanied by high humidity of more than 70% all year round (Ede, 2015). The natural vegetation is the low latitude evergreen rainforest, though much has been depleted due to anthropogenic activities. In some areas that still retain the unique characteristics of the rainforest, such as the three-layer canopy, floristic diversity and open floor, such fancied wood species as Iroko, *Chlorophoraexelsa*; Obeche, *Triplochintos scleroxylon*; Afara, *Terminaliasuperba*, Mahogany, *Khayairoriensis* still exist (Judith, 2013; Rilwani and Emejuru, 2014). In recent times, remote sensing has become a veritable tool for observation and measurement of land use/land cover (LULC) changes and other biophysical characteristics. Identification and separation of the observed objects are accomplished partly through analyses of spectral signatures (Jensen, 2004). Additionally, data can be collected at multiple scales and at multiple times, offering opportunity for analyses of various phenomena from local to global scales through time (Njoroge, Maina and Nda'Nganga, 2011).

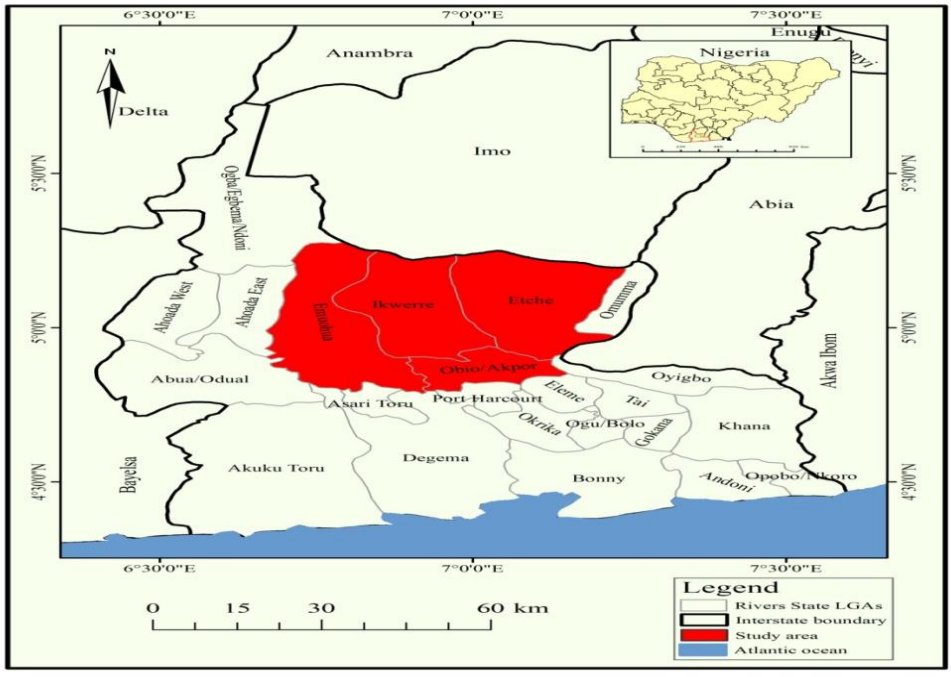

Fig 1: Study Area, Port Harcourt North Region, showing administrative boundaries

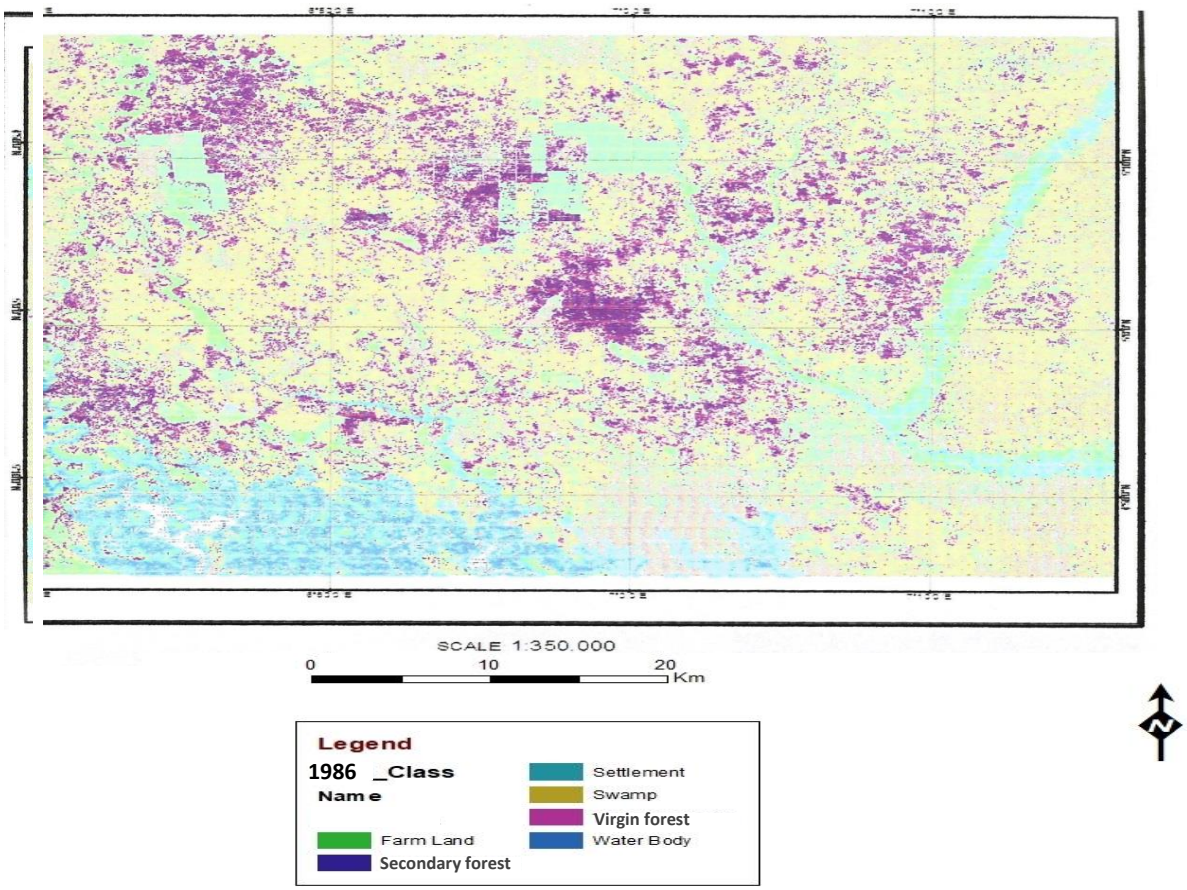

Fig. 2: Land use/land cover map of study area derived from tm lands at image 1986

