

Coastal Erosion in Equatorial Guinea

Rosendo Nzomo Mico¹², Obai Kargbo¹²

1. State Key Laboratory of Hydrology-Water Resources and Hydraulic Engineering, Hohai University, Nanjing 210098, China.
2. College of Harbour Coastal and Offshore Engineering, Hohai University, Nanjing 210098, China

Abstract—Equatorial Guinea is a country in Africa. It lies on Africa's west coast. The country consists of a mainland territory, Río Muni, which is bordered by Cameroon to the north and Gabon to the east and south, and five small islands: Bioko, Corisco, Annobon, Small Elobey, and Great Elobey. The country's total area is 10,831 square miles (28,051 km²) and has 296 km of coastline which has been having problems with coastal erosion due to various natural as well as human coastal activities. Some of the possible causes of the eroding landscape and coastline synonymous to Equatorial Guinea were highlighted and discussed. Various erosion mitigation measures were raised for the benefit and attention of concerned parties, with the aim of aiding the formation of an Integrated Coastal Zone Management policy for Equatorial Guinea, which would effectively address coastal erosion management, prevention and mitigation.

Keywords—Coastal erosion, erosion mitigation measures, coastal zone management policy for Equatorial Guinea, sediment transport

1 INTRODUCTION

THIS presentation gives an illustrative view of the coastal and marine environment characteristics of Equatorial Guinea located within the Gulf of Guinea, in terms of natural factors and anthropogenic influences. The approach in the methodology used for the work consisted of field and desk data collection; collection of information from existing reports and other documents; desk study and development of various products from existing information. These and other illustrations gave the natural characteristics and anthropogenic influences to confirm what was seen in terms of the physical Characteristics: continental shelf; wind conditions ;climate ; precipitation ; rivers and how sea level rise is influenced by temperature, salinity variations and current patterns. Other economic activities along the coast are illustrated. All these will meet up with the need to develop various products from the coastal and marine zones of Equatorial Guinea; as expressed by most scientists, students, researchers, economic and other operators including private sectors operating there. It is important to emphasize that engineering works should be designed and constructed or built in harmony rather than in conflict with nature. This 'building with nature' approach requires a profound understanding of the sediment transport processes in morphological systems.

Equatorial Guinea has a tropical climate with distinct wet and dry seasons. From June to August, Río Muni is dry and Bioko wet; from December to February, the reverse obtains. In between there is gradual transition [1]. Rain or mist occurs daily on Annobon, where a cloudless day has never been registered. The temperature at Malabo, Bioko, ranges from 16° C to 33° C (61– 91° F), though on the southern Moka Plateau normal high temperatures are only 21° C (70° F). In Río Muni, the average temperature is about 27° C (80° F). Annual rainfall varies from 193 cm (76 in) at Malabo to 1,092 cm (430 in) at Ureka, Bioko, but Río Muni is somewhat drier. The country is found on the west central coast of Africa having a total area of 28,051 km² with a coastline of 296 km. Equatorial Guinea lies

between latitudes 4°N and 2°S, and longitudes 5° and 12°E [2]. Equatorial Guinea or Republic of Equatorial Guinea, a country of west central Africa. It lies near the Equator and consists of a mainland region, called Río Muni, and several islands, the largest of which is Bioko (formerly Fernando Po). Río Muni faces the Gulf of Guinea and is bounded by Cameroon and Gabon. Bioko lies about 100 miles (160 km) northwest of Río Muni; Annobon, the next-largest island, is some 300 miles (480 km) southwest of the mainland. In Río Muni, a coastal plain rises inland to hills that reach elevations of more than 3,900 feet (1,200 m) above sea level. Bioko is volcanic in origin and rises to two main peaks, the higher of which is 9,869 feet (3,008 m) above the sea (as shown in Fig.2). Much of the country is heavily forested, except at higher elevations on Bioko and where the land has been cleared for farming. The coastline stretches along 296 km. The coastline is also very irregular in formation. The coastal land form of Equatorial Guinea can be seen in figure forming many bays and peninsulas. Fresh water swamps and mangrove swamps occupy large extents of the coastline and the coastal plain is characterized with a large number of estuaries.



