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Examination of the Rising SEA Levels as a Product of Climate Change

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Abstract: *Sea level rise (SLR) due to climate change is a serious global threat. The scientific evidence is now overwhelming. The tide gauge measurements show that the current global sea level rise began at the start of the 20th century. Between 1900 and 2017, the globally averaged sea level rose by 16–21cm. and more precisely, data gathered from satellite radar measurements reveals an accelerating rise of 7.5cm (3 in) from 1993 to 2017 (WCRP Global Sea Level Budget Group, 2018), for an average rate of 31mm per year. This paper reviewed some related conceptual works including concept of sea, concept of rising sea level, concept of climate change, effect of climate change on rising sea level. The paper also reviewed the remedies to rising sea levels such as creating natural infrastructure, using beaches as barriers, building storm water pumps etc. and the control to climate change which involves the use of adaptation and mitigation as the complementary strategies for reducing and managing the risks of climate change. However, in all the paper concluded that climate change is one of the most challenging issues facing the world today. It has led to a rise in the earth's average surface temperature by about 0.7°C over the past 100 years. The resultant thermal expansion of the ocean and the increased melting of the glaciers have facilitated the sea level rise in the oceanic system. One of the recommendations made was that, to plan responsibly to respond to sea level rise which is inevitable due to climate change, it is crucial that the government of all levels should jointly plan for human and ecological systems. And they should be aware of the causes, effect of climate change and sea level rise amongst the coastal population in areas which are more vulnerable to flooding for the preservation of properties and lives.*

Keywords: *Rising Sea Levels, Implications and Climate Change.*

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Introduction

Sea level rise is closely linked to increasing global temperatures. In recent years, sea level rise induced by global warming and its impacts on climate change has become a topic of growing interest in the scientific community, as well as the media and the public. It is now well established that the Earth's climate is warming and that the main cause is the accumulation of greenhouse gases (GHGs) inside the atmosphere, produced by anthropogenic fossil fuel combustion and change in land use (mostly deforestation) (Intergovernmental Panel on Climate Change, 2013).Even as uncertainties remain about just how much sea level may rise, it is virtually certain that as sea level rises, it poses a growing challenge to coastal communities, infrastructure, and ecosystems from increased (permanent) inundation, more frequent and extreme coastal flooding, erosion of coastal landforms, and saltwater intrusion within coastal rivers and aquifers (Sweet, Horton, Kopp, LeGrande & Romanou, 2017). Assessment of vulnerability to rising sea levels requires consideration of physical causes, historical evidence, and projections.

It is important to note that the myriad of other potential impacts associated with sea level rise may involve wave action and an increase in coastal flooding. These impacts include loss of life, damage to infrastructure and the built environment, salinization of coastal aquifers, mobilisation of pollutants, changing sediment budgets, coastal erosion, and ecosystem changes such as marsh loss and threats to endangered flora and fauna (Wong, Losada, Gattuso, Hinkel, Khattabi, McInnes, Saito & Sallenger, 2014). While all of these impacts are inherently important, some also have the potential to influence local rates of sea level rise and the extent of wave-driven and coastal flooding impacts. For example, there is evidence that wave action and flooding of beaches and marshes can induce changes in coastal geomorphology, such as sediment buildup, that may iteratively modify the future flood risk profile of communities and ecosystems (Lentz, Thieler, Plant, Stippa, Horton & Gesch, 2016).

Nonetheless, modeling of future climate change under different radiative forcing scenarios indicates that sea level will continue to rise during the next decades and even centuries (IPCC, 2013; Levermann, Clark, Marzeion, Milne, Pollard, Radic&Robinson, 2013). Adverse effects of sea level rise in coastal areas are generally considered as a major threat of climate change if we consider that 10% of the world population is living in coastal areas less than 10m above sea level (McGranahan, Balk&Anderson, 2007).

