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11. Analysis of the Trends in Land use changes in the Southern Nigeria's Calabar River Basin from 1980 to 2020

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Abstract:

This research was motivated by the requirement of a policy for a variety of spatiotemporal analyses in the area under investigation. An approach based on a Geographic Information System (GIS) was utilised to analyse the changes in land use that have occurred over the past four decades (1980-2020). With respective losses of 12.01 percent in grassland, 11.01 percent in forests, 4.62 percent in bareland, and 3.5 percent in water bodies, urban and agricultural land use types encroached on these land types by a total of 17.54 percent and 13.59 percent, respectively. The results of the study are depicted on maps and charts as a change in land use, which reveals that the area under investigation has undergone rapid deforestation to make space for agricultural and urban expansion.

This discovery will make it possible for planners and decision-makers to rapidly evaluate the potential effects of human activities in the region under study and to initiate relevant actions to decrease the severity of those effects. Because it has accurately described how land use shifts over time, it will also be helpful in analysing the environmental consequences of rising population pressure, agriculture, urban expansion, resettlement programmes, climate change, and public administrators, as well as environmentalists. This is because it has accurately described how land use shifts over time.

Keywords:

GIS, land use, land cover, river basin, urbanization.

11.1 Introduction:

As a consequence of the changing patterns of land use and cover, there is a growing interest in the coastal environment among both researchers and policymakers. Land is in a precarious position as a result of competing demands for agricultural use and the consistently rising number of people living in the world [1].

Because of the opportunities for residential, industrial, agricultural, recreational, and commercial land use development [2], the population in the coastal belt has increased significantly in recent years. Concerns regarding land use change initially surfaced in the agenda of global environmental change studies a few decades ago, when scientists first began to realise that variations in land use contribute to climate change and soil degradation.

Since the International Geosphere and Biosphere Programme (IGBP) and the International Human Dimension Programme (IHDP) on global environmental change launched their major effort on it in the middle of the decade of the 1990s, there has been an increase in the general public's knowledge of this field of study. This can be attributed to the fact that the International Geosphere and Biosphere Programme (IGBP) and the International Human Dimension Programme (IHDP) both focus on global environmental. Unprecedented alterations in land usage have taken place, both nationally and specifically in the city of Calabar in Nigeria.

The tropics are home to the vast majority of the world's ever-changing plant life and agricultural practises. There has been a significant movement of developing land from the eastern and southern areas of the metropolis to the northern region of the State as a result of the limitations imposed by the Calabar River, the Great Kwa River estuary, and the wetlands of the Cross River estuary.

For instance, the Pamol Rubber Plantation, Tinapa Leisure, and the National Integrated Power Project (NIPP) are all utilising vast swaths of land in the Odukpani neighbourhood of Ikot-Nyong [3]. The resort can be found in Odukpani and Municipality, both of which are within the study area and are situated adjacent to the Calabar-Itu highway.

People participate in continuing economic activity at these areas, which have the effect of altering the pattern of land use in the region. In spite of these measures, there is scant evidence to suggest that the government is taking any action at all to improve the environment in the surrounding area. There is a lack of relevant literature, and ecological considerations in land use studies in Nigeria receive a disproportionately small amount of focus [4].

The state capital of Cross River State is Calabar, which is influenced either directly or indirectly by the Calabar river basin. This city is home to some of the most popular vacation destinations in all of Africa. Both the rate of urban expansion and the rate of deforestation in the area are high due to the many different human activities that take place in the area.

The pattern provides a description of the significant shifts in land use that have taken place over the course of time in the area under consideration. In any coastal environment, the expansion of an urban or residential area over time encroaches on other land uses such as farms, bodies of water, swamps or mangroves, grassland, bareland, or woodlands [5].

For example, due to the high temperatures, the Cross River National Park (CRNP), which was formed in 1994 and has a forested area of around 4,000 square kilometres, is being rapidly destroyed by commercial logging. This is happening both inside and outside of the park's specified borders.

According to [6], multinational logging and wood processing companies such as Hanseatic Nigeria Limited (German), Kisari Investment Company Limited (Belgian), and most recently Wempco Agro-Forestry Company Limited (Hong Kong/Chinese), have gradually turned this priceless vegetation into a commercial logging target. According to, there is no connection between the location of the city of Calabar and the apparent lack of flora cover, the sandy nature of the soil, or the high temperature regimes that are present in the area.

They argue that the vulnerability of the soil to rainwash cannot be linked to the geography of the area. In a similar vein, the increasing rate of urbanisation in the region is one of the many human activities that is contributing to the rapid rate of deforestation in the region. The pattern sheds light on the substantial shifts in land use that have taken place over the course of the research in the area under consideration. [8] pointed out that in every coastal setting, the growth of an urban or residential area over the course of some period of time encroaches onto other land uses such as farms, water bodies, swamps or mangroves, grassland, barren ground, and forests. Within the research region, urban and farming land uses have risen dramatically over the course of a 30-year period (1980-2010); declines have been seen in forest land uses (35.85% - 24.84%), water body land uses (8.77% - 5.27%), grassland land uses (24.68% - 12.67%), and bare land uses (17.31% - 12.69%).

