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Managing the impacts of storm surges on Victoria Island, Lagos, Nigeria

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Abstract Victoria Island has been experiencing acute erosion problems due to the construction of breakwaters at the entrance to the part of Lagos, the presence of Avon canyon near the coast, the steep nature of the coast and the nature of the waves. Recently, however, these erosion problems have been exacerbated by the more frequent occurrence of storm surges and relative rise in sea level. This has led to the loss of beaches, the flooding of buildings and the destruction of the infrastructure such as roads, drains, and water pipelines. During storm surge periods, the sea level has often risen by up to 2.0 m above normal. Government response has been in the form of regular beach replenishment and monitoring of the replenished coast. There is also a proposal to build breakwaters as a form of permanent solution. It is, however, suggested that a more permanent solution is the collection and analysis of sea level, surge, wave, bathymetric and topographic data/information. These data will be of immense assistance in the design of an appropriate protection measure for Victoria Island. In addition, the design must take into consideration the impact of hard engineering measures on the Lekki Peninsula located on the downdrift side of Victoria Island.

INTRODUCTION

Nigeria has a coastline of about 850 km, from the western border with the Benin Republic to the eastern border with the Republic of Cameroon. Geomorphologically, the Nigerian coast is divided into four main units: the Barrier Lagoon coast, the Mud coast, the Niger Delta and the Strand coast. Detailed information on these geomorphological units are available in a number of published texts, journals and conference proceedings such as Ibe (1988); Nwilo (1995) and Nwilo & Onuoha (1993).

The Nigerian coast is a very important resource base. Crude oil and gas which contributes very significantly to the economy of the country are obtained from the coastal areas particularly the Niger Delta. Other important activities that take place within the coastal areas include: shipping, fishing, tourism, agriculture, lumbering and communication. Some fish that are caught as far away as Senegal, Republic of Guinea and Mauritania are hatched and grown within the coastal wetlands of Nigeria.

The Barrier Lagoon coast

General characteristics of the Barrier Lagoon coast The Barrier Lagoon coast of Nigeria is part of a series of Barrier Lagoon coasts along the West African coast starting from Cote d'Ivoire and ending in Nigeria. Within Nigeria, it is made up of a number of islands, lagoons and creeks including Lagos Island, Ikoyi Island, Victoria Island, Lekki, the Lekki and Lagos Lagoons, Badagry and Badagry Creeks. One common feature of the islands is that they are low lying. In Lagos and Victoria

islands for example, heights of 1.5–4.0 m a.m.s.l. are very common. This is despite the fact that these islands were sand filled.

In addition to the low topography of these barrier islands, some of them such as Ikoyi, Lagos, Victoria Island and Lekki are either fully or partially developed commercial and residential areas and could be said to constitute the most important commercial and residential parts of the country.

Location of Victoria Island Victoria Island is located approximately between latitudes 06°25′00″ and 06°26′20″ and longitudes 03°24′00″ and 03°28′00″ (Balogun, 1995). It is located immediately east of the sea entrance into Lagos harbour. On the south it is bounded by the Atlantic Ocean, on the north by the Five Cowrie Creek, and on the east by the Kuramo Waters and the Igbosere Creek. This is, however, only an administrative boundary as the beach continues as a narrow strip between the sea and Lagos Lagoon further inland and merges at about 5 km distance with the Ilado-Maroko beach (Ibe, 1988).

EROSION AND FLOODING ON VICTORIA ISLAND

Erosion on Victoria Island

The origin of erosion in Victoria Island can be traced to the construction of two breakwaters between 1908 and 1912 at the entrance to Lagos harbour from the sea. This inlet was known to be constantly silted thereby constituting a navigational hazard to ships going into Lagos harbour (Ibe, 1986, 1988; Nwilo, 1995; Fowora-Ranardet Associates, 1981). The construction of these breakwaters which are almost perpendicular to the coastline and projecting into the Atlantic Ocean affected the normal flow of sediments which on this part of the Nigerian coast is from west to east. Although, it solved the problem of siltation, it starved the Victoria Island beach which is on the east of the breakwater of sediments. So, while areas on the west of the breakwaters were accreting, Victoria Island which is on the east was experiencing acute erosion. Ibe (1988) has estimated that over 1.5 km of the coast has been lost in Victoria Island. Annual rates of erosion of between 20–30 m have been recorded (Orupabo, 1990; Ibe, 1988; Nwilo & Onuoha, 1993). This coastal erosion has often destroyed the beach, constituted a regular threat to the inhabitants and affected several infrastructures within the island.

