PROBABLE EFFECTS OF SEA LEVEL RISE AND LAND RECLAMATION ACTIVITIES ON COASTLINES AND WETLANDS OF LAGOS NIGERIA

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Abstract
The yearly volumetric increase in the globe's oceans and seas leading to "Sea Level Rise" has been a subject of research and debate in recent years. Coastal regions have been most vulnerable to this phenomenon sometimes resulting in serious disasters. Climate change and anthropogenic activities are major causes of many of these disasters. Lagos, the main commercial centre of Nigeria is not an exception. It has a long strip of coastline and wetland regions. However, the wetlands are rapidly declining due to increased pressure for residential and industrial lands. Hence, land reclamation activities have been on the increase in recent years especially in the Victoria Island, Lekki and Ikoyi axes of the state. These are essentially coastlines and wetlands. Despite environmental concerns about increased vulnerability to floods, sea water intrusion, salinization of the freshwater, and a risk of sea water resurgence into the reclaimed lands, the reclamation activities are increasingly becoming popular. Weak enforcement of Land use policies and inadequate empirical assessment of these activities birthed the need for this in-depth study. This study uses literature from across various disciplines, predictions and reports from monitoring agencies, global organisations, and real-life experiences. Inferences are made from these relevant and up to date information to assess critically and come up with empirical predictions on the probable effects of the land reclamation activities coupled with projected sea level rise. Current projections for Global mean sea level rise is 3.2mm/year, and regional levels could be higher depending on local factors. The findings show that the imminent dangers associated with these activities on low-lying, densely populated and slum areas like Makoko, Iwaya, Ilaje-bariga are far greater and closer than envisaged. This review proffers proactive and pragmatic solutions for stakeholders involved to abate these effects.

Key words: Land reclamation, sea water intrusion, sea level rise, climate change, coastlines, wetlands

1.0 Introduction

The concept of Climate change has generated massive interest from stakeholders across disciplines from the last century. It is a major phenomenon, subject to studies and research across disciplines due to its far reaching effects. The third assessment report of Intergovernmental Panel (TAR) on Climate Change notes that current and future climate change would be expected to have significant impacts, particularly on coastal systems. Such impacts may include; increased coastal erosion and inundation, increased storm-surges, salt water intrusion of freshwater sources, loss of coastal ecosystems, increased risk of floods and potential loss of life" (Third Assessment Report-IPCC 2001).

This research covers the global overview of sea level rise as a component of the change in climate and narrows down to the regional settings and its probable impacts on the case study. Discussion on the subject of Land reclamation activities as a component of anthropogenic influences follows the top-down approach from a global to the regional perspective down to the case study which is Lagos Nigeria.

The Global overview of sea level rise covered in this work uses Intergovernmental Panel on Climate Change(IPCC) reports from the third assessment report (TAR) up to the fifth. Inferences can be drawn from the IPCC reports and published articles from relevant authors, that, sea level has seen a rapid increase in the twentieth and twenty-first century with respect to previous centuries. Many studies support the notion that the rate of sea level rise in the twentieth rise was at a range of 1mm to 2mm per annum (Laury 2006; TAR IPCC 2001)

1.1 Background to Sea Level Rise

Causes of sea level rise in recent centuries are generally attributed to; 1. melting of the glaciers and polar ice caps, 2. melting of the Ice sheets covering Greenland and Antarctica, and 3. the expansion of sea water as it warms due mainly to the effects of Greenhouse gases emissions. Church et al. (2011a) attribute these three causes as primary contributors to sea level rise. It is worthy of note that sea level is also influenced by other phenomena not directly

related to climate change. Extraction of groundwater, building of reservoirs and irrigation, coastal subsidence in river delta regions, vertical land movements caused by natural geological processes and changes in atmospheric and ocean dynamics (e.g. El Niño events) are all factors which may play significant roles in the increasing rate of sea level rise (TAR IPCC 2001; Church et al., 2013; Sahagian, 2000; Wada et al., 2010.).

1.2 Sea Level Rise in the 21st Century

Church et.al (2013) made reference to earlier editions of IPCC assessment reports that indicate the rate of sea level rise during the 21st century is projected to be faster than during the 20th century. Rise in sea levels is not expected to be uniform throughout the world. Not only that, sea level rise would continue even after Greenhouse gas emissions have drastically reduced. In the same vein, Church et al. (2011a) also identified ocean thermal expansion and the melting of glaciers as the main contributors to the 21st-century sea level rise. An estimation of global mean sea-level inferred from tide-gauge measurements carried out by Hagedoorn et al., (2007) puts global mean sea-level rise is (1.46±0.2) mm per annum.

