

REVIEW ARTICLE

A REVIEW OF WETLANDS AND COASTAL RESOURCES OF THE NIGER DELTA: POTENTIALS, CHALLENGES AND PROSPECTS

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ABSTRACT

Wetlands are areas where water covers the soil or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season. The Niger Delta in Nigeria is the largest wetland in Africa and the third largest mangrove forest in the world with three sites listed as Ramsar Wetlands of International Importance. The Niger Delta wetlands and coastal resources are of high monetary significance to the local dwellers and the nation in general. This highly coveted wetland is changing rapidly, raising concern for its attendant implication on the communities relying upon its ecosystem potentials. A comprehensive data of the facilities delivered by wetlands is a significant key for real-time wetland ecosystem management. Existing literatures, were synthesized for this review on the potentials, challenges and prospects of the Niger Delta wetlands. It is pertinent from this review that the Niger Delta Wetland is wealthy in aquatic and terrestrial biodiversity of high financial significance to development of Nigeria, and is being challenged by natural and human activities such as dam construction, logging/lumbering, over-grazing, unrestrained tilling of soil for crop production, wetland reclamation, dredging, oil and gas exploration, over-fishing, invasive plant infestation, pollution, Coastal Infrastructure construction, poverty, droughts, desertification, sand storm, alien invasion, sea rising, erosion, etc. The Niger Delta Wetlands harbor tremendous wealth and supply many services that are necessary for human well-being such as location for spiritual renewal and recreation (eco-tourism), flood control, climate regulation, crop pollination, soil regeneration, raw material, energy, air and water purification; food chain supply, and medicines (Herbal solutions). This review postulates that in view of the immense significance and status of the Niger Delta Wetlands, effective and sequential monitoring be put in place by the establishment of centers of excellence in all universities in the Niger Delta Region with emphasis on studying the rich economic diversity of the wetland using remote sensing and Geographic Information System technologies for efficient conservation and management of the wetland resources.

KEYWORDS

Wetlands, Niger Delta, Potentials, challenges and Prospects.

1. INTRODUCTION

This review is aimed at highlighting the significance and importance of the Niger Delta Wetlands with respect to its prospects, challenges and potential, with the objective of elucidating interest in effective and sequential monitoring by establishing centers of excellence in all universities in the Niger Delta Region with emphasis on studying the rich economic diversity of the wetland using remote sensing and Geographic Information System technologies for efficient conservation and management of the wetland resources.

A wetland is a piece of water-filled land. This is an ecosystem where land and water meet and may be permanently or seasonally submerged or saturated with water (fresh water, brackish water or salt water), where anaerobic processes are common (Keddy, 2010). There are many types of

wetlands, and there are many ways to classify them. Wetlands are divided into five categories by the NOAA: oceans (oceans), estuaries (estuaries), rivers (rivers), lakes (lakes), and Palustrine (swamps), which can be tidal (submerged by tidal water) or non-tidal (US EPA 2015). Common designations for wetlands are: floodplains, lakes, shallow seas, coral reefs, deltas, ponds, mudflats, mangroves, estuaries, swamps, quays, Birabang, lagoons, Karl, Pokosin, Mire, spring pool, sink, and many other contents (Keddy, 2010).

Because of the diversity in soil, terrain, climate, hydrochemistry, and vegetation, wetlands look very different alongside waterways and flood plains. Large wetland areas can also have several small types of wetland. Wetland plays an important role in the local ecosystem, including acting as a water filter and controlling flooding and erosion, and fish for food and housing and wildlife. But what they do is not just to maintain the flora and

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fauna in the watershed. Because the water level changes with the seasons, many wetlands are not wet throughout the year. During heavy rains, wetlands absorb floods and slow down flooding, helping to reduce property damage and potentially saving lives. Before reaching rivers, lakes, and other water sources, wetlands absorb too much pollutants, sediments, and nutrients.

It's an ideal place for hiking, canoeing, fishing, and birdwatching, serving as an outdoor "classroom" for all. The largest wetland in the world is the Amazon Basin, the Western Siberian Plateau. Pantanal Wetlands in South America, and the Sundarbans in the Ganges-Brahmaputra Delta and the Niger Delta which is the largest wetland in Africa and the third largest mangrove forest in the world (Nwankwoala, 2012; Fraser and Keddy 2005; Giri et al., 2007). A study by the National Millennium Institute of the Western Hemisphere concludes that environmental degradation within ecosystems is more significant than any other ecosystem on the planet (Davidson et al., 2005).

