Geospatial Analysis of Urban Expansion on Wetlands Management in Calabar Metropolis: A Case of Edim Otop District, Cross River State, Nigeria

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Abstract- ***The study examined the Geospatial Analysis of Urban Expansion on Wetland Management in Calabar Metropolis: A Case of Edim Otop District, Cross River State. The main objective was to assess the rate of change in urban expansion between the period of 2000 and 2019. A survey research design was adopted to elicit information from the respondents. A total of 355 copies of questionnaire were distributed to the respondent using simple random technique. Data on land use cover change between 2000 and 2019 was gotten from Erdas imagine. Data analysis was carried out using independent sample t test and Pearson correlation statistic. The result proved that in the year 2000 built-up area was 3.12 sqkm and in the year 2019 built-up area was 33.54 sqkm while in the year 2000, wetland covered an area of 11.57 sqkm and in the year 2019, wetland covered an area 9.39 sqkm this showed that there was a drastic change between the year 2000 and 2019 with wetland reducing and urban expansion increasing implying that urban expansion has negative impact on wetland areas. It was also revealed that there is a significant relationship between urban expansion and wetland loss in Edim Axis. Statistical test showed that a Pearson correlation(r) was achieved at 0.650 or 65 percent, hence there is strong positive correlation between urban expansion and wetland loss in Edim Otop axis. Furthermore, the result revealed a significant value p (0.002)< 0.05. Hence, urban expansion has negatively impacted on the wetland leading to its loss in Edim Otop. The study recommends that government should strictly enforce its sustainable urban policies so as to control rapid urbanization to mitigate the impact associate with wetland degradation in Calabar Municipality.***

Indexed Terms- ***Geospatial Analysis, Urban Expansion, Wetland Management, Calabar Metropolis, Edim Otop District, Cross River State.***

I. INTRODUCTION

Urbanization is the condition of a region or location expanding in size, increasing in population, developing in socio-economic activities and diversity of people and organizing in complex societal administration. The rate of urbanization is increasing in the world today. Particularly in the developing world, the rate of urbanization has double its size since the past decades and will continue to experience a rapid growth in the next few decades (United Nation Development Program. (UNDP) 2014). The negative implication of this rapid growth in urbanization is the increase in urban challenges such as unemployment, poverty, inadequate health, poor sanitation, urban slums, degradation, unfavourable land use change and most importantly loss of sensitive ecosystem like wetlands, which act as carbon sinks (Obia, Itam & Archibong, 2016).

Ajibola et al (2012) opined that urbanization is a major cause of loss of coastal wetlands. The researchers posited that urbanization impacts wetlands in numerous direct and indirect ways. For instance, the development of housing projects, creation of new roads, development of new urban features and other forms of urban development impact wetlands by causing direct habitat loss, suspended solids additions, hydrologic changes and altered water quality. Indirect impacts could manifest in the form of changes in hydrology and sedimentations which substantially alter wetlands. It also exerts significant influences on the structure and function of coastal wetlands, mainly through modifying the hydrological and sedimentation

regimes, and the dynamics of nutrients and chemical pollutants.

The wetlands are important ecosystem to man and nature. Turner (1990) noted that wetland ecosystems account for about six per cent of the global land area and are considered by many authorities to be among the most threatened of all environmental resources. The rate of wetland loss is known to be greater than any other type of ecosystem (UN-Habitat, 2010). Most of the physical losses have been due to the conversion of wetlands to other landuses, which is most times facilitated by urbanization. Urban areas are known to generate negative impacts on the environment (UN-Habitat, 2010) as they lead to changes in landscape patterns, ecosystem functions and their capacity to perform functions in support of human populations. This is especially so when rapid or unplanned growth occur in areas of highly vulnerable systems such as wetlands. The conversion of large tracts of wetlands into built – up area results in increased impervious surfaces which can lead to flooding and altered aquifer recharge (Odunuga & Oyebande, 2007).

