



Geo-Spatial Analysis of Urban Wetlands Loss in Obio/Akpor Local Government Area of Rivers State, Nigeria

Wizor, Collins H.^{1*} and Wali, Elekwachi²

¹*Department of Geography and Environmental Management, University of Port Harcourt, Choba, Nigeria.*

²*Department of Geography, University of Nigeria, Nsukka, Nigeria.*

Authors' contributions

This work was carried out in collaboration between both authors. Author WCH designed the study, performed the statistical analysis, wrote the protocol, wrote the first draft of the manuscript and managed the analyses of the study. Author WE managed the literature searches. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJGR/2020/v3i130099

Editor(s):

(1) Dr. Xu Chong, Professor, Institute of Geology, China.

Reviewers:

(1) Eyankware Moses Ogheneyoreme, Ebonyi State University, Nigeria.

(2) James T. Anderson, West Virginia University, USA.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/54603>

Original Research Article

Received 07 December 2019

Accepted 13 February 2020

Published 19 February 2020

ABSTRACT

Urban wetlands make cities livable in many important ways. They reduce flooding, replenish drinking water, filter waste, provide urban green spaces, and are a source of livelihoods in most urban areas. This 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 the study area. After processing the imagery, five LULC classes were developed in ArcGIS environment, such as wetland, built-up area, vegetation, water bodies and bare surface. The 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. In 2009, the study revealed that the built-up area (urban land use) rose to 19.3% (4975.11 sq.km) and

*Corresponding author: E-mail: collins.wizor@uniport.edu.ng, wizorcollins@yahoo.com, collins.wizor@uniport.edu.com, collinswizor@gmail.com;

maintained an increase in urban growth due to changes from constructions of many roads and houses while wetlands also surprisingly experienced an increase and occupied the third-highest classes with 19.17% (4942.26 sq.km). Evidence from the study show that 2018 witnessed an expansion in terms of developmental activities in all facets as the built-up area increased in three-fold size within the year, bare surface reduced to a class of 15.47% (4057.29 sq.km) forcing developers to develop towards the wetland ecosystem. The wetlands, therefore, experienced a sharp decline to 4.91% (1266.75 sq.km) 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 study concluded that there is a need for the wise use of wetland resources and improvement of institutional arrangement so that wetland policies can be fully integrated into the planning process across all disciplines.

Keywords: GIS; land use/land cover; Nigeria; remote sensing; urban wetland.

1. INTRODUCTION

Urban wetlands consist of a wide diversity of inland habitats such as marshes, peatlands, floodplains, rivers and lakes, and coastal areas such as salt marshes, mangroves, intertidal mudflats and seagrass beds, and also coral reefs and other marine areas no deeper than six meters at low tide, as well as human-made wetlands such as dams, reservoirs, rice paddies and wastewater treatment ponds and lagoons [1,2,3,4]. In addition, Ramsar convention on wetlands (Article 2.1) also provide that they may integrate riparian and coastal zones nearby to the wetlands, and islands or bodies of marine water deeper than six meters at low tide lying within the wetland [1,2,3].

The world's wetlands continue to be lost and degraded at an alarming rate as a result of human activities. Consequently, the essential benefits provided by wetlands to people continue to be seriously eroded. These benefits, derived from wetland ecosystem services, are unique, varied and extend across many sectors, but their contribution and value are not always fully captured in wetland management decision-making. A better understanding of wetland benefits is required in order to make the case for halting further loss and degradation and to support activities that assist in the recovery of their biodiversity and ecosystem functioning. Removing the stressors or pressures on the ecological character of wetlands is the best practice for preventing further loss and degradation; when this is not feasible, however, or when degradation has already occurred, wetland restoration must be considered as a potential response option [5].

Urban wetlands make cities livable in many important ways. They reduce flooding, replenish drinking water, filter waste, provide urban green

spaces, and are a source of livelihoods. These urban wetland benefits continue to be crucial as the number of people living in cities has now passed the 4 billion mark and continues to rise. By 2050, 66% of humanity will live in cities, as people move into urban areas searching for better jobs. Unfortunately, most people are unaware of the value and importance of urban wetlands. In fast-growing cities, wetlands are often viewed as wasteland; places to dump rubbish, fill in or convert to other uses. Scientists estimate that at least 64% of the world's wetlands have disappeared since 1900, while in parallel, cities have exploded in growth [6].

A rapidly growing urban population comes with enormous challenges for city planners and managers. They have to ensure that cities today can deliver not only basic services such as accommodation, transport and water but that these cities are safe, resilient and environmentally friendly. During storms, urban wetlands absorb excess rainfall, which reduces flooding in cities and prevents disasters and their subsequent costs. The abundant vegetation found in urban wetlands acts as a filter for domestic and industrial waste and this contributes to improving water quality. Urban wetlands supply cities with water and are green spaces for recreation which helps to promote human wellbeing. Today's current development of human settlements is a major concern for wetland conservation and wise use. As cities grow and the demand for land increases, there is always the tendency to encroach on urban wetlands. They are often viewed as wasteland available to dump waste or be converted for other purposes. Yet when preserved and sustainably used, urban wetlands can provide cities with multiple economic, social and cultural benefits. They are prize land, not wasteland and therefore should be integrated into the development and management plans of cities [7].

Scientist /Environmentalist in the last decades have detected a trend of diminishing wetlands in terms of areal extent and health or quality, primarily linked to numerous anthropogenic interactions and indirect forces of the changing climate [8,9]. 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 [8,10,11,12]. As the impacts of climate change and land-use practices in the environment have become more abundantly apparent, remote sensing becomes a vital tool for the assessment of the status and well-being of wetlands [13], and in maintaining accurate records of the state of wetlands which is crucial in their preservation [14,15,12].

