International Scholars Journals

African Journal of Ecology and Ecosystems ISSN: 9428-167X Vol. 3 (3), pp. 185-197, April, 2016. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Review

Importance of wetland resources, their threats and the need to protect them

Chukwuma B. Eze*, Ekene Gabriel Anthony and O. B. Nathaniel

School of Environmental and Rural Science, University of New England, Armidale, NSW, 2351, Australia.

Accepted 05 March, 2016

The Niger Delta wetland ecosystem is of high economic importance to the local dwellers and the nation in general. The region is rich in both aquatic and terrestrial biodiversity and serves as a main source of livelihood for rural dwellers as well as stabilizing the ecosystem. Tremendous changes have occurred recently in the Niger Delta wetlands due to anthropogenic activities, thus raising awareness on the need for effective monitoring, protection and conservation of the wetland ecosystem. A good knowledge of the services provided by wetland ecosystems is an important key for an effective ecosystem management. The aim of this paper therefore was to review the importance of wetland resources, their threats and the need to protect them. This review shows that the region is rich in biodiversity of high economic importance to national development, and has been under severe threat from human activities, especially pollution. It is recommended that effective monitoring be employed using modern techniques such as GIS and remote sensing in the conservation and management of this important ecosystem.

Key words: Niger Delta, wetland, ecosystem.

INTRODUCTION

The Niger Delta region

Located on the Atlantic coast of Southern Nigeria, the Niger Delta lies within the lower reaches of the Niger river, extending between latitudes 05°19′34″N 06°28′15″E and 5.32611°N 6.47083°E (World Geodetic System, 1984). The average monthly temperature of the region is 27°C, and an annual rainfall ranging from 3000 to 4500 mm. There are two distinct seasons with the wet season occurring from July to September and the dry season from December to February (World Bank, 1995). The Niger Delta is made up of nine states (Figure 1) and home to some 30 million people, approximately 22% of the country's population (2006 census).

The Delta is among the 10 largest in the world, with a coastline of about 450 km which ends at Imo river

*Corresponding author. E-mail: dr.eze22@yahoo.com

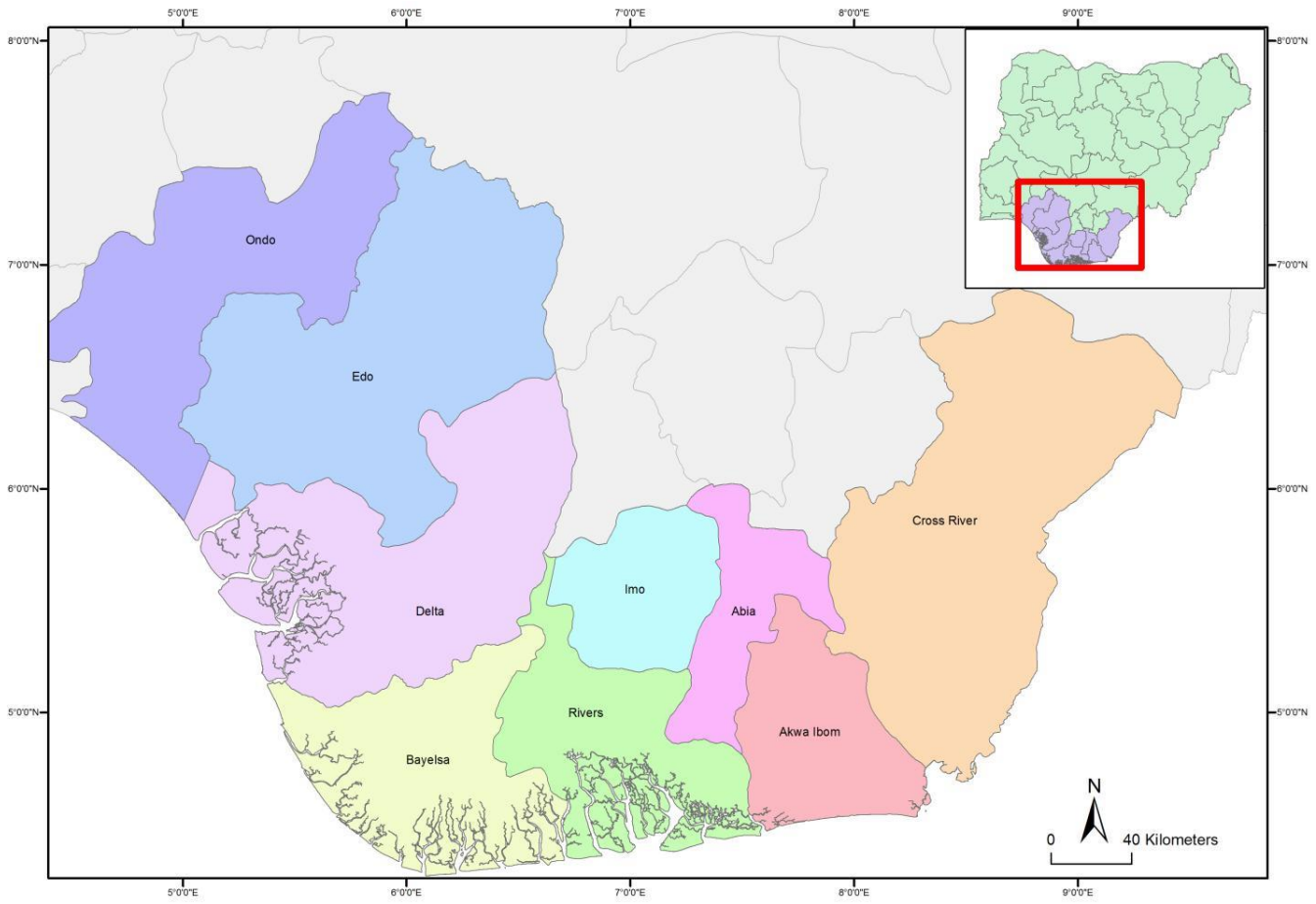

Figure 1. Map of Nigeria showing the nine states of the Niger Delta.

entrance. The region encompasses an area of 20,000 km^2 and is the largest delta in Africa and the world's third largest (Uluocha and Okeke, 2004; Ajonina et al., 2008; Dupont et al., 2000; Umoh, 2008). Over the decades, water discharges, sediment deposits and other loads across Southern Nigeria and beyond into the Atlantic Ocean has resulted in the formation of a complex and fragile Delta, abundant in biodiversity (Ogbe, 2005; Abam, 2001). About 2,370 km^2 of the Niger Delta area consists of rivers, creeks, estuaries and stagnant swamps. Approximately 50% of the Delta is covered with water accounting for 55% of all freshwater swamps in Nigeria (Ikelegbe, 2006; Umoh, 2008). The Delta mangrove swamp spans about 1900 km^2 as the largest mangrove swamp in Africa and about one third of the Delta consists of wetlands (Spalding et al., 1997). This system of wetlands was formed by the accumulation of sedimentary deposits, transported by rivers Benue and Niger (World Bank,1995) and is considered one of the 10 most important wetlands and marine ecosystems in the world (Uluocha and Okeke, 2004). This region contains an array of characteristic ecological zones comprising seasonal rainforests, sandy coastal ridge, fresh water swamp forests and saline mangroves (Ogbe, 2005; Olomukoro, 2005). It is considered the richest wetland in the world in terms of biodiversity (Ebeku, 2004; Iyayi, 2004). In this paper, we (1) discussed the importance of wetlands in general; (2) identify the Niger Delta wetlands of international importance; (3) review the ecosystem services provided by the Niger Delta wetlands; (4) review the fisheries resources of the Niger Delta wetlands over the last two decades; (5) review the threats faced by the wetlands and (6) make some recommendations to reduce the impacts of threats on the wetlands.

