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Climate Change Impacts, Adaptation and Vulnerability in the Niger Delta Region of Nigeria

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Abstract
The aim of this review was to examine the impacts, adaptation and vulnerability of the Niger Delta to climate change. From a comprehensive review of the literature, it was revealed that the Niger Delta is currently being faced with climate change impacts such as increased temperature, irregular precipitation patterns and sea level rise, which had caused serious negative impacts in the region, exacerbating natural hazards such as flooding, coastal erosion and salt water intrusion into fresh water aquifers. Future projections have it that these impacts may be more severe if urgent steps are not taken to address the situation. Unfortunately, current adaptation strategies are poorly designed and have been found to be inadequate in dealing with the current situation, because of the reported poor adaptive capacity of both ecological and human systems. The paper recommends that a comprehensive adaptation strategy for the region should be developed involving the governments and all relevant stakeholders, to increase the adaptive capacity of the region and moderate the impacts of climate change.
Keywords: Adaptation, Climate Change, Niger Delta, Vulnerability

1. Introduction

A review of several studies on climate change has shown that the potential impacts of climate change are broad based, interconnected and complex. There are both direct and indirect impacts of climate change, which have the potentials of unleashing devastating impacts on both geophysical and human systems. These impacts could led to serious environmental, health and socio-economic dislocations in some parts of the world (Ohwo, 2015; IPCC, 2014; Ifeanyi-obi et al, 2012; IPCC, 2007), especially in sub-Sahara Africa and the Niger Delta region of Nigeria in particular. This is due to the multiple stresses and low adaptive capacity of the region (IPCC, 2007), which are attributable to poverty, poor technology, high dependence on natural resources, rain-fed agriculture and weak institutions and governance.

Vulnerability is “the degree to which a system is susceptible to or unable to cope with, adverse effects of climate change, including climate variability and extremes” (IPCC, 2001). On the other hand, climate change adaptation is defined as “adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities” (IPCC, 2001). The adaptive capacity of a system is its ability to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2001).

The concepts of climate change impact; vulnerability and adaptation are linked and reinforces one another. For instance, if the adaptive capacity of a system is very high, its vulnerability to climate change would be low and the level of impact on the system would be moderated. This explains why the capacity to respond to climate change is lowest in developing countries and among the poorest (Olmos, 2001), which accounts for the spatial variation in the response of people to climatic stimuli within a region or country. Unfortunately, the actual and potential impact of climate change in the Niger Delta is probably among the highest in Nigeria as a result of poor adaptation and high level of vulnerability, occasioned by its coastal location, height above sea level, high poverty level, pollution and dependence on rain-fed agriculture, poor infrastructure and institutions.

IPCC (2000) noted that “decreasing the vulnerability of socio-economic sectors and ecological systems to natural climate variability through a more informed choice of policies, practices and technologies, will in many cases reduce the long-term vulnerability of these systems to climate change.” Hence, this study was designed to review existing literature on the current and future impacts, adaptation and vulnerability of the Niger Delta region of Nigeria to climate change. This would help to highlight the level of vulnerability of the region to the impacts of climate change, which would enable policy and decision makers to develop informed and sustainable strategies to reverse the current trend.

2. The Study Area

The Niger Delta can be defined geographically and geopolitically. The geographical definition of the Niger Delta is limited to three states of Bayelsa, Delta and Rivers. The conventional geographical perimeter extends from the Benin River in the west to the Imo River in the east, and from the southernmost tip at Palm Point near Akasa to Aboh in the north where the Niger River bifurcates into its two main tributaries. The geopolitical Niger Delta covers nine southern states of Nigeria, which include Abia, Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Imo, Ondo and Rivers (Figure 1). The geopolitical definition was a recent creation of the Federal Government in 2000 to include all the oil producing states in Nigeria, and appears to be more popular (Odjugo, 2011), hence its adoption in this review. The geopolitical Niger Delta covers about 70,000 km² and makes up 7.5% of Nigeria's land mass, with a total population of 27,696,577 (National Population Commission, 2006). The geopolitical Niger Delta is located within latitudes 4^{O} 15$^{'}$ and 8^{O} 00$^{'}$ North of the Equator and longitudes 4^{O} 30$^{'}$ and 9^{O} 15$^{'}$ East of the Greenwich Meridian.