Umeuduiji *et al.*, [16] investigated the perception of indigenous people to wetland conservation and protection in Rumuagholu community in Obio/Akpor. The study made use of both experimental and survey research design. The study also revealed that wetland within the period of the study lost 10.64% of its original state moving from 11 km² to 6 km² and that the loss of wetland in the community can be categorized as a major wetland loss. In a likewise manner, Wali *et al.* [17] studied wetland changes overtime in Port-Harcourt metropolis using remote sensing techniques from 1984-2013. The study shows that total percentage of change and total rate of change for the entire trend after conversion are thus: Saltwater Wetland 23.44% to -2.17%, Freshwater Wetland -26.44% to -11.49%, Fallow land -47.13% to -5.41%, Built-up Area 43.33% to 7.41% and Water bodies 43.36% to 3.06%. The study recommended that activities shrinking wetlands size should be thoroughly put in check by the government and better efforts should be concentrated on those activities that encourage wetland conservation.

This present study, therefore, aims at mapping and identifying wetlands loss for different study epochs in Obio/Akpor Local Government Area of Rivers State, Nigeria for 18-years period (2000-2018) using GIS data and Remotely Sensed Image interpretation data to ascertain wetland loss within the study period.

2. MATERIALS AND METHODS

We adopted the longitudinal and survey research design in the conduct of the study; here remote sensed data, GIS and satellite imageries of the

area for 2000, 2009 and 2018 were used and classification was done to ascertain the extent of wetland loss in Obio/Akpor LGA. The Data for this study was presented using an image map, tables and graphs. The maps were projected using Universal Transverse Mercator (UTM) and datum WGS 84 of zone 32. Also, ArcGIS 10.6 was used in developing, display and processing of the location maps and to classify the aerial photographs into various land uses. A Global Positioning System (GPS) was used to locate the various wetlands in the study area and to collect coordinates.

3. STUDY AREA

Obio-Akpor is a local government area in the metropolis of Port Harcourt, one of the major centres of economic activities in Nigeria and one of the major cities of the Niger Delta, located in Rivers State. Obio-Akpor LGA is constituted mainly by the people of Ikwerre ethnic nationality. Specifically, there are four (4) prominent Ikwerre Kingdoms that constitute the LGA, which are: Akpor, Apará, Evo and Rumueme Kingdoms. The LGA is rich with land and natural resources, such as land, soil, vegetation, water, coal, petroleum, gas, animals, wildlife, air, wind and atmosphere, clay, sand and gravel [18].

The area is influenced by urbanization and urban sprawl whereby smaller communities have merged together and formed a megacity. The reason is due to the high influx of people resulting in the rapid growth of the population. This, in turn, is largely due to the expansion of the oil and allied industries, which have also attracted many varied manufacturing industries. The population of the area, therefore, increases on a daily basis. It has an average of 2.82% growth rate which puts the population of the LGA as at 2006 to be 464,789 people (National Bureau of Statistics, 2006). The original indigenous occupants of the area are the Ikwerre people. The LGA has its headquarters at Rumuodomaya.

3.1 Location / Extent

Obio-Akpor LGA is bounded by Port Harcourt LGA to the south, Oyigbo and Eleme LGAs to the east, Ikwerre and Etche LGAs to the north, and Emohua LGA to the west (see Fig. 1). It is located between latitudes 4°45'N and 4°60'N and longitudes 6°50'E and 8°00'E (see Fig. 2). The LGA covers 260 km² (100 sq mi) [18].

