WETLANDS; A REVIEW OF THEIR CLASSIFICATION, SIGNIFICANCE AND MANAGEMENT FOR SUSTAINABLE DEVELOPMENT

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Abstract

A wetland is a distinct ecosystem that is inundated by water, either permanently or seasonally, where oxygen-free processes prevail. Wetlands are very important and valuable components of the ecosystem. They serve as habitat for man and animal, source of food, shelter and other ecosystem services which provide many societal benefits: water quality improvement; flood storage; shoreline erosion control; economically beneficial natural products for human use; and opportunities for recreation, education, and research. There are different wetlands in the world and Nigeria owns one of the internationally recognized wetlands in the world, the first wetland recorded as a Ramsar site. The main wetland types are swamp, marsh, bog, fen; sub-type includes mangrove forest, carr, pocosin, floodplains, mire, vernal pool, sink, and many others. There are different challenges facing wetlands globally, some of which are pollution, excessive agricultural activities, industrialization and urbanization. Some of the challenges in wetlands are due to the lack of monitoring and sustainability measures.

Keywords: Wetlands, Water Management, Habitat, Floodplains, Mangrove and Pollution.

1.0 Introduction

A wetland is a distinct ecosystem that is inundated by water, either permanently or seasonally, where oxygen-free processes prevail (Keddy, 2010). The primary factor that distinguishes wetlands from other land forms or water bodies is the characteristic vegetation of aquatic plants, adapted to the unique hydric soil (Butler, 2010). Wetlands play a number of roles, sometimes referred to as functions. Among these are water purification, water storage, processing of carbon and other nutrients, stabilization of shorelines, and support of plants and animals.

Under the Ramsar international wetland conservation treaty (Ramsar, 2011), wetlands are defined as follows:

Article 1.1: "...wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres."

Article 2.1: "Wetlands may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands."

Wetlands are also considered the most biologically diverse of all ecosystems, serving as home to a wide range of plant and animal life. Whether any individual wetland performs these functions, and the degree to which it performs them, depends on characteristics of that wetland and the lands and waters near it. Methods (tools) for rapidly assessing these functions, wetland ecological health, and general wetland condition have been developed in many regions and have contributed to wetland conservation partly by raising public awareness of the functions and the ecosystem services some wetlands provide.

1.1 Wetlands of Nigeria

Table 1: Wetlands in Nigeria

Freshwater Wetlands	Coastal Saline Wetlands
Imo River	Cross River estuary
Lake Chad	Imo River
Ogun-Osun River	Qua Iboec River estuary
Niger delta	Niger River
Cross River	
Benue River	

List of wetlands belts by regions, in Nigeria ranging from the North to the Southern part of the country:

i. Sokoto-Rima
ii. Komadugu Yobe

iii. Lake Chad
iv. Upper Niger Lake
v. Kainji Lake,
vi. Middle Niger (Lokoja wetlands, Jebba wetlands, Lower Kaduna wetlands, Lower Benue (Makurdi Wetlands), trans boundary wetlands of the Upper Benue and the Cross River.
vii. Others are the Lower Niger, Niger Delta, Benin (Owena River and the Okomu River), Lower Ogun River, Yewa Creeks, Badagry Creeks, Ologe Lagoon Lekki Peninsula and the Lagos Lagoon (Figure 1)