Conceptual Review

Concept of Sea

Sea refers to the large body of salt water that covers a large portion of the globe. The earth's seas, as opposed to the land and air, in general. Sea is defined as a portion of the ocean that is partly surrounded by land. According to the National Geographic Society (2013), sea is a huge body of salt water, typically a part of the ocean and is surrounded by lands. Much grander than a lake or river, a sea can appear open and endless when you view it from the shore. Given that definition, there are about 50 seas around the world. But that number includes water bodies not always thought of as seas, such as the Gulf of Mexico and the Hudson Bay (National Geographic Society, 2019). The sea, connected as the world ocean or simply the ocean, is the body of salty water that covers approximately 71 percent of the Earth's surface. The word sea is also used to denote second-order sections of the sea, such as the Mediterranean Sea, as well as certain large, entirely landlocked, saltwater lakes, such as the Caspian Sea (Wikipedia, 2021). The sea is the salty water that covers about three-quarters of the Earth's surface. Sea refers to the salt waters that cover the greater part of the earth's surface in a division of waters and considerable extent, more or less definitely marked off by land boundaries.

A sea is a region of water within an ocean that is partly enclosed by land, such as the North Sea. The continuous body of salt water covering most of the earth's surface, especially this body, is regarded as a geophysical entity distinct from earth and sky (Dictionary, 2022). The sea moderates Earth's climate and has an important role in the water cycle, carbon cycle, and nitrogen cycle. Humans harnessing and studying the sea have been recorded since ancient times and evidenced well into prehistory, while its modern scientific study is called oceanography (Wikipedia, 2021). The most abundant solid dissolved in seawater is sodium chloride. The sea also contains salts of magnesium, calcium, potassium, and mercury, amongst many other elements.

Concept of Rising Sea Level

According to the National Geographic Society (2019), sea level rise is an increase in the level of the world’s oceans due to the effects of global warming. Tide gauge measurements show that the current global sea level rise began at the start of the 20th century. Between 1900 and 2017, the globally averaged sea level rose by 16–21cm (6+½–8+½ in)(Sweet, et al., 2017).More precise data gathered from satellite radar measurements reveals an accelerating rise of 7.5cm (3 in) from 1993 to 2017 (WCRP Global Sea Level Budget Group, 2018), for an average rate of 31mm (1+¼ in) per decade. This acceleration is mostly due to climate change, which includes heating of the ocean and melting of the land-based ice sheets and glaciers (Mengel, Levermann, Frieler, Robinson, Marzeion & Winkelmann, 2016). Between 1993 and 2018, the thermal expansion of water contributed 42% to sea level rise; melting of temperate glaciers, 21%; Greenland, 15%; and Antarctica, 8% (WCRP Global Sea Level Budget Group, 2018). Climate scientists have noted that the rate of rise will accelerate more in the 21st century, with the latest measurements saying the sea levels are currently rising by 3.6mm per year (Sweet, et al., 2017).

