

Factors affecting the population trend of biodiversity in the Niger Delta region of Nigeria

Abstract

Some biodiversity of global importance are found in the Niger Delta region of Nigeria. The biodiversity resources of the Niger Delta comprises of several species of mammals, reptiles, amphibians, avian fauna, microorganisms, fisheries (animals), and mosses, liverworts, pteridophytes, gymnosperms, chlamyosperms, monocotyledons, dicotyledons etc (plants). The region is hotspots of several endemic species. In recent times, the biodiversity distribution with regard to abundance and diversity appears to be on the decline trend. Hence, this study assessed the factors leading to decline of biodiversity resources in the Niger Delta. The study found that excessive exploitation, urbanization/industrialization, deforestation/habitat destruction, bush burning, soil erosion and pollution, climate change are the leading cause of loss of biodiversity. The loss of biodiversity affects its roles including source of medicinal plants, shelters, habitats, raw materials for several art and construction works (plants), nutrient mineralization through biogeochemical cycles, loss of animal protein and species of global importance. The paper concludes by suggesting full implementation and enforcement of several environmental conventions, laws and legislations geared towards protection of biodiversity at both international and national level of which Nigeria is part of. Furthermore, outlining biodiversity conservation strategies in curriculum of school is another potential option for conserving biodiversity.

Keywords: animals, ecology; conservation; environmental pollution; plants; niger delta

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Introduction

Environmental protection and conservation of resources is a major challenge in developing nations like Nigeria. The intensity and severity of environmental pollution is in the increasing trend. Both living and non-living components of the ecosystem are affected by environmental pollution. According to Izah et al.,¹ and Ohimain et al.,² emission of greenhouse gases, changes in climatic condition and increased atmospheric temperature are some of the factors leading to environmental degradation.

Human activities in the environment including deforestation, application of chemical fertilizers, bush burning, fuel-wood extraction, pollution resulting from petrochemical industries, logging, urbanization/industrialization etc are major causes of environmental degradation while natural effects such as windstorms, land degradation, drought and high temperature, rainfall and flooding are also causing environmental effects to a lower magnitude in the Niger Delta region.^{1,3} Furthermore, the severity of some of the natural effects tends to be aggravated by anthropogenic activities. For instance, the severity of water flooding in the coastal region is becoming more intense probably due to blockage of canals through erection of building and infrastructure along the water course, obstruction of the drainage system by dirt's and debris. Hamid et al.,⁴ and Ibimilua⁵, Izah et al.,¹ is with the opinion that majority of the adverse environmental dilapidation is associated to upsurge in population, intensive agricultural practices, industrialization and urbanization, excessive exploitation of natural resources and land fragmentation.

According to Unanaonwi & Amonum³, Izah et al.,¹ the impacts of environmental degradation is usually long-term causing poverty, hunger, environmental degradation, climate change, sickness and diseases and loss of valuable biodiversity including medicinal plants and wildlife of ecological importance. For instance, biodiversity such

as insects are major pollinators, some plants have medicinal values and they are also used for construction works, some animal hides and skin are used for leather works.^{1,6} According to Emma-Okafor et al.,⁷ biodiversity involves several concepts including diversity (that refers to the range of variation among some set of entities), biological diversity (involves a variety of living organisms which comprise of individuals, their relationships and interactions in their habitats). Biodiversity embraces different organisms from all sources and ecological complexes including diversity within and between species. Emma-Okafor et al.,⁷ reported that there are three major hierarchical trend related to biological organization including genetic diversity (this involves genetic variability between individuals of the same species within a population), species diversity (involving diversity of species within an ecosystem) and ecosystem diversity (involving diversity within an area or habitats). In recent times, there is an increased global concern on biodiversity loss. These have led to increased global attention toward sustainable proliferation of conventions, protocols and declarations geared toward minimizing loss of biodiversity.⁸ To these effects, several institutions including local, state, national and international legislation have been established towards curtailing excessive loss of biodiversity through strategic policies and interventions⁸ in many developing countries including Nigeria.