IMPORTANCE OF WETLANDS

Wetlands, referred to as swamps or marshes, are among the most important ecosystems in the world. They are

essential for performing many ecosystem services, such as food control, maintenance of biodiversity, fish production, carbon storage, aquifer discharge and flood control as well as providing habitat for many endangered species (Barbier et al., 1997). Asibor (2009) estimated that about one third of all endangered species are dependent on wetlands. According to the Ramsar Convention Secretariat (2007), wetlands are “areas of marsh, fen, peat-land 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 6 m”. In addition, the convention suggests that wetlands may incorporate “riparian and coastal zones adjacent to the wetlands and island bodies of marine water, deeper than 6 m at low tide lying within the wetland”. Wetlands can also be distinguished by the presence of water, either at the surface or within the root zone, seasonally or permanently, they often have unique soil conditions that differ from adjacent uplands, and they support vegetation adapted to the wet conditions (hydrophytes) and, conversely, are characterized by an absence of flooding-intolerant vegetation (Mitsch and Gosselink, 2007). Wetlands have been estimated to cover 5-10% of the earth surface, about 1280 million hectares (Mitsch and Goselink, 2007; Ramsar Convention Secretariat, 2007). According to Turner et al. (2000) wetland ecosystems are the only group of ecosystems with their own international convention, they as well gave rise to the first modern global nature conservation convention (Mathews 1993). Wetlands of tropical Africa play a vital role in the provision of food and water and is a source of livelihood to the many rural dwellers living around them (Silvieus et al., 2000; Rebelo et al., 2009), increasing their interest because of their importance as hot spots for development (Dungan et al., 2006).

Wetlands are of high agricultural and aquaculture interest, as well as environmental conservation. Its benefits and values to the society have attracted increasing global importance, but unfortunately, wetland areas are under increasing pressure stemming from developments and industrialization, including oil exploration and spillage. According to Moser et al. (1996), globally wetlands have been reduced by 50% in the last one hundred years. The millennium ecosystem assessment (2005) stressed that global wetland loss is more rapid than those of other ecosystems (Agardy and Alder, 2005) with the United States and Europe having lost over 50% of their wetlands (Finlayson and Davidson, 1999). Some other severe cases include the loss of 80% of Pacific Coast estuarine wetlands in Canada; about 90% of New Zealand wetland areas and 88% of Cauca river system in Columbia (Morse et al., 1996).

Welcomme (1976) stated that in Africa, a continent where protein shortage continues to cause malnutrition, the area of wetlands in watersheds strongly predicts fish harvests. Benefits provided by wetlands are quite enormous, with increased importance worldwide, hence the need to protect the remaining wetlands (Millenium Ecosystem Assessment, 2005). Many wetlands have been greatly destroyed and altered as a result of anthropogenic activities resulting from oil exploration and exploitation, therefore the need to develop an approach for monitoring wetlands is necessary in order to identify, plan and implement proper management and containment responses to affected sites, at local, regional, national and international levels. In Nigeria, an estimated 28,000 km^2 (about 3%) of the 923,768 km^2 land surface area of the country area is covered with wetlands (Uluocha and Okeke, 2004).

Majority of the threats to Nigerian wetlands include oil and industrial waste pollution, population pressure, rapid urbanization, mining, dam construction and transportation routes among others. The Niger Delta Region has been faced with different environmental, social, health and economic threats from oil exploration and exploitation activities. For the purpose of this paper, the environmental threats and impacts are discussed.

Dredging

Dredging involves cutting away large swathes of seafloor, lifting or sucking it up and dumping it somewhere else – usually into deeper water further out to sea or to “reclamation” areas where sea is turned into land. This activity is usually undertaken in coastal waters so that large ships can access ports. Seabeds, seagrasses and marine animals living on the sea floor in the dredged area are totally eradicated. Dredging can also cause the direct death of larger mobile species such as turtles by being drawn into the path of the dredgers. Studies by Rim-Rukeh et al. (2007) and Ohimain et al. *(*2008) reveal that dredging is responsible for physico-chemical changes in the water of the delta, particularly pH, total dissolved and suspended solids (TDS and TSS), conductivity, turbidity, sulphate, dissolved oxygen and oxygen demand. The process of dredging causes water degradation as well as harmful effects on fishes.

Wetland reclamation

Wetland reclamation exists in the form of forest clearing for agriculture and road constructions, which drastically change the natural state of the wetlands and impacts heavily on the flora and fauna of the wetland ecosystem. According to Abam and Okogbue (1993), the Nigerian governments have been forced to reclaim marginal lands in the swamps of the Niger Delta. Wetland reclamation remains one of the most important issues regarding

development in the Niger Delta Region, due to increase in population which has resulted in an increase in demand for space for housing, industrialisation and urbanisation (Wolf et al., 2002). Reports by Etuonovbe (2007) also suggested that multinational companies, especially those in the oil and gas sector, also reclaim wetlands for industrial use.

Oil spill

The discovery of oil in the 1950s in the Niger delta region of Nigeria, with subsequent oil production activities in the region has brought various adverse impacts on its environment. According to Badejo and Nwilo (2004), the rapid development and production of the Niger Delta discovered resources in terms of crude oil with associated population and industrialisation increase has resulted in environmental degradation in this region of the country.

According to a UNDP report (2006:181), 3 million barrels of oil were lost in 6,817 oil spill incidences between the periods of 1976-2001, of which over 70% of the spilled oil was not recovered. Another oil disaster occurred in 2004 where Nigerian Liquefied Natural Gas pipeline transversing through Kala-Akama, Okrika mangrove forest leaked and set ablaze and burnt for three days. The local plant and animals within the areas where engulfed (Nenibarini, 2004). Also on April 29, 2002 an oil pipeline burst at Royal/Dutch Shells Yorla oilfield and spilled into Ogoniland, which flowed for several days into the environment, covering surrounding rivers and farmlands, before the pipeline was repaired (Aigbedion et al., 2007).

Several authors have reported that local communities are directly impacted by the negative environmental effects of oil production activities, such as pollution of water supply (Ekundayo and Fodeke, 2000) and loss of biodiversity (Phil-Eze and Okoro, 2009; Uluocha and Okeke, 2004; James et al., 2007) .

THE NIGER DELTA WETLANDS

The Niger Delta region, which occupies the largest extension of freshwater swamps, is predominantly occupied by rural communities that depend solely on the natural environment for sustenance and livelihood (UNDP Report, 2006; Ogon, 2006). The original Niger delta region (about 29,900 km^2) consists of areas covered by the natural delta of the river Niger and areas to the East and West which produces oil (Environmental Resources Management Ltd., 1997). The Niger Delta mangrove forest is reported to be the most exploited in the world and this region is regarded as the second most sensitive environment in Africa and a global biodiversity hot spot (Food and Agriculture Organisation, 1997). Furthermore, it is considered to be critically endangered under the World Wide Fund for Nature (WWF) Global 200 Ecoregion classification (World Bank, 1995). According to Oyebande et al. *(*2003), 14 major wetland belts are identified in Nigeria. The World Bank (1995) identified four different ecological zones; fresh water swamps, lowland rain forests, mangroves and barrier island forests which had earlier been classified into two distinct ecological zones: (1) the coastal area of the mangrove vegetation, transversed by many creeks, tributaries and rivers in the south and (2) the tropical rainforest in the northern reaches of delta (Hutchful, 1985). Hutchful further subdivided these into (a) salt water riverine area which adjourns the coast where the Niger and its tributaries flow into the sea; and (b) a freshwater riverine area, which is further inland.

According to the World Bank (1995), Nigeria has the third largest area of mangrove forests in the world and the largest in Africa, a majority of which are found in the Niger delta (Ebeku, 2005). It is pertinent to note that the mangrove swamps lie at the centre of a sensitive and complex ecosystem, vital for fishing industries and sources of employment and income of the local dwellers. The mangrove occupies many of the important fauna and flora of the country as well, and is identified as the most important economically rich ecological zone, among the four main zones (World Bank, 1995). Figure 2 shows the Deltaic plain of the Niger delta, with its tributaries, coastal and mangrove zones as well as rivers, states and vegetation zones.

Another important service rendered by the Niger Delta is the extensive forest reserve which harbors a variety of important economic trees used as timber. Economic timber species found in the Niger Delta include mahogany (*khaya* sp), red mangrove (*rhizopora* sp), abura (*Hallea ledermanmi*), iroko (*Milicia excelsa*) and cotton tree (*Ceiba pentandra*). According to the World Bank (1995), these species are popularly used for building poles, fuel wood, saw logs and transmission poles. Other common species in the Niger Delta are *Lophira alata*, *Pycnanthus angolensis*, *Ricinodendron heudelotii*, *Sacoglottis gabonensis*, *Uapaca* spp., *Hallea ledermannii*, *Albizia adianthi- folia*, *Irvingia gabonensis*, *Klainedoxa gabonensis*, *Treculia africana* and *Ficus vogeliana* (McGinley and Duffy, 2007).

