

Sea Level Rise and its Impact on Ayetoro Community, Ondo State, Nigeria

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Abstract

Nigerian coast is low-lying, a 1 to 5m rise in sea level which may result from climate change will have a catastrophic effect on the people in these regions. This study explores how sea level rise has impacted Ayetoro community. Questionnaire survey and focus group discussion were used to elicit information on the socio-environmental impacts of sea incursion on the people of the community. Findings show that the community is facing extinction on account of recurring sea level rise. The community which used to be about 20 km away from the sea now has a larger part of its landmass submerged. Findings also show that the impacts of sea level rise on Ayetoro community falls into four categories namely intensified flooding, increased erosion of shorelines, salt water intrusion into freshwater and decline in coastal biodiversity. This study provides information concerning the impact of sea level rise which is useful for coastal planners and managers to develop a framework for integrated coastal zone management to support sustainable development of the coast in the light of rising sea levels. This must ensure the active involvement of stakeholders at all levels ranging from the government to the community to generate their commitment and support and to identify what actions are most needed.

Keywords: *Sea Level Rise, Coastal Erosion, Flooding, Saltwater Intrusion, Ayetoro, Nigeria*

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Background to the Study

Coastal zone is a region of interactions between marine and terrestrial processes which can be classified according to geology, vegetation and drainage system of the coastline (Udu-Akuaibit and Bassey, 2021). Coastal zone, which are notable for human settlement are characterized by a multiplicity of ecological resources (Senevirathna et al., 2018). About 20% of the global population inhabit within 30km of the sea, and twice this number settles within the nearest 100km of the shoreline (Fashae and Onafeso, 2011). In fact, Nigerian coastal zone especially the Niger Delta region is quintessential as it is the richest in petroleum and fishery resources in the Sub-Sahara Africa (Akande et al., 2017). However, the integrity and sustainability of coastal zone are threatened by sea level rise and coupled with anthropogenic pressure. The coastline of the Niger Delta is dynamic in nature and this dynamism has made it and the coastal communities which dwell on the shoreline vulnerable to coastal erosion and ocean surge accentuated by the rising sea level. Coastal settlements are increasingly becoming vulnerable to natural and human-induced hazards given the global trend of climate change (Prasad and Kumar, 2014).

One of the effects of climate change is the rise in the level of the sea along major coastlines, which usually result in flooding, coastal erosion, wetland inundation and other ecological losses. A rise in sea level usually increase the flooding depth and extend the area that stays wet in the dry season (Brammer, 2014). Sea level rise poses a major threat to most lands along the coast and also major development having direct access to the shorelines especially in cities and other form of development within the low-lying area around the coast (McGranahan et al., 2007). In Nigeria, as at 2000, one quarter of the population of 100million people lived in the coastal zone (Folorunsho and Awosika, 2000). It has been reported that 1m rise in sea level by 2100 would threaten 18,000km² of Nigeria's land and 3.2million people would be at risk of flooding (French et al., 1995). A 1m rise in sea level would make over 800 villages uninhabitable in the Niger Delta region. Moreover, coastal erosion which is already s problem in the Niger Delta region will exacerbate with sea level rise. With sea level rise, there could be a potential loss of 17,000km² of wetlands in the Niger Delta (Folorunsho and Awosika, 2000). This could result to a potentially massive environmental refugee migration.

Sea level rise has been a major concern for coastal and low-lying areas of the world since these areas undergoes several morpho-dynamic processes due to several geomorphological, climate and oceanographic factors. Stuart et al. (2020) noted that coastal communities are currently being faced sea level rise which have further exacerbated the environmental challenges confronting coastal cities. This situation could cause serious stress on the population, resulting to human suffering, slow socioeconomic activities, loss of properties, health challenges and loss of lives. Sea level rise has far reaching consequences for low-lying coastal communities and beyond. The direct impacts of sea level rise can be quite several including flooding of low-lying areas, erosion of coastline, destruction of coastal wetlands, infiltration of saltwater into freshwater sources, higher groundwater levels and elevated water levels that can cause coastal flooding (Leatherman and Nicholls, 1995; Lacava and Ciancia, 2020; Dada et al., 2023). Sea level rise in Nigeria have continued to attract the attention of researchers considering its devastating impact on proximate human settlements, which in recent times,

has further been exacerbated by climate change (Olorunlana, 2013; Udo-Akuaibit, 2017). This is the situation in Ayetoro, a coastal community in the Ilaje area of Ondo State, where sea level rise has been raging. The scenario in this community negates the achievement of the Sustainable Development Goals 2030 which aim at ensuring a habitable and healthy environment for all humans. In light of this, this study aims at presenting a case study of sea level rise and its impacts on Ayetoro community in Ondo State, Nigeria.

