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Geo-Spatial Analysis of Land Use- Land Cover Changes in Coastal Wetlands of Akwa Ibom State, Nigeria

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Abstract

The study was done primarily to first of all map the change detection that has occurred within the thirty-two-year period of the study in sixteen years intervals. Secondly, it was also carried out to estimate the land use and land cover changes that has occurred to the different classes over the thirty-two years period and finally to investigate the implications of these changes on the wetland ecosystem of Akwa Ibom State. The study identified a couple of patterns of expected change like in the built-up areas but at the same time it also identified some unexpected change patterns like the steady shrinking of farmlands and the simple harmonic rise and fall of water levels. Based on the findings in this study, migration, industrialization, climate change, rise in population density, expansion of urban areas constitutes some of the major determinant driving the change in the study area. In another set of findings, the growth of the wetland ecosystem in terms of the presence of the mangrove is not impressive because it nosedived downwards in the first sixteen years and came slowly back up in the second sixteen years. Further research will be required to unbundle the mysteries behind these dramatic changes. Judging by the indices presented in this study, it is also worrisome to note that agricultural practices and cultivation of crops have been relegated to the background in these areas. This calls for concern especially in the face of the dwindling economy and food shortages. Based on the findings of this study, recommendations made were not limited to intentional efforts by government and non-governmental organizations to increase the population of mangrove trees and this will help to strengthen the ecosystem. Moreover, since the study has identified a huge gap in agricultural practices, governments at all levels and relevant organizations should intensify efforts to rekindle enthusiasm towards embracing agricultural practices by the residents of the study area. This can be done by giving loans or grants to individuals and corporate bodies that set themselves up for agriculture.

Key words: Geospatial, Land Use-Land Cover Changes, Coastal Wetlands, Akwa Ibom State, Remote Sensing, GIS

1. Introduction

Wetland management in the recent years is necessary because of its roles in the ecological balance and biodiversity management. The functions of wetland include flood storage and distribution, retention of sediments and nutrients, aquifer recharge, water quality improvement, aesthetic and educational benefits (USEPA 2009, Obiefuna *et al*. 2013). USEPA (2011) also highlighted that wetland biodiversity has value to humans, supporting people's livelihoods in numerous ways, by creating highly productive ecosystem services such as food resources for a wide range of species. Wetlands which are land areas covered with water or where water is present at or near the soil surface all year or varying periods of the year (Muhammad *et al*. 2022) could undergo changes in terms of spatial extent and the species diversity of the fauna and flora deriving their livelihood from the wetland ecosystem.

Davidson (2014) alerted that global extent of wetland has declined between 64-71% in the 20th century and this constitutes threat to wetland biodiversity. Aggravating the problem of water management in Nigeria is the fact that wetlands which naturally recharge and protect both the surface and groundwater resources are being unscrupulously degraded at a rather alarming rate (Uluocha and Okeke 2004). Oseni et al (2020) opined that poor understanding of economic values of wetlands is one of the contributory factors that make people to see wetland as wastelands, culminating in massive destruction of this highly productive resource. Most importantly, poor control of development in urban areas has created major problems for existing tropical wetlands. Obiefuna *et al*. (2013) reported that more than 50% of the world's population currently resides in cities and urban settlements. Taiwo & Areola (2009) noted that urbanization rates were expected in developing and least developed countries while Turner et al (2003) also reported that 95% of the net increase in global population would be in cities of the developing world.

Activities leading to industrialization and urban development are land clearing and land reclamation which often result to loss of wetlands. However, wetland change is embedded in landuse change overtime and requires in-depth analysis in terms of the spatial coverage at a given time with the use of geo-information technologies. The use of geo-spatial information establishes a dialogue linking local knowledge and science; and national development strategies because of the provision of automate image processing tasks with the use of high spectral resolution data that can provide an increased ability to differentiate land cover classes (Tokuma & Debissa, 2020 Akpan et al, 2019). Dahl (2006) viewed that remotely sensed imagery provides the primary data source for wetland change detection and the imagery is used in conjunction with reliable collateral data such as topographic maps, coastal navigation charts, soils information, and historic imagery or studies. Thus, the identification and delineation of wetland habitat through image analysis forms the foundation for deriving all subsequent wetland status and trend of change.