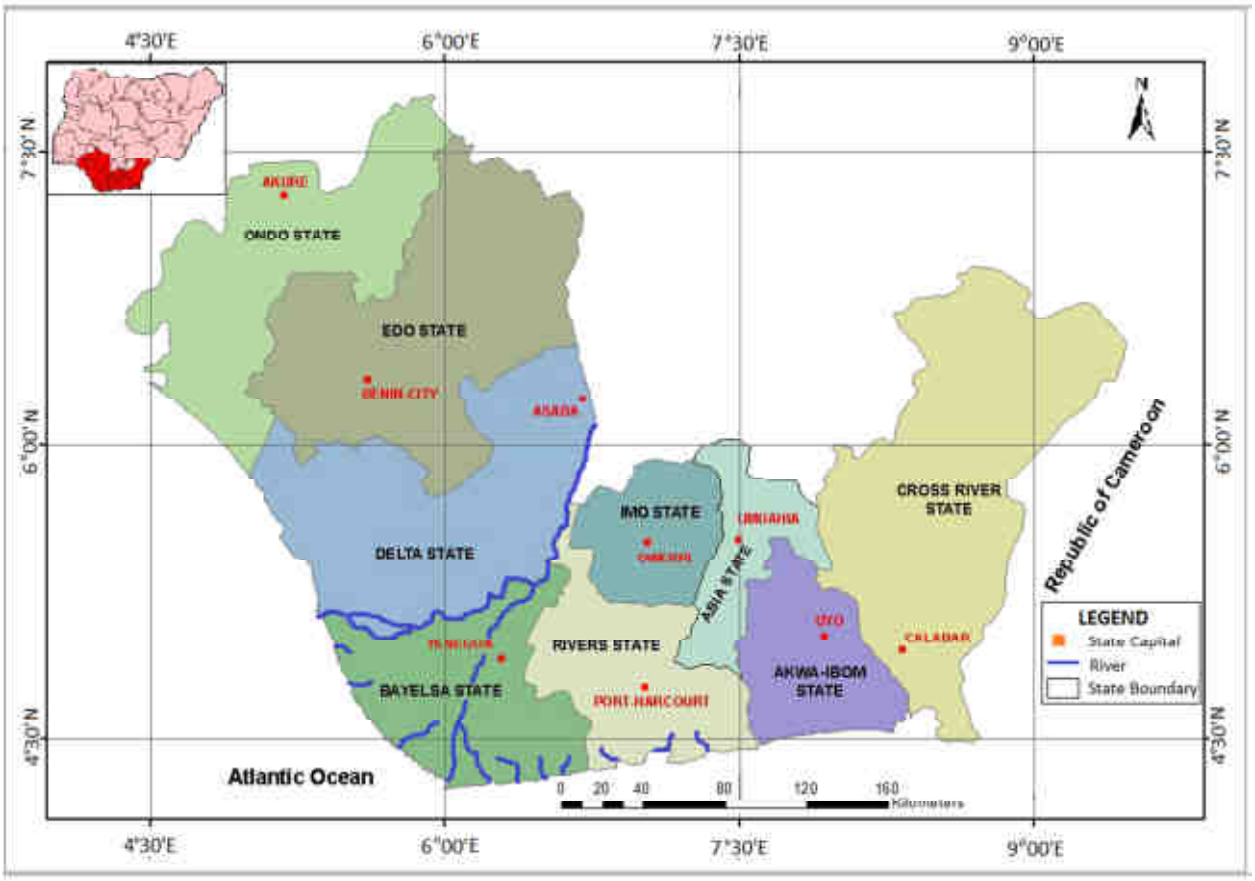

Figure 1: Geopolitical Niger Delta

The Niger Delta experiences Equatorial type of climate (Koppen's Af classification) in the southern coastal area and Subequatorial in the northern part of the region. The mean monthly temperature ranges from 25^{O}C to 29^{O}C and annual rainfall from 2,000mm to 4,000mm (Odjugo, 2011), with a relative humidity above 70%. The region experiences two major seasons-rainy and dry. The rainy season, which last from March to October, is influenced by the southwest monsoon winds, which carry's moisture from the ocean into the hinterland, with a little dry spell in the month of August (August break). On the other hand, the dry season last from November to February (extend from October to March in the northern part of the region), and is influenced by Tropical Continental air mass from the North, which brings slight *harmattan* between the months of December and February.

The soils of the region are generally sandy, muddy and clayey, which provide an unstable base for roads and building construction works, especially in the coastal areas. The vegetation of the Niger Delta consists mainly of swamp forest and tropical rain forest (Olorode, 2002). The major occupation of the people is farming and

fishing, which are usually practiced at subsistence level. The region is endowed with very substantial hydrocarbon deposits. Crude oil production from the region runs at almost 2 million barrels per day, which roughly accounts for over 80% of Nigerian export revenues. Unfortunately, the exploration and exploitation of the crude oil deposit has brought serious environmental degradation, which has negatively affected the socio-economic activities of the people leading to increased poverty. The coastal location of the region exposes it to climate change hazards of sea level rise (resulting to flooding, coastal erosion and salt water intrusion into freshwater aquifers), irregular precipitation patterns and increasing temperatures. In addition, population increases, urbanization and industrialization, and social conflicts, have all reacted to create a huge complex challenge that requires urgent attention.

3. Impact of Climate Change in the Niger Delta