Fig.1 Situation of Equatorial Guinea

Erosion along the coast in Equatorial Guinea is phenomenon that has long been of great concern to the most affected communities. Its causes usually range from global to local. Equatorial Guinea is one such nation which is experiencing coastal erosion due to natural and man-made causes [3]. During the stormy months of August and October, wave heights can reach up to 3 meters along the coast. Fishing activities is very much part of the lives of many Equatoguinean along the coast. In other words, the 296 km coastline of this small West Central African country is interwoven into the daily activities of its inhabitants. An eroding coastline is eminent in most areas with a greater extent in the Rio Muni region in the North. To most of the local inhabitant it may be seen as just a natural phenomenon, for which they need not worry about. Owing to inadequate sensitization, high illiteracy among coastal communities and to some extent ignorance, the issue of erosion has not been given the attention it deserves. In most cases inhabitants along rivers and coastlines fail to understand that their activities may have some effects on the environment, thus leading to erosion [4].

Erosion is more or less the wearing off of a surface or loss of land due to wind water and other natural or man-made causes. This process can take place over a period of time or may happen at an instant, depending on the prevailing circumstances. For a coastal region the concept is more or less the same but very much dependent on sediment motion, tidal currents, beach dynamics and human activities. The coastal form of Equatorial Guinea can be seen in Fig.3 and Fig.4.

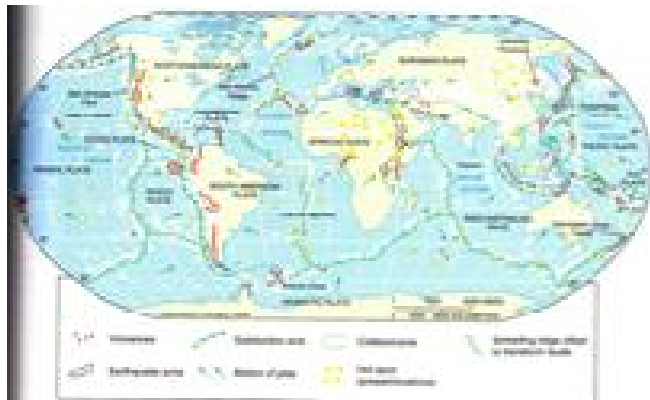


Fig.2 Present locations for volcanoes

Equatorial Guinea coastal and marine environment is located within the Gulf of Guinea (GOG) Large Marine ecosystem. The GOG in the Equatorial Guinea lies between latitudes 4°N and 2°S, and longitudes 5° and 12°E, with a total coastline is 296km. Within this coastal and marine ecosystem, operate several socio-economic activities such as fisheries, offshore and onshore oil exploitation, industrial, port and agricultural activities; sand and mineral resources exploitation [5]. These anthropogenic characteristics exists in line with dynamics in natural futures of the zone such as natural disasters, hydrodynamics, winds, ocean waves etc. to determine the state and characteristics of the coastal and marine environment [6]. These have resulted in very productive ecosystems when con-

sidered from a global perspective, with much prospects for socio-economic development.

2 METHODOLOGY

The approach in the methodology used for the work consisted

- Author name: Rosendo Nzomo Mico, currently pursuing masters degree program in harbour, coastal and offshore engineering in Hohai University, Nanjing, China, PH-+8613851405838. E-mail: rosen-zomo@hotmail.com
- Co-Author name: Obai Kargbo, currently pursuing masters degree program in harbour, coastal and offshore engineering Hohai University, Nanjing China, PH-+8615850795470. E-mail: obaikargbo@mail.com

of:

1. Field and desk data collection,
2. Collection of information from existing reports and other documents,
3. Desk study and development of various products from existing information.

Within each of these ecosystems, observations were made on the natural and anthropogenic characteristics and other man made influences. Photographs and observations were also made on the natural characteristics and anthropogenic influences to confirm what was seen. This product development was geared towards meeting up with the needs for further studies of coastal and marine resources/areas with particular emphasis as a field guide and on physical processes that most influence the coastal and marine resources, contributing to its sustainable management. The possible beneficiaries of this study include, among others, port services, coastal engineering, fisheries, coastal management, scientific research and students.

2.1 Methodology of Study

A review on literature available in both Government and Non-Government organisations, Libraries in Equatorial Guinea coastal and Marine Environment institutions, the capital city Malabo (administrative) and Bata (economic) was made to gain background knowledge on the natural and anthropogenic influences. Field data and information acquisition came from direct observations, photographs, structured and semi-structured interviews and literature. The natural factors covered consisted of the physical characteristics, continental shelf, wind conditions climate, precipitation, hydrology, sea level rise, temperature, salinity variations and current patterns. The anthropogenic influences were determined through visits to existing structures and locations of economic based activities as shown in fig.