NIGERIAN WETLANDS OF INTERNATIONAL IMPORTANCE

Nigeria presently has 11 sites designated as Wetlands of International Importance (Figure 3); with a surface area of 10767 km^2 and three of these wetlands Apoi Creek,

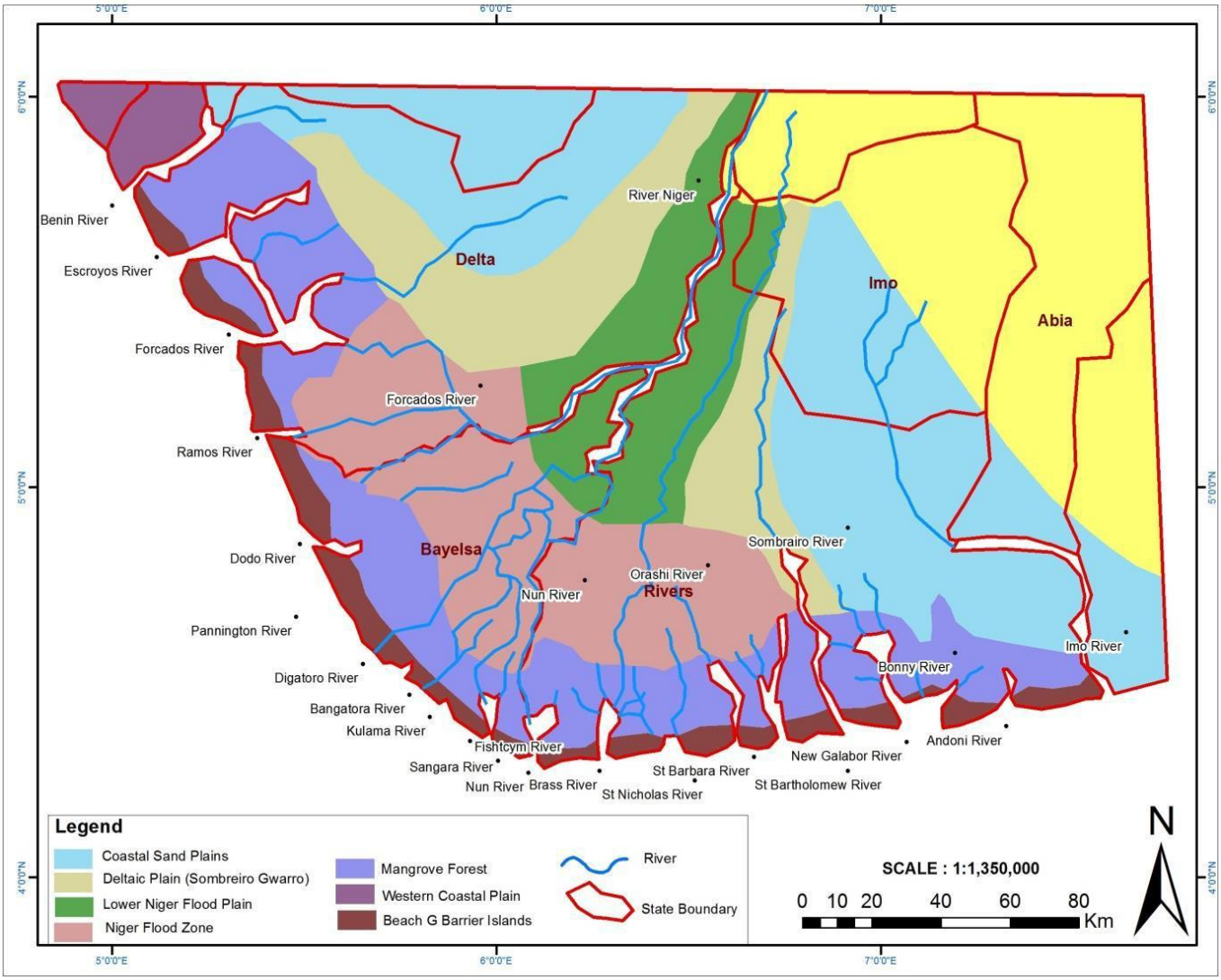

Figure 2. Map of Niger Delta showing, rivers, states and vegetation zones. Adapted from Ugochukwu and Ertel (2008).

Oguta Lake and Upper Orashi Forests, occur in the Niger Delta.

Apoi Creek forests

The Apoi Creek forest reserve is located in the central part of the Niger Delta and composed mainly of marshes, mangrove forests and fresh water swamps. It covers about 2.9 km^2 and is a tidal freshwater, lowland swamp-forest. The forest is dense and rich in several ecologically and economically valuable flora and fauna species. One of the endemic and endangered species supported by this forest is the Niger Delta Red Colobus monkey (*Procolobus badius*) amongst others. The site also serves as an important spawning and nursery ground for fish.

The Apoi creek forests contribute numerously to the livelihood of local dwellers through provision of non-timber forest products, agricultural land and fisheries (The Annotated Ramsar List: Nigeria (2010) available online at http://ramsar.org).

Oguta Lake

The Oguta Lake, located in a natural depression within the floodplain of River Niger, is a natural, freshwater lake in Southeastern Nigeria covering about 5.72 km^2. Its water surface area varies from 1.8 - 3.0 km² depending on the season, and its average depth is 5.5 m. The lake receives perennial drainage from Rivers Njaba, Utu and Awbuna and the lake drains into River Orashi. It contains

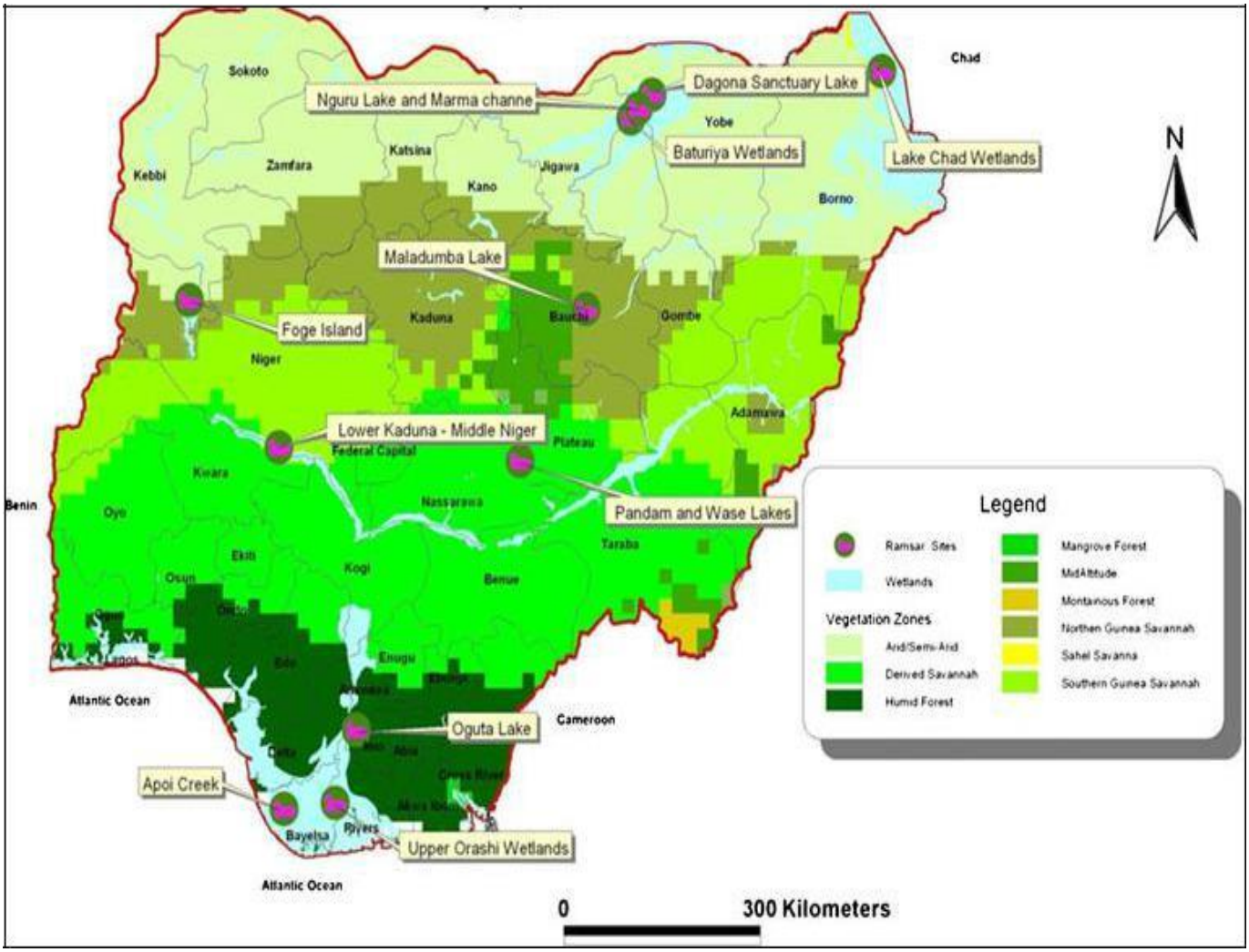

Figure 3. Map of Nigeria showing the Ramsar sites. Source: Adekola et al. (2012).

