A rapid overview of coastal erosion in Ghana

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Abstract— This paper provides an overview of the coastline eroding occurrences in Ghana. Ghana is located in West Africa boarded at the south by the Gulf of Guinea and the Atlantic Ocean with four of its ten regions having its major cities lying along the coast. The coastline of Ghana has over the decades experience minor coastal erosion but the recent situation is becoming apocalyptic and needs further attention. This study hence identified and discussed the various cases of occurrence and also key facilitating source of this problem for the attention of pertained parties. It also provides various eroding control measures and a baseline for improving the coastal erosion in the country.

Keywords— erosion, Ghana coastal erosion, sand mining, coastal erosion impacts, seawall, vegetation, waves

1 INTRODUCTION

Rapid climate changes globally have contributed to significant degradation of the environment. The current anthropogenic activities have also transformed the planet which has brought about uncalculated effects to the natural ecosystem [1].

Issues of coastal erosion are a worldwide problem. [2] claimed that about 70% of sandy beaches around the globe are recessional. It was also recorded by [3] that almost 85% of US East Coast barrier beaches have been eroded during the last 100years and also serious erosion has been recorded in other places ([4]; [5]). This has drawn the attention of various international organizations and governments to deal with this situation by instituting different coastal erosion management strategies and policies. However, many other places especially third world countries still experience severe coastal erosion. According to [6], coastal erosion is probably the most serious environmental problem facing West African coast. This phenomenon is particularly more pronounced in Ghana especially on the eastern shores. Specifically, the most severe and internationally known areas are located in the Volta estuary basin, at Keta and Ada [7]. This poses great challenge to the nation.

In the early years, these cases were seen by most Ghanaians living along the coast as a natural phenomenon; hence, much attention was not given to its development. However, the recent devastating effects have brought intense worries to the nation especially the adversely affected communities.

[8] noted that some coastal inhabitants engage in activities like uncontrolled sand mining along various sections of the coastline for variety of uses such as construction of estates, highways and bridges as well as irrigation and water works. There is also the occurrence of mining of alluvial gold in some of the rivers within the coastal plains. These activities are increasingly exposing the coast to erosion with its associated problems. Not only that but also the aesthetic value of the beaches is declining. Regrettably, the problem of coastal erosion has been given little or no attention. The coastal municipalities have ignored the adverse condition of the coast largely due to ignorance. Mostly, the inhabitants are uneducated so they barely care or understand what their activities will cause. It is quite unfortunate to note that while millions of dollars are being spent by the government to combat erosion along coastal areas such as Sekondi, Nkotompo and Keta, some communities are actively encouraging coastal erosion. Overall, there is little concern for the sustainability of the fragile coastal environment for both the present and future generations.

However, with about almost half of the population in the regions along the coast in Ghana living in the coastal municipalities, the idea of strategic coastal planning and stretched integrated coastal zone management should become an integral component of regional spatial planning for effective coastal protection. As of now, very limited studies have been done to quantify the damage caused by coastal erosion despite the detrimental effects of this phenomenon in the country.

Hence, this study seeks to provide a comprehensive review

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and bring to the attention of stakeholders the issues of coastal erosion along the coast of Ghana. This study particularly highlights the major causes of the coastal erosion as well as the adverse impacts and also suggests prudent measures in effective monitoring and controlling its occurrence in the country.

2 STUDY AREA

Ghana is located in latitude 8°N and longitude 2°W in the west of Sub-saharan Africa. It lies almost in the centre of the nations along the Gulf of Guinea. Its southern coast extends between latitude 4°N at cape three points and 6°N in the extreme east along the equator. Ghana is boarded by Ivory Coast, Burkina Faso and Togo to the west, north and east respectively and to the south by the Gulf of Guinea and the Atlantic Ocean (Figure 1). It has a total land area of 238,535 km^2, 3.5% of this being covered by water. The country enjoys a typical tropical climate. It experiences two main seasons, namely; rainy and dry seasons. The average minimum and maximum annual precipitation are about 900mm and 2000mm occurring around the Southeastern and Southwestern portions of Ghana respectively. The range of the annual average minimum and maximum temperatures are 20°C - 22°C and 29°C - 34°C respectively. The annual average evapotranspiration rate is 190mm (high) in Northern Ghana and 80mm (low) in the southern part.