Other factors that may have contributed to erosion in Victoria Island include: the presence of the Avon Canyon near the coast, the wave characteristics, subsidence, the steep nature of the coast and tidal characteristics.

Storm surges

Storm surges in this context refer to any departure from the normal sea levels due to the action of storms passing over the seas or the oceans (Flather & Khandker, 1993; Kana *et al.*, 1984). This departure takes the form of a set up or rise in the sea surface due to excess water piling up against the shore. These storm surges cause serious

coastal erosion, flooding of the houses, inundation, destruction of the roads and the beaches, salinity intrusion into the coastal lagoons and sources of water for domestic use in Victoria Island and other parts of the Nigerian coast. In some cases up to 20 m of the beach has been lost in a single surge event. Victoria Island is of much concern because it is fully developed, has several private, public and commercial houses and is about the most expensive part of Nigeria.

Recent experiences in Victoria Island show that the storm surges are becoming more frequent. The more frequent occurrences of storm surges could be attributed to the global sea level rise, subsidence, topography and the concentration of several heavy infrastructures in an island that is already subject to natural compaction.

Nwilo (1995) has shown, using 19 years of hourly values of sea level data for Bonny, that the rate of sea level rise along the Nigerian coast is 1 mm per annum. This value did not take into account subsidence. He also showed the rate of sea level rise at Takoradi port, Ghana, was 3.9 mm per annum. The result for Takoradi was obtained using 40 years of annual mean sea level records. There is no evidence that subsidence phenomenon has been accounted for in this result too. That not withstanding, this value which is much more than the global average of 1–2 mm $year^{-1}$ could be regarded as a better representation of a regional average for most of the West African coast. There is no conclusive study so far to determine the rate of subsidence along the Nigerian coast. However, a study at a crude oil tank site in the Niger delta gave a value of 25 mm per annum (Ibe, 1988). If this value is assumed to be right, it implies that in 10 years the total subsidence would be 250 mm and a relative sea level rise of 260 mm for the Nigerian coast. For this reason, certain sea level values that hitherto did not cause any flooding could now do so especially in a situation where the topography is low lying such as the Nigerian coast.

Most of the storm surges have occurred in the months of May and August. A most recent occurrence was the storm surge of 17 August 1995 in which over half of Victoria Island was flooded causing severe damages to infrastructures such as roads, electric power lines, drainage systems and flooding of houses. On that day, the wave height was over 4 m as against the normal 2 m. The surge component observed from the hourly sea level was 1.33 m accounting for the extensive flooding observed. Fortunately, the maximum surge was observed at neap tide, otherwise the situation would have been worse. There is a little or no interaction between the tide and the surges along the Nigerian coast.

A study of sea level variations along the Nigerian coast by Nwilo (1995) has shown that maximum heights of sea level occur between September and October while the minimum occurs in the month of June. This trend is also observed all over the coast of West Africa from Nigeria to Cote d'Ivoire. The trend can exacerbate the frequency of storm surges along the coast.

Other factors that may have contributed to the extent of flooding in Victoria Island apart from the low-lying topography, sea level rise and subsidence include the poor drainage system. Most of the drains in Victoria Island are regularly blocked by refuse due to poor maintenance and poor living conditions. The Federal and Lagos State Governments have not put in place an effective strategy for cleaning blocked drains regularly. Most of the drains empty into the Five Cowrie Creek which is on the northern end of Victoria Island. Five Cowrie Creek forms a connection between

the lagoon and the ocean. In the event of flooding, water is expected to escape through these drains into the creek. But due to the blocked drains, it takes much more time for the water to drain away than would otherwise have been expected. This delay causes more damage to properties and the infrastructure.

