

Impact of Climate Change-Induced Coastal Erosion on Infrastructure in Ilaje Local Government Area, Nigeria

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ABSTRACT

The study appraised the impact of climate change-induced coastal erosion on infrastructure in Ilaje Local Government area, Nigeria. The study investigated the trend of climate variability, as it focuses on temperature and rainfall data. It adopted mixed method of qualitative and quantitative approaches. Questionnaire, personal observation, Geographic Information System (GIS) and archival climatic data were used. Using Systematic Sampling Technique, 338 copies of questionnaire were administered and analyzed using SPSS 8.1. Mann Kendall Trend Analysis was adopted to analyze the temperature and rainfall data for a period of 35 years; between 1980 and 2015, while Landsat TM 2008 and OLI 2023 of Ayetoro community in Ilaje LGA were adopted. All geo-processing operations and analyses were carried out in ILWIS 3.1 and ArcGIS 10.4 software. The variability of temperature and rainfall pattern, is an evidence of climate change menace in the study area. Findings revealed that, in 2008, Ayetoro, a prominent coastal community in Ilaje, experienced sea incursion induced by climate change, as this resulted to coastal erosion. Buildings were and people were displaced while Ayetoro city hall and the community primary school were almost affected. While in 2023, a total number of 260 houses, the city hall and the community primary school were already submerged into the sea. The study recommends the adoption of an Integrated Coastal Zone Management (ICZM) framework for coordinated coastal planning and implementation of nature-based and hybrid coastal protection strategies.

Keywords: Climate change, coast, impact, infrastructure, Ilaje LGA.

I. INTRODUCTION

Climate change represents long-term alterations in weather elements such as temperature, precipitation, wind patterns, and other elements of the earth's climate system, largely driven by human activities that increase greenhouse gas concentrations in the atmosphere (Idowu, et al., 2011). The amount of disruption and urbanization's impact on infrastructure in coastal regions are quickly turning into a nightmare, and some of these issues are anticipated to get worse owing to a changing climate (Satterthwaite, 2012). One of the most visible consequences of these changes is the increasing vulnerability of coastal regions to flooding, sea-level rise, and coastal erosion.

Coastal zones are defined as the interface between land and sea, are ecologically rich and economically significant, yet among the most exposed to climate-induced hazards (Stephen, 2018). The Intergovernmental Panel on Climate

Change (IPCC, 2021) highlights that continued global warming intensifies extreme weather events, leading to more frequent and severe floods, storm surges, and coastal inundation. These events have far-reaching impacts on human settlements, infrastructure, and ecosystems. In Nigeria, particularly in Ilaje Local Government Area (LGA) of Ondo State, climate change has manifested through recurrent flooding and shoreline retreat, resulting in the destruction of roads, buildings, and public utilities (Anthony, et al., 2016).

Natural events and human activities are believed to be contributing to an increase in average global temperatures. Evidence of climate change includes sea level rise, global temperature rise, warming oceans, shrinking ice sheets, declining Arctic sea ice, glacial retreat, extreme weather events, ocean acidification, and decreased snow cover (Olorunlana, 2024). The changes in climate in recent years and those of the future are largely

human-induced. Greenhouse effects are intensified by human activity and the emission of gases into the atmosphere which has led to global warming causing climate change. Global warming is not the only problem now facing mankind, but it is one of the most serious with which humanity has ever been confronted. Others such as overpopulation as predicted by Malthus in the 19th century did not occur as forecast, and water shortages, already plaguing many regions of the world. This has become a new reality with harmful impacts. Many elements of the environment and human society are sensitive to climate change has affected virtually every human life in contemporary, society and has also brought daunting challenges to virtually all facets of life in contemporary society, including, economic development (Osakede, et al., 2016).

The low-lying terrain of Ilaje, coupled with poor drainage and rapid coastal development, has exacerbated the exposure of infrastructure to climate-related damages. Furthermore, unsustainable human activities such as sand mining, deforestation, and improper waste disposal contribute to the degradation of the coastal environment. As a result, the area faces growing socio-economic and environmental challenges, including displacement of residents, loss of livelihood, and infrastructural decay. Against this backdrop, this study aims to assess the impact of climate change-induced coastal erosion on infrastructure in Ilaje LGA, Ondo State, with a view to understanding the extent of vulnerability and proposing strategies for sustainable coastal management.