258 phytoplankton species, 107 phytoplankton genera and 40 fish species. Small scattered populations of the endan-gered Sclater's guenon (*Cercopithecus sclateri*) occur in some relict forests south of the lake. The lake is an important source of municipal and domestic water to the people of Oguta, but is also the recipient of urban sewage. It is also of cultural and spiritual importance to many community members. Fishing and tourism are important socioeconomic activities in this area. Overfishing is stressing the lake and sewage and sedimentation aided by deforestation are seen as threats, mitigated by the fact that the lake is annually flushed by floodwaters through an active outlet. The Oguta Lake Watershed Protection Project involves local communities in revitalizing the lake and promoting sustainability (The Annotated Ramsar List: Nigeria (2010) available online at http://ramsar.org).

Upper Orashi forests

This forest reserve is a freshwater swamp forest in the Central Niger. It is inundated from September to November by floodwaters of the River Orashi, resulting in siltation and soil fertility augmentation. The reserve is the remnant of a small centre of endemism, noted for hosting the critically endangered Sclater's guenon (*Cercopithecus sclateri*) and endangered White-throated guenon (*Cercopithecus erythrogaster*), Red Colobus monkey (*Procolobus badius*) and Heslop's pygmy hippotamus (*Choeropsis liberiensis*).

This site is a roost for the Grey Parrot (*Psittacus erithacas*) and also hosts a significant number of water bird species whose distribution is confined to the Guinea-Congo Forest biome. The forest reserve has an official management plan which is, however, not being implemented, and the reserve

Is recommended for a more articulate management plan and management structure. Opportunities for tourism, education and research are currently hampered by ethnic militancy, insecurity, poaching and uncontrolled logging (The Annotated Ramsar List: Nigeria (2010) available online at http://ramsar.org).

ECOSYSTEM SERVICES OF THE NIGER DELTA WETLANDS

According to Nenibarini (2004), the Niger Delta, based on its extraordinary biodiversity has been declared a key zone for the conservation of the western coast of Africa and a highly diverse ecosystem that supports human life as well as various species of terrestrial and aquatic fauna and flora. Numerous species of plants found within the region are used for medicine and also as raw materials such as gums, starch, ink, wood for fuel, fibres and rubbers for Nigerian industries.

Fisheries Resources of the Niger Delta wetlands

The Niger Delta region is very rich in aquatic resources with high diversity and abundance of over 200 species of fishes (Uluocha and Okeke, 2004; Ebeku, 2004; Nwadiaro, 1984; Fentiman, 1996; NDWC, 1995). It has more species of freshwater fishes (197) than any other coastal ecosystem in West Africa (Powell, 1993). These wetlands provide a cheap and common source of animal protein for most of its inhabitants (Chindah and Osumakpe, 2005; Davies et al., 2009). Previous studies have revealed that about 16 species of the 200 species of fishes found in the Niger Delta have been identified as endemic to the region, while another 29 are near endemic (Moffat and Linden, 1995; Ebeku, 2004; Niger Delta Wetland Centre, NDWC, 1995).

Fish, which remains the main source of protein for over one billion people, is arguably the most important wetland product at a global level, accounting for at least 15% of animal protein for more than two billion people (Wetland Ecosystem Services Fact Sheet 7, www.http://ramsar.org). It is important to note that more than two-thirds of all the fishes consumed are dependent on coastal wetlands such as estuaries and mangroves, which in turn depend on freshwater wetlands upstream to maintain water quality and provide the basis for food chains that culminate in human consumption of seafood. Fish provides vital nutrition as well as employment and source of income for at least 150 million people worldwide (Wetland Ecosystem Services Fact Sheet 7 available at www.http://ramsar.org). Fish contributes more than 60% of the world's supply of protein, especially in developing countries (FAO, 2007). Fish species are more dependent on wetland ecosystems. than any other type of habitat, since all or part of their life-cycle occurs within a wetland system.

The Nigerian inland water fisheries resource has been described as having the richest diversity in West Africa with over 311 species (Powell, 1993; Idodo-Umeh, 2003). Approximately 110,000-130,000 tonnes of fish are harvested annually from inland freshwater fisheries, accounting for about 45% of local fish production in Nigeria (Neiland and Béné, 2003). Furthermore, the Niger Delta also has abundant fresh, brackish and marine water bodies that are inhabited by many species of both fin fish and non-fish fauna that supports artisanal fisheries, and contributes more than 50% of the entire domestic Nigerian fish supply (Akankali and Jamabo, 2011). Previous studies reveal that there are over 199 species in 78 families of fin-fish and shell-fish recorded in the brackish and marine waters (Tobor, 1965; 1968; 1992). The marine fisheries are dominated by small pelagic species which account for over 50% of total fish catch (FAO, 1997).

Several studies have reported that the Niger Delta region has high biodiversity richness (Phil-Eze, 2001; Nigerian Conservation Foundation, 2006; Niger Delta Development Commission NDDC, 2004; Niger Delta environmental survey (NDES), 1997; Federal Ministry of Environment (FMENV), 2004). One of the most important biodiversity resources of the Niger Delta region is its fisheries resources, which is relied upon by the rural people (artisanal fishermen).

Apart from its abundant fisheries and aquatic resources, some major ecosystem services provided by or derived from the Niger Delta wetlands are described in Table 1. Fisheries resources of the Niger Delta can be placed in threegroups;freshwater,marineandaquaculture resources. According to Talabi (2004) "more than 70% of the fish stocks targeted by the industrial fishery are caught in coastal zones of the Niger Delta region" (Figure 4).

The region's brackish water systems (creeks, estuaries and lagoons), occupies a total area of about 4800 km^2 with about 2267 km^2 of estuaries and 937 km^2 of coastal lagoons (Lowenberg and Kunzel, 1991). Some of the common species popularly exploited by artisanal fishermen are *Ethmalosa fimbriata* (Bonga), *Ilisha africana* (West African shad), *Sardinella maderensis* (Flat sardine) and some Carangnids. Tobor (1991) noted that the Bonga fish is the most abundant and the most widely exploited. Records from the Federal Department of Fisheries (FDF, 2000) show that an average of 19, 831 and 11, 332 tonnes of Bonga and flat sardine, respectively, were landed annually between 1999 and 2003 while the Clupeid species also remains abundant, despite its massive exploitation by artisanal fishermen.

Available records show that the three core Niger Delta states (Rivers, Delta and Bayelsa) rank amongst the highest fish producing states from artisanal sources amongst

Table 1. Major ecosystem services provided by or derived from Niger Delta wetlands.

General ecosystem services[a]	Niger Delta ecosystem services[b]
Provisioning	
Food	Fish and other aquatic food such as barnacles, crabs and other invertebrates (Nwadiaro 1984; Fentiman 1996; Davies et al., 2009)
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	Timber products: saw logs, transmission poles, bamboo, building poles, fuel wood and chewing sticks (World Bank 1995; NDDC 2006; Alogoa 2005; McGinley 2008).
Biochemical	Aquatic insects (Arimoro and Ikomi 2009)
Genetic materials	Medicinal species (Ndukwu and Ben-Nwadibia 2005)
Other products	Bush meat (Luiselli 2003; Luiselli *et al*., 2006), other products including raffia, snail, spices, mangrove salts, reeds and sedge (World Bank 1995; UNDP 2006).
Regulating	
Climate regulation	Provides a good sink for greenhouse gases of CO_2 and CH_4 (Brooks *et al*. 2000).
Water regulation (hydrological flows)	Provides buffer against natural disaster including coastal erosion and regulates flood (Cugusi and Piccarozzi 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).
Cultural	
Spiritual and inspirational	Source of spiritual inspiration (Isichei 1982)
Recreational and tourism	Site for fishing festivals (Jonathan 2006)
Aesthetic	Spiritual and sacred sites (Anderson and Peek 2002; Bisina 2006)
Educational	Vast biodiversity (indicative of tourism) (World Bank 1995; Ebeku 2004)
Supporting	
Soil formation	Supports delta's biodiversity (Ejechi 2003)
Nutrient cycling	Soils support nitrogen mineralization (Iwegbue et al. 2006)

[a]Based on MEA (2005). [b]Some Niger Delta wetlands ecosystem services, such as sacred sites, are little known and subject to ongoing research.Based on Adekola and Mitchell (2011).

the listed eight maritime states in the country. These statistics show that the fisheries resources of the Niger Delta are very important in terms of sustainability of the Nigerian fisheries, especially in the artisanal sub sector. Furthermore, shrimps are the most valued shell-fish/crustacean resources abundant in the region. These shell-fish/crustacean resources are found around the mouths of the rivers and lagoons feeding on rich organic matter sediments. Species include the brackish water prawn (*Macrobrachium vollenhonenii*), White shrimp (*Nematopalaecom hastaus*), and the pink shrimp (*Panaeus notialis*) (Dublin-Green and Tobor, 1992; Ajayi and Talabi, 1984). Approximately 81% of the white shrimp, an estuarine species, represented shrimp landings (Enin *et al*., 1996).