However, the National Aeronautics and Space Administration (NASA)'s current Satellite data indicates that the rate of change of the sea level stands at 3.21mm per annum. The fifth assessment report of IPCC reports that global mean sea level rose at a yearly rate of 1.5 (1.3 to 1.7) mm/year between the years 1901 – 1990 and from 1993 to 2010 a rate of 3.2 (2.8 to 3.6) mm/year was recorded. It is projected that 21st-century mean rate will exceed that of 1971- 2010 (Gregory, J., 2013). There is a high confidence that 95% of the total ocean will experience sea level rise while about 70% of the world's coastlines are projected to experience SLR within 20% range of the global mean sea level rise value (Gregory, 2013).

End of the century projections, by the four assessment reports prior to the fifth were all quite within the same range; "31 to 110 cm in the First Assessment Report (FAR), 13 to 94 cm in the second assessment report (SAR), 9 to 88 cm in the third assessment report (TAR) and 18 to 59 cm in the fourth assessment report (AR4) (not including a possible additional allowance for a dynamic ice-sheet response)" (Church, et.al., 2013).

The reducing trend of the upper boundaries are reflections of projected reductions in Greenhouse gas emissions, inclusions of aerosols and increasing certainty in the projections for contributions. Since the publication of the Nobel-prize winning AR4, semi-empirical models (SEMs) have been used to estimate upper bounds of Global Mean Sea Level rise of 2.4m by the end of the century. (Church, *et. al.* 2013).

1.3 Regional Sea Level Rise

Regional sea level changes may differ significantly from the global mean sea level rise. For instance, from 1993 to 2001 the region between Japan and Korea experienced a sea rise of 5.4 ± 0.3 mm/year. That is nearly two times the Global Mean Sea Level (GMSL) rise trend (Kang et al., 2005). Variations like this occur because Regional sea level rise is not only influenced by the global phenomena but also other anthropogenic factors and natural processes. The processes such as the expansion of the warming ocean water, shifting surface winds, the addition of melting Ice are not uniform with all areas. Land subsidence which automatically elevates relative sea level can also be a reason regional sea level rise differs from the global mean rate. This Land subsidence can be due to natural or anthropogenic influences; such as extraction of groundwater or fossil fuels. In considering our case study, we look at sea level rise from the regional perspective based on these natural and anthropogenic influences (Church et al. 2013).

1.4 Land Reclamation

Land reclamation from seas and wetlands around the world is not an entirely new practice. It entails dredging and transporting large amount of sand from the sea-bed to create an artificial land for infrastructural and industrial development. (Mostafa, 2012).

Large parts of Netherlands and many coastlines along Hong Kong, North Korea, South Korea and Mainland China are reclaimed lands. Main parts of Helsinki in Finland, Yas Island of Abu Dhabi and Eko Atlantic of Lagos are just a few of the many cases of land reclamation activities around the world. De Jong *et al.* (2005) reports the series of land reclamation works in the United Arab Emirates at 200km^2. To put in perspective, that is the size of 18,519 football pitches put together. Land reclamation activities have generated mixed responses in the academia. For instance, Alpano Priyandes (2009) investigated the effects of Land reclamation activities on the Northern coast of Bantam. He observed that Land reclamation causes floods and erosion, reduced quality of sea water and loss of

fish species and sea biota. Usually, both the reclamation site and dredging site undergo biological, physical and chemical impacts (Mostafa, 2012). Jiu, et al. (2001) backs up the idea that land reclamation may impact ground water regime near coast areas as well as the coast areas opposite the reclamation area. They reported that size of reclaimed areas is one of the causes change in groundwater dynamics. In principle, a positive consequence of Land Reclamation is that it raises the water table, and shifts salt water- fresh water interface seaward. That is because the reclaimed land can be an additional aquifer and rain recharge takes place over a larger area (Ospar., 2008). However, from the environmental perspective, the adverse impacts of widespread land reclamation outweigh the positive effects. For instance, Temmerman et.al.(2013), noted that reclamation of wetlands leads to reduced flood storage area, leading to faster and higher storm surges being propagated inland. Extensive wetland reclamation raises water levels and reduces the resistance of the wetlands to landward flood propagation (Temmerman et.al., 2012). Land reclamation on wetlands could also be far more decisive in raising water levels than sea level rise. For instance, the water level of the inland part of Scheldt estuary in Belgium was observed to experience an increase of 1.3m since 1930. That is five times faster than the coastal high water level rise (Temmerman et.al., 2004).