The coastline consists primarily of sandy beaches that expand to about 560km. It is lined with coconut palms, merging seamlessly with mangrove vegetation, high evergreen forest reserves, diverse wildlife, and a people whose vibrant culture you can sample in the fishing villages. The sandy coastline is characterized by a coastal plain with several rivers and streams. Ghana has four of its ten regions having its cities along the coast. The major cities include Tema, Accra, Winneba, Cape Coast, Elmina and Sekondi-Takoradi. Primary activities along the coast include fishing which is mostly the main occupation of the people living there.

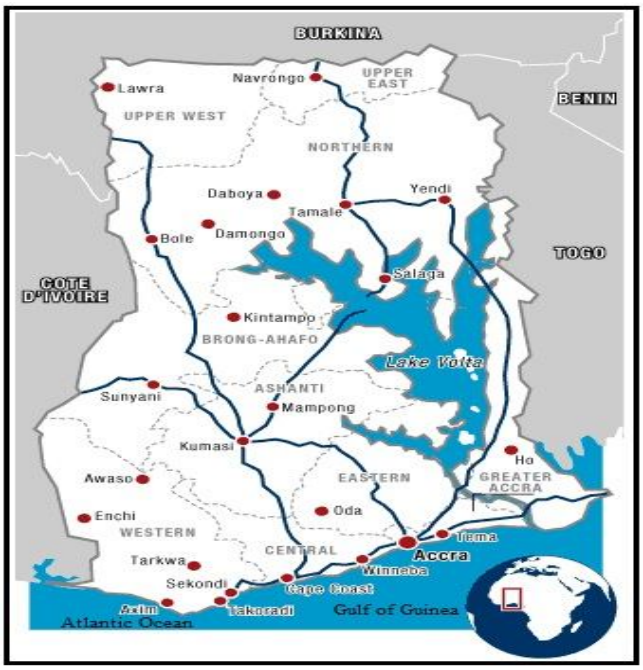

Figure 1. Map of Ghana

3 COASTAL EROSION

The coastline which is described as the physical interface of water and land is constantly changing as it seeks to achieve and maintain equilibrium among many opposing natural and human induced forces in the coastal regions. Coastline changes which are a natural phenomenon with respect to the changes in relative sea level, climate and ecosystem may be influence by recent human activities. Coastal erosion is the wearing away of land or the removal of beach or dune sediments by wave action, tidal or wave currents. The causes of this disturbing phenomenon could be both natural and man-made. It involves a redistribution of sand from the beach face to offshore. It commonly occurs during coastal storms and strong wind action which may take the form of long-term losses of sediment and rocks, or merely the temporary redistribution of coastal sediments. The erosion in one location may result in the pile-up of sand or sediments elsewhere.

3.1 Overview of the current coastal erosion in Ghana

Erosion is a chronic issue along the Ghanaian coastline, where high erosion rates are adversely affecting coastal infrastructure and valuable cultural resources [9]. The current eroding state of Ghana's coastline raises serious concerns. The extensive erosion along the beaches has greatly impacted the surrounding environment. Due to the total negligence on the part of the surrounding communities and the government of Ghana as a whole, the situation is growing worse every day. Figure 2 shows images of some of the various devastating na-

ture of the coastline as a result of coastal erosion at different places.