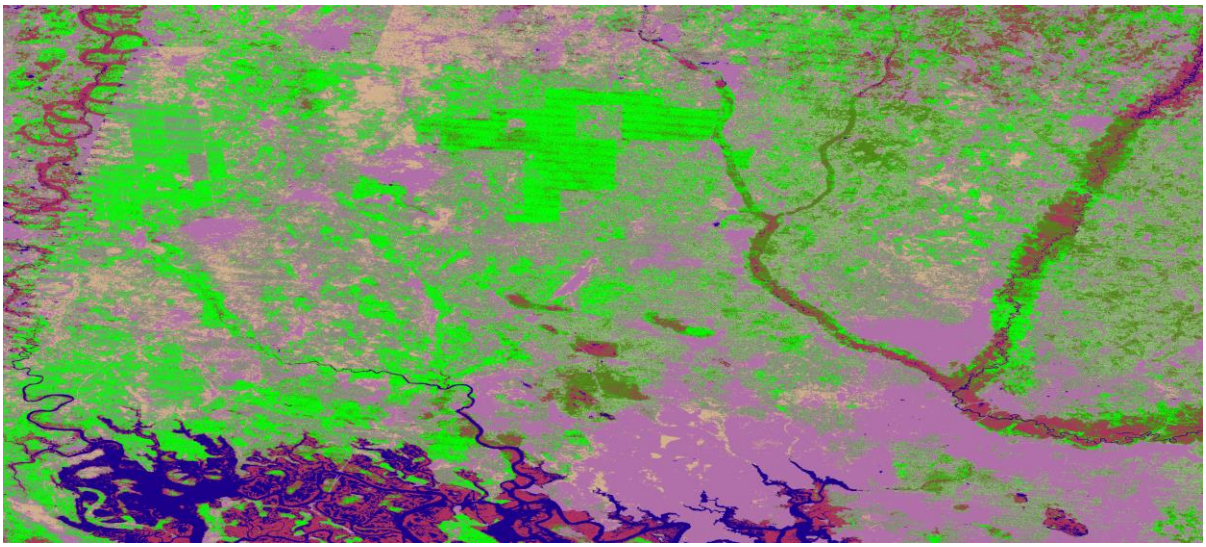

Fig. 3: Land use/Land cover classification of study area derived from lands at ETM+ 2008 imagery

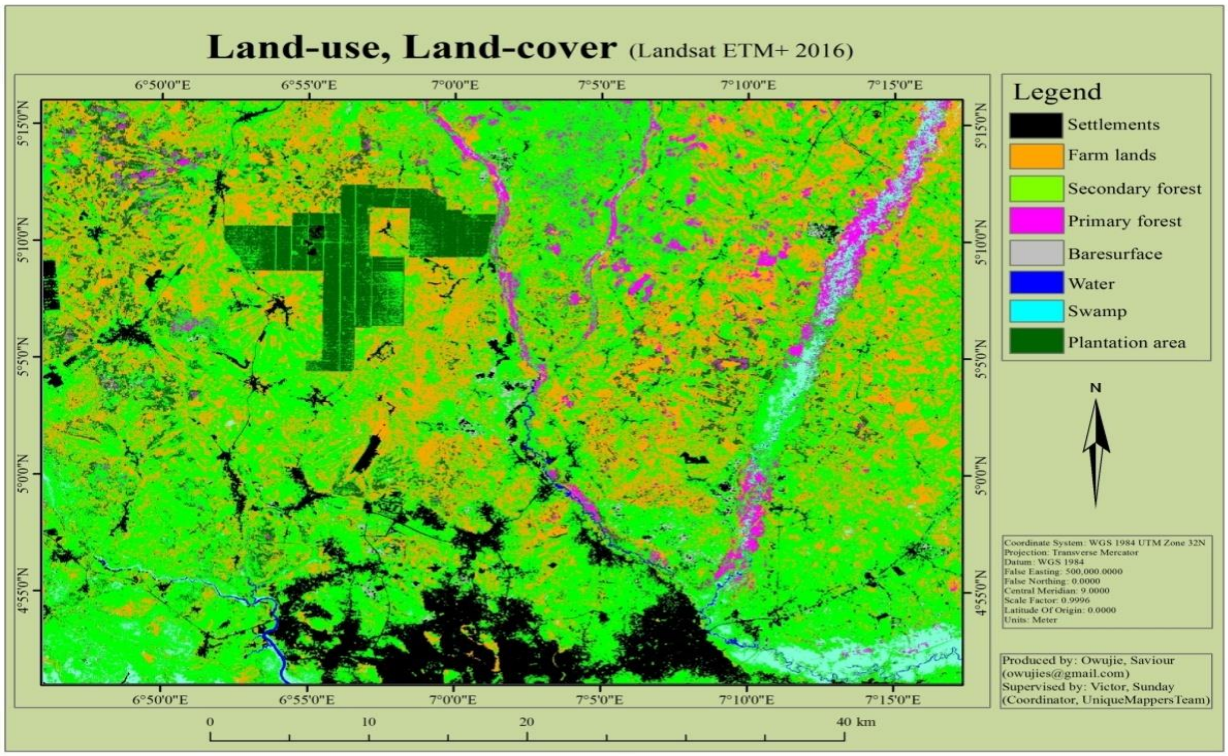

Fig. 4: Land use/land cover classification of study area derived from lands at ETM+ 2016 imagery