II. THEORETICAL FRAMEWORKS AND LITERATURE REVIEW

Coastal communities must better comprehend how changes to the biological and physical environment (such as the direct and indirect removal of natural habitats for coastal development) can affect their exposure to storm-induced erosion and flooding as a result of intensifying human activities and a changing climate (inundation). Coastal locations naturally experience erosion and inundation on a variety of temporal and spatial dimensions due to the ongoing activity of ocean waves and storms (Mandala, 2023). However, in light of a changing climate and an increase in coastal populations, coastal erosion and inundation represent a hazard to human populations, activities, and infrastructure. Additionally, these anthropogenic pressure increases have the potential to cause coastal ecosystems to decline and lose their capacity to protect people from storms (Watson, et al., 2017). Sustainable Development as a concept is people-centered in that, it aims at improving the quality of human life and is conservation-based (WCED,

1987). It is conditioned by the need to respect nature's capacity to provide resources and life-support services. From this perspective, sustainable development implies improving human well-being while living within the ecological carrying capacity of the environment. Therefore, the coastal environment and its rich biodiversity should be preserved against the growing threats posed by climate change. The Ilaje coastal area, characterized by its low-lying terrain and dependence on natural resources, requires sustainable development practices that balance infrastructural expansion with environmental protection. Without proper planning and ecological consideration, the continuous degradation of the coastline will jeopardize the livelihoods of the people and the integrity of physical infrastructure in the area. Therefore, to effectively plan for future development, it is crucial to understand the role that different biological and geophysical processes play in influencing how likely coastal erosion and inundation are to occur. For management decisions to best conserve the protective functions offered by coastal ecosystems, it is crucial to understand how natural habitats might reduce the forces causing coastal erosion and inundation.

Global climate changes are expected to affect coastal communities around the world, many of which are already considered vulnerable to ongoing climatic variability (IPCC, 2012). In recent times, it has been observed from the climate models that the societal weather patterns are changing and as a result of this, sea levels will rise. The consequence of this for many coastal communities will be devastating (Zacarias, 2018). Thus, it should come as no surprise that climate variability and the potential consequences of future climate change are of considerable interest to stakeholders, policymakers, and the general public, especially as they may act as an additional stressor to coastal and marine resources. The heightened impacts of climate change in Nigeria and other developing countries, which are likely to intensify in the coming years, have overwhelmed local and traditional knowledge and technologies, leaving many people with inadequate information and little means to deal with the challenges (Zacarias, 2018). The gradual loss of landmass in the coastal zone is a consequence of the relentless forces of nature, primarily wave action, tides, and other marine processes that continuously reshape coastlines (Mandana, et al., 2024). However, the landscape of coastal erosion is undergoing a dramatic shift due to the ever-present influence of climate change, rising sea levels act as a potent accelerant, intensifying the erosive power of the ocean and significantly accelerating the rate of retreat (Sanjay, 2023).). The consequences of coastal retreat extend

far beyond the loss of scenic beaches, also essential infrastructure that forms the backbone of coastal communities is particularly vulnerable. Roads, bridges, and buildings all face the very real threat of being directly impacted by shoreline movement, this can lead to a cascading series of devastating consequences, including the destruction of critical infrastructure, disruption of transportation networks, and significant economic losses for affected communities (Vicent, and Jose, 2021). Coastal infrastructure systems form the backbone of every society, providing essential services that include coastal defense, trade, tourism, fisheries and aquaculture, energy, water, waste management, transport, telecommunications and other industries. Urbanization is however, not only a land-based problem, coastal development has led to a proliferation of coastal infrastructure, commonly referred to as “ocean sprawl”, that is occurring worldwide along coastlines and in near-shore waters, and is more recently expanding offshore as industries seek to utilize new resources and access space to operate. Along and adjacent to coastal foreshores, infrastructure for defense, residential and commercial developments, transport and tourism/ recreation are common; while moving further offshore infrastructure for aquaculture, oil and gas, offshore renewable energy, mineral extraction and desalination occurs (Lubchenco & Haugan, 2023).