Several scientific studies, most especially by the Intergovernmental Panel on Climate Change (IPCC) have identified current and potential impacts of climate change (temperature increases, sea level rise, melting ice, changes in precipitation patterns, health challenges, ecological dislocation, flooding, erosion, drought and desertification) on both geophysical and human systems all over the world. The peculiar nature of the Niger Delta (coastal location, height above sea level, high precipitation, high poverty level, and environmental degradation due to oil exploration and exploitation activities, and poor agricultural practices) makes the region to be highly susceptible to vagaries of climate. Some of the impacts of climate change in the Niger Delta region as identified by past studies include sea level rise, which has led to salt water intrusion into fresh water aquifers; flooding, coastal erosion, irregular precipitation pattern, high temperature, ecological dislocation, socio-economic and health hazards (Ohwo, 2015; Ikehi, *et al*, 2014; Musa *et al*, 2014, NEST, 2011; Uyigue and Agho, 2007). These impacts have led to the displacement of people and livestock (NEST, 2011), which has further increased the poverty level of the region and human sufferings

Flooding and coastal erosion are serious environmental problems in the Niger Delta region, which has been exacerbated by climate change. This is not surprising as Wong *et al* (2014) had noted that due to sea level rise, coastal systems and low-lying areas would increasingly experience adverse impacts such as submergence, coastal flooding and erosion. They further projected that in the absence of adaptation, increasing sea level would intensify current erosion of beaches, sand dunes and cliffs. Attesting to the severity of flooding and coastal erosion in the region as a result of climate change, Uyigue and Agho (2007) submitted that coastal erosion is the most important environmental problem facing the Niger Delta region. They added that flooding of low-lying areas in the region has devastated settlements and destroyed oil wells in Forcados and other economic activities in the region especially primary activities such as farming and fishing. Also, coastal vegetation especially the mangroves forest has been lost to coastal erosion (Awosika, 1995) with negative consequences on coastal biodiversities. Although there is not enough evidence shown by the authors on the link of climate change to these devastations, however, they can be exacerbated by climate change.