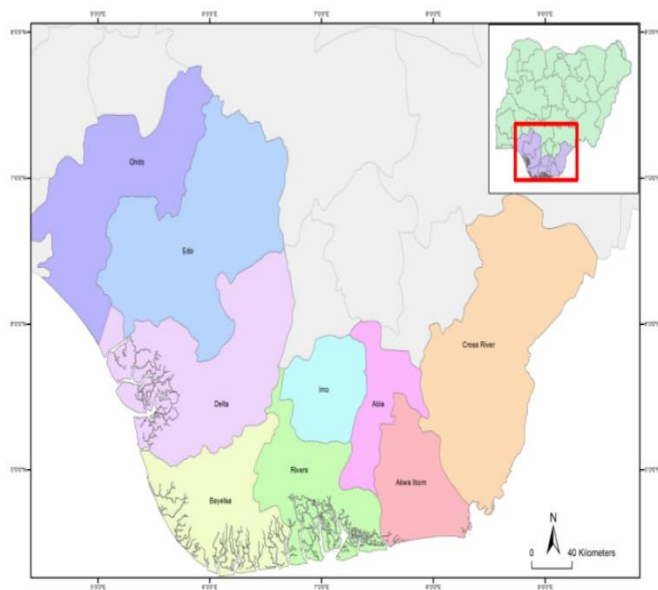


Figure 1: Map of Nigeria showing the nine states of the Niger Delta (Okonkwo et al., 2015).

2. NIGER DELTA WETLAND

Niger Delta is located on the Atlantic coast in southern Nigeria, the southern part of the Niger River extends between $05^{\circ} 19'34''$ N $06^{\circ} 28'15''$ E and 5.32611° N 6.47083° E Longitude (World Geodetic System 1984). The average monthly temperature in the area is 27° C and the annual rainfall is between 3,000 and 4500 mm. There are two different seasons, the rainy season occurs from July to September and the dry season occurs between December and February (World Bank, 1995). The Niger Delta consists of 9 states (Figure 1) with a population of about 30 million, representing approximately 22% of the country's population (Census, 2006). The Niger Delta wetlands are the largest in Africa and the world's largest of the three major mangrove forests, there are currently three sites listed as internationally important Ramsar wetlands (Figure 2) (Nwankwoala, 2012; Nwankwoal and Ngh 2014). This area is well known for biodiversity and oil and gas fields with nearly 30 million people, of which 60% depend on services received directly from the environment, such as fish and clean drinking water.

The Niger Delta consists of mangrove forests, lowland rainforests, freshwater forests and aquatic ecosystems serving the indigenous genes in the region and the West African economy (Anyalade, 2015). Numerous biodiversity has been found in the Niger Delta. (Izah and Seiyaboh, 2018; Izah, et al., 2018). Biodiversity has a different ecological, social financial effect on people. For instance, in the pollination process insects carry out a significant role. Wildlife supplies all the protein, and skin, while plant asserts are used in developments projects while shrubs and herbs are mainly used to deal with a range of illnesses (Izah et al., 2017, 2018).

Numerous forests have medicinal potentials, thus depicted biodiversity as a real life-saving system in the biosphere (Ibimilua, 2013). In any case, these days, some human exercises are influencing the environment negatively.

2.1 Lowland Rainforest

The lowland rainforest species, it is one of the most complex ecological areas in the Niger Delta. Consistent with Ayanlade, the rainforest area (first floor / layer characterized by dense / dense forest) is characterized by tall trees (Ayanlade, 2014). The bark is approximately 40 to 50 meters high, sometimes attached to epiphytes and vines. At the back of the tree, a large canopy (second row / higher plants, 20-35 meters high, can provide shade), bare trunks of low trees (third layer / stratum, about 20 meters high Plants) The fourth layer is moss, small stem shrubs, lichens, herbs and ferns (fourth layer / stratum). The vegetation found in the rainforest is mainly used for timber, firewood, sawn timber, particle board, pulp / paper, telephone poles and traditional medicines. Some common species include Kaya ivory, Guaara thompsonii, and eucalyptus (*Entandophragma cylindricum*), Angandense, Angandense, Guarea cedrata, Lovoa trichilioides, pear balsam azalea, Milicia excelsa, Terminalia ivorensis, Triplechiton scleroxylon A Terminalia superminalia

2.2 Mangroves Ecosystem (estuarine and marine)

The estuary is called estuarine water (salt and freshwater mesophase) (Izah et al., 2017). They disrupt part of the mangrove forest in the Niger Delta. In general, the Niger Delta mangrove forest is one of the largest mangrove forests in Africa. The salinity of the estuary is lower than seawater, but higher than freshwater. The area is dominated by mangrove plants and narrow coastal ridges. *Rhizophora racemosa* (tall mangroves), *R. Mangle* and *Rhizophora harrisonii* (short mangrove), *avicania* (white mangrove) and *Laguncularia racemosa*, etc (Jamabo and Chinda, 2010; Ogamba et al., 2016; Ohimain et al., 2014). species have been reported to exist among the Nigerian mangroves in Niger Delta Wetlands. Usually, *Rhizophora* and *Avicennia* found important mangrove species in the mangrove area. Niger door. Niger's freshwater (10,000 sq km) door and mangroves are classified as *Dalburger escatophylum*, *Machaerum lunatus* and *Pandanus sp.* The main wetlands are separated of the mangroves in the Niger door (Ohimain et al., 2014).

