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ADAPTATION STRATEGIES FOR, NIGERIAN COASTAL COMMUNITIES FACING RISING SEA LEVELS AND ENCOURAGEMENT OF AGRICULTURAL ACTIVITIES: A COMPREHENSIVE REVIEW

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Abstract: In an effort to gather adaptation strategies for reducing or combating rising sea levels (RSLs) faced by Nigerian coastal communities, and encouragement of agricultural activities, a comprehensive review of literature was conducted on similar subject matter based on the previous studies carried out by other researchers across the world. However, impact of and factors promoting rising sea levels were discussed. Their approaches of adaptation were explored on the basis of restricted solutions implemented for efficient management of the RSLs. The study further presents a wide-range of different and well-defined native adaptation strategies and utilized by the affected coastal communities to combat the impact of the RSLs. These strategies included wetland protection and restoration, coastal engineering solutions, among others. This study also underscores the importance of community involvement and collaboration with government in implementing coastal zoning protocols and government policy recommendations to alleviate the negative effect of RSLs.

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By providing hands-on solutions, this study contributes to the ongoing global dissertation on climate adaptation and resilience in vulnerable coastal areas, especially in Nigeria.

Keywords: Rising sea levels, coastal communities, adaptation strategies, agricultural activities.

INTRODUCTION

The coastal communities in Nigeria comprises of states that are closest to the Atlantic Ocean. These include Akwa Ibom, Bayelsa, Cross-River, Delta, Edo, Lagos, Ogun, Ondo and Rivers States (Figure 1), [1].

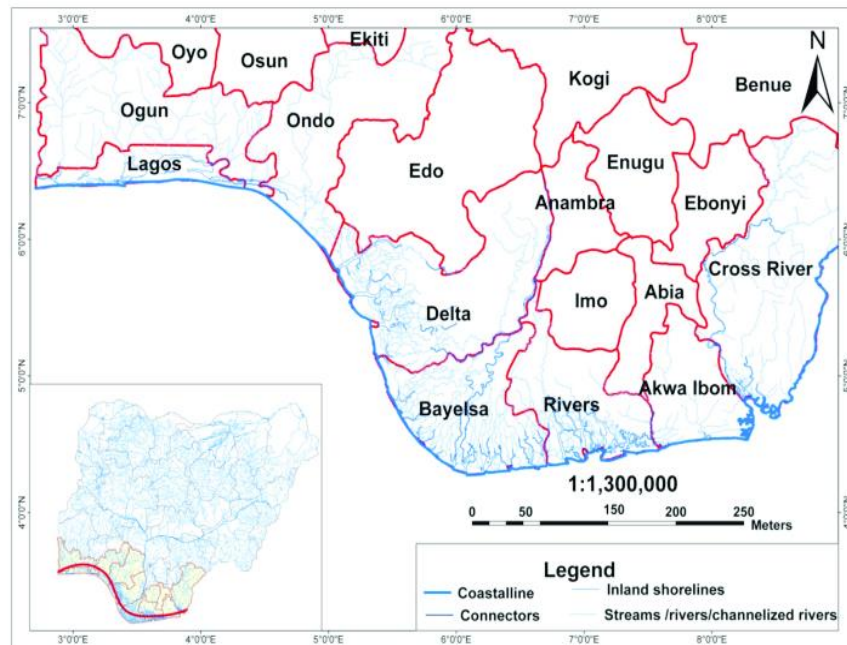


Fig. 1. Coastal regions of Nigeria, [2].

A number of coastal communities has in recent times suffered series of environmental pollution and flooding which indirectly hinder agricultural activities. Among the aforementioned states are oil-producing states. These include Akwa Ibom, Bayelsa, Cross-River, Delta, Edo and Rivers States. Commercial activities are also prevalent in these coastal states – besides the oil producing states. Lagos, for instance, is generally considered as the economic capital of the country. As a result, large number of people migrate to the area for available job opportunities. The inland-coastal migration in Nigeria is not an isolated scenario; such migration is experienced globally, [1]. The rise in populace in these coastal areas and pollution generated from industrial activities, worsen the condition of global climate.