It is therefore conceived that in Nigeria, the urban centre is linked with rapid rate of urban expansion. Consequently, where simultaneous provision for adequate urban runoff disposal system is lacking as in the study area, then, the contributive role of urban surface characteristics is severe erosion and flooding as well as other environmental hazards. [9] asserted that the persistent flooding in Calabar has regularly resulted in reduced socio-economic activities, causing residential houses and fences to collapse.

The flood in Calabar region has been categorized into severe, moderate and low. Between January, 2012 and October, 2013; an estimated total number of 482 buildings were affected by severe flood in Calabar [10]. In the urban centre, the growing human desire to settle in the area has worsened the incidence of flood because residents tend to ignore flood aspect of urban development planning, land use and rainfall pattern [11]. However, since flooding in the area mainly results from rainfall, then change in rainfall pattern definitely brings about change in the dimension of flooding.

As the area is quickly urbanizing, it may be inferred from the aforementioned that the Calabar River watershed follows a decade trend of land use change/cover pattern. In light of this, the following research questions are addressed in this study:

- What primary land use types are present in the research area?
- How has land usage changed over time in the study area?
- How do the changes in land use/cover affect the locals' means of subsistence?
- What are the remedies or mitigation strategies for changes in land use or covers?

11.2 Aim and Objectives:

The aim of the study to examine the dynamics of land use changes in the Calabar river basin, Cross River State, Nigeria. Specific objectives of this study include:

- Identify the main land use types in the research region.
- track changes in the study area's land use pattern over time.
- Identify how the people' way of life is affected by changes in land usage.
- Offer remedies for the alterations in land use and cover.

11.3 Literature Review:

The term "land use" refers to any activity carried out by man on land that is directly connected to the land itself. According to [12], the term "land use" refers to "how a portion of the earth is used by man" (for activities such as industry, dwelling, agriculture, etc.). Studies of change acknowledge not only the biotic but also the abiotic aspects of multi-spectral and multi-temporal modifications that are taking place within an ecosystem [13].

Comparisons of images to images and maps to maps will be the primary methods utilised here. This will be centred on these two basic approaches. There are seven distinct types of change detection processes, including algebra, transformation, classification, advanced models, a Geographical Information System (GIS) approach, visual analysis, and various strategies.

The first categories have each been provided with an explanation of their major characteristics, as well as their benefits and drawbacks, the significant variables that influence change detection findings, and some application examples. Techniques for change detection that cannot be categorised into any of the other six different groups and are not generally utilised [14] make up the seventh category of change detection methods.

There have been many attempts made at change detection programmes, and these programmes have been put through considerable testing in a variety of study fields. However, the results have not provided any definitive answers. For the purpose of this investigation, we utilised the visual analysis that is typically utilised for detecting land change, which is based on the way of comparing maps to one other. [15–18] have shown their support and enthusiasm for this method. In Nigeria, there is dearth of empirical work on this subject matter. [19] in their work which added [20] studied‘‘NIRAD’’ project (1976/79), [21-22].

It should be pointed out that the‘‘NIRAD’’ project and ‘‘FORMECU’’ project were mainly domiciled on land use. However, [23] extended his work to accommodate change detection. In a similar development, [24] adopted ‘‘GIS’’ database as a model for land use and cover change in Akwa Ibom State, Nigeria between the year 1984 and 2003. The result indicated a sharp reduction of the areas once covered by mangrove forest by 50 percent which had led to a massive expansion of urban dwellers to fallow rural lands and forests. This development has led to a threat in food security and severe dramatic climate change.

[25] studied the effect of land use conversion rate in South-eastern Nigeria from 1972-2001, the founding revealed that deforestation was lower in the communal lands than in the public controlled land. It also showed a strong correlation between agricultural land use characteristics and deforestation rates.

The imagery of Abuja, the Federal Capital Territory, spanning 1987 and 2004 was juxtaposed to observe whether the use of land changed over time. The optimum likelihood procedure was employed to categorize the images into five categories.

The categories included agriculture, rocky outcrops, water bodies, vegetation, and built-up areas. To find any differences, the two categorized imageries were compared. Additionally, a quantitative change in the kind of land use was acquired over space and time. According to the data, between 1987 and 2004 overall was an 85.22 percent decrease in vegetation cover. Once more, cropland increased by 0.14 percent while the built-up area increased by 21.99 percent.