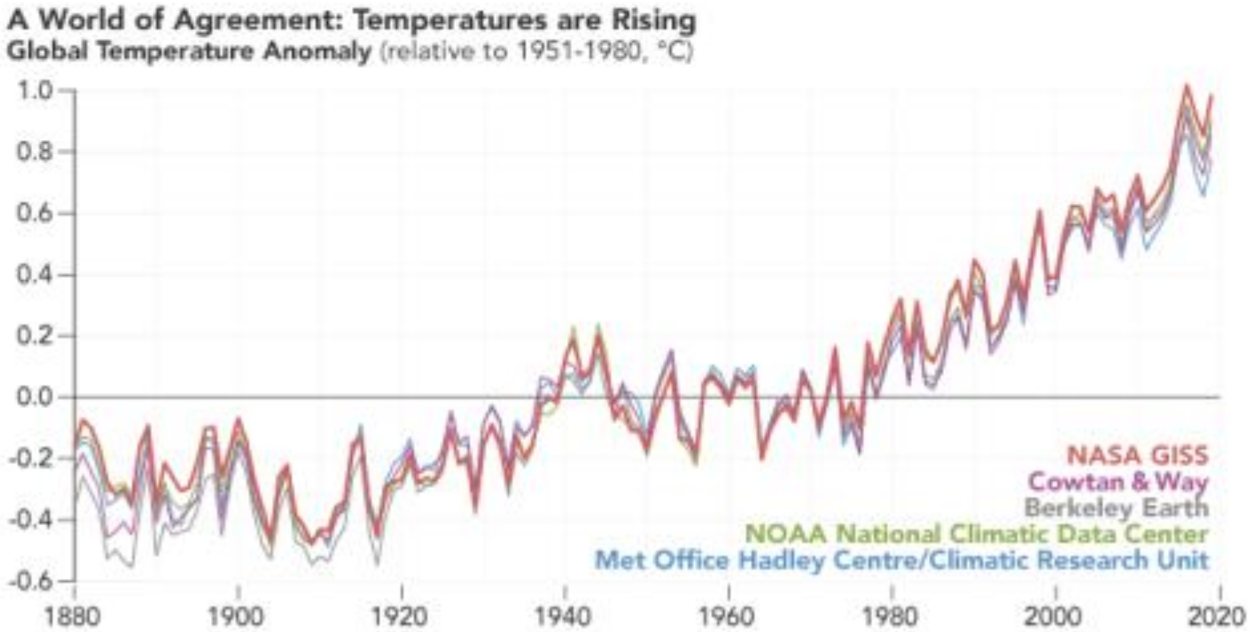

Figure 1: Annual global surface temperature 1850–2019.

Source: (NASA Earth Observatory/Robert Simmon), Griggs and Reguero (2021).The line plot above shows yearly temperature anomalies from 1880 to 2019 as recorded by NASA, NOAA, the Berkeley Earth research group, the Met Office Hadley Centre (United Kingdom), and the Cowtan and Way analysis. NASA's temperature analyses incorporate surface temperature measurements from more than 20,000 weather stations, ship- and buoy-based observations of sea surface temperatures, and temperature measurements from Antarctic research stations. Credits: NASA's Earth Observatory, obtained from: https://earthobservatory.nasa.gov/world-of-change/global-temperatures.

Tide gauges and satellite-based observations provide a good understanding of past and present sea level. However, the challenge for coastal regions around the planet is projecting sea-level rise and its impacts into the future. This is an important objective of the Intergovernmental Panel on Climate Change (IPCC), but individual geographic entities (local to national governments) are simultaneously involved in developing future sea-level rise projections for their own regions (USGCRP, 2017). Future climate projections are developed through global climate models that include uncertainties and assumptions about future greenhouse gas emissions (i.e., Representative Concentration Pathways) and the inputs or factors that will affect the global climate, including ice melt and consequently sea-level rise (Church, Clark, Cazenave, Gregory, Jevrejeva, Levermann, Merrifield, Milne, Nerem, & Nunn, 2013). Today, the predictions or projections for the next few decades are in general agreement, but estimates for the end-of-century vary between models and depend on Representative Concentration Pathways (RCPs), with increasingly wider uncertainties and ranges by 2100. The latest estimates indicate that values for the end-of-century (2100) range from a low of ~50 cm (~20 inches) to as high as ~310 cm (~10 feet), as a function of greenhouse gas emission scenarios and various probabilities or uncertainties, especially concerning the extent of Greenland and Antarctica ice melt (DeConto & Pollard, 2016) (Figure 2).