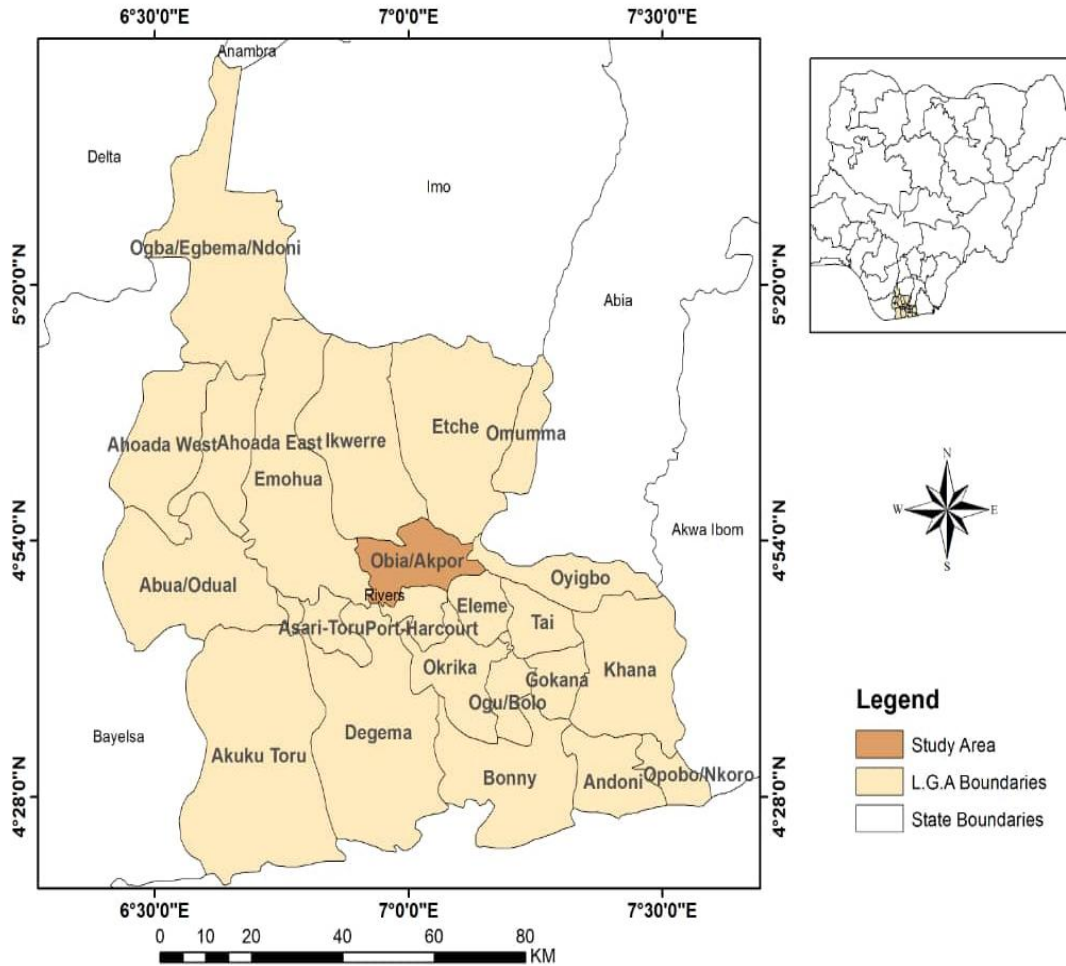


Fig. 1. Rivers State showing Obio-Akpor Local Government Area

The study area enjoys a tropical hot monsoon climate due to its latitudinal position. The tropical monsoon climate is characterized by heavy rainfall from April to October ranging from 2000 to 2500 mm with high temperature all the year-round and a relatively constant high humidity [18].

4. RESULTS

4.1 Classification and Mapping of Urban Wetlands in the Study Area

The study was divided into three epoch years (2000, 2009, and 2018) for easy classification (See Figs. 3,4 and 5). After processing the imageries, five land use/land cover (LULC) classes such as wetlands, built-up areas, vegetation, water bodies and bare surface were developed.

4.2 Land Use Change Process/ Distribution

This section addresses urban land use maps delineated from change distribution data of 2000, 2009, and 2018 study periods. The urban land-use change of Obio-Akpor LGA had changed dramatically during the period of 18 years. The data interpretation analysis/discussion is based on the comparison between urban land use (built-up area) and wetland ecosystem for different timelines, in 18 years' period. The spatial patterning of land use/ land cover distribution area of 2000, 2009, and 2018 as derived from the image maps is presented in Table 1 and Figs. 3-5. The total area under study is 25,773.39 (Sq.km). The analysis and discussion on the result are presented below:

A review of the table shows that in 2000, wetlands occupied the second-lowest classes with 9.12% (2352.15 sq.km) of the total classes. This could be connected to a high level of urban development, more pressure on wetlands, people not having enough space to occupy and therefore encroaching on the wetlands. Built-up areas occupied the third-highest classes with 17.62% (4543.83 sq.km) of the total classes. In 2009, the built-up area (urban land use) rose to 19.3% (4975.11 sq.km) and maintained an increase in urban growth due to

change from constructions of many roads and houses. Wetlands experienced an increase and occupied the third-highest classes with 19.17% (4942.26 sq.km). The increase could be attributed to the 2006 flooding incident in the study area and its environs that over flooded most rivers, creeks, ponds and streams. From 2006 to 2009 these over flooded rivers had drained into the nearest wetlands as water bodies saw a slow decline in 2009 occupying the lowest classes with 1.59% (411.75 sq.km).

Table 1. Size and proportion of land cover classes from 2000-2018

Class Name	2000 Image Area (Sq.km)	%	2009 Image Area (Sq.km)	%	2018 Image Area (Sq.km)	%
Wetlands	2352.15	9.12	4942.26	19.17	1266.75	4.91
Built-up Areas	4543.83	17.62	4975.11	19.3	14543.01	56.42
Vegetation	10694.61	41.49	9796.5	38.01	5487.21	21.28
Water Bodies	694.44	2.69	411.75	1.59	419.13	1.62
Bare Surface	7488.36	29.05	5647.77	21.91	4057.29	15.47
Total	25773.39	100	25773.39	100	25773.39	100