11.4 Research Methods:

The data that was obtained from the topographical map and aerial pictures that are currently available were incorporated into the land use activities that were being carried out inside the basin of the research region. This provided a mechanism for analysing and evaluating the change of different land use types in the study's area.

Four epochs of satellite imagery were used to interpret the research region on a scale of 1:500,000: 1980, 1990, 2000, and 2010. The study contained a 1:160,000 scale topographical map of the study area as well. To analyse long-term land use/cover changes and trends in the four decades of investigation region, the study adopted data from diverse sources and applied a wide range of methods and approaches.

The approaches utilised involved fieldwork surveys, application of forest inventory, and imageries from many satellites (Landsat), multi-temporal dates (MSS 1980, TM 1990, ETM 2000, and ETM+ 2010). A newly developed method of defining photos uses pixel-based categorisation. For image processing, masking, and classification, the Earth Resources Data Analysis System (ERDAS) version 9.1 and the Integrated Land and Water Information System (ILWIS) software version 3.7 were used.

While SPSS was applied for statistical analysis, ArcGIS was used to build databases, analyze spatial data, to make thematic maps. Using a GPS and the WGS 84 32N Minna Datum, coordinates of numerous localities within the study geographic area were obtained.

For four epochs: 1980, 1990, 2000, and 2010, Global Land Cover Facilities (GLCF) and the United State Geological Survey (USGS) collected Landsat satellite imagery of the study location.

The technique includes imageries from different satellites (Landsat), multi-temporal data such as Landsat 1-5, the Landsat Multi-Spectral Scanner) 60m resolution in multispectral (MSS1980), Landsat TM 1990 (Landsat 4 and 5 Thematic Mapper) 30m resolution in multispectral (TM 1990), Landsat 7 Enhanced Thematic Mapper 30m resolution in multi-multi-spectral (ETM 2000) and Landsat ETM + 2010 (Landsat Level1 Enhanced Thematic Mapper Plus) 30m resolution (ETM+ 2010). Six land use types were consequently identified, each exhibiting varied degrees of change. They consist of grassy, barren, urban, farm, and aquatic bodies (Fig. 1).