The extensive study on flooding and rising sea levels (RSLs) has principally focused on societal adaptation to combat RSLs, whereas there has been relatively less emphasis on studying the coastal erosion menaces. Coastal erosion is a natural process involving alterations in coastal landforms as a result of sediments deposition or loss, leading to either advancing or retreating coastlines, [3]. In densely populated regions, such as retreating coasts, this natural phenomenon transmutes into a hazard, worsened by both human activities and climate change. Studies have showed that human activities, like construction and coastal development, have been less explored as origins of coastal erosion but should be a substantial concern, [4, 5].

Also, human activities have meaningfully affected coastal regions, creating environmental problems that require attention not only physical and environmental factors but also human-induced influences, [5]. Coastal zones are gradually utilized for various purposes such as agriculture, tourism, harbours, and settlements, leading to widespread engineering and interruption of natural coastal processes, [6]. The convergence of a growing population at risk and the expected impact of climate change on coastal dynamics will intensify the effects of coastal hazards on social-ecological systems. These systems associate both ecological and social elements in controlling resource flow, [7].

The resultant impact of RSLs under a sustained period result in the loss of sediment (land). This process is known as coastal erosion. The coastal erosion triggered by rise in sea level evaluated between 1984 and 2016 increased the shore line of Rivers State coast, with 30% of the coast accreted and 70% undergoing erosion, [8]. Climate alteration deteriorates the rate of coastal erosion. Consequently, people are displaced from their homes and forced to move further inland. Regrettably, sometimes, flooding occurs even at night, leading to destruction of valuable items, including farmlands and even human lives, [9].

The unlucky reality at the global level, at present, is that the efforts aimed at decreasing the progression of climate alteration seems insufficient. The rate of climate change impact far outpaces global attempts to adapt to them. Moreover, the degree and magnitude of climate alteration are larger than earlier prediction. By middle of the century, about one billion people would be exposed to greater risks of flooding caused by RSLs, [9]. Hence, in this study, effort is made to assess the adaptation strategies that could be implemented to reduce the effects of RSLs and encouragement of agricultural activities on the coastal communities in Nigeria. Specifically, we shall look at: (i) assessment of the impacts of RSLs on coastal communities in Nigeria; (ii) review of adaptation strategies implemented in various parts of the world to manage the RSLs and (iii) the appraisal of local strategies implemented to manage the situation.

IMPACT OF AND FACTORS PROMOTING RISING SEA LEVELS (RSLs), AND ADAPTATION STRATEGIES / MEASURES

Impact of Rising Sea Levels (RSLs) in Nigerian Coastal Communities

The augmented atmospheric water content due to sharp evaporation, as a result of global warming, has led to a prominent increase in heavy rainfall across Nigeria, especially in the year 2012., [10].

These increased rainfalls triggered considerable flooding, making urban drainage channels to overflow, breach in riverbanks, submergence of floodplains and tidal flats. The costs of such flooding are terrible, involving the loss of terrestrial wildlife, widespread damage to crops in farmlands, and the destruction of both human lives and property, particularly regions situated within tidal flat and flood-plains regions. Unfortunately, coastal inhabitants are plunged into hardships and economic distress. Remarkably, the Niger Delta coastal zone, considered to have complex network of rivers and drainage systems, serves as a deposition region for inland floodwaters across Nigeria, [10]. Moreover, the coastal zones face with the destructive aftermath of extreme rainfall and wind storms, inflict havoc on power transmission lines, sub-station equipment, and agricultural lands, [11, 12].

The effect of rainfall on the coastal zone results in landward floods from the mainland to the continental shelf, whereas the impact of RSLs outspreads from the shoreline towards the hinterland.

The movement of seawater into coastal aquifers creates a stern threat to the groundwater resources in the Nigerian Coastal Zone. This intrusion meaningfully changes the water table, hydrogeochemical features, and the interface between freshwater and saltwater, resulting in considerable dislodgment of the hydraulic slope landward, [13]. Simultaneously, the rising rate of coastal erosion attributed to increased wind velocities and the intensified influence of wave energy on shorelines has resulted in rapid shoreline retreat in areas such as Lagos, Awoye/Molome, Ogberedo, Forcados, Escravos, Ibeno, Brass and others, [14]. Nevertheless, coastal region such as Niger Delta had displayed temporary shoreline progression due to sediment inflow from hinterland floods, [15].