Coastal communities worldwide, including those in developing nations like Nigeria, face a growing threat from coastal disasters (Komolafe, 2021). In Nigeria, for example, devastating floods in 2020 directly impacted over 2 million people and tragically claimed at least 69 lives (National Emergency Management Agency, 2020), these catastrophic events are demonstrably linked to the unsustainable development practices impacting coastal ecosystems. The constant pressure for physical development along shorelines, waterways, and low-lying coastal areas frequently leads to the misuse and degradation of these vital ecosystems and their natural protective functions (Dada, et al., 2024). The Ilaje coastline in Nigeria exemplifies this critical challenge, as existing research by Komolafe (2021) highlights a particularly alarming rate of coastal erosion within the Ayetoro Community, located within Ilaje Local Government Area which has caused loss of lives and infrastructure within the community. However, a crucial knowledge gap persists which existing research has not addressed the development of concrete management strategies to mitigate the adverse effects of this ongoing coastal retreat on infrastructure in Ayetoro, Ilaje Local Government Area. A comprehensive approach is necessary to address the coastal retreats challenges on

infrastructure, hence this study seeks to appraise the impact of climate change-induced coastal erosion on infrastructure in Ayetoro, Ilaje Local Government Area of Ondo State, Nigeria.

III. THE STUDY AREA

This research focuses on the coastal region of Ondo State, Nigeria, which is geographically situated between Latitudes 3°0' N and 6°41'N and Longitude 3°9'E and 3°28'E in the Southwestern part of Nigeria along the Atlantic coastline (Figure 1). The study specifically concentrates on Ilaje Local Government Area, one of the eighteen (18) LGAs in Ondo State, with Igbokoda serving as its administrative headquarters. According to the National Population Commission (NPC, 2006), the area has a population of 290,615 inhabitants. Geographically, Ilaje territory shares boundaries with the Ijebu people to its Western flank, the Ikale communities to the North, the Itsekiri settlements to the East, and the Apoi and Arogbo Ijaw to the Northeast, while its Southern border is defined by the Atlantic Ocean. The Ilaje people represent a unique and identifiable linguistic subgroup within the Yoruba ethnic family, comprising four distinct geopolitical divisions: Ugbo, Mahin, Etikan, and Aheri. Nigeria's coastal geomorphological regions encompass the Barrier Lagoon, the Mahin Mud, the Niger Delta, and the Strand Coast, each exhibiting distinctive physical features. These coastal zones extend inland for varying distances, ranging from approximately 15 kilometers in Lagos to the west, 150 kilometers within the Niger Delta region, and 25 kilometers to the East of the Niger Delta (Adati, 2012). The nation's coastline spans 853 kilometers and incorporates inshore waters, coastal lagoons, estuaries, and extensive mangrove ecosystems, particularly prominent in the Niger Delta area (Ibe, 1988). Ilaje LGA is located within the Mahin mud coastal zone and possesses a shoreline extending approximately 180 kilometers, which establishes Ondo State as having the most extensive coastal shoreline among Nigeria states. The exceptional maritime expertise of the Ilaje people, combined with their sophisticated adaptive mechanisms, have enabled them to successfully navigate and exploit their challenging geographical setting to their benefit. The natural landscape of Ilaje presents favorable conditions for large-scale rice cultivation and salt production ventures; nevertheless, the predominant economic activities of the Ilaje population encompass fishing, canoe construction, agricultural cultivation, and commercial trading. The strategic proximity of Ilaje to Lagos, approximately 75 kilometers distant, along with its aquatic characteristics, positions the region as an attractive location for tourism industry development.



Source: Authors' compilation, 2024

Table 2: Copies of Questionnaire Administered and Retrieved in the study area

S/N	Study Area	No. of Buildings	Administered (10%)	Retrieved Copies
1	Ayetoro	640	64	36
2	Zion Iluabo	1653	165	91
3	Orioke Iwamimo	470	47	24
4	Igbokoda	1713	171	93
5	Okun Etikan	946	95	49
6	Ode Etikan	168	17	11
7	Araromi	301	30	18
8	Zion Pepe	296	30	16
	TOTAL	6187	618	338

