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Research paper

Assessments of coastal erosion in rivers state, Nigeria, using global cover 30

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Abstract

Coastal dynamics and erosion are phenomena that have a considerable impact on inhabitants of coastal areas, regardless of whether the activity driving them is natural or manmade. Because a high percentage of the world's population lives along the shoreline, a raise in sea level will have a substantial effect on many people. Additionally, it will have an effect on low-lying coastal areas and islands. Using satellites for coastal management and monitoring changes in land cover and land use, it is possible to gain a better understanding of global changes in Coastal Erosion, especially in Rivers State, Nigeria. This study investigated coastal erosion in Rivers state, Nigeria, utilizing Global cover 30 land cover data. GIS and post-processing data were utilized to track changes occurring over the twenty-year period from 2000 to 2020. Two distinct temporal frames were identified within the given time span. The result of the analysis indicated that there was more erosion as the gain by the major Rivers indicated erosion along the coastline, Furthermore, changes of 47151000m2 were observed within 2000 and 2020, that is a period of twenty years with over 47151km2 land lost within Rivers state coastline. It is suggested that regular utilization of remote sensing data and geographic information system together with ground surveys be employed to monitor erosion rates, thereby assist-ing in pinpointing the most advantageous sites for protective barriers along the Nigerian coast in an effort to curtail coastal erosion.

Keywords: *Rivers State; Landcover; Erosion; Coastal Areas; Global Cover 30.*

1. Introduction

It is estimated that 25% of the world's population are currently living in coastal regions, with many of the world's bigger cities being concentrated on the coastlines (GAF, 1999). This statistic is expected to rise due to population growth, as the current coastal urban population of 220 million is projected to almost double in the next 20 to 30 years (GAF, 1999). In order to mitigate the effects of population pressure, governments and resource users need to take appropriate actions to ensure the protection of coastal resources and habitats, as overexploitation of these resources has already caused extensive harm (GAF, 1999). Furthermore, disputes concerning resources in coastal areas, as well as traditional users being displaced by newer economic activities such as tourism and industrial sea farming, further add to the problems that need to be addressed.

The need for a more exact description and categorization of land cover and land use in certain regions is becoming ever more pressing (GAF, 1999). Through doing so, it is possible to develop sustainable land use systems within those areas which can feature increased productivity yet retain environmental protection, preserve biodiversity and don't disrupt global climate systems (GAF, 1999). To meet these objectives, comprehensive and informative knowledge concerning the capabilities and restrictions of the current land uses is essential (GAF, 1999). This information ensures a reliable basis for the monitoring and modelling of environmental changes and can be utilized in numerous elements of land use planning and policy formation (GAF, 1999).

Governments as a regulator and the stakeholders within the coastal areas and its resources users should evaluate the problems associated with the pressure of increased economic undertakings within the zone.

Assessing alterations to the shoreline resulting from erosion-induced coastal changes is considered an essential component of marine zone management. Coastal or shoreline zones serve as a transition area between the land and waterways, and have a tendency to be frequently disturbed or unsettled zones around the globe (Crossland et al., 2005). The flux of the ocean and the fluctuating nature of the tides between the equator and the poles have a profound impact on the surrounding terrestrial environment and all the inhabitants thereof. People's curiosity in marine assets, particularly those that border the coastline, encourages movement to the region, thereby increasing human activity and the subsequent implementation of industrialization and transport of goods within the marine environment. Establishing the seasonal changes and ramifications of erosion using suitable techniques such as context-dependent imagery resolution is essential in understanding the area.

Small and Nicholls (2003) reported that nearly half of the global population is situated along 60 km of the world's shoreline. Prasad and Kumar (2014) predicted the amount of people living in these coastal regions is expected to rise in the coming years. In 2020, Andersen et al. asserted that human activities such as fishing and recreational activities in these areas put increased pressure and stress on the coastal environment. Their findings have also shown that due to such activities, coastal environments are experiencing seasonal flooding and the extinction of various habitats and species (Prasad and Kumar, 2014). Changes in land use, such as the conversion of vegetation to an urban environment, are also further exacerbating the degradation of the coastal environment.

