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Research paper

Spatial-temporal changes assessments of wetlands in port Harcourt city council area of rivers state, Nigeria

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Abstract

Wetland ecosystems, found in nature, serve as vital habitats for numerous wildlife species and play a crucial role in providing sustenance to both migratory and local animals. Various factors such as climate change, population growth, unemployment, limited market access, inade-quate physical accessibility to wetlands, and lack of knowledge regarding their use contribute to the direct causes of changes in these wet-land areas. Therefore, it becomes crucial to study the spatio-temporal transformation of wetlands to understand the correlation between hu-man activities and wetland evolution. The objective of this study was to determine the distribution and size of wetlands in Port Harcourt city Local Government Area (LGA) in Rivers State, Nigeria. Additionally, the study classifies land cover into different types, identify their pat-terns, and measure the changes that occurred from 2000 to 2020. Land cover change was analysed to understand the specific alterations between the years 2000 and 2020. The Global Land Cover 30 post-processing imageries and Geographic Information System (GIS) tech-niques were employed to capture these changes spanning a 20-year period. By dividing the analysis into two different time periods, it was observed that the wetland area expanded by 1,144,800 square meters from 2000 to 2010. However, between 2010 and 2020, a reduction of 522,900 square meters was observed in the wetland size. Overall, the results demonstrate a net expansion of the wetland area by 621,900 square meters from 2000 to 2020. To ensure sustainable land use, it is crucial to strike a balance between utilization and conservation efforts. Therefore, it is recommended that Nigeria develops and implements policies and laws that effectively address this issue. Moreover, it is imperative to enforce existing policies and laws related to wetland conservation. Furthermore, creating awareness among the population is pivotal in curbing the excessive and inappropriate exploitation of wetlands.

Keywords: *Port Harcourt LGA; Wetland; Change Detection; Climate Change; Environment.*

1. Introduction

Wetlands hold immense value, providing exceptional wildlife habitats and indispensable services to society. These unique ecosystems cover just approximately 6% of the global surface area, but they are recognized for their exceptional fertility (Turner and Jones, 1990). With their nourishing soil and consistently moist conditions, wetlands possess significant potential for agricultural activities, enabling fruitful crop production (Roggeri, 1995). Additionally, wetlands serve as crucial grazing grasslands, fishing zones, recreational havens, and a vital source of macrophytes that are extensively employed in handcraft production (Roggeri, 1995).

A floodplain wetland is a flat area found next to a river or stream, extending from the riverbanks to the edges of the valley (National Geographic Society, 2016). When a stream carries loose sediments called alluvium and deposits them, it creates different landforms like floodplains, terraces, and deltas. Basically, a floodplain is a flat and low-lying area beside a stream channel that frequently gets flooded. The floodplain gets submerged during floods, and when the water recedes, it leaves behind alluvial deposits (Sarianna, 2008). It is important to note that the alluvium or sediments found in a floodplain can vary in texture and composition based on the surrounding landscape and the speed of the flowing water that shapes the floodplain. As a result, floodplains can have different compositions, with some being mainly composed of fine-grained silt and others having different materials.

Throughout history, wetlands have always attracted human attention due to their significant productivity. However, in recent times, the pressure on wetlands has increased substantially, primarily driven by the combined forces of human activities and global climate change. Presently, there is a growing trend of converting wetlands for various purposes. This phenomenon is observed worldwide, as wetlands are being drained for agricultural expansion, urban development, industrial growth, and recreational utilization.

During the period from the 1780s to the 1980s, there were significant transformations observed in wetlands across America (Dahl, 1990). An alarming number of these natural water bodies were subjected to manipulation, drainage, and filling, primarily to cater to unnatural services and products. Consequently, a staggering 53% of the wetlands were lost (Dahl, 1990). Europe has also witnessed extensive losses of wetlands, with countries such as the Netherlands, Germany, Spain, Greece, Italy, and France experiencing up to a 50% reduction. Similarly, in Asia, wetlands are predominantly drained to make way for agricultural activities like rice production, as well as to accommo-date human settlements. African wetlands are also confronted with risks. Being the world's most impoverished and driest continent, Africa faces mounting pressure to utilize wetlands for industrial and urban purposes, agricultural expansion, settlement development, and various other activities (Haack, 1996).