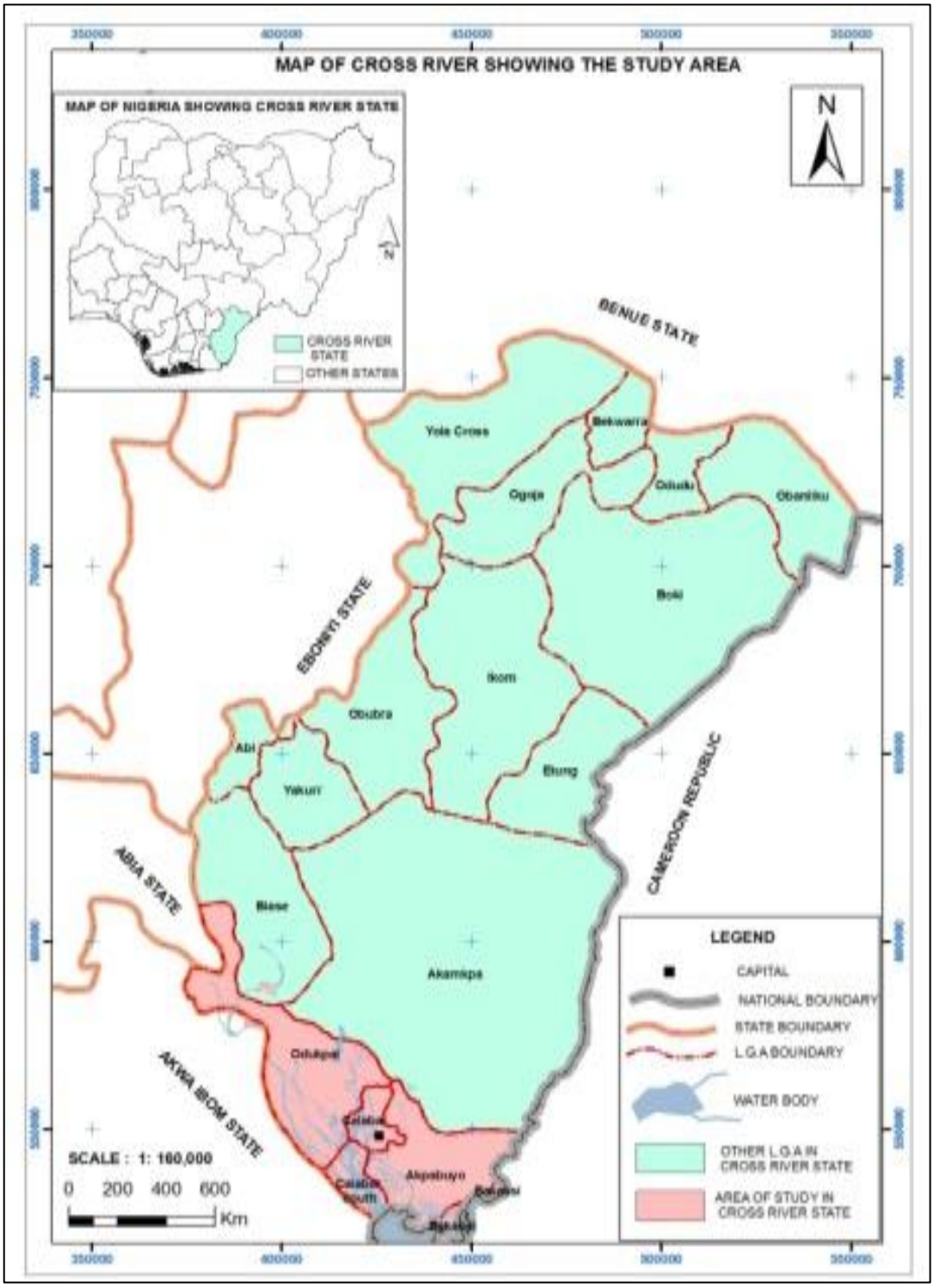


Figure 11.1: Calabar River basin, Nigeria

11.5 Relief and Drainage:

The Oban highlands in Akamkpa are the source of the Calabar River, which then runs southwards through the high rainforest along the south-east coast of Nigeria until emptying into the Cross River estuary in Calabar. The Calabar River is named after the city of Calabar. Calabar is located within the Cross River Basin, as indicated by the country of Nigeria's geographical classification and separation into geographic areas. This suggests that the region is made mostly of lowlands. It is located in the swampland and lowlands in the south-eastern region of Nigeria.

The plain predominates as the primary topographic characteristic of the region surrounding Calabar in Nigeria. The lowlands that make up the southern half of the state of Cross River, which are the subject of this investigation, are covered by sands from the coastal plain and do not rise much higher than 68 metres, with the exception of Oban hill, which is 300 metres in height. As a result, the uniqueness of the terrain's uniformity comes from the fact that it is virtually entirely devoid of physiographic differentiations. On the other hand, extensive interfluves are characterised by dry valleys, which break up the otherwise homogeneous topography into undulating depressions and low hills in the centre and northern parts of the area.

River valleys make up the majority of the landscape despite the relatively homogeneous appearance of the surrounding terrain. However, there are only a few rivers scattered about. The few rivers that drain the area originate inside the coastal plain sand's formation, with the exception of Cross River; the others are tributaries of Cross River. Cross River is the only river in the area. The Kwa Iboe, the Great Kwa, the Calabar, and the Akpa Yafe are these rivers.

In spite of the fact that large portions of these river valleys are frequently highly swampy and foster the growth of dense populations of mangrove trees and raffia palms, the region is in general fairly good draining. Surface drainage of the region is carried by these rivers and the dry valleys that are found in between the interfluves, particularly at the time of year when there is an extremely large amount of rainfall. The tidal Calabar River is not typically subject to the onslaught of powerful ocean waves. However, it is affected by wind-induced waves brought on by the trade winds that blow from the south-west, as well as shockwaves created by moving boats. The only significant physical feature that affects the climate of the area, other than the flow of winds (air masses), is the distinctive physiographic feature of the region, which means that there is no other physical feature that significantly influences the climate of the region. Due to the fact that the climate of the region does not experience substantial shifts, it is possible to accurately forecast it.

The drainage areas, lengths, and slope features of the landscape are the most essential factors in any drainage network study (Knapp, 1978; Gregory, 1979 and Linsley, et al. 1982). Other channel network characteristics like drainage density, bifurcation ratios, and others are also crucial (Knapp, 1978; Gregory, 1979 and Linsley, et al. 1982).

When it comes to evaluating the effect that runoff has on soil erosion in the area under consideration, each of these criteria has been identified as an essential element.

11.6 Climate:

Calabar region lies within the sub-equatorial climatic belt (IIoeje, 1991). This makes the region possesses a distinctive climate type peculiar to those found in the humid sub-tropical region. The humid tropics with three highs – high temperature, high humidity and high rainfall. Lying generally between latitudes 4^0 and 6^0 north of the equator, Calabar region experiences the full influence of the overhead sun throughout the year, since the angle of the sun's rays is almost vertical over the area, and so, there is a high intensity of solar radiation, thus providing abundant and constant insolation. The atmospheric temperatures within the area are constantly high and only changes slightly with the year. The mean daily temperature remains around 27^{o}C throughout the year, except during the rainy season when the temperatures are cooler, owing to the cooling effects of the rains and the fact that cloud cover curtails the amount of insolation. Since the temperature is constantly high throughout the year, Udo (1982) asserted that rainfall rather than temperature is the most important determinant of climate in the area. Rainfall is therefore very high in the area. With a total rainfall of about 300cm, Calabar region ranks very high among stations receiving heavy precipitation in the coastal zone of Nigeria and West African sub-region. The region like many other areas in the sub-tropical humid climate experiences double maxima, usually in the months of July and September. There is hardly any month of the year without rainfall even when there is a marked rainy season lasting between March to October. The relative humidity remains high all throughout the year, except during the short harmattan spell. The relative humidity is estimated to reach 90 percent much higher in the morning. The region is characterized by a long-wet season between April and November, and relatively short dry season from December to March.