Remote sensing techniques have been used successfully in the United States and Canada to detect and monitor wetlands by some studies which include Karagama, Adnan & Umar (2020), Lillesand and Kieffer (1998), Kindscher et al (1998), Daniel & Ayobami (2007), Patience and Klemas (1993), Tiner (1996), Dechka *et al*. (2002), Tijani et al (2011), Watmough *et al*. (2002) and Li and Chen (2005). The capability of geoinformation has also been demonstrated in some wetland studies in Nigeria. Tijani *et al.* (2011) examined the impacts of urbanization on wetlands degradation in Eleyele Lake, SouthWestern Nigeria; Obiefuna *et al*. (2013) determined the spatial changes in the wetlands of Lagos/Lekki Lagoons of Lagos, Nigeria; Mmom and Fred-Wagwu (2013) examined the landuse and land cover change around Port Harcourt City using a GIS; Taiwo and Areola (2009) investigated the spatio-temporal analysis of wetland losses in the Lagos Coastal region, southwestern Nigeria; Odunuga and Oyebande (2007) examined the change detection and hydrological implications in the lower Ogun flood plain, Ajibola *et al*. (2012) compared the wetland valuation purposes in Lagos metropolis and Niger Delta, Nigeria while Orimoogunje *et al*. (2009) examined the geospatial mapping of wetlands potential in Ilesa, Southwestern Nigeria. Although, most of these studies made use of geo-information technologies but none investigated wetland status in Port Harcourt metropolis. Against this background, the present study focuses at analyzing the spatio-temporal changes of wetland in coastal part of Akwa Ibom State.

In the past, wetlands were considered as „waste land", and a source of disease like malaria and needed to be transformed into more useful purposes. This attitude led to reclamation of wetlands for agriculture, and settlement. They continued reducing in sizes as modern techniques of draining made them even more attractive for agriculture and their location, for instance, in the coast, makes them the perfect site for construction of harbours and large plants and for waste disposal.

In recent past, the importance of wetland ecosystems was recognized internationally which led to the Convention of Wetlands of National Importance in 1970 in Ramsar, Iran (Ayele, 2011). Kenya ratified the Ramsar Convention in 1990 and has designated 5 sites as wetlands of national importance. These sites which include lakes Baringo, Bogoria, Nakuru, Elementaita and Naivasha. The Kenya Wildlife Service (KWS) and the National Museums of Kenya (NMK) are the implementing bodies of the convention.

In Nigeria, numerous authors have made series of attempt to address wetlands degradation challenges using spatio-temporal technology. Among such works include that of Harsh & Singh (2015) who utilized Spatio- Temporal techniques to undertake Landuse Change Monitoring of Surajpur Wetlands, and Elekwachi et al (2021)who assessed the spatiotemporal characteristics of wetlands ecosystem in the Niger Delta Region of Nigeria from 1986-2016. Meanwhile, Nigerian coastal environment is facing a major threat of degradation due to anthropogenic and hydrodynamic driving forces which could disrupt the environmental balances, irreparably destroy the wetland and affect the livelihood of the riparian communities who benefit from the resources of the ecosystem. The natural landscape of the wetland is rapidly being converted to agricultural land use and most of which involve destruction of indigenous wetland cover types. Furthermore, population dynamics in the administrative units, which is believed to be a critical driver of these land use conversion is rapidly changing and is expected to continue into the future. However the characteristics of the economic activities that drive these changes even as the more resource exploitation itself increases are yet to be clearly understood. If they are not well understood, it design of sustainable management measures will not be attainable and this causes a major threat to the existence of the coastal wetland of Nigeria and Akwa Ibom State of which this study seeks to investigate. The study aimed at examining the Spatio-Temporal Land Use Cover Changes in Coastal Wetlands of Akwa Ibom State Using Remote Sensing and GIS. The following objectives were discussed: to map land use cover of study area for 1986, 2002 and 2018, to estimate the land use change between 1986 to 2018 and the implications of the spatio-temporal change on the wetland eco-system