The escalating population growth in East Africa is currently exerting increased pressure on numerous wetlands, aggravating their condition. As a result, there is a growing demand for exploitable land, food, and water resources in the region (Roggeri, 1995). According to Frenken and Mharapara (2002), Kenya is witnessing a surge in development pressure on its wetlands, driven by the need to enhance food production, create employment opportunities, and accommodate the rapidly expanding populations. Similarly, in Tanzania, the degradation of wetlands is primarily caused by human activities such as farming, livestock keeping, informal settlements, and sand mining, as well as natural threats like drought and rising sea levels (Kamukala and Crafter, 1993).

In the latter half of the 20th century, the Ramsar Convention on wetlands emerged in 1971, leading to an increased knowledge and recognition of the vital role played by wetlands. Through a combination of domestic efforts and international collaboration, the Convention aimed to promote the preservation and prudent utilization of wetlands, thereby driving sustainable development worldwide. Signatory countries are obligated to support the responsible use of all wetlands within their territories, regardless of their classification. This entails the encouragement of sustainable practices that safeguard the natural ecosystem of wetlands, ultimately benefiting humanity (Ramsar Convention Secretariat, 2006: 49). However, despite their significance, small wetlands have often been overlooked, with attention primarily focused on larger wetlands exceeding 500 hectares (Owor et al., 2007, Thenkabail and Nolte, 2000).

In an attempt to forecast the response of coastal wetlands to declining water levels and environmental disruptions, Anhua (2007) conducted a study. The primary focus of this research was to examine the effects of increasing stressors, both man-made and natural, on the movement of aquatic plants and fish along Ontario's Great Lakes shoreline. The study employed high-resolution satellite imagery to accurately assess the availability of fish habitat and measure the disturbance caused by waves in these wetland areas. The results of the study revealed that fish communities in the Great Lakes exhibit a disproportionate reliance on wetlands compared to their population levels. Furthermore, the specific type of wetland was found to influence the distribution of species associated with these habitats. Another significant finding was that disturbances originating from the lake itself as well as within the wetland had an impact on aquatic plants.

Likewise, Obiefuna et al., (2013) carried out an analysis of the geographical changes in the Lagos/Lekki Lagoons' wetlands in Lagos, Nigeria. They integrated remote sensing data and Geographic Information System (GIS) to conduct this analysis, using topographical maps as the primary reference. Their goal was to accurately determine and quantify the location and extent of these changes that took place from 1984 to 2006. To process the collected Landsat images, they utilized ENVI software and parallelepiped supervised classification. The study showed a significant decrease in the size of mangrove wetlands from 88.51km2 to 19.95km2, declining at the rate of -3.12km2 per year. In the same vein, the size of swamps also diminished from 344.75km2 to 165.37km2, at the rate of -8.15km2 annually.

An evaluation of satellite images obtained from Nigeria during the timeframe of 1984 to 2004 has uncovered a noteworthy increase in developed regions, thereby leading to a decline in wetland forests and adversely affecting the overall quality of nearby freshwater sources. Utilizing this data, future projections were generated for the year 2014, based on scenarios constructed for the period of 1994. These findings unequivocally prove the indispensable role played by Geographic Information System (GIS) tools in conducting investigations related to environmental resources. These tools not only offer a multitude of cost-effective strategies but also uphold an exceptional level of precision.

"In this research, we employed remote sensing techniques to collect and map digital information on the wetlands located in the local government areas of Port Harcourt City in Rivers State. Thanks to the advanced features of remote sensing, such as multi-sensor, multi-spectral, and multi-spatial resolution capabilities, we had access to a wide range of methods for gathering digital data. Utilizing digital data not only standardized the collection process but also facilitated its integration into a geographical information system (Murphy et al., 2007). This integration enabled us to generate a comprehensive distribution map of the wetlands and effectively monitor any alterations occurring in these regions using remote sensing and GIS techniques."

Wetlands play a vital role in fulfilling numerous socio-ecological needs of human beings. However, the encroachment of urbanization, coupled with the growing human population, poses a severe threat to their survival. The ever-evolving utilization and alterations, occurring over time and across various locations, have led to the depletion of these precious wetlands. The dire concern is that their disappearance might transpire unnoticed due to inadequate documentation. Specifically in the context of Port Harcourt city, the absence of recorded transformations in the wetlands hinders the ability to make well-informed decisions pertaining to their sustainable use and management. This alarming situation underscores the urgent requirement for proactive measures to identify, thoroughly document, and accurately map these vulnerable wetlands. The detection and meticulous documentation of the ongoing changes within these wetlands hold paramount importance. Moreover, it is imperative to propose future utilization possibilities that do not compromise their continued existence.

