Journal of Oceanography and Marine Research

Udo-Akuaibit, J Oceanogr Mar Res 2017, 5:4
DOI: 10.4172/2572-3103.1000172

Conference Proceedings Open Access

Sea-Level Rise and Coastal Submergence along the South – East Coast of Nigeria

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Abstract

Coastal submergence and shoreline retreat constitute a serious threat to shoreline management in the Niger Delta. Short-term and long-term changes on the shoreline adjoining Qua-Iboe River estuary, south-east coast of Nigeria are analysed to assess the impact of sea-level rise and climate change on the shoreline. A comparison of the 2002 and 2013 editions of the maps of the shoreline indicates a landward retreat of the shoreline and a submergence of village of Itak Abasi in the Atlantic Ocean over an estimated area of 180000 m^2 along the coastline. Analysis of shoreline changes over neap-spring tidal phase confirmed that the submerged area of the updrift shoreline was threatened by severe and chronic erosion in which the rate has reduced to 178 m^3 per day. The downdrift experienced high rate of accretion at 1490 m^3 per day with sediment gained from the updrift shoreline and the ebb tidal delta as well as input from fluvial discharge into the estuary. Near-shore wave climate was characterized by the wave breaker heights which fluctuated between 30 cm and 70 cm at a period which ranged between 5 to 8 seconds, the occurrence of edge waves during mid-flood tidal stage along the mid foreshore, predominantly eastward directed long-shore currents and storm surge events at the updrift shoreline are considered as the hydrodynamic processes which caused the shoreline retreat and submergence. The intensity and magnitude of the impact of the processes on the shoreline are attributed to sea-level rise and climate change. Sustainable shoreline management strategies including measures for mitigations and adaptations to climate change are recommended.

Keywords: Shoreline; Retreat; Sea-level rise; Submergence and management

Introduction

Sea-level rise and climate change are global issues which need global effort to tackle its undesirable consequences in the world coastal zones. These are some of the major geo-hazards which threaten the structural integrity and retreat of Nigeria coastline. Some of the effects on the coastline include coastal erosion, storm surges, flooding, sea water intrusion and coastal submergence. The degree of impact is much noticed along the coastal fringes where many structures have been eroded away and some areas completely submerged in the Atlantic Ocean such as Lagos. Apart from sediment loss to the sea due to coastal erosion, the adjoining mangrove swamp forest especially in the Niger Delta is also under the threat of marine water incursion into and landward displacement of the brackish water ecosystem as well as sea water intrusion to coastal aquifer. This poses salinity stress on biodiversity in the mangrove ecosystem. It has been reported that before the end of the century, the coastline of West Africa extending from orange dune in Mauritania down to Cameroun will be submerged as a consequence of climate change and sea-level rise. Sea-level rise at the rate of 2 cm per year along the Nigeria coastline in the Gulf of Guinea will be dramatic around Lagos which is 5 m above the sea level and some areas located belowt he sea-level; and the Niger Delta region is expected to be swamped [1]. According to a report by the Center for Environment and Development in Africa [2] on the Coastal Profile of Nigeria, the Sea-level rise of 0.3 m could cause shoreline recessions of more than 35 m and estimated one-meter sea level rise in Nigeria would flood 18000 km^2 of coastal land [3]. Global sea-level rise which ranged 10-20 mm/y in the last century is expected to rise at the rate of 20-88 mm/y during the next 100 years [4].

Various incidents of storm surges have occurred in the past decades along Nigeria coastline especially along the barrier coast of Lagos and the Niger Delta region. Of recent past is the storm surge incidence in 2011 which struck the strand coastline adjoining Qua-Iboe River estuary, Ibeno, Akwa Ibom State, South-east coast of Nigeria. The incident wiped out the former Itak Abasi village, a fishing settlement, into the sea, with a landward offset displacement of updrift shoreline over a distance of 600 m off its former seaward limit.

This paper, as an extract from my Master of Science Degree dissertation, aimed at analyzing shoreline recession as a result of sea level rise as accelerated by the storm surge incidence. It also examines the impact on the strand coastline.