2. Materials and Methods

This study was conducted in the coastal region of Akwa Ibom State. It lies along Nigeria's southern edge, bordering the Atlantic Ocean. It is characterized by a diverse range of geographical features, including low-lying terrain, beaches, lagoons, mangrove swamps, and estuaries. The region is heavily influenced by tidal patterns and the flow of the Atlantic Ocean, which significantly impacts its ecosystem and the livelihoods of the people who live there (Ekanem, 2014). It spans several towns, including Oron, Ibeno, and Eket, all of which have strong cultural and economic ties to the water.

The landscape includes extensive mangrove forests that are critical for environmental protection. These mangrove forests act as natural barriers against coastal erosion, absorb excess carbon, and provide habitats for diverse species of flora and fauna. The region also features a variety of wetlands and estuaries that host important ecosystems for fish and other aquatic life. The intertidal zones—where the land meets the sea—are rich in biodiversity, contributing to the overall ecological health of the region (Akinmoladun et al., 2021).

The topography of the region is mostly flat, with little elevation above sea level. This feature makes the area highly susceptible to flooding and erosion, particularly during the rainy season.

Human activities such as unsustainable farming, dredging, deforestation, oil and gas/solid mineral exploitation tends to impact substantially upon land use and land cover.

This research adopted descriptive and explanatory research design. In this design, the study attempts to explain the procedure for implementation of the itemized objectives from data collection to data validation and capturing, data/image processing, and mapping. The major data used in the study was Boundaries of Akwa Ibom State and the Wetland Demarcation Base Maps. In addition, Landsat Imageries were captured with the aid of a space borne satellite. Precisely, the original source of the image was gotten from the United States Geological Survey with an acceptable resolution standard.