The collective influence of RSLs, flooding and erosion seriously looms to diminish Nigeria's already scanty beaches, possibly displacing key recreational facilities for tourism, [16]. Universally, RSLs, mainly come from global warming and subsequent result in polar ice melting. RSL is likely to increase from 15 cm to 95 cm. Locally, climate-induced sea-level rise in Nigeria is related to regular storm increase, which results in vast erosion along the coastline, [17].

Based on geographical setting, coastal erosion, amplified precipitation and flooding, the Niger Delta region is susceptible to sea-level rise, [18]. This disastrous event led to the submersion of substantial land area into the Atlantic Ocean, posing significant fears to both the populace and the regional economy, [19, 20]. The coastal regions are liable to undergo environmental changes due to shifts in ocean and atmospheric activities. These changes influence fish migration patterns in response to salinity and thermocline variations, thereby meaningfully affect fishes both in the ocean and inland waters, [21]. Also, the changes could lead to reduction in fishing yields, which may likely influence the availability and cost of fish resources, an essential dietary food in Nigeria, [22, 23].

Coastal environmental degradation, resulting from industrial pollution through oil and gas exploration and the hostile effects of climate variation, sternly endangers fresh water supplies, exposing several coastal inhabitants to precarious water sources. This situation causes numerous health hazards, including heat-related diseases in both human and animal populations, and ozone layer depletion in the coastal zone, [24].

Factors Facilitating the Rising Sea Levels in Nigeria

Coastal communities have lower elevation compared to other neighbouring regions. As a result, the water-tables are higher than those in-land areas, hence, decreases soil seepage capacity in coastal areas. Simultaneously, precipitation is higher and there are greater likelihoods of heavy rainfall to be experienced, coupled with poor waste disposal management aggravates the situation, [1]. Deforestation, caused by human activities, appears to be a key player increasing coastal erosion. Moreover, anthropogenic activities such as engineering projects, land reclamation, establishment of seaports and jetties, sand and gravel mining, dredging, and altering river channels aggravate coastal erosion, [25, 26, 27]. Persistent urbanization tendency could drive coastal erosion to uncontrollable levels, [27].

Quest for building materials and roofing leads to backshore vegetation removal, leaving coastlines vulnerable to weathering agents such as strong winds, waves and RSLs. As one of the most densely populated areas, coastal areas require effective monitoring and management strategies to control erosion. Inefficient coastal management practices, excessive water extraction, river diversion, sand mining, building and construction activities could pose major threats to coastal erosion, [28]. As mentioned beforehand, coastal regions in the world attract immigration, particularly when such regions are favourable shipping courses. It is extensively reported by numerous scholars that economic activities, i.e., industrialization has contributed enormously to the predominant global warming experienced today. Regrettably, the coastal communities are toughest hit by the RSLs. However, Table 1 shows information on the economic activities that occur in the coastal areas in Nigeria.

Table 1. General Economic Information on the Nigerian Coastal Area

S/N	State	Population (persons)	Land Area (km ²)	Population Density (persons /km ²)	Economic Activities
1.	Akwa Ibom	5,780,581	7,081	816.35	Oil and gas, agro-allied, industries, wood work and furniture, soap and detergent manufacture, metal works, hide and skin, lumbering and sawmilling, arts and crafts.
2.	Bayelsa	2,394,725	10,773	222.29	Oil and gas, coastal tourism, agriculture, aquaculture, palm oil milling, local gin making, carving and weaving, and trading.
3.	Cross Rivers	4,175,020	22,590	184.82	Petrochemical, wood processing, agriculture, aquaculture, quarrying and cement manufacturing, rubber and latex, metals processing
4.	Delta	6,107,543	17,698	345.10	Oil and gas, processing, wood, petrochemical, foam, metals, manufacturing, and alloys

Cont.	Table 1.				Agriculture and fishing, petrochemical, wood processing, foam manufacturing, metals and alloys
5.	Edo	5,161,137	17,802	289.92	
6.	Lagos	15,772,884	3,345	4715.36	Textile, food processing, foam and water, asbestos, pharmaceuticals, metals and alloys, shipping
7.	Ogun	6,445,275	16,762	384.52	Textile, breweries, lumbering and sawmill, foam, plastics and rubber manufacture and quarrying
8.	Ondo	5,469,707	15,500	352.88	Agriculture, lumbering and sawmill, oil and gas, quarrying, sand mining.
9.	Rivers	7,234,973	11,077	653.15	Petrochemical, oil and gas, foam manufacturing, metals and alloys, and pharmaceuticals