Literature Review

Coastlines are complex systems, where different deposition and erosion features such as caves, cliffs, beaches and mudflats exist. Coastal areas are rich in natural resources which have made them to become important habitats for significant percentage of the world's population (Bird, 2008). Nigeria's coast is 850km long and comprises (from west to east) a barrier-lagoon coast (250km), a mud coast (75km), the Niger Delta (440km) and a sandy coast (85km) (Fig. 1). One quarter of the population live in the coastal zone (Folorunsho and Awosika, 2000). The Nigeria coast is richly endowed with a variety of natural resources, especially forests and mangroves, fisheries, touristic resources (beaches, lagoons, creeks), and mineral resources such as crude oil and gas. The environmentally sensitive wetland ecosystems which make up the Nigerian coast, therefore, have been areas of intense human activities connected with port and urban development, sand mining, dredging, land reclamation, wood harvesting, tourism development, and oil and gas exploration and exploitation.

Climate change induced sea level rise has been a major concern for coastal and low-lying areas of the world (Ahmed et al., 2018; Hassan and Hassaan, 2020). Sea level rise is one of the most significant effects of climate change. The level of the sea varies with time and space due to physical processes such as tides and waves. Low-lying coastal regions around the world are vulnerable to sea level rise (Rowley et al., 2007). According to IPCC (2013), the average global sea level rise is likely going to be between 28-61 cm and 52-98cm by the year 2100. Sea level rise is a global phenomenon attributable to global warming and subsequent melting of polar ice. A sea level rise of 15cm to 95cm is projected by IPCC. It can also be induced regionally by tectonic uplift in the ocean, changes in atmospheric dynamics that develop hurricanes, typhons, tsunamis, wind storms and tornadoes which generate astronomical tides and destructive wave heights and speeds from the ocean that impact the coastline and devastate its area of impact. The direct environmental consequences of sea level rise to the coast include increased flooding and erosion, intrusion of saltwater into surface water and wetland loss (Vitousek et al., 2017).

Over the last 20 years, rising sea level and more intense storm surge have battered Ayetoro. Recurrent floods have damaged hundreds of buildings including houses, schools and swept away over 50% of the town which is more below sea level. These have prompted individual environmental scientists, research institutions, and government agencies to proffer and implement lasting solutions to this problem. Unfortunately, many have failed woefully to solve the problems. In fact, in most cases, they have further undermined the stability of the coastal environment. All these underscores the need for research and database for coastline protection, coastal zone planning, and management. This is particularly desirable in respect of

the Ondo State coast owing to its uniqueness which makes it unwise to transfer to the area solutions which have worked in other but dissimilar areas.

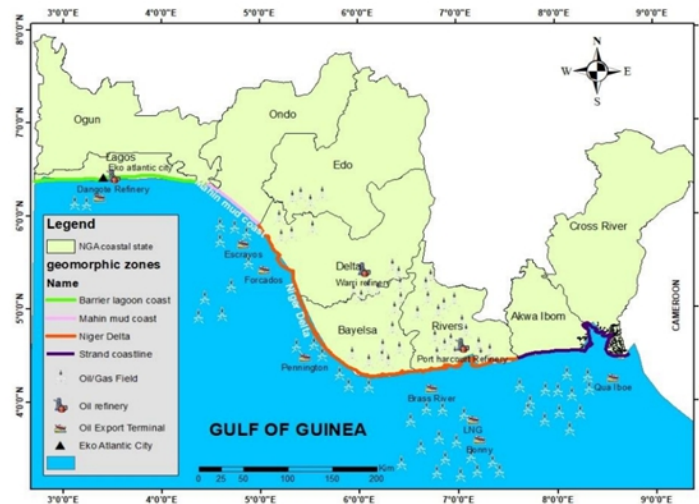


Figure 1: The coastline of Nigeria (Source: Olakunle et al., 2021)