3. Results and Findings

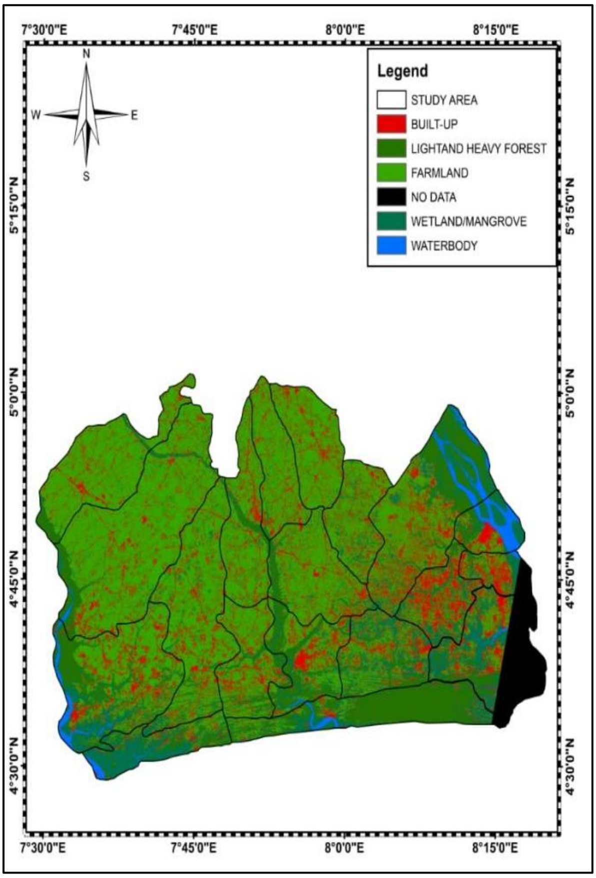

Figure 3: Land Use Detection of Parts of Akwa Ibom State for 2003

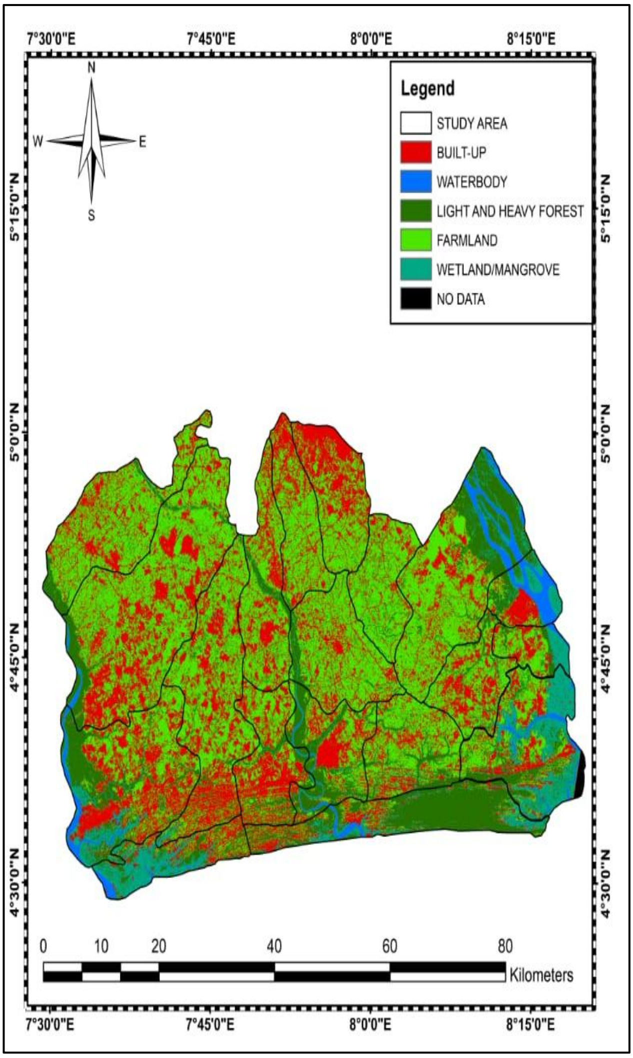

Figure 2: Land Use Detection of Parts of Akwa Ibom State for 1986

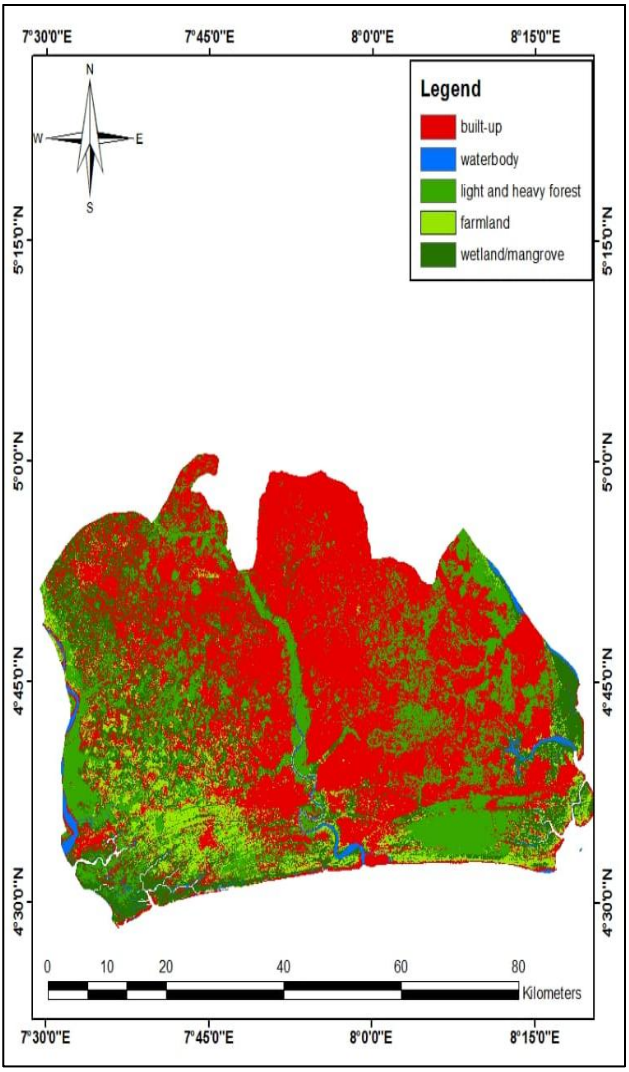

Figure 4: Land Use Detection of Parts of Akwa Ibom State for 2018

Table 1: The Land Use Classes

	AREA 1986	1986%	AREA 2002	2002%	AREA 2018	2018%
BUILT-UP	523.7637341	13%	1123.151562	28%	2013.190176	53%
FARMLAND	2211.866993	56%	1833.811595	46%	312.3469436	8%
LIGHT AND HEAVY FOREST	464.427335	12%	578.8296033	15%	762.2795435	20%
NO DATA	121.8040127	3%	6.141617244	0%	0	0%
WATERBODY	72.71958769	2%	91.70780075	2%	53.98780086	1%
WETLAND/MANGROVE	557.3540757	14%	317.9131807	8%	643.1831433	17%
GRAND TOTAL	3951.935738	100	3951.555359	100	3784.987607	100%

Table 2: The Land Use Classes

	AREA 1986	%	AREA 2002	%	AREA 2018	%	2002-1986	2018-2002	2018-1986
BUILT-UP	523.76	13	1123.15	28%	2013.19	53%	599.39	890.04	1489.43
FARMLAND	2211.87	56	1833.81	46%	312.35	8%	-378.06	-1521.46	-1899.52
LIGHT AND HEAVY FOREST	464.43	12	578.83	15%	762.28	20%	114.40	183.45	297.85
NO DATA	121.80	3	6.14	0%	0.00	0%	-115.66	-6.14	-121.80
WATERBODY	72.72	2	91.71	2%	53.99	1%	18.99	-37.72	-18.73
WETLAND/MANGROVE	557.35	14	317.91	8%	643.18	17%	-239.44	325.27	85.83

Table 3: The Land Use Classes and the numeric differences

	AREA 1986	AREA 2002	AREA 2018	AREA AFTER 1ST 16YRS	AREA AFTER 2ND 16YRS	AREA AFTER 32YRS
BUILT-UP	523.76	1123.15	2013.19	599.39	890.04	1489.43
FARMLAND	2211.87	1833.81	312.35	-378.06	-1521.46	-1899.52
LIGHT AND HEAVY FOREST	464.43	578.83	762.28	114.40	183.45	297.85
NO DATA	121.80	6.14	0.00	-115.66	-6.14	-121.80
WATERBODY	72.72	91.71	53.99	18.99	-37.72	-18.73
WETLAND/MANGROVE	557.35	317.91	643.18	-239.44	325.27	85.83

4. Discussion of Findings