It has been established that natural agents such as the riparian interface are responsible for shifts in the coastal areas and their dynamics (Addo, 2011). These changes have been hypothesized to be instigated by climatic phenomena, including oceanic waves, the tides, wind, high levels of precipitation and temperature-related shifts, which can lead to changes in sea levels. High winds are a major contributing factor to strong waves and the transport of sediment particles away from the coasts (Addo, 2011), leading to a movement of fine rock onshore and offshore. The resulting gradual change of coastlines has been observed in different countries (Portner et al., 2019). Furthermore, increased tides can increase the force of this sediment to be oft-transported even further ashore and potentially cause erosion, which could be augmented by the projected rise in sea levels and the expected strengthening of storms (McDonnel, 2019). All of these effects combined could lead to up to 200 million people being displaced by 2050.

The monitoring of coastal dynamics within maritime zones through land use and land cover studies has the potential to have direct and indirect implications for both the economic and ecological environment of coastal areas. With urbanization and an increasing population, economic activity within these areas can be heightened. However, this could result in a decrease in coastal ecology, leading to diminishing economic activity.

Mangroves are an important type of vegetation found along many coastlines, particularly in Rivers State and West Africa. As suggested by Blasco et al. (1996), these ecosystems are useful for measuring coastal vegetation dynamics, amongst other biological indices. Kirui et al. (2013) supported this by emphasising the role of mangroves in providing a healthy, productive environment. The ecosystems are known for their ability to absorb and store carbon, provide food for fish and micro-organisms, and also protect coastal areas from erosion and disturbances.

The coastal zones are facing consistent changes due to anthropogenic interventions. Prioritization of economic benefits of industrialization and urbanization overlook the harmful effects on the ecology and ecosystems. In 2010, Kudale suggested that port constructions and their associated activities have resulted in littoral drift, changes inside the seabed and geomorphology, and further erosion in shoreline areas near the port site.

One of the significant issues faced by coastal regions in Nigeria is the erosion of the coastline. Orupabo (2014) estimated that the coastlines of the country erode annually at a rate of 20-30m. This shoreline change has had a detrimental effect on protecting coastal settlements of Rivers State. To improve socio-economic conditions of the coastal settlements and ensure that sustainable goals can be met, there is a necessity for an effective solution to protect and manage the coastal zones sustainably. A way to better comprehend the nature of marine ecosystems is to monitor and accurately map coastal dynamics. Thus, it is essential to make full use of this information to satisfy the global demand of sustainable management of our coastal regions.

Most of the modifications to coastal ecosystems are geographic and temporal in scope. In this work, such modifications are analyzed physically with data gathered from Remote sensing observation sources. Combining social, physical, and natural sciences with Geographical Information Systems (GIS) and Remote Sensing techniques, the temporal and spatial variability in the social-ecological system can be better understood. GIS has proven to be a useful tool for evaluating changes in land use/land cover and for observation of trends in shoreline movements and variation.

This study aims to explore the spatial-temporal evolution of coastal erosion along the coasts of Rivers State, Nigeria, by analyzing land use and land cover changes between 2000, 2010 and 2020. Human actions such as unsustainable development activities have led to drastic transformations of the natural environment and coastal ecosystems, thus resulting in coastal erosion and the flooding of coastal areas. To successfully handle this issue, new management strategies need to be developed.

Major Problems includes;

- Lack of digital coastal data for planning purposes
- Lack of historical shoreline measurement of erosion rate data

This research will provide essential information to ensure adequate planning and development of coastal communities in Rivers state and Nigeria as a whole.

1.1. Objectives

The social, economic, and ecological significance of the coastal regions of Rivers State must be acknowledged by stakeholders who reside there. It is necessary to conduct a comprehensive evaluation of coastal erosion through the observation and analysis of land use/land cover changes in the coastal zones over a particular period of time, so that suitable management decisions can be made. Thus, the overarching objective of this study is: to assess the changes that have occurred on the coastal areas of Rivers State using Geographical Information System (GIS) and remote sensing as a tool. Objectives are;

- To map difference Land cover areas in Rivers State between 2000, 2010 and 2020
- To analysis land cover as it's relate to major Rivers in Rivers State between 2000, 2010 and 2020.
- Determine changes in water bodies over twenty years.