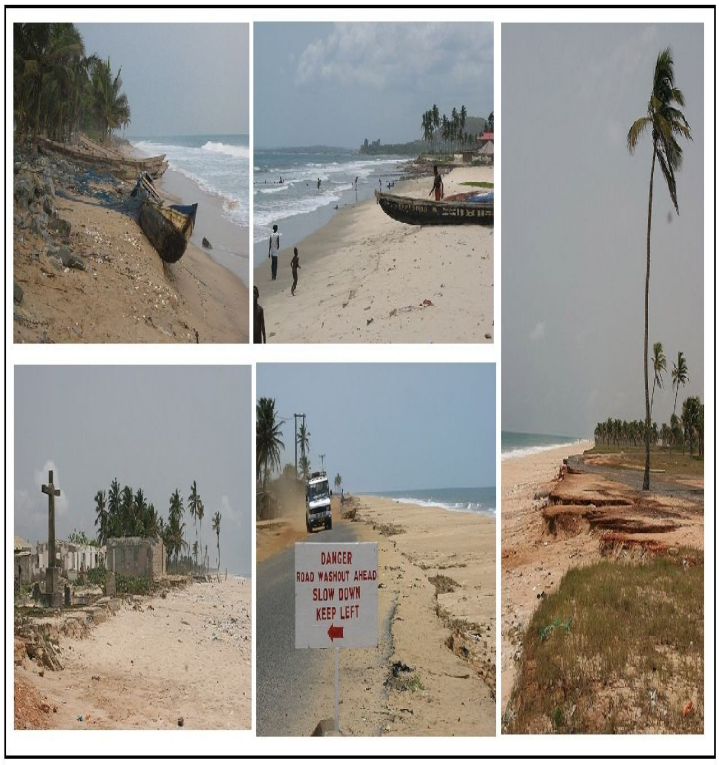

Figure 2. Images of various cases of coastline erosion in Ghana at different places

Figure 3. Images showing various extent of the coastal erosion.

According to estimates, the ocean claims 1.5 to 2 m of the 560 km coastline annually; with the most risky areas, Ada Foah and the Eastern parts of Keta, recording 4 m [10]. This was so severe that the government of Ghana has instituted the Ada Sea Defence Project which seeks to construct a sea defense wall at that region to protect the people in the area from the ravages of the sea.

It must be noted that a tremendous amount of sand is just offshore many beaches. However, this resource is unprecedentedly exploited causing a severe range of coastal environmental problems. For instance, in Accra, the capital city of Ghana, an estimated 82% of the beach is eroding at a rate of 1.13 m/yr [11]. At some points, scarps and undercut asphalt are revealed indicating high rates of erosion. Also the coconut palm trees which characterized most beaches in Ghana are beginning to fall and disappear. A serious case is recorded at Elmina coast. These come from a short stretch about 4km west of Elmina town, where there exists popular beach resorts that include Coconut Grove, Elmina Bayand Stumble Inn. The sea is eating its way towards these resorts with subsequent dire effects on the tourism sector of the country (Figure 3). Recently, one serious situation was also recorded at Ada Foah Beach. It was estimated that the coastline in the area is eroding at a rate of 4m annually. Hence, in response to this gravely eroded coastline, the government of Ghana had no choice but to embark on a costly and controversial project to the building of an estimated 68 million euro, 30 km Ada Sea Defense Wall along the 44 km-stretch of the Ada coastline. This project was undertaken to ensure maximum protection of the people and the infrastructure as well as the environment. It is also recorded that many structures such as hotels and restaurants where foreigners especially tourists reside along the coast has to be evacuated due to danger the erosion is posing. Occasions like beach recreational activities especially during festive seasons have also been affected because foreigners and even locals are no more attracted to the beach. It was reported that the age-long devastating coastal erosion had turned many investors away for fear of losing their investment as a result. Also, residential houses have been washed away by the ocean.

In an effort to render the country with a broad in scope database to assist in tackling the current situation, various organizations have willingly decided to embark on some small studies. Example is the Department of Oceanography and Fisheries of the University of Ghana who have mapped the following cities in the Greater Accra Region with red flags indicating that those places are experiencing severe cases of coastal erosion: Kokrobite, Bortiano, Labadi, Teshie, Nungua, Tema, Prampram, Old Ningo and Ada. The Office of Naval Research (ONR) is also investing and partnering in research that could lessen the impacts of Ghana's eroding coastline such as loss of structures, human life and economic well-being. Nevertheless, these situations continue to exist and even are becoming more serious.