In the Niger Delta saline water resources, the major seabirds found include the *Tympanotonus* and *Pachymelania* sign, of which one *Tympanotonus* species has two variants, namely *T. fuscatus* var *radula* and *T. fuscatus* var *fuscatus* (Bob-Manuel, 2012; Ogamba et al., 2016). *F. catususus* is distributed mainly in the temporal region and is rich in dritus and muddy substrates. They live together with *Nartina adensoniana* and *Pachimelania posca* var *quadriseriata* (Jamabo and Chinda, 2010; Ogamba et al., 2016). In addition to fires, several other catfish, plankton (phytoplankton and zooplankton) and enormous benthic life forms were found in sewage and marine ecosystems. In addition, the mangrove forest protects the area from salt water intrusion. The plant is a potential source of tree, medicinal and breeding ground for fish, especially mangrove roots and mud flats that often support oyster, crab and other invertebrate species (Ayanlade, 2014).

2.3 Freshwater Swamp

Freshwater swamps in the Niger Delta are located between lowland rainforests in the north and mangrove swamps in Igu and Merchant in the south (2017). Sweet forest swamps provide a transition area between two ecosystems and provide a route for the transfer of biodiversity (Igu and Marchant, 2017). According to freshwater swamps in the Niger Door are formed by the alluvium of the Niger River (Ayanalda, 2014). Freshwater swamps are the base habit of fishing, especially during floods and a habitat for crabs and alligators (Igu and Marchant, 2017).

Freshwater forest vegetation is characterized by tall trees such as *Harungana madagascariensis*, *Eleais guineensis*, *Anthocliesta vogelii*, *Musanga cecropioides*, *Annona Senegal*, *Juncus sp*, *Pandanus sp*, *Raphia hookeri*, *R. vinifera* and *Tectonia grandisyanla*. Most plants in the area are used as fuel foods, medicines, boat engraving, and also protect the coast of (Ayanlade, 2014). Moreover, fresh water is the most water source for

household use such as drinking, bathing, cooking etc. The area that has fresh water source is often called freshwater marsh. In freshwater rap, other habitats such as shores and arable land are common. Some authors have depicted the biodiversity in the Niger Delta as freshwater marshes. There are several freshwater creeks and creeks in the Niger Delta, and they have various names. For example, in Bayelsa State, some well-known water bodies include Epic Creek, Sagbama Creek, Ikoli Creek (Ikoli Creek), Kolo Creek, Taylor Creek, (Seiyaboh et al., 2016; Seiyaboh et al., 2017; Saiyaboh et al., 2016; Ogamba et al., 2015; Ogamba et al., 2016; Ogamba et al., 2015; Ogamba et al., 2017; Dhaka et al., 2014). Most freshwater resources in the area are connected to estuaries and discharged into the ocean from there. The activity of the temporary oil furnace at the mouth of the River Nun affects the physical and chemical properties of water (Gijo et al., 2016). sediments and large invertebrates affect mangrove plants and large invertebrates (such as Marphysa, Lumbrinereis, Lillyalla, Mandippi species, Marphysa sanguinae, Notomastus Latericeus, Marianida pinniger, Littorina anguilifera, Neritina. Aurita, Pachymelania bryonensis and Crassostrea gasari, etc.) (Gijo et al., 2016).

In the Niger Delta, quite a lot of large plants are reported in surface water, including water hyacinth, water lily, apple powdery mildew, water duckweed, Salvinia nymphellula, Azolla pinnata var Africana etc. (Ohimain and Akinnibosun, 2007; Ogamba et al., 2015; Nyananyo et al., 2007; Ohimain and Akinnibosun, 2008). In terrestrial habitats, many plants are reported in the area. In the terrestrial ecosystem of freshwater marshes, several plant species have been reported in the Niger Delta. Igu and Marchant have not fully estimated and understood the research on the importance of the light cement carbon ecosystem (Igu and Marchant, 2017). The Niger Delta ecosystem is very fragile and provides many useful resources for people in the area. Therefore, sustainability surveys will increase the ecosystem potential of (Igu and Marchant, 2017).

In addition to the three main ecosystems in the Niger Delta, derivative pastures have also been discovered. According to Ayanlade, the grasslands (consisting of a small amount of grass, shrubs and trees) in the northern part of the region may come from secondary rain forests (Ayanlade, 2014). Due to the impact of agriculture and forestry, these secondary rain forests have been reduced to open forests. Due to ongoing human activities, it is difficult for trees in this area to grow. The author also reports that land scarcity is caused by population growth, industry and urbanization, which are the main reasons for pasture in the area.

3. NIGERIAN WETLANDS OF INTERNATIONAL IMPORTANCE

There are currently 11 sites designated as internationally important wetlands in Nigeria (Figure 3) the Niger Delta has an area of 10,767 square kilometers, including three wetlands Apoi Creek, Oguta Lake and Orashi Forest.