Source: Authors' Fieldwork, 2024

V. DISCUSSION OF FINDINGS

5.1 Demographic and Socioeconomic Attributes of the Respondents

Table 3 presents the sex distribution of respondents across the study areas. In Ilaje Local Government Area, 61.5% of respondents were males, while 38.5% were females, indicating a predominance of male participants. This higher proportion of men may be attributed to the dominance of fishing activities in the area, a livelihood typically undertaken by males. This observation aligns with Benson et al. (2017), who noted that men are more actively involved in fish-harvesting activities than women, either as a family livelihood strategy or for personal economic interest. In terms of age distribution, 5.0% of respondents were between 18–25 years, 32.8% fell within 26–33 years, 35.2% were aged 34–41 years, 12.1% were within 42–49 years, and 14.8% were 50 years and above. The results indicate that most respondents were within

the 26–41-year age bracket. This suggests that the majority were mature individuals who had lived in the area long enough to acquire relevant experience and substantial knowledge about the environmental challenges affecting their communities. Regarding educational attainment, 12.1% of respondents had no formal education, 24.9% completed primary education, 42.6% attained secondary education, and 20.4% had post-secondary qualifications. Occupationally, 33.7% were engaged in fishing, 9.8% were arable farmers, 22.2% were traders or involved in business activities, 15.1% were artisans, 6.5% worked in corporate or private establishments, and 12.7% were civil servants. This occupational structure reflects the relatively low level of urbanization and development in Ilaje LGA. Majority of the respondents (60%) were married individual, as this reveals the high level of reliability of the data obtained during the survey.

Table 3: Socioeconomic Characteristics

SEX	Frequency	Percentage (%)
Male	208	61.5
Female	130	38.5
AGE (YRS)		
18-15	19	5.6
26-33	109	32.2
34-41	119	35.2
42-49	41	12.1
50 and Above	50	14.8
LEVEL OF EDUCATION		
No formal education	41	12.1
Primary	84	24.9
Secondary	144	42.6
Post-secondary	69	20.4
OCCUPATION STATUS		
Fishing	114	33.7
Arable farming	33	9.8
Trading	75	22.2
Artisans	51	15.1
Corporate workers	22	6.5
Civil servants	43	12.7
MARITAL STATUS		

Single	98	29.0
Married	203	60.0
Divorced	27	8.0
Widow	10	3.1
TOTAL	338	100.0

Source: Authors' Fieldwork, 2024

5.2 Evidence of Climate Change from Temperature and Rainfall Data

Pitshu and Concepcion (2021) asserted that the search for definitive evidence of climate variability can be challenging, and the most effective approach may be to examine long-term time series of climatic parameters, such as atmospheric greenhouse gas concentrations and variations in temperature and rainfall patterns. This perspective is supported by Birhanu et al. (2019), who emphasized that long-term patterns in precipitation and temperature, offer clear indications of climate variability within a region.

Based on these established insights, this study analysed temperature and rainfall data for Ilaje LGA, Ondo State, covering the period from 1980 to 2015 to assess the extent of climate variability. Figure 3 presents the annual temperature distribution for Ilaje LGA between 1980 and 2015, considering minimum, maximum, and mean temperature values. The slope of the temperature trend was determined to be 0.02°C over the 36-year period, indicating measurable temperature

variability within the study area. This observed variation aligns with reports from the National Oceanic and Atmospheric Administration (NOAA, 2018), which state that global warming refers to the long-term increase in average global temperatures since the industrial revolution, with global temperatures having risen by approximately 0.8°C since 1880. Similarly, Figure 3 illustrates the annual rainfall distribution in Ilaje LGA from 1980 to 2015. According to interviews conducted with meteorological officials in Akure (Ondo State), Southwest Nigeria experiences two distinct wet seasons annually: a major wet season from February to August and a minor wet season from September to November. Due to the unavailability of daily rainfall records, average monthly rainfall data (mm/month) were utilized in this analysis. Across the 36-year precipitation record, noticeable irregularities in rainfall patterns were observed an indication of climate variability within the study area. The slope of the rainfall trend line was calculated at 0.49 mm over the 36-year period, further supporting this variability.

