Blue Carbon Ecosystems: Sources, Threats and Implications for Climate change in the Niger Delta Region, Nigeria

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Abstract- Blue carbon ecosystems also known as coastal or marine ecosystems are biodiversity hotspots that render invaluable ecosystem services, and possessed high capacity for carbon sequestration and storage. Whereas societies are well informed about the roles and significance of terrestrial ecosystems in climate change mitigation, there is comparative lack of awareness, knowledge gap and absence of legislative framework at national and international level to protect and conserve blue carbon ecosystems and their resources. This study identifies blue carbon sources in the Niger Delta region of Nigeria and analyzed their ecological characteristics in relation to ecosystem services, carbon sequestration and storage and social economic significance. Primary data were obtained through physical observations and documentations of biophysical resources of blue carbon ecosystems, and over 70 publications on related subjects of blue carbon sources, carbon markets and climate change were empirically reviewed. A narrative analysis of the data were carried out and further discussed and characterized various threats to blue carbon ecosystems in the Niger Delta and implications for climate change mitigation and adaptation to people living in the region. It concludes with policy recommendations for conservation, restoration, protection and management of blue carbon ecosystems in the Niger Delta region.

Index Terms- Blue carbon, climate change, ecosystems, implications, threats

I. Introduction

There are four types of carbon which are black carbon (carbon in form of soot and dust produced from impure combustion of coal power plants), brown carbon (emissions from the burning of fossil fuels for transportation, energy and industry), green carbon also known as terrestrial carbon (carbon stored in plant biomass and soil in the forest, plantations, agricultural and pasture lands), and blue carbon also known as coastal or marine carbon (carbon capture or sequestered and stored in mangroves, tidal wetlands, sea grasses, Oceans, and salt marshes (Elizabeth, Gail, Steve, Rodney, Mats, Carlos, Catherine, William & Brian, 2011, Nellemann, Corcoran, Duarte, Valdés, De Young, Fonseca, & Grimsditch, 2009, Trumper, Bertzky, Dickson, Van der Heijden, Jenkins & Manning, 2009, Lovelock, Ruess & Feller, 2011, Chevallier, 2012). Green and blue carbon ecosystems have common characteristics which include biodiversity hotspots, provision of invaluable ecosystem services, and capacity for high carbon sequestration and storage. For instance, the rate of carbon sequestration and storage in healthy blue carbon ecosystems continue to increase in volume over time and consistently accumulate because the soil and sediments which healthy mangroves, tidal wetlands, and sea grasses grow increase in response to rising sea water level. Additionally, carbon stored in the soil over a long period of time in blue carbon ecosystems does not plateau like that of terrestrial ecosystems, and the quantity of carbon dioxide stored in a single hectare of mangroves could generate as much greenhouse gas emissions as four to five hectares of mature tropical forests (Stephen, Crocks and Jette, 2010).

However, a publication made by Duke University (2011) on State of Science on Coastal Blue Carbon Ecosystems emphasized that unlike terrestrial ecosystems, the ecological, socio-economic and cultural values of blue carbon ecosystems have not been communicated effectively to broader communities of climate change policy makers at national and international level, and other relevant stakeholders who are frontiers of global climate change mitigation debates. Thus, the benefits of blue carbon ecosystems in global climate change mitigation are yet to be explored in many developed and developing countries. Also, owing to little or none availability of finances and incentive mechanisms, there is loose effort for conservation and protection of blue carbon ecosystems at national level and this has led to critical loses of the ecosystems (Elizath et al. 2009). According to Gabriel (2011) whereas societies are well informed about the importance of conserving biodiversity in terrestrial ecosystems and their significance in climate change mitigation strategies, there is a comparative lack of awareness and absence of legislative framework at national and international level to protect and conserve blue carbon ecosystems and their resources. Furthermore, Lina, Emma, Masahiro, Jimena, Pedro and Joel (2018) who carried out studies on sea grass ecosystem services points out that public knowledge about sea grasses is very limited and there is low public awareness on the benefits they provide in the scientific community. Similarly, Sabastian (2014) who conducted studies on knowledge gaps, critical issues and novel approaches to blue carbon in financial carbon markets reveals that literature publications about blue carbon are dominated by technical commentary, and there is dearth of scholarly work on practical social considerations and stark absence of private sector perspectives as well as low

understanding of investment priorities and risk considerations in coastal ecosystem management.

Juha, James, Sunny, David & Daniel (2013) established that the social and economic significance of coastal ecosystems are under-studied and under-represented in policy development and decision making at national level in several countries, and ignored in global climate change mitigation strategies. For instance, many international climate change framework including the United Nations Framework Convention on Climate Change (UNFCCC), National Appropriate Mitigation Actions (NAMAs), Reducing Emissions from Deforestation and Forest Degradation (REDD+), Clean Development Mechanisms (CDM) and Land Use, Land Use-change and Forestry (LULUCF) all excluded consideration and provisions to fund blue carbon ecosystems (Herr, Pidgeon, & Laffoley, 2011, Gacia, Duarte & Middelburg, 2002, Duarte, Dennison, Orth & Carruthers, 2008, Ariana, Sutton, Amberk, Peter, Peter & Edwards, 2013, Roger, Vasco & Gabriel, 2012). Nonetheless, these frameworks have financial provisions aimed to upscale national and regional level project activities and improve carbon accounting market schemes for promoting sustainable restoration, conservation, management and enhancement of sinks and reservoirs of greenhouse gases (Chevallier, 2012, Lindsay, Ariana, Sutton. & Amber, 2016, Herr, Agardy, Benzaken, Hicks, Howard, Landis, Soles & Vegh, 2015). Moreover, Cullen & Unsworth (2016) assert that the existing 2006 IPCC guidelines for National GHG Inventories does not cover sea grasses which are critical components of blue carbon ecosystems and this prevent the development of carbon financing mechanisms for conservation of blue carbon, a missed opportunity in global portfolio of options for climate change mitigation measures (Linda, Emma, Masahiro, Jimena, Pedro & Joel, 2018).