The research project focused on examining the changes in wetland land-use in the local government areas of Port Harcourt city in Rivers state. The study conducted a detailed mapping and analysis of the spatio-temporal patterns from 2000 to 2020. The specific objectives of this analysis included using Globalland 30 data to determine the spatial distribution and size of wetlands in 2000, 2010, and 2020. The research also aimed to assess the modifications in wetlands from 2000 to 2010, as well as from 2010 to 2020. Additionally, the study evaluated the historical changes in wetland areas within Port Harcourt LGA from 2000 to 2020.

2. Materials and methods

2.1. Study area

The Local Government Area of Port Harcourt in Rivers State, Nigeria, is strategically positioned within the geographical coordinates of Latitude 4°45’N to 4°55’N and Longitude 6°55’E to 7°05’E. Situated in the Niger Delta region, this area serves as the vibrant heart of Port Harcourt city and occupies a prime location at the mouth of the River Bonny. One of its key advantages is its proximity to the Atlantic Ocean, with just approximately 25 km separating it. Positioned between Dockyard Creek/Bonny River and the Amadi Creek, this location offers a unique and advantageous position. Additionally, it enjoys an average altitude of around 12 meters above mean sea level, which provides a commanding and captivating view of the surrounding environment.

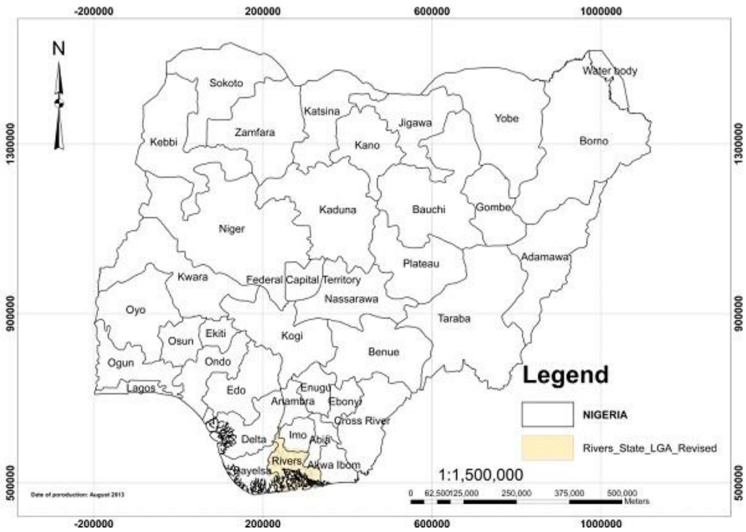

Fig. 1: Map Of Nigeria and Location of Rivers State.

Source: Office of Surveyor General Rivers State.

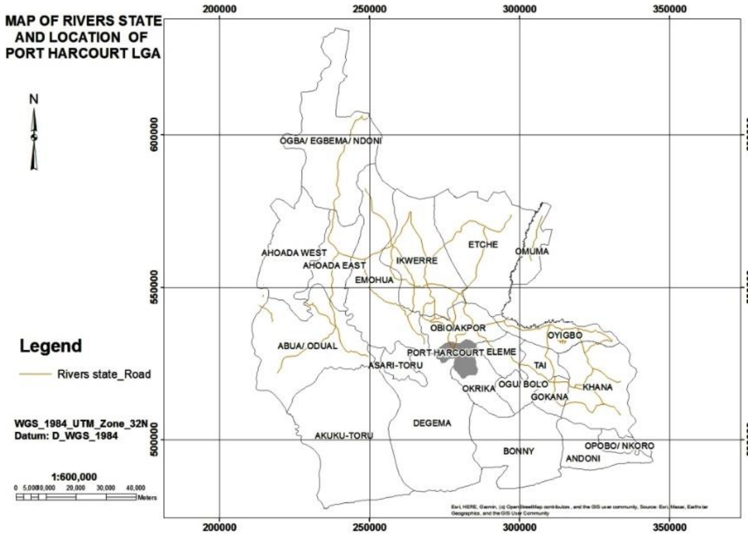

Fig. 2: Map of Rivers State with Location of Port Harcourt LGA.