According to the findings of the study, built-up areas were on the constant proportional increase. In the first sixteen (16) years which is between 1986 and 2002, built-up areas increased by approximately five hundred and ninety-nine (599.39) square kilometers corresponding to about one hundred and fifteen percent (115%) increase and one thousand four hundred and eighty-nine plus (1489.43.65) square kilometers after thirty-two (32) years with a growth percent of close to two hundred percent (200%). Lastly, between 2002 and 2018 (second sixteen years), the growth percentage was about thirty two percent (32%) only.

This signifies that the growth rate at the first sixteen years (1986-2002) and the second sixteen years (2002-2018) has been on a steady rise almost proportionally. This means that there is only a steady rise in infrastructural development in the thirty-two (32) years period under consideration in the study. This also means the human population of the study area has been on a steady increase as a result of migration to the area within that interval of time. Influx or strong presence of companies and other socio-economic institutions that may stimulate that growth.

In the analysis of the light and heavy forest areas between 1986 and 2002, sixteen (16) years which is the first interval period of the study, light and heavy forest zones within the study area have increased by about a hundred and fourteen square kilometers (precisely 114.40) which translates to the increase percentage of about nineteen percent (19%) while in the second sixteen years of the study, the growth rate of the forest areas increased by additional hundred and thirty three square kilometres. The implication is that light and heavy forests have been on the steady increase since 1986. This is probably because more people are drifting away from agricultural activities because of industrialization and the less involvement in agricultural activities imply that more agricultural lands are allowed to fallow which gives rise light forest.