1.5 Coastal and Wetland Areas

Estimates show that 23 percent of the world's population reside within 100 km distance from the coast, located in regions less than 100m above sea level. To put that in perspective, that is a ratio of 3 to 1 with respect to global average(Small and Nicholls;2003 in Nicholls et al.; 2007). As a result, coastal regions are prone to higher risks of stresses from anthropogenic factors. In fact, research works have shown that human activities have significantly higher direct impacts on coastal areas than of climate change alone (Scavia et al., 2002; Lotze et al., 2006). Of the direct human activities, land reclamation is a key component.

Many researchers have pointed out that most of the world's sandy shorelines have retreated in the past century (Bird, 1985; NRC, 1990; Leatherman, 2001; Eurosion,2004), with sea level rise playing a large causative role (Nicholls, 2007c). However, the adaptive capability for coastlines varies from place to place. Nicholls et al. (2007c) further note that when it comes to the vulnerability of humans, lack of adaptive capacity is the most decisive factor.

In West Africa, it is estimated that 40% of the population reside in the coastline cities. By 2020, 50 million lives are expected to be residing on the 500km stretch of coastline between the Niger Delta region of Nigeria and Accra Ghana (Hewawasam, 2002). It was predicted that Africa will possibly have a coastal megacity by 2015(United Nations, 2014). Lagos state made that cut. Now, it is not just a coastal megacity but also the one of largest mega metropolitan cities in Africa. Wetlands encompass marshes, swamps, bogs, estuaries and creeks. They play major roles in groundwater replenishment and flood protection, acting like sponges in reducing the impacts of floods (Uluocha and Okeke 2004).

1.6 Study Area

Lagos is a rapidly growing megacity located in the southwestern part of Nigeria, which lies on latitude$6^0$27'11" North and Longitude $3^0$23'45" E of the globe. The elevation of most parts of the state is below 15m. The city comprises the mainland, wetlands, creeks, swamps, a large lagoon, Islands and a long stretch of coastline opened to the Atlantic Ocean. Lagos coastline is a component of the Nigerian Barrier coastal system which is roughly 220km long and a varying width of 0.5 to 21km and characterised mainly by sandy coastlines (French et al., 1995). Lagos coastline itself is approximately 180km in length, characterised by predominantly flat terrain. The elevation of these coastlines is averagely less than 1.5m above sea level. The Lagoon has only one main (relatively narrow) outlet through which its water and water from the creeks drain into the Atlantic. In between the Atlantic and the Lagoon are two main urban Islands- Lagos Island and Victoria Island. Creeks separate these two islands while they are both separated from the mainland by a channel that connects the large Lagoon to the Atlantic Ocean. Lekki Phase 1 and the rest of Lekki is an adjoining settlement to Victoria Island. Lekki and Victoria Island are home to a scenic landscape and several expensive real estate properties. Ikoyi is located in the eastern part of Lagos Island and surrounded by the Lagos Lagoon and resident mostly to the upper class of the society. Ikoyi also boasts of a comparatively higher amount of rainfall to the rest of Lagos.

Lagos metropolis attracts thousands of individuals yearly from other parts of Nigeria and the world seeking greener pastures. Hence, the state is characterised by a high population density. The nationwide census of 2006

recorded its population as 17.5 million, geographical size of 3568.6 km^2, wetlands size of 757.55Km^2 and 3.2% growth rate (Population, 2005, Digest of Statistics 2013). This growth rate puts the current population of the state at well over 23 million (Digest of Statistics, 2013). To put this ratio in perspective, the population density of some highly populated parts of the state are higher than 100 thousand persons per square km.
According to 2014 revised edition of United Nations projections on world Urbanisation, Africa is expected to be the fasted urbanising region in terms of population upwards of 2020 to 2050. Lagos state is currently the most populous city in Africa and one of the top 28 Megacities in the world (UN WUP, 2014). These population statistics reveal the severity of impacts of human activities have and could have on the environment.