A study conducted by Uyigue and Agho (2007) in some communities in the Niger Delta region reported the level of devastation by both flooding and erosion in the studied communities. They stated that the socio-economic lives of the people in Egor and Ogida communities in Edo State have been severely impacted by flood and erosion, which has eroded the top soil, affected fresh water resources, destroy roads, render many people homeless and threaten lives and properties.. This scenario is not deferent from what is obtainable in other parts of the Niger Delta region, though the severity of the impacts varies spatially. The Intergovernmental Panel on Climate Change (IPCC) has linked sea level rise to climate change, and a rise in mean sea level of 0.462m was recorded in the coastal waters of Nigeria between 1960 and 1970 (Udofa, and Fajemirokun, 1978) cited in (Uyigue and Agho (2007). This probably has informed the authors' conclusion on the link of flooding severity to climate change in the Niger Delta region.

The 2012 flood episode in the Niger Delta region was the most recently recorded flood episode, which was largely attributed to climate change. The Nigeria Post-Disaster Needs Assessment 2012 Floods, reported that the impact of the 2012 flooding was very high in terms of human, material, and production loss, with 363 people killed, 5,851 injured, 3,891,314 affected, and 3, 871, 530 displaced (Federal Government of Nigeria, 2013). The Niger Delta region contributed significantly to this statistics, as four states (Bayelsa, Delta, Edo and Rivers) in the region were significantly impacted because of its coastal location.

In spite of the impacts of the 2012 flood episode in the Niger Delta region, projections of future impacts as a result of sea level rise (SLR) propelled flooding is alarming. For instance, Awosika *et al*, (1992) estimated that the region could lose over 15, 000 square kilometers of land by the year 2100 with a one metre rise in sea level (see Table 1), which would result in the displacement of at least 80 per cent of the people in the Niger Delta

region as a result of its low elevation. By implication, if practical steps are not taken to check sea level rise, large propulsions of the Niger Delta can be washed away with severe consequences on human life and other geophysical systems in the region.

Table 1: Projected Total Land Loss Due to Coastal Erosion and Inundation from Different Scenarios of Sea Level Rise in the Niger Delta Region

S/N	SLR (m)	Low Estimates (km^2)	High Estimate (km^2)
1	0.2	2, 846	2, 865
2	0.5	7, 453	7, 500
3	1.0	15, 125	15, 332
4	2.0	18, 398	18, 803

Source: Adapted from Awosika *et al*, 1992

Scientific investigations have identified temperature increases as potential impact of climate change (IPCC, 2005; Nyelong, 2004), which has the capacity to influence agricultural productivities. Studies have shown that in the Niger Delta region most crops thrive within the temperature range of 23^OC and 30^OC (Okpeke, 1987; Udoh *et al*., 2005). Unfortunately, studies have confirmed annual temperature ranges of three studied states by NEST (2011) to be above this temperature threshold. The study revealed that mean annual temperatures from 1971 - 2006 have increased in the three studied states of Akwa Ibom (29.6^OC - 31.4^OC), Ondo (30.3^OC - 33.3^OC) and Rivers (30.2^OC – 31.2^OC). Based on these data the report concluded that temperature have steadily increased within these periods, which has implications for the environment and source of livelihoods (farming and fishing) in the region, as higher temperatures could lead to low fish catch as well as lower crop yield, a situation which may result in loss of income by the majority of the Niger Delta population who depend on these activities for sustenance (NEST, 2011).

Variation in temperature and humidity in the Niger Delta may alter the spread of pests and diseases, and increase the risk of invasion and the emergence of health related hazards (Ikehi, *et al*, 2014). Although scientific evidence on the link between climate change and the spread of pest and diseases is still sketchy in the Niger Delta, however, such situation coupled with irregular precipitation patterns could exacerbate the poverty level in the region. In addition, studies have shown that in recent decades, climate change has contributed to levels of ill health, as rising temperatures have exacerbated the risk of heat-related death and illness. Although the present worldwide burden of ill health from climate change is relatively small compared with other stressors on health, however, local changes in temperature and rainfall have altered distribution of some water-borne illnesses and disease vectors, and reduced food production for some vulnerable populations (Smith *et al*, 2014).