3.1 Apoi Creek forests

Apoi Creek Forest Reserve is located in the center of the Niger River Delta and is mainly composed of swamps, mangroves and freshwater marches. The freshwater marshland covers an area of about 2.9 square kilometers. The forest is dense, with a large number of animals and plants of ecological and economic value. The Red Co (Procolobus badius) monkey in the Niger Delta is one of the endemic and endangered species supported by wildlife. This area is also an important spawning area and nursery area. Apoi Creek Forest has made a significant contribution to the livelihoods of local residents by providing non-timber forest products, agricultural areas and fisheries (Ramsar Annotated List: Nigeria (2010), available online: <http://ramsar.org>)

3.2 Oguta Lake

Augusta Lake is located in a natural lowland on the plains of the Niger River. It is a natural freshwater lake in southeastern Nigeria, covering an area of approximately 5.72 square kilometers. Depending on the season, the water surface area of 1.8-3.0 sq km and an average depth of 5.5 m, the Njaba, Utu and Awbuna Rivers are usually released from the lake and the lake water is released into the Orashi River which contains plankton. 258

plants, 107 species and 40 endangered gas sclater species. (Cercopithecus sclateri) spread in the pristine forests of Hunan. The lake is an important water and city source for Augusta residents, and it also receives urban sewage. Many members of the community are also of cultural and spiritual importance. Fishing and tourism are important economic and social activities in the region. Overfishing is putting pressure on lakes, and deforestation sewage and sediments are seen as a threat, as lake water sprinkled through a working sewer reduces any threat. The Augusta Lake Basin Protection Program collaborates with local communities to restore the lake and promote sustainable development ("Annotated Ramsar List: Nigeria" (2010), available online: <http://ramsar.org>).

3.3 Upper Orashi forests

The forest reserve in central Niger is a freshwater swampy forest. From September to November, it was flooded by the Orashi River, resulting in improved siltation and soil fertility. The reserve consists of the remains of a small endemic center where endangered Cournot Sclater (Cercopithecus sclateri) and endangered diphtheria Cournot (Cercopithecus erythrogaster), red monkey monkey (Procolobus badius) and Famous Heslop snake (Hypotamus). The site is the habitat of the gray parrot (Psittacus erithacas) and also contains a large number of species of waterfowl, whose distribution is limited to the forest biomass of Guinea-Congo. The forest reserve has a formal management plan, but it has not yet been implemented. It is recommended that the reserve be used for a clearer management plan and management structure. Currently, ethnically belligerent, insecure, poaching and unregulated logging hinder opportunities for tourism, education and research (The Annotated Ramsar List: Nigeria can be viewed online at <http://ramsar.org> "(year 2010)).

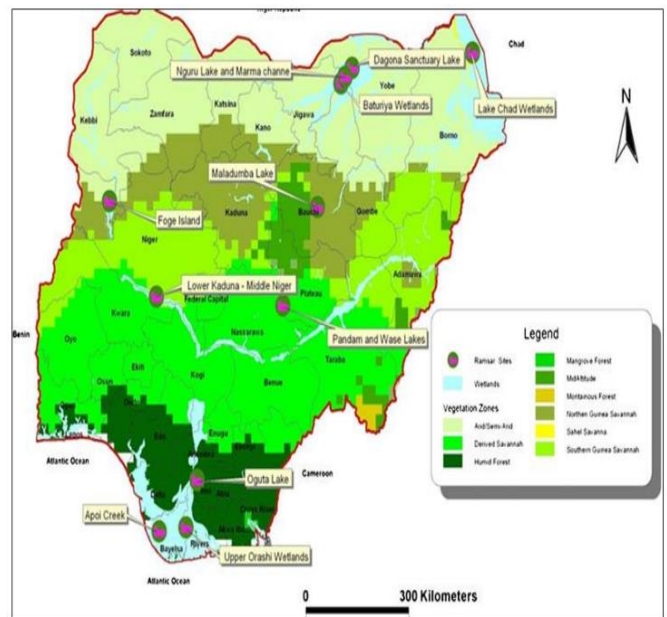


Figure 2: Map of Nigeria showing the Ramsar sites. (Source: Adekola et al., 2012)

4. POTENTIALS OF NIGER DELTA WETLANDS

Wetlands play a vital ecological, social and economic role (Izah et al., 2017; 2018). According to data from Kadafa in 2012, wetlands tend to decompose and absorb pollutants. In the Niger Delta, wetland resources are vital because it is used for firewood, timber, etc. For arts and construction projects, breeding grounds for various types of wild animals and plants, habitats for migratory birds, spawning grounds for various fish, and a variety of fish. Class source. Plants with insecticidal and antibacterial properties (Ohimain, 2009; Izah et al., 2017; Ayanlade 2014; Ohimain 2009). The area is widely reported to be endemic to biodiversity, including plants, mammals, birds, reptiles, and amphibians (Ohimain, 2009). Ecosystem forest products in the Niger Delta include food, firewood, and protein sources - crabs, green lobsters, fish, shrimp, periwinkle, snails, and other raw materials (Igu and Marchant, 2017; Ayanlade 2014).