Source: Author's Computation

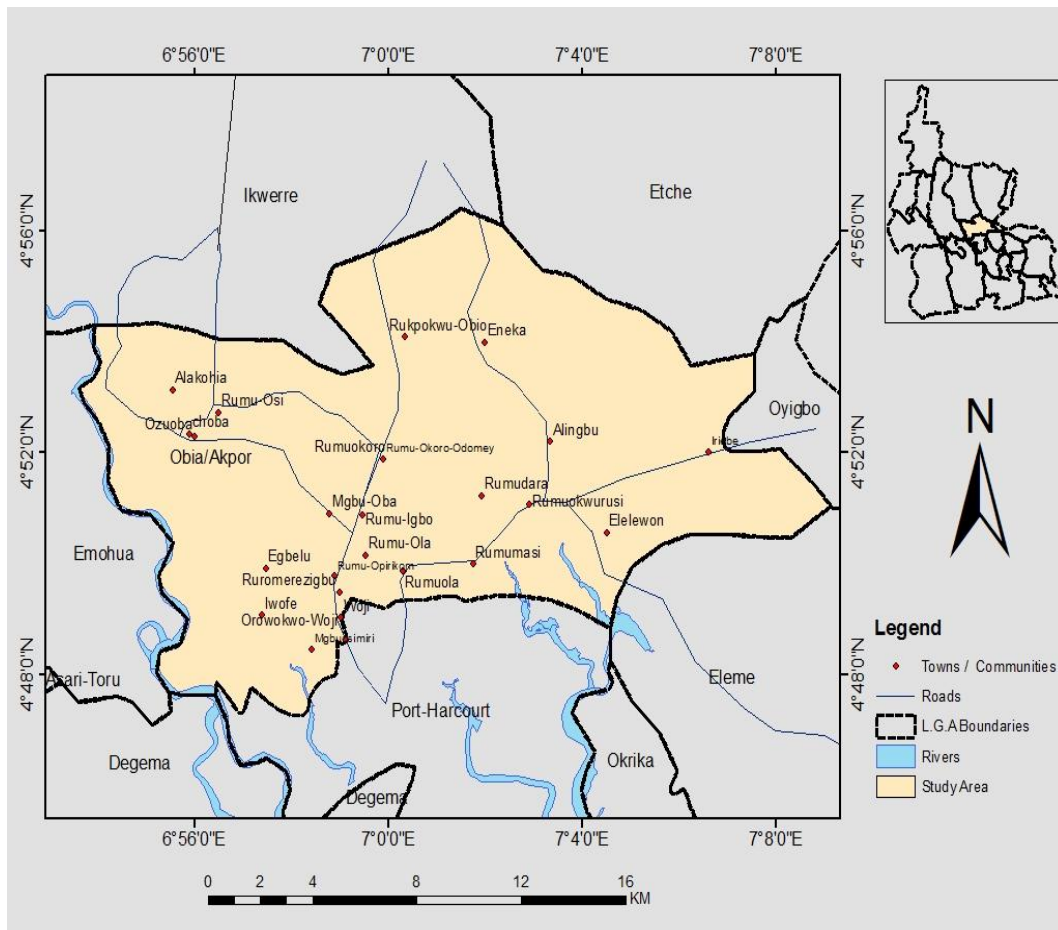


Fig. 2. Rivers State showing Obio-Akpor local government area

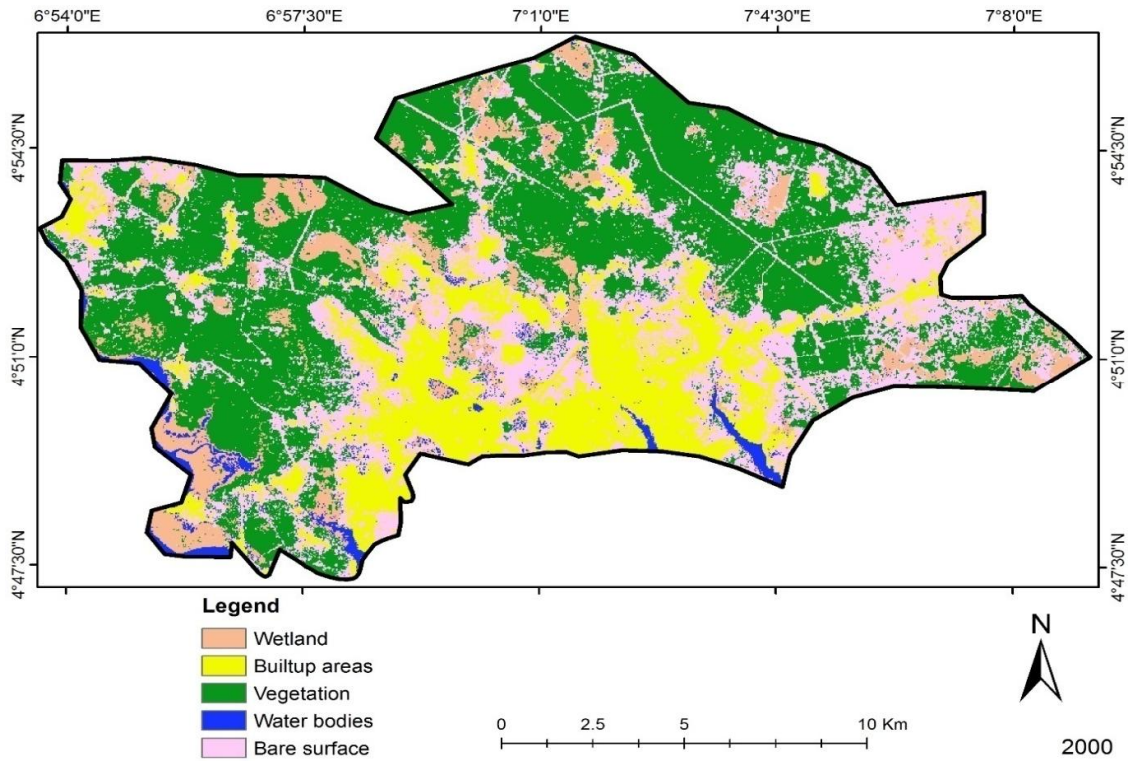


Fig. 3. 2000 Landsat TM Image

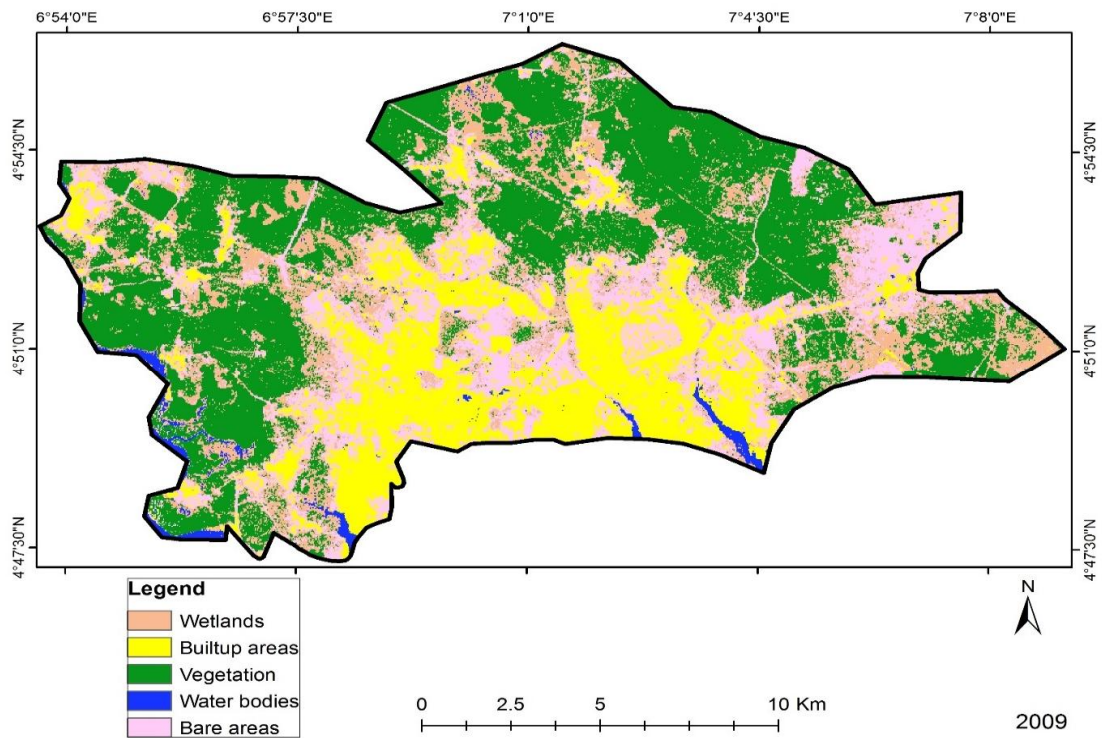


Fig. 4. 2009 Landsat TM Image

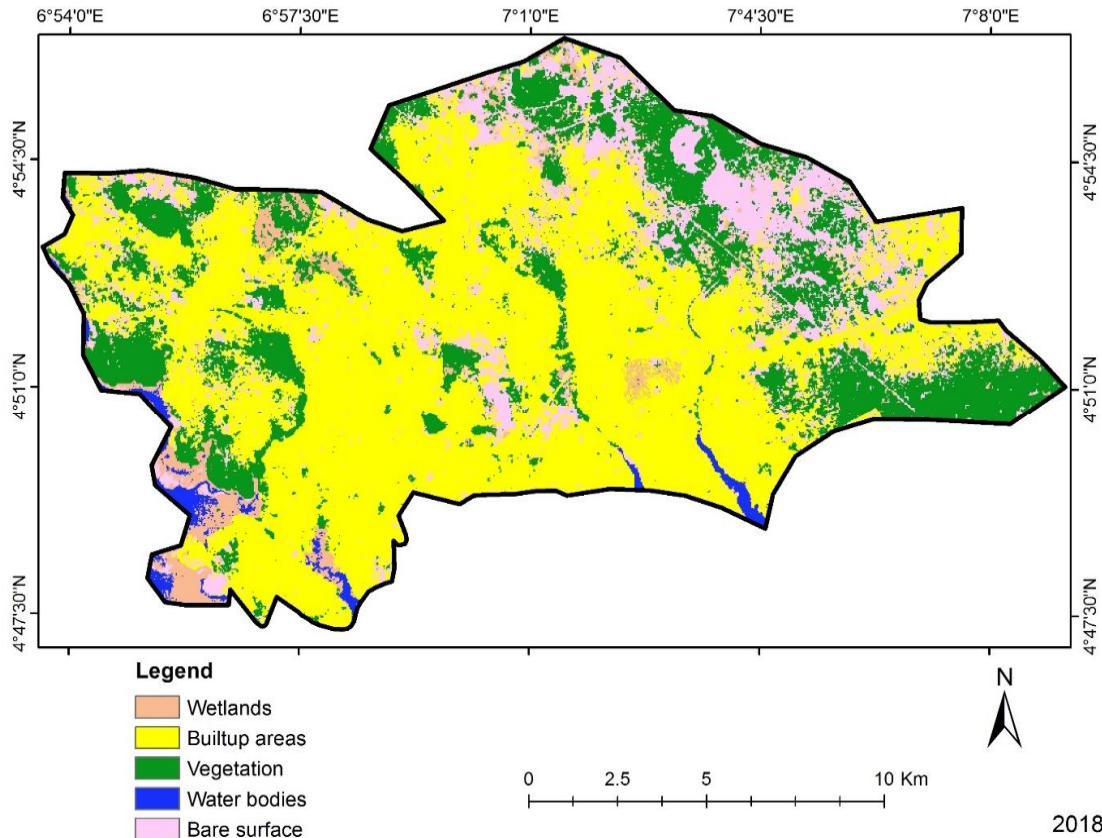


Fig. 5. 2018 Landsat TM Image

The year 2018 witnessed an expansion in terms of developmental activities in all facets. Here, the built-up area increased in three-fold size within the year. As development rate increased drastically, bare surface reduced to a class of 15.47% (4057.29 sq.km), people, therefore, tended to develop towards the wetland ecosystem. The table shows that wetlands saw a sharp decline to 4.91% (1266.75 sq.km). This is to say that there is a reduction in the size of 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.

Water bodies over the years maintained a constant decline in volume from 2000 with a volume of 2.69% (694.44 sq.km) to 2009 with a lower volume of 1.59% (411.75 sq.km). However, 2018 saw a slight increase in volume with a class of 1.62% (419.13 sq.km) due to the various flooding incidents that plagued the area in previous years. Similarly, the result presented

indicates that in 2000, bare surface occupied 29.05 % (7488.36 sq.km) of the land-use area, and decreased to 21.91% (5647.77sq.km) in the year 2009, and to 15.47% (4057.29 sq. km) in 2018. Vegetation also saw a steady decline from 41.49% (10694.61sq.km) in 2000, to 38.01% (9796.5 sq.km) in 2009 and finally to 21.28% (5487.21 sq.km) in 2018 (See Figs. 6–8).

4.3 Result of Accuracy Assessment of Land Use/Land Cover Map of the Study Area

In order to correctly perform a classification accuracy assessment, it is necessary to systematically compare two sources of information, the first one is pixels or polygon in remote sensing-derived classification map and the second one is ground reference test information. The relation between these two sets of data is usually summarized in an error matrix. The error matrix compares, on a category-by-category basis, the relation between known reference data and the corresponding result of

an automated classification [19]. Jensen [20] has proposed that two ways to evaluate and validate the error matrix are descriptive statistical and multivariate analytical statistical methods.