Many studies have examined the rate of wetland loss using different technologies. For instance, Cook, Miller & Seager (2009) posited that remote sensing is a vital tool for assessing the rate of wetland loss. Also, Anule and Ujoh (2017), study the loss of wetland degradation in Markurdi using geospatial analysis and discovered that land use degrades at a rate of 22.57%. similarly, Rabine (2018), examined the loss of wetlands using remote sensing technique and discovered there are over 2,311 acres of lost wetlands in the Minnesota landscape. Remote sensing is crucial in maintaining accurate records of the state of wetlands which is crucial in their preservation (Klemas, 2011; Robertson, 2015). One of the main aspects that can be closely monitored remotely is the overall behavior of wetlands over time (Klemas, 2011; Robertson, 2015) using a series of images from different years (Wright and Gallant, 2007). A wealthy amount of information can be extracted through the comparison of multiple images, and this data can sometimes be extrapolated to predict future changes (Klemas, 2011; Robertson, 2015). The flexibility of GIS allows the analyst to control the scale of their research, depending on the data available. A major step towards the preservation and conservation of wetlands begins with understanding the level of degradation of these fragile ecosystems at regional and local spatial scales. Thus, providing an accurate evaluation of the spread and health of the world's forest, grassland, water, and agricultural and land resources has become an important priority (Mengistu & Salami, 2007).

The reason for studying the impact of urbanization on wetlands is due to the dire consequences posed by wetland loss on human socio-economic endeavor. On this note, Kassa, Teshome and Teshome (2015) observed that the degradation of wetlands in Tekuma, Ethiopia has reduced the socio-economic benefits provided the wetlands to residents in the region. Similarly, Nijamir (2017) maintained that the loss of wetlands in Navithanveli DS Division in Sri Lanka, has resulted in the degradation of socio-economic livelihood within the region. Wetland destruction pose magnitudes of impact on the lives of human and the rate of wetland loss have been traced to the expansion of urban landuse by many researchers.

Rapid loss of wetlands can generate negative impacts on the environment as they lead to changes in landscape patterns, ecosystem functions and their capacity to perform functions in support of human survival like providing sinks for Carbon emission. Furthermore, the rapid conversion of large tracts of wetlands into built –up area results in increased impervious surfaces which can lead to flooding and altered aquifer recharge. However, due to the urgent need for economic development the rapid loss of wetlands facilitated by uncontrolled urbanization is of little concern to majority of residents in citizens around wetland regions such as Calabar Metropolis.

Calabar Metropolis, like every other city in Nigeria is faced with rapid urban growth facilitated by the incessant trend in rural-urban migration from settlement located around the urban fringes. The rapid growth of Calabar Metropolis has resulted in the expansion of the metropolis size. The implication of the expansion is the invasion of wetlands by urban developments such as residential development, infrastructural development and other forms of urban landuses. This growth has apparent lead to the conversion of other forms of land uses within and outside the metropolitan boundary. One of the

obvious district in Calabar Metropolis that has been impacted by the rapid change in land use and which is of particular concern to this study is Edim Otop/Atimbo Axis, which is located along the urban fringes of Calabar Metropolis.

Hence, this study is designed to examine the impact of urbanization on wetlands in Edim Otop, a district of Calabar Metropolis, and the following specific objectives were guided in the study: determine the rate of urban expansion and the change in wetland land use in Edim Otop / Atimbo district of Calabar Muncipality, between the year of 2000, and 2019, find out the cause of wetland degradation in Edim Otop / Atimbo district of Calabar Municipality, find out the socio-economic impact of wetland loss, in Edim Otop / Atimbo district of Calabar Municipality and to examine the relationship between urban expansion and wetland loss

II. MATERIALS AND METHODS

Materials- Study area

The study was conducted in Edim Otop/Atimbo district which is located within the urban fringes of Calabar Metropolis and Akpabuyo LGA of Cross River State. It lies geographically between longitudes 8º 21'29" E and 8°21'42.16"E of the Greenwich Meridian and latitudes 4º 58' 33" N and 4°58'7.61"N of the equator. The district is home to the Atimbo Navy Barrack and the Nigeria Immigration Service. The district is located at the fringe of Calabar Municipality as it connects the Municipality to Akpabuyo Local Government Area through the Calabar-Ikang road.