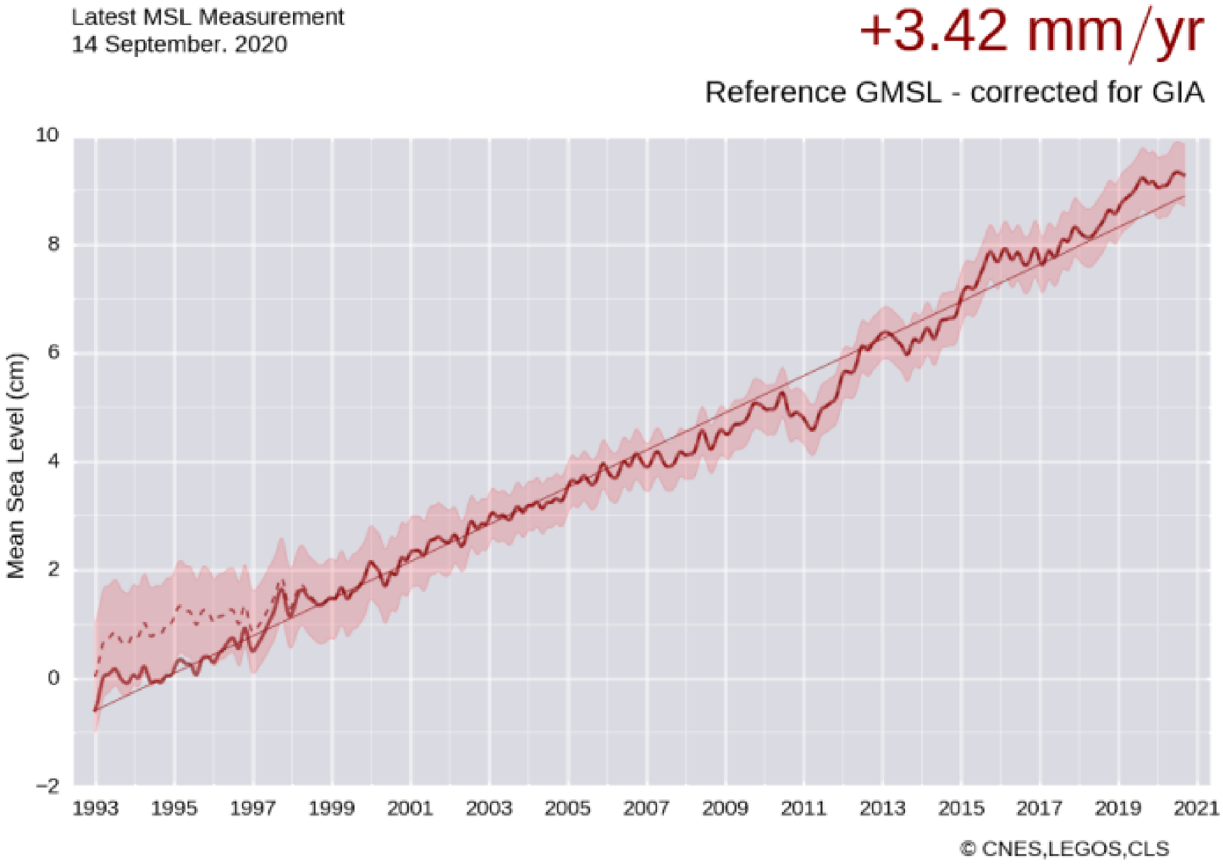

Figure 2: Sea-level rise from satellite altimetry 1993–2020.

Source: based on Ablain et. al. (2019), obtained from:

https://www.aviso.altimetry.fr/en/data/products/ocean-indicators-products/mean-sea-level.html. The reference global mean sea level (GMSL) is based on data from the TOPEX/Poseidon, Jason-1, Jason-2 and Jason-3 missions from January 1993 to present, after removing the annual and semi-annual signals and applying a 6-month filter. By applying the postglacial rebound correction (-0.3mm/year), the rise in mean sea level has thus been estimated as 3.4mm/year (straight line on the figure).

Understandably, while projections of future sea levels typically only extend out to 2100 due to increasing uncertainties, sea level rise will not stop then, but will likely continue for decades and even centuries into the future (Griggs and Reguero, 2021). Even in the absence of further greenhouse emissions, the sea level rise inertia will continue, and sea levels will increase in the future. There is approximately 66m (~216 feet) of potential sea level rise containedin the ice sheets and glaciers of Antarctica, Greenland, and the mountain glaciers of the planet.