2. Study areas

Rivers State was established as a state of the then Eastern Nigeria, by Yakubu Gowom, on May 27th 1967, with Port Harcourt as its capital. Rivers State is situated between the coordinates of 210590.00m and 344490.00m North and 477432.00m and 634925.00m East (these coordinates are based on UTM Zone 32N as origin -- please refer to Figures 1 and 2. The state is located within the Niger Delta of the Gulf of Guinea; with Akwa Ibom to the East, the Atlantic Ocean to the South, Anambra, Imo and Abia States to the North, and Bayelsa and Rivers States to the West. It covers an area of 10,432.3 square kilometers and has a population of 5,185,400 according to the National Population Commission (2006).

According to Eludoyin et al. (2011), Rivers State has a tropical hot climate owing to its latitudinal location. Its highest rainfall is recorded between April and October and measures up to 2000-2500mm, along with very high temperature and humidity. The landscape consists of tropical rainforest and mangrove towards the coastal areas,while the upland is occupied by the rainforest. Apart from the oil and gas industry, the inhabitants of the upland areas engage in subsistence farming, while those of the inland pursue fishing.

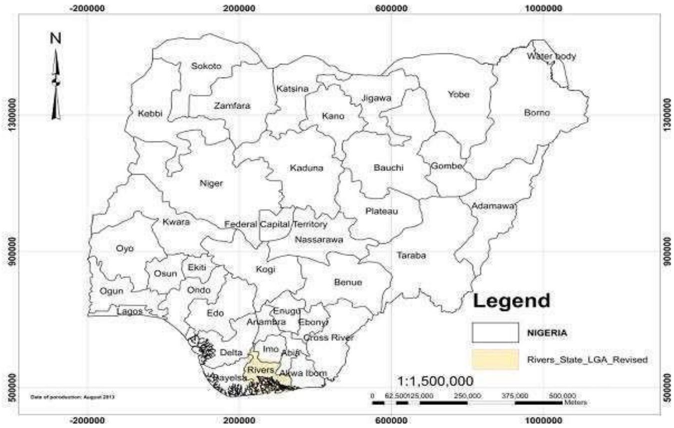

Fig. 1: Situation Map of Nigeria and Location of Rivers State.

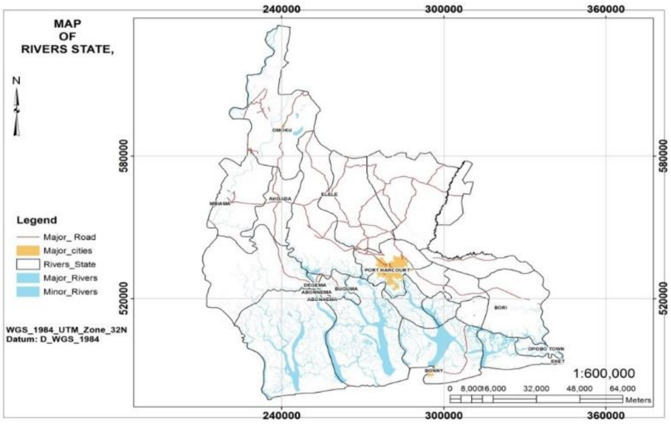

Fig. 2: Situation Map of Rivers State

3. Methodology

The Global land covers 30 were design in the Modular-Hierarchical Phase were; The Boolean formula showing each classifier were used with all classifiers coded); and unique number DN use for Geographical Information Systems (GIS) tools and standard name supplied for user-well defined key.

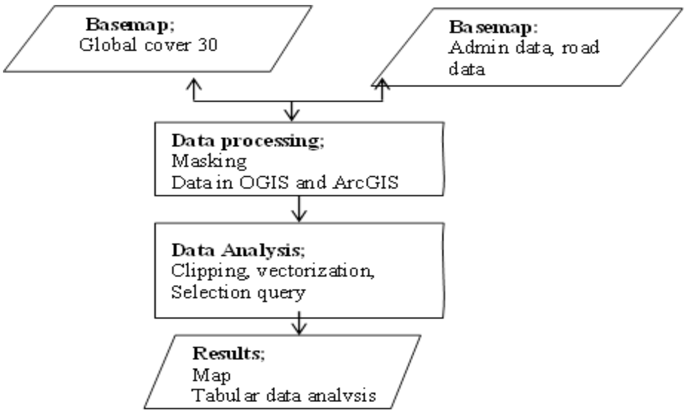

Fig. 3: Methodology Flowchart.