But in Nigeria, the enforcement, surveillance and possible punishment of offenders is still very minimal. As such, the rate of decline in biological diversity has been on the increasing trend. The Niger Delta region has been referred to as hotspot of biodiversity of global significance. The Niger Delta region (involving Ondo, Edo, Delta, Bayelsa, Rivers, Imo, Abia, Akwa-Ibom and Cross Rivers states) of Nigeria has the largest wetland in Africa and third largest in the world.^{1,9-11} According to Ajao & Anurigwo,¹² Ogbe,⁹ Izah et al.,¹ the Niger Delta ecosystem is distributed as barrier islands, estuarine,

mangroves, freshwater swamp, lowland rainforest and creeks. The Niger Delta ecosystem plays an essential role in the sustenance of the Nigerian economy. Due to human activities, the region is under intense degradation affecting biodiversity resources. The forest used to host several endangered species including elephant, chimpanzee, leopard, yellow-backed duiker, the Royal python, the Nigerian quonon (*Cercopithecus erythrogaster*).⁷ Some of these species have been in extinction, with no new individuals found recently in the region. Hence, this study aimed at assessing the factors leading to decline in biodiversity resources within the Niger Delta region of Nigeria.

Biodiversity resources of the Niger Delta region of Nigeria

Biodiversity typically involves the totality of species, its genes and variability within the ecosystem. Biodiversity resources involve all life forms including animals (mammals, amphibians, birds, reptiles, insects, fisheries, microorganisms) and different plant species. Biodiversity also involves several lives in different habitats including terrestrial, aquatic (viz: marine, estuarine or brackish water and fresh water) and arboreal. Several diversities exist within and between species. Biodiversity have gained tremendous significance, especially in major global hotspots. This section focused on the biodiversity found in Nigeria with a major emphasis on the Niger Delta.

Animals

Nigeria is endowed with several biodiversity (plants and animals).¹³ Nigeria has about 22,000 vertebrate and invertebrate species, and of these, about 0.14% is threatened and 0.22% is endangered.^{7,13} IUCN Red List of Threatened Species showed that 148 animals are found in Nigeria, and of these, 26 are classified as endangered and 3 as critically endangered on a global level.¹³ Niger Delta has several biodiversity but varies according to locations.¹ Some of the mammals, amphibians, birds, reptiles, insects, fisheries etc found in the Niger Delta are discussed under this subsection.

Mammal

Nigeria has about 247 species of mammals.^{7,13} Nigeria is one of the global hotspot of primate species, and several of them are found in the Gulf of Guinea forests of Cross River State including three species of monkeys viz: white-throated monkey (*Cercopithecus erythrogaster*), Sclater's guenon (*Cercopithecus sclateri*) and the Niger Delta red colobus (*Procolobus pennantii epieni*), and Cross River gorilla (*Gorilla gorilla diehli*); one of the most endangered gorilla subspecies on earth, with an estimated population of < 250 individuals found in protected areas in Cross-River State.¹³ According to FRN,¹⁴ Nigeria's wildlife is rapidly declining due to habitat loss and increased pressure from hunters, poachers, and bush burning, and animals such as Giant Eland (*Taurotragus derbianus*), the Giraffe (*Giraffa camelopardalis*), Black Rhino (*Diceros bicornis*), Cheetah (*Acinonyx jubatus*) and Pygmy hippopotamus (*Choeropsis liberiensis*) have disappeared. The authors further reported that about 10-12 species of primates such as the white throated guenon and sclater's guenon are under serious threat of extinction.

In the Niger Delta region, studies have reported wildlife species found in some of the forest. For instance, Ohimain et al.,² reported a total of 45 mammalian species belonging to 21 families in Wilberforce Island, Bayelsa state after the 2012 water flooding events