Murray, Pendleton, Jenkins & Sifleet (2011) emphasized that despite scientific evidence exist to support the carbon sequestration and storage of coastal ecosystems, there is limited international regulatory framework or conventions focusing on stimulating and sustaining strong momentum for strategic national policy planning, development and enforcement against coastal ecosystem pollution and degradation. According to Gabriel (2011) large scale emissions from blue carbon pools are ongoing at national and regional level globally, but currently not being accounted for, and there is lack of awareness among critical stakeholders. Equally, there is dearth understanding of the significance of blue carbon ecosystems in climate change mitigation especially in African countries. Nonetheless, according to Chevallier (2012) Africa is home to 3.5 million hectares of mangroves – 20% of the world's total mangroves and also a major hub for sea grasses, coastal reefs, barrier islands and tidal wetlands. For instance, many African countries including South Africa, Mozambique, Guinea Bissau, Togo, Sierra Leon, Ghana, Benin, Angola, Liberia, Garbon, Cameron, Equatorial Guinea and Nigeria have long coastlines with abundant mangrove forests, sea grasses, wetlands and tidal marsh ecosystems. The value of these blue carbon ecosystems as both carbon sources and sink make them significant for climate change mitigations to help meet government pledges for emission reduction and improve food security.

Nigeria has the largest mangrove forests in Africa, followed by Mozambique, but there are issues of low awareness and scientific knowledge gaps about the environmental value and roles of mangroves and other sources of blue carbon in climate change mitigation and adaptation among critical stakeholders including state actors at all level. Also, there is paucity of scholarly publications about sources, threats and implications on continuous degradation or loss of blue carbon ecosystems in Nigeria, more especially in the Niger Delta region where the environment is dominated by coastal resources. Moreover, generally, there is lack of interests and commitments from policy makers and state actors to fund climate change mitigation related policies and programs in Nigeria's Niger Delta region which is devastated by oil spills from oil exploration activities, gas flaring, deforestation and sea level rise. Hence, the Niger Delta region is faced with rapid losses of mangrove forests, pollution of tidal wetlands, degradation of fresh water aquifers; and pollution of marine waters which undermined the impacts of climate change in the region, and renders people in the region vulnerable and exposed to various negative effects associated with climate change related disasters. Therefore, this study identifies blue carbon sources in the Niger Delta region of Nigeria and analyzed their ecological characteristics in relation to ecosystem services, carbon sequestration and storage and social economic significance. It further discussed and characterized various threats to blue carbon ecosystem sustainability in the region and implications for climate change mitigation and adaptation to people in the region. It concludes with policy recommendations for conservation, restoration, protection and management of blue carbon ecosystems in Nigeria's Niger Delta region.

II. THE NIGER DELTA REGION

Nigeria occupies a land mass of 910,768km^2 and 13,000km^{2}water on 92 million hectares with an estimated population of 190 million people (Amarchi and Kabari, 2020). The Niger Delta region is located at the apex of the Gulf of Guinea on the West coast of Africa in Southern geopolitical zone of Nigeria on a flat low land of about 3 to 5 meters above sea level. The physical environment of the region is wholly deltaic in nature and comprised of nine states in Nigeria in no particular order (Fig.1) (Etiosa., & Matthew, 2007, Nwabueze & Rob, 2017).

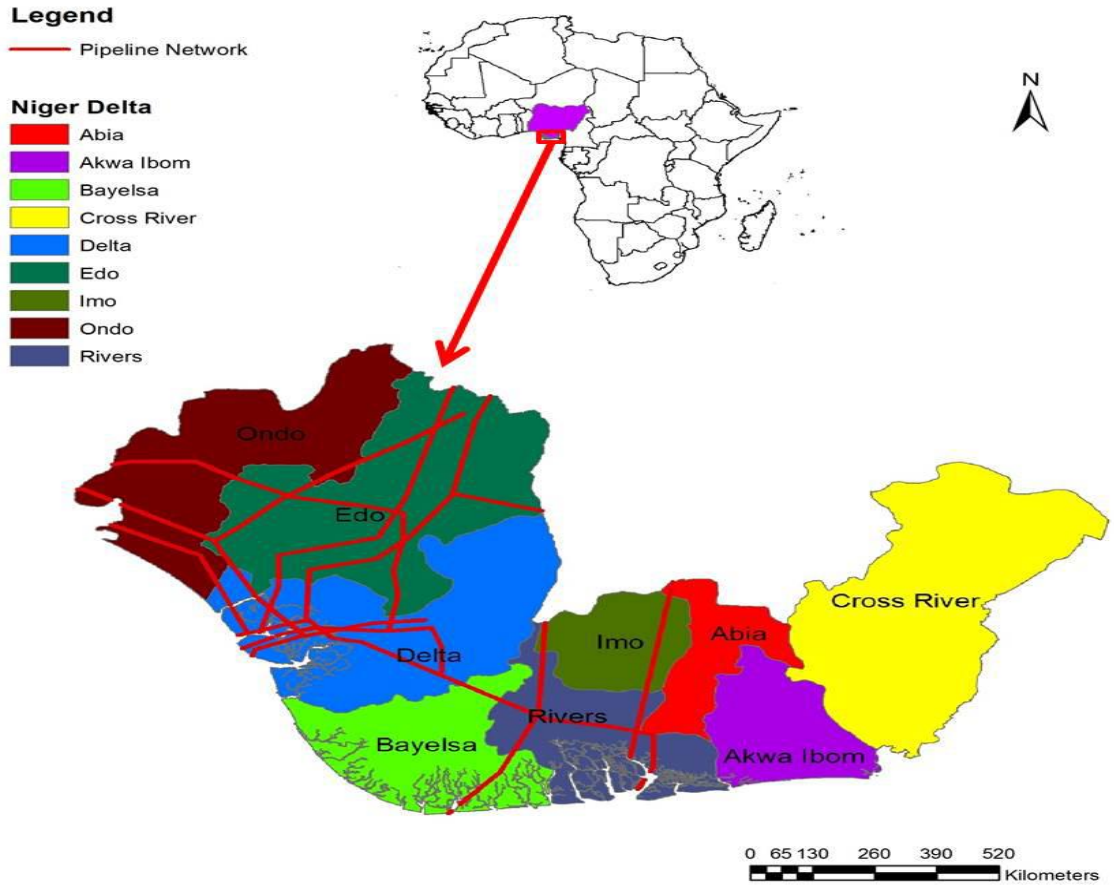

Fig. 1. Shows map of Niger Delta region of Nigeria with oil pipelines in red lines criss-crossing the region. (Adopted from Kabari, Fredrec & George, 2017).