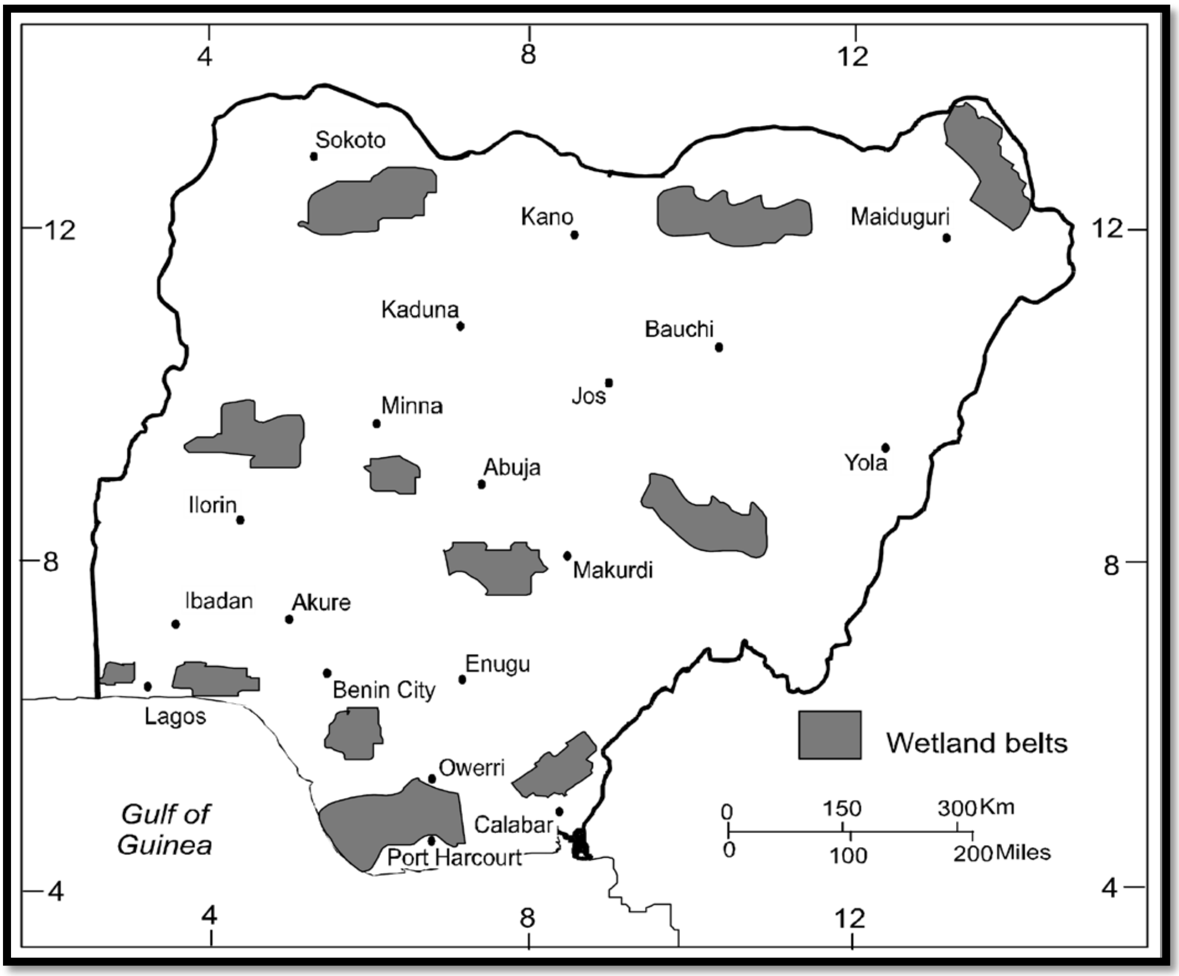

Figure 1: Representation of the Nigerian wetlands belts region (Uluocha and Okeke, 2004; Nwankwoala, 2012).

1.1.1Wetland species resources of Nigeria

The value and resources of the Nigeria freshwater wetlands could produce about 510,000 tonnes of fish, the wetland resources for vertebrates worth over 14 reptile species, 7 mammal species, 5 amphibian species, about 72 birds species and over 200 species of fish (Olalekan et al., 2014). Some of these species especially the birds are endemic to Nigeria while some are non-endemic; in the food chain many of the birds and mammals are categorized as piscivorous. The mammals enjoy swimming in the wetlands; some examples include the otter, marsh, civets, mongoose and the genets (Olalekan et al., 2014). The Nigeria wetland resource is endowed with two species of hippopotamus, namely the *Choeropsis liberiensi* and the *Hippopotamus amphibious* found around the rivers of the savanna and River Niger of the forest zone. The manatee species, *Trichechus senegalensis* is also a local breed found in the wetland, especially in the delta and coastal wetlands area in the eastern part of the country (Olalekan et al., 2014). The reptiles found in the Nigeria wetlands also include the *Varanus niloticus* (Nile monitor), *Crocodylus niloticus* (Nile crocodile), *C. cataphractus* (long snouted) and the *Osteolaemus tetraspis* (West African dwarf crocodile) (Olalekan et al., 2014).