Kappa analysis is a multivariate analytical statistical method used and introduced to the remote sensing community in 1981 and was first published in Remote Sensing Journal in 1983 [21,22]. It measures accuracy between the remote sensing derived classification map (in this study LULC map of the study area) and the ground-truth data by the major diagonal of the error matrix, as well as the chance agreement, which is indicated by the row and column total referred to as marginal [23,24]. According to

Landis and Koch [25], a Kappa value >0.80 represent a strong agreement or accuracy between the classification map and the ground reference, a Kappa value between 0.40 and 0.80 is considered moderate, and a Kappa value < 0.4 represents a poor agreement.

Accuracy assessment for 2000 shows an overall kappa statistic of 0.985947, which represents a strong agreement between the ground-truth and the remotely sensed image acquired.

Accuracy assessment for 2009 shows an overall kappa statistic of 0.986392, which represents a strong agreement between the ground-truth and the remotely sensed image acquired.

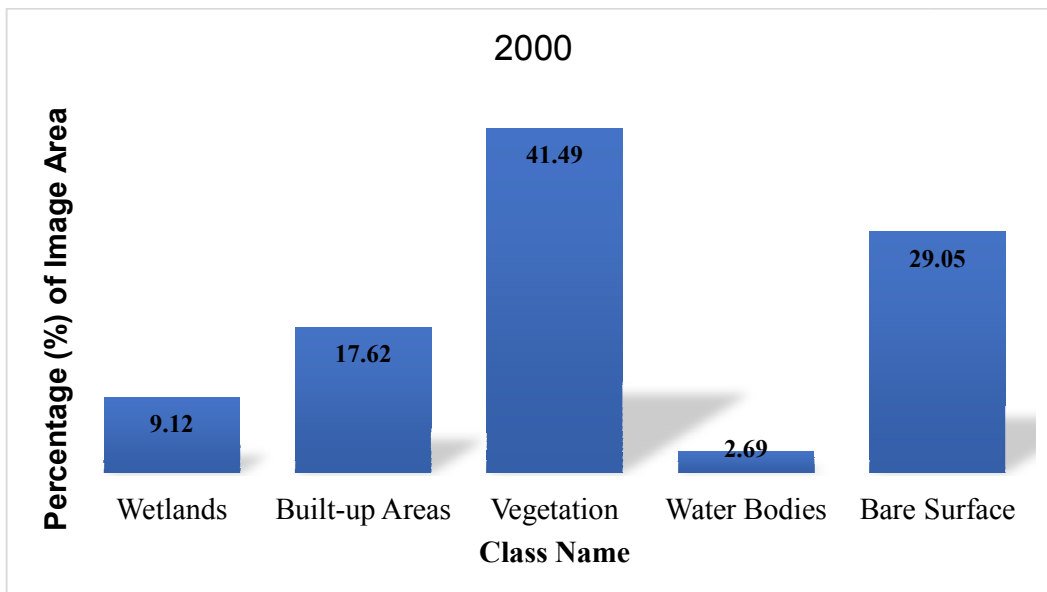


Fig. 6. Percentage of Image Area of Classes for 2000

Table 2. Accuracy Total Report (2000) of Obio-Akpor LGA

Class Name	Wetlands	Built-up Areas	Vegetation	Water Bodies	Bare Surface	Total	U Accuracy	Kappa
Wetlands	15	0	0	0	0	15	1	0
Built-up Areas	0	40	0	0	0	40	1	0
Vegetation	0	0	77	0	0	77	1	0
Water Bodies	0	0	0	4	0	4	1	0
Bare Surface	1	1	0	0	62	64	0.96875	0
Total	16	41	77	4	62	200	0	0
P Accuracy	0.9375	0.97561	1	1	1	0	0.99005	0
Kappa	0	0	0	0	0	0	0	0.985947