Crude oil was first discovered in 1956 by Shell Petroleum Development Corporation (SPDC) at Otuabagi community in Oloibiri town which was a colonial district headquarter in Ogbia Local Government Area of Bayelsa State in Southern Niger Delta region. Thereafter, hundreds of oil and gas wells were discovered onshore and offshore in various locations in the region. Hence, the Niger Delta is the hub of oil and gas in Nigeria as it produces over 90% of Nigeria's economic mainstay (Sylvester, 2018, Ayanlede & Poske, 2015). The Niger Delta have over 37.4 billion barrels of proven oil reserves, estimated 202 trillion cubic feet of natural gas, 606 oil fields and over 900 active oil wells (OPEC, 2015, Kabari, Fredrec & George, 2017, Ogbe, 2011).

Furthermore, approximately 31 million people live in the Niger Delta region as at 2005 accounting for about 23% of Nigeria's total population in a geographical space of 112,000km^2 (Kadafa, 2012). People in the Niger Delta live in about 13,329 settlements out of which only 98 are in urban areas, the remaining ones are mainly rural areas with over 3000 oil producing communities without infrastructural facilities and basic amenities (Adekola & Mitchell, 2011). Thus, the Niger Delta region is vulnerable to conflicts and violence from aggrieved youths against international oil companies and the Nigeria's Federal Government owing to government negligence to the plights of oil producing communities. Over the years the response of Nigeria Federal Government to oil producing communities demanding for equal share of oil wealth has been characterized with military repressions and corruption in connivance with the oil companies.

III. SOURCES OF BLUE CARBON ECOSYSTEMS IN NIGER DELTA REGION

A technical report published by Niger Delta Development Regional Master Plan (NDRMP) in 2001 indicates that the Niger Delta has five ecological zones. These include mangrove forest and coastal vegetation, fresh water swamp forest, low land rain forest, derived savannah and montane region. Of these, the fresh water swamp forest is the largest and major source of timber, wildlife, fisheries, agriculture and highly prone to seasonal flooding. While the mangrove forest is surrounded by coastal vegetation perched on low sandy barrier islands. The low land rain forest, derived savannah and montane zone are high land areas rich in diverse flora and fauna species and less fertile for agriculture as they are characterized by re-growth forests, scattered trees and shrubs. Some authors assert that the Niger Delta region has only four ecological zones which are mangrove swamp forest, coastal barrier islands, lowland forest and fresh water swamp forests of sand bars, salt marshes, beach ridges, tidal channels and lagoons marches (Michael, Abdul-Rahman, Tambeke, Eman, Julia, Ekenma, Martins & Johnny, 2019).

Furthermore, Weli, Nwankwoala, Ocheje & Chinedu, (2019) assert that the Niger Delta has four ecological zones which are fresh water zone, lowland rainforest zone, coastal inland and mangrove swamp zone. The major cities in the region such as Port

Harcourt, Warri, Yenagoa, Calabar, Bonny and Uyo are developed on high islands of relatively large land mass that intersperse with coastal ecological zones. According to Chidumeje, Lalit, & Subhashni (2015) who carried out studies on Niger Delta wetland ecosystems, about 50% of the region is covered by water which account for about 55% of fresh water swamp in Nigeria, and 2,370km^2 in Niger Delta are made up of creeks, rivers, stagnant swamps and estuaries. These unique environmental characteristics of varied ecological zones described the deltaic rich ecosystems in the Niger Delta and underscore the need for scholarly studies and documentations to identify the sources and clarify the concepts and functions of blue carbon ecosystems in relation to climate change. Specifically, blue carbon ecosystems in the Niger Delta are made up of mangroves, tidal wetlands, barrier islands, sea grasses, salt marshes and the Ocean (Fig. 2).

Fig. 2. A marine river leading to the Atlantic Ocean at Brass in Bayelsa State in the Niger Delta region. The mud is rich in blue carbon owing to decades of increase in soil surface in response to rise in sea water level (physical observation and documentation by author).

IV. MANGROVES

Nigeria has the largest mangrove area in Africa situated along its entire coastal areas that stretched throughout the Niger Delta region covering about 105,000 hectares (Nwankwoala, 2012). Nigeria estuaries and mangroves span about 105km inland along its huge coastline of approximately 853km bordering the Republic of Benin to her Western border and Cameroon at eastern borders (IPIECA, 2002). The country has the entire eight mangrove species in West Africa which are Rhizophora mangle, Acrostichum aureum, Avicennia germinans, Rhizophora harrisonbgii, Nypa frutican, Rhizophora racemosa, Conocarpus erectus and Laguncularia racemosa. Out of these the Rhizophora racemosa (African red mangrove) is the most common and populated dominant species in the Niger Delta, while the Avicennia germinans species grows on edge of river shores leading to the Atlantic Ocean (UNEP, 2007). These mangrove species grow together in mixed form interchangeably in coastal areas in all the coastal states in Nigeria including Lagos, Ondo, Ogun, Edo, Cross River, Delta, Akwa-Ibom, Rivers state and Bayelsa state. Nonetheless, the population of mangroves varies with states with Bayelsa, Delta and Rivers state having the largest area of mangroves (Aroloye, 2019, Numbere & Camilo, 2016).

Furthermore, among the eight species of mangroves found in Nigeria, the Nypa frutican (Nipa palm) is a foreign invasive species that was brought to Nigeria from Southeast Asia far back 1906 and planted in Cross State along the coastal route of Oron and Calabar for the purpose of erosion control and social economic benefits. Nevertheless, the Nypa palm grows in population and spread westward to Ondo State where it invaded large areas and displaced indigenous mangrove tree species including the Rhizophora racemosa, Conocarpus erectus and Rhizophora mangle and posed ecological and economic threats to hundreds of fishing communities (Mmom & Arokoyu, 2009). Mangroves are playing critical roles in sustaining and balancing food chain in the Niger Delta region because they provide huge habitats for biodiversity sustainability, serve as source of herbal medicine, fuel-lwood, food crop cultivations and fish farming (Fig. 3). It also serves as source of timber which are harvested by local population as fuel wood for cooking and construction of shelter. Additionally, mangroves provide natural buffer zone to coastal communities against storm surges, reducing shoreline erosions, flooding, and landslides and as well as serve as wind breakers, regulating water quality and protecting adjacent deep-sea blue carbon ecosystems such as Coral Reefs (Chima & Larinde, 2016).