using questionnaire and survey assessment. Lameed¹⁵ reported a total 47 mammalian species in Kwale forest reserve and the Okpai ecosystem (transit pipeline to Onitsha), Delta state. Hamadina et al.,¹⁶ reported the existence of 36 mammals which are distributed into 20 families in Nun River reserve in Bayelsa state. Akani et al.,¹⁷ reported a total of 21 mammalian species displayed for sale at Swali market in Yenagoa metropolis, Bayelsa state between 2010-2014. The authors at the time of study further reported an array of live biodiversity been sold in the local market which included 12 *Cercopithecus mona*, 2 *Cercopithecus sclateri*, 8 *Cercopithecus nictitans*, and 5 pangolins, while *Thryonomys swinderianus*, *Cricetomys cf. emini*, *Atherurus africanus*, *Crossarchus platycephalus*, antelopes, and monkeys are the most commonly traded mammals in Yenagoa, Bayelsa state. Akani et al.,¹⁸ reported the presence of 28 mammalian species, which many are distributed into ACT 11 schedule 1 and 2 in Edumanon Forest Reserve. Akani et al.¹⁹ through quantitative and qualitative study reported the presence of 27 species of mammals in Taylor creek forest reserve. Amadi et al.,²⁰ reported the presence of two-spotted civet (*Nandinia binotata*) in some forest reserves in the Niger Delta region. Akani et al.,²¹ reported the presence of several mammals in bush meat market which were been traded in some locations in the Niger Delta region including Oyigbo, Omagwa, Akabuka and Ahoada (Rivers state), Swali (Bayelsa state), Patani and Adeje (Delta state) and Ologbo and Oredo (Edo state). According to the authors, among 28 wildlife species, about 90% are mammals comprising of rodents (37.8%), small carnivores such as genets, civet cats and mongooses (18.81%) and antelopes (14.24%) which are the most traded bush meat in the area. Ikemeh²² reported population trend of Niger Delta red colobus (*Procolobus epieni*) in central Niger Delta in 2013 and revealed that the population has decreased significantly since it was first assessed in 1996. Oates & Were²³ also reported that *Procolobus epieni* have been classified by International Union for Conservation of Nature as 'Critically Endangered' species. Hamadina et al.,¹⁶ reported that Nun river forest reserve used to be home to elephant (*Loxodonta africana*), African buffalos (*Syncerus coffa*) and Pygmy hippos (*Hexaprotodon liberiensis*). New species have not been sighted in the last three decades with the area.

Reptiles

Approximately 127 species of reptiles are found in Nigeria.^{7,13} Lameed¹⁵ reported a total 7 reptilian species in Kwale forest reserve and the Okpai ecosystem (transit pipeline to Onitsha), Delta state. Hamadina et al.,¹⁶ reported the existence of 18 reptilian species which are distributed into 12 families in the Nun River reserve in Bayelsa state through interview and survey. Akani et al.,¹⁸ reported the presence of 31 reptilian species and few are distributed into ACT 11 schedule 1 within Edumanon forest reserve. Akani et al.,¹⁹ reported the presence of 34 reptiles in Taylor creek forest reserve. Akani et al.,²⁴ used qualitative and quantitative approach to report the presence of 60 reptile species including 3 crocodiles, 7 turtles, 13 lizards, and 37 snakes in the eastern Niger Delta. But till date, human interference and excessive exploitation has led to a declining trend in their population. Some species that are associated with totem are under threat. Hamadina et al.,¹⁶ reported *Crocodylus niloticus* (Nile crocodile), *Varanus niloticus* (Nile monitor lizard), *Kinixys erosa* (serrated hinge backed tortoise), *Python sebae* (Rock python), *Python reguis* (Royal python) and *Naja nigricollis* (black-necked cobra) as some reptiles associated with totem in Nun River reserve.

Avian fauna

Over 1,000 species of avian fauna are found in Nigeria⁷ including some endemic species such as Anambra waxbill (*Estrilda poliopareia*), the Ibadan malimbe, (*Malimbus ibadanensis*), the Jos Plateau indigo-bird (*Vidua maryae*) and the Rock Fire-Finch *Lagonostica sanguinodorialis*.¹³ Several species of birds have been reported in the Niger Delta region. For instance, Ohimain et al.,² reported 78 avian fauna belonging to 27 families in Wilberforce Island after the 2012 water flooding event. Lameed¹⁵ reported that bird population varies according to locations and are characterized by 19 species (villages and farmlands), 49 species (forest area), 14 species (river bank and beaches) in Kwale forest with predominant species being African Black kite (*Milvus migrans*) and pied hornbill (*Tochus nasutus*). Hamadina et al. [16] reported the existence of 67 avian fauna which are distributed into 25 families in Nun River reserve in Bayelsa state. Some of the species are associated with taboos. Some of the species include *Gypohierax angolensis* (palm-nut vulture), *Haliaeetus vocifer* (West African river eagle), *Centropus leucogaster* (black-throated coucal), *Chrysococcyx klaas* (Klaas's cuckoo), *Psittacus erithacus* (Grey parrot) and *Tauraco persa* (Green-crested turaco) [16]. Some of these avian fauna that are associated with taboo are also under threat due to human interference.