Study Area and Techniques

The study area is the exposed updrift shoreline of the partly submerged Itak Abasi village located west of and adjoined to Qua-Iboe estuary in Ibeno, Local Government Area, Akwa Ibom State, south-east coast of Nigeria. The ocean shoreline is exposed to semidiurnal tides with tidal range of 2-5 m and southwesterly waves with amplitudes which are less than 20 cm and modal periods close to the shore are 8-12 s [5]. The wind conditions usually vary from calm (November-February) through transitional (February-April) and storm (May-October) [6]. The area is located in a climatic belt where daily temperature varies between 20^{0}C and 30^{0}C, and heavy annual rainfall from April to October which ranged 2500 mm-4500 mm. South-Westerly wind conditions prevail in the rainy season with North-East trade wind being the prevalent wind condition in the dry season [7]. The shoreline is an exposed section of abandoned beach ridges which

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Received October 13, 2017; **Accepted** November 08, 2017; **Published** November 15, 2017

Citation: Udo-Akuaibit SP (2017) Sea-Level Rise and Coastal Submergence along the South–East Coast of Nigeria. J Oceanogr Mar Res 5: 172. doi: 10.4172/2572-3103.1000172

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are laterally bounded by mangrove swamp of the lower Deltaic plain of Holocene age. It is probably underlain by Sombreiro-Warri Deltaic plain sand of late Pleistocene [8]. The grain size characteristics of the shoreline are texturally homogenous, predominantly well to very well sorted and very fined grained sand [9].

The recent shoreline alignment of the study site was surveyed with the aid of Global Positioning System (GPS) during my field study. As part of the scope of my dissertation which cover a period from September 28-October 6, 2013 over neap- spring tidal phase. The geographic coordinates-way points recorded were plotted along x-and y- axes on a topographic transparent sheet to produce the map of the study area. The recent map of the shoreline was superimposed on the 2002 edition of the shoreline map of the study area to analyze the shoreline changes and recession in the past ten years and the impact of the storm surge incidents on the coastline in 2011. Current monitoring and beach profile stations were established at intervals 200 m and 300 m of within a 500 m stretch at the updrift and downdrift surf zone shoreline respectively. Daily beach profile surveys were carried out during low tide with the aids of graduated staff and a measuring tape using horizon as a reference point over a neap-spring tidal phase. Long-shore current velocities were measured at the monitoring stations at half hourly intervals using Langrangian technique. Near-shore wave breaker heights and water depths were also measured at half hourly intervals using graduated staff at the monitoring stations [7].

Result and Discussions

Figure 1 shows the shoreline map of the study area in 2002, The map and Figures 2 and 3 depict two areas of intense and localized erosion arcs on the downdrift estuarine shoreline. This was attributed to the scouring action on the shoreline around the elbow/convex segment of the meandering ebb tidal channel in the estuary [9]. The degree of channel meandering in the estuary is suggestive of and enhanced by sea- level rise with a landward shift in the hydrodynamic boundary of sea water incursion in the estuary. It is the barrier or obstructive effect of upstream flow of the seawater against downstream flow of fluvial current in the ebb tidal channel in the estuary which is suggested to trigger-off channel meandering upstream of the estuary.

(Figure 4) which is the 2013 edition of the map of the study area shows the updrift shoreline which is the specific study site for the storm surge incident. The area labeled ABC on the map in (Figure 5) was the former coastland of Itak Abasi village which is now under the ocean. An estimated area of 180000 m^2 of the land is submerged during low water and the shoreline has recessed along the estuary over a distance of 600 m off the seaward limit as at 2002, the Itak Abasi Creek entrance which opened directly into the estuary before 2011 is sealed up with sediment (Figure 6) and displaced the discharge point upstream of the estuary to about 700 meters from its former location. The above finding is consistent with the prediction of [3] on the effect of sea-level rise on Nigeria