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Fig. 3. Mangroves swamps (Rhizophora racemosa -African red mangrove) at Bonny Island in Rivers State are source of fuel-wood, fishing, fish farming and herbal medicine to coastal communities (physical observation and documentation by author).

According to Adewumi, Agunbiade, Longe, Fadiya & Adewumi (2018) about 50% of fish consume in Nigeria is supply from the Niger Delta and 60% of fishes in the Gulf of Guinea breed in the mangroves of the Niger Delta. Though the exact amount of losses of mangroves per hectares per year in the Niger Delta is poorly documented and relatively unknown, likewise the exact quantity of carbon sequestered by mangroves in the region is also unknown and under studied. Nonetheless, various studies have shown that mangroves are critical source of blue carbon known to store about 90% of carbon dioxide captured in the atmosphere, soil and its biomas over a very long period of time (Amarachi, & Kabari, 2020, Taillardat, Friess, & Lupascu, 2018, Hori, Bayne & Kuwae, 2019, Das Gupta & Shaw, 2013). Some authors who carried out studies on improved understanding on carbon sequestration of coastal vegetations asserts that the dense leafy canopy and complex roots of mangrove trees render them efficient at trapping associated organic carbon sediments from external riverine and internal ocean sources, this make them efficient natural carbon sinks (Elizabeth et al., 2011).

However, because of the capacity of mangrove to trap and store large quantity of carbon in their biomass and accumulated surrounding soil, when degraded or destroyed, they also release large quantity of carbon into the atmosphere. However, mangroves in the Niger Delta region are declining every year due to natural factors such as coastal erosions and sea-level rise and as well as uncontrolled impacts of anthropogenic activities in coastal areas. These anthropogenic activities include oil spills, fish farming, road construction, land reclamations, uncontrolled logging, and gas flaring which constitute major threats to the overall existence of mangroves in the region.

V. COASTAL WETLANDS

The Ramsar Convention on Wetland Secretariat established in 1971 at Ramsar in Iran is an intergovernmental treaty that provides framework for national programmes and activities as well as international collaboration and participation for wise use of wetlands and its resources (Ramsar Convention Secretariat, 2007). The convention emphasized the preservation of ecological characteristics of wetlands, and allowing for sustainable use through control access, exploitation, exploration and management of natural resources on wetlands. The treaty broadly defines wetlands as ‘‘areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six metres.’’ Furthermore, Maureen, 2016) who carried out studies on Legal Framework for the Protection of Wetlands in Nigeria described wetlands as “areas of marsh, fen, wetland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters.

Some scholars who reviewed empirical studies on classifications, significance and management of wetlands in the Niger Delta asserts that tidal wetlands in the Niger Delta are dominated by fresh water, brackish or salt water (Fagoritel, Odundun, Iwueke, Nwaigbo, & Okeke, 2019). These authors classified wetlands as natural types (coastal/marine and inlands) and anthropogenic type (human made). Some examples of coastal wetlands include rocky marine shores including sea cliffs, intertidal marshes such as fresh water marshes, salt marshes, coral reefs, marine waters shallow water less than 6 meter deep, fresh water lagoons, brackish lagoons and non-tidal freshwater forested wetlands. While some examples of inland wetlands are permanent rivers and streams including water fall, seasonal rivers and streams, permanent freshwater lakes, inland deltas, permanent brackish or saline lakes, fresh water swamp forest, peat lands, shrub swamp and shrub dominated freshwater marshes. Furthermore, examples of human made wetlands are hydro-electric dam, ponds including farm ponds, aquaculture ponds (fish ponds and shrimp ponds), irrigated land or farm such as rice field, waste water treatment plants and pit excavations. The Niger Delta region is the third largest wetlands in the world, other examples of large wetlands are Okavongo Delta in Bostwana, Pantanal wetland

in Brazil, Ga-Mampa wetland in South Africa and Niger Delta in Southern Nigeria (Asibor, 2009).

According to Weli, et al., (2019) the Niger Delta is an important wetland covering about 76,000km^2 and has the largest mangrove forest ecosystem in Africa with 11,134km^2, it is the third largest wetland in the world characterized with huge floodplains in Southern Nigeria. Generally, wetlands in the Niger Delta are divided into two categories, namely; natural and anthropogenic wetlands. Natural wetlands include wetlands along rivers and streams (riverine), coastal lagoons, coral reefs and rocky shores (marine), tidal marshes, mangrove swamps, deltas (estuarine), wetlands link with lakes (lacustrine), bogs, marshes and swamps (palustrine). While anthropogenic wetlands include fish ponds, sewage farms, canals and reservoirs. Adekola, Mitchell, & Grainger (2015) posits that natural wetlands in the region were formed by accumulation of sedimentary deposits transported and circulated by River Niger and River Benue discharged by seasonal flooding across Southern Nigeria and beyond into the Atlantic Ocean over the years. Furthermore, Nwankwoala, (2012) who carried out case studies on coastal wetlands and water resources in Nigeria identified eleven tidal wetlands in Nigeria on the Ramsar lists, out of which three wetlands are located in the Niger Delta region. These include Apoi Creek Forest in Bayelsa State, Upper Orashi Forest in Rivers State and Oguta Lake in Imo State. Nonetheless, there are other tidal wetlands in the Niger Delta including Taylor Creek wetland in Bayelsa State, Olague wetland forest and Ethiop River in Delta State and Leisure wetland beach in Oron at Akwa Ibom State which are yet to be included in the Ramsar list.