1.6.1 Reclamation Activities in the State

A significant number of Land reclamation activities have taken place over the years and are still taking place. Metropolitan Lagos including parts of Ikoyi, Lekki and Victoria Islands are former wetlands reclaimed mainly due to pressure for more Land use. Reports reveal that wetlands coverage was about 53% of the total landmass in 1965 but has shrunk to 20% at present (Lagos state Climate change policy, 2012-2014 draft). Most of the wetlands were lost through anthropogenic activities; such as Land Reclamation. Also, it is a common practice for places along the Lagoon to be sand filled for the purpose of erecting structures. Obiefuna, J.N et al (2013) researched on the changes in the wetlands of Lagos/Lekki between 1984 and 2006 and discovered the following; "swamps decreased from 344.75 km^2 to 165.37 km^2 and mangroves decreased from 88.51 km^2 to 19.95 square kilometres, built-up areas increased from 48.97 km^2 to 282.78 km^2 at 10.61 km^2/year; water body decreased from 685.58 km^2 to 654.98 km^2 at 0.16 km^2/year; bare land increased from 24.32 km^2 to 72.73 km^2 at 2.2 km^2/year; and vegetation decreased marginally from 1369.15 km2 to 1361.08 km2 at_0.37 km2/year".

The built-up areas were mostly former wetlands formed through Land Reclamation (Obiefuna, et al. 2013). That is a 40% loss of wetlands in a time frame of twenty-two (22) years.
However, very few analytical and empirical researches have been carried out on the overall, short-term and long-term effects of these Land reclamation activities.

1.6.2 Reclamation on the Atlantic- Eko Atlantic City

The report on Land reclamation activities in the state will not be complete without reviewing the ambitious "The Eko-Atlantic City Project". It is an artificial city built on Land reclaimed from the Atlantic Ocean, adjacent to Victoria Island on the North end, and along the coastline, off the Bar beach.

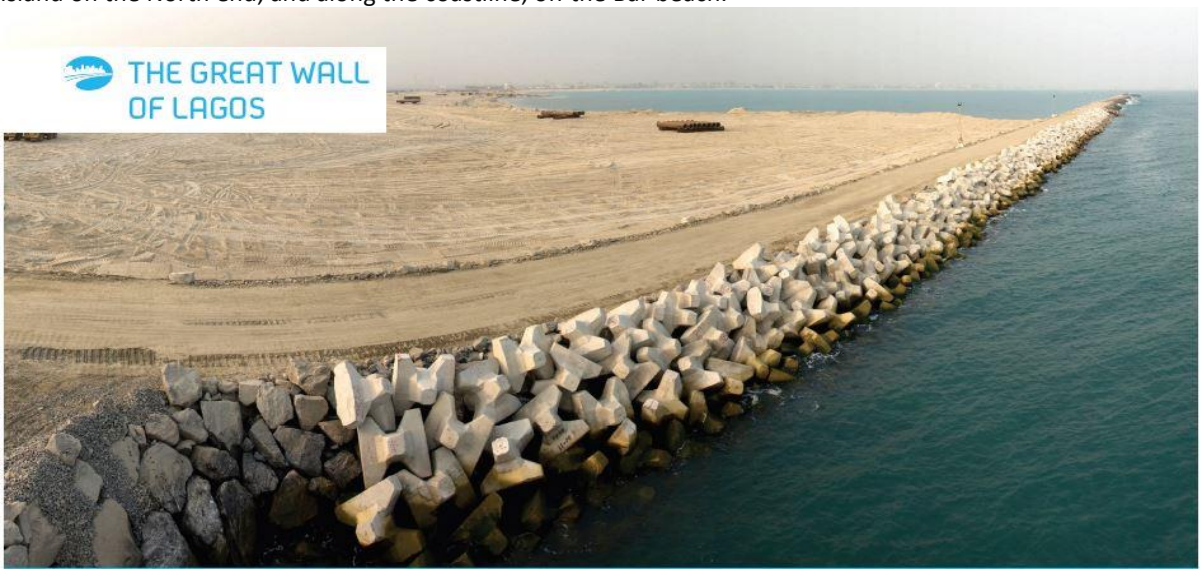

Figure 1: The Great Wall of Lagos
Source: www.ekoatlantic.com

Figure 2: Satellite Image of the Land reclamation for Eko-Atlantic City (2013)
Source: www.ekoatlantic.com