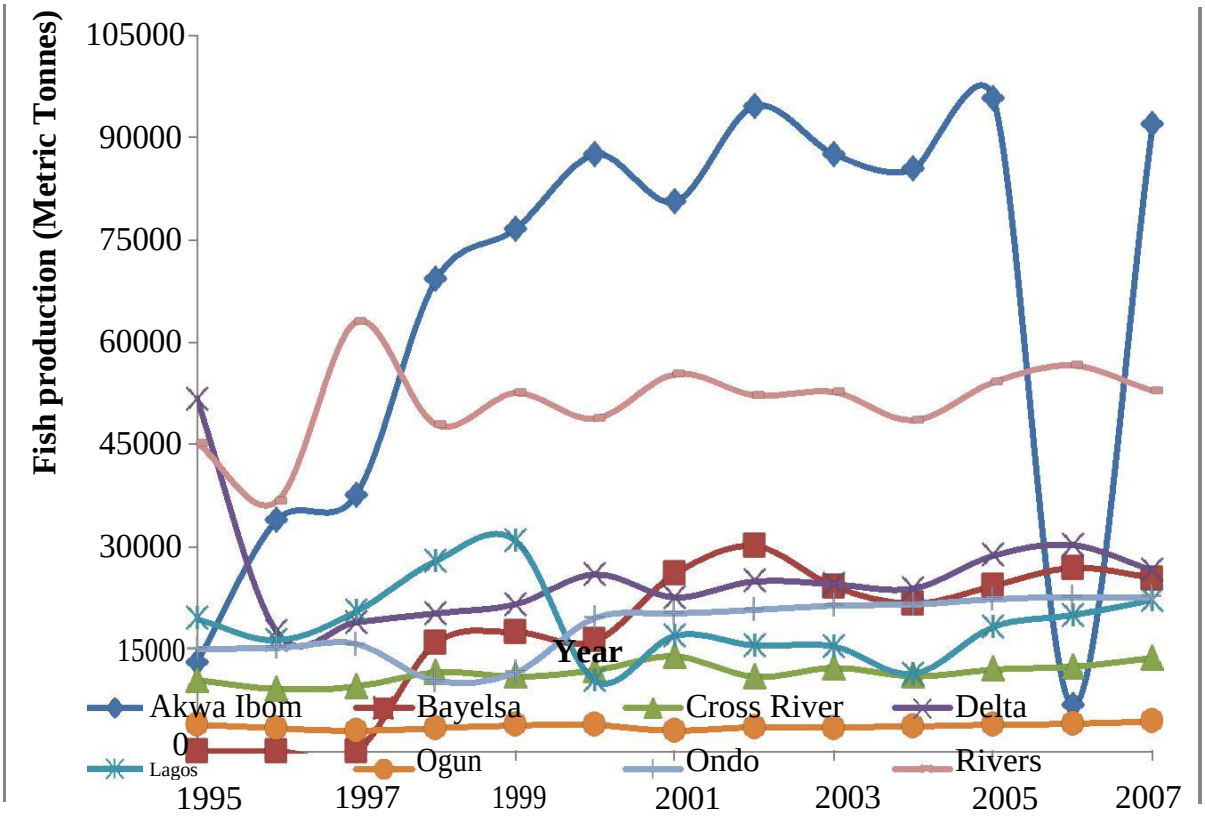

Figure 4. Nigeria Fish Production (Artisanal) from Maritime States (Metric Tons). Based on data from Akankali and Jamabo (2012).

Studies by Agbeja and Falaye (2007) reveals that average landing of shrimps per vessel was 44,028.. Their study of an estimation of maximum sustainable yield (MSY) revealed that MSY was at 12,191 kg per annum per vessel and the corresponding effort was 89 vessels.

The aquatic biodiversity of the Niger delta supports viable commercial fishery, employment and income to rural community dwellers (Davies et al., 2009). Some of the popular species found are the tilapia, barracuda, catfish, shellfish, denticle, herring, finfish, croakers, and hinge mouth (Oribhabor and Ansa, 2006; Eboh *et al*., 2006; Ekeke et al., 2008). Arimoro and Ikomi (2009) identified about 57 taxa of aquatic insects, some of which are edible and act as water quality bioindicators of Niger Delta. Others include diverse edible aquatic organisms such as crabs, barnacles and periwinkles (World Bank, 1995).

Apart from its rich diverse and abundant fisheries and aquatic resources, the Niger Delta region presents an important ecosystem that provides diverse food and cash crops, thus ensuring food security (Umoh, 2008). Some of the important food and cash crops include rice, plantain, raffia palm, cocoa, mango, yam and potatoes, which are cultivated on the rich soil resource in the wetland. Similar to other wetlands in providing significant regulating services, the Niger delta replenishes and sustains groundwater, provides flood control, regulates surface water quality and volume and is also responsible for regulating the movement of essential water and sediments in the region (Uluocha and Okeke, 2004; Abam, 2001; Oladipo, 1995). Available data abound which shows that the Niger Delta region of Nigeria is richly endowed with both renewable and non-renewable natural resources, important among which is crude oil, which dominates the Nigerian economy (NDES, 1997). The Delta is described as the most extensive and complex lowland forest and aquatic ecosystem in West Africa whose biodiversity is of national and international importance (IUCN, 1992).

OIL POLLUTION THREATS FACED BY THE NIGER DELTA WETLANDS

Nigeria has recorded oil spill incidents at different times along its coastline. Available literature reveals that oil

spillage routinely occurs in the Niger Delta region, despite its fragile ecosystem and biodiversity. According to Dublin -Green et al. (1998) about 5,334 reported cases of crude oil spillage occurred between 1976 and 1997, with an estimated 2.8 million barrels of oil released into estuaries, inland and coastal waters, land and swamps of Nigeria.

The associated impacts of oil spills in mangrove vegetation and coastal waters cannot be overemphasized. Generally, oil spills in Nigeria are not reported, as they are considered “minor” spills. Major spills recorded in the coastal zone are the Texaco Funiwa-5 blowout in 1980 of about 400,000 barrels, GOCON’s Escravos spill in 1978 of about 300,000 barrels and SPDC’s Forcados Terminal tank failure in 1978 of about 580,000 barrels. Others are those of the Jesse Fire Incident with a loss of about 1,000 people and the Idoho Oil Spill in January 1998, of about 40,000 barrels and the Abudu pipe line in 1982 of about 18,818 barrels. Nigeria's largest spill was an offshore well-blow out in January 1980 when an estimated 200,000 barrels of oil (8.4million US gallons) spilled into the Atlantic Ocean from an oil industry facility, damaging 340 ha of mangrove (Nwilo and Badejo, 2005). Annon (2006) described Nigeria’s Niger Delta as one of the world’s most severely impacted ecosystem by petroleum, with an estimate of 9 to 13 million barrels of oil spilled in the Niger Delta ecosystem in the past 53 years, 50 times the volume spilled in the Exxon Valdez Oil Spill in Alaska in 1989 (Leschine et al., 1993; Weiner et al., 1997). Others include the Okoma pipeline spillage in 1985, the Bomu 11 blowout in 1970, the Oyakana pipeline spillage of 1980 and the Oshaka pipeline of 1993, among others.

Between 1976 and 1996 a total of 4,647 incidents resulted in the spill of approximately 2,369,470 barrels of oil into the environment. An estimated 1,820,410.5 barrels (77%) of this quantity was lost to the environment. About 549,060 barrels of oil, representing 23.17% of the total oil spilt into the environment, was recovered. The heaviest recorded spill so far occurred in 1979 and 1980 with a net volume of 694,117 barrels and 600,511 barrels, respect-tively (Department of Petroleum Resources (DPR 1991).