Source: Author's Computation

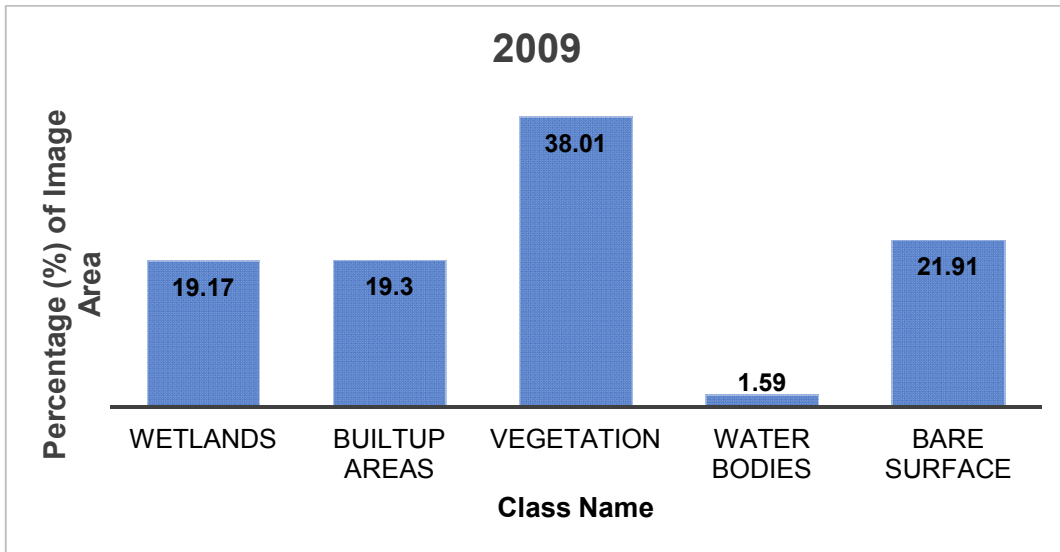


Fig. 7. Percentage of image area of classes for 2009

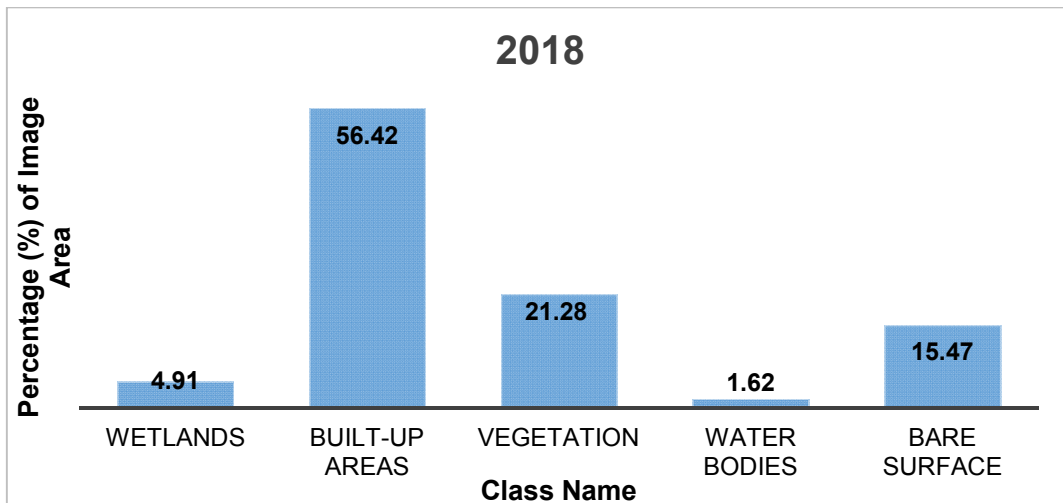


Fig. 8. Percentage of image area of classes for 2018

Accuracy assessment for 2018 shows an overall kappa statistic of 0.921883, which represents a strong agreement between the ground-truth and the remotely sensed image acquired.

5. DISCUSSION

The analysis shows the increase of built-up areas throughout the period of study and the depreciation of wetlands. The high rate of urbanization in the area has led to the construction of more roads, houses, industries and other infrastructural facilities. Urban land use and other activities have put pressure on the wetland in the study area. The study of Wali et al.

[26] and Asibore [27] corroborates this finding. Urbanization and encroachment to the wetland due to the high population and the suitability of the areas for infrastructural development have increased stress to the wetland in the study area. For instance, the population of the local government area has increased rapidly over the years. As a result of population explosion, areas that were known as wetlands (see Figs. 3-5) have been converted into built-up areas and areas for other infrastructures, which is consistent with the findings of Akpofure [28] and Wali [29]. This rapid development has led to the encroachment of wetlands, vegetation, bare surface and water bodies. These depreciating

ecosystems have led to the loss of biodiversity, wildlife and a deteriorating environment.

From the analysis of land use land cover between 2000-2018, it was observed that there is an increase in built-up area by 9999.18 sq.km. This is mainly due to housing and infrastructural development that has already taken place and will continue to take place because of the development in the study area. The implication of this change will definitely have an adverse impact on the urban environment and proper urban management strategies are necessary to mitigate these effects. Wetlands, however, saw a reduction throughout the period of study from 2000-2018 by 1265.4 sq.km. The results above also indicate that from 2009-2018, other land use classes such as vegetation saw a

two-fold decline by 5207.4 sq.km, water bodies experienced a reduction by 275.11 sq.km, and bare surface also saw a reduction by 3431.09 sq.km. With the rapid rate of urbanization in most cities of the global south, housing and infrastructural development will continue unabated while wetland loss will be very glaring [30,31].

In summary, no other land use classes experience this magnitude of change except the built-up area. This extensive growth creates difficulties in the lack of adequate infrastructure and creates various negative environmental impacts.

Plate 1 - 4 shows wetlands ecosystems under threat in the study area.

Table 3. Accuracy Total Report (2009) of Obio-Akpor LGA

Class Name	Wetlands	Built-up Areas	Vegetation	Water Bodies	Bare Surface	Total	U Accuracy	Kappa
Wetlands	42	0	0	0	0	42	1	0
Built-up Areas	0	44	0	0	0	44	1	0
Vegetation	0	0	69	0	1	70	0.985714	0
Water Bodies	0	0	0	3	0	3	1	0
Bare Surface	0	1	0	0	38	39	0.974359	0
Total	42	45	69	3	39	198	0	0
P Accuracy	1	0.977778	1	1	0.974369	0	0.989899	0
Kappa	0	0	0	0	0	0	0	0.986392

Source: Author's Computation

Table 4. Accuracy Total Report (2018) of Obio-Akpor LGA

Class Name	Wetlands	Built-up Areas	Vegetation	Water Bodies	Bare Surface	Total	U Accuracy	Kappa
Wetlands	8	0	0	0	0	8	1	0
Built-up Areas	94	2	0	0	0	96	0.090833	0
Vegetation	42	0	0	0	0	42	1	0
Water Bodies	6	0	0	1	0	7	0.142857	0
Bare Surface	28	0	0	0	2	30	0.066667	0
Total	16	41	77	4	62	200	0	0
P Accuracy	0.44944	1	0	1	1	0	0.070138	0
Kappa	0	0	0	0	0	0	0	0.921883

Source: Author's Computation



Plate 1. Wetland ecosystem experiencing seasonal high tide at Choba during the authors' fieldwork (25th November 2019)



Plate 2. Wetland ecosystem experiencing seasonal high tide at Choba, during the authors' fieldwork (25th of November, 2019)



Plate 3. Wetland Ecosystem at Rumuigbo, being encroached by the urbanization process during the authors' fieldwork (22nd of November, 2019)



Plate 4. Wetland Ecosystem at low tide at Rumuigbo, during the authors' fieldwork (22nd of November, 2019)

6. CONCLUSION AND RECOMMENDATIONS

This study was designed to demonstrate the capacity of remote sensing and GIS in capturing,

retrieving and analyzing Spatio-temporal data. The study displays the extent of changes in land use/ land cover from 2000-2018 with a major highlight on urban wetlands loss. Comprehensive land use and land cover maps were developed

for the three separate years for a period of 18 years to study urban development in Obio-Akpor Local Government Area. Thus, land use and land cover were strongly developed for each land use and land cover class but with more emphasis on wetlands and built-up areas which are used to measure urban growth and development.