Edim Otop district like any other district in Calabar Metropolis is characterized by a humid tropical climate with a double maxima rainfall pattern of approximately 3063mm annually (Edet, Okereke, Teme & Esu, 1998). Calabar have a short dry season usually occurring between November and March, and a relatively longer wet season from April to October (Akpan, 1994). The dry season is dominated by North east trade wind, while the south east trade wind dominates the wet season. The rains are usually of long duration and with very high intensity. Rainfall during the peak of the wet season, that is, between July and September may last a whole day and are usually characterized by relatively high peak intensities which range between 50 and 100 $mmhr^{-1}$, while the onset of the rainy season is characterized by short-lived high intensity rainstorms. During the wet season the value of evapo-transpiration is low, giving rise to very high surface runoff. The unique characteristics of high humidity high rainfall and temperature have culminated into a highly unique complex and diverse flora and fauna. The vegetation of Edim Otop/Atimbo district is not different from the vegetations of other districts in Calabar. It is evergreen tropical vegetation with tall trees and creeping ferns. The floristic richness is due to the high rate of speciation. The vegetation is very rich in both timber and non-timber species. Most of the flora and fauna found in the forest are endemic to the area. Mangrove swamp forest dominates the coastal areas of the river valleys in this area (CRBDA, 1982).

Edim Otop/Atimbo district is characterized with rapid urbanization regime owing to the massive urban-rural migration. based on the population census of 1991 the population of Calabar was 1789, however, at the rate of urbanization, the population of Calabar metropolis is projected to rise to 3180 in 2017 (National Population Census, 1991 and 2017). The implication of this rise in population is the increase in urban land use of the city, which would result in loss of contending other land uses in the city.

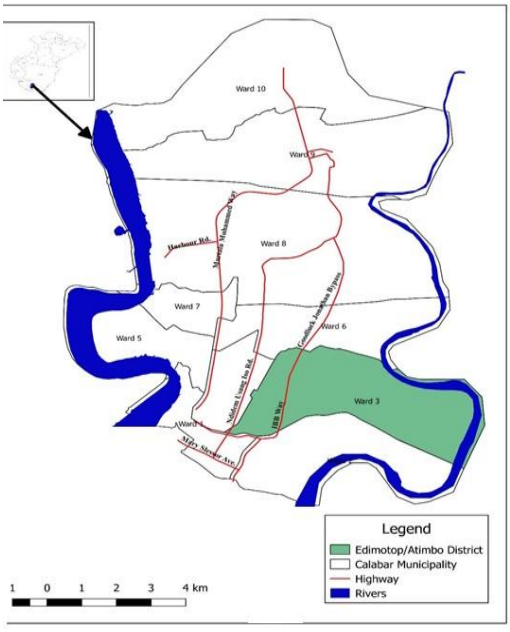

Figure 1: Map of EdimOtop/Atimbo District
Source: GIS Unit, Department of Geography and Environmental Science, University of Calabar (2025).

III. METHODS

The study adopted both survey research design and geospatial mapping. Data for the study were collected via remote sensing procedure and questionnaire survey. The satellite imageries were obtained from the *ESRI Landsat unlock – earths - secrets Platform* The boundary data of Edim Otop, Calabar Municipality, Nigeria was obtained from Google Earth platform. The simple random technique was adopted for the study.

In the remote sensing procedure, the imageries were classified into several land uses, needed for the Land Use Land Cover analysis, geo-referencing of the imageries was relevant since the internal coordinate of the imageries compared to real ground coordinate is not the same. The imageries were geo-referenced to WGS84 UTM Zone 32^0 North. After the imageries were geo-referenced, the outputs were clipped according to the boundary of the study area, using the clip tool in the QGIS platform. The clipped imageries for the years 2000 and 2019.

A post classification comparison of the change detection techniques was utilized in order to detect the changes within 2000 and 2018. The classification of the images was carried out using ERDAS imagine pixel-based classification. An unsupervised classification was performed. The two images were classified into different land cover types. This method of classification involves the procedure of identifying pixels possessing the same spectral features automatically (Wakirwa, 2015). ERDAS imagine software was used in digitally processing and identifying the spectral clusters on the Landsat images and QGIS was used for the final embellishment of the ERDAS outputs.