Amphibians

Nigeria listed 109 amphibian species in the forests in Cross River State.^{7,13} Lameed¹⁵ reported 3 amphibian species in Kwale forest reserve and the Okpai ecosystem (transit pipeline to Onitsha), Delta state. Akani et al.,¹⁸ reported the presence of 9 amphibian species in Edumanon forest reserve in Bayelsa state. Akani et al.,¹⁷ reported 10 species of amphibians in Taylor creek forest reserve. Akani et al.,²⁵ reported the capture of 28 species at four sites affected by oil and gas development from 1996–2002. They included 3 Bufonidae (genera *Bufo* and *Nectophryne*), 2 Pipidae (*Silurana* and *Hymenochirus*), 9 Ranidae (genera *Hylarana*, *Ptychadena*, *Aubria*, *Conraua*, *Hoplobatrachus*, and *Phrynobatrachus*), 1 Arthroleptidae (genera *Arthroleptis*), 1 Rhacophoridae (genera *Chiromantis*), 1 Microhylidae (genera *Phrynomantis*) and 11 Hyperoliidae (genera *Hyperolius*, *Afrixalus*, *Leptopelis*, *Phlyctimantis*, and *Opisthoxylax*). The authors also showed that *Silurana tropicalis*, *Bufo maculatus*, *Ptychadena* species, *Hylarana alboblavris*, *Hoplobatrachus occipitalis*, *Hyperolius cf. concolor* and *Afrixalus dorsalis* were the predominant species in the area.

Insects

Most insects are high in protein content, and they play an essential role in degradation.¹ This may be responsible for the presence of most insects in decaying organic matter. Nigeria has about 20,000 species of insects.¹³ Several insects have been reported in the Niger Delta region of Nigeria. Most species of *Rhynchophorus* sp are found in decaying palm trunk. Some of the insects such as crickets are widely consumed in Africa including Nigeria.²⁶ In the Niger Delta region of Nigeria, several species of edible insects including *Macrotermes* sp. (Termites), *Brachytrypes membranaceus* (Crickets), *Zonocerus sp* (including Grasshopper and Praying mantis), *Rhynchophorus phoenicis* (Palm weevil/Edible worm), *Rhinoceros oryctes* (Rhinoceros), *Heteroligus meles* (Yam beetle), *Sitophilus oryzae* (Rice weevil), *Callosobruchus maculatus* (Bean beetle), *Dermestes maculatus* (Fish/hides beetle), *Daraba (Sceloides) laisalis* (Egg fruit

borers), *Gonimbrasia belina* (Mopane worm), *Apis mellifera* (Bees), *Musca domestica* (House flies), uncertain species of Cotton stainer, aphids and locust have been reported by Okore et al.²⁷ The authors further reported that most of the insects belong to the order viz: Isoptera, Orthoptera, Coleoptera, Lepidoptera, Hemiptera and Diptera. Most insects are consumed intentionally while several others are eaten unknowingly. For instance, *Rhynchophorus* sp are consumed intentionally in Bayelsa state, Nigeria. While several ones like beans and rice weevils are consumed unknowingly through consumption of infected beans and rice.

Microorganisms

Nearly 1,489 species of microorganisms are found in the Nigerian environment.^{7,13} Typically, microbes are ubiquitous and can be found in diversity of environment including soil, sediment, water, reservoir, food, human body, extreme environmental conditions including acidic, thermophilic environment etc. The tendency for microbes to survive in different environment could be due to their different adaptation strategies. Some microbes are extremely pathogenic to the humans and some other wildlife resources. Several others are beneficial for the sustenance of life. Hence, the reduction in population of beneficial microbes due to anthropogenic activities could be detrimental to the environment. Some microbes such as coliforms (particularly *E.coli*) are indicator organisms. They are essential in determining the suitability of potable water resources. Different microbial species have been reported in several food and environmental components including palm oil,^{28–31} palm oil mill effluents,^{32,33} cassava mill effluents contaminated soil,^{34,35} cassava flake (gari),³⁶ groundnut,³⁷ sliced fruits viz: pineapple, paw-paw,³⁸ smoked fish,³⁹ Kunu drink.⁴⁰ Most of the microbes found in these are microbes of public health importance. The presence of *E.coli* suggests fecal contamination.