Commissioning of the dredging operations for the foundation of the project took place in February 2008. This project is expected to consume 95 million m^3 of sand dredged from the sea shelf. Upon completion it shall be protected by a long stretch of wall comprising boulders and huge interlocking concrete blocks to form the "Great Wall of Lagos" (Eko Atlantic City,2012). The project will produce nine million square meters ($9km^2$) of reclaimed land for development and is expected to reduce the coastline erosions that has plagued the coastline areas for years. The bar beach coastline is said to have eroded by at least 2km in the last 100 years (Eko Atlantic, 2012). This project is expected to accommodate 250,000 people and provide 150000 commuters daily (Awofeso, 2010, Eko Atlantic City, 2012). This project has received bought criticisms and applauses from the public as well as the academia at large.

2.0 Materials and Methods

2.1 Materials Used

Some of the publications on global to regional issues consulted are;

- The third, fourth and fifth assessment reports on Intergovernmental panel on climate change and other secondary reports and presentations
- United Nations World Urbanization Prospects
- United Nations World Population Prospects

Some of the National/local reports also consulted include;

- Digest of Statistics- Lagos State Bureau of Statistics
- Lagos state Climate-change policy
- "Building Nigeria's Response to Climate change (BNRCC)" reports for Lagos state
- Environmental Impact Assessment documents

Others are a broad range of relevant publications from recognised Authors within and outside the country, detailing reports of anthropogenic activities, effects of sea level rise and other related information.

2.2 Methods

The methodology employed in this report adapts chapter 19 of IPCC's Third Assessment Report, which gave seven criteria under which key and potential vulnerabilities, can be identified and used for deductions. The seven criteria are listed below;

- "magnitude of impacts,
- the timing of impacts,
- persistence and reversibility of impacts,
- likelihood (estimates of uncertainty) of impacts and
- vulnerabilities and confidence in those estimates
- potential for adaptation
- distributional aspects of impacts and vulnerabilities
- importance of the system(s) at risk." (Schneider, et. al, 2007)

These frameworks though applied on the global scale is a viable framework applicable for the Case Study. The potentially affected systems, processes and groups considered given these criteria; Loss of Biodiversity, Marine ecosystem alteration, Health, Extreme events, water provisioning, and livelihoods.

3.0 Results

We highlight relevant information on the topic under review in this section. The information are categorised into the four systems, processes and groups identified for assessment for probable effects.

Lagos state is currently one of the 50 most vulnerable cities to extreme sea levels. It occupied the thirtieth position on residents' exposure to flooding in 2005 and is projected at fifteenth by the 2070s with an exposed population of 3-5 million people (Nicholls, 2007b). By the year 2100, 80% of the state could have inundated due to sea-level rise induced by climate change (Triple-E et al., 2010) unless drastic and proactive measures are taken.

According to 2015 United Nations reports on population, more than half of the Africa is expected to produce more than half of the world's population growth between 2015 and 2050 due to its high growth rate. Between 2010 to 2015, the growth rate was 2.55%, the highest continental growth rate in the world. The official growth rate for Lagos given from 2006 is 3.6% per annum. Lagos growth rate stands higher and informal sources claims the current rate to be as high as 8.6% per annum. That is a serious dilemma which is bound to aggravate the impacts of sea level rise and land reclamation on the socio-economic life of the state.

3.1 Extreme Events

Land reclamation carried out in many parts of metropolitan Lagos has led to the loss of a substantial size swamps, floodplains, mangroves and wetlands. Hence, a reduction of flood storage capacity of these regions and high vulnerability to flash floods (Adelekan, 2010). The floods have serious negative impacts on the socio-economic and health conditions of the people. In 2012, thousands of people were displaced from their homes, properties destroyed and lives lost due to unusual extreme flooding. The most affected were the poorer neighbourhoods of the Islands, wetlands and low-lying areas of the state (Oshodi, 2013). Komolafe et.al (2014) note that these climate-induced extreme events are increasing in "frequency and intensity". These events are increasingly becoming an annual disaster. Komolafe et.al. (2014) believes extreme events such as floods and storms are the chief Climate-related hazards of the state. Information from "Climate Change Adaptation strategy" for Lagos state also confirms that the magnitude and frequency of extreme weather events and violent tropical storms will keep increasing. By the year 2100, sea level is expected to have risen by over 1m due to climate change. This one-metre rise is capable of submerging 22.9% of the land area (BNRCC, 2012). Furthermore, more days with extreme rainfall of over 50mm and more violent tropical storms should be expected especially from 2046 to 2065 (BNRCC, 2012). The extreme events identified are those directly linked to sea level rise and Land reclamation activities. These include intense storms, flash floods, washing away of lives and properties.