Table 1. Nigeria's 11 Ramsar Site (1,076,728 Hectares)

S/N	Sites	Date of designation	State (s)	Area (ha)	Coordinates
1	Apoi Creek Forests	30/04/2008	Bayelsa	29, 213	05^0 47′ N. 004^0 42′ E
2	Upper Orashi Forests	30/04/2008	Rivers	25, 165	04^0 53′ N, 006^0 30′ E
3	Oguta Lake	30/04/2008	Imo	572	$05^0$42′ N, 006^0 47′ E
4	Nguru lake (and Marma Channel) complex	02/10/2000	Jigawa & Yobe	58, 100	10^0 22′ N, 012^0 46′ E
5	Baturiya Wetlands	30/04/2008	Kano	101, 095	12^0 31′ N, 010^0 29′ E
6	Dangona Sanctuary Lake	30/04/2008	Yobe	344	12^0 48′ N, 010^0 44′ E
7	Foge Islands	30/04/2008	Kebbi & Niger	4, 229	10^0 30′ N, 004^0 33′ E
8	Lake Chad Wetland	30/04/2008	Borno	607, 354	13^0 04′ N, 013^0 48′ E
9	Lower Kaduna-Middle Niger Floodplain	30/04/2008	Kwara & Niger	229, 054	08^0 51′ N, 005^0 45′ E
10	Maladumba Lake	30/04/2008	Bauchi	1, 860	$10^0$24′ N, 009^0 51′ E
11	Pandam & Wase Lake	30/04/2008	Nasarawa	19, 742	08^0 42′ N, 008^0 58′ E

These wetlands provide various ecosystem services including timber products, flood control, underground fresh water recharge, climate regulation and spiritual benefits. Wetlands in the Niger Delta are also homes to several endangered animal species. For instance, the Apoi Creek Wetland Forest reserve is a home to one of the critically endangered and endemic species in the world, i.e. Red Colobus Monkey (Procolobus Badius), Nigerian white throated Guenon (Cercopithecus erythrogaster pococki) and the Red-capped mangabey (Cercocebus torquatus) amongst others (Oates & Struhsaker, 2016). The wetlands also houses several economic timber species including red mangrove (rhizopora sp), Mahogany (Khaya sp), Iroko trees (milicia excels) and Cotton tree (ceiba pentandra) amongst others. Similarly, the Upper Orashi Forest wetland in Rivers State is a home to several endemic fauna species which are listed by the International Union for the Conservation of Nature (IUCN) in 2008. These include the Sclater's guenon (cercopithecus sclateri), White-throat guenon (cecopithecus erythrogaster), Red Colobus monkey (procolobus badius) and Heslop's pygmy hippotamus (Choeropsis liberiensis) and Grey Parrot (Psittacus erithacas) and hosting several water bird species. However, tidal wetlands in the Niger Delta have been severely polluted and degraded by oil spills, dredging activities, soil and land reclamation projects, agricultural and industrial effluents amongst other factors. This have been confirmed in various studies including that of Ayansina & Ulrike (2015) who assessed wetlands degradation and loss of ecosystem services in the Niger Delta using satellite data, GIS and social information to evaluate the degree of degradation of fresh water lands and its consequences in the Niger Delta. The authors found that coastal wetlands in the Niger Delta have experienced serious pollution and degradation since 1980s.

VI. THREATS TO BLUE CARBON ECOSYSTEMS IN NIGER DELTA

Despite the huge environmental and socioeconomic values and benefits of blue carbon ecosystems in the Niger Delta region, particularly mangrove forests and tidal wetlands, they are severely threatened by both natural and anthropogenic factors. These factors undermine the natural capacity of the ecosystems to function in their normal natural state and alter eco-services to hundreds of communities in the Niger Delta that depends on them for livelihood and economic sustenance. However, though the anthropogenic threats are severe and numerous, they are easier to solve or manage when compared to natural threats.

i. ANTHROPOGENIC THREATS

Gideon (2011) points out that the country has a maritime area of about 46,500km^2 of about 0 to 20 meter deep with exclusive economic zone of 21,900km^2. Additionally, the estimated brackish area in Nigeria is about 12,940km^2 out of which mangroves alone cover about 9700km^2 and all are situated in the Niger Delta region which occupies 750,000 hectares of saline swamp forest. The coastal areas in the region is lace with abundant aquatic resources which are vital for artisanal commercial fisheries, recreation, transportation and mining for crude oil, gravels and sand. The major cities in the Niger Delta such as Port-Harcourt, Calabar, Warri, Benin, Uyo and Yenagoa are industrial hubs for oil exploration, development and production activities by various international oil companies including Shell Petroleum Development Corporation (SPDC), Agip National Oil Company (NAOC), Total Oil Company, Chevron and Elf and Mobile.

Over the years the activities of these oil companies onshore and off shore have results to large quantity of accidental oil spills into the highly sensitive and vulnerable blue carbon ecosystems without adequate remediation and ecological restoration measures (Authority, 2020). Oil spills which have severe impacts on the soil, biomass, sediments, surface and ground water is rampant in the Niger Delta with correspondent degradation on biota, thereby destroying the roots of vegetations including mangroves and poisoning marine wildlife, seagrasses and fresh water fishes which are extremely susceptible (Adita, 2012.). For instance, several oil flow stations are located directly inside the Sea or fresh water basins or rivers which are habitats to thousands of benthic organisms including communities of microorganisms, mangroves, marine mammals, habitat-forming species, Sea birds and turtles which are polluted and poison by toxic oil treatment chemicals and gas explosion (Weli et al. 2019). Crude oil contain various harmful chemicals include various heavy mental such as Pb, Cr, Cu, Co, Cd an Ni that kill all types of flora and fauna by damaging plant phytochemical and animal organ systems such formation of thick coat layer on water surface that prevent oxygen and light rays from penetrating water bodies. Therefore, causing hypoxia to both plants and animal species (Oyegun, Lawal and Ogoro, 2016). The process of crude oil and gas prospection itself involves cutting down trees, seismic activities and shooting of dynamites for soil excavations which destroy soil structures, alter food chains and nutrient cycling.