Fishes

Nearly 1,000 species of fishes are found in Nigeria.^{7,13} Several species of fish have been reported in several part of the Niger Delta region of Nigeria. For instance, FRN¹³ reported the presence of 648 fish species in Cross River State. Fishes have been widely studied in surface water resources in several water resources in the Niger Delta.^{41–45} Fish composition frequently found in surface water includes both shelled and fin fish depending on the habitat. In the present situation the fish composition, diversity and abundance is on the decreasing trend especially in surface water resources with high level of human interference.

Plants

In Nigeria, there are about 7,895 plant species identified in 338 families and 2,215 genera, and of these, about 0.4% are threatened and 8.5 % endangered.^{7,13} These plants include 1335 (algae), 17 (lichens), 134 (fungi (mushroom)), 16 (mosses), 6 (liverworts), 165 (pteridophytes), 5 (gymnosperms), 6 (chlamyosperms), 1575 (monocotyledons) and 4636 (dicotyledons) species.¹³ IUCN Red List of Threatened Species showed that 146 plants are found in Nigeria, and of these 18 are classified as endangered and 15 as critically endangered on a global scale.¹³ Ohimain et al.,² reported over 56 species of vegetation are found in Wilberforce Island, Bayelsa state, Nigeria. In Taylor creek, Akani et al.,¹⁹ reported the presence of *Raphia hookeri* (*Raphia* palm), *Mitragyna ciliata* (*Abura*), *Nauclea diderrichii* (*Opepe*), *Khaya ivorensis* (*Mahogany*),

Irvingia gabonensis (African bush mango), *Eleais guineensis* (Oil palm), *Musanga cecropoides* (Umbrella tree), ferns, epiphytes and macrophytes in a freshwater swamp and riparian forests of the area. Furthermore, Ubom⁵⁶ reported the presence of 339 plant species in some Niger Delta states (Akwa-Ibom, Bayelsa, Cross River, Delta, Imo and Rivers) which are distributed into 88 families. According to the authors, *Elaeis guineensis*, *Raphia hookeri*, *Cocos nucifera*, *Irvingia gabonensis*, *Hevea brasiliensis*, *Lonchocarpus cyanescens*, *Pterocarpus santalinoides* and *Dacryodes edulis* are some of most utilized plants compared to the others. Typically, plant uses depends on the region and locality as well as its availability.

Role of biodiversity to the ecosystem and sustainable development

Biodiversity is a valuable resource that is essential to life-sustaining processes of the biosphere.⁵ Several biodiversity resources are used as food, fuel, fibre, wood, nutrients, energy sources, educational materials, shelter, clothing, income, construction, utensils, medicine and ecotourism for several people.^{1,5} Typically, the conservation of biodiversity is essential because they play essential role in industry, agriculture (food) and industry. For instance, in industry, timber from the forest is an important source of wood used in construction works including bridges, roofing, cooking and decking of buildings. According to United Nation's Food and Agriculture Organization over 1.5 billion out of the 2 billion world population uses fuel wood for domestic purposes such as cooking.³ In agriculture, biodiversity is an important source of food including animal protein from bush meat, carbohydrate crops cultivated including cassava, yam, maize, among others. Many plants with medicinal values are also found in the Niger Delta forest. Several studies have reported the diversity of medicinal plants found in the Niger Delta. For instance, studies have indicated diversity of medicinal properties in Ogi, Okigwe Imo State,⁵⁷ around University of Port Harcourt, River state,⁵⁸ in Ezinihitte Mbaise local government area of Imo State,⁵⁹ plants used during natality by Okpe-Speaking people of Delta State.⁶⁰ Furthermore, species such as *Vitex grandifolia*,⁶¹ *Alstonia boonei*,⁶² *Musanga cercopoides*,⁶³ *Piper nigrum*^{64,66} also have medicinal properties.