Water bodies in sixteen (16) years, water bodies within the study area increased from about seventy two (72) to about ninety-one (91) translating to the increase rate of about twenty one percent (21%). After another sixteen (16) years which is the second interval of the study, the water level within the study area shrank from ninety-one (91.71) back to fifty three (53.99) and a fraction of square kilometers which is about fourty-two (42%) percent shrinking rate from what obtained in 2002 and in turn about twenty seven percent overall shrinking rate as a differentiation to what obtained in 1986. The implication of this is that infrastructural development, emigration and climate change has been the major factor(s) contributing to the swelling and shrinking of water bodies in the study area.

Contrary to popular expectation, farmlands were shrinking in the first sixteen (16) years (1986 – 2002). Precisely, farmlands within the study area have decreased to about one thousand eight hundred and thirty three (1833.81) and a fraction of square kilometers from two thousand two hundred and eleven (2211.87) square kilometers which translates to the decrease rate of about eighteen percent (18%). After another sixteen (16) years which is the second interval of the study, the farmlands within the study area further decreased to three hundred and twelve (312.32) and a fraction of square kilometers which is about eighty three percent (83%) decrease rate from 2002 and about eighty six percent (86%) from 1986. The implication of this is that the size of farmlands have been shrinking or experiencing free fall at a steady rate since the beginning of the research period. The implication of this is that since water bodies were shrinking back at a time, it is safe to say that in the last interval of the study, the areas water withdrew from eventually ended up as either forest or built-up areas. Hence the steady decrease in the sizes of farmlands.

Wetland/Mangrove Swamp Forest in sixteen (16) years, decreased from five hundred and fifty-seven (557.35) to three hundred and seventeen (317.91) and a fraction of square kilometers which translates to a decrease rate of about forty-four percent (44%). After another sixteen (16) years, the wetland/mangrove level rose again from three hundred and seventeen (317.91) to six hundred and forty-three (643.18) and a fraction of square kilometers which is about a hundred and twelve percent (112%) increase within the second sixteen years. This indicates that in the thirty-two years of the study, the wetland ecosystem has only managed to grow by fifteen percent. This indicates that the wetland/mangrove growth rate is probably affected by the effects of changing climate.

5. Conclusion and Recommendations

The study was done primarily to first of all map the change detection that has occurred within the thirty-two-year period of the study in sixteen years intervals. Secondly, it was also carried out to estimate the land use and land cover changes that has occurred to the different classes over the thirty-two years period and finally to investigate the implications of these changes on the wetland ecosystem of Akwa Ibom State. The study identified a couple of patterns of expected change like in the built-up areas but at the same time it also identified some unexpected change patterns like the steady shrinking of farmlands and the simple harmonic rise and fall of water levels.

Based on the findings in this study, migration, industrialization, climate change, rise in population density, expansion of urban areas constitutes some of the major determinant driving the change in the study area. In another set of findings, the growth of the wetland ecosystem in terms of the presence of the mangrove is not impressive because it nosedived downwards in the first sixteen years and came slowly back up in the second sixteen years. Further research will be required to unbundle the mysteries behind these dramatic changes.

Judging by the indices presented in this study, it is also worrisome to note that agricultural practices and cultivation of crops have been relegated to the background in these areas. This calls for concern especially in the face of the dwindling economy and food shortages. Another issue the study raised as a good concern is the fact that water levels faulters in these areas. Based on the findings of this study, the following recommendations are made:

1. There should be intentional efforts by government and non-governmental organizations to increase the population of mangrove trees. This will help to strengthen the ecosystem.
2. Since the study has identified a huge gap in agricultural practices, governments at all levels and relevant organizations should intensify efforts to rekindle enthusiasm towards embracing agricultural practices by the residents of the study area. This can be done by giving loans or grants to individuals and corporate bodies that set themselves up for agriculture.
3. At the rate infrastructural development is going, in few year’s times, there will definitely be a need to regulate the tampering in the mangrove ecosystem. This will be necessary to keep residents from destroying the wetland ecosystem. Also deliberate mangrove tree planting and nurturing is required to register a substantial wetland growth in a few years’ time.

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