2.0 Classification of Wetlands

Wetlands occur naturally on every continent (Davidson, 2014). The main wetland types are swamp, marsh, bog, fen; sub-type includes mangrove forest, carr, pocosin, floodplains, mire, vernal pool, sink, and many others. Many peatlands are wetlands.

The water in wetlands is either freshwater, brackish, or saltwater. Wetlands can be tidal (inundated by tides) or non-tidal (USEPA, 2015). The largest wetlands include the Amazon River basin, the West Siberian Plain (Fraser and Keddy, 2005), the Pantanal in South America, and the Sundarbans in the Ganges-Brahmaputra delta (Giri et al., 2007).

The following list is that used within Australia (Australian Department of the Environment, 2009) to classify wetland by type:

A- Marine and Coastal Zone wetlands

i. Marine waters—permanent shallow waters less than six metres deep at low tide; includes sea bays, straits
ii. Subtidal aquatic beds; includes kelp beds, seagrasses, tropical marine meadows
iii. Coral reefs
iv. Rocky marine shores; includes rocky offshore islands, sea cliffs
v. Sand, shingle or pebble beaches; includes sand bars, spits, sandy islets
vi. Intertidal mud, sand or salt flats
vii. Intertidal marshes; includes saltmarshes, salt meadows, saltings, raised salt marshes, tidal brackish and freshwater marshes
viii. Intertidal forested wetlands; includes mangrove swamps, nipa swamps, tidal freshwater swamp forests
ix. Brackish to saline lagoons and marshes with one or more relatively narrow connections with the sea
x. Freshwater lagoons and marshes in the coastal zone
xi. Non-tidal freshwater forested wetlands

B-Inland wetlands

i. Permanent rivers and streams; includes waterfalls
ii. Seasonal and irregular rivers and streams

iii. Inland deltas (permanent)
iv. Riverine floodplains; includes river flats, flooded river basins, seasonally flooded grassland, savanna and palm savanna
v. Permanent freshwater lakes (> 8 ha); includes large oxbow lakes
vi. Seasonal/intermittent freshwater lakes (> 8 ha), floodplain lakes
vii. Permanent saline/brackish lakes
viii. Seasonal/intermittent saline lakes
ix. Permanent freshwater ponds (< 8 ha), marshes and swamps on inorganic soils; with emergent vegetation waterlogged for at least most of the growing season
x. Seasonal/intermittent freshwater ponds and marshes on inorganic soils; includes sloughs, potholes; seasonally flooded meadows, sedge marshes
xi. Permanent saline/brackish marshes
xii. Seasonal saline marshes
xiii. Shrub swamps; shrub-dominated freshwater marsh, shrub carr, alder thicket on inorganic soils
xiv. Freshwater swamp forest; seasonally flooded forest, wooded swamps; on inorganic soils
xv. Peatlands; forest, shrub or open bogs
xvi. Alpine and tundra wetlands; includes alpine meadows, tundra pools, temporary waters from snow melt
xvii. Freshwater springs, oases and rock pools
xviii. Geothermal wetlands
xix. Inland, subterranean karst wetland

C-Human-made wetlands

i. Water storage areas; reservoirs, barrages, hydro-electric dams, impoundments (generally > 8 ha)
ii. Ponds, including farm ponds, stock ponds, small tanks (generally < 8 ha)
iii. Aquaculture ponds; fish ponds, shrimp ponds
iv. Salt exploitation; salt pans, salines
v. Excavations; gravel pits, borrow pits, mining pools
vi. Wastewater treatment; sewage farms, settling ponds, oxidation basins
vii. Irrigated land and irrigation channels; rice fields, canals, ditches
viii. Seasonally flooded arable land, farm land

Other classification systems for wetlands exist. In the US, the best known are the Cowardin classification system and the hydrogeomorphic (HGM) classification system (NPWRC, 2018).

3.0 Significance of wetlands

Only relatively recently have we begun to understand the many ecological functions associated with wetlands and their significance to society. Wetlands were once considered useless, disease ridden places (e.g., malaria and yellow fever) that were to be avoided (USEPA, 1994). We now realize that wetlands provide many benefits to society– such as fish and wildlife habitats, natural water quality improvement, flood storage, shoreline erosion protection, opportunities for recreation and aesthetic appreciation, and natural products for our use at little or no cost. Protecting wetlands can, in turn, protect our health and safety by reducing flood damage and preserving water quality (USEPA, 1995).