Concept of Climate Change

Climate change is a long-term shift in the average weather conditions of a region, such as its typical temperature, rainfall, and windiness. Climate change means that the range of conditions expected in many regions will change over the coming decades. This means that there will also be changes in extreme conditions (Government of Canada, 2020). Climate change is the global phenomenon of climate transformation characterized by the changes in the usual climate of the planet (regarding temperature, precipitation, and wind) that are especially caused by human activities. According to Thiessen (2020), climate change is a long-term shift in global or regional climate patterns. Often, climate change refers specifically to the rise in global temperatures from the mid-20th century to the present. Climate change is the long-term alteration of temperature and typical weather patterns in a place. Climate change could refer to a particular location or the planet as a whole. Climate change may cause weather patterns to be less predictable. Climate change is a long-term change in the average weather patterns that have come to define Earth's local, regional, and global climates. These changes have a broad range of observed effects that are synonymous with the term (NASA, 2020). Global warming is the long-term heating of the Earth's climate system observed since the pre-industrial period (between 1850 and 1900) due to human activities, primarily fossil fuel burning, which increases heat-trapping greenhouse gas levels in the Earth's atmosphere.

Climate change refers to the periodic modification of Earth's climate brought about as a result of changes in the atmosphere as well as interactions between the atmosphere and various other geologic, chemical, biological, and geographic factors within the Earth's system (Jackson, 2021). Contemporary climate change includes both global warming and its impacts on the Earth's weather patterns. There have been previous periods of climate change, but the current changes are distinctly more rapid and not due to natural causes. Instead, they are caused by the emission of greenhouse gases, mostly carbon dioxide (CO2) and methane. Burning fossil fuels for energy use creates most of these emissions. According to Sharifi (2020), climate change is a change in either the average climate or climate variability that persists over an extended period. The Earth's climate has always changed. Changes in the Earth's orbit, the energy output of the sun, volcanic activity, the geographic distribution of the Earth's land masses, and other internal or external processes can influence the climate. Scientists refer to this type of long-term climate change as "natural climate change." Climate change is also of interest to sociologists because the activities that are responsible for anthropogenic climate change are embedded in human social life (Riedy, 2016). Everyday social practices like eating, working, moving about, and heating and cooling our homes result in emissions of greenhouse gases that contribute to climate change. Further, the causes and impacts of climate change are unevenly distributed, raising questions about the sea level.

Effect of Climate Change on Rising Sea Level

Climate Change is one of the most challenging issuesfacing the world today. It has led to a rise in the earth's average surface temperature by about 0.7°C over thepast 100 years (Gornitz, 2010). The resultant thermal expansion of the ocean and the increased melting of the glaciers have facilitated the sea level rise in the oceanic system. Sea level rise differs from one place to another because of isostatic adjustment of the mantle, nevertheless their impact on the coastal zone is significant. It threatens vulnerable coastal areas with flooding, frequent storm surges and increased erosion as the shoreline moves more inland enabling waves to break and dissipate more energy nearer to the shore. This enhanced landward movement of the coastline brings about loss of life and properties and the destruction of businesses which leads to loss of revenue to both local and national government, creating a general environmental catastrophe (Appeaning-Addo, 2009).

Economic activities coupled with the complex oceanic processes results in certain morphological changes which affects the coastal environment greatly. Human impacts in the coastal zone worsens the natural stress from wave and tidal forces. Anokwa, Martin and Muff, (2005) identified the ranging geological constituents along the coast as a major driver of erosion. Beach sand gravel mining and general lack of enforcement of laws banning beach sand mining was identified by Appeaning-Addo, Walkden and Mills (2008) as a major cause of increased erosion in Accra. They further identified the unplanned physical infrastructure development, population increase and increasing tourism development in the coastal zone as a cause of increased erosion. Coastal vegetation is cleared and wetland are drained for infrastructure development (Nicholls & Klein, 2005).

Also, Folorunsho and Awosika (2009)researched extensively on meteorologically induced storm surges in the Gulf of Guinea. This work gives account of how the average of higher high water (HHW) level for the Victoria island near to Lagos, Nigeria has increased from 0.9m above the zero of the tide gauge with tidal range of about 1m to over 2m above the zero of the tide gauge in recent years. These oceanographic conditions were further aggravated when the swells coincided with the high tides and spring tide. Thus, from the studies, it can be shown that while natural oceanic processes result in a cyclic event, human activities from construction along the coast accelerates cyclic behaviour which results in these storm surges and coastal erosion or flooding in most vulnerable areas. The vulnerability of coastal systems to sea level rise and to other drivers of climate change is determined by their sensitivity, exposure and adaptive capacity (Oteng-Ababio, Owusu & Appeaning-Addo, 2011).