Note: The population is 2019 forecast based on the 2006 Nigeria Census figures

Source: [29,30,31]

Adaptation Strategies and Measures

The realistic technique to tackle the present trend of RSLs and its associated consequences is adaptation. This truth is worthy of note, reason been that the emissions drop cannot be dealt with near and the mid-term impact of RSLs. This means that even though all the carbon emissions were removed now, the RSLs would still rise, due to global warming effect, [9]. Luckily, those people that lived on the coastlines, for numerous decades, have learnt to adapt to coastal fluctuations. The experience summed up over time has been passed down to the present generations. Still, the rate of coastal variations nowadays is rather considered momentous and the implementation of more real solutions are important. However, the strategies for implementing adaptive solutions have characteristic limitations which must be addressed. Such limitations range from methodological or technical to economic constraints. Social constraints may also exist and acceptable by the affected inhabitants. For example, the use of sea walls technology could lead to the safety of some inhabitants behind it and some who reside in the adjacent coastlines may be vulnerable, [32]. Based on this premise, it is essential to implement adaptive solutions that are locally-sensed. If successful, the solutions may be scaled up to sustainable level. Besides, the adjacent communities could also learn and implement the same. Successful adaptation entails the implementation of the following, [33]: (i) the use of dykes, rip-raps, seawalls and groynes.

These facilities, if adequately calibrated, could aid in the estimation of safety levels; (ii) construction of new natural bumper areas or renewal of degraded ecosystems; and (iii) planned relocation of inhabitants and properties from affected areas.

In Nigeria, numerous approaches have been adopted by affected coastal communities to control the situation. Such approaches include: (i) utilization of bags filled with sand and placed along the shore; (ii) building of canals and channels; (iii) construction of river embankments; and (iv) raising the existing ground above its level or shore protection embankments, [34].

Communities within the coastal regions require mutual support, in cases of disasters such as flood. Assistance to flood victims could be in form of grant, loan or temporary accommodation until the flood water recedes. Materials used in the design and construction of walkways in such communities have evolved over time. These materials can withstand frequent devastating flood experienced in such communities, [2].

CASE STUDIES, POLICY COMMENDATIONS AND EXECUTION, AND APPRAISING THE EFFICIENCY OF ADAPTATION STRATEGIES

Case Studies

Non-governmental organizations (NGOs), for instance, in Papua New Guinea's, New Ireland Province introduced training programs for locals, where advanced methods for building and maintaining lasting boat jetties and seawalls (Figure 2) were adopted. Here, rock from deceased coral and near-by community's materials were used. Equipped in the training was the sharing of their knowledge with the neighbouring areas, which aided them to hand-pick and implement the strategy. Ecosystem-based adaptation approaches, used natural bionetworks as shown in Figure 3, [32].



Fig. 2. Seawalls, [32].



Fig 3. Restored Mangroves in Papua New Guinea, [32].

The aforementioned strategies offer various benefits such as erosion control, flood reduction and storm protection. The involvement of local bionetworks control naturally aligns with local needs and contexts. For example, successful mangrove restoration was initiated in Indonesia, Fiji and southern Florida [32].

In Manus Province, Papua New Guinea, island regions sought to reproduce a rich coral reef restoration project from a neighbouring island to protect shorelines and boost fish habitats. Nevertheless, local adaptation strategies may suffer some limitations. Failures abound, in terms of poor local support or ownership, poor maintenance needs and inadequate community consultation [35]. Also, in Vanuatu, a locally engrossed ecosystem restoration scheme was carried out. It involved tree nurseries which were faltered due to the neglect of maintenance and replenishment of coastal vegetation amid increased tidal heaves. Besides, seawall building schemes aimed at fighting erosion and land loss in Federated States of Micronesia and Fiji failed due to their inefficient and inadequate local approval or ownership. The future adaptation strategies could be redefine based on the setbacks learnt from similar failed projects [36].