Wetlands are among the most productive ecosystems in the world, comparable to rain forests and coral reefs. They also are a source of substantial biodiversity in supporting numerous species from all of the major groups of organisms – from microbes to mammals. Physical and chemical features such as climate, topography (landscape shape), geology, nutrients, and hydrology (the quantity and movement of water) help to determine the plants and animals that inhabit various wetlands. Wetlands in Texas, North Carolina, and Alaska, for example, differ substantially from one another because of their varying physical and biotic nature (USEPA, 1995).

3.1 Wetland functions and values

Wetlands can be thought of as "biological supermarkets." They produce great quantities of food that attract many animal species (Figure 2). The complex, dynamic feeding relationships among the organisms inhabiting wetland environments are referred to as food webs (USEPA, 1995). The combination of shallow water, high levels of inorganic nutrients, and high rates of primary productivity (the synthesis of new plant biomass through photosynthesis) in many wetlands is ideal for the development of organisms that form the base of the food web -- for example, many species of insects, mollusks, and crustaceans (Figure 3) (USEPA, 1995). Some animals consume the above-ground live vegetation (herbivore-carnivore food web); others utilize the dead plant leaves and stems, which break down in the water to form small, nutrient-enriched particles of organic material called detritus (Figure 4) (USEPA, 1995).

As the plant material continues to break down into smaller and smaller particles, it becomes increasingly enriched (nutritious) due to bacterial, fungal and protozoan activity. This enriched proteinaceous material, including the various microbes that colonize it, feeds many small aquatic invertebrates and small fish (Figure 4). Many of these invertebrates and fish then serve as food for larger predatory amphibians, reptiles, fish, birds, and mammals (Figure 6). Numerous species of birds and mammals rely on wetlands for food, water, and shelter, especially while migrating and breeding (USEPA, 1995).

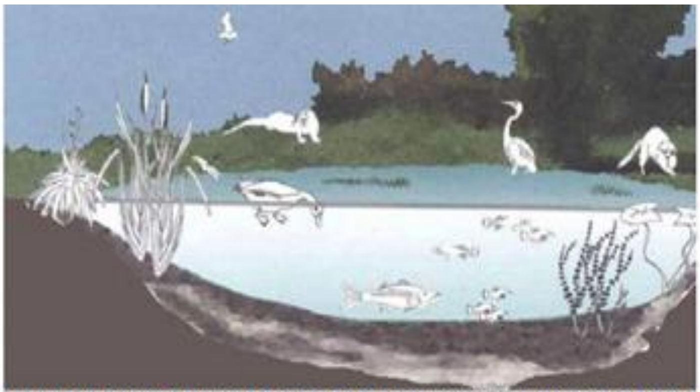

Figure 2: Wetlands support a rich web from microscopic algae and submerged vascular plants to great blue herons and others (USEPA, 1995)

Figure 3: Gulf Periwinkle on a smooth cordgrass(USEPA, 1995)

Figure 4: Decaying plants in a tidal gut (USEPA, 1995)

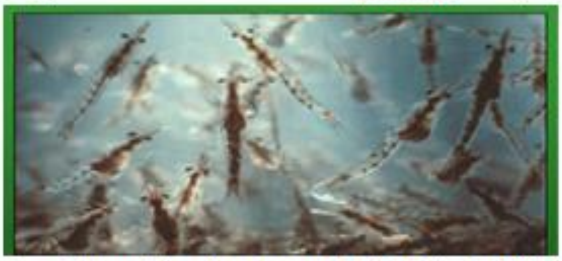

Figure 5: Grass shrimp, importance in detrital food web (USEPA, 1995)

Figure 6: Seine haul near saltmarsh/estuarine interface (USEPA, 1995)

3.1.1 Water storage (Flood Control)

The Major wetland types used are floodplain and closed-depression wetlands.

Storage reservoirs and flood protection:

According to Ramsar (2011), the floodplains of major rivers act as natural storage reservoirs, enabling excess water to spread out over a wide area, which reduces its depth and speed. Wetlands close to the headwaters of streams and rivers can slow down rainwater runoff and spring snowmelt so that it doesn't run straight off the land into water courses. This can help prevent sudden, damaging floods downstream (Ramsar, 2011). Notable river systems that produce large spans of floodplain include the Nile River, the Niger river inland delta, [the Zambezi River flood plain], [the Okavango River inland delta], [the Kafue River flood plain][the Lake Bangweulu flood plain] (Africa), Mississippi River (USA), Amazon River (South America), Yangtze River (China), Danube River (Central Europe) and Murray-Darling River (Australia).