Materials and Methods

Study Area

Ayetoro community is situated between latitude 5°16' N and 6°30'N of the Equator, and longitude 4°45'E and 5°45'E of the Greenwich Meridian. It is a coastal community in Ilaje Local Government Area, Ondo State, Nigeria (Figure 2). The major geological formations in the area include general alluvium, lagoonal marshes, abandoned beach ridges and coastal plains sand. The general alluvium comprises coarse, clayey, unsorted sands with clay lenses and occasional pebble beds which are lithological indistinguishable from typical coastal plains sand strata Ayetoro community occupies a part of the mahin mud coast with a soil textural composition of 54% clayey mud, 34% silt mud, and 12% sandy mud (Olakunle et al., 2021). Elevation ranges between 0 and 5 metres above sea level. Ayetoro is an ecologically endowed community with a characteristic richness in seafood such as periwinkles, crayfish, crabs, and the number of fish species. The study area experiences a tropical climate with a rainy season (April to November) and dry season (December to March), and average annual precipitation of 1648 mm rainfall with maxima occurring in June and October. The mean annual temperature is about 30°C. The main occupation of Ayetoro inhabitants is fishing due to the proximity to the sea. The inhabitants also engage boat making craft, farming, salt mining and commercial activities as means of sustenance.

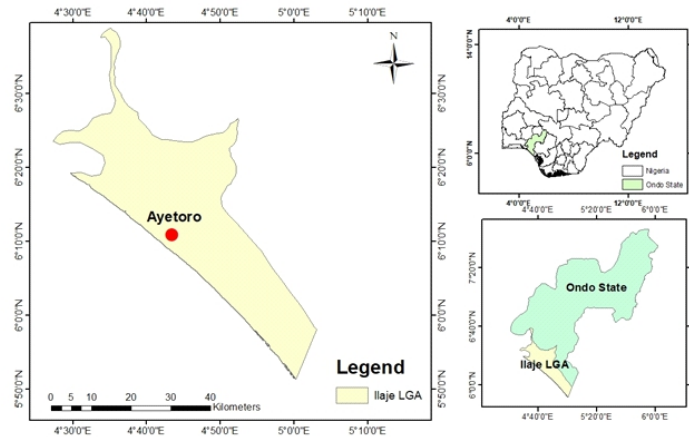


Figure 2: Map of the Study Area

Data Collection and Processing

Both quantitative and qualitative research approaches were adopted in this study. The quantitative approach involved a questionnaire survey to elicit information on the socio-economic characteristics of the inhabitants as well as the social and economic impacts of the sea in the community. The convenience sampling method was used to administer a close-ended questionnaire to a total of 300 people at a response rate of 100 percent. The samples were taken from residents above the age of 18 years. The qualitative approach adopted was the focus group discussion. Participants were selected using the snowball sampling technique. This was to allow the community inhabitants to express opinions and provide some valuable information on the incidence, causes, and impacts of sea incursion in the area as well as probable mitigation measures.

Results and Findings

Socio-economic Characteristics of Respondents

The socio-economic characteristics of the respondents are presented in Table 1. The Age distribution varies from below 20 to above 50 years; 40.3% of the respondents were in the age group of 31 – 40 years, 29.7% were 41 – 50 years, 15% were 21 – 30 years, and 8.3% were below 20 years. Education plays a vital role in exposing people to coping strategies against adverse situations (Muttarak and Lutz, 2014). Thus, it is paramount in enhancing respondents' understanding of sea level rise. Thus, literate individuals will tend to have a better understanding of the mechanisms and risks of sea level rise. Except for the few (8.3%) who had no formal education, most of the respondents are literate. The majority (33.3%) of them had secondary education, 31.7% had tertiary education, and 26.7% had primary education.

Gender is also an important social factor that influences the kind of profession an individual undertakes. Some professions are referred to as male-dominant while others are said to be female dominant especially in the African traditional society. Out of 300 respondents, 179 (59.7%) respondents were male while 121 (40.3%) were females. Women in this environment are beset with the inability to influence decisions in society (Adesemolu and Olukoya, 2020).

Considering the occupation of the respondents, 37.3% were involved in fishing activities, 21.7% were involved in trading; 12% were students, 11% were civil servants, 10.7% were artisan, while 7.3% are involved in other activities like farming, salt mining, and lumbering. Adesemolu and Olukoya (2020) reported that a significant proportion of women in Ilaje communities took part in farming activities ranging from production through cultivation, weeding, to harvesting and storage. Assessing the monthly income, it was observed that the majority (33.7%) of the respondents earned between ₦31,000 - ₦60,000. Also, 32% and 27.3% earned between ₦1,000 - ₦30,000 and ₦61,000 - ₦90,000, respectively; 7% earned between ₦91,000 - ₦120,000, while 5% earned up to ₦121,000.