Therefore, crude oil spills is the primary principal anthropogenic threat to blue carbon ecosystems function and sustainability in the Niger Delta, because it practically compromise and destroy all living things on tidal wetlands and kill mangrove trees. However, widespread oil spills incidents have become a normal phenomenon in both aquatic and terrestrial environment in the Niger Delta for the past 30 years due to inadequate Federal regulatory standards and non-enforcement of environmental laws against oil companies (Sam & Zabbey, 2018, Ukpaka, 2012, Gideon, 2011). The situation is aggravated by resentments and anger against the oil companies and Nigeria's Government by unemployed youths due to poverty and poor infrastructural development in oil producing communities. This has results to proliferations of light weapons, militancy, illegal crude oil bunkering, deliberate sabotage of oil facilities and increase in artisanal oil refining activities in the creeks, tidal wetlands and mangrove forests leading to increasing incidents of oil spills and destruction of blue carbon ecosystems in the Niger Delta. While secondary anthropogenic threats to blue carbon ecosystem in the region include industrial and domestic effluents, river modifications, urban storm water run offs, illegal logging, over grazing, deforestation and transportation of timber via water ways, mining effluents, shipping activities including motorized boating, unregulated land reclamations, commercial fishing activities, atmospheric sources including gas flaring, agricultural run offs from farmlands such as fertilizer and pesticides leading to eutrophication, river and ocean acidification.

ii. NATURAL THREATS

Coastal erosion, flood and Sea level rise are the major environmental problems in the Niger Delta region as a result of the low-lying topographic flood plain and climate variability disaster incidents. Like other parts of the world, coastal erosion in the Niger Delta is a phenomenon associated with natural disasters which are characterized by removal of topsoil, mud slides and lose of biodiversity (Angela, 2006). Natural threats to blue carbon ecosystems can be defined as natural incidents, factors or phenomena that destabilize and damage the functions and value that blue carbon ecosystems provide. In the Niger Delta, the threats are driven by rise in sea-water level, intense waves, increase in temperature, siltation, invasion of alien flora and fauna, flooding, lose of biodiversity, droughts, desertification and erosions (Oyegun et al. 2016). Moreover, the natural threats have been negatively influenced by human interferences include construction of Jetties, building of sea port, dredging of port channels, deforestation of coastal vegetation, sand mining, oil field prospection, development and exploration operations (Eze, Alozie, & Nwogu, 2016). Various natural threats to blue carbon ecosystems in the region has continue to disrupt food chains and exacerbate carbon emission thereby directly and indirectly contributing to climate change and global warming with associated negative impacts on social cultural institutions, economic development and the environment (Kabari et al. 2017).

VII. IMPLICATION FOR CLIMATE CHANGE

The pollution and degradation of blue carbon ecosystems in the Niger Delta region from anthropogenic and natural factors impairs their natural services and undermines the values of the ecosystems to communities, and also render many riverine communities extremely vulnerable to the negative impacts of climate change. These impacts include environmental, economic and health hazards. They include increasing flooding in both upland and riverine communities leading to destruction of properties worth hundreds of millions of dollars, spreading of various diseases such as malaria, typhoid and topical skin diseases due to rampant movement of vectors and human consumption of polluted and contaminated water leading to cancer and short life span. Others are biodiversity lose (depletion of fish nurseries, loss of vegetations and endangered animal species) desertification, coastal erosions, storm surges, and lose of arable agricultural lands leading to poverty and violence community conflicts due to competition for natural resources (Authority, 2020).

Previous studies had established that climate change has affected rainfall patterns and temperature in the Niger Delta region which has negative affected blue carbon sequestration and storage as a result of severe flooding, sea-water intrusion into fresh water, coastal erosion and destabilizations of blue carbon resources including mangroves, fisheries and rivers (Ifeanyieze, Alkali, Okoye & Ikehi, 2016**,** Prince & Aifesehi, 2013, Oyegun, 1993, Odafivwotu, 2014). Nonetheless, the implications of the destruction, contamination, degradation and pollution of mangroves, fresh water swamps and wetlands (blue carbon sources and sinks) in the Niger Delta in relation to climate change is much severe compared to other parts of the country because it has the lowest land surface, largely riverine and coastal with a breeding population of poverty.

The problem is also compounded by lack of adaptive capacity of the population, low awareness, and poor environmental regulatory standards and enforcement, lack of government commitments and interest to mitigate climate change problems and dearth scholarly publications (Aniefiok, Udo, Margaret & Sunday, 2013, Snowden & Ekweozor, 1987). This assertions correlate with the work of Odafivwotu (2014) who carried out studies on public perception of climate change in Yenagoa, Bayelsa State of Niger Delta region using 360 questionnaires found that 48.7% of the participants believed that climate change is a divine providence. The author also asserts that the direct impacts of climate change on the people of Niger Delta include exposure to changing precipitation patterns, sea level rise, coastal erosions and increase in temperature. While the indirect impacts of climate change on the people of the region include air and water contaminations, reduction in crop yield, and displacement of coastal and riverine communities. Specifically, there are two major implication scenarios in the future that would arise from the destruction and incapacitation of blue carbon ecosystems in the Niger Delta region; these are siltation, drought and desertification together and coastal erosion, and flood and water submersion.

a). SILTATION, DROUGHT AND DESERTIFICATION

The projected impacts of climate change on fresh water resources and tidal wetlands in Niger Delta would be very damaging because the two ecosystems are inextricably linked and naturally inter-dependent for water supply, purification and renewal. However, physical changes in hydrological cycle driven by anthropogenic activities and climate change will cause increase in temperature, high water evaporation and reduce rainfall patterns, thus lowering water table in wetlands, shrinking river water level and reducing water velocity in riverine systems. This would usher in drought and desertification as rivers would become disconnected from wetlands and floodplains, thus, wetlands, creeks, streams, lakes and rivers may dry up and the region would become silted out. Presently, hundreds of creeks, streams and rivers in the Niger Delta have become shallow and unable to hold large volume of water and discharge effectively due to siltation, deforestation, canalizations and development on floodplains. Thus, communities are highly exposed and vulnerable to rampant flooding associated with economic loses from heavy rainfall.

Increase in temperature may not kill people directly in the Niger Delta, but indirectly, because high temperature can adversely affect various food sources including livestock production (poultry and aquaculture) leading to high cost of labour, input and low yield which would result to starvation and lose of livelihood (Authority, 2020). A lose of livelihood can cause someone to commit suicide. These assertions corroborate with the findings of Onu & Ikehi (2016) who carried out studies on mitigation and adaptation strategies to the effects of climate change on the environment and agriculture in Nigeria using secondary data, they found that climate change is characterized by variability in weather patterns such as rainfall regime, wind, solar radiation, temperature variation and relative humidity which agriculture is the most affected factor in Nigeria because most farmers practice non-irrigation subsistence farming and depends heavily on rain fed agriculture. Similarly, Eyenghe, Ibama & Wocha (2015) carried out studies on climate change, disaster risk management and urban poor in Port Harcourt, Rivers state using field observation method found that the city of Port Harcourt is one of the worst hit by climate change in the world due to its geographical locations, increase in population of urban poverty, settlement on low lands such as swamps and marshy lands, use of substandard building materials that cannot stand environmental stresses, environmental degradation and lack of government commitments to managing climate related disasters. Siltation and drought can lead to water scarcity in the region resulting to irrigation dependent agriculture which majority of farmers cannot afford, and thus exacerbating food insecurity. According to Ifeanyieze, Alkali, Okoye & Ikehi (2016) who conducted studies on altered climate and livelihood of farming families in Niger Delta using questionnaires and Focus Group Discussion (FGD) methods established that agriculture is one of the most climate sensitive sectors because altered climate have direct bearing on agricultural productivity as it affect, land fertility, pollination, planting, weeding, quantity and quality of yield, harvest and transportation and these scenarios are observable in the Niger Delta.