3.1.2 Groundwater replenishment

The Major wetland types used are marsh, swamp, and subterranean karst and cave hydrological systems.

The surface water which is the water visibly seen in wetland systems only represents a portion of the overall water cycle which also includes atmospheric water and groundwater. Wetland systems are directly linked to groundwater and a crucial regulator of both the quantity and quality of water found below the ground. Wetland systems that are made of permeable sediments like limestone occur in areas with highly variable and fluctuating water tables especially have a role in groundwater replenishment or water recharge. Sediments that are porous allow water to filter down through the soil and overlying rock into aquifers which are the source of 95% of the world's drinking water. Wetlands can also act as recharge areas when the surrounding water table is low and as a discharge zone when it is too high. Karst (cave) systems are a unique example of this system and are a connection of underground rivers influenced by rain and other forms of precipitation. These wetland systems are capable of regulating changes in the water table on upwards of 130 m (430 ft).

3.1.3 Shoreline stabilization and storm protection

The Wetland types used are mangroves, coral reefs, salt marsh. Tidal and inter-tidal wetland systems protect and stabilize coastal zones. Coral reefs provide a protective barrier to coastal shoreline. Mangroves stabilize the coastal zone from the interior and will migrate with the shoreline to remain adjacent to the boundary of the water. The main conservation benefit these systems have against storms and storm surges is the ability to reduce the speed and height of waves and floodwaters.

3.1.4 Water purification

The wetland types used are floodplain, closed-depression wetlands, mudflat, salt marsh, mangroves.

Nutrient retention

Wetlands cycle both sediments and nutrients balancing terrestrial and aquatic ecosystems. A natural function of wetland vegetation is the up-take, storage, and (for nitrate) the removal of nutrients found in runoff from the surrounding soil and water (UNEP, 2011). In many wetlands, nutrients are retained until plants die or are harvested by animals or humans and taken to another location, or until microbial processes convert soluble nutrients to a gas as is the case with nitrate.

Sediment and heavy metal traps

Precipitation and surface runoff induces soil erosion, transporting sediment in suspension into and through waterways. These sediments move towards larger and more sizable waterways through a natural process that moves water towards oceans. All types of sediments which may be composed of clay, sand, silt, and rock can be carried into wetland systems through this process. Wetland vegetation acts as a physical barrier to slow water flow and trap sediment for short or long periods of time. Suspended sediment often contains heavy metals that are retained when wetlands trap the sediment. In some cases, certain metals are taken up through wetland plant stems, roots, and leaves.

4.0 Management for Sustainable Development

The UN Millennium Ecosystem Assessment determined that environmental degradation is more prominent within wetland systems than any other ecosystem on Earth (Davidson et al., 2018).

Constructed wetlands are used to treat municipal and industrial wastewater as well as storm water runoff. They may also play a role in water-sensitive urban design.

4.1 Constructed wetlands

The function of most natural wetland systems is not to manage wastewater. However, their high potential for the filtering and the treatment of pollutants has been recognized by environmental engineers that specialize in the area of wastewater treatment. These constructed wetland systems are highly controlled environments that intend to mimic the occurrences of soil, flora, and microorganisms in natural wetlands to aid in treating wastewater effluent. Constructed wetlands can be used to treat raw sewage, storm water, agricultural and industrial effluent. They are constructed with flow regimes, micro-biotic composition, and suitable plants in order to produce the most efficient treatment process. Other advantages of constructed wetlands are the control of retention times and hydraulic channels (Brix, 1993). The most important factors of constructed wetlands are the water flow processes combined with plant growth.

Constructed wetland systems can be surface flow systems with only free-floating macrophytes, floating-leaved macrophytes, or submerged macrophytes; however, typical free water surface systems are usually constructed with emergent macrophytes (Vymazal and Kröpfleova, 2008). Subsurface flow-constructed wetlands with a vertical or a horizontal flow regime are also common and can be integrated into urban areas as they require relatively little space (Hoffmann et al., 2011).