4. Adaptation Strategies to Climate Change in the Niger Delta

The peculiar location and nature of the Niger Delta have motivated individuals and communities in the region to develop strategies for effective adaptation to the challenging environment. Over the years the developed adaptation strategies, which were embedded in the communal cultural practices, were found to be compatible with flood regimes and associated fluvial processes (NEST, 2011), which characterize the region. In recent years however, the increase in population, in association with other stressors (urbanization, industrial development, agricultural expansion, the reduction of sediment load of the major rivers in the region due to upstream dams) have impacted negatively on agriculture in the flood plains and exacerbated coastal and river bank erosion. This situation has altered considerably the subsisting equilibrium in the area, which has led to flooding and other environmental hazards, with negative impacts on the livelihoods of the people (NEST, 2011).

Although many adaptive strategies can be developed to contend the negative impacts of climate change; adjustments are possible in practice within the limits of available income and technology. The urgent adaptation needs of the Niger Delta stem from the fact that the region is highly vulnerable to climate change, together with its low levels of adaptive capacity. Although efforts are being made to support adaptation activities, they are not enough to guarantee effective adaptation for projected climate change impacts in the region. The major adaptation strategies adopted by the people to cope with some of the identified impacts of climate change include construction of foot bridges with wood, stones and sand bags; raising walls with sand bags and/or blocks to divert flood water, using improved crop varieties and animal breed, use of mulching materials for crops and shades for animals, change of harvesting date, mix cropping, using early maturing plants/animals, changing planting/stocking time and change of livelihood by those who once depended on natural sectors such as farming and fishing (Ikehi *et al*, 2014; Uyigue and Agho, 2007). Most of these adaptation methods are reactive, private

and autonomous**,** which are weak in dealing with current and anticipated future impacts of climate change. This is a clear indication that the people relied more on their indigenous strategies to adapt to climate change.

Although some of the adaptation strategies were found to be effective in the past when the situation was less severe, however, due to increasing intensity of climate change, coupled with high population and other environmental stressors, the adaptation strategies are no longer able to effectively cope with current climate change impacts, talk less of more severe projected impacts. To ameliorate the current and projected impacts of climate change in the Niger Delta and Nigeria in general, there should be a change in the adaptation strategies to include planned, anticipatory and public adaptation, with proper integration of local and traditional knowledge.

5. Climate Change Adaptation Options in the Niger Delta

The above review of the adaptation strategies adopted by the people of the Niger Delta have been found to be inadequate in dealing with current and projected future climate change impacts in the region. However, there are other options which could be adopted to effectively reduce the level of vulnerabilities to climate change. According to Nicholls *et al* (2007) the IPCC have classified coastal adaptation strategies into three classes, which include retreat, accommodation, and protection, which are now widely used in most countries of the world (Linham and Nicholls, 2012). These tripod coastal adaptation strategies to climate change is what has expanded into broad approaches of retreat, defend, and attack (Peel, 2010). According to Wong *et al* (2014) "protection aims at advancing or holding existing defense lines by means of different options such as land claim; beach and dune nourishment; the construction of artificial dunes and hard structures such as seawalls, sea dikes, and storm surge barriers; or removing invasive and restoring native species. Accommodation is achieved by increasing flexibility, flood proofing, flood-resistant agriculture, flood hazard mapping, the implementation of flood warning systems, or replacing armored with living shorelines. Retreat options include allowing wetlands to migrate inland, shoreline setbacks, and managed realignment by, for example, breaching coastal defenses allowing the creation of an intertidal habitat. The appropriate measure may depend on several factors requiring a careful decision-making and governance process."