4 Causes of Coastal erosion in Ghana

Various causes were identified which include both natural and man-made induced phenomena.

a. Man-made induced causes

Sand Mining - Sand mining is a kind of open-cast mining that provides material in Ghana for the construction industry. The construction sector in the coastal areas of Ghana relies heavily on coastal sand and pebbles in the building of houses, bridges and roads. The world's beaches are being mined for sand for a variety of uses (aggregate in concrete, fill, beach renourishment). The practice is often very destructive and poorly managed and this is not different in Ghana. Although sand mining is banned along beaches in the country, it continues to be a source of sand supply for the real estate sector. The activities of the sand miners who are desperate to make their living, vent their irascibility on the volumes of sand on the country's beaches. This theft of beach and dune sand is a direct cause of erosion along many shorelines. Since coastal sand serves as a barrier between the sea and the land, uncontrolled sand mining causes a range of coastal environmental problems. Specifically, it is very damaging to the beach fauna and flora, ruinous to beach aesthetics, and frequently causes environmental damage to other coastal ecosystems associated with the beach such as wetlands. In a time of rising sea level, the sand is sorely needed as a storm energy buffer. The process of sand mining has accelerated coastal environmental degradation to an alarming rate and the extent of the impairment is obvious in many areas. Another major impact of beach sand mining is the loss of protection from storms surges associated with tropical cyclones. Some communities affected by the 2004 tsunami in the Indian Ocean had higher storm surges probably due to beach sand mining resulting in human death.

Inadequate Coast Management - Over the years, there has been cases of poor management at the coast especially by the inhabitants of the coastal communities. Obviously, the locals there are fully not concerned about the problem their activities can bring on the coast. These include building indiscriminately along the coast which is properly not checked. In recent years, some communities even continue to undertake activities such as sand mining as a means of financing local development projects [8]. Even though there may exist logistics to ensure that this does not happen, authorities concerned have turned blind eyes to them. Unplanned and unwise land use developments have resulted in higher erosion rates, in some areas.

Dredging of canals and Protective building - Dredging of canals are normally done to help salt water reach further inland and also to direct other water sources to the sea. This activity causes death of trees and vegetation that would normally stabilize the coastline. Trees or vegetation along shorelines of water bodies have been scientifically proven to help stabilize and protect shoreline against cases of flood and erosion. Wind blowing along the canals creates waves that erode the coast and create storm surges. Also it has been noticed that some of the coastal inhabitants dike their building and properties which they believe lie in low-level areas by building seawalls. These structures are mostly not properly constructed and they sometimes prevent sand from restoring the coastlines. This implies that the structures that are built to curb the menace rather create further erosion in the long term.

Modification of ecosystems – In the past, the coastline in Ghana was surrounded by green forests and thick trees. However, over the years, activities like deforestation as a result of population growth and urbanization have resulted in those areas being cleared for infrastructural development. These activities have increased the susceptibility of the sea to global climate change and natural occurrences like winds which can cause severe waves and tides to wash away the coast. The overexploitation of mangroves in Ghana, as for example in the Ada-Volta Delta Anyanui Estuary Mangrove Complex (AVDE-AMC) and the damming on the Volta River has also contributed to the menace.

Mineral mining - Some rivers and streams within the coastal areas along the coastline in different regions are noted for some alluvial gold mining as well salt mining. Illegal small scale mining (Galamsey) operations along the coast are noted to cause havoc to the ecosystem within coastal areas. These activities leave the land prone to coastal erosion where the sand and other land material believed to posses the mineral is washed away. Even though Ghana is not noted for ocean disasters like tsunamis and cyclones like in other nations, the sand along the shore protects the nation from strong storm surges as it serves as a storm energy buffer. If this sand is scooped away, the coastal communities will be devastated if such a disaster should ever happen in Ghana. This in effect is going to cost the nation economically, socially and environmentally if nothing is done about it immediately.

b. Natural causes

Sea level rises and heavy storms– Coastal erosion has been greatly affected by the rising sea levels globally. The anticipated rise in sea levels due to climate change will result in coastlines receding worldwide through erosion. This is a known phenomenon that can, in principle, be calculated and predicted based on a given sea-level rise, by means of the so-called Bruun effect. Also, cases of heavy storm situation coupled with severe wind blow can affect the coast within a short period. Coast regions like Greater Accra have experienced severe heavy storm during the rainy season in June and July which resulted in flooding in areas below the coastal areas.