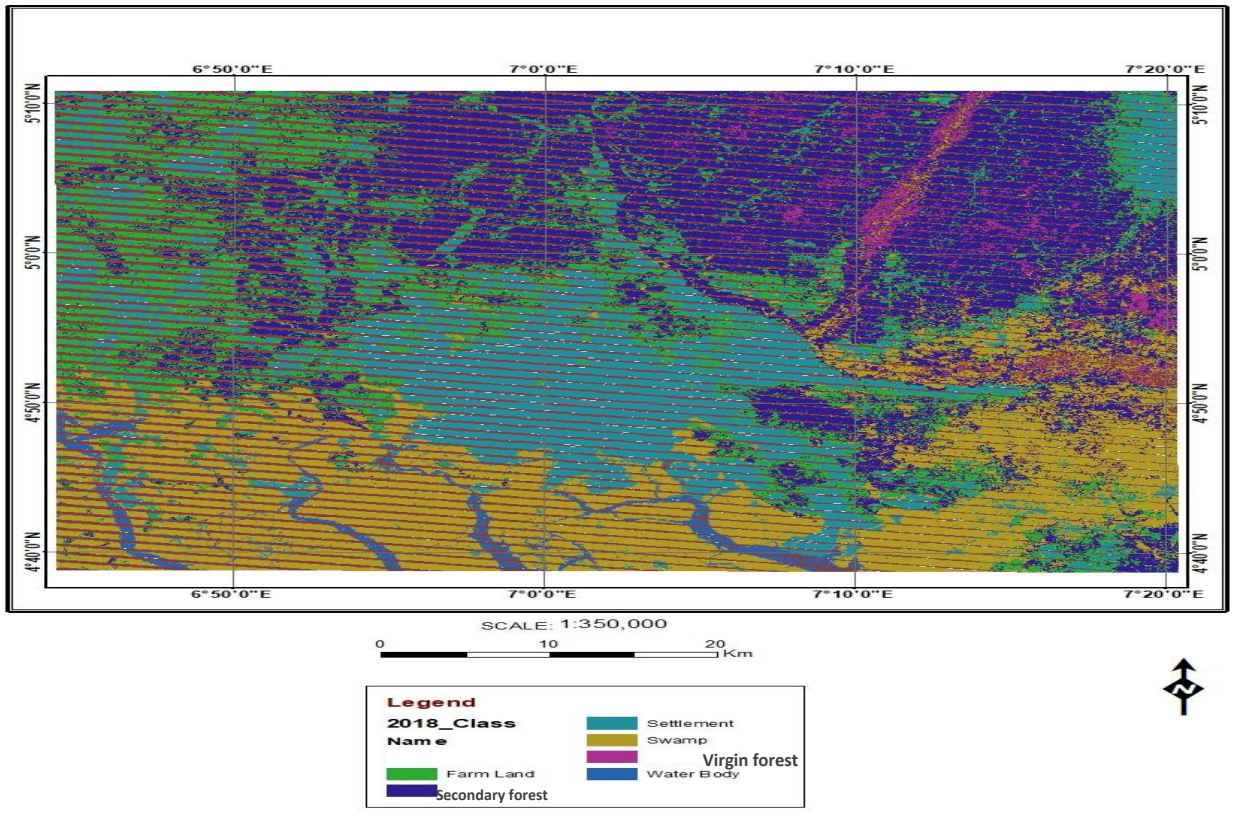

Fig.5: Land use/land cover classification of study area derived from lands at ETM+ 2018 imagery

2.2 Data Preparation and Image Classification

The satellite images used in this study were lands at TM 1986, Lands at ETM (2008), lands at ETM (2016) and ETM 2018, all acquired between the months of January and February on cloud free days. The images were ortho rectified and the processed satellite images were used to identify the main thematic land use/land cover (LULC) classes for the study area by applying the supervised classification techniques. Idrisi32 was used in the development and processing of the different land use/land cover (LULC) classes. The maximum likelihood algorithm was used for supervised classification by taking sixty (60) training sites for the six LULC class categories.

The training sites were selected based on ancillary data from ground truthing and topographic maps. Arc GIS 10.3 software was used in the processing, developing and display of the location maps. The classified images of 1986, 2008, 2016 and 2018 with the respective thematic classes were put into post-classification comparison analysis to identify the trajectory of LULC changes through time.