Impacts of flooding and erosion in Victoria Island

The impacts of flooding and erosion in Victoria Island and other parts of the Nigerian coast has been treated extensively by Nwilo & Onuoha (1993), Nwilo (1995), Ibe (1988, 1990) and Awosika (1992, 1993). These include: the destruction of beaches, infrastructures such as roads, electricity connections and drainage systems; disruption of commercial and beach activities; flooding of houses; prevention of free flow of traffic; salt water intrusion into the lagoon and sources of water; and stress to the lagoon ecosystem including the surrounding wetlands. The recent storm surge of 17 August 1995 which was unprecedented caused very extensive damage. The properties of Hotel Eko de Meridian were flooded just like most other houses in Victoria Island.

RESPONSE MEASURES

Government response to the problem of flooding and erosion in Victoria Island has been to construct groins at the foot of the east breakwater at the entrance into Lagos harbour, dump sediment dredged from the Commodore channel on the beach (1958–1960), construct a permanent pumping station at the eastern breakwater to supply an average of 0.66 m^3 of sediment from the Commodore channel (1960–1968), as well as some artificial sand replenishment (1968 to date) and the recent construction of granite groins at Victoria Island beach and the clearing of blocked drains after the surges.

Regular monitoring of the sand replenishment projects has also been part of the programmes adopted by the Federal Government to tackle the problem of erosion and flooding in Victoria Island. But for a replenishment programme to be successful without necessarily using models, Pilkey *et al.* (1994) have suggested that:

(a) Imitate nature: observe shore line behaviour over some time span and assume similar post replenishment behaviour of the artificial beach.
(b) Replace the beach and see what happens and take advantage of the lessons learned from careful monitoring of the first replacement to help in the design of succeeding replenishment.
(c) Learn from the past—research the fate of the previous beach replenishment projects (or similar nearby projects) and assume similar behaviour for the new beach. Steps (a) to (c) are normally applicable where data are not available for modelling as is the situation in Nigeria. These steps have for quite sometime been applied at Victoria Island. The extent of application of the results of these studies in the design of new sand replenishment programmes leaves much to be desired. This is due to the fact that the sand replenishment programmes have often taken place only when lives and properties are at risk and the Federal

Government has to act very quickly. There is, therefore, a need to incorporate the results of these studies in the design of land replenishment programmes.

Sand replenishment programmes do not seem to have solved the problem of erosion and flooding in Victoria Island. Part of the responsibility for the failure of these sand replenishment programmes may have to due to the choice of the sand grains used for the exercise, the slope of the coast and the location of the source of sand. The site of the source of sand had in the past not been far enough from the coastline. Pilkey (1991) has suggested about 2.5 km as an ideal distance from the coastline into the ocean for the source of sand for coastal sand replenishment. Another cause of the failure of the replenishment programmes is the relative rise in sea level.

The current thinking of the Federal Government of Nigeria is to construct breakwaters some distance away from the coastline. It is believed that this would dampen the effect of waves reaching the coastline and, consequently reduce the problem of flooding and erosion on the island. Although this is definitely true, the lack of long-term data on sea level values, waves, surges and meteorology will constitute serious design problems. The tendency under such circumstances is to over design which invariably increases the cost of implementation. It must also be borne in mind that hard engineering coastal protection measures normally have adverse environmental consequences on the downdrift side of a coast. The Lekki beach and the new housing estates springing up there are most likely to be adversely affected by the construction of breakwaters at Victoria Island. It is, therefore, very necessary to incorporate these problems in the design and implementation of a breakwater project at this coast.

Data collection on a continuous basis in the form of bathymetry, topography, subsidence, waves, tides, surges, wind and salinity and the storage and analysis of these data is an important aspect of coastal protection measure that has not received the attention it deserves in Victoria Island. Although these data have been collected at one time or another, the practice has not been continuous. There is, therefore, a need to design a strategy for the collection, storage and analysis of these relevant data. The strategy must include regular funding.

CONCLUSION

The Federal Government of Nigeria has applied a number of measures which have been discussed in the paper for managing storm surges and erosion problems in Victoria Island. Most of these measures have not been successful while others are known to have created some other problems.

Collection, storage and analysis of some hydrographic and oceanographic data which is lacking in Victoria Island is seen as a very important aspect of the management of storm surges in Victoria Island. In addition, the design and implementation of the breakwater project on this island must take into consideration its impacts at Lekki which is on the downdrift side of the coast. A coastal environmental impact assessment report should form part of the design inputs.

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