On the bright side, Odunuga et al. (2014) proved that IPCC's mean Sea Level rise projection will have no serious impact on the Badagry axis of Lagos Coastal Area. However, if Locally Oriented economic development scenarios (LOEDS) attains 4 meters and above, shoreline retrogradation and reversal of the current accretion process should be expected.

3.2 Health

In the research work carried out by Adelekan (2010) on four coastal and vulnerable communities of the state, over 90 percent of her respondents attributed their ill-health and frequent visits to health care centres to floods. BNRCC (2012) report for the state equally affirms there is likely to be an increase in water-borne diseases.

3.3 Water Provisioning

These reclaimed lands all have one feature in common, and that is the challenge of drinking water availability due to salinization of the ground water. In such places as Victoria Island, Lekki and Ikoyi, it is not uncommon to have drinking and portable water being supplied through water tankers. BNRCC (2012) attributes one of the causes of Groundwater pollution in the state as Saltwater. With the annual increase in sea levels, one of the resultant effects may be damage to water storage and supply systems and salt water intrusion into groundwater resources in the coastal areas (BNRCC., 2012; Nicholls, & Cazenave, 2010). Jiao, et.al. (2001) established that land reclamation affects both the groundwater regime of the surrounding and opposite coastal regions of the reclaimed areas. This poses a further threat to the availability of drinking water not just in these coastal areas and wetlands but also areas Landward. The salinity of the Lekki Lagoon has drastically increased, and one of the reasons is the saltwater intrusion from the ocean through the barrier beach (Emmanuel BE, Chukwu LO., 2010). With raised water tables, industrial effluents and agrochemicals can easily leach into the groundwater (Lagos State Climate Change Policy-First draft., 2012). In short, loss of wetlands (which is a serious challenge in the state), affects supply and management of water negatively (Uluocha & Okeke 2004).

Loss of biodiversity, Marine ecosystem alteration

Sea level rises and hence frequent surging of the ocean will aggravate the imbalance and loss of mangrove ecosystem (Neumann et al., 2010; Nicholls, & Cazenave, A. 2010). Floods and saltwater intrusion into freshwater swamps (which are secondary effects of sea level rise) will lead to loss and change in composition of species and habitats, short-term ecosystem disruptions (BNRCC, 2012).

3.4 Livelihoods

There will possibly be a large scale displacement of residents in coastal areas and wetlands due to surges and increased frequency of floods- resulting in more conversion of large forest areas into human settlements BNRCC (2012). Infrastructures, commercial activities, factories and industries are closely tied to livelihoods. Sea-level rise might lead to incapacitation of communications, industrial and business infrastructure as a result of surges and floods BNRCC (2012). Land reclamation activities coupled with weak adaptation frameworks will aggravate the impacts. The most vulnerable people are the slum dwellers especially the children, women and the elderly. The loss of wetlands will also negatively impact the lumber industry and subsistence fishing. Impacts of these floods on the poorer settlements in the wetlands are multifaceted, with uncoordinated Land reclamation activities an important contributing factor (Olajide, & Lawanson, 2014).

The Eko Atlantic City project received massive criticism by the close community dwellers in the wake of excessive ocean water surges that occurred in August 2012. The event claimed lives and properties in the Kuramo Beach, Victoria Island and the major parts of the coastlines. It is believed that the effects of the Ocean surge were aggravated by the Land reclamation activities for the man-made city.

4.0 Discussion

The results show that proactive steps beyond mere talks and policy formation need to be taken. The probable negative impacts attributed to sea level rise and Land reclamation activities need more than "mere talks" and policy formations. Adaptive frameworks need to be followed through with actions.