Biodiversity has some medicinal benefits, including flora and fauna. This is because some animals use fats, oils and skin to treat certain human ailments in addition to food. For example, Costa-Neto 2005 suggested that hippos, ivory (Amphibious hippopotamus) can be used as an aphrodisiac and ornamental plant, and the fat extracted from the manatee (*Trichechus senegalensis* in Senegal) can be used to treat arthritis, its and back pain. Costa-Neto also reported in 2005 that it can Black caiman (*Melanosuchus niger*) blood is used to treat epilepsy and stroke. Ants of the genus *Pseudomonas* can be used to treat toothache and relieve joint pain. The anatomical parts of rats (*Crotalus* sp.) Are used to treat a wide range of ailments from skin stiffness to bronchitis. Camelback spinal manure is used outside the affected area to reduce fatty arthritis, lions (*Panthera leo*) and dogs.

In (*Crocota crocuta*) can be used to reduce abdominal pain. Curraghs (*Sylvicapra grimmia*) and antelope (*Hippotragus*) are used as special containers mixed with herbs to camouflage traditional gods and witches. Different parts of animals are used in traditional medicine (Izah and Seiyaboh, 2018). Costa-Neto 2005 pointed out that most mammals have hoofs, ivory, bones, feathers and skin with severe medicinal properties. The Niger Delta has previously reported some animals mentioned by Costa-Neto 2005. However, in the past 20 years, most people have not been found in the area. Several plants found in the Niger Delta have been widely reported for medicinal purposes. In a retrospective study conducted by Bassey & Izah in 2017, several plants in Nigeria proved effective against mosquitoes at various stages of development. Several plants mentioned by the author have been found in the Niger Delta.

Some plants are reported to have antimicrobial effects, including *Musanga cecropioides*, *Vitex grandifolia*, *Alstonia boonei*, *Alchornea cordifolia* and that many other Species of plants (Kigigha and Atuzie 2012; Kigigha et al., 2016; Epiidi et al., 2016; Epiidi et al., 2016). Some of these plants are a reliable source of new synthetic drugs (Izah et al., 2018; Costa-Neto 2005, Izah and Seiyaboh 2018). In 2018, indigenous people's knowledge of biological resources, especially the knowledge of their health benefits, will help commercialize cultivation. Some parts of mangrove plants are used as telegraph pole communication lines, foundation piles, local road signs, mud and straw construction for young trees and branches (Eleanya et al., 2015, James et al., 2013). It was reported in 2013 that Niger Delta mangroves have social value, including healing value, comfort, spirit, heritage and survival.

According to Ohimain and Akinnibosun, wetlands characterized by soil interactions, vegetation and hydrology were developed in the area (Ohimain and Akinnibosun 2010). Forests are a barrier to underground soils, especially under the influence of natural factors. (Eg heavy rains, high temperatures, destructive winds and erosion), according to a study, mangrove forests act as buffers waves, helping to filter water resources and carbon sinks, thereby minimizing the effects of global warming, protecting cultivated land and coastal areas, and minimizing erosion and flood impacts (Ogboru and anga, 2015; Eleanya et al., 2015). The Niger Delta Wetlands support cultural services such as spirituality and inspiration, entertainment/eco-tourism (Ramsar website) and educational functions. Some delta communities worship the crocodiles and turtles found in the delta (Isichei, 1982).

It is said to bring happiness and is considered a symbol of peace or a symbol of the son of a rich man, other cultural services of the wetland, including the use of autumn ceremonies. Fish such as Lake Opuaduno and Se Bein Fishing Festival have few documents on the spiritual and sacred values of the Niger Delta wetlands (Akani and Luiselli, 2001; Jonathan, 2006). This may be due to the confidentiality of these services in most African societies, but we know that wetlands have many essential spiritual and sacred places (Anderson and Peek, 2002; Speranza et al., 2008; Bisina, 2006). Niger Delta wetlands are also known for the support services they provide, that is, they support the other types of ecosystem services listed in Table 1 and above. These measures include nutrient cycling, oxygen production and soil formation. These activities can support delta biodiversity; nitrogen enrichment to promote carbon sequestration and climate control, as

wetlands provide fast transportation routes in difficult terrain and important support for the establishment of wetlands, so this service is often overlooked (Uluocha and Okeke, 2004; Ejechi, 2003; Iwegbue et al., 2006). Many urban and rural settlements can only be accessed through wetlands (Wolf et al., 2002).