The area occupied by each LULC class was computed and the percentage change and rate of change (in km^2/yr) estimated using the formula presented in i and ii.

$$\text{Percentage change} = \frac{Area\ year\ k+t - Area\ year\ k}{Area k} \ x\ 100 \text{.....} \text{ i}$$

$$\text{Rate of change} = \frac{Area\ year\ k+t - Area\ year\ k}{t\ years} \ x\ 100 \text{.....} \text{ ii}$$

Where,

Area year *k* = area of land cover at initial date

Area year *k* + *t* = area of land cover at the next date

***t* years** = number of years between successive dates of image acquisition (Njorege *et al.*, 2011).

3. Results and Discussion

3.1 Land use/Land covers Change Analysis

Land use/Land cover pattern which varies from one region to the other is a function of several variables such as, and not limited to climate, level of economic and industrial development and soil characteristics. These variables will also have effect on the area coverage (Table 1) of each identified land use/land cover type of the region. Thus results of the image classification of the study area for the three acquisition dates are represented in figure 2-5. Also the area coverage and percentage distribution (Table 2) as well as the rate of change of the different land use/land cover type is shown in Table 3.

3.2 Land use/Land covers Change Process

The change analyses result of the study area has shown that settlement and secondary forest recorded positive rates of change between 1986 and 2018, while farmland, swamp, water body and virgin forest all recorded negative rates of change. Settlement recorded the highest rate of change of $56.84km^2/yr$ followed by secondary forest with a rate of $16.00km^2/yr$ between 2008 and 2016.

Amount of area occupied by swamp was the most dominant taking about 32.49% of the area in 1986, followed by farmland with area coverage of 30.68% for same year, (Table 2). However, by 2016, settlement (urban expansion) had recorded the highest area and percentage coverage of land, $921.71km^2$ and 56.90% respectively. Between 1986 and 2008, swamp recorded the highest rate of decline, followed by farmland. The decline in the size of swamp corroborates with the study of Wali et al (2018) of wetlands in Port Harcourt metropolis which includes Obio/Akpor where wetlands decreased progressively due to urbanization. Within the same 22 – year period (1986 – 2008) the highest percentage increase in order of decreasing magnitude was in settlement, waterbody, virgin forest and secondary forest. The period with the highest number of negative change in LULC types was between 2008 – 2016, with farmland, waterbody, swamp and virgin forest all recording negative changes in that order of decreasing magnitude. Within the same period, settlement and secondary forest recorded positive changes. Between 2016 – 2018, a 2 – year period was the only period that settlement recorded a negative growth of – 34.16, while swamp and virgin forest records were also negative. However, farmland, secondary forest and water body all recorded positive changes in that order of decreasing magnitude.

Conversion of farmland and swamp to settlement occurred between 1986 and 2008 and between 2008 and 2016 when settlement recorded positive growth rates. This positive growth rate of settlement (urban expansion) between 2008 and 2016 declined to negative between 2016 and 2018 respectively. This could be attributed to the recession experienced in the country within this period of mention, when majority of the people lost their jobs and new ones were not created. The result of this phenomenon was the slow growth in development and construction, as

exemplified by the lack of development in Greater Port Harcourt Area.

Also there is a continuous positive increase in the area coverage of secondary forest, with a corresponding decrease of virgin forest from 1986 to 2018. These LULC types (virgin and secondary forests) are mainly seen at the Northwest and North-eastern (Fig. 1) parts of the study region covering Emohua and Etche Local Government Areas respectively. These secondary forests are in practice fallow plots of land waiting to be cultivated.