Oil spills pose one of the greatest environmental challenges globally, constituting harmful effects on both human health and aquatic organisms. Fishing resources can be damaged through physical contamination, bio-accumulation, and damaging of spawning grounds, as well as habitat destruction, depending on the circumstances of the spill and time of response. Many coastal communities are affected.

A summary of major pollutants released from oil industries into the environment has been highlighted by Ukoli (2005) as follows:

i) Pollutants from petroleum refining activities which includes: Phenol, suspended solids, oil and grease, hydro-carbons and total suspended solids, cyanide and sulphide,

ii) Oil exploration and oil production activities causing changes to the physical and chemical properties of the wetlands such as changes in temperature, turbidity, drilling muds, biological oxygen demand, heavy metals, salinity and pH.

THE NEED TO PROTECT WETLANDS

The Ramsar convention on wetlands was established at the international level to protect wetlands (Frazier, 1999). Public attitudes towards wetlands are changing rapidly, with laws set out to protect them. For example, the United States has a National Policy on net loss of wetlands; projects that eliminate one must replace it with another area of similar wetland. The law also states that higher priority be given to avoid wetland loss (before compensa-tion) (NRC 2001). Therefore, wetlands and estuaries are receiving more attention and protection from the public following many years of degradation arising from eutrophic-cation, dredge and fill operations, subsidence/erosion, urban development toxic pollutants, and impoundments (Morris et al., 2002). The need to protect wetlands cannot be overemphasized, based on these following important reasons.

i) Wetlands are among the most fertile, productive ecosystems in the world, rivalling the likes of tropical rainforests and coral reefs (www.ramsar.org).

ii) Two thirds of all fish consumed worldwide are dependent on coastal wetlands at some stage in their life cycle (www.ramsar.org).

iii) Annual fish and seafood production in swamps and marshes worldwide has been estimated at an average of nine tons per km^2, 259 ha or 640 acres) (www.ramsar.org).

Recommendations

Industries, including agriculture, should improve their best management practices to reduce the effects of non-point source pollution on wetlands and the surrounding environments. International organizations, such as IUCN and UNEP, oil companies, the federal ministry of environment, Nigeria Oil Spill Detection and Response Agency (NOSDRA) and NESREA should put strict regulatory policies and sanctions on pollution. Acts and legislations should be put in place by appropriate national environmental bodies. Villagers should report as early as possible any case of oil spill. Quality control of pesticides and chemicals used for agricultural purposes should be carried out. Preventing oil pollution through adequate monitoring of oil pipelines and oil wells, as well as illegal discharge of toxic wastes and crude oil into water bodies can be effectively achieved by employing GIS and remote sensing techniques.

CONCLUSION

This paper has reviewed the importance of the Niger delta coastal wetlands in terms of its fisheries biodiversity, as well as its economic, social and cultural services, and the need to conserve the region from anthropogenic activities arising from oil activities which leads to biodiversity loss. Statistics show that fisheries production from the Niger delta states has declined over the years.

It is recommended that international bodies, oil companies as well as the federal government should put in place strict policies to mitigate wetland pollution and degradation. Also recommended is the adoption of the use of appropriate tools, such as GIS and remote sensing, to ensure adequate monitoring of the Niger Delta coastal wetlands, considering its importance to the Nigerian natural resource and fisheries sectors.

Conflict of interest

The authors did not declare any conflict of interest.

REFERENCES

Abam TKS (2001). Regional hydrological research perspectives in the Niger Delta. Hydrol Sci. 46:13–25.

Abam TKS, Okogbue CO (1993). Utilization of marginal lands for construction in the Niger Delta. Bull. of the Int. Association of Engr. Geology 48: pp. 5-14

Abu GO, Dike PO (2008). A study of natural attenuation processes involved in a microcosm model of a crude oil-impacted wetland sediment in the Niger Delta. Biores Technol. 99: 4761–4767.

Adekola O, Mitchell G (2011) .The Niger Delta wetlands: threats to ecosystem services, Their importance to dependent communities and possible management measures, Intl J. Biodiversity Science, Ecosystem Services & Management, 7:1, 50-68.

Adekola O, Morardet S, De-Groot RS, Grelot F (2012). Economic value of provisioning services and livelihood dependence on the Ga-Mampe wetland, South Africa. 13th IWRA World Water Congress.

Agardy T, Alder J (2005). Coastal Systems. In Millennium Ecosystem Assessment. Vol. 1,

Ecosystems and Human Wellbeing: Current State and Trends. Findings of the Conditions and Trends Working Group.Washington, D.C: Island Press

Aigbedion I, Iyayi SE Agbeboh GU (2007). Prospect Assessment and Risk Analysis: Example from Niger Delta, Nigeria Basin, World Applied Science Journal, 2(6):569-574.

Ajonina G, Diamé A, Kairo J (2008). Current status and conservation of mangroves in Africa: an overview. World Rainforest Mov Bull [Internet]. [cited 2014 March 13]; 133. Available from: http: // wrmbulletin.wordpress.com/2008/08/25/current-status-and-conservation-of-mangroves-in-africa-an-overview.

Akankali JA, Jamabo NA (2012) Effects of Flooding and Erosion on Fisheries Resources in Niger Delta, Nigeria European Journal of Scientific Research ISSN 1450-216X Vol. 90 No 1 November, , pp.14-25© EuroJournals Publishing, Inc.

Alogoa AJ (2005). A history of the Niger Delta: an historical interpretation of Ijo oral tradition. Port Harcourt (Nigeria): Onyoma Research Publications.

Anderson MG, Peek PM (2002). Ways of the rivers: arts and environment of the Niger Delta. 1st ed. Los Angeles (CA): University of California Los Angeles, Fowler.

Annon (2006). Niger Delta *Natural Resource Damage Assessment and Restoration* Project. Phase 1– Scoping Report. Federal Ministry of Environment, Abuja Nigeria Conservation Foundation,Lagos.

Arimoro FO, Ikomi RB (2009). Ecological integrity of upper Warri River, Niger Delta using aquatic insects as bioindicators. Ecol Indic. 9:455–461.

Agbeja YE, Falaye AE (2007). Economic Analysis of Industrial Shrimp Fishery in Nigeria. J Fis Intl, 2: 171-177.

Asibor G (2009). Wetlands: values, uses and challenges. A Paper presented to the Nigerian Environmental Society at the Petroleum Training Institute, Effurun, 21stNovember, 2009.

Barbier EB, Acreman M, Knowler D (1997). Economic Valuation of Wetlands, A Guide for Policy Makers and Planners Ramsar Convention Bureau, Gland, Switzerland.

Bisina J (2006). Environmental degradation in the Niger Delta. Port Harcourt (Nigeria): Niger Delta Environmental Roundtable Hotel Presidential Port Harcourt.

Benka-Coker MO, Ekundayo JA (1995). Effects of an oil spill on soil physico-chemical properties of a spill site in the Niger Delta area of Nigeria. Environ Monit Assess. 36:93–104.

Brook BW, O'Grady JJ, Chapman, AP, Burgman MA, Akçakaya H R, Frankham R (2000). Predictive accuracy of population viability analysis in conservation biology. Nature 404:385-387.

Chindah AC, Osuamkpe A (2008). The fish assemblage of the lower Bonny River, Niger Delta, Nigeria. Afr J Ecol. 32:58–65.

Chinweze C, Abiola G, Onyeri I, Echetebu CK, Jideani C (2012) Oil And Gas Activities And The Nigerian Environment 'IAIA12 Conference Proceedings 'Energy Future The Role of Impact Assessment 32nd Annual Meeting of the International Association for Impact Assessment 27 May -1 June 2012, Centro de Congresso da Alfândega, Porto Portugal (www.iaia.org).

Cugusi B, Piccarozzi M (2009). Environmental change and human mobility. A thematic literature and organisational review. Paper presented at: International Conference: Towards the G8 Summit Climate Change and Human Mobility in Africa Dialogue for a Strategic Cooperation Between Italy and Africa; 2009 Apr 21; Rome, Italy

Davies RM, Davies OA, Abowei JFN (2009). The status of fish storage technologies in Niger Delta Nigeria. Am J Sci Res.1:55–63.

Department of Petroleum Resources (DPR) (1991). Environmental Guidelines and Standards for the Petroleum Industry, DPR, Lagos.