The classified raster output was converted to vector (polygons) to allow for measurements to be done. The areas coverage of each of the LULC (Land Use Land Cover) classes were measured (in Square Kilometers [sqkm]) for each of the years under consideration using the export geometry tool in QGIS platform. A comparison of the land cover statistics assists in identifying the change in percentage, trend and rate of change in Edim Otop, Calabar Municipality, Cross River State over the periods of 2000 and 2019.

The second stage of the data collection process, involved the use of questionnaire in the collection of data. The questionnaires were designed by a combination of various techniques to accommodate close ended questions and open-ended questions simultaneously. A total of 355 questionnaires were administered to 355 respondents at Edim Otop, Calabar Metropolis, Cross River State. The population of the study were selected residents who live around the wetland regions of the district. Taro Yamane (1967) method of sample size determination was used and 355 copies of the questionnaire were administered.

Data gotten from the satellite imagery was computed into an excel sheet, where the area coverage of the different land uses as well as the percentage were computed to estimate the percentage coverage of each land use. Furthermore, the responses from the questionnaire were first coded into a coding sheet using Statistical Package for Social Science (SPSS) version 20.1. These data were presented in charts, tables and maps for effectively visualization of the outputs. Furthermore, relevant variables of the hypotheses formulated were subjected to statistical test. The Pearson Product Moment Correlation test (PPMC) and a simple t test were used in testing the hypotheses.

IV. RESULTS AND DISCUSSION

Table 4.1: Land use land cover Calabar 2000

LULC 2000	Area (sqkm)	Per cent (%)
Water bodies	1.23	7.72
Wetlands	11.57	72.6
Built Up area	3.12	19.59
Total	15.92	100

Source: Researcher's analysis 2025

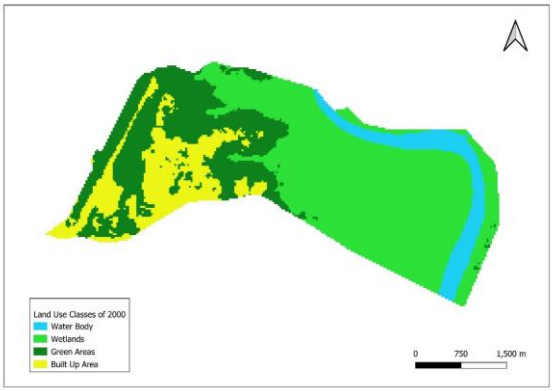

Figure 2 Land cover of Edim Otop Axis 2000

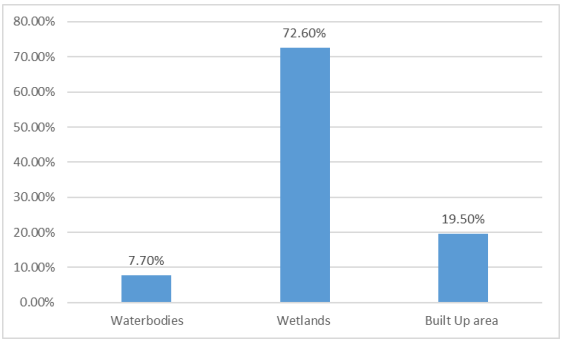

Figure 3. Graphical representation of land cover of Edim Otop Axis 2000

Source: Researcher's compilation, 2025

Table 4.2: Land use land cover Calabar 2019

LULC 2019	Area (sqkm)	Per cent (%)
Waterbodies	1.19	7.47
Wetlands	9.39	58.981
Built Up area	5.34	33.54
total	15.92	100