Furthermore, the IPCC (2007) AR4 Report identifies several major factors that climate change currently contributes to sea level rise. These are:

- Ocean thermal expansion
- Changes in glaciers and icecaps
- Glacial melt from the Greenland and Antarctica Ice Sheets

Ocean Thermal Expansion: Instrumental records reveal that the world’s oceans have warmed since 1955, accounting over this period for more than 80% of the changes in the energy content of the Earth’s climate system. Records further reveal during the period 1961 to 2003, the 0 to 3000 m ocean layer has absorbed up to 14.1 × 1022 Joules, equivalent to an average heating rate of 0.2 Watts/m2 (per unit area of the Earth’s surface). During 1993 to 2003, the corresponding rate of warming in the shallower 0 to 700 m ocean layer was higher, about 0.5 ± 0.18 W/m2. Hence, relative to 1961 to 2003, the period 1993 to 2003 had much higher rates of warming, especially in the upper 700 m of the global ocean.

Changes in Glaciers and Icecaps: During the 20th century, glaciers and ice caps have experienced widespread mass losses. These losses (excluding those around the ice sheets of Greenland and Antarctica) are estimated to have contributed 0.50 ± 0.18 mm/yr in sea level equivalent (SLE) between 1961 and 2003, and 0.77 ± 0.22 mm/yr between 1991 and 2003.

Glacial Melt from Greenland and Antarctica: Whether the Greenland and Antarctic ice sheets have been growing or shrinking over time scales of longer than a decade is not well established from observations. Lack of agreement between techniques and the small number of estimates preclude assignment of best estimates or statistically rigorous error bounds for changes in ice sheet mass balances. However, acceleration of outlet glaciers draining from the interior has been observed in both the Greenland and Antarctic ice sheets.

Control of Climate Change

Adaptation and mitigation are complementary strategies for reducing and managing the risks of climate change. Adaptation is the process of adjustment to the actual or expected climate and its effects in order to either lessen or avoid harm or exploit beneficial opportunities. Mitigation is the process of reducing emissions or enhancing sinks of greenhouse gases (GHGs) so as to limit future climate change (IPCC, 2013). According to Akeh and Mshelia (2016), climate change mitigation and adaptation initiatives should be integrated into development projects and programmes in order to reduce the vulnerability of people to the impact of climate change. Both adaptation and mitigation can help reduce and manage the risks of climate change, but no single option is sufficient by itself. Effective implementation depends on policies and cooperation at all scales and can be enhanced through integrated responses that link mitigation and adaptation with other societal objectives.

Mitigation

Renewable/clean energy**:** In Nigeria, as elsewhere in the world, the energy sector is the most important sector for climate change mitigation (Federal Ministry of Environment, 2014). In Nigeria, conventional energy (oil and gas) with gas flaring has the highest percentage of carbon dioxide. It is important to control CO2 emissions and other associated greenhouse gases by moving towards renewable energy development and an energy efficiency mechanism (Yahaya and Nwabuogo, 2016). Nigeria has an abundance of renewable energy resources, but there is insufficient government banking to harness these resources for electricity generation (Akuru, 2017). Despite movement toward the development of policy and legislation in support of renewable energy, in particular the Renewable Energy Master Plan (REMP), developed in 2006 and updated in 2011, there has been limited progress in implementation (Elum and Momodu, 2017). In addition, fossil fuels in Nigeria have benefitted more from subsidies and incentives than the renewable energy industry. However, there are few existing renewable energy projects. In order for Nigeria to provide energy for its entire population while limiting greenhouse gas emissions, all forms of renewable energy need to be exploited (Dioha and Emodi, 2018). These include solar power, tidal, ocean energy, geothermal power, wind power, nuclear power, the use of carbon sinks, and carbon capture and storage (Yahaya and Nwabuogo, 2016).