It should be noted at this point that the climate change adaptation options discussed above have their limitations. Adger *et al* (2007) identified some barriers such as physical and ecological, technological, social and cultural, financial, informational and cognitive barriers, which may affect the effective adoption of some of these options. For instance, Tam (2009) noted that building sea wall barriers are expensive. She cited the examples of the Maeslant Barrier, located in Rotterdam, Netherlands, which cost estimates was $4 billion, and the famous Three Gorges Dam in China, which was estimated at a cost of $25 billion. In addition, the author reported that the Bay Conservation and Development Commission (BCDC) study revealed that a barrier would affect the Bay's salinity, sedimentation, coastal erosion, wetlands, wildlife and endangered species.

Howden *et al* (2007) had stated that there are perceived risk to public health and safety, and ecological risk in the introduction of new genetic crop variants to natural environment, in the form of biotechnology and genetically modified crops. Also, coastal hazard mapping may increase fear and anxiety in some people, as residents become more aware of the risks, but not how to address them. Considering the limitations of each of these options, it is therefore necessary to undertake a comprehensive analysis of all contending issues before a decision is reached on the choice of the most appropriate options.

A critical assessment of the climate change adaptation options in the Niger Delta revealed that most of the measures cannot be executed at the household/private level, which is the current dominant adaptation strategy in the region, due to high financial and technical requirements. Therefore, the governments (Federal, State, and Local), NGOs, donour agencies, and all relevant stakeholders must come together, with the federal government providing leadership to implement some of the strategies that best suit the region to tackle the menace of climate change.

6. Vulnerability and Adaptation Constraints to Climate Change in the Niger Delta

NEST (2011) reported that communities in the Niger Delta are vulnerable and have limited adaptation capacities to climate change-related events and extremes. It also noted that communities with different livelihoods experience different types of climate risks; as communities along the coastline are confronted with the risk of ocean surge and sea level rise, while the wetland communities are faced with the risk of pests and flooding. Some of the reasons responsible for households' vulnerability to climate hazards are: low agricultural output and income, non-availability of irrigation facilities, insufficient farm labour, lack of storage facilities and inadequate transport (NEST, 2011). The high vulnerability of most parts is because the region is already under stress of demographic and environmental constraints, due to unsustainable human activities (Ogba and Utang, 2007). In

addition, there is low level of economic development; consequently the monetary capacity to adapt is limited.

From the reported constraints to adaptation in the Niger Delta, it is evident why the adaptive capacity of the region is low. The identified determinants of adaptive capacity by IPCC (2001) which include available technology options; available resources and their distribution; stock of human capacity including education and security; stock of social capacity including property rights; structure of critical institutions; ability of decision-makers to manage information and validate it; and public perception, are majorly not provided or poorly attainable in the Niger Delta. According to Wong *et al* (2014) "different constraints typically do not act in isolation, but in interacting bundles. Therefore it is difficult to predict which constraints matter most in any specific context but instead multiple constraints need to be addressed if adaptation is to move successfully through the different stages of the management process."

7. Principles for Effective Adaptation

In order to enhance the adaptive capacity of any system (geophysical or human), to adequately adapt to both current and projected climate change impacts, certain principles should be adopted. Based on comprehensive studies on climate change adaptation, Field *et al* (2014) had proposed some basic principles for effective adaptation to climate change. Some of these principles, which are presented below can enhance the adaptive capacity of the Niger Delta, and reduce its vulnerability to climate change impacts and risks, if well implemented.

One of the first steps towards adaptation to future climate change is reducing vulnerability and exposure to present climate variability. This can be achieved by developing resilience across a range of possible future climates, while helping to improve human health, livelihoods, social and economic well-being, and environmental quality. In addition, there should be a conscious integration of adaptation into planning and decision making to promote synergies, which can enhance development and disaster risk reduction.