Table 1: Socio-economic Characteristics of Respondents in Ayetoro Community

Variable	Option	Frequency	Percentage (%)
Age	<21 years	25	8.3
	21 – 30 years	45	15
	31 – 40 years	121	40.3
	41 – 50 years	89	29.7
	>50 years	20	6.7
Gender	Male	179	59.7
	Female	121	40.3
Marital status	Single	35	11.6
	Married	240	80
	Divorced	5	1.7
	Widowed	20	6.7
Educational qualification	No Formal education	25	8.3
	Primary education	80	26.7
	Secondary education	100	33.3
	Tertiary education	95	31.7
Occupation	Civil servant	33	11
	Fishing	112	37.3
	Trading	65	21.7
	Artisan	32	10.7
	Student	36	12
	Others	22	7.3

Source: Author's fieldwork (2023)

Impacts of Sea Level Rise on Ayetoro Community

The impacts of sea level rise on Ayetoro community falls into four categories namely intensified flooding, increased erosion of shorelines, salt water intrusion into freshwater and decline in coastal biodiversity (Table 2). Information given by 32.7% of the respondents shows that increased erosion of the shorelines impacts the community significantly (Fig.3). Intensified flooding received significant frequency (27.3%) as well (Fig.4). This was followed saltwater intrusion into freshwater (25%) and decline in coastal biodiversity (15%). The result

in Table 2 was further supported by field observation and information offered by the participants of the focus group discussion. When the coastal plain is flooded, it becomes dotted with flood pools for several days, restricting the movement of people within the community. This is more severe when the tidal waves dismantle the mudflats and dump the mud on wide areas of the coastal plain.

The raging sea level rise, which has claimed more than three kilometres length of land space of the island community has continued to render many families homeless. According to the respondents, sea level rise has become a constant occurrence, destroying buildings and properties worth millions of naira (Figure 5). Ayetoro was initially a 20 km landmass away from the sea, but recently has a larger part of its building under the sea. Findings show that more than 200 buildings have been destroyed while more than 85% of the entire land had been claimed.



Fig. 3: Coast Erosion of Shorelines



Fig. 4: Flooding of Community



Fig 5: Destruction of buildings in the Community

Table 2: Impacts of Sea Level Rise on Ayetoro community

Variables	Frequency	Percentage (%)
Intensified flooding	82	27.3
Increased coastal erosion	98	32.7
Saltwater intrusion	75	25
Decline in coastal biodiversity	45	15

Source: Author's fieldwork (2023)

Saltwater intrusion is also a serious environmental problem caused by sea level rise. The pollution of the freshwater has brought about a marked depletion of freshwater resources, and deterioration of drinking water supply in an area with no pipe-borne water. This has forced the local people to travel long distances further inland to fetch potable water from the swamp forest zone. This imposes an additional burden on women and children who at times, especially during the rainy season and high spring tides, spend a whole day in search of salt-free water. The depletion of freshwater resources by saltwater intrusion has also adversely affected the fishing economy by disrupting fishing activities in the swamps. The open swamp zone with its numerous lagoons used to be very rich fishing grounds. Pollution by saltwater and marine mud has turned the swamps into an unfavorable ecological environment for fishes. This brought about a sharp decline in fishing activities in the area and fishermen are driven further inland into the freshwater swamp forest zone which is naturally poor in fish resources.

Discussion

Although the socio-economic characteristics of respondents (Table 1) show more males than females, Adesemolu & Olukoya (2020) reported that women constitute the majority in the Ilaje area of Ondo State, and are more dependent on natural resources for sustenance than men. Women are saddled with the responsibility of ensuring the availability of food, domestic fuel, and water. Generally, safe drinking water scarcity is a common problem in the coastal zone of Ondo State, and this compels women and children to walk long distances to fetch water (Babatunde, 2010). Arora-Jonsson (2011) argued that water scarcity renders the Ilaje area vulnerable to a higher incidence of water-borne diseases and deaths, because water

fetched from distant sources may get contaminated while in transit. It has also been reported that climate variability will increase mortality by 250,000 per year (WHO, 2017).