Other sectors/lifestyle choices**:** While the energy sector has been identified as the largest contributor to Nigeria's national greenhouse gas inventory, efforts toward climate change mitigation should be distributed across various sectors, such as agriculture (Dioha and Emodi, 2018). There is also a need to encourage sustainable lifestyle choices among Nigerians. These include less meat consumption, phasing out of inefficient appliances, such as incandescent bulbs, greater access to and use of public transportation, and greater use of non-motorised modes of transport (Nkechi, 2016). Public infrastructure and services for effective waste reduction also need to be encouraged. This should include private sector partnerships for the purpose of collection and disposal of domestic and industrial wastes, as well as waste reduction strategies (Elias and Omojola, 2015).

Tree planting/reforestation**:** More than 70 percent of the people living in rural areas of Nigeria use fuel wood, which has been a key contributor to deforestation. However, reforestation accounts for only about 10% of total deforestation (Elum and Momodu, 2017). There is an urgent need for more aggressive tree planting.

- ✓ **Adaptation**

Mitigation efforts take time and may only occur to a limited extent. Adaptation efforts are thus essential (Otitoju and Enete, 2016; Olaniyi, 2013). Adaptation focuses on actions that would help to lessen the sensitivity of systems in different ecological zones in Nigeria (Federal Ministry of Environment, 2014). Planned adaptation strategies include government intervention and public policy, such as investment in infrastructure, subsidies, research, innovation, and tax regimes (Jellason, 2019). Autonomous adaptation involves coping strategies by farmers and others affected in rural settings. These include crop diversification, irrigation, planting date changes, crop and livestock insurance, and the use of tolerant crop varieties (Jellason, 2019).

Studies find that there are socio-economic characteristics that determine the level of use of climate change adaptation strategies. Education level, farming experience, use of extension services, access to weather information, access to agricultural inputs, level of household income, and availability of credit are all positively and significantly related to climate change adaptation uptake (Solomon and Edet, 2018). A study conducted in Osun state in Southwest Nigeria finds that the length of farming experience determines the level of awareness that farmers have about climate change, which in turn increases the likelihood of adopting climate change adaptation measures (Oluwole, 2016).

Agricultural initiatives**:** The patterns and linkages between rurality and climate change vulnerability make agriculture a key sector for climate change adaptation measures to foster sustainable agricultural production. Rural infrastructure development, including irrigation; skills training and assistance in adopting climate resilient technologies; education and weather information services; and agricultural insurance are examples of adaptation strategies (Achike, 2019; Madu, 2016; Federal Ministry of Environment, 2014). Adoption of existing and new technologies for adapting to climate change and variability is a high priority for many ecological regions in Nigeria, requiring medium-level financial commitment. This includes crop diversification and the adoption of climate-adapted crops (e.g. drought-tolerant and early maturing varieties of crops) that would allow for profitable crop harvest with less rain and prolonged dry periods (Amadi and Udo, 2015; Enete, 2014). Improved soil management practises and crop cover, such as the use of potatoes, melon, and groundnuts, can also be used to protect topsoil from the effects of soil erosion (Amadi and Udo, 2015; Federal Ministry of Environment, 2014).

Insurance and other financial tools**:** Insurance can be an effective adaptation strategy, with the potential to reduce the impact of climate change on insurance policy holders (Elum and Simonyan, 2016). Nigerian insurers have not, however, paid sufficient attention to the impact of climate change as there is no evidence to demonstrate that they have investigated the potential effects on the industry of incorporating climate change and weather-related losses. There has been a general reluctance to take up risks in climate-related ventures (Federal Ministry of Environment, 2014).

Infrastructure**:** The quality and availability of infrastructure and institutions is an important measure of the adaptive capacity of a given community. The low infrastructural capacity of farmers in Nigeria contributes to their high dependency on rain-fed agriculture (Ifeanyi-obi and Nnadi, 2014). Government and non-government organisations in Nigeria should seek to understand the infrastructural and technological constraints experienced by farmers and intensify efforts with regard to land tenure and information systems (Otitoju and Enete, 2016). Rural areas also require attention to irrigation infrastructure in rural settings. Irrigation facilities are becoming increasingly important as rain-fed agriculture becomes increasingly unreliable. In Nigeria, they are currently limited because only about 1% of irrigable land is irrigated (Federal Ministry of Environment, 2014). Good roads are also important for the efficient distribution of agricultural inputs to rural farmers. In addition, the availability of health facilities can assist in the provision of preventive treatments for diseases associated with climate change, such as malaria and cholera (Otitoju and Enete, 2016).