Based on the findings of the study, the following are suggested:

- a. The land-use system in the study area should integrate environmental consideration and establishment of urban management plans as designed for Ramsar sites are strongly advocated.
- b. Wetlands study should be reviewed based on inventory and conservation priorities.
- c. Efforts should be made to increase knowledge and awareness on the wetlands' values through the dissemination of information, using traditional techniques and training of appropriate staff.
- d. There is a need for appropriate wetland laws and legislation policies for sustainable management in the conservation of wetland. There is a need for improvement of institutional arrangement so that wetland policies can be fully integrated into the urban planning process.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. RAMSAR IRAN: The Ramsar Convention Manual: A guide to the Convention on Wetlands (Ramsar Gland Iran, 6th Edition. Ramsar Convention Secretariat. 1971;112.
2. Ramsar Convention Secretariat: Wise use of Wetlands: A conceptual framework for the wise use of wetlands. Ramsar Handbooks for the Wise use of Wetlands. 3rd ed. Gland (Switzerland): RCS; 2007.
3. Ramsar Convention Secretariat RCS: An introduction to the convention on wetlands, RCS, Gland, Switzerland; 2016.
4. Wali et al. Saltwater- Freshwater wetland ecosystem and urban land use change in Port Harcourt metropolis, Nigeria. *Earth Sciences Malaysia*. 2018;2(1):1-7. DOI:<http://doi.org/10.26480/esmyl.01.2018.01.07>
5. Scientific and Technical Review Panel (STRP): Wetlands and water storage: current and future trend and issues. Briefing Note, No. 2, February RCW; 2012.
6. Global Wetland Outlook: State of the world's wetlands and their services to people. Gland, Switzerland. RCS; 2018.
7. World Wetlands Day (WWD): Wetlands for sustainable urban future: Urban wetlands making cities liveable. Theme for World Wetlands Day; 2018.
8. Eppink et al. Modelling biodiversity and land use: Urban growth, agriculture and nature in a wetland area. *Ecological Economics*. 2004;51:201-216.
9. Hartig, et al. Tracking restoration in natural and urban field settings. *Journal of Environmental Psychology*. 2003;23:109–123
10. Ujoh F. Estimating urban agricultural land loss in Makurdi, Nigeria, using remote sensing and GIS techniques. Unpublished MSc dissertation, Department of Geography and Environmental Management, University of Abuja, Nigeria; 2009.
11. Ujoh F, Eneche PSU, Ecological assessment of infrastructure development in Kaduna State, Nigeria. *Geospatial Information Science (GSIS) Journal (Article Under Review)*; 2017.
12. 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 2017, 18–22 September, Wuhan, China; 2017.
13. Cook, et al. Amplification of the North American "Dust Bowl" drought through human induced land degradation. *Proc. Natl. Acad. Sci*. 2009;106:4997-5001.
14. Klemas V. Remote sensing of wetland: case studies comparing practical techniques". *Journal of Coastal Research*. 2011; 27(3):418-427.
15. 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.
16. Umeuduji et al. Wetland conservation and protection; implications for sustainable flood disaster management in a critical urban fringe area of Port Harcourt. *Archives of Organic and Inorganic Chemical Sciences*. 2018;2(3).

17. Wali et al. Analysis of land use and land cover changes in the wetland ecosystem of Port-Harcourt metro polis, Nigeria. *International Journal of Ground Sediment and Water*. 2019;9:503-524.
18. Wokocha CC, Omenihu ER. Land resources appraisal and management activities using remote sensing techniques: case study of Akpor Town, Rivers State. *Journal of Environment and Earth Science*; 2015.
19. Lillesland et al. Remote sensing and image interpretation. 5th Edition, John Wiley and Son, Inc., New York; 2004.
20. Jensen JR. Introductory Digital Image Processing: A remote sensing perspectives. 3rd Edition Prentice Hall series in Geographic Information Science; 2005
21. Congalton RG. A review of assessing the accuracy of classification of remotely sensed data. *Remote Sensing of Environment*. 1991;37(1):35-46.
22. Congalton, et al Assessing Landsat classification accuracy using discrete multivariate analysis statistical techniques. *Photogrammetric Engineering and Remote Sensing*. 1983;59:529-535.
23. Rosenfield G, Fitzpatrick-Lines KA. Coefficient of agreement as a measure of thematic classification accuracy. *Photogrammetric Engineering and Remote Sensing*. 1986;52(2):223-227.
24. Congalton RG. Accuracy assessment: A critical component of land cover mapping Gap analysis. *American Society for Photogrammetric and Remote Sensing*. 1996;119-131.
25. Landis JR, Koch GG. The Measurement of observer's agreement for categorical data. *Biometric*. 1997;33:159.
26. Wali et al. Saltwater-freshwater wetland ecosystem and urban land use change in Port Harcourt metropolis, Nigeria. *Earth Sciences Malaysia, Zibeline International Publishing*. 2018;2(1):1-17.
27. Asibor G. Wetland: values, uses and challenges". A Paper presented to the Nigerian Training Institute, Effurum; 2009.
28. Akpofure R. *Environmental Sciences: An Introduction*. Ibadan, Kraft Books Limited; 2009.
29. Wali E. *Urbanization and Loss of Wetland in Port Harcourt Metropolis, Nigeria*; 2015.
30. Agardy et al. *Coastal Systems and Coastal Communities*; 2005.
31. Orji G, Pepple GT. *Wetland inventory and mapping for Ikorodu Local Government Area, Lagos. Nigeria*; 2015.

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