Climatic and geomorphological factors influence flooding to a great extent especially as human activities gain greater prominence in natural systems such as in urban and other densely populated areas of the region. The degree of relevance of both climatic and geomorphological factors is bound to increase in the humid tropical areas, as people who occupy some of the areas are involved in various developmental activities with little or no attention to runoff and land use changes.

Rainfall, which is of great relevance to this study, varies from place to place and over time at a given location. The nature of the surface and relief, distance from major water bodies, nature of prevailing winds and ocean current, however influence rainfall. South-east trade winds that move from the South Atlantic across the Equator, when they diverge and become the strong monsoon winds from the south-west, bring heavy rainfall to the coastlands of West Africa. Calabar and environs, which lie along the coastlands of Nigeria, experience the full influence of rainfall, which is determined by distance from the sea.

Precipitation tends to be more seasonal in its incidence in the tropics and oceans exert considerable influence on the pattern of precipitation distribution. At the peak of the rainy season between June and September along the coastlands of most tropical countries, the soil would be saturated as rainfall exceeds evaporation and increases the volume of water both on the land surface and in the rivers. Over-saturated soil due to excess water and an increase in the volume of water in the river helps to produce major floods during the period of excessive torrential downpour.

11.7 Findings and Discussions:

Below are the categorization of land use and cover (Figs. 2-6), the summary table of results (Table 11.1), and statistical data (Figs. 11.7-11.10).