Source: Office of Surveyor General Rivers State

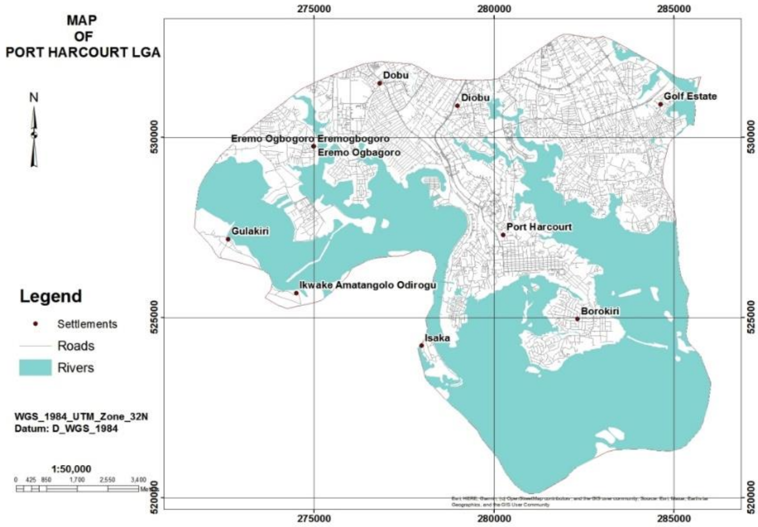

Fig. 3: Map of Port Harcourt Local Government Area.

Source: Office of Surveyor General Rivers State

The research site is situated in the jurisdiction of the Tropical Rainforest climate zone, where the monthly average temperature consistently surpasses 18°C. Adequate humidity can be observed throughout the year. Port Harcourt experiences two distinct seasons, namely dry and rainy periods. The city frequently encounters high temperatures, with an average peak of approximately 34°C and a minimum of around 21°C. The hottest temperatures are primarily observed between April and October.

According to a study conducted by Eludoyin et al (2011), the low-lying area mentioned in the research encounters substantial surface water and heavy precipitation, ranging from 3,420 mm to 7,300 mm. The hydrology of this region is primarily influenced by the freshwater systems derived from the river Niger and the tidal systems originating from the Bonny New Calabar River. These two river systems are prominently significant in the southern part of the state.

In the northern region, the freshwater zones display a notable increase in both breadth and speed as they flow downstream, which serves as evidence of the effectiveness of these systems. Along the riverbanks, levees serve as clear boundaries, while the slopes on either side of the valley demonstrate an exceptionally gentle incline. These slopes undergo significant erosion and sediment accumulation processes. Eventually, all the rivers merge into the expansive estuaries of the Bonny River, serving as essential pathways to the sea. These interconnected rivers boast a rich abundance of diverse marine life, offering valuable seafood such as crabs, oysters, shrimps, and fish. Furthermore, they provide critical habitats for various species of mammals and birds, thereby augmenting their ecological significance.

2.2. Data used

The freely available dataset known as Globalland 30, provided by the National Geomatics Center of China (NGCC), offers a post processing global land cover dataset. This dataset consists of 10 distinct classes and has a resolution of 30 m, spanning from the year 2000 to 2020. The Global Land Cover (GLC) information proves immensely valuable for research on environmental change, efficient land resource management, and the fostering of sustainable development, benefiting various sectors of society. The dataset's global coverage encompasses the entire Earth and comprises more than 10,000 satellite images resembling Landsat, each possessing a resolution of 30 m. To accomplish the classification, automated methods were employed, intertwining pixel- and object-based approaches in conjunction with knowledgeable techniques.

The dataset containing the administrative map of Nigeria, as well as the maps of Rivers State and Port Harcourt Local Government Area, along with settlement and road data, was procured from the esteemed Office of the Surveyor-General of River State. For the purpose of our study, this dataset was primarily employed and customized to accurately represent the study area, resulting in the creation of a precise map delineating the area of interest.

2.3. Methods

The primary method used in this study involves the application of change detection methodology. Specifically, we utilized the pre-processed remote sensing-based Globalland 30 land cover dataset from the National Geomatics Center of China. The dataset was downloaded and tailored to the study area using ArcGIS 10.1. A raster unique values geographic information systems (GIS) analysis technique was employed in QGIS to calculate the areas of different land uses for the years 2000, 2010, and 2020. In addition, the estimation of spatial-temporal changes in wetlands for the same years was conducted in the Microsoft Excel environment.