Table 1: Land use/Land cover change: Trend of Change (in Km^2/yr) analysis for the 4 –time intervals of the study area

Land use/ Land cover	1986 Area in Km^2	2008 Area in Km^2	2016 Area in Km^2	2018 Area in Km^2
Settlement	234.19	471.99	921.71	606.86
Farmland	503.77	491.19	62.68	326.29
Swamp	533.56	187.93	92.84	89.23
Water body	70.75	111.51	50.75	62.01
Virgin forest	124.66	169.03	144.42	59.44
Secondary forest	175.06	217.98	347.58	499.66

Table 2: Area coverage and percentage distribution of Landuse/Landcover types 1986, 2008, 2016 and 2018

Land use/ Land cover	1986		2008		2016		2018	
Landuse/landcover types	Area (Km^2)	Percentage	Area (Km^2)	Percentage	Area (Km^2)	Percentage	Area (Km^2)	Percentage
Settlement	234.19	14.26	472.00	28.61	921.71	56.90	606.86	36.92
Farmland	503.77	30.68	491.20	29.78	62.68	3.877	326.29	19.85
Swamp	533.56	32.49	187.94	11.39	92.85	5.73	89.23	5.43
Water Body	70.75	4.31	111.51	6.76	50.75	3.13	61.93	3.77
Virgin Forest	124.66	7.59	169.04	10.25	144.42	8.91	59.94	3.65
Secondary Forest	175.06	10.66	217.98	13.21	347.58	21.46	499.66	30.39
	1642.006	**100**	**1649.658**	**100**	**1619.985**	**100**	**1643.909**	**100**

Table 3: Percentage change and rate of change of Landuse/Landcover (1986-2008, 2008-2016 and 2016-2018)

Landuse/ Landcover	1986-2008			2008-2016			2016-2018			1986-2018	
Landuse/landcover types	Area (Km^2)	% Change	(Km^2/yr)	Area (Km^2)	% Change	(Km^2/yr)	Area (Km^2)	% Change	(Km^2/yr)	Area (Km^2)	% Change
Settlement	234.19	101.54	+14.90	472.00	95.28	+56.84	921.71	-34.16	-157.43	606.86	159.13
Farmland	503.77	-2.50	-00.57	491.20	-87.24	-53.57	62.68	420.52	-131.805	326.29	-35.23
Swamp	533.56	-64.78	-15.71	187.94	-50.60	-11.89	92.85	-3.89	-1.81	89.23	-83.28
Water Body	70.75	57.61	+1.85	111.51	54.49	-7.60	50.75	22.04	+5.59	61.93	-12.47
Virgin Forest	124.66	35.59	+2.02	169.04	14.56	-3.08	144.42	-58.49	-42.24	59.94	-51.92
Secondary Forest	175.06	24.51	+1.95	217.98	59.46	+16.0	347.58	43.75	+76.04	499.66	185.42
	1642.006			**1649.658**			**1619.985**			**1643.909**	

Similar studies by Belay (2002) Gessesse and Kleman (2007) had indicated the expansion of agricultural land size at the expense of natural vegetation of virgin forest. The increase in the size of settlement and the decrease of farmland size and swamp could be observed in the central portion of the study area (Fig. 1) which is the location of Obio/Akpor and Ikwerre Local Government Areas.

Over this 32 year period (1986-2018) of this study, Obio/Akpor had witnessed a dramatic conversion of its farmlands and swamp areas (both freshwater and salt water) to residential and commercial functions. The construction of Ada-George Road through to Obiri-Ikwerre to the Airport Junction facilitated the influx of development to these remaining tracts of farmlands in that particular zone under consideration.

Similarly, the creation of Greater Port Harcourt Development Authority which has Ikwerre Local Government Area as part of its area of jurisdiction has

also led to population spillover into that Local Government Area. Thus most of the farmlands that hitherto were cultivated by indigenes in settlements such as Aluu, Igwuruta, Omagwa, Ipo up to Elele are now being converted to residential sites.

Then, fate of the farmers who use the farmlands as means of sustenance may be jeopardized if new means of livelihood are not adopted. Also the decrease in the size of virgin forests could be attributed to the following anthropogenic activities:

i. Deforestation to make way for new/emerging farmlands for cultivation.

ii. Sand mining along the river banks of Rivers Otamiri (Fig. 6) and Imo in Etche Local Government Areas and New Calabar River in Obio/Akpor and Emohua Local Government areas where there are flourishing fringing (Gallery Forest) forests with rich floral diversity. Again the unregulated sand mining activities along these rivers are negatively impacting on the water quality as well as the hydrological services of the river systems.

iii. Timber harvesting of wood in the study area is another contributory factor to the decreasing area of virgin forests as the local inhabitants still dwell more on the use of firewood as a major source of their daily fuel energy needs.