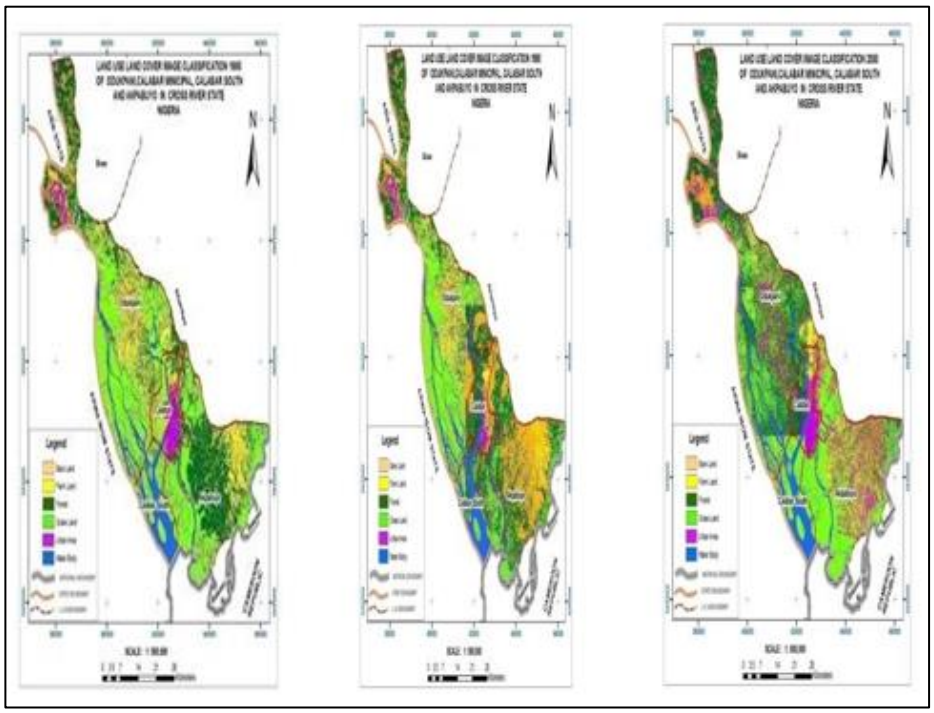


Figure 11.2: Lu/Lc 1980 **Figure 11.3: Lu/Lc 1990** **Figure 11.4: Lu/Lc 2000**

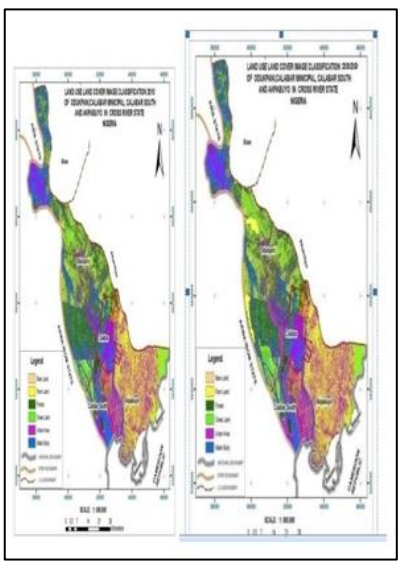


Figure 11.5: Lu/Lc 2010

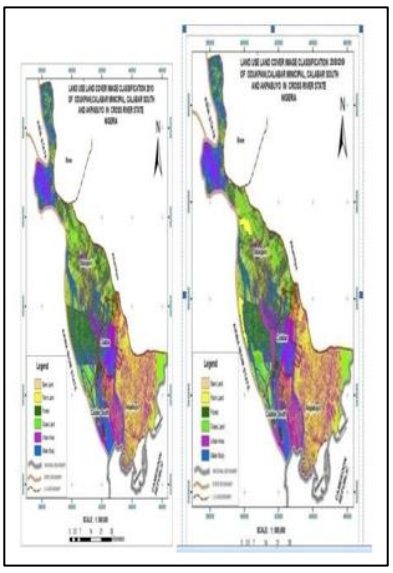


Figure 11.6: Lu/Lc 2020

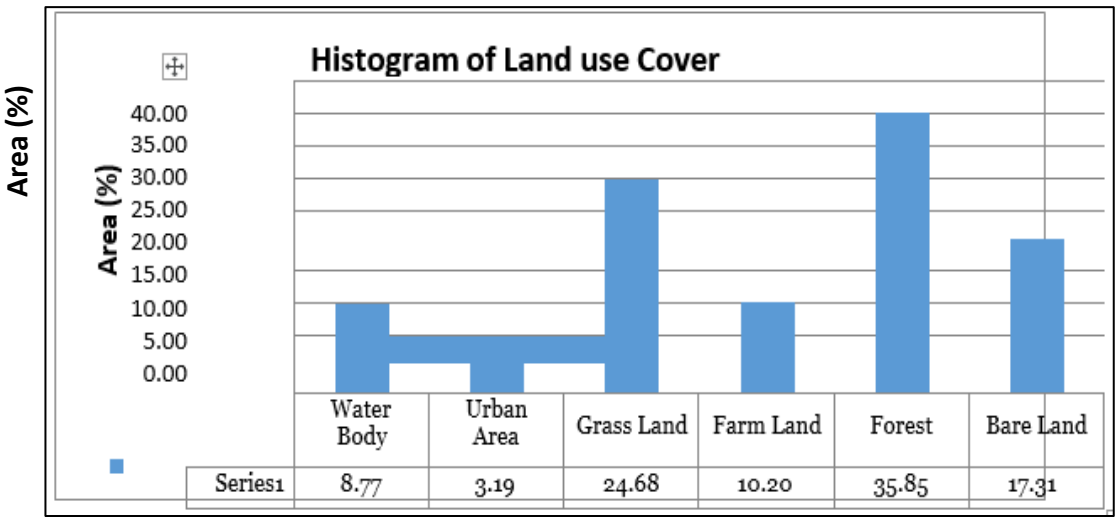
Table 1: Summary of Land use Change Category at Different Epochs (1980 - 2020) in the Study Area

Landuse Change Category	*1980*		*1990*		*2000*		*2010*		*2020*	
	Area (m2)	***(%)***	**Area (m^2)**	***(%)***	**Area (m^2)**	***(%)***	**Area (m^2)**	***(%)***	**Area (m^2)**	***(%)***
Water bodies	205098300	8.77	136590300	5.84	128119500	5.48	123402600	5.27	4.98	1196038620
Urban	74699100	3.19	173699100	7.42	271471500	11.60	485040600	20.73	23.99	5753254310
Grass	577357200	24.68	574892100	24.57	583918200	24.96	296449200	12.67	11.48	2752264560
Farm	238747500	10.20	283138200	12.10	282449700	12.07	556709400	23.79	25.12	6025165400
Forest	838700100	35.85	705433500	30.15	606020400	25.90	581134500	24.84	23.06	5532260170
Bare	405070200	17.31	465919200	19.91	467693100	19.99	296936100	12.69	11.36	2724395340
Total	**2339672400**	**100.00**	**2339672400**	**100.00**	**2339672400**	**100.00**	**2339672400**	**100.00**	**100.00**	**23983378400**

Source: Researchers' Analysis

According to the preliminary findings on land use changes and cover types that were collected in 1980, which are displayed in the table that is located above, water bodies occupied 8.77% of the total land area. This was followed by urban areas (3.19%), grasslands (24.68%), farms (10.20%), forests (35.85%), and bare land (17.31%).

The entirety of the investigation points to the presence of forests as the most typical type of land use. Figure 11.7 displays the period of time during which there was the least amount of urban land use.