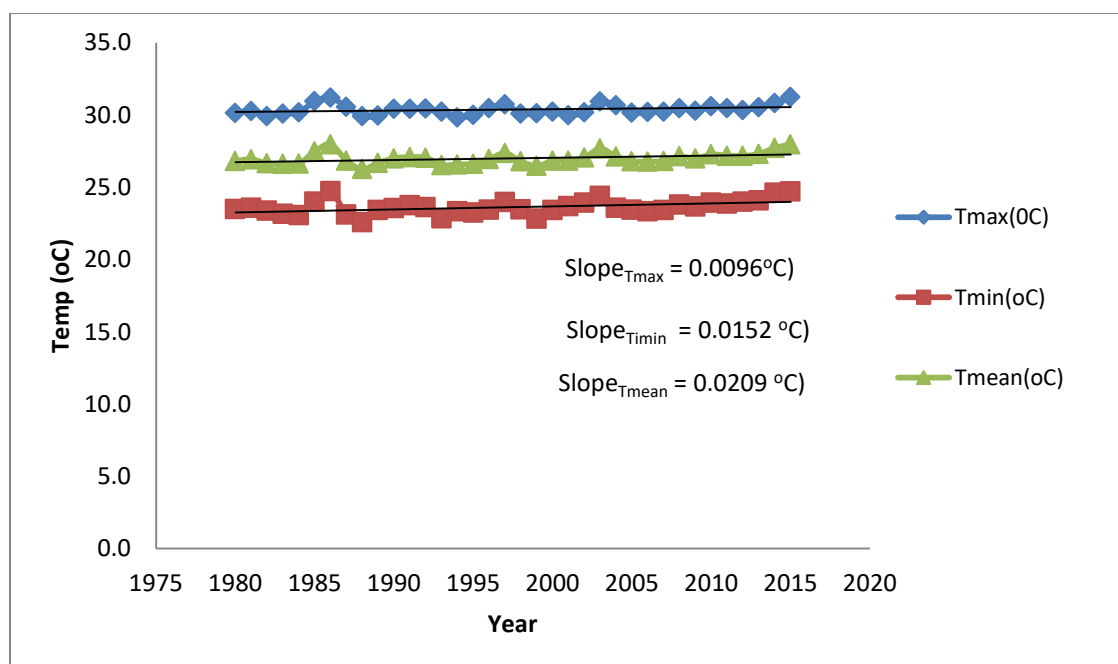


Figure 2: A 36-Year Temperature Distribution for Ilaje LGA 1980-2015

Source: Nigerian Meteorological Station (2020)

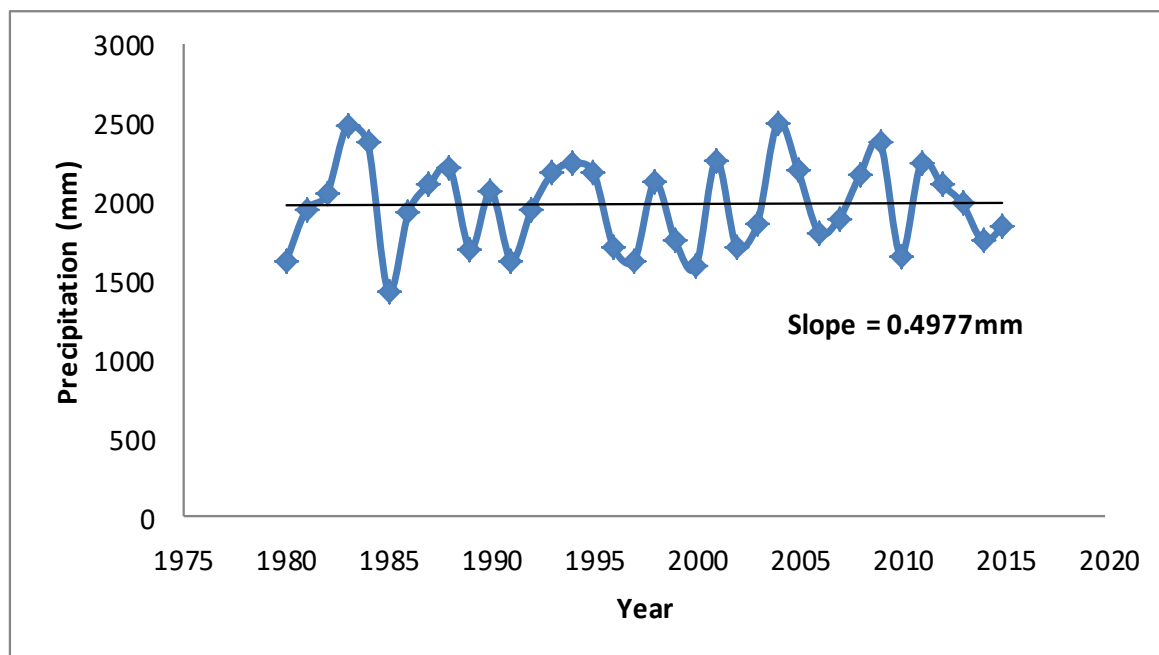


Figure 3: A 36-Year Precipitation (Rainfall) Distribution for Ilaje LGA 1980-2015