In the case of Lagos state, a holistic framework that provides limits to which land reclamation activities take place has not been provided yet. However, a climate change policy has been formed by the state but the extent of implementation of this policy in the control and regulation of swamps and wetlands reclamation is ineffective. The

inference from Adelekan (2010) is that the indigent and vulnerable communities are not feeling the positive impacts of the implementation of these policies. For a developing state like Lagos, an equitable means of solving Land settlement problems is needed for effective policy implementation (McGranahan et.al, 2007). The poor settlers usually live in informal, un-serviced and hazard-prone areas. Indeed, this is a challenge for urban planners, as the biggest Climate change induced threats in these overpopulated areas are unexpected rapid-onset hazards like storm surges and flash floods (Freeman, 2003).

4.1 Adaptation (Challenges and Bright sides)

The state's Ministry of Waterfront Infrastructure development has made some achievements in improving the adaptive capacities of some coastal areas. Some of these achievements include; finding holistic solution to shoreline erosion at Alpha Beach, Elegushi Beach, Maiyegun Beach, and Goshen Estate (which are all component parts of the state's coastal regions) and also the restoration and stabilization of the Lagos Bar Beach. These adaptive strategies have coped fairly well with the current sea levels but are not capable of addressing extreme events.

The state government has taken some proactive steps to adapt to the challenges posed by sea level rise due to climate change. Climate change summits are organised annually to create awareness and increase the sense of responsibility to challenges posed by climate change to the society. The maiden edition took place in 2009 and was tagged "Reclaiming the Environmental-Challenges and consequences of Climate Change". Topics for last two editions of the summits have centred around "Vulnerability and Adaptation" of the various sectors to the effects of climate change.

Identified challenges to adaptation mostly relate to compliance levels of the residents to housing and space standards. They include, "Increasing Urban poverty, delays in obtaining permission for development by developers, access constraints of Low-income residents to Land thereby forcing them into unregulated informal sector which are highly vulnerable, weak enforcement of Land use laws, lack of competent and dedicated staff to enforce the laws, and violation of bulk, density and air space requirements" (Aluko, 2011).

One of the bright spots in the Long-term adaptation of the state to the challenges of sea level rise is the Eko Atlantic City. Going by the project's Environmental Impact Assessment (EIA) reports, the long-term benefit of this project is that the Victoria Island axis of the state will be shielded and protected from direct impacts of the Ocean by the "Great Wall of Lagos". The wall is more than two kilometres offshore and has now exceeded 5km in length (Eko, Atlantic, 2012; Eko Atlantic, 2015; Eko Atlantic Project-EIA).

The EIA report, however, has its shortcomings; 1. It was completed two years after the actual dredging exercise had started meaning there was no collection of relevant baseline data to measure performance and carry out reliable Environmental Audit. 2. The report lacked information on the possible impact of the project on the ecosystem. 3. The EIA had low public and stakeholder participation thus; there is no information on the potential health and socio-economic impact of the project on the host communities, and how the project affects neighbouring coastal and littoral states.

Another major challenge will be the maintenance costs. Temmerman, et al., (2013) highlights that sea walls and barriers have an ever increasingly high maintenance cost. Also, the protections cause other unwanted side effects to the eco-system. A typical instance is the case of the Dutch government. By 2050, the Dutch government may spend up to 1.6 billion euros per year for their flood defence while damage or inadequacy of the mechanism may cost the government up to 3.7 billion euros (Kabat, et.al., 2009)

4.2 Imminent Risks

An over-bloated population puts extreme pressure on the available resources such as portable and drinkable water. More Wells and boreholes might be dug to meet water demand in such places not covered by the public water distribution system. This spells over-abstraction of the available ground water which will aggravate the dilemma of sea water intrusion already prevalent in the state. Another consequence is a risk of Land subsidence

The state's wetlands stand at a risk of being totally lost by the end of the century, based on Triple-E (2010)'s projections except drastic measures are put in place. Thus, leading to ecosystem imbalance, loss of bio-diversity and disappearance of marine species.

As land reclamation activities continue in a widespread manner, the natural resilience of the Lands to flooding is reduced as highlighted by (Temmerman, et al., 2004, 2012, and 2013). Thus, wetlands livelihoods may be under threat in case of extreme rainfall (above 50mm in a single downpour). Furthermore, natural processes and sediment deposition are hindered as reclaimed lands are cut off from the estuary or the sea thereby hindering natural land rise (Temmerman, et al., 2013). In order words, chances of wetland submergence against the increasing sea levels become high due to the extensive Land reclamation activities.