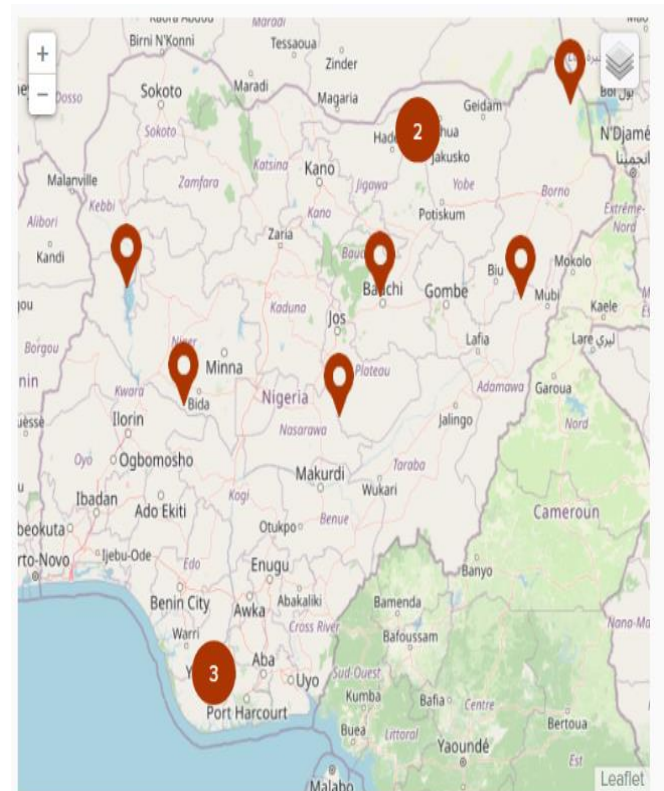


Figure 3: Nigerian Ramsar Wetlands of International Importance

5. CHALLENGES OF THE NIGER DELTA WETLAND

Nigeria is the eighth largest exporter of oil in the world. The development of rich oil and gas resources has created many environmental and social challenges. Wetland degradation is a serious ongoing problem due to urbanization, industry, intensive agricultural practices, deforestation, use of chemical-based fertilizers, pesticides, and emissions from fossil fuel consumption are the main factors causing environmental degradation. Some researchers lists human activities and biophysical effects, including positive population growth rate, urbanization / industrialization, emissions from industrial activities (such as mining, oil and gas activities), unrestricted farming crops Soil cultivation, grazing, logging / logging, unprecedented land reclamation, dam construction, physical infrastructure, erosion, sea level rise, alien invasion, sandstorms, desertification, drought, poverty, overfishing, etc. threatening wetland resources in a key factor of the Niger Delta (Uluocha and Okeke, 2004; Nwankwoala, 2012).

Historically, the oil revenue generated in the Delta region is rarely reused for local communities. The standard of living in the Niger Delta community is very low, and most people lack basic necessities such as access to clean water, sanitation, and education. To solve some of these problems, developing development plans to integrate the livelihoods of local communities with ecosystem restoration is essential. Despite the importance of the Niger Delta as a wetland, the oil and gas industry has long lacked environmental improvement plans. The lack of understanding of the value of wetlands and their importance to various stakeholders is a major disadvantage. Without an understanding of the link between wetlands and livelihoods, development initiatives aimed at addressing the challenges facing sustainable or thriving communities may not be possible. Table 1 lists the challenges facing Olalekan Adekola and Gordon Mitchell in the Niger Delta wetlands after 2011.

Table 1: Challenges of the Niger Delta wetlands

Factors	Challenge	Source
Aquaculture	Loss of mangrove with its rich biodiversity and attendant impact on livelihoods	(Davies et al., 2009; Zabbey et al., 2010)
Oil exploration and exploitation activities	Narcotic effects and mortality of fish and other faunal organisms/dynamite shooting causes increases in turbidity, blockage of filter feeding apparatuses in benthic (bottom dwelling) fauna and reduction of plant photosynthetic activity due to reduced light penetration.	(Ekundayo and Fodeke, 2000; Uluocha and Okeke, 2004; Twumasi and Merem, 2006; James et al., 2007; Uyigwe and Agbo, 2007; Obot, 2007; Ugochukwu and Ertel, 2008; Watts, 2008; Luiselli, 2009; Phil-Eze and Okoro, 2009; Zabbey et al., 2010)
Dredging	Direct burial and destruction of fringing mangroves and associated fauna/changing topography and hydrology/increased erosion and siltation/excessive flooding and ponding of the backswamp/estuarine acidification and heavy metal pollution/succession to freshwater vegetation	(Ohimain et al., 2004; Rim-Rukeh et al., 2007; James et al., 2007)
Damming activities	Top of form reduction in water flow and sediment	(Abam, 1999; Uluocha and Okeke, 2004)
Human activities (such as deforestation unsustainable hunting, overfishing, logging)	Loss of flora and fauna	(Luiselli, 2003; Luiselli et al., 2006; Phil-Eze and Okoro, 2009)
Wetland reclamation (agricultural and urbanisation)	Loss of flora and fauna	(Wolf et al., 2002; Twumasi and Merem 2006; James <i>et al.</i> , 2007; Phil-Eze and Okoro, 2009)
Climate change	Sea-level rise, flooding, loss of lives and properties	(Uyigwe and Agbo, 2007)
Other industrial and domestic effluents	Soil and water pollution, Oil Spill	(Ugochukwu and Ertel, 2008; Wali et al., 2019)
Indiscriminate use of fertiliser	Water pollution	(Obire et al., 2008)