Figure 7: Constructed wetland in an ecological settlement in Flintenbreite near Luebeck, Germany (Wikipedia.org)

4.2 Balancing wetland conservation with the needs of people

Wetlands are vital ecosystems that provide livelihoods for the millions of people who live in and around them. The Millennium Development Goals (MDGs) called for different sectors to join forces to secure wetland environments in the context of sustainable development and improving human wellbeing. A three-year project carried out by Wetlands International in partnership with the International Water Management Institute found that it is possible to conserve wetlands while improving the livelihoods of people living among them. Case studies conducted in Malawi and Zambia looked at how dambos – wet, grassy valleys or depressions where water seeps to the surface – can be farmed sustainably to improve livelihoods. Mismanaged or overused dambos often become degraded, however, using a knowledge exchange between local farmers and environmental managers, a protocol was developed using soil and water management practices. Project outcomes included a high yield of crops, development of sustainable farming techniques, and adequate water management generating enough water for use as irrigation. Before the project, there were cases where people had died from starvation due to food shortages. By the end of it, many more people had access to enough water to grow vegetables. A key achievement was that villagers had secure food supplies during long, dry months. They also benefited in other ways: nutrition was improved by growing a wider range of crops, and villagers could also invest in health and education by selling produce and saving money (Ramsar, 2008).

4.3 Case History

The Hadejia-Nguru Wetlands

The Hadejia-Nguru Wetlands is a wide expanse of floodplain wetlands situated in the northeast Nigeria, the location lies in the sudano-sahelian zone, which is the zone between the Sudanian Savanna in the south and the Sahel in the North. The wetland is found in Yobe state, located in the northern part of Nigeria, which include the Nguru lake (Figure 8). According to Ramsar (1994), the Nguru Lake and the Marma Channel complex, which is a section of the Hadejia Nguru Wetlands, is located on the Latitude 10°22’N and Longitude 12°46’E. The catchment area of the wetlands covers an area of about 3,500 km2, which includes two rivers, the Hadejia and the Jama’are, which flows and converges into the Chad Lake. The wetlands are notably known for recharge and replenishment of underground water in the Komadugu-Yobe Basin, it is an ecological and economical rich habitat for biodiversity of various fauna and flora. The area is a major tourism location for the Palaearctic and Afrotropical migrant water birds (Eaton and Sarch, 1997).

The Hadejia Nguru wetland is the first Nigeria wetland to be named as a Ramsar site (Ramsar, 1994). The area is dominated by Hausa, Fulani, Kanuri and the Bede ethnic groups with population capacity of 1,000,000 people; these people depend on this wetland for water supply and other daily activities. The pictures of some of the people and the lifestyle are shown in Figure 9. Some of the inhabitants of the area emigrated around the 60s at the time of drought, the wetland area has abundant agricultural resources worth about €26,982,651.60, and the region serves as a centre point of cattle trade worth of 250,000 cattle (Eaton and Sarch, 1997; Ramsar, 1994) (Figure 8).