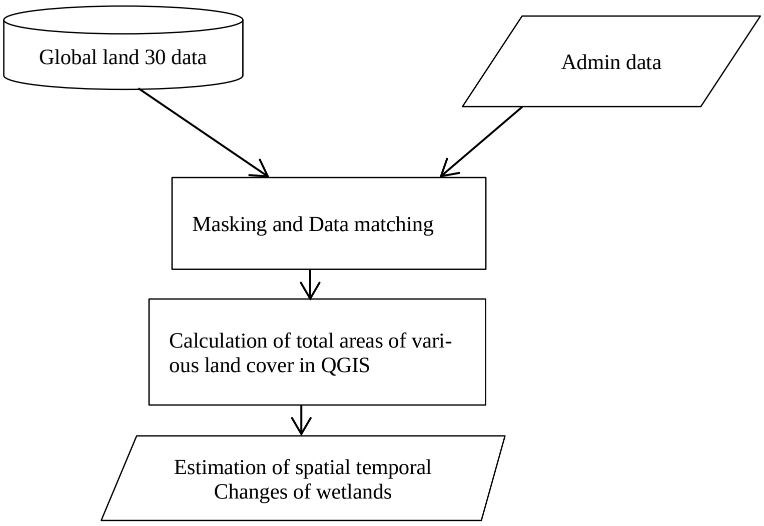

Fig. 4: Methodology Flowchart.

3. Results

The outcomes derived from the analysis of data are illustrated in the form of raster surfaces and tabular representation. Figure 5 to 7 below showcases the land cover distributions in Port Harcourt L.G.A for the years 2000, 2010, and 2020 respectively. The data is projected using UTM Zone 32N Projection and WGS 84 Datum, with units measured in meters.

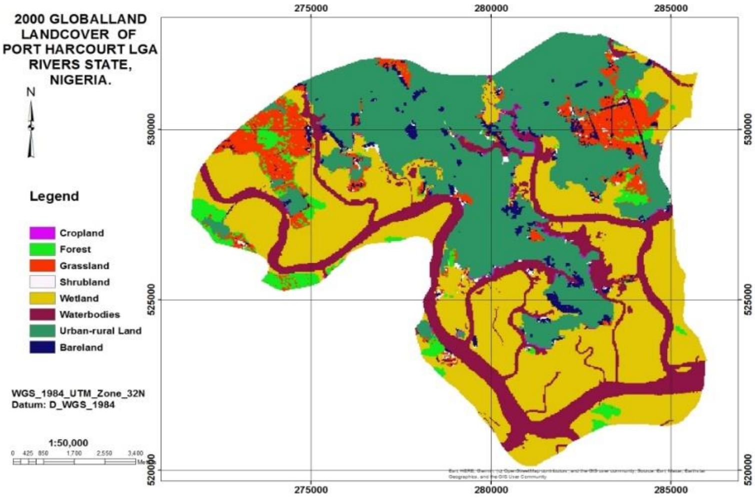

Fig. 5: 2000 Land Cover Distributions Map of Port Harcourt Local Government Area.

The study area was divided into eight land use/cover change categories, namely cropland, forest, grassland, shrub land, wetland, water bodies, artificial surfaces, and bare land. Each of these categories was assigned a digital number (DN) ranging from 10 to 90. The findings of the change detection analysis are presented in Table 1 and Table 2. Table 2 highlights that the wetland area witnessed an expansion of 1,144,800 m^2 between 2000 and 2010. However, from 2010 to 2020, there was a decrease in the wetland area by -522,900 m^2. Moreover, the results also indicate an overall expansion of 621,900 m^2 in the wetland area between 2000 and 2020.