In addition, biodiversity plays an essential role in life processes including stabilization of the climate, protection of watersheds, soil and nurseries and breeding grounds. As formally indicated, biodiversity comprises of all life forms. Fish is an important resource that is a means of animal protein to several families. The cultivation of fishes in the wild is a major source of livelihood to several residents of coastal communities especially in Bayelsa state. As such, destruction of the habitats and pollution of natural water resources could cause a shift in the fish balance with regard to abundance and species composition.

The soil is important for several species of terrestrial life forms.^{35,65-69} According to Izah et al.,^{67,68} the soil plays social, ecological and economic roles. This could be due to the fact that several activities are carried out in the soil. The soil is an habitat to several species of invertebrates such as earthworm and some species of microbes that play essential role especially in nutrient cycling. Insects play an essential role in the ecosystem.⁷⁰ Izah et al.,¹ is with the opinion that biodiversity contributes vastly to the continued existence of humans in diverse forms such as pollinator of plants (insects). Pollination of fruits aid in life sustenance processes. Life without insects (pollinator)

that play essential role in some fruit productivity could be catastrophic. Some beetle larvae, flies, ants, and termites clean up dead plant matter and feed on agricultural waste humans and livestock do not.²⁶

Factors affecting population trend of biodiversity in the Niger delta region of Nigeria

Several factors are leading to change in population trends and species of biodiversity in the Niger Delta region of Nigeria. Some of the notable factors include soil erosion, flooding, urbanization, industrialization, population growth, pollution, deforestation, habitat destruction, excessive exploitation and uncontrolled bush burning.

Flooding

In the coastal region, flooding usually occurs during the end of the wet season (that is, September and October) in most communities aligning surface water resources especially in Bayelsa state. Probably due to this, most farmers in the area harvest their farm produce in area prone to water flooding before end of July. In addition, flooding leads to blockage of water canals in the region as well. This type of flooding partially submerges buildings within residential areas close to major surface water like rivers, streams and even creeks. Flooding in the area is due to the relative topography, land use pattern, population density, rainfall patterns and its intensity, nature of the drainage systems and flood plain. Besides impact on health (through predisposition of residents of the area to water borne diseases viz: contamination of water resources), infrastructures/social amenities (viz: roads, market, schools, hospitals, electricity, telecommunication system), farm lands are devastated and biodiversity in the area is impacted upon. Some of the biodiversity commonly impacted by flooding is fern plant. When the plant is submerged in water, it could lead to withering of vegetation. Furthermore, the wildlife species in the area could be killed and used as bush meat or migrate to other territory. Excessive water flooding event like the type that occurred in 2012, could also impact on vegetation and wildlife resources. Ohimain et al.,² reported that 2012 water flooding event impacted on some vegetation cover and wildlife species (through destruction of food sources, habitats). The authors also reported that the water flooding event caused irreversible effect to some vegetation and wildlife species.

Soil erosion

Soil erosion typically involves land degradation through loss of top soil by the agent of water, wind or mass movement. Under severe cases, soil erosion affects productivity of the soil (deterioration of physical, chemical and biological or economic properties of soil). Factors such as clearing of natural vegetation cover (deforestation), increased population and changes in land use pattern, developmental projects through urbanization and industrialization are the major leading cause of soil erosion. Over a long period of time, soil erosion could cause loss of natural vegetation. It could also lead to decline in soil fertility, loss of arable farmland and indirectly affects water and sediment quality. The soil is home of several species of microbes and several other lower invertebrates such as earth worms. In addition the soil environment is a major recipient of waste streams emanating from food processing including oil palm,⁷¹ cassava processing.^{35,67-69,72} These wastes are rarely treated in Nigeria before disposal. After heavy precipitation they could be washed into the nearby surface water (major sink of pollutants) thereby causing an alteration in water and sediment quality depending on the constituents and concentration of

toxicants/ hazardous substances found in the water. In soil, the wastes could cause change in the flora composition. For instance, Izah & Aigberua³⁴ reported that cassava mill effluents lead to reduction of microbial load in the soil. Izah et al.,⁷¹ also reported that palm oil mill effluents cause odour pollution and makes the soil become bare and devoid of vegetation. On the overall, these activities affect the productivity and nutrient composition of such environment.³⁵