Source: Nigerian Meteorological Station (2020)

5.3 Coastal Erosion and its Impact on Infrastructure

In the coastal area of Ondo State, especially in Ayetoro community, sea incursion induced by climate change results to coastal erosion, as it is a prominent perennial environmental challenge ravaging this area with concomitant impact on residents and infrastructure. In 2008, sea incursion affected buildings and displaced people in the community as the distance between the coastlines to its present boundary was 700 meters. Ayetoro city hall and the community primary school were almost affected by the sea incursion (Figure 4). As at 2023, it was found that, a total number of 260 houses including the city hall and the community primary school were already submerged into the sea in Ayetoro communities. Across the Ilaje Local Government area of Ondo State, more than 260 households were rendered homeless, also caused the closure of some primary schools in Ilaje LGA (Figure 5).

The study revealed that, 60.5% of the respondents claimed, coastal erosion had resulted to carrying away of buildings, 53.1% claimed it had caused destruction of coastal biodiversity. In addition, it was revealed that, 45.7% of the respondents claimed that, coastal erosion induced by climate change had resulted to submergence of the some primary schools in Ilaje. The study further revealed

that 45.7% of the respondents revealed the menace had resulted in the destruction of community hall in some communities of Ilaje while 18.9% of the respondents had relocated. It was found that, majority of the respondents indicated that, coastal erosion had resulted to carrying away of buildings, destruction of coastal biodiversity, and washing away of coastal sand/deposits in Ilaje LGA (Table 4; Figures 6 and 7). The sea incursion in the community had great negative impacts on the buildings, valuable land, road infrastructure and on coastal biodiversity (Figures 6 and 7). Personal observation by the researchers during survey confirmed the impacts of this great environmental menace, in the coastal region of Ondo State, Ilaje LGA in particular. This environmental challenge had great economic, psychological and social impacts on the residents. Economic impact in the sense that, when their houses were destroyed due to coastal erosion, they lost their buildings and properties to the sea, the affected residents had resulted to squatting in another area during relocation. Psychologically they are in state of trauma, pains and emotional stress due to the coastal degradation effect, while socially, they were impacted due to breakage in initial social ties with their neighbours and forced movement to other community.

Table 4: Impact of coastland erosion

Impacts	Yes	%	No	%	Don'tKnow	%	Mean
Washing away of coastal sand deposits	413	52.6	178	22.7	188	23.9	1.71
Destruction of coastal biodiversity	417	53.1	169	21.5	199	25.4	1.72
Submergence of city hall	359	45.7	221	28.2	205	26.1	1.80
Carrying away of buildings	475	60.5	119	15.2	191	24.3	1.64
Relocation of communities' dwellers	148	18.9	349	44.5	288	36.7	2.18
Destruction of primary school	375	47.8	162	20.6	248	31.6	1.84