Plate 1: Sand Mining near Otamiri River in Etche Local Government Area

3.3 Overall Classification Accuracy Report and Kappa Statistics

The result of the analysis based on overall classification accuracy of assessed Lands at TM 1986 – image was 96.00% with a Kappa Coefficient statistic of 0.944. Similarly, the overall classification accuracy of lands at ETM 2008 was 96.00% with a Kappa Statistic of 0.9291; while the overall accuracy for ETM 2016 image classification was 91.20% with a Kappa statistic of 0.9093. Also the overall classification accuracy for ETM 2018 image was 94.00% with a Kappa coefficient statistic of 0.9291.

4. Conclusion

Change, it is said is the only permanent thing in life, so the positive and negative changes observed in the LULC studies of the region must be followed methodically to avoid systems collapse. This is necessary in order to accommodate modern development in terms of settlement expansion (urbanization) as well as encourage food production. Also maintenance of the natural hydrological cycle is crucial in the retention of these virgin forest types of land cover. There should be proper policy guidelines and implementation on land use issues by the state government. Also new framework should be put in place for proper re-orientation of the displaced farmers

into another means of livelihood different from arable farming, in order to reduce hunger and extreme poverty.

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References

1. Abam, T. K. S. (2001). Regional hydrology research perspectives in the Niger Delta. *Hydrological Sciences Journal,* 46 (1):5-18.
2. Abate, S. (2011). Evaluating the land use and land cover dynamics in Borena Woreda of South Wolto highlands, Ethiopia. *Journal of Sustainable Development in Africa,* 13(1): 87-105.
3. Bakpo, M. T. and Solomon, L. (2018). Relationship between soil and vegetation in an oil and gas polluted environment as revealed by regression analysis. *Journal of Petroleum and Environmental Biotechnology*, 9: 385.
4. Belay, T. (2002). Land cover/Land use changes in the Perekoli Catchment of the South Welo Zone of Ambara Region, Ethiopia. *Michigan State University Press,* 18(1): 1- 20.
5. Doygun, H. and Alphan, H. (2006). Monitoring urbanization of Iskenderun, Turkeu and its negative implications. *Environmental Monitoring and Assessment,* 114(1-3): 145 – 155.
6. Ede, P. N. (2015). Morphometric features of a low-elevation urban catchment and the implications for flooding. *Global Journal of Geological Sciences*, 14: 9-14.
7. Gessesse D. and Kleman, J. (2007). Pattern and Magnitude of Deforestation in the South Central Rift Valley Region of Ethiopia. *Mountain Research and Development*, 27 (2).
8. Judith M. S. (2013). Land use and Land cover changes and their implications for human-wildlife conflicts in the semi-arid rangelands of southern Kenya. *Journal of Geography and Regional Planning,* 6(5): 193-199.
9. Meyer, J. L. Paul, M. J. and Taulbee, W. K. (2005). Stream Ecosystem function in urbanizing landscapes. *J.N. Am. Bentholsoc.* 24:602-612.
10. Njoroge, J. B., Maina, M.G. and Nda'Nganga, K. (2011). Assessment of landscape change and occurrence at watershed level in city of Nairobi. *African Journal of Environmental Science and Technology*, 5 (10): 873-883.
11. Ofomata, G. E. K. (1975). Nigeria in Maps, London, Longmans.
12. Rilwani, M. L. and Emejuru, S.A. (2014). Effect of Changing Land use/land cover pattern on traditional farming system in the Upper Niger Delta Region of Rivers State, Nigeria. *Journal of Environment and Earth Science*, 4 (11): 82 – 89.
13. Wali, E., Phil-Eze, P. O. and Nwankwoala, H. O. (2018). Saltwater-Freshwater Wetland Ecosystem and Urban Land use Change in Port Harcourt Metropolis Nigeria. *Malaysian Journal of Sustainable Agriculture*, 1(1): 15-21.

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7/20/2019