Another principle is the realization that adaptation is place-and context-specific, with no single approach for reducing risks appropriate across all settings. Therefore, adaptation strategies for effective risk reduction, should consider the dynamics of vulnerability and exposure and their linkages with socioeconomic processes, sustainable development, and climate change. Complementary actions across levels, from individual to governments (Federal, State and Local) and organized private sector can enhance adaptation planning and implementation. In this regard the federal government should play a leading and coordinating role, for example, by protecting vulnerable groups, supporting economic diversification, and by providing information, policy and legal frameworks, and financial support.

Poor planning, overemphasizing short-term outcomes, or failing to sufficiently anticipate consequences can result in poor adaptation, which can increase the vulnerability or exposure of the target group in the future, or the vulnerability of other people, places, or sectors. Some near-term responses to increasing risks related to climate change may also limit future choices. Therefore, adaptation planning should also recognize long-term outcomes and incorporate existing and emerging economic instruments as they can foster adaptation by providing incentives for anticipating and reducing impacts. Such instruments include public-private finance partnerships, loans, payments for environmental services, improved resource pricing, charges and subsidies, norms and regulations, and risk sharing and transfer mechanisms.

Adaptation planning and implementation at all levels of governance should be contingent on societal values, objectives, and risk perceptions, as the recognition of diverse interests, circumstances, social-cultural contexts, and expectations can benefit decision-making processes. In addition, indigenous, local, and traditional knowledge systems and practices, including indigenous peoples' holistic view of community and environment, are a major resource for adapting to climate change, but these have not been used consistently in existing adaptation efforts. Thus, integrating such forms of knowledge with existing practices increases the effectiveness of adaptation as the local people easily key in and identify with such measures, which enhances their adaptive capacity and resilience to climate change impacts.

These principles can enhance effective adaptation to climate change in the Niger Delta region, if well implemented. The principles addressed some of the basic constraints of adaptation of both natural and human systems in the region. For instance, the adaptation constraints to climate change in the Niger Delta, as identified by NEST (2011) and the determinants of adaptation capacity by IPCC (2001) as earlier presented, can be addressed and enhanced, respectively by the adaptation principles. For instance, the first principle, which proposes the development of resilience across a range of possible future climate, health, livelihoods, social and

economic well-being, environmental quality, and the conscious integration of adaptation into planning and decision making; can promote synergies, which can address some of the adaptation constraints identified by NEST (2011) such as governments' unresponsiveness to climate risk management, inadequate knowledge on how to build resilience, limited income and lack of access to credit facilities. Addressing these issues would reduce the vulnerability of the Niger Delta region to climate change impacts and risks.

8. Conclusion

The reviewed papers in this work revealed that the Niger Delta is currently facing the impacts of climate change, which include sea level rise, resulting in flooding, coastal erosion and salt water intrusion; increase temperatures, irregular precipitation patterns amongst other impacts. These impacts had negatively affected both geophysical and human systems. Unfortunately, projected future impacts would be more severe if urgent measures are not put in place to mitigate climate change and enhance the adaptive capacity of both ecological and human systems. Currently, the adaptive capacity of the Niger Delta to the impact of climate change and associated risks is low as revealed by several studies undertaken in the region. Some of the reasons for this low adaptive capacity include high poverty level, coastal location of the Niger Delta, poor institutions, high reliance on natural economic resources and poor governance system. In addition, the major adaptation types employed in the region are classified as private, autonomous and reactive adaptations, which have been found to be inadequate in dealing with climate change impacts in the region. This has made the region to be highly vulnerable and less resilient to the impacts of climate change.

In order to reverse this ugly trend, there is an urgent need to develop a comprehensive adaptation strategy for the region. The governments (Federal, State and Local), organized private sector, NGOs, donour agencies and all relevant stakeholders should come together to produce a blue print with the federal government providing leadership. In the design of this blue print, the basic steps for effective coastal adaptation should be considered, and local indigenous adaptation strategies should be integrated, while the focus should be public, planned and proactive adaptation.

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