Fig.3 shaded relief in Equatorial Guinea

3 COASTAL EROSION

The actions of waves, heavy rainfall and human activities have resulted in intense coastal erosion in Equatorial Guinea. This is common in the towns of river Muni, Campo and Benito; this is a zone with alternating sandy and rocky beaches. The withdrawal of the coast from the sea is quite significant at river Consul and Tiburrones: with great impacts of coastal erosion on road infrastructure and building (hotels, living houses etc.). There is great need for their protection. Protective measures against erosion are common through the use of sand bags in river Campo. The intensive sand mining within the mangroves and rivers getting into the sea has contributed significantly to erosion and reduced the stabilization impact of the mangroves to the coastal zone [7].



Fig.4 coastline in Equatorial Guinea

4 EQUATORIAL GUINEA COASTAL AND MARINE ENVIRONMENT

The Republic of Equatorial Guinea is one of the Central African countries located at the centre of the Gulf of Guinea, within the Bay of Biafra as shown in Fig.5. It has an area of 28,051km² with a population of approximately 676,000 inhabitants (year 2009 estimate). The coastal environment of Equatorial Guinea is opened to the Atlantic Ocean with a coastline

of about 296km. Equatorial Guinea lies between latitudes 4°N and 2°S, and longitudes 5° and 12°E. Río Muni faces the Gulf of Guinea and is bounded by Cameroon and Gabon. Bioko lies about 100 miles (160 km) northwest of Río Muni; Annobon, the next-largest island, is some 300 miles (480 km) southwest of the mainland. In Río Muni, a coastal plain rises inland into hills that reach elevations of more than 3,900 feet (1,200 m) above sea level. Bioko is volcanic in origin and rises to two main peaks, the higher of which is 9,869 feet (3,008 m) above the sea. Much of the country is heavily forested, except at higher elevations on Bioko and where the land has been cleared for farming. All aquatic ecosystems of this coastal plain of the Atlantic are covered within these limits, notably: ocean, coastal forests, deltas, sand dunes, mangroves, coastal rivers, estuaries, bays, lakes, beaches and muddy coasts. The continental limit is illustrated by a hypothetical line drawn from the north to the south which passes through: Litoral, Bioko Norte, Bioko Sur and Annobon. This line passes through the national provinces of South – West, Littoral and South.



Fig.5 coastal and marine environment in Equatorial Guinea.

5 CAUSES OF EROSION IN EQUATORIAL GUINEA

The likely causes of erosion in general were looked at, and the causes were found to be more prevalent along the Equatorial Guinea coast as seen below:

5.1 Alluvial Method

Equatorial Guinea is a country which has gold and diamond, along flowing streams and rivers. Channel gravel mining (Alluvial method) activities by the locals, involve gravel collection. This activity mostly takes place along river Muni and Campo where diamond and gold deposits are high along the banks. Huge quantities of gravel suspected to have diamonds and gold are collected from these rivers on a daily basis. In most cases, the gravel residue is never returned to the extraction site but used for domestic purposes such as building local mud houses. This will consequently have an effect on the sediment deposition along the beach or coastal areas, thus triggering erosion.

5.2 Sand Mining for construction

Sand extraction from the coast for construction purposes has also devastated the coastline and made it more prone to erosion. Huge quantity of sand is removed from beaches on a daily basis to support the booming construction works going on in the country. This leads to or triggers erosion and creates sink holes. With loose regulations and monitoring, the coastline is stripped off its sand. Places which ones used to be thriving and beautiful coastlines have been devastated by this activity. The huge unemployment in the country has made sand mining an easy source of employment for the youths at the detriment of the coastline. Minor studies have been carried out to ascertain the extent of this damage but visible signs can clearly be seen when one takes a good look at the vastly changing coastal landscape and the reduction in coastline.

5.3 Wave Action

Wave action also causes erosion along the coast. This can be observed as waves break on cliffs. For some regions in Equatorial Guinea, especially the North West part of Equatorial Guinea, the cliffs are made of softer material and thus when waves break on them with intensity; they gradually collapse into the sea.