Urbanization and deforestation

Deforestation in Nigeria is another main area of environmental concern and a major threat to sustainable development. Deforestation is one of the most important issues of the last few decades. Urbanization and agricultural practices are the major cause of loss of vegetation cover. The vegetation cover is habitat to several wildlife including mammals, avian fauna, amphibians, reptiles among others. Unsustainable management practices (extraction of fuel wood, timber and non-timber forest products such as medicines and human habitat provided by forests) and poor enforcement and surveillance of law/ legislations are the leading cause of deforestation. The agricultural practice of shifting cultivation is also leading to deforestation. During developmental projects (viz: road construction, markets, hospitals, among others), agricultural practices, several trees, shrubs, herbs are removed thereby leading to loss of different biodiversity especially potential timbers, medicinal plants, wildlife species, water resources (leading to decline in quantity of water that is intercepted by vegetation and evaporated back to the atmosphere) and wetlands. It also predisposes the soil to erosion, leading to reduction in soil available nutrients. Deforestation in Nigeria occurs in the major ecological zones which include mangroves, lowland rainforest and freshwater forest. Typically, Nigeria has several national parks and protected areas but in recent times they are on the shrinking trend probably due to deforestation and other developmental projects.⁷⁴

Urban pollution

Environmental degradation in urban centers in Nigeria resulting from pollution due to domestic and industrial wastes and emissions have been on the rise causing enormous environmental, health and socio-economic problems. Several factors are leading determinants of pollution magnitude including physical characteristics of the pollutants. Pollution is mostly caused by congestion of industrial, commercial and business activities in an area with adequate physical and social welfare infrastructures. Others factors such as unplanned expansion, traffic congestion, inadequate infrastructure, poor waste management strategies especially from activities leading to emission of lead-acid battery, fertilizer, pesticides, paints, pharmaceutical, food processing, textiles, hospital and medical, beverages and different type of waste streams (especially the hazardous wastes) may also lead to pollution. Several studies have indicated that pollution leads to alteration of hydrological and biogeochemical cycles,³⁵ land degradation, respiratory and cardiovascular diseases associated with air borne particulates and gases. Pollution associated with waste dump sites could promote the transfer of vector borne diseases. Furthermore, most waste streams emanating from runoff ends of the aquatic ecosystem.^{71,75-94} Hence, high concentration of toxicants emanating from wastes could have effect on the fisheries resources and other components of the food chain. Fisheries are known to bioaccumulate toxicants such as heavy metals in their tissues; hence consumption of fish food containing high level of heavy metals over a prolonged period

of time could expose the individuals to some diseases associated with heavy metals.⁵⁵ Some of the toxicants could lead to death of fisheries in the aquatic ecosystem at certain concentrations.

Industrialization

The Niger Delta region of Nigeria is the center of oil and gas exploration. During exploration, drilling and production, transportation, refining, storage, distribution, marketing, terminal operation pollution resulting from spill sometimes occur. In addition, in most facilities, excess gas is flared in to the environment.⁹⁵ Flares have been reported to have severe impact on vegetation, soil nutrients, and water quality through the formation of acid rain from the deposition of the oxides of sulphur and carbon that are released into the atmosphere. These gases now react with water to form weak acids. Acid rain has been reported to cause corrosion to several infrastructures. Acid rain in aquatic ecosystem is also detrimental to life forms. Instances of oil spill leading to fire have been reported in literature.¹ The impacts lead to loss of valuable medicinal plants and wildlife. Oil spill could lead to land degradation, and in aquatic ecosystem it could lead to loss of nursery grounds for valuable fish production, and water resources. Authors have variously reported potable water resources in Nigeria to be surface, ground and rain water.^{58,94-96}

Excessive exploitation

Most terrestrial biodiversity are found in the forest. Several others are found in the aquatic ecosystem. The forest acts as habitat and food source to several wildlife species. As a result, the level of exploitation of natural resources in quest of bush meat, timber, farmland for agricultural practices, deforestation due to urbanization and industrialization and other developmental projects have increased. For wildlife, hunting is a major factor leading to their decline in their natural ecosystem with regard to their composition and abundance.