Dublin-Green, CO, Nwankwo, JN, Irechukwu, DO (1998). Effective regulation and management of the issues in the petroleum industry in Nigeria. Paper presented at: SPE International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production; 1998 Jun 7–10; Caracas, Venezuela.

Dugan PJ (ed) 1990. Wetland conservation: A review of current issues and required action IUCN, Gland, Switzerland.

Dugan P, Dey MM, Sugunan VV (2006). Fisheries and water productivity in tropical river basins: enhancing food security and livelihoods by managing water for fish. Agric Water Manage.80:262-275.

Dupont LM, Jahns S, Marret F, Ning S (2000). Vegetation change in equatorial West Africa: time-slices for the last 150 ka. Palaeogeogr Palaeoclimatol Palaeoecol. 155:95–122.

Economic Valuation of Wetlands: A Guide for Policy Makers and Planners. www.ramsar.org

Ebeku KSA (2004). Biodiversity conservation in Nigeria: an appraisal of the legal regime in relation to the Niger Delta area of the country. J Environ Law. 16:361–375.

Eboh L, Mepba HD, EkpoMB (2006). Heavy metal contaminants and processing effects on the composition, storage stability and fatty acid profiles of five common commercially available fish species in Oron Local Government, Nigeria. Food Chem. 51:115–118

Egbagbe E (2009). Investment opportunities in the Niger Delta Region – infrastructure. Paper presented at: Regenerating the Niger Delta forum. Challenges and opportunities; 2009 Jul 7; London, UK.

Ejechi BO (2003). Microbial deterioration of partially submerged service

timbers in a tropical inter-tidal zone. *Int Biodeterior* Biodegradation.97:490–497.
Ekeke BA, Davies OA, Alfred-Ockiya JF (2008). Sand dredging impact on fish catch in Bonny River Estuary, Nigeria. Environ Res J. 2:299–305.
Ekundayo EO, Fodeke VO (2000). Microbial densities and physico-chemical qualities of some crude oil flow stations saver pit effluents in the Niger Delta Basin of Southern Nigeria Environmental Monitoring and Assessment. 65(3): 523 – 530.
Environmental Resources Management Ltd. (1997), Environmental and Socioeconomic Characteristics of the Niger Delta. ERML, Lagos.
Etuonovbe AK (2007). Coastal Settlement and Climate Changes The Effects of Climatic Change / Sea Level Rise on the People of Awoye in Ondo State Nigeria. A paper presented at the FIG working week 2007, in Hong Kong.
Fentiman A (1996). The anthropology of oil: the impact of the oil industry on a fishing community in the Niger Delta. Soc Justice. Winter: 23.

Fingas M (2001). The basics of oil spill cleanup. Lewis Publishers.
Finlayson CM, Davidson NC. (1999). Global Review of Wetland Resources and Priorities for Wetland Inventory. Ramsar Bureau Contract 56. Gland (Switzerland): Ramsar Convention Bureau.
Food and Agriculture Organisation of the United Nations (FAO) (1997). Review of the State of the World Fishery Resource: Marine Resource. FAO Fisheries Circular No. 920 Firm/C920, Rome , 173pp
Frazier S (1999). Ramsar Sites Overview: A Synopsis of the World's Wetlands of International Importance. Wageningen (Netherlands): Wetlands International. (27 October 2008; www.wetlands.org/RSIS/Publications/enovervw.pdf).
GESAMP (IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP) Joint Group of Experts on the Scientific Aspects of Marine Pollution) (1993). Impact of Oil and Related Chemicals and Wastes on the Marine Environment. Rep. Stud. GESAMP (50): 180pp.
Hutchful E (1985). Oil Companies and environmental pollution in Nigeria.In Political Economy of Nigeria, ed. In Claude Ake, pp.113–140.London and Lagos: Longman.
Idodo-Umeh G (2003). Freshwater Fishes of Nigeria (Taxonomy,Ecological Notes, Diets and Utlization*)*. Idodo-Umeh Publ. Ltd., Benin-City, Nigeria, 232pp.
Ikelegbe A (2006). The economy of conflict in the oil rich Niger Delta region of Nigeria. Afr Asian Stud. 5:23–56
Isirimah NO (2000) Soils and Environmental Pollution Management, Nichdano Publishers, Owerri.
Isichei E (1982). Varieties of Christian experience in Nigeria. London (UK): Macmillan Press.
Iwegbue CMA, Ekakitie AO, Egun AC (2006). Mineralization of nitrogen in wetlands soils of the Niger Delta amended with water hyacinth (Eichhornia sp.). Waste Int J Soil Sci. 1:258–263.
James GK, Adegoke JO, Saba E, Nwilo P, Akinyede J. (2007). Satellite-based assessment of the extent and changes in the mangrove ecosystem of the Niger Delta. Mar Geod. 30:249–267.
Jonathan G. (2006). Bayelsa State Nigeria: background infor- mation [Internet]. Bayelsa (Nigeria): Bayelsa Council for Arts and Culture.
Leschine TM, McGee J, Gaunt R (1993). Federal on-scene Coordinator's report T/V Exxon Valdez Oil Spill, vol. I. Department of Transportation, Springfield, Virginia.
Lowernbeg U, Kunzel T (1991). Investigation on the trawl fishery of the Cross River Estuary, Nigeria. J. Appl. Ichthyol., 7:44-53.
Luiselli L (2003). Comparative abundance and population structure of sympatric Afrotropical tortoises in six rainforest areas: the differential effects of "traditional veneration" and of "sub- sistence hunting" by local people. Acta Oecol. 24:157–163.
Luiselli L, Politano E, Lea J (2006). Assessment of the vulnerable status of Kinixys homeana (Testudines: Testudinidae) for the IUCN Red List. Chelonian Conserv Biol. 5:130-138.
International Union for Conservation of Nature (IUCN) (1992). Coastal and marine, biodiversity report for UNEP: Identification establishment and management of specially protected areas in the WACAF region, Gland, Switzerland.
Iyayi F (2004). An integrated approach to development in the Niger Delta. A paper prepared for the Centre for Democracy and Development (CDD)
Li J (2002) Spill Management for the Toronto AOC: The City of Toronto Study. Report and factsheet prepared for the Great Lakes Sustainability Fund, Burlington, Ontario, Canada.
Matthews GVT (1993). The Ramsar Convention on Wetlands: its history and development. In: Luthi E, Ramsar, editors. Gland (Switzerland): Ramsar Convention Bureau.
McGinley M (2008). Niger Delta swamp forests. In: Cleveland CJ, editor. Encyclopedia of earth. Washington (DC): Environmental Information Coalition, National Council for Science and the Environment.
McGinley M, Duffy JE (2007). Species diversity. In Encyclo- pedia of Earth, ed. Cutler J Cleveland. Washington DC: Environmental Information Coalition, National Council for Sci- ence and the Environment
Millenium Ecosystem Assesment (2005).Ecosystems and Human Well-Being:Wetlands and Water Synthesis. World Recourses Institute,Washington,DC.
Mitsch WJ, Gosselink JG (2007). Wetlands. 4th ed. Hoboken (NJ): Wiley
Mmom PC (2003). The Niger Delta: A spatial Perspective to its Development. Port Harcourt. Zelon Enterprises.
Moffat D, Linden O (1995). Perception and reality: assessing priorities for sustainable development in the Niger River Delta. Ambio. 24:527–538.
Moser M, Prentice C, Frazier S (1996). A global Overview of wetland loss and degradation. In proceedings of the sixth meeting of the conference of contracting parties of the Ramsar Convention. Vol.10 March 19-27,Brisbane, Austarlia. Gland, Switzerland : Ramsar Convention Bureau.
National Population Commission. (2006). 2006 population and housing census of the federal republic of Nigeria 2006 census: priority tables. Abuja (Nigeria): National Population Commission.
National Research Council. (NRC)2001. Compensating for Wetland Losses under the Clean Water Act. National Academy Press.
Niger Delta Development Commission (NDDC). Nigerian Conservation Foundation. 2006. Niger Delta named most polluted ecosystem [Internet]. Lagos (Nigeria): Nigerian Conservation Foundation.
Niger Delta Environmental Survey (NDES) (1997). Environmental and Socio-economic Characteristics , second phase of field re-port, Vol. 1, 10 July 1997. Environmental Resource Manager Limited. Nigeria Country Analysis Brief 2005. Report published by the Energy Information Administration (EIA), USA Government Department of Energy, April 2005.
NDWC, Niger Delta Wetland Centre (1995). Biodiversity management of the Niger Delta region, a field report, 5 June 1995.
Ndukwu BC, Ben-Nwadibia NB (2005). Ethnomedicinal aspects of plants used as spices and condiments in the Niger Delta area of Nigeria. Ethnobot Leafl Int Web J [Internet]. [cited 2014 March 15]. Available from: http://www.ethnoleaflets.com/leaflets/niger.htm.
Neiland AE, Béné C (2003). Review of river fisheries valuation in West and Central Africa. *Water, Ecosystem and Fisheries Review Workshop, Organised by the World Fish Centre, Phnom Penh*, 15-17 Feb., 65pp.
Nenibarini Z (2004). Impacts of Extractive Industries on the Biodiversity of the Niger Delta. National Workshop on Coastal and Marine Biodiversity Management. NNPC, Nigerian National Petroleum Coperation, Monthly Petroleum Information. September, Lagos, Nigeria, 1984:53
Nigerian Conservation Foundation, WWF UK and International Union for Conservation of Nature (IUCN), Commission on Environmental, Economic and Social Policy, with Federal Ministry of Environment (Abuja), "Niger Delta Natural Resources Damage Assessment and Restoration Project Scoping Report", May 2006
Nigerian Population Commission (NPC) (2006). Report of National Census of 2006