6. PROSPECTS OF NIGER DELTA WETLANDS

Wetland ecosystems provide many services essential to human survival (de Groot et al., 2002; MEA was added in 2005). Wetlands provide abundant mineral resources, fresh air and water. The purchase of food, medicine, energy and raw materials can also cultivate the soil and fertilize crops, improve the climate, control floods, and provide areas for recreation and spiritual rejuvenation, MEA classification. Products and services such as procurement, cultural control and support services (Mitsch and Gosselink, 2000; Brander et al., 2006). While each wetland has the potential to provide many such services, it should be noted that there is one or more major services require the use of different wetlands. In general, wetlands in underdeveloped societies are mainly known for their direct interests, such as farming, collecting reeds, sedges and fuelwood, as well as fishing and hunting prey (Emerton et al., 1999; Schuyt, 1999; Turpie et al., 1999; Turpie 2000; Mmopelwa 2006). Wetlands in developed countries are known for indirect benefits (such as aesthetics and biodiversity), (International Water Management Association 2006).

Wetland areas provide the following benefits:

1. Development (agriculture and urban)
2. Social activities (Recreation, eco-tourism with three Ramsar sites, bird watching, education, utility)
3. Erosion control

4. Hydrology (flood attenuation, water storage)
5. Pollution control
6. Habitat value (vegetation, fish and wildlife).
7. Groundwater replenishment
8. Shoreline stabilisation and storm protection
9. Water purification
10. Reservoirs of biodiversity
11. Pollination
12. Wetland products
13. Cultural values
14. Climate change mitigation and adaptation

Wetlands are of extreme importance to the landscape in which they are found. This is because:

1. they influence the flow of water, sediment and nutrients over the landscape, thus have implication for water storage, streamflow regulation, flood attenuation, soil erosion and water purification;
2. abundant moisture and hydromorphic soils allow for the development of a characteristic flora and fauna. Wetlands therefore provide a specific and much sought-after fish and wildlife habitat.

Table 2 summarizes the key ecosystem services derived from the Niger Delta wetlands modified after MEA 2005, Olalekan Adekola & Gordon Mitchell 2011.

Table 2: Major ecosystem services provided by or derived from Niger Delta wetlands

Service Provided	Examples of Service Provided from the Niger Delta Wetland
• Food and Building Materials	• Bush meat (Luiselli 2003; Luiselli et al., 2006) • raffia, snail, spices, mangrove salts, reeds and sedge (World Bank 1995) •Timber products: saw logs, transmission poles, bamboo, building poles, fuelwood and chewing sticks (World Bank 1995; NDDC 2006; Alogoa 2005; McGinley 2008)
• Fresh water	• Agricultural and tree crops: cassava, yam, cocoyam, rice, maize, ogbono, cocoa, etc. (World Bank, 1995; Umoh, 2008; Omofonmwan and Odia, 2009)
• Fibre and fuel	• Fish and other aquatic food such as barnacles, crabs and other invertebrates (Nwadiaro, 1984; Fentiman, 1996; Davies et al., 2009)
• Biochemical	• Aquatic insects (Arimoro and Ikomi, 2009)
• Genetic materials	• Medicinal species (Ndukwe and Ben-Nwadibia, 2005)
• Climate regulation	• Provides a good sink for greenhouse gases of CO ₂ and CH ₄ (Brook et al., 2000)
• Water regulation (hydrological flows)	Provides buffer against natural disaster including coastal erosion and regulates flood (Cugusi and Piccarozzi, 2009; Sanford, 2009)
• Water purification and waste treatment	Regulates water movement, quality and volume (Abam, 2001; Uluocha and Okeke, 2004)
• Erosion regulation	• Habitat for pollinators (Dupont et al., 2000)
• Natural hazard regulation	• Natural attenuation (Benka-Coker and Ekundayo, 1995; Abu and Dike, 2008)
• Spiritual and inspirational	• Source of spiritual inspiration (Isichei, 1982)
• Recreational (Eco-tourism and transportation)	• Site for fishing festivals (Jonathan, 2006) Supports transportation (inland ports) that link places (Wolf et al., 2002; NDDC 2006; Egbagbe 2009)
• Aesthetic	•Spiritual and sacred sites (Anderson and Peek 2002; Bisina 2006)
• Educational	Vast biodiversity (indicative of tourism) (World Bank 1995; Ebeku 2004)
• Soil formation	• Supports delta's biodiversity (Ejechi, 2003)
• Nutrient cycling	• Soils support nitrogen mineralization (Iwegbue et al., 2006)

7. THE NEED TO PROTECT AND STUDY THE NIGER DELTA WETLANDS

The Ramsar Convention on Wetlands was established internationally to protect wetlands (Frazier, 1999). The public's attitude towards wetlands is changing rapidly, and legislation to protect wetlands is being formulated. For example, the United States has a national policy on net wetland losses. A project that has been deleted should be replaced with another project that resembles a wetland. The law also states that avoidance of wetland losses (before compensation) should be a priority (NRC 2001). Thus, due to many years of eutrophication, edge dredging and landfill operations, settlement / erosion, degradation of toxic pollutants and water storage in urban development, wetlands and estuaries have received increased public attention and protection (Morris et al., 2002; Hembra et al., 2020). The need for research and protection of wetlands cannot be overemphasized for the following key reasons:

- i) Wetlands are one of the most productive and fertile ecosystems in the world, similar to tropical rainforests and coral reefs.
- ii) Two thirds of the fish consumed worldwide depend on coastal wetlands at some point in their life cycle.
- iii) The average annual fish and seafood production of the wetland and its surrounding areas is about 9 tons/259 hectares, or 640 acres per square kilometer.