Fishing, which is the people's main occupation, has become impossible due to water pollution and high tide. The pollution of the area and the rising sea level have led to the loss of plants and animal species (Figure 4). This usually leads to a decrease in income of the people which in turn affects their livelihood. This gives credence to the findings of Adesemolu & Olukoya (2020) who reported that the changing climate affects the socio-environmental determinants of health which include safe drinking water, clean air, food security and good shelter. Thus, Ayetoro community is characterized by low resilience and adaptive capacity to coastal problems. The study also shows that the Ilaje area, of which Ayetoro is a component, is vulnerable to weather extremities that include flooding, drought, and sea level rise, having recourse to a multiplicity of natural and anthropogenic drivers (Adesemolu & Olukoya, 2020). The locational characteristic of the settlement, particularly in terms of altitude and proximity to the Indian Ocean, increased the susceptibility of its populace to climate change (Danladi et al., 2017).

Sea level rise will mean less land for terrestrial activities (Adesemolu & Olukoya, 2020). Coastal flooding in Ayetoro community sometimes causes temporary and or permanent displacement of the inhabitants. As the areal extent, depth, duration, and frequency of flood and mud pools increase, life becomes unbearable, and the people are forced to abandon their houses and move to safer grounds further inland. Paskoff (2009) posited that given the prevailing situation of sea level rise orchestrated by climate change, coastal settlements are likely to experience an increased storm surge frequency causing sporadic or perpetual inundation. Paskoff (2009) also asserted that coastal erosion will persist considerably because sea level rise will cause increased frequency and severity of storms, thereby producing surges that will penetrate inland farther. The return period of sea incursion water levels will decrease over time, thus, causing an increased incidence of sea surge as currently being experienced in Ayetoro community. This has been predicted by Olakunle et al. (2021) who reported that extreme significant wave height will rise to 1.29 m, 1.54 m, 1.59 m, 1.91 m, 2.12 m, and 2.27 m for 2-year, 5-year, 10-year, 25-year, 50-year and 100-year return periods, respectively. Moreover, coastal flooding and sea level rise will adversely impact the social and health determinants of wellbeing by damaging infrastructure and impeding access to health resources (Neumayer and Plümper, 2007).

Loads of suspended silt and clay eroded from the sub-tidal flat, mudflats, and the coastal plain are regularly moved through numerous inlets into the inland swamps. As they enter calm waters, they rapidly settle and are deposited in the creeks and waterways at ebb tide. The silting and complete eutrophication of the numerous lagoons which were rich freshwater fishing grounds has brought about a sharp decline in fish resources. According to Nwankwoala and Udom (2008), as 80% of the world biodiversity is concentrated in the coastal areas, changes in ocean and atmospheric dynamics are expected to alter the ecology of micro and macro faunal and floral assemblages in the coastal zone in response to fluctuations in thermocline and salinity. Consequently, these changes will affect the migration patterns of fishery resources in

search for food and congenial ecosystems both in inland and waters in the ocean. The decline in quantity of daily catch of fish stock due to impact of sea level rise will increase the cost of consumption of aquatic resources in Nigeria. Eventually, many artisans' fishermen could change their occupation for alternative means of sustenance of their livelihoods. These will also lead to decline in economic activities of the people in Ayetoro who trade in fishery resources. The muddy saline waters constitute an unfavorable habitat for freshwater fishes. Olakunle et al. (2021) established that about 95% of the spatial extent of Ayetoro is vulnerable to river flooding and storm surges from the sea due to low topography, high mean wave heights, nearness to the shore, and characteristic landforms such as sandy beach, delta and estuaries.

Conclusion

The present environmental concern of low-lying settlements in the coastal region calls for concern. This study has shown that there is impact of sea level rise on Ayetoro community. These impacts are detrimental, and taking all measures to combat sea incursion is more than necessary in any society. The Nigerian government and private sectors operating in the coastal communities should assist in the blocking of channel openings into the sea at Awoye and Abereke and the construction of special channels with adequate safeguards against sea level rise. Hence, it is concluded that Ayetoro community would not be spared from the severe impact of sea level rise which will affect several houses/households depending on the level of sea rise. Awareness campaign on possible impact of sea level rise should be carried out by the appropriate agencies of government including the Federal Emergency Management Agency and their state counterparts.

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