By the year 1990, the percentage of land that was used for urban purposes had increased by 7.42%; it had also spread into farmlands, bare surfaces, water bodies, and the secondary forest that was nearby. The amount of mangrove swamp, woodland, bare surfaces, and farmlands had drastically decreased throughout the of the time (Figure 11.7).

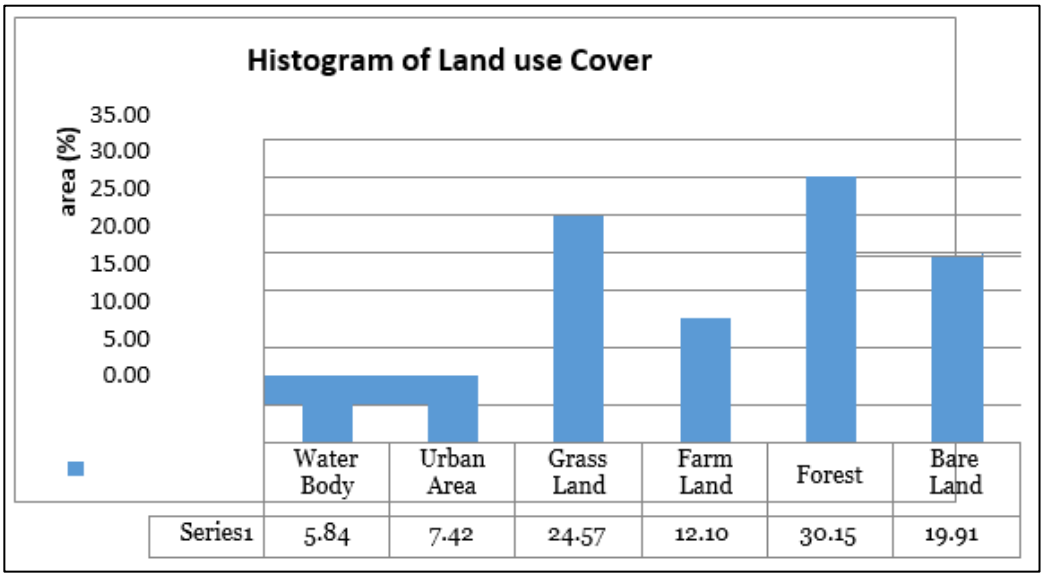


Figure 11.7: Histogram of Land use Cover (1990) of the Study Area

By the year 2000, the percentage of land that was used for urban purposes had increased by 11.60%. Subsequently, urban land use had expanded into farmlands, bare surfaces, water bodies, and the secondary forest that was nearby. During that time period, there was a decrease in the amount of mangrove, bare surfaces, and woodland (Figure 11.8).

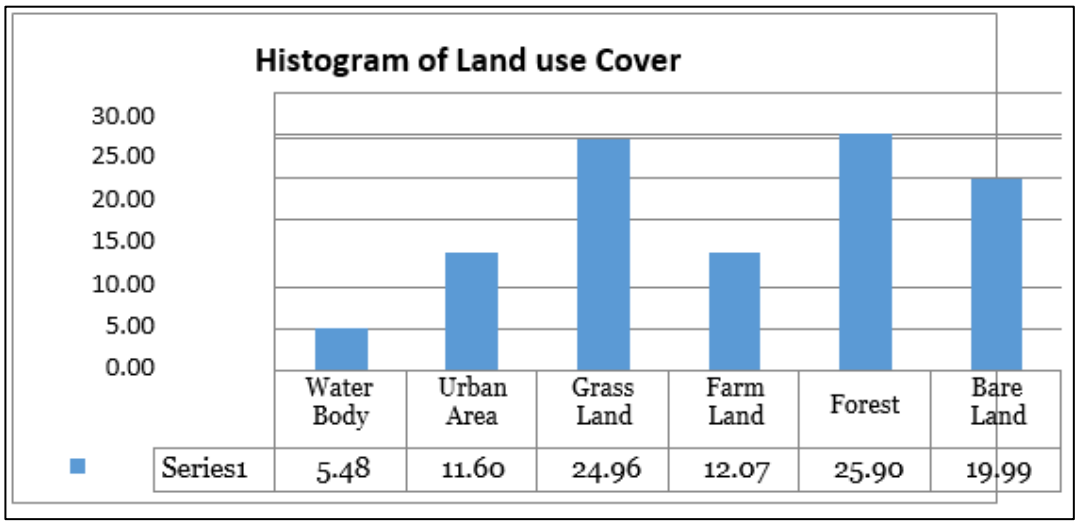


Figure 11.8: Histogram of Land use Cover (2000) of the Study Area

The percentage of land that was used for urban purposes had expanded by 20.73% by the year 2010, and since then it has spread to include farms, undeveloped land, bodies of water, and the secondary forest that is close. During that time span, both mangroves and woodlands experienced a significant loss (Figure 11.9).