Policy Commendations and Execution

Based on the predominant condition, integrating policies such as complete coastal zone control strategies that embrace both environmental and human aspects, in-line with specific climate variation adaptation policies must be put in place. Partnerships between non-governmental organizations (NGOs), government bodies, research institutes, and local communities are vital. Partnerships is to ensure inclusive decision-making processes and effective implementation of adaptation strategies. Furthermore, community involvement is important. Allowing local communities to involve in planning, decision-making, and capacity-construction enterprises is paramount. This inclusion permits contribution of traditional practices and local knowledge, and adaptation strategies to be more efficient and sustainable. Funding and resource provision play a substantial role. There is a need to provide funds for coastal adaptation schemes, ensure fair distribution and effective usage. Encouragement of public-private partnerships (PPPs) could enhance additional financial resources for adaptation plans.

These partnerships should secure private sector investments while the host communities derive target benefits and ensure environmental sustainability. Moreover, supports for research and development in some robust infrastructures and sustainable livelihoods are indispensable.

Appraising the Efficiency of Adaptation Strategies

There is need to regularly evaluate and appraise the adaptation strategies implemented in the coastal communities. Such evaluation can create room for progress and in turn ensure the inhabitants' safety in such places. It will also promote sustained economic activities in the coastal areas such agriculture, trade, etc.

CONCLUSION

In a nutshell, the coastal regions of Nigeria (Akwa Ibom, Bayelsa, Cross-River, Delta, Edo, Lagos, Ogun, Ondo and Rivers) have been faced with innumerable challenges aggravated by flooding, environmental pollution, impact of industrial activities, predominantly in oil-producing states. The concentration of commercial activities, as well as considerable inland-coastal migration, deepens the strain on these areas, which result in high vulnerability to impact of climate variation. In order to tackle these challenges, healthy policy frameworks, all-inclusive coastal zone management strategies and explicit climate variation adaptation policies must be put in place. Collective efforts of governmental bodies, NGOs, research institutes and local communities are vital to enhance efficient planning, decision-making, and implementation of adaptation strategies. Engagement of local communities in planning and capacity-building plans, traditional knowledge sharing is very important to ensure more sustainable adaptation measures. Furthermore, provision of adequate funding and resource allocation and encouragement of public-private partnerships, can boost financial support for adaptation initiatives. Supports for research and development in some robust infrastructures and sustainable livelihoods are indispensable which further strengthen the adaptive capacity of coastal communities. Again, to ensure the success of these strategies, continuous assessment and review must be upheld. Frequent assessments of implemented adaptation strategies would enable improvements, ensure the safety of coastal populaces and foster sustained economic activities in these regions.

CONFLICT OF INTEREST

None is declared.

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**STRATEGIJE PRILAGOĐAVANJA OBALSKIH ZAJEDNICA NIGERIJE
KOJE SE SUOČAVAJU SA PORASTOM NIVOA MORA,
I PODSTICANJE POLJOPRIVREDNIH AKTIVNOSTI:
SVEOBUH VATNI PREGLED**

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Apstrakt: U nastojanju da se prikupe strategije prilagođavanja za smanjenje ili suzbijanje porasta nivoa mora ((PNM – porast nivoa mora, eng. RSLs - rising sea levels) sa kojima se suočavaju zajednice stanovnika na obalama mora u Nigeriji, sa podsticanjem poljoprivrednih aktivnosti. Zato je sproveden sveobuhvatan pregled literature o sličnoj temi na osnovu prethodnih studija koje su sprovedli drugi istraživači u Svetu, gde se raspravlja o uticaju i faktorima koji podstiču porast nivoa mora. Njihovi pristupi prilagođavanju istraženi su na osnovu različitih rešenja implementiranih za efikasno upravljanje (PNM – porast nivoa mora).

Studija dalje predstavlja širok spektar različitih i dobro definisanih strategija prilagođavanja stanovnika koje koriste pogođene obalske zajednice u borbi protiv uticaja (PNM – porast nivoa mora). Između ostalog, ove strategije su uključivale zaštitu i obnovu močvara, i inženjerska rešenja obale mora. Ova studija takođe naglašava važnost uključivanja zajednice i saradnje sa vladom u implementaciji protokola o uređenju priobalja i preporuka vladine politike za ublažavanje negativnih efekata (PNM – porast nivoa mora).

Pružajući praktična rešenja, ova studija doprinosi aktuelnoj globalnoj problematici o klimatskoj adaptaciji i otpornosti u osetljivim obalnim oblastima, posebno u Nigeriji.

Ključne reči: Porast nivoa mora, obalske zajednice, strategije prilagođavanja, poljoprivredne delatnosti

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