Source: Author's Fieldwork, 2



Figure 4: Effects of Sea-incursion in Ayetoro in 2008

Source: Author's Fieldwork, 2024

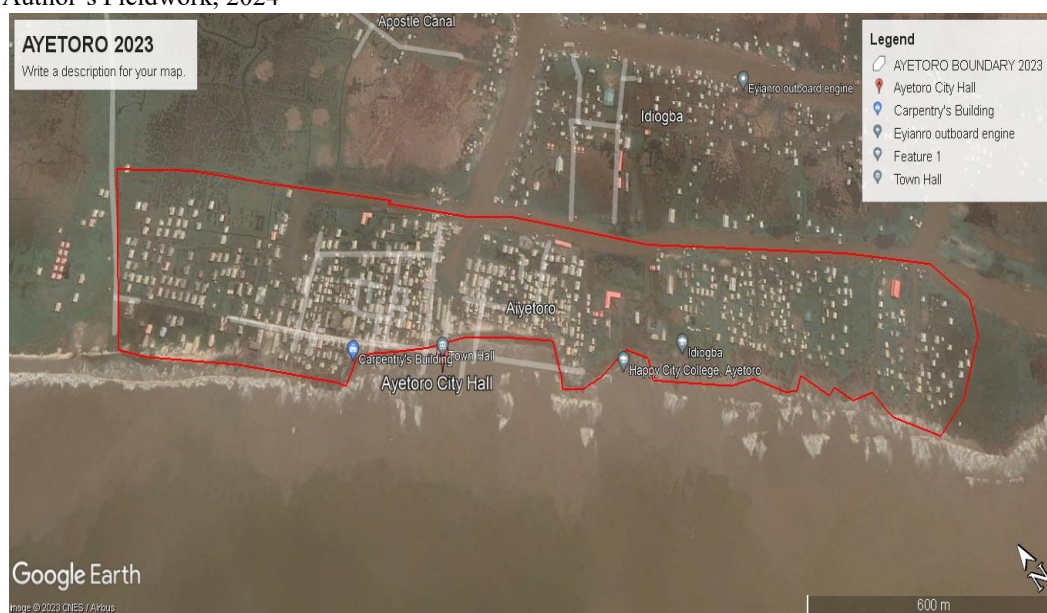


Figure 5: Effects of Sea-incursion in Ayetoro in 2023

Source: Author's Fieldwork, 2024



Figure 6: Destruction of building Infrastructure in Ayetoro

Source: Author's Fieldwork, 2023



Figure 7: Destruction of Biodiversity and Infrastructure in Ilaje Coastal Area by Ocean surge

Source: Author's Fieldwork, 2023

VI. RECOMMENDATIONS AND CONCLUSION

This study has examined the impacts of climate change- induced coastal erosion on infrastructure in

Ilaje Local Government Area. Based on the findings, the following are recommended;

6.1 Adoption of an Integrated Coastal Zone Management (ICZM) framework: This approach encourages coordinated, long-term planning that

balances environmental sustainability with infrastructural development and community needs. By integrating scientific data, community input, and multi-agency collaboration, ICZM would help regulate human activities that prevent erosion such as sand mining, unplanned settlements, and vegetation destruction while ensuring that development respects the natural dynamics of the coastline. Effective implementation will require strong institutional commitment, regular environmental assessments, and strict enforcement of planning regulations to reduce vulnerability and promote sustainable use of coastal resources.

6.2 Implementation of nature-based and hybrid coastal protection strategies:

The study revealed that conventional interventions such as embankments and sand-filling have been largely unsustainable in Ilaje. Therefore, combining engineered structures with nature-based solutions such as mangrove reforestation, dune stabilization, wetland restoration, and strategic planting of coastal vegetation offers a more effective, long-term defense against flooding, erosion, and sea-level rise. These ecological systems act as natural barriers, absorbing wave energy, enhancing soil stability, and supporting biodiversity. In addition to protecting infrastructure, nature-based solutions contribute to socio-economic resilience by supporting fisheries, improving water quality, and maintaining vital ecosystems essential to local livelihoods.

6.3 Strengthening community resilience through capacity building and livelihood diversification.

Given that a significant proportion of the population that depends on fishing and natural resource-based occupations, exposure to climate-induced hazards directly threatens household income and social stability. Community education, training programs, and climate awareness campaigns should therefore be prioritized. These efforts should empower residents with knowledge on disaster preparedness, sustainable resource use, and adaptive livelihood strategies. Encouraging alternative income sources such as eco-tourism, aquaculture, and small-scale enterprises will help reduce overdependence on climate-sensitive activities and enhance the community's ability to cope with environmental shocks, reducing vulnerability and enhancing long-term adaptation. In conclusion, the study has clearly shown that climate change-induced coastal erosion poses a profound and escalating threat to infrastructure, livelihoods, and environmental stability in Ilaje Local Government Area. The evidence of temperature and rainfall variability, coupled with the severe impact of coastal erosion and its

destructive effects on infrastructure underscores the urgent need for coordinated and sustainable intervention. Addressing these challenges requires a holistic approach one that integrates scientific data, community knowledge, and robust governance. By strengthening coastal management practices, embracing nature-based solutions, and building community resilience, Ilaje can chart a path toward long-term environmental security and sustainable development. A resilient Ilaje coastline will not only safeguard lives and infrastructure but also contribute meaningfully to broader climate adaptation efforts in Nigeria.

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