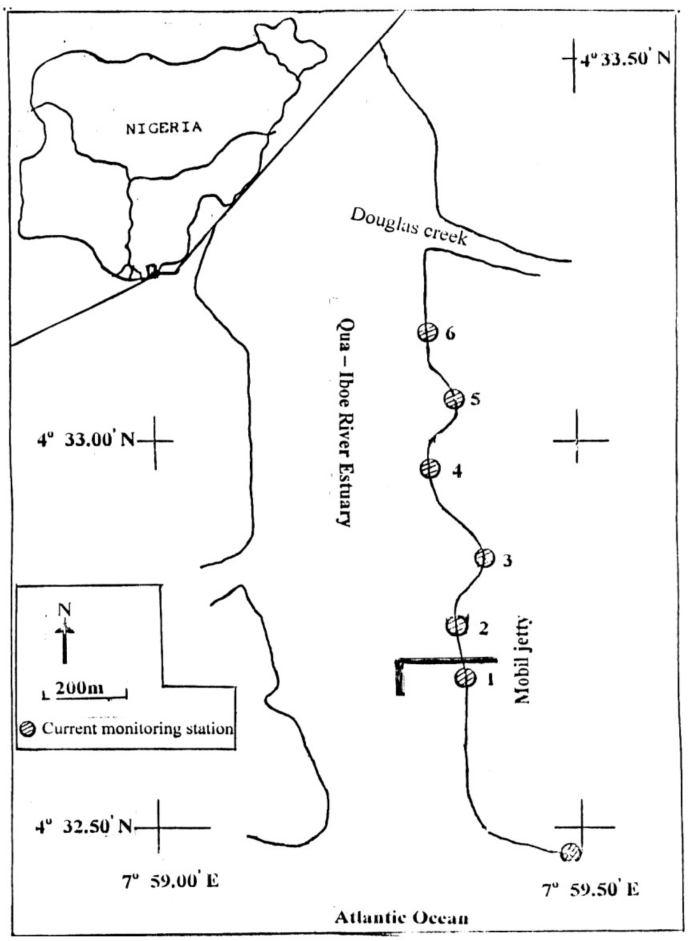

Figure 1: Location map of the study in 2002 – Qua-Iboe estuarine shoreline (After Udo, 2002).

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Figure 2: Aerial photo of Qua-Iboe River Estuary in 2002.

Figure 3: Aerial photo of Qua-Iboe estuary in 2002 showing areas of severe erosion.

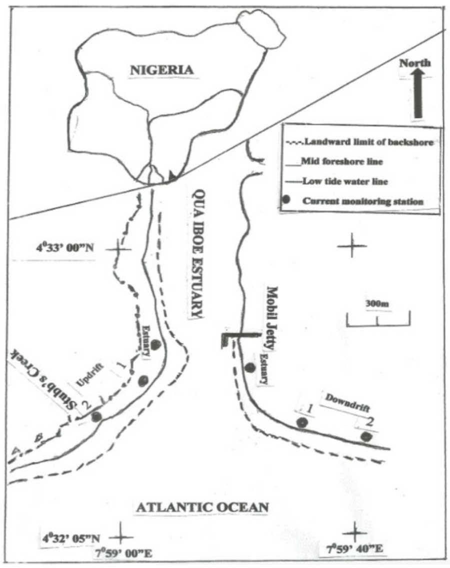

Figure 4: Location map of the study area showing current monitoring/beach profile stations(Surveyed and produced by Saviour Udo Akuaibit, October 2013.

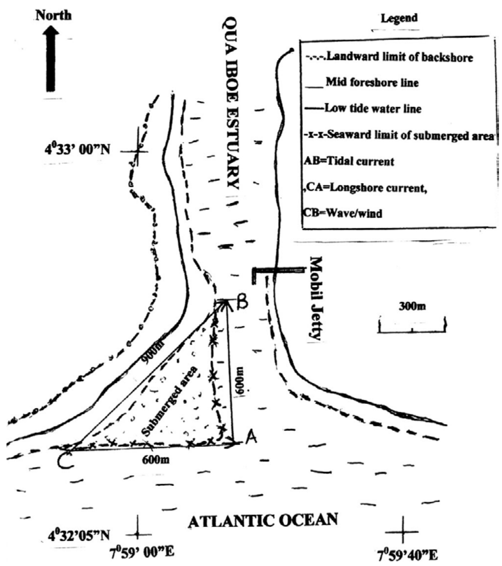

Figure 5: Location map of the study area showing updrift shoreline offset distance and submerged area. (Udo – Akuaibit, 2013).

coastline. (Figure 6) shows surging wave-breaker sedimentary marks which were dominant during this investigation in the areas impacted by the storm surge incidence. The north-east alignment of the crests of the surging breaker marks is indicative of the fact that surging waves in the Gulf of Guinea which are generally developed in the offshore by the South-Westerly wind propagate onshore due north-east. The continuous dominance of surging breaker sedimentary marks close to the estuary mouth over sinusoidal wave sedimentary marks at about 500 m away from the estuary on the updrift beach of the study area are the relics of attenuated impact of storm surge event since 2011 (Figures 7-8).