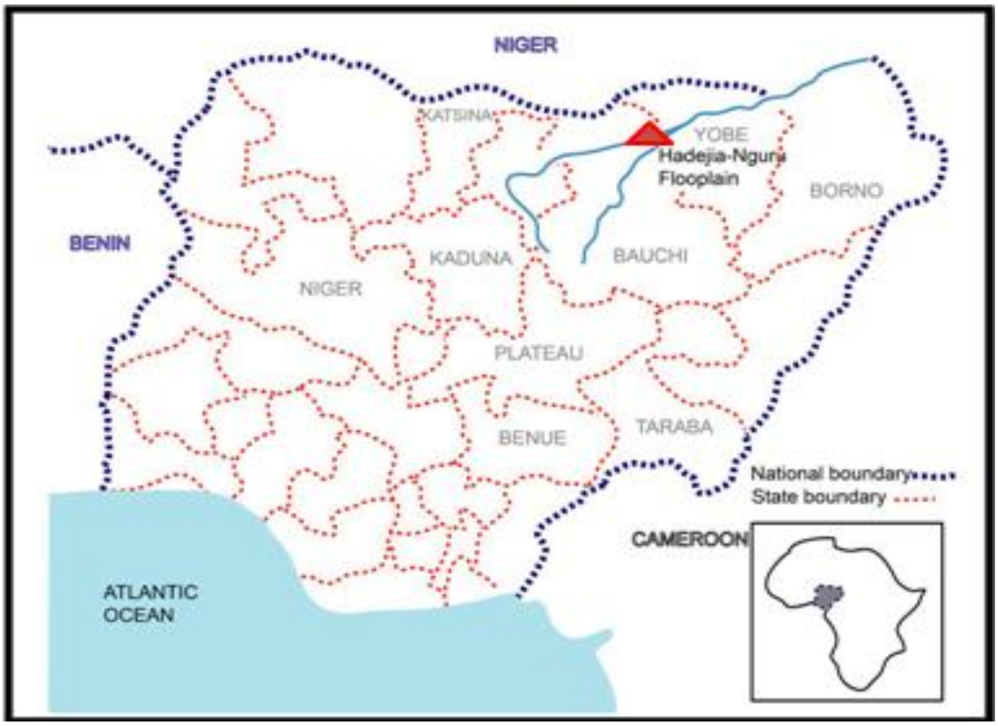

Figure 8: Map showing the location of the Hadejia-Nguru Wetland in Nigeria (Adapted from Eaton and Sarch, 1997).

Figure 9: Pictures showing the people of Hadejia-Nguru Wetlands area of Yobe state, Nigeria (Olalekan et al., 2014).

4.3.1 Challenges Facing the Hadejia-Nguru Wetlands

Globally, different threats have been observed affecting the world wetlands, namely pollution, over-intensification of agricultural activities, industrialization and urbanization. One of the major challenges is the overuse of the resources in the dry arid regions which are the decrease of water resources for the establishment, construction of irrigations for agricultural and for other purposes. In the western part of Africa, more than 100 dam projects have been constructed which affected the existence and sustainability of wetlands (Thompson and Hollis, 1995). The rate and level of wetlands reduction is highly alarming all over the world, a reduction percentage of about 50% have been observed, these affected the wetland resources, hence, species became affected and endangered. Climate change is also a challenge of the wetland resource in Nigeria; this is significantly affected by change in hydrology and biogeochemistry of the aquatic ecosystem (Nwankwoala, 2012). Bioinvasion has been recognized as a major problem affecting the wetlands. Typha grass has been reported to invade the rice and cassava field, which blocks and redirect the flow and channel of the associated river, also the fisheries resources of the area are affected (Ramsar, 1994). The Hadejia-Nguru wetlands are prone to environmental degradation and ecosystem, food chain imbalance, biodiversity deformation; these are majorly caused by human induced impacts, such as industrialization, mineral exploitation, urbanization and civilization (Nwankwoala, 2012). Nigeria has a vast amount of surface and groundwater resources, these are being sustained by wetlands, however, the degradation of the wetlands has greatly affected the supply and channeling of the surface water and ground water resources. The rate of degradation confirms maximum abuse for eco-diversity, which the international and local community should do something positive to save the wetland resources (Uluocha and Okeke, 2004). However, about 78 wetlands reclamation and intervention initiatives have been engaged in West Africa which are attempts to resuscitate some of the wetlands, but social and political issues have proved some intervention projects abortive (Thompson and Hollis, 1995).

Figure 10: Showing people engaging in fishing activities in the Hadejia- Nguru Wetlands (Idris, 2008).

4.4 Conclusion

Wetlands provide many societal benefits which include food and habitat for fish and wildlife (threatened and endangered species), water quality improvement; flood storage; shoreline erosion control; economically beneficial natural products for human use; and opportunities for recreation, education, and research. The Hadejia-Nguru Wetlands is highly rich in both aquatic and terrestrial resources, the area of the wetlands is dominated by many people who engage in various economic and social activities around the water body (fishing, grazing, trading and farming). The wetland is filled with waters from rainfall inflow from the rivers through channels. The wetland faces various impacts and challenges due to lack of monitoring and sustainability measures such as pollution, excessive agricultural activities. The resources of the wetlands include birds, fish, amphibians and mammals; these have improved the wetland as a well functioning ecosystem. Some of the wildlife resources have been going into extinction as a result of human activities. However, in order to harness more opportunities from this and other wetlands, the government is urged to invest in the sustainability and improvement of the hydrological feature, resources and the surrounding environment.

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