The indiscriminate dredging of sand from the lagoon for Land Reclamation has the tendency of disrupting the hydraulics of the lagoon and increase flood risk in certain parts of the wetlands. Furthermore, in the advent of an excessive rainfall, structures on reclaimed lands could be prone to flooding. Thus, potentially leading to colossal loss of lives and properties.

4.3 Summary

The criteria under which the vulnerabilities of the systems are measured are explained briefly below;
The magnitude of Impact: This captures the scale and intensity of the impact. For instance, the size of the area, the number of people, the degree of damage.

The timing of Impact: This is a measure of how imminent the impact is. It also captures the rate and suddenness of its occurrence and level of perceived surprise attached to the impact.
Persistence and Reversibility; An impact has a very high confidence level if it is persistent and irreversible.
Likelihood of Impacts; Is the measure of the probability of occurring in the nearest future and the confidence in available predictions made on the impacts.
Potential for Adaptation; this expresses the ability and capability of the people, individuals and society to adapt to or minimise the impacts.
Distributional aspects of the Impacts and vulnerability; this highlights the spread of the impacts on different categories of people, income brackets, gender, age… The wider the distribution, the higher the confidence level.

Importance of the system at risk: This is a measure of how people perceive the value of the vulnerable system which may be rooted in belief systems, norms and culture.

Table 1: Summary of Impacts of Sea level Rise and Land Reclamation Activities

S/P/G \ Criteria	Magnitude of Impacts	Timing of Impacts	Persistence and reversibility of impacts	Likelihood of Impacts	Potential for adaptation	Distributional aspects of impacts and vulnerabilities	Importance of the system at Risk
Extreme Events	***	*	**	***	•	*	***
Health	*	*	*	**	*	•	***
Water Provisioning	**	***	***	***	**	**	***
Loss of Biodiversity and Marine Ecosytem	***	***	***	***	*	***	**
Livelihoods	***	***	**	***	*	*	***

Confidence symbol legend: *** very high confidence, ** high confidence, * medium confidence, • low confidence

S/P/G : Systems, Processes and Groups

4.4 Suggestions and Recommendation

Accurate Topographic Analyses: These analyses of the entire Nigerian coastal zone are critical for accurate assessment of the consequences of sea-level rise. (French et.al, 1995)
There is need for a more robust and efficient disaster management framework in the state, especially in the indigent communities.

McGranahan et.al, (2007) note that a combination of "mitigation, migration and settlement modification" will be needed to ameliorate the risk of climate change-induced disasters in coastal settlements. The work also shows that damage to sensitive ecosystems is inevitable when coastal development due to human needs are uncontrolled.
Similar local-scale studies like that of Odunuga, et al. (2014) should take place for other areas of the state, especially the densely populated coastal and wetlands slum of the state.
A proactive and accountable framework should be set up to seek a constant flow of resources for the maintenance of the Lagos long sea barrier after its completion.
Creeks and outlets of the Lagoon to the sea should be mapped out, and Land reclamation activities should be prohibited in such areas.

5.0 Conclusion

On the global scene, various predictions on sea level rise indicate the global sea level is not likely to go beyond 1m by the end of the century. Therefore, the risks arising directly from SLR on the coastlines will depend largely on adaptive and coping strategies. However, the high uncertainty attached to existing models for predicting sea-level rise based on continental ice melting is a cause of concern.
Excessive Land reclamation activities on the lagoon side of the city, flood risks when rain falls as it becomes more challenging for the lagoon to cope with draining into the sea in time. Impacts of extreme outlier storm events will be aggravated by the uncontrolled land reclamation activities around the Lagoon, and is likely to increase loss of lives and properties. The clustered coastal areas of the state inhabited by the poor have weak adaptation and coping frameworks.
Sea level rise and Land reclamation activities will impact the livelihoods by indirectly increasing "rich-poor" divide. That might fuel more social frictions in the between the two classes.
The long-term benefits of Eko Atlantic City may be the protection of the coastlines shielded by the "great wall" from direct impacts of Ocean surges and coastal erosions. However, in the short term, some unprotected places might be more prone to extreme floods aggravated by sudden sea level rises and intense storms. Also, the project may cause other ecological side effects.
Anthropogenic activities such as Land Reclamation will aggravate the imminent Direct and Indirect Impacts of sea level rise.

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