b). COASTAL EROSION, FLOODING AND WATER SUBMERSION

Onyeka & Adaobi (2008) established that a rise in sea water level to about 59cm will lead to submersion of several coastal communities in the Niger Delta region. According to some authors who employed mixed scale approach with descriptive statistics and secondary data connected to GIS to assess climate change in southern Nigeria drawing spatial information from published works emphasized that Nigeria is experience persistent off-season rainfall, and dried spills due to climate change, and 75% of the Niger Delta may lose if sea level rises to one meter as mangrove forest which are buffer zones are being destroyed by oil spills and coastal erosions (Merem, Twumasi, Wesley, Alsarari1, Fageir1, Crisler, Romorno, Olagbegi, Hines, Ochai, Nwagboso, Leggett, Foster, Purry, & Washington, 2019. Also, the authors emphasized that about 12 million Metric Tones (MT) of flared CH_4 is being discharged to the environment yearly by oil companies heating up the atmosphere in the region. Also between 1960-1970 sea level rises to 0.462m which caused flooding and erosion of coastal communities and infrastructures, and between 1999 to 2015 natural disasters led to the dead of many people and a major flood in 2012 completely submerged over 19 towns in the lower Niger basin where substantial amount of land in Lagos state, Port Harcourt, Bayelsa and Delta is below 3 meter level.

Additionally, Merem et al. (2019) asserts that high forms of coastal erosion may spread across the Niger Delta, land lose of low areas will exacerbate climate change related disasters and sea level rise of 0.2cm to 2.0cm, and this may lead to the disappearance of 2,846km^2- 18,803km^2 of land. In addition, at a variation measured at 0.5m, 1m – 2.0cm in sea level rise they estimated future lose of land from coastal erosion to be 7,453, 15,125 and 18,398km^2 respectively. The authors also found that in places like Forcardos and Warri in Delta state GHG sinks between 1988–2008 and coastal buffer zones like mature forest and mangroves declined beginning from 69.96km, 55,59km, to 41.9km and 15.97km, 10.76 to 10.15km while there was increase in stress vegetations from 2.42km to 3.33km. These assertions and findings are in tandem with the work of Oyegun, et al. (2016) who assessed the vulnerability of coastal communities in the Niger Delta region to sea level rise using Geographical Information System (GIS) and Remote Sensing Technology to identify vulnerable areas to sea level rise and vulnerability to coastal erosions, inundations and flooding. They found that several states in the Niger Delta are very exposed to coastal erosions, flooding and vulnerable to sea level rise which could submerge hundreds of communities in the future as results of both anthropogenic and natural factors impacting stream morphology and shorelines dynamics. For instance, Oyegun, et al. (2016) also found that 95 communities in Bayelsa State have a mean distance of 16.10km to the sea, 58 communities in Rivers state have 14.86km mean distance, 31 communities in Cross Rivers state have a mean distance of 136.83km, 34 communities in Akaw-Ibom state have a mean distance of 36.1km, 68 communities in Delta state have a mean distance of 16.79km to sea shore and 73 communities in Edo state have a mean distance of 105.95km.

Furthermore, Adewumi, Agunbiade, Longe, Fadiya, & Adewumi (2018) who analyzed the causes and impacts of climate change in the Niger Delta region cited the work of Udofa and Fajemirokun (1978) who carried out studies on mechanical analysis of tide data between 1960 – 1970 and found increase in sea level to be 0.462m above zero level of the tide gauge. Additionally, a scholar had long established that with one meter rise in sea level the Niger Delta may lose about 15000km^2 of land by year 2100, equally, a rise in sea level to 20- 30cm may inundate about 3400km of Nigeria coastal land and displace about 80% of people living in the Niger Delta region (Onofeghara, 1990). Furthermore, sea level rise will lead to salinization of underground water and cause fresh water scarcity in the Niger Delta. This will negatively affect agriculture (livestock and crop production) and cause health hazards. In a nutshell, given the proximity of communities in the Niger Delta to sea shorelines, coupled with our bedded coastal low land surface, huge flood plains and dearth adaptive capacity, the Niger Delta is exposed and vulnerable to sea-level rise which is exacerbating coastal erosions that can lead to invasion of upland areas by coastal flooding and consequently submerge the entire Niger Delta in water.

VIII. CONCLUSION AND POLICY RECOMMENDATIONS

IX. COMPREHENSIVE SURVEILLANCE, MAPPING, INVENTORY, MONITORING AND ANALYSIS

Given the various anthropogenic and natural threats to the stability and sustainability of blue carbon ecosystems in the region, there is need for the Federal Government to carry out comprehensive surveillance, mapping, monitoring, analysis and documentations of specific threats to the status of blue carbon ecosystem for the purpose of conservation, protection and restoration. The process will enable government to effectively model and predict the implications of blue carbon ecosystems losses in connection to various adverse effects of climate change. Essentially, the goal of this process should include quantifying carbon stored below and above the soil of coastal ecosystems; wetlands and fresh water ecosystems over the years in the region and to determine their storage capacity.

Presently, there is no existing greenhouse gas (GHG) emission tracking systems in the Niger Delta, the surveillance of blue carbon ecosystems should help to identify and document blue carbon pools or fluxes in a spatial manner that is consistence with international standards. The mapping process should help to identify locations and sizes which will support inventory and monitoring process leading to data sharing among institutions, development of database, information management and dissemination of the rates and levels of carbon pools in blue carbon ecosystems. This will also be the first level exploration of natural coastal carbon, and their associated natural services in the Niger Delta which shall aid Federal and State Government with concrete baseline information for policy actions, and dissemination of correct information to potential investors in the private sector.