Waves - Large storm-generated waves typically cause coastal erosion, which may take the form of long-term losses of sediment and rocks, or merely in the temporary redistribution of coastal sediments. Wave action is observed to contribute to coastal erosion by breaking on cliff faces at the shore and slowly erode it (abrasion). The rate at which cliff fall debris is removed from the foreshore depends on the power of the waves crossing the beach. The waves cause loose pieces of rock debris to collide with each other, grinding and chipping each other, progressively becoming smaller, smoother and rounder. The rock debris also collides with the base of the cliff

face, chipping small pieces of rock from the cliff or similar to sandpapering. This scenario is paramount in the central region along the coastline where there exists a lot of soft material which is easily eroded by this action.

Weathering and transport slope processes - Limestone cliff faces which are found in most of the regions along the coastline especially in Cape Coast and Elmina , which have a high pH, are particularly affected by chemical weathering when the sea's pH (below pH 7.0) corrodes rocks on a cliff face. Wave action also increases the rate of reaction by removing the reacted material.

5 COASTAL EROSION IMPACTS

The effects of coastal erosion have so far been felt across the regions in Ghana (Figures 2 and 3). Generally, the adverse situation has currently drawn attention in some places especially the sites in the capital. Yet, other regions have received little or no attention at all. Among the prominent features and impacts observed in most coastal places in Ghana are;

i. Vegetation at the shore of the coast which serves as a protective screen on the high water mark fringe to prevent erosion caused by wind and wave action, protect against flooding and also improve the aesthetic value of the coast are being washed away (Figure 2).
ii. The age-long devastating coastal erosion had turned many investors away for fear of losing their investment due to the sea erosion.
iii. It is causing threat to structures close to coast such as roads as well as buildings which are gradually being washed away and collapsing into the water endangering lives (Figure 2).
iv. Also there seems to be a reduction of the beach size for recreational purpose as more sand are being washed away affecting ecotourism as tourist stay away from such places. This is affecting business for the commercial points around the coast especially in the nation's capital (Accra).
v. It is also causing huge loss to the country as a lot of money is used to salvage the affected areas. Example is the Ada Sea Defense Wall Project which is causing the country an estimated € 68 million.
vi. Also, it is recorded that the issue of erosion of shoreline destroys the habitat of some organisms. It is known that turtle egg-laying sites have been affected and also exposes this critical stage of the life of the turtle to predators such as dogs, pigs and humans.
vii. Cases of injury have also been recorded at the beach where people accidently fall from seemingly strong grounds and cliffs.

6 MITIGATION MEASURES

This section provides suggestions on how we can help through further research to effectively mitigate the current situation and prevent future occurrences. Preserving the coastline as part of the environment requires protecting its boundaries as well as preserving its environmental quality to promote its attractive nature. To achieve this goal for the current coastline status, a holistic and integrated approach needs to be taken. This includes;

i. ***Strategic management framework:*** a proper framework which seeks to ensure the management of the coast should be instituted. The Ministry of Environment should decentralize its duties especially regarding the coast to the local level where agents can be set up at the various coastal communities to see to its management. It is obvious the Ministry is piled up with responsibilities of pursuing all sectors of the environment and is not surprising that sometimes little attention is paid to the occurrences of the coastal erosion. For instance, they may be busy with other things deemed important such as the provision safe drinking water. This normally leads to the negligence of equally important environmental issues unless it becomes very serious and fatal. They end up spending relatively more money in managing the issues which could have been avoided if attended to earlier. Example is the Ada Foah case.
ii. ***Management and control policies:*** just like every other environment sector, conservation of the coastline will need basic policy control measures that will serve to check the activities along the coast. The Ministry of Environment should ensure these policies are strictly enforced and followed by all stakeholders and offenders punished to prevent others from doing same. All developments undertaken within the coastal zone should require permits and approval from the authorities.
iii. ***Employing Ecosystem approach:*** since all water bodies including the sea are very sensitive to the changes in its environment, conserving it will necessitate coverage in ecosystem basis by systematic approach. One way is to employ vegetation protection to replace the loss vegetation which would help to prevent further erosion. Vegetation cover provides a good protection against erosion by stabilizing the shore. It diminished soil bed stress that promote sedimentation and retention of particles and increase habitat diversity ([12]; [13]). The beach and the ridge scarp already eaten up by coastal erosion could be reprofiled and colonized with some vegetation such as grasses and managed. Trees which can stand the salt water (e.g. velontier, filao, bios manioc, e.t.c) could be planted to serve as a protective screen on the high water mark fringe to prevent erosion caused by wind and wave action. Mangrove plants can also be planted. Already the coast is sandy hence without the vegetation, the soil will loosen up the