Methods: QGIS and ArcGIS 10 were used in the processing of data. The Global Land Cover 30 dataset between 2000, 2010 and 2020 was masked to the designated study area and an estimation of the land cover size was posted using QGIS. Change detection was conducted using Excel by noting the discrepancies in the size of the major Rivers and water bodies between the previously mentioned years. The Global Land Cover 30 data was empirically derived from the classification of digital numbers (DN). The dataset were downloaded in a post-classification format using the DN. Change detection analysis based the dataset between 2000, 2010, and 2020. Methods flowchart(see Fig 3):

- Base maps including Administrative dataset.
- Processing of the data
- Analysis of data in tabular format.
- Visualization

4. Results and discussion

The data analysis results are shown in raster continuous surfaces and tables below. To assess land lost to rivers, Global Land Cover 30's post-classification dataset was utilized (please refer to Figures 4 to 6 and Tables 1 and 2). Overall, nine land use/cover change classes were classified for the study area: Cultivated Land, Forest, Grassland, Shrub Land, Wetland, Water bodies, Artificial Surfaces, Bare Land and Major Rivers, with a digital number ranging from 10 to 90. The outcome from the land use change detection is summarized in Table 1. The table provides evidence that Artificial Surfaces experienced a 104026500 m2 expansion between 2000 and 2020; Major Rivers increased by 47151000m2. This research also uncovered a -22028400m2 decrease in Water bodies, implying that climate change, due to an increase in global temperatures, may have influenced this result. It is imperative to note, however, that current data has limitations in accuracy due to it being generated from global-scale post-classification data. Consequently, to procure more effective conclusions, ground truthing and localized data gathering is recommended.

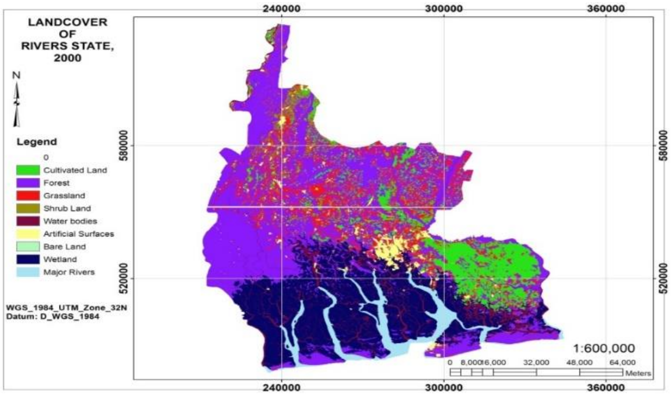

Fig. 4: Land Cover Distributions of Rivers State in 2000.

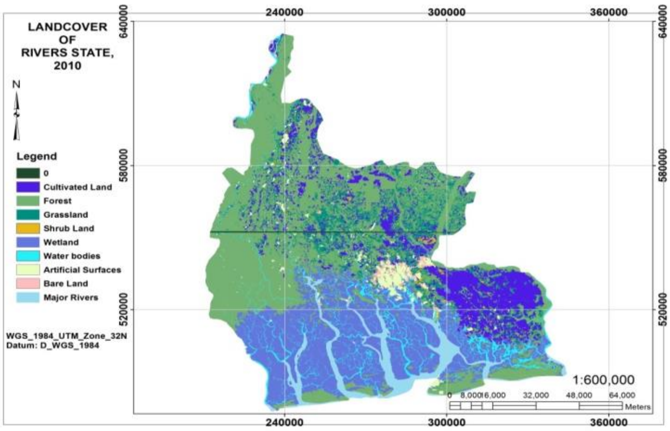

Fig. 5: Land Cover Distributions of Rivers State in 2010.