Ntukekpo DS (1996). Spillage: Bane of Petroleum. Report published in

Ultimate Water Technology & Environment.
Nwadiaro C (1984). The longitudinal distribution of macroinvertebrates and fish in a lower Niger Delta river (River Sombreiro) in Nigeria. Aquat Ecol. 18:133–140.
Nwilo PC, Badejo OT (2005). Oil spill problems and management in the Niger Delta. Paper presented at International Oil Spill Conference, Miami, Florida, USA, May 2005. Oil and Gas Journal 2005. Oil and gas reserves in the Niger Delta of Nigeria. Oil and Gas Journal, 103 (41), November, 67–75.
Nwilo PC, Badejo OT (2004) Management of Oil Spill Dispersal Along the Nigerian Coastal Areas, Department of Surveying and Geoinformatics, University of Lagos.
Odiete WO (1999): Environ Phy animal pollollution. Inno Obonna and Associates, Lagos, 261 p.
Ogbe MO (2005). Biological resource conservation: a major tool for poverty reduction in Delta State. A key note address delivered at the Delta State maiden Council meeting on Environment with all stakeholders held at Nelrose Hotel, Delta State, Nigeria between 28th and 29th September, 2005, 16p.
Ogon EK (2006) Natural resource abundance in Nigeria: from dependence to development. *Resources Policy*, 33, 168-174.
Ogon P (2006). Land and forest resource use in the Niger Delta: issues in regulation and sustainable management. Berkeley (CA): Green Governance Project, Institute of International Studies, UC.
Ohimain EI,. Imoobe TOT, Bawo DDS (2008). Changes in water physico-chemical properties following the dredging of an oil well access canal in the Niger Delta. World J. Agric. Sc., 4: 752-758.
Oladipo EO (1995). An indication of abrupt change of rainfall and it potential impact on energy development in Nigeria. In: Umolu JC, editor. Global climate change: impact on energy development. Lagos (Nigeria): DAMTECH Nigeria Limited .p. 30–42
Olomukoro JO (2005). Environmental pollution and its implication in Nigeria. A paper presented at the Delta State maiden council meeting on Environment with all stakeholders held at Nelrose Hotel, Delta State, Nigeria Between 28th and 29th September, 2005, 23p.
Omofonmwan SI, Odia LO (2009). Oil exploitation and conflict in the Niger-Delta region of Nigeria. J Hum Ecol. 26:25–30.
Onuoha F (2007) Poverty, pipeline vandalisation/explosion and human security: Integrating disaster management into poverty reduction in Nigeria African Security Review 16.2: 95-108.
Oribhabor BJ, Ansa EJ (2006). Organic waste reclamation, recycling and re-use in integrated fish farming in the Niger Delta.J Appl Sci Environ Manage. 10:47–53
Oyebande L, Obot, EO, Bdiliya HH, Oshunsanya CO (2003): An Inventory Of Wetlands in Nigeria. World Conservation Union – IUCN, West African Regional Office Ouagadougou, Burkina Faso.
Petroconsultants (1996). Petroleum exploration and production database: Houston, Texas, Petroconsultants, Inc., [database available from Petroconsultants, Inc., P.O. Box 740619, Houston, TX 77274-0619].

Phil-Eze PO, Okoro IC (2009). Sustainable biodiversity conservation in the Niger Delta: a practical approach to conservation site selection. Biodivers Conserv. 18:1247–1257
Powell C B (1993). Sites and species of conservation interest in the Central Axis of the Niger Delta (Section C), report submitted to the Natural Resources Conservation Council of Nigeria, Biodiversity Unit, Rivers State University of Science and Technology, Port Harcourt, Nigeria.
Ramsar Convention Secretariat (RCS) (2007) Wise use of wetlands: a conceptual framework for the wise use of wetlands Ramsar handbooks for the wise use of wetlands. 3rd edn. Ramsar Convention Secretariat Gland, Switzerland.
Rim-Rukeh A, Koyeme J, Ikhifa GO Okokoyo PA (2006). Chemistry of harvested
rainwater in the refinery area of Warri, Nigeria between November, 2003 and October, 2005.
Int. J. Chem. 16 (2): 65-74. Robinson, D (1996). Ogoni: The Struggle Continues. Geneva: World Council of Churches.
Rebelo LM, McCartney M, Finlayson C. (2009). Wetlands of Sub-Saharan Africa: distribution and contribution of agricultureto livelihoods. Wetlands Ecol Manage. 18:557–572.
Salau DA (1993). Environmental Crisis and Development in Nigeria, No 13, University of Port Harcourt Inaugural Lecture series.
Silvius MJ, Oneka M, Verhagen A. (2000). Wetlands: lifeline for people at the edge. Phys Chem Earth B Hydrol Oceans Atmos. 25:645–652.
Spalding M, F. Blasco C. Field, 1997. World Mangrove Atlas. The International Society for Mangrove Ecosystems, Okinawa, Japan . 178 pp
Tobor JG (1997). The Fish Industry in Nigeria: Status and Potential for Self Sufficiency in Fish Production. Nigeria Institute of Maritime NIOMR Technical Paper, 54: 34
The Annotated Ramsar List: Nigeria (2010) available online at http://ramsar.org).
Turner RK, van den Bergh JCJM, Söderqvist T, BarendregtA, van der Straaten J, Maltby E, van Ierland EC. 2000 Ecological-economic analysis of wetlands: scientific integration for management and policy. Ecol Econ. 35:7-23
Ukoli MK (2005). Environmental Factors in the Management of the Oil and Gas Industry in Nigeria. Retrieved from www.cenbank.org.
Uluocha N, Okeke I (2004) Implications of wetlands degradation for water resources management: lessons from Nigeria. Geo. J 61:151.
Umoh SG (2008). The promise of wetland farming; evidence from Nigeria. Agric J. 3:107–112.
United Nations Development Programme (UNDP). (2006). Niger Delta human development report. Lagos (Nigeria): United Nations Development Programme.
United Nations Environmental Programme (UNEP) (2007). The status of the Nigerian Coastal Zones. Retrieved online from www.unep.org/abdjanconvention/docs. on march 3rd, 2014.
Uzoka O (2002). Chairman, House Committee on Solid Minerals, National Assembly, Nigeria, Interview with Thisday Newspapers.
Weiner A, Berg C, Gerlach T, Grunblatt J, Holbrook K, Kuwanda M (1997). “The Exxon *Valdez* Oil Spill, vol. I. Department of Transportation, Springfield, Virginia. Valdez Oil Spill: Habitat Protection as a Restoration Strategy”. Rest Ecol 5(1): 44-55.
Were JLR (2001) Cross-Niger transition forests (AT0106). Report to the World Wildlife Fund (WWF).
Wolf CP, Emerh I EA, Okosi PH (2002). Community impact assessment of lower Niger River dredging. In: Comparing Rivers: the Mississippi and the Niger – the Fifth Randall L Gibson Tulane University – US Army Corps of Engineers Conference on the Mississippi River French Quarter of New Orleans (LA). New Orleans (LA): Tulane University.
World Bank (2005). The Niger River Basin: A Vision for Sustainable Management. The World Geodetic System (WGS) (1984).
World Bank. (1995). Defining an environmental strategy for the Niger Delta. Nigeria: World Bank Industry and Energy Operations Division, West Central Africa Department.