Bush burning

Bush burning in several parts of the world is a traditional farming practice especially in third world nations.^{1,3,4,97} According to Jamala et al.,⁹⁸ two type of bush burning include controlled (prescribed) and wildfire. Controlled bush burning which typically involves fire management processes⁴ appears not to be the major cause of wildfire in the Niger Delta region. The effect of wild fire is usually severe causing effect on the ecosystem and constitute public disturbance.^{1,98}

In recent time, the intensity of bush burning has increased and impacted on the composition and abundance of biodiversity in the Niger Delta region of Nigeria.¹ According to Izah et al.,¹ quest for bush meat, burning of solid wastes, unsustainable discharge of remains of cigarette and intentional uncontrolled in-situ burning by farmers are the major cause of bush burning, and its leading habitat fragmentation, loss of biodiversity (including medicinal plant, extinction of species in the wild, loss of food sources, raw material for several art work, wood fuel, construction and shelter materials), and alteration of ecological balance such as biogeochemical or nutrient cycling. In addition, bush burning leads to desert encroachment and contribute to global warming through the release of emissions.^{4,98}

Climate change

There has been an emerging recognition of important links between various global environmental issues such as loss of biodiversity,

climate change and land use change/degradation.⁹⁹ According to Obayelu,⁹⁹ climate change is among the natural drivers leading to loss of biodiversity probably due to the ability of the natural ecosystem to support life. The authors further reported that climate change is affecting all aspects of biodiversity from individual organisms, within populations and species, ecosystem composition and function, decline in water quality, water resources and increased risk of floods and droughts, incidence of vector-borne diseases in Nigeria. Sea rise affects crop, land, surface and underground water resources, transportation, residential and industrial layouts and other land uses.

Increased atmospheric temperature (leads to shifts in phenology of species and population), seasonal precipitation (variation in structure and composition of resources), extreme events such as flooding, disease outbreak (leads to mortality), hydrological regimes (variation in river flow affects community composition), increase in atmospheric carbon dioxide (cause an impairment in behavioral response among marine organisms), sea rise (leads to loss of habitat which could affect population of organisms) and changes in coastal upwelling (causing variation in productivity of coastal ecosystems and fisheries).¹⁰⁰

Conclusion and the way forward

The Nigerian biodiversity (plants and animals) is on the decreasing trend with regard to composition and species diversity, and several other species are endangered, threatened and few have gone on extinction within the last 5 decades in the Niger Delta region. The decline in plant biodiversity poses a serious threat to the native that uses the plants (medicinal purpose, timber for construction works). Human activities on the ecosystem are the major cause of loss of biodiversity. For instance, human activities affect agricultural practices leading to soil erosion, decline in agricultural productivity and genetic resources making the species to be susceptible to diseases, and providing resilience in time of stress). Impacts on water resources through soil erosion, sedimentation, siltation and flooding could also lead to loss of biodiversity. Excessive exploitation and deforestation has made several species to be endangered. Quest for economic trees have led to loss of valuable medicinal plants and many other products. Due to the decline in biodiversity resources there is the need to conserve them and these can be achieved through stabilization of the climate, protection of watersheds, soil and breeding grounds, poverty eradication, effective implementation of sustainable development goals, enforcement of legislation protecting threatened, endangered and species at risk of extinction.

Some of the international environmental related conventions towards conservation of biodiversity that Nigeria have ratified include African Convention on the Conservation of Nature and Natural Resources, Algiers, 1968, International Convention for the Prevention of Pollution of the Sea by Oil, 1954-62, Convention on Fishing and Conservation of the living resources of the High Sea, 1985, Convention on Biological Diversity 1992, Convention on the Conservation of Migratory Species of Wild Animals, 1973, Convention on International Trade in Endangered Species of Fauna and Flora, 1973, The Convention concerning the Protection of the World Culture and Natural Heritage, 1972, The RAMSAR Convention on the Conservation of Wetlands of International Importