Original Research Article

Evaluating Coastal Communities' Sea Level Rise Adaptation Plans in Nigeria's Niger Delta

ABSTRACT

With a focus on Opobo/Nkoro communities, this study examines the adaptation tactics used by coastal communities in Nigeria's Niger Delta Region in response to sea level rise. Nigeria's low-lying coastal areas are increasingly at risk from sea level rise, but little is known about how the local population will adjust. Assessing shoreline changes over time and evaluating community-level responses to the continuous effects of coastal erosion and inundation were the objectives of the study. Using a combination of physical, socioeconomic, and participatory GIS data, a qualitative research methodology was chosen. Shoreline evolution over both short-term (2015–2020) and long-term (1984–2020) periods was evaluated using remotely sensed imagery. With a total average linear regression rate (LRR) of -2.7 ± 0.18 m/year from 1984 to 2020 and -3.94 ± 1.28 m/year between 2015 and 2020, the shoreline change analysis's findings showed steady erosional trends. These results support the idea that sea level rise is to blame for the gradual coastal retreat. Furthermore, survey information was gathered from 384 randomly chosen household heads in various residential densities in order to investigate socioeconomic characteristics, awareness levels, and adaptation tactics. According to the analysis, residents took a variety of actions, such as moving away from high-risk areas, fixing or replacing damaged property, and urging the government and neighborhood organizations to build more drainage systems. According to the study, these adaptation techniques differed greatly depending on socioeconomic status and residential density. The results highlight how urgently localized, integrated climate change adaptation policies are needed. To improve the absorptive, adaptive, and transformative capacities of coastal households in the area, policymakers are advised to give priority to awareness campaigns and the execution of community-based adaptation measures.

Keywords: sea level rise, adaptation strategies, shoreline erosion, Niger Delta, coastal communities, climate resilience, Opobo/Nkoro.

1. INTRODUCTION

The Niger Delta is the area where the River Niger splits into numerous tributaries, and it is located on the Atlantic Coast of southern Nigeria. With a littoral that stretches for about 450 kilometers and ends at the Imo River's entrance, it is the second-longest delta in the world (Awosika, 2015). With an area of over 20,000 square kilometers, the wetland is the largest in Africa and among the three largest worldwide (CLO, 2018). The Niger Delta region is made up of about 8,600 square kilometers of stagnant swamps and 2,370 square kilometers of rivers, waterways, and estuaries. With a total area of about 1900 square kilometers, the delta is home to the largest mangrove wetlands in Africa (Awosika, 2015). The delta is part of the tropical rain forest zone. The ecosystem of the area is extremely diverse and supports a wide range of aquatic and terrestrial plants and animals in addition to human life.

The Niger Delta is particularly susceptible to the negative environmental changes brought about by climate change because of its location in the world's littoral region. The littoral geology, vegetation, and drainage system define the coastal zone, which is an area where terrestrial and marine processes coexist. Ajao (2014) states that it can be broadly described as a zone of variable width that includes the

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It is a crucial area that produces biological and mineral resources necessary for the economic development of many countries, including Nigeria. Because of its ecological and economic significance, the Nigerian littoral zone is experiencing daily increases in human population pressure. Given the wealth of its fisheries and petroleum resources in Sub-Saharan Africa, the Niger Delta region of Nigeria is, in fact, essential (Akande et al., 2017). However, the sustainability and integrity of the coastal zone are at risk due to anthropogenic pressure and climate change. Allen (2016) states that sea level rise may occur in 2050, possibly submerging all coastal cities in the Niger Delta region and a greater portion of Lagos, as confirmed by the Model for the Assessment of Greenhouse Gas Induced Climate Change (MAGICC-SCENGEN) and geographical information system (GIS) interpolation techniques. Sea level rise and the height of water above a reference level are two factors contributing to the flooding of low-lying coastal areas. It is one of the most common geological hazards and affects people and property more than any other hazard. Any significant rise in sea level causes the littoral zone to erode (Bell, 2014). The tectonic environment, shoreline materials, and wave energy all influence the littoral and coastal zone's character. The most vulnerable sediments to coastal erosion are the brittle, loose sediments. The equilibrium of the beach profile, lithospheric uplift and/or subsidence, wave and current forces, and sediment supply are all necessary for a progradation or erosion environment to predominate. Human activity and erosion are at odds in the coastal zone, and infrastructure development has increased vulnerability, calling for better planning and management of the coastal zone (Bell, 2014).

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common household adaptation to climate change in the North-Eastern region of the Czech Republic, according to Stojanov et al. (2016). Kreibich and associates (2005) and Kreibich et al. (2011) also divided domestic adaptation strategies into three cost categories: low, medium, and high. These low-cost strategies include helping residents impacted by climate change events, gathering information about preventive measures, and moving vulnerable properties from the ground floor to safer locations (Dey et al. 2016; Okunola and Bako, 2021). According to Kreibich et al. (2011), flood insurance, interior adaptation (such as replacing floors), and the protection of flood embankments and barriers are examples of medium adaptation strategies to the effects of climate change. On the other hand, the expensive flood adaptation measures included building small flood barriers on the nearby lands, strengthening the building's foundations and substructure, using sturdy, water-resistant materials, and sealing off important parts of the house (Daramola et al. 2016). This study also looked into the variables that affect the methods locals use to adjust to the consequences of climate change.

The factors influencing household participation in the process of recovering from significant trauma were examined in studies by Grothmann and Patt (2003) and Ekegren et al. (2020). These authors showed that perceived ability and self-motivation are important variables that affect how well people and households adjust to major disasters. Additionally, the authors claimed that self-motivation is typically necessary for households or individuals to take preventative actions in order to adapt and manage the risks of climate change, without necessarily depending on outside motivation to protect themselves from climatic hazards. In Leeds, the United Kingdom, Ihemezie et al. (2018) emphasized that income, house type, and house ownership are important factors that affect how well households and individuals adapt to the effects of climate change. Such studies are rare in the West African Subregion, especially in Port Harcourt, Nigeria.

Many studies have examined how households in sub-Saharan Africa are adapting to climate change (Belay et al. 2017; Yaméogo et al. 2018; Chete 2019). For instance, Belay et al. (2017) showed that farmers' access to climate information and extension, markets, livestock production, income, household demographics, and farm size all have a significant impact on the adaptation strategies they choose in Ethiopia's Central Rift Valley. Similarly, in a study in Osun state, Nigeria, Chete (2019) found that farmers' choice of climate change adaptation strategies is influenced by household size, farm income, access to credit and extension agents, and climate change information. Nonetheless, these studies' main focus was on the variables that affected farmers' choices to adjust to sea level rise in Sub-Saharan Africa's rural areas. In order to address the effects of climate change, researchers like Weru et al. (2017) and Jabeen et al. (2010) examined household resilience strategies in sub-Saharan African cities' informal settlements. These studies showed that in the informal settlements of Dhaka and Nairobi, the resilience of households to the effects of climate change has been significantly influenced by the provision of funds to low-income households for the construction of improved housing, barriers to keep floodwater from entering homes, house designs that reduce high temperatures, food stores on top of high furniture or shelves, and electrical wiring. The official settlements of these cities were not taken into consideration in these investigations, though. Therefore, the goal of this study is to add to the body of literature by investigating how households and individuals in a particular coastal community in Nigeria's Niger Delta have adapted to the rising sea level.

2. METHODOLOGY

The study was conducted in the Kingdom of Opobo. Five thousand residents of the Opobo Local Government Area made up the study's population. 540 residents of the Opobo Local Government Area, or 10.8% of the total population, made up the study's sample. The sample size was chosen using a non-stratified random sampling technique. Both primary and secondary data were used in the study. A questionnaire and GIS data were used as the study's data collection tools. The researcher created the instrument. There were two parts to it: A and B. The demographic information was in Section A, and the items used to measure the construct were in Section B. Strongly Agree (SA), Agree (A), Disagree (D), and strongly Disagree (SD) are the four responses on a modified four-point Likert scale that was used in the instrument. The data obtained from the questionnaires was analyzed using percentage, mean, and standard deviation; the data obtained from the field survey will be analyzed using R, GIS, DSAS, and ArcGIS.

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3. RESULT AND DISCUSSION

3.1 Results

Four susceptibility classes were created from the shoreline change result derived from the linear regression rate (1984-2020), with class 4 being the most vulnerable to shoreline changes and class 1 being the least. Murali et al. (2013) served as the basis for the rank classification, which classifies accretion > 2m as very low susceptibility, accretion < 2m as low susceptibility, erosion < 2m as high susceptibility, and erosion > 2m as very high susceptibility. Figure 1 shows the spatial distribution according to the studycoast's vulnerability to shoreline changes.

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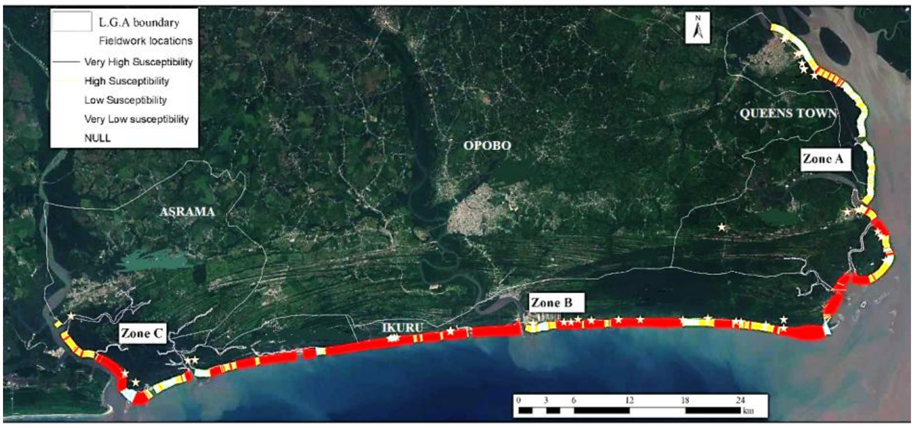

Figure 1. Map shows the spatial distribution of the susceptibility of the Opobo coast to coastal erosion of the study area.

Table 1. Shoreline change susceptibility ranking

Parameter	Shoreline change Susceptibility ranking

	Very low (1)	Low (2)	High (3)	Very High (4)
Shoreline change (m/yr)	Accretion >2	Accretion < 2	Erosion < 2	Erosion > 2
% coverage	4.01	19.81	22.73	53.45
Total	23.82%		76.18%	

According to Table 1, 23.82% of the coast is vulnerable to accretion and 76.18% is vulnerable to erosion. It implies that, from 1984 to 2020, coastal erosion will be the most noticeable process along the coast. Even though erosion predominates, 23.82% of the coast has accreted, meaning that land has been added there over the course of 36 years.

3.1.1 Erosion and Accretion 'Hot Spot' Assessment

The results from the LRR statistics in the long-term change (1984-2020) results were used to identify both accretion and erosion hotspots. Figure 2 depicts the erosion and accretion changes along the Opobo coast over a 36-year period. It identifies hot spot accretion hot spots with rates > 2 m/yr along 23.82% of the studied coast and hot spot erosion hot spots with rates > 2 m/yr along 53.45% of the coast.

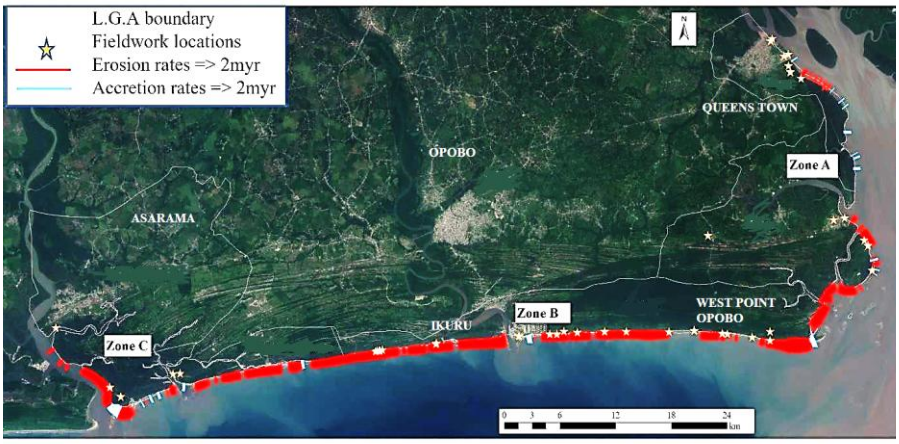

Figure 2. Erosion and Accretion map generated from the extracted shorelines (1984-2020) of the study area.

Both desktop analysis and fieldwork were used in this study to assess the changes along the coast. Four sites were chosen to serve as a guide for the ground truthing of the research area after an initial desktop GIS analysis was done to identify the zones with the highest human densities before the fieldwork began. The final hot spots selected to evaluate vulnerability at a much local scale are areas with the largest coastal human settlements, significant erosion, and areas where sufficient social data was generated through focus group discussions (FGD), interviews, and participatory GIS (PGIS), as this study takes an interdisciplinary mixed-approach and focuses on the vulnerability of the people in the study area. These sites were then used for field research in order to produce data through firsthand field observations and local knowledge.

3.1.2 SEA LEVEL RISE ADAPTABILITY STRATEGIES

Table 2 displays the socioeconomic characteristics of the study participants. Opobo/Nkoro L.G.A. residents' reactions to sea level rise are influenced by a number of factors, including age, income, education, household size, and length of residence.

Table 2. Socioeconomic and demographic characteristic distribution of the respondents.

	High density %	Medium density %	Low density %
Gender			
Female	70.4	73.4	62.2
Male	29.6	26.6	37.8
Age group			
19–30	14.0	5.3	19.7
31–55	72.9	73.4	57.4
56–65	13.1	21.3	23.0
Income group			
Less than N 30,000	34.5	8.5	3.5
N30, 000–150,000	38.4	48.9	17.5
Above N150,000	27.1	42.6	79.0
Education status			
Primary	38.3	21.6	18.4
Secondary	46.1	35.1	28.9
Tertiary	15.6	43.3	52.7
Household size			
Small (≤6)	33.7	78.7	90.2
Medium (7–10)	45.2	21.3	9.8
Large (/ 10)	21.1	—	—
Total	n = 229 (100.0)	n = 94 (100.0)	n = 61 (100.0)

The results showed that 30.2% of the residents were men and 69.8% of the residents were women. This supported Carlsson et al. (2012)'s earlier claim that women are essential in addressing climate change because of their local understanding of sustainable resource management at the home and community levels. Additionally, the three residential densities of Opobo/Nkoro L.G.A. were categorized by the age of the head of the household. These were: youths aged 19–30, young adults aged 31–55, and adults aged 56–65 (Okunola 2019). Table 2 made clear that young adults made up the majority of respondents in Opobo/Nkoro L.G.A. (70.6%). However, 12.8% of respondents were young people, and 16.7% were adults. According to Dahlgren and Whitehead (2007), this implies that mature adults should have a high level of reasoning regarding sea level rise adaptation, which will enable them to participate in mitigation and adaptation to the effects of climate change. Using the Federal Government of Nigeria's minimum wage as the benchmark (2019), the income group for household

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heads in this study was based on the income classification modified from Ezeah (2010). Accordingly, household heads who make less than N30,000 (US$ 1 = 410,25 (Central Bank of Nigeria 2020)) per month are considered low income earners, those who make between 30,000 and 150,000 are considered middle income earners, and those who make more than 150,000 are considered high income earners. Additional results from the examination of the average monthly income in the city showed that the average monthly income in the high, medium, and low residential densities was 38,176.00 K, 94,456.98 K, and 189,653.06 K, respectively. Additionally, it was revealed that 34.5%, 8.5%, and 3.5% of respondents in the high, medium, and low residential densities, respectively, fell into the low income category. Subsequent investigation showed that, at a 95% confidence level, the respondents' income variation across the three residential densities was statistically significant (F = 183.484 and p = 0.000). This suggested that the three residential densities in the city would have different levels of financial capacity to adapt to climate change.

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Results regarding respondents' educational attainment showed that primary, secondary, and tertiary education were held by 38.3%, 46.1%, and 15.6% of respondents in the high residential area, respectively. It changed to 21.6% for respondents with only a primary education, 35.1% for those with a secondary education, and 43.3% for those with a certificate of tertiary education in the medium density. Additionally, there was a notable improvement in the educational attainment of the respondents in the low residential density, with 18.4% of primary school graduates, 28.9%, and 52.7%, respectively, having secondary and tertiary education. Therefore, the study found that respondents' educational status varied across the three residential densities that were identified.

Household size has also been identified as an indicator of how residents are responding to climate change. The household size classification system developed by Afon (2007) and Okunola and Bako (2021) was used in this context and divided into three groups. households with six or fewer people, those with seven to ten people, and those with more than ten people. These were considered small, medium, and large households, respectively. According to Table 2's summary, the majority of respondents with small households lived in areas with low residential densities. In Opobo/Nkoro L.G.A., 90.2% of the households belonged to this group. The percentages of small-sized households in high and medium residential densities were 33.7% and 78.7%, respectively. Additionally, a study of medium-sized households showed that the majority lived in areas with high residential densities. 33.7% of Opobo/Nkoro L.G.A. was made up of this group. Additionally, the One-Way Analysis of Variance resulted in a confirmation of the household size difference across the three residential densities (F = 4.304; p = 0.014 at 95% confidence level).

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Table 3. Intra-urban responses to climate change in Opobo/Nkoro L.G.A.

Adaptation Strategies	Mean	SD
Relocation from sea level rise areas	4.21	0.50
Repair and replace damaged property	4.09	0.38
Construction of more drainages system by government and community groups	4.19	0.48
Cleaning or helping to maintain public drainage systems from waste	3.72	0.01
Sensitizing fellow residents' about causes of sea level rise	3.84	0.13
Construction of high wall to prevent flood	3.62	−0.09
Shun haphazard bush burning	3.79	0.08
Listening to information on climate change	3.82	0.11
Enforcement of building codes/ guidelines	3.41	−0.30
Constructing property above flood level	3.32	−0.40
Planting of trees for shading from sun heat and breaking wind speed	3.72	0.01
Provide efficient mechanisms for disaster risk reduction	3.58	−0.13
Emplacement of storm surge barriers by government and community groups	3.79	0.08
Adoption of green roofs in building	3.61	−0.11
Children staying at home until flood subsides	3.65	−0.06
Use of windbreaks/shelter belts	3.58	−0.13
Complied with setback during property development	3.48	−0.23
Restriction of land reclamation activities in newly developed areas by government	3.45	−0.26
Mean Score	**3.59**	**0.69**

The respondents were asked to rank the adaptation strategies they had adopted on a five-point Likert scale (1 to 5), in order to fulfill the primary goal of this study, which is to identify and evaluate factors influencing individual and household adaptation to climate change in the study area. Relocating away from sea level rise areas was the adaptation strategy with the highest rank (MD = 0.64), according to Table 3, while complying with setbacks during property development was the strategy with the lowest rank (MD = -0.43). Twelve of the 18 adaptation measures were classified as (negative) not important, and six were classified as (positive) important. High level adaptation measures included replacing and repairing damaged property, cleaning or assisting in the maintenance of public drainage systems from waste, constructing additional drainage systems by the government and community organizations, moving away from areas affected by sea level rise, avoiding haphazard bush burning, and keeping up with climate change information.

3.2 Discussion

Along the Opobo coast, a thorough assessment of the coastal changes between 1984 and 2020 was conducted. This study's shoreline change map is based on findings from the DSAS-LRR change statistical approach, which assessed the rate of accretion and erosion along the coast over 36 years, from 1984 to 2020. Rate of sea level rise-induced geomorphological changes along the coast

Using Landsat medium-resolution data (2015–2020) for the short-term coastal change evaluation, the study evaluated the rapid geomorphological changes along the coast. Given the erosional pattern revealed by the long-term analysis along the entire coast, it is imperative to compare and assess the rate of change along the coast. Management choices in the area may be influenced by a more complete knowledge of the shoreline changes made possible by this assessment. To look into these rapid changes, we performed a short-term historical trend study (from 2015 to 2020). The average LRR result for the short-term analysis was -3.94+1.28 m/yr, suggesting that erosion is a frequent occurrence along the shore. There will be a lot of activity along the coast over the next five years, based on the size of the changes observed in the data from 2015 to 2020. In line with the results of the long-term analysis, the short-term overall average LRR along each of the three shoreline segments of the study coast showed an erosional trend. Zone B was the most dynamic section of the coast, with an average LRR of -5.89+3 m/yr, while Zone A was the least dynamic, with an average LRR of -2.23+ 0.75 m/yr. These findings are consistent with the long-term analysis's conclusions as well. However, this study discovered that the recent and rapid erosion of the coastline may be caused by a combination of natural and man-made forces. In the field, there was proof of the consequences of the recent, rapid rates of erosion, which have been exacerbated by human activity. Along with the destruction of homes and farmlands, there were also reports of local fatalities in a number of coastal communities. Wang et al.'s (2019) study of Haikou Village, China, offers a great example of how to successfully integrate indigenous and scientific knowledge in community-based research, which is a result of growing awareness of the importance of indigenous knowledge in scientific research. This study also uses local knowledge to better understand the rate of coastal erosion in the region.

In order to cope with the effects of climate change in the study area, respondents used similar reactive or ex-post adaptation strategies, according to an analysis of adaptation strategies used by households in the study area. In order to prevent and adapt to the effects of climate change, they therefore depended more on individual efforts than on government interventions. These coping mechanisms may be categorized as coping responses, according to Porter et al. (2014). It is a behavioural shift that happens naturally, sometimes after the effects of climate change have been felt, and doesn't require a planned strategy. This result is consistent with a prior study by Mertz et al. (2009) that discovered that households in developing nations frequently take coping response measures in response to extreme climate change events.

Additionally, the study found that the average monthly income, house type, degree of education, and ownership of a home all have a significant impact on the adaptation strategies that households in the study area choose to use in response to the effects of climate change. This suggested that people's degree of risk and adaptability seem to be more influenced by their formal education. This result further supports the conclusions of earlier research, including Wamsler et al. (2012) and Alexander et al. (2016), which found that education plays a significant role in determining how well a household or individual adapts to the effects of climate change. There is compelling evidence that households in the study area choose sea level rise adaptation strategies based in

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large part on age. The need to focus on how the young adults who make up the majority of the residential densities in the study area can contribute innovative adaptation strategies to current and future sea level rises is highlighted by this analysis of age as a factor to be taken into account in adaptation pathways. Because age shapes the positions from which residents negotiate, engage, and evaluate various technical adaptation practices, these findings thus support previous claims by Ng'ang'a and Crane (2020) that adaptation to climate change is a contingent process highly influenced by age. However, in the study area, factors such as gender, family size, and years of residence were found to be statistically insignificant when it came to sea level rise adaptation. The study also found that people who own their homes are more likely to use adaptation strategies to climate change than people who rent apartments. This finding supports the findings of other studies, like Ihemezie et al. (2018), which found that homeowners are more likely to adopt adaptation strategies as a protective measure against their property than tenants who have little stake or self-interest in the property. Accordingly, the type of home a household lives in may likely influence the level of adaptation strategies that the household adopts to climate change. During field observation and respondent interaction, it was found that households in high-rise buildings, duplexes, and terraced houses adopted more adaptation strategies than households in bungalows and terraced houses. This could be explained by the fact that households in bungalows and terraced houses tend to have lower incomes than those in duplexes and high-rise buildings, which are typically occupied by households with higher incomes. According to Uddin et al. (2014) and Ihemezie et al. (2018), households with higher incomes are more likely to be able to cope with and adjust to the effects of climate change. This finding further established the significance of income in households' choice of adaptation strategies to these effects.

Additionally, this study found that the income levels of households were positively and statistically significantly impacted by sea level rise adaptation strategies. This result confirms the findings of Ihemezie et al. (2018) and Berhe et al. (2017) that households or individuals with higher monthly incomes are more likely to adopt more adaptation strategies, particularly the more expensive and technical adaptation measures. The implication is that disparities in vulnerability and exposure to the risk of climate change are likely to persist due to income inequality among individuals or households. Furthermore, adaptation responses have the potential to exacerbate already-existing disparities or even generate new ones. Overall, the study's findings support those of Ihemezie et al. (2018) and Ng'ang'a and Crane (2020), who found that respondents' attitudes and behavior regarding sea level rise adaptation are significantly influenced by their socioeconomic status.

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4. CONCLUSION

Although the phenomenon of climate change is not new to Earth's history, the remarkable and worrisome climatic variations of this era are the result of human-caused factors, primarily from the world's developed nations. In the Niger Delta, erosion, coastal flooding, and relative sea level rise have all become realities. It is advised to monitor and manage it continuously due to its dynamic nature under the influence of continuous flooding. The findings suggested that respondents in the three residential densities relied more on coping strategies than on proactive ones to deal with the effects of climate change. However, the three adaptation measures that were deemed to be of the least importance were: the government and community groups' installation of storm surge barriers; the provision of effective mechanisms for disaster risk reduction; the use of windbreaks and shelter belts; and the government's restriction of land reclamation activities in recently developed areas. In addition, the study area's average residents' response index (RRI) was 3.67, whereas the RRIs for the high, medium, and low residential densities were 3.59, 3.69, and 3.72, respectively. These answers suggested that as residential densities increased, so did the intensity of responses to the effects of climate change.

RECOMMENDATIONS

1. Given the importance of the Nigerian Coastal Zone in Nigerian economy, adequate attention should be made by implementing sustainable mitigation measures which are location specific and guarantee effective adaptation to climate change in the area.
2. The state and the federal government of Nigeria, development partners, and the private sector actors under the current climate variation should undertake their designated roles in climate change responses, measures and actions to implement context-specific policies to address impediments to the adoption of advanced sea level rise adaptation strategies across different residential densities in Opobo and others with similar attributes.
3. Furthermore, it is strongly recommended that stakeholders at all levels must assess, plan and implement sea level rise reduction measures with the relevant communities to foster collaboration across sectors, addressing the immediate challenge of sea level rises and increasing awareness.

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