Moreover, scientific data gathered through surveillance and critically developed will empower government to support international communities for policy actions for blue carbon ecosystems through UNFCCC international funding. The process will enable government to promote public awareness programmes on blue carbon ecosystems in general which will lead to a better informed Nigeria's general public about the locations and benefits of blue carbon ecosystems, and also close knowledge gaps and boost the capacity of relevant institutions to undertake policy making for blue carbon ecosystem conservation. Furthermore, public awareness through media agenda setting and use of workshops and symposium will mobilize public support and engage the minds of young people to campaign for environmental protection in the region.

The above recommendations overlap with the founding of Gabriel (2011) at United Nations Environment Programme who conducted research on Abu Dhabi blue carbon policy (climate policy report) aimed to enhance public understanding of various ecosystem services that the Emirate's coastal and marine ecosystem provides, with a focus on carbon sequestration and storage. The author recommendations include institutional coordination, information management, ecosystem services valuation, public awareness programme, national support for international actions and establishment of national secretariat for blue carbon ecosystem management.

I. Establish Integrated Institutional Framework for Blue Carbon Conservation

The Integrated Coastal zone management framework should aim at restoration, conservation and sustainable management of blue carbon ecosystems in the Niger Delta through stakeholders' engagement and participation across all levels of the society with representatives from coastal communities, government regulatory agencies, private and public research institutions and Civil Society Organizations. The framework should be institutionalized and funded by government in every state in the Niger Delta to promote shared responsibility among communities to carry out mangrove forestation and create norms for wetlands conservation and as well as develop community laws and enforce it against anthropogenic threats to blue carbon ecosystems within their immediate environment.

Under the framework, State and Local Government agencies should have defined roles so as to avoid overlapping policies and regulations but work in collaboration to support community efforts through planning, scientific data gathering, analysis, information sharing and capacity building. These recommendations are in line with the work of Amarachi and Kabari (2020) who carried out studies on threats of oil exploitation to mangroves ecosystems in the Niger Delta and recommends that Government should uplift mangrove dependent communities from poverty by providing economic opportunities in form of training for alternative livelihoods and financial incentives to conserving of wetlands, mangroves and fresh water bodies.

Despite blue carbon ecosystems are rich in biodiversity and serve as food baskets to millions of Nigerians, they are also major attractive sites for industrial activities. Thus, the blue carbon ecosystems have witnessed varied coastal industrial activities which have continued to exacerbate fragmentations and lose of habitats of various aquatic lives. Given the growing knowledge and international recognitions of the functions and values of blue carbon ecosystems in climate change mitigation. There is need to resolve these conflicts of economic development and environmental conservation through empirical studies and evaluation of stakeholders' interests as it affect the interest of multiple communities of stakeholders.

II. Review, Amend and Enforce National Environmental Laws

Presently, Nigeria national legislations governing the protection of environment are fragmented, inadequate, not specific, and inchoate and also not well enforced. For instance, these include the Environmental Impact Assessment Legislation (EIA) Act No. 86 of 1992, Harmful Waste Act 1988, Federal Environmental Protection Act Decree No. 44 of 1988, Sea Fisheries Degree No.71 of 1992, National Environmental Standards and Regulation Enforcement Agency (NESREA) 2007, Federal Environmental Protection Act 1998, Oil Pollution Act 1990, Environmental Guidelines and Standards for Petroleum Industry in Nigeria (EGASPIN) 2002 and National Environmental Protection (Effluent limitation) Regulation 1991 (Maureen, N.A. (2016). For instance, the Land Use Act of 1978 vested authority and control firmly on government to acquire, lease and use lands. This situation has led to eviction of farmers from ancestrally owned lands by government with little or no consultation or compensation, thus forcing them to farm in coastal areas leading to destruction of mangroves and degradation of tidal wetlands. Similarly, the Sea Fisheries Degree No.71 of 1992 leaves out provision for monitoring, documentation and control of urban and rural small scale commercial fisheries activities on wetlands and estuaries.

Though in Nigeria the issue of environmental management falls on several agencies at Federal, State and Local Government Level. For instance, at the Federal level there is Federal Ministry of Environment and Ministry of Petroleum Resources coordinating various agencies including the National Environmental Standards and Regulations Enforcement Agency (NESREA), National Oil Spill Detection and Response Agency (NOSDRA), Department of Petroleum Resources (DPR) and Hydrocarbon Pollution Restoration Project (HYPREP). There are conflicts among the agencies due to overlapping of duties and duplication of responsibility leading to duplication of budget, conflicting recommendations, politicization and corruptions. Kabari, Frederic, & George, (2017) established that the current statutory definition of contaminated lands in Nigeria which defined contaminated land as ''The presence in the environment of an alien substance or agent or energy, with a potential to cause harm'', is ambiguous and does not make reference to source of hazards, pathways and receptors''.

Kabari et al. (2017) also observed issues related to lack of consistent funding mechanisms, absence of training programs resulting to low capacity among personnel, overlapping regulations among agencies and inadequate structure for identifying and allocating liability to a polluter. The authors therefore recommends the revision of existing laws to clearly define the roles and responsibility of agencies, provision of regular training to improve the capacity of personnel for identification and remediation of contaminated sites including coastal wetlands.

There is need to review and amend all existing environmental laws and policies at the Federal, State, and Local Government level to include the polluter pays principle and enforcement. Input and integrate environmental sustainability indicators that reduce cost, maximized social benefits and reduce environmental foot print from anthropogenic source at national and state development policies. A Trust Fund should be created with monthly or quarterly donations from the Federal Government and Oil companies operating in the Niger Delta based on crude oil sales aimed to restore and remediate all polluted wetlands, mangroves and fresh water in the Niger Delta region. There should be extensive stakeholders' consultations in the process of law making and public education on new policies and changes to existing laws on blue carbon ecosystem management. Healthy and well functioning wetlands, mangroves and freshwater ecosystems in the Niger Delta is vital to provide continues free flow of clean and reliable fresh water, air, fertile soil, balanced biota and healthy food supplies to people of the region. Therefore, government laws and policies should target Ecosystem Base Management method; this method recognized the interplay of marine, fresh water and

terrestrial ecosystems and implication of anthropogenic impacts on them in relation to climate change.

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