more making it difficult to stand the impacts of the wave and moving water.

iv. ***Education:*** [14] indicated that environmental education is the most effective way for conservation and protection. People should be made to understand that when you throw a ball to a wall, it comes back to you hence whatever they do to the environment will consequently affect them. It was obvious that most inhabitants are sincerely not aware of the implications of their activities whiles others are fully aware but have decided to ignore it. We can have all the protection plans and spend huge sums of money dealing with it but all will amount to nothing if the attitudes of the grass root people do not change. Proper education would help to create the awareness that they will be the beneficiaries after optimizing the environment and victims when it's degraded. It can help understand how their actions are affecting the coast.

v. ***Improved Research:*** just as this study has purpose to address the coastal erosion issue, further rigorous research is needed to ascertain the extent of the damage. If possible, research centers can be established which will be solely responsible to investigate and monitor coastal processes and activities. As of now, there is no such thing or intense studies which address this. Where the coast is getting eroded a scientific investigation should be undertaken to identify the factors effecting erosion, wave climate, hydrodynamic regime and sediment disposal pattern. These will help to come up with control measures.

vi. ***Soft Protection:*** for places where immediate control or remedy cannot be provided maybe due to lack of funds or prioritization, cheap soft protection in the form of artificial beach nourishment, sand bags, tyres, etc. can be employed. However, in doing this, care should be taken to put materials of appropriate grain size and declivity. The newly sand deposited should be protected from wave action until they are completely stabilized.

vii. ***Coastline buffer zoning:*** coastline erosion can be controlled by creating a buffer around the coast by authorities where certain activities such as sand and mineral mining will not be allowed. One thing we need to acknowledge is that it will be difficult to entirely prevent these activities so measures like this need to be taken to control it. Also, the building of structures along the coastline area which will undermine the natural coast processes like sedimentation can be prohibited.

viii. ***Seawall:*** to protect the beach front and the neighboring properties, many structures have been constructed and most of which are not providing the intended results. Such structures have to be dismantled and redesigned. It is imperative that during their dismantling, care should be taken to remove them phase wise or the stability of the adjacent system would be upset as some cases when the removal of one groyne caused severe erosion of the beach and the collapse and cracking of the adjacent sea wall. In most of the cases it is recommended to use either an inclined sea wall with appropriate batter angle that effectively dissipate wave energy and increase deposition. A reno mattress at the foot and a geo textile screen behind the gabion wall which helps to prevent rilling and collapse of the village [15] should be placed.

ix. It must also be noted that since cases of many investors turning away for fear of losing their investment due to the coastal erosion are predominant in the tourism industry of the nation, the aesthetic nature should be restored. In addition, appropriate measures should be taken to ensure that the coast is safe to attract investors and tourists. This will in the long term help to improve the nation economically.

7 Conclusion and Recommendation

This study reviewed the causes and impacts of the coastal erosion in Ghana as well as the appropriate mitigating measures needed to curb the menace. It was observed that Ghana as of now is recording severe cases of coastal erosion along its coastline. Various cases of occurrence of this event and key facilitating sources of this problem were identified and discussed. It was established that proper management policies and attention is needed to mitigate the situation. The issue of coastal erosion can be minimized or prevented if the necessary planning and efficient measures are taken and ensured. The Ministry of Environment and all other related agencies involved should take a more holistic approach to preserve and maintain the coast.

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