Remedies to Rising Sea Levels

1. **Using Beaches as Barriers:** Similar to seawalls, beaches and dunes can act as a natural wall and reduce the impact of storm surge. The bigger the beach or larger the dune, the more water can be stopped from reaching homes and roads. Towns can add sand to make beaches bigger or to prevent them from eroding. Using this type of natural infrastructure can protect against flooding while maintaining beaches for the community to enjoy (First Street Foundation 2018).

2. Building Stormwater Pumps: With higher seas, water doesn't drain out to the ocean as easily. Drainage systems are designed to channel excess rainwater from the streets and drain it into the sea, but the pressure from rising sea levels and higher tides can push too much water into these pipes, causing water to spill out into streets. Pumps can speed up the process of getting water out of the streets by vacuuming up the flood water and releasing it back into the sea.

3. Upgrading Sewage Systems: Flooding can disrupt sewage systems and in particular, threaten septic tanks. Since saltwater is corrosive, it can breakdown tanks and cause sewage to spew out, creating health hazards. Towns can upgrade sewage systems so that stormwater doesn't seep into pipes, upgrade septic tanks, or replace them with sewer lines for about $15,000 per replacement (First Street Foundation 2018).

4. Creating Natural Infrastructure: Coastal communities can restore natural infrastructure, which can act as a buffer against storms and coastal flooding. Natural structures such as barrier islands, oyster and coral reefs, mangroves, seagrass, and salt marshes can work alone or in unison with built infrastructure, like seawalls, to absorb storm surge. These projects are often cost-effective, can improve the natural environment for the community, and save important habitats.

Conclusion

Based on the findings of the paper, it was concluded that climate change is one of the most challenging issues facing the world today. It has led to a rise in the earth's average surface temperature by about 0.7°C over the past 100 years. The resultant thermal expansion of the ocean and the increased melting of the glaciers have facilitated the sea level rise in the oceanic system. Sea level rise differs from one place to another because of isostatic adjustment of the mantle, nevertheless their impact on the coastal zone is significant. Sea level rise is closely linked to increasing global temperatures. It is virtually certain that as sea level rises, it poses a growing challenge to coastal communities, infrastructure, and ecosystems from increased (permanent) inundation, more frequent and extreme coastal flooding, erosion of coastal landforms, and saltwater intrusion within coastal rivers and aquifers. However, governments are integrating into mitigation and adaptation initiatives development projects and programmes in order to reduce the vulnerability of people to the impact of climate change and that of sea level rise.

Recommendations

Based on the findings, the following recommendations were deemed necessary:

1. To plan responsibly to respond to sea level rise which is inevitable due to climate change, it is crucial that the government of all levels should jointly plan for human and ecological systems. And they should be aware of the causes, effect of climate change and sea level rise amongst the coastal population in areas which are more vulnerable to flooding for the preservation of properties and lives

2. Decisions on adaptation or mitigation measures should also take into consideration economic, social and environmental costs. There is therefore also need to explore the option of using this adaptive and measuring steps such as renewable/clean energy, tree planting/reforestation, creating natural infrastructure, and building stormwater pumps etc. to manage the rate of sea level rise problems in the coastal section in order to help preserve the source of livelihood of the inhabitants as well as their social life and the marine ecosystem.

3. The global, national, local and regional authorities should set up a long-term monitoring system to establish a baseline against which future changes can be measured, particularly because the signal-to-noise ratio is low for sea-level changes.

4. Knowing that sea level rise is among the major threats posed by climate change, it is of primary importance to develop multidisciplinary studies to understand and discriminate causes of current sea level changes in some key coastal regions, integrating the various factors that are important at local scales (climate component, oceanographic processes, sediment supply, ground subsidence, anthropogenic forcing, etc.). Ultimately, such studies would be useful for coastal scientists and stakeholders concerned by sea level rise, as it can be felt at the coast.

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