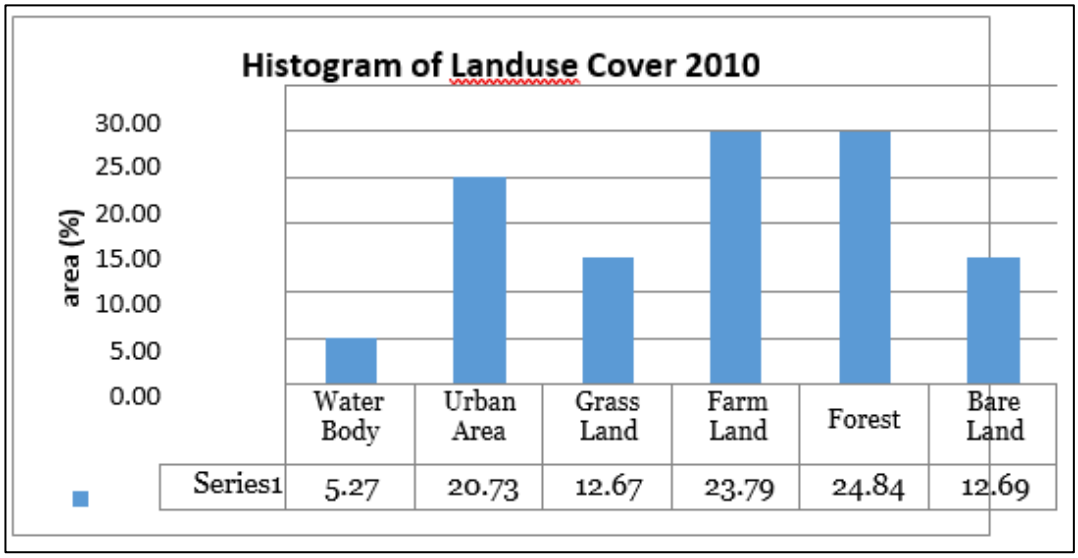


Figure 11.9: Histogram of Land use Cover (2010) of the Study Area

By the year 2020, the utilization of urban land had increased by 23.99%, and it had subsequently stretched to include farmlands, barren ground, water bodies, and the secondary forest that was located nearby. During the time period depicted in Figure 11.10, both mangroves and woodlands experienced a significant loss in area.

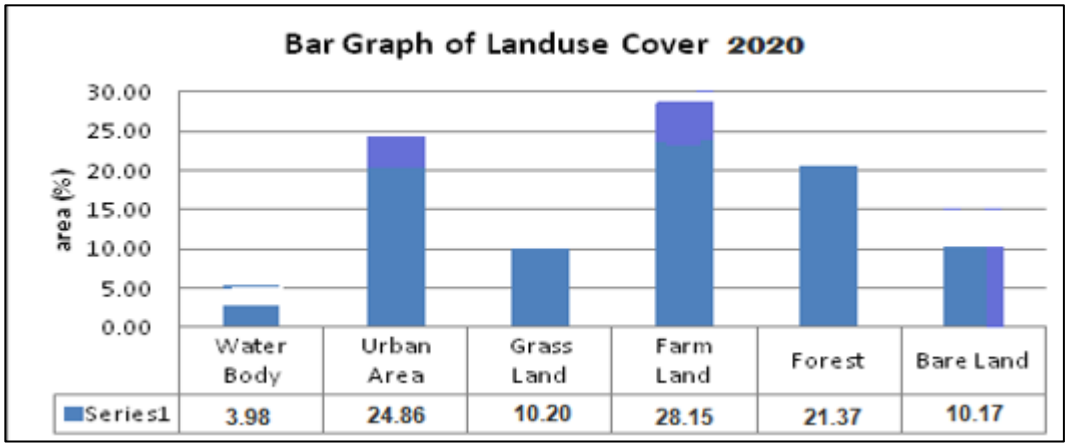


Figure 11.10: Histogram of Land use Cover (2020) of the Study Area

11.8 Conclusion:

The dynamics of land use and land cover in the Calabar River Catchment are primarily responsible for the increasing urbanisation that has been observed in this region. The composition of the urban land in the region is the primary driver of the pattern of land use change that may be observed there. This suggests that urbanisation of the Calabar River watershed is increasing, despite the fact that agriculture is the predominant form of

economic activity among the locals. Agriculture, grassland, bare land, water bodies, and grassland were all severely encroached upon by the urban land use type, as shown by the findings of the land use changes that occurred in the research region over a period of 40 years (1980–2020).

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Conflict of Interest: The authors declare no conflict of interest.

Notes: The foundation of this research is from the Coastal Research Group (COREG) of the Department of Geography and Environmental Management, Rivers State University and the original work of the researchers.

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