5.4 Poor Coastal Management

What has been of great concern is that there has been poor coastal management in the areas affected and the inhabitants of the affected regions have not been made aware of the effect that their activities may have on the coast. Authorities need to propagate a message to these communities in order to raise their awareness. The issue is also of concern to tourist locations along the beach. Private owners of hotels and other coastal recreational facilities have been implementing developmental activities and corrective measures for the protection of their property with no regard for the effects this may have on the coast. The problem is unchecked or just left to go on since beach nourishment is a concept not practiced in Equatorial Guinea.

5.5 Nature

A more natural cause for erosion is a major storm. A very heavy storm with high wind velocity and wave action has the ability to alter the coastal landscape in a very short time. Equatorial Guinea experiences very intensive winds during the rainy season and high winds along the coastline. There is a high possibility for the coastline to erode several feet in a single storm depending on its intensity. Local settlements in mostly low lying coastal areas such as Luba which is a slump in the Capital Malabo is usually submersed in water after heavy downpour of rain. A lot of infrastructure is usually lost in this area and the inhabitants have fought futile battles with nature but have always ended up on the receiving end.

5.6 Local construction

with the aim of preventing property damage in most cases, local dwellers with the aim of protecting their household and property may construct undersigned seawalls and other locally designed revetments which are not designed in a way to least disrupt sediment movement along the coast. In a sense they may be protecting their own structure along the coast while at the same time disrupting downstream sediment movement along the coast. Since they only care about protecting their own structure, they hardly know or care what their action may have on other ends along the coast such as the downstream. The eventual outcome is that there will be a net reduction in sediment deposition in the downstream which will gradually lead to loss of shoreline

5.7 Dynamics of Sedimentation

Sediment deposition leads to the creation of sandy offshore bars whose origin is either marine (effect of the Gulf of Guinea currents) or volcanic (Mount Alen and Mount Basile) [8]. The progression of offshore bars and sandy spits parallel to the coast and of various points between Rio Muni and Lake Bihao is caused by:

- The predominance of river Campo current over that of the Gulf of Guinea which flows from west to east.
 - The low amplitude to tides (2 m on the average)
 - The low charges of coarse detritus material in rivers which through a woody hinterland. The edification of these coastal structures tends to regularise the coastal profile [9].
- Erosion is significant along the volcanic coast of Equatorial Guinea. A displacement of the coastline towards the continent has been observed in the South West Province. The estuaries and mangroves are characterised by high turbidity. This phenomenon is also noticed in the estuaries of "Muni" [11]. The entire eastern part of the Rio -Del-Rey basin is blocked by accumulations of mud and fine sand advancing southwards towards the river Campo. The evolution of the coast will also depend on the quantity and rate of deposition of alluvial material [12]. Fig.6 and Fig.5 gives the discharge of the main rivers within the Equatorial Guinea coastal zone. This rocky portion is characterised by the absence of significant deposits of sand and mud [13].



Fig.6 Rivers in Equatorial Guinea

5.8 Infrastructure Development

Most of the essential infrastructure is found in the coastal region: roads, ports, airports, telecommunication, schools, hospitals etc. However, a good portion of the coastal zone is occupied by mangroves and creeks, and thus remains enclave.

6 RESULTS

6.1 Indicators of coastal erosion observed

Coastal erosion has many ways in which it may present itself. Below are some of the most observed indicators supporting the fact that there is coastal erosion in Equatorial Guinea:

- (1) A reduction in beach dunes and areas [14] - When observing the coastline and most beaches in the western Area of Equatorial Guinea. It was observed that there was a visible reduction in beach dunes
- (2) A reduction in protective vegetation-Natural vegetation which may serve as a deterrent to eroding rivers and coastal regions is being reduced by human and natural activities. This can be observed in Equatorial Guinea.
- (3) Coastal structures such as walls or trees collapsing and falling into the water-Sea walls and seaside structures collapsing are evident. This is an indication that there is a loss of coastline. Even huge trees can be seen tumbling into the water as the water erodes the soil beneath them.
- (4) Very steep cliff - Steep faced cliffs were seen along some coastal locations. This may be due to the fact that chemical weathering has been occurring on the lower part of the cliffs which have been in contact with the seawater.
- (5) Vegetation appearing to be dislodged- One evidence of coastal erosion could be the fact that the vegetation along the coast is continually dislodged. This may be due to the violent actions of coastal waters. This is also very much observed in Coastal of Equatorial Guinea.