Source: Researcher's compilation, 2025

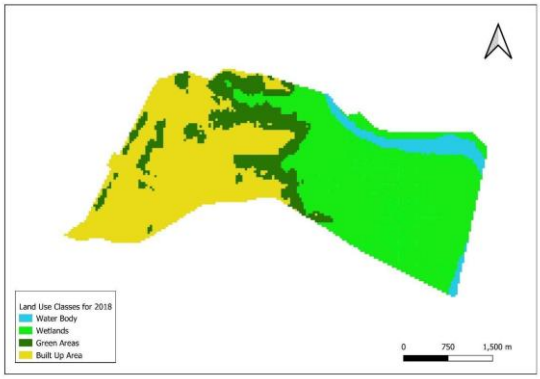

Figure 4: Land cover of Edim Otop Axis 2019

Source : Researcher's compilation, 2025

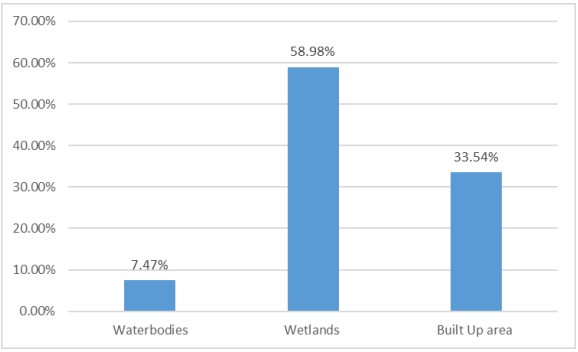

Figure 5: Graphical representation of land cover of Edim Otop Axis 2019

Source: Researcher's analysis 2025

Table 4.3. Respondent opinion on Cause of wetland degradation

	Frequency	Percent
Rapid urbanization	96	27.04
Climate change	51	14.3
Pollution	56	15.77
Drought	69	19.43
Circle of life	50	14.08
Other	3	0.84
Total	355	100.0

Source: Researcher's Field Survey, 2025

Table 4.4 Severity of wetland degradation

	Frequency	Percent
Very severe	156	43.9
Severe	91	25.6
Moderate	81	22.8
Less	21	5.91
Total	355	100.0

Source: Researcher's Field Survey, 2025

Table 4.5 Major causes of wetland degradation

	Frequency	Percent
Man	253	71.2
Nature	102	28.8
Total	355	100.0

Source: Researcher's Field Survey, 2025

Table 4.6 Opinion on the impact of wetland loss

	Frequency	Percent
Loss of income	71	20
Loss of employment	65	18.3
Loss of recreation spots	67	18.8
Loss of natural resources	81	22.8
Loss of state revenue	55	15.4
Increase carbon foot print	16	4.5
Total	355	100.0

Source: Researcher's Field Survey, 2025

Table 4.7 Mitigation measures

	Frequency	Percent
Creation of buffer zones	96	27.0
Enforcing strict protection of wetlands	83	23.38
Pollution pay principle	97	27.3
Compensation for wetland protection	79	22.25
Total	355	100.0

Source: Researcher's Field Survey, 2025

V. DISCUSSION OF FINDINGS

The study sought to examine the rate of urban expansion in edim otop district of calabar municipality, between the year 2000, and 2019. The result of the study showed that in the year 2000, built-up area was 3.12 sqkm and in the year 2019 built-up area was 33.54 sqkm. There was a significant change in built-up area between 2000 to 2019, with built-up area increasing in the year 2019 due to rapid urbanization. Also the findings showed that in the year 2000, wetland covered an area of 11.57 sqkm and in the year 2019, wetland areal coverage decreased to 9.39 sqkm which shows that in the year 2019, wetland was impacted by urbanization. This finding correlates with the finding of Alsharif, pradhan and mansor (2015) and Elekwachi (2015). It was noticed that loss of wetlands affected the socio-economic livelihood of the inhabitants and this finding supports the finding of Nijamir (2017) on the implications of wetland loss on livelihood.

From the result obtained from questionnaire survey, it was revealed by majority of respondents that the cause of wetland degradation is rapid urbanization, it was also noted that the cause is very severe, more so, it was also discovered that the major cause of wetland degradation is man. Based on the field results, most respondents complained that wetland degradation has affected their livelihood support system and the extent of degradation is very severe.

CONCLUSION AND RECOMMENDATIONS

The study aimed to examine the impact of urban expansion on wetland in Edim Otop District of Calabar municipality, in view of the findings of this study it was concluded that urban expansion has

negatively impacted on wetland leading to degradation and threatening of livelihood. Following this findings, the following suggestions were raised:

- The government should strictly enforce its sustainable urban policies so as to control the urbanization process in the district.
- Buffer zones should be developed to restrict developers from developing in sensitive wetland ecosystem in Edim Otop district.
- The government should compensate the locals living within the wetland ecosystem so as to dissuade them from over-depending on the wetland ecosystem
- The polluter pay principle should be strictly enacted to evade exploitation of wetland ecosystem.

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