Table 2: Distributions of Wetland Sizes for 2000 to 2020

Period	Wetland Changes (m^2)
2000 - 2010	1144800
2010 - 2020	-522900
2000 - 2020	621900

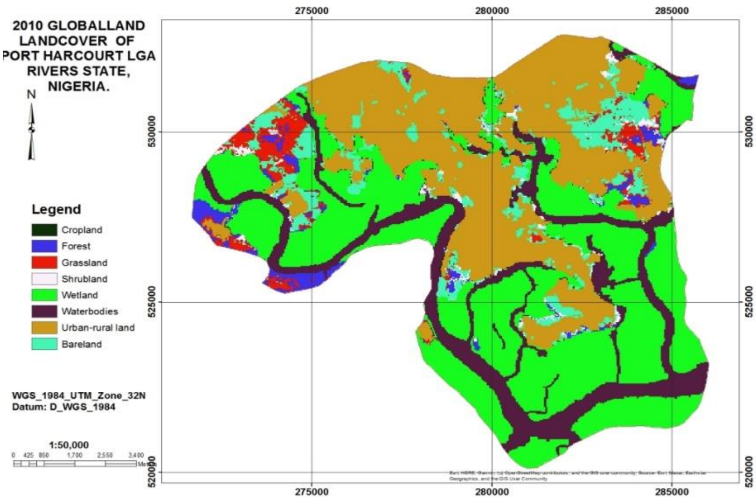

Fig. 6: 2010 Land Cover Distributions Map of Port Harcourt Local Government Area.

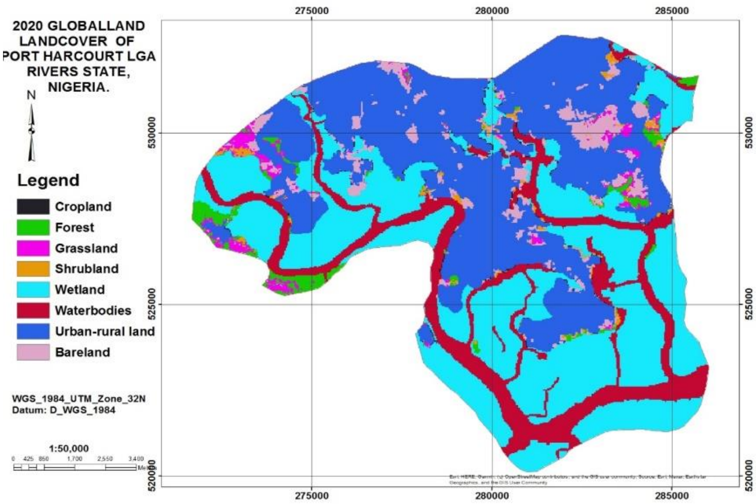

Fig. 7: 2020 Land Cover Distributions Map of Obio/Akpor Local Government Area.

Table 1: Distributions of Land Cover Sizes for 2000 to 2020

DN	Count	2000 (Area in m²)	2010 (Area in m²)	2020 (Area in m²)	Land Cover
10	484	435600	502200	477000	Cropland
20	4558	4102200	2996100	2475000	Forest
30	8238	7414200	3773700	2014200	Grassland
40	606	545400	1386000	1045800	Shrubland
50	46344	41709600	42854400	42331500	Wetland
60	18387	16548300	15254100	15238800	Waterbodies
80	39293	35363700	34520400	40319100	Urban-rural land

4. Discussion and conclusion

This study implements the use of geo-informatics and Remote sensing technique to analyze wetland dynamics and changes over time in Port Harcourt L.G.A of Rivers State, Nigeria. The investigation covers the periods between 2000 to 2010 and 2010 to 2020, highlighting the escalating expansion of the wetland due to erosion. The findings demonstrate that coastal wetlands are undergoing erosion without intervention from relevant authorities. As Rivers State is predominantly characterized by wetlands, it is imperative to prioritize the protection of the coastline. Further examination of the results reveals a significant loss of 522,900 square meters of wetland between 2000 and 2010. This phenomenon can potentially be attributed to unregulated development and various human economic activities.

A study was conducted to evaluate the changes in the wetlands of Port Harcourt L.G.A in Rivers State, Nigeria between 2000 and 2020. By utilizing Globalland 30 remote sensing data and employing change detection methods, it has been demonstrated that remote sensing plays a crucial role in monitoring and assessing wetlands. These wetlands not only support the livelihoods of local communities but also undergo modifications to cater to their needs for food production and income generation, resulting in degradation and loss. Various factors, including climate change, population growth, and infrastructure development, contribute to the transformation of wetland usage. The diverse nature and extensive utilization of wetlands, coupled with the absence or inadequate enforcement of policies, further exacerbate their degradation. Therefore, it is imperative to strike a balance between utilizing and conserving these wetlands. This can be achieved through the formulation and implementation of effective policies and laws in Nigeria, as well as the enforcement of existing regulations.

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