Figure 6: Itak Abasi Creek sealed with sediment during storm surge in 2002.

Figure 7: Updrift shoreline showing trough with water at the foreshore during low tide.

Figure 8: Surging wave sedimentary marks on the updrift shoreline close to the estuary.

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The near-shore wave breaker height pattern fluctuated between 30 cm at low tide and 70 cm at high water and 91.97% of long-shore current velocities with the average of 59.78 cm/s east were directed to the east at the updrift [7-10].

Result of beach profile plots as shown in (Figures 10 and 11) depict a concave beach profile on the foreshore which indicate erosion at the updrift and a convex beach profile on the foreshore of the downdrift beach which is attributed to accretion of sediment. The erosion on the concave foreshore of the updrift beach was accentuated by the action of the edge wave which propagate due west during rising flood tide along the shoreline and later reversed eastward to the estuary mostly as long-shore current. A comparison of the rate of erosion/accretion at the study area revealed that the downdrift accretes at the rate of 1490 m^3 per day while the updrift erodes at the rate of 178 m^3 per day. The low rate of erosion at the updrift is indicative of a reduction in the erosive energy of wave action resulting from attenuation of storm surge influence with time in the area. Moreover, the submergence process of the coastline and the rise in mean high water level on the shoreline are expected to approach the climax hence the reduction in the rate of erosion. In the contrary, the high rate of accretion at the downdrift beach is due to massive loss of sediment from the updrift into, and subsequently by passed the estuary mouth to accrete the downdrift beach (Figures 12 and 13).

The storm surge submerged the coastal fishing settlement, displaced landward the adjoining shoreline to the estuary in not less than 600 m northward from its former orientation, sealed up the entrance of Itak Abasi Creek with sediment up to 500 m away from the estuary, developed a wider backshore of 90 m in length across-shore close to the estuary, etc. (Figures 9, 14-16a, b). The runnel in the mid foreshore of the beach could be the drown valley of Itak Abasi Creek in which natural coastal processes are in progress to re-open and reconnect the sealed tidal creek with the estuary. The triangular configuration of the submerged area relative to the landward offset shoreline can be resolved into three principal components of forces which operate on the shoreline. These include, tidal currents along the vertical axis, long-shore current due east along the horizontal axis and south-westerly wave/wind actions along the hypotenuse in the north-east direction (Figure 17).

The (Figure 17) suggests that tidal current and wave actions were involved in scouring and agitation of sediments into suspension and bed load, while wind winnowed fine sediments from the backshore and deposited in the estuary. In the other hand, long-shore currents transport sediments into the estuary which are finally transported away from the estuary by ebb tidal currents to the sea.

Figure 9: Sinusoidal wave sedimentary marks on the shoreline at 500m away from the estuary mouth at the updrift.

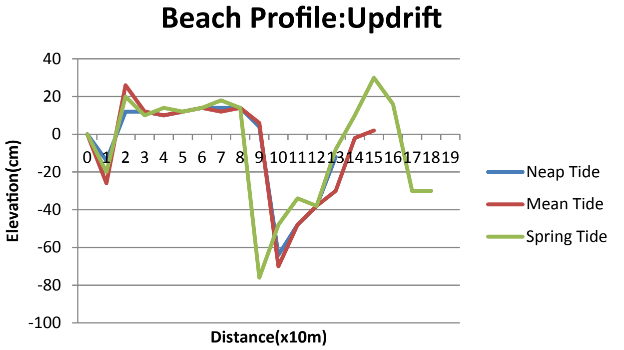

Figure 10: Beach profile changes at updrift shoreline [7].

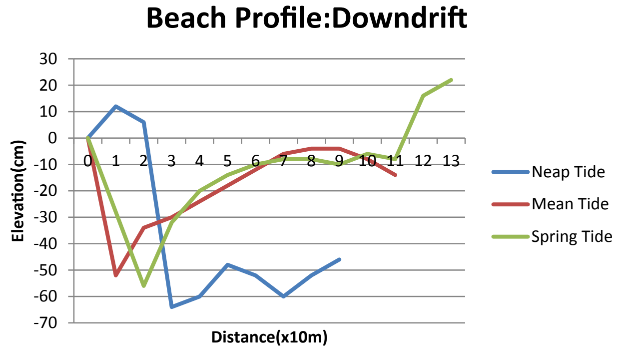

Figure 11: Beach profile change at downdrift shoreline [7].