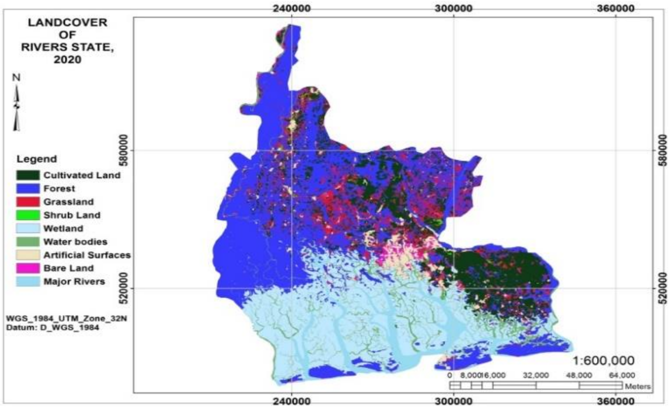

Fig. 6: Land Cover Distributions of Rivers State in 2020.

Table 1: Various Land Cover and Changes in M^2

Land Cover	2000 (Area m²)	2010 (Area m²)	2020 (Area m²)	Changes 2000 – 2010 (Area m²)	Changes 2010 – 2020 (Area m²)	Changes 2000 – 2020 (Area m²)
Cultivated Land	1203577200	1248200100	1582994700	44622900	334794600	379417500
Forest	4181413500	4420011600	4230202500	238598100	-189809100	48789000
Grassland	1361709900	1033026300	876561300	-328683600	-156465000	-485148600
Shrub Land	131574600	95709600	77616000	-35865000	-18093600	-53958600
Wetland	2507696100	2559681000	2556892800	51984900	-2788200	49196700

Water bodies	498078000	477710100	476049600	-20367900	-1660500	-22028400
Artificial Surfaces	234615600	232982100	338642100	-1633500	105660000	104026500
Bare Land	69081300	137707200	104840100	68625900	-32867100	35758800
Major Rivers	511533000	558103500	558684000	46570500	580500	47151000

Table 2: Sizes of Lands Gain by Major Rivers

Period	Lost coastal land Erosion (m^2)
2000 - 2010	46570500
2010 - 2020	580500
2000 - 2020	47151000

Overall, Table 2 indicates that, in the twenty-year period from 2000 to 2020, the total magnitude of coastal land lost due to erosion was 47151 km^2. Specifically, the data suggest that from 2000 to 2010, 46570500 m^2 of coastal land was lost due to the expansion of major rivers (representing shoreline erosion), whereas from 2010 to 2020, an increase of 580500 m^2 was observed (indicating coastal erosion). Geo-informatics and Remote sensing techniques were used in order to gain insight into this coastal erosion in Rivers State. These findings highlight the worrying reality that coastal land is eroding without any action being taken by the relevant authorities. Given that Rivers State is heavily reliant on wetland environments (see Table 1), protective measures will need to be implemented in order to ensure long-term sustainability.

5. Conclusion

The results of this study have uncovered that the coastline of Rivers state is disintegrating at a rapid rate. This deterioration is attributed to human activities such as the installation of oil and gas pipelines at the river estuary along the shoreline. Inevitably, this suggests that infrastructure situated near eroding segments of the shoreline could be endangered. Nevertheless, considered physical planning initiatives could be employed to limit the influence of human activities on the erosion of the landscape.

This research proposes the utilization of Remote sensing tools, notably by state and Federal authorities, in order to create a best practice scheme for the management of degradation and coastal habitats and to identify potential protected areas. Such tools are of great value for implementing successful conservation and rehabilitation initiatives. Earth Observation provides spatio-temporal data and derived information for management and planning of coastal zone, such as;

- Present and/or update topographical/thematic/satellite maps, nautical charts at various scales (ranging from 1:25,000, 1:50,000 – 1:200,000 or smaller).
- Spatial database, statistics and functions of interest for integrated coastal zone management and planning, covering especially coastal, intertidal and offshore zones up to the continental shelf in Rivers State.
- Elevation, Infrastructure, Actual Land Use, Soil and Soil Condition, Erosion, Soil Capacity, Rivers State Coastline Geometrically Correct Baseline, Seabed Types and Sediment Coverage, Bathymetry, Marine Farming and Tourism Locations and Sites, etc.
- Information for assessment and monitoring of the environment and especially degraded resources, Like mangroves and corals

The results of this study demonstrated the potential for leveraging Geospatial technology and Remote Sensing for managing coastal areas in Rivers State and Nigeria. To further advance research in this field, future applications will concentrate on employing RADAR data at the regional level in order to determine the most impacted locations and to offer solutions for those inhabiting and living in the affected areas.

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