7 OBJECTIVES

This presentation gives an illustrative view of the coastal erosion and marine environment characteristics of Equatorial Guinea located within the Gulf of Guinea, in terms of natural factors and anthropogenic influences. The need to develop various products from the coastal and marine zones of Equatorial Guinea has been expressed by most scientists, students, researchers, economic and other operators including private sectors operating here. There is the need for well documented characteristics of the coastal and marine zone.

8 DISCUSSION AND RECOMMENDATION

The following recommendations shown below were made and discussed on. The recommendations aimed to serve as a platform for further studies which would more effectively mitigate coastal erosion as a whole and create an effective coastal zone management policy for Equatorial Guinea.

- (1) It is very important that issues regarding erosion are addressed at both local and National levels in Equatorial Guinea. Policies and control measures should be put in place to mitigate the loss of shoreline due to erosion. Coastal Agencies must be empowered to monitor activities in and around the coast as well as along river banks to ensure proper use of the environment and prevent activities that will excessively affect natural sediment movement.
- (2) Reducing deforestation along riverbanks and coast-lines. The roots of trees and vegetation hold soil together. With the absence or reduction of vegetation along the coast or river bank, the soil along the banks will be looser and thus less capable of withstanding the effects of the forces of the flowing water or wave action. Stakeholders must aid coastal community builders with technical or engineering approaches in the construction of seawalls and breakwaters; however, care must be taken to ensure that these structures do not end up speeding up the processes of erosion. Proper studies must be first conducted to ensure that such structure are adequately designed and constructed in the right locations.
- (3) Beach Nourishment should be used to revitalize the coastline [15]. It must also be ensured that beach nourishment is conducted in conjunction with finding ways to stop or reduce the erosion at the same time. If mitigation measures are not put in place, the sand used to nourish the beach will eventually erode again. Therefore, the first priority measure is to find the cause of erosion and mitigate it in conjunction with the beach nourishment.
- (4) Restoring the coastline vegetation. Replacing coastal vegetation which might have been lost due to previous erosion helps to improve the slope stability of the coast and consolidates sediments. It also reduces the wave impact on the shore by reducing its energy as it approaches the coast.

REFERENCES

- [1] http://www.nationsonline.org/oneworld/equatorial_guinea.htm
- [2] [http://www.ducksters.com/geography/country.php?country=Equatorial %20Guinea](http://www.ducksters.com/geography/country.php?country=Equatorial%20Guinea)

- [3] http://en.wikipedia.org/wiki/Geography_of_Equatorial_Guinea.
- [4] National Adaption Programme of Action (NAPA) in Equatorial Guinea
- [5] www.nationsencyclopedia.com
- [6] The national integrated coastal zone management strategy for Belize (2001)
- [7] J.P. Doody. "Coastal squeeze- an historical perspective". Journal of Coastal Conservation, pp.129-138, 2004
- [8] J.Pethick. "An Introduction to Coastal Geomorphology". Edward Arnold, 1984.
- [9] T.R. Healy. "Estuaries". In: Encyclopedia of Coastal Science, ed., M. Schwartz, Springer, pp. 436-439, 2005
- [10] R.A. Warrick, E.M. Barrow & T.M.L. Wigley. "Climate and sea level change: a synthesis. In: Climate and Sea level Change - Observations, Projections and Implications, eds". Wigley, University Press, Cambridge, pp.3-24, 1993.
- [11] M.J. Tooley. Long term changes in eustatic sea level. In: Climate and Sea Level Change - Observations, Projections and Implications, eds. University Press, Cambridge, 81-110, 1993.
- [12] Chen X, Zong Y. Estuarine. "Coastal erosion along the Changjiang deltaic shoreline, China: history and prospective". Coastal and Shelf Science, 1998 (Elsevier)
- [13] K Zhang, BC Douglas, SP Leatherman "Global warming and coastal erosion". Climatic Change, 2004 (Springer)
- [14] FAO Corporate document repository (Chapter4 Protection from coastal erosion)-Gegar Prasetya
- [15] Rising seas, coastal erosion, and the takings clause: how to save wetlands and beaches without hurting property owners, JG Titus - Md. L. Rev., 1998 (HeinOnline)