Figure 12: Itak Abasi village partly submerged in water showing sand bar at low tide.

Figure 13: Retreated updrift shoreline currently bounded at Okorutip village along the estuary.

Figure 14: Updrift backshore showing some patches of the coastland not washed away during the storm surge incidence.

Sustainable shoreline management strategies

Sustainable management plan for the study area requires an integrated coastal zone management (ICZM) strategies and approaches to tackle the existing complex coastal problems. These, entail documentation of the existing coastal problems, risk assessment and socio-economic and cultural impact on the inhabitants of the area and a sound understanding of coastal processes in the area, and implementation of sustainable coastal zone development and management plan for the area.

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Figure 15: Fomer Itak Abasi Primary school damaged by the storm surge incident in 2011.

Figure 16(a): Former Itak Abasi Health Center damaged by the storm surge in 2011.

Figure 16(b): Former Itak Abasi Health Center damaged by the storm surge in 2011.

The major coastal problems in the area are shoreline erosion and coastal flooding exacerbated by sea-level rise, limited land space for development, ecological succession of mangrove vegetation by Nypa Palm, etc. The present study identifies the updrift coastline to be severely impacted by coastal erosion and flooding which resulted in the complete submergence of a greater part of Itak Abasi Village in 2011 rendering the indigenes homeless, while the downdrift shoreline is accreting from sediments eroded from the updrift.

In order to tackle effectively the problems of coastal erosion, flooding and other coastal zone management issues at the updrift coastline, there is need for intervention by public and private sectors

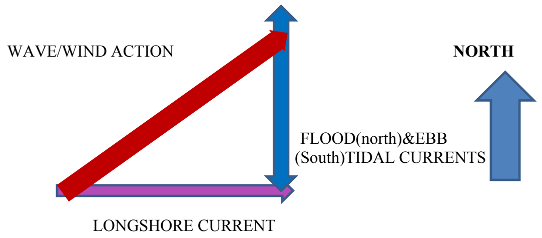

Figure 17: Schematic diagram showing the major agents of erosion and its directions of impact on the submerged area of updriftshoreline [7].

from the Local, State and the Federal levels. These interventions will require the appraisal of the Integrated Shoreline Management Plan generic options outlined by DEFRA (2006). These include:

- Hold the existing defense line; by maintaining or changing the standard of protection.
- Advance the existing defense line; by building new defenses on the seaward side of the original defenses
- Managed realignment; by allowing the shoreline to move backwards or forwards, with management control or limit movement.
- No active intervention, where there is no investment in coastal defenses or operations.

The outcome of this appraisal would enable strategic sustainable management option to be adopted for implementation. For instance, it is obvious that the updrift coastline has no major capital intensive, economic and infrastructural investment. Therefore, no active intervention generic plan should be an ideal option but since protection and conservation of cultural heritage are a consideration as the fourth pillar of sustainable development, there is need to reclaim the submerged coastline by the government and resettled the displaced indigenes of the former ItakAbasi village, who are refugees now in other fishing settlements in the area. This would be expected to restore their cultural identity and prestige as well as revive their economic livelihood.

Conclusion

The particular incidence of coastal submergence along the south east coast of Nigeria which is attributed to sea-level rise related storm surge can be considered as a signature of climate change in Nigeria. Therefore, more attentions should be given and concerted effort made by the government and private sectors to reduce any anthropogenic activity which accelerate climate change and sea-level rise. Proactive measures such as regular beach nourishment should be made as a means to adapt to climate change and sea-level rise in the coastal areas in Nigeria.

Acknowledgment

I wish to thank my Master of Science Degree Thesis Supervisor- Professor A, Chidi Ibe of the Institute of Natural Resources, Environment and Sustainable Development (INRES), University of Port Harcourt, Rivers State, my co-Supervisor- Professor E. E. Antia- Director, National Centre for Marine Geosciences, Nigerian Geological Survey Agency, Yenagoa, Bayelsa State and the Director of INRES, Professor E. Akpokodje for their inspirations. Additional thanks to Charles Odeh, Theresa Udeh and Kinsley Nwogbidi for field assistance. Also, I wish to acknowledge the financial support for the thesis by the Mac Arthur Foundation, Chicago, U.S.A. through the Institute of Natural Resources, Environment and Sustainable Development, University of Port Harcourt, Rivers State, Nigeria.

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