Centers of excellence should be established in all universities in the Niger Delta, focusing on the use of remote sensing technology and geographic information systems to study the diversified economic diversity of wetlands in the conservation and resource management of the region. Efficient water saving

8. CONCLUSION

This review of the Niger Delta Wetlands and coastal resources have shown clearly that the ecosystem of the Niger Delta has three sites listed as Ramsar Wetlands of International Importance. The Niger Delta Wetlands play vital ecological, social, cultural, economic, medicinal and other support services for the sustainable development of the region and country at large. The region is equally faced with several challenges of degradation from oil spill and industrial pollution with unsustainable use of the wetland resources. The impact of the Niger Delta challenges, span hundreds of kilometers on regional and global scales. A group researcher highlighted the migration of pollutants from wetlands to regional waters (Guinea Bay). According to FOEI (2004), Niger Delta provides greenhouse gases more than the sum of all sub-Saharan Africa. There is an urgent need to protect the Niger Delta wetland sequel to its current state of ecological degradation and pollution with the dissemination of scientific research findings and recommendations via centers of excellence for wetlands studies all across the universities in Niger Delta Region.

RECOMMENDATIONS

The review recommends that the United Nations and its allies, oil and gas companies, and the Federal Government of Nigeria should develop strict policies to mitigate the challenges of the Niger Delta wetlands. In addition, considering the importance of coastal wetlands in the Niger Delta, appropriate tools such as GIS and remote sensing are used to effectively monitor the coastal wetlands in the Niger Delta.

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CONFLICT OF INTEREST

There are no conflicts of interest regarding the publication of this article.

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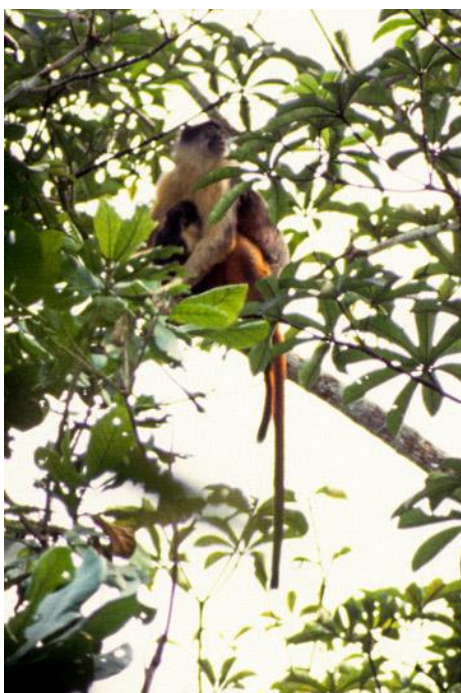
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APPENDIX

Pictures of Niger Delta Wetlands



Niger Delta red colobus. Image courtesy Noel Rowe. (Source Mongabay July 2020)



With farmland and streams polluted by the oil industry, people across the Niger Delta have increasingly turned to hunting and logging to sustain themselves. Image courtesy Rachel Ashegbofe Ikemeh. (Source Mongabay July 2020)



Oil pollution in the Niger Delta Wetland (Source The Economist July 2020)



View of the mangrove ecosystem in Niger Delta (credit: <http://www.panoramio.com/photo/22375787>)



View of the mangrove ecosystem in Niger Delta (credit: <http://www.panoramio.com/photo/22375787>)



Development encroaching the water (using land that was once inhabited by mangroves) (credit:)

http://cas.umkc.edu/GeoSciences/LCAM/NIGER_DELTA/PAGES/N_Factors_drivin_Man



Niger Delta mangroves at night

(credit: <http://www.naijatreks.com/2011/02/a-peace-like-the-creeks-of-niger-delta/>)



The polluted mangrove swamp of the riverine area in Warri Niger Delta area of Nigeria.

[Source]: <https://platformlondon-org.exactdn.com/wp-content/uploads/2012/07/ND-mangrove-polution.jpg> (Photo/George Osodi)



Areas of the Niger Delta Unaffected by Oil Spillage. Taken from [Google, 2017].



Oil Pollution in the Niger Delta, George Osodi. Taken from [Al Jazeera, 2016].



Illegal Refineries in the Niger Delta. Taken from [Al Jazeera, 2016].



The Niger Delta, Nigeria - Photo courtesy, <https://photorator.com/photo/94701/the-niger-delta-nigeria->



Picture from the oil spill of the inch Ogboinbiri-Tebidaba pipeline, near the Ikienghenbiri community in 2017 - Source: https://www.youtube.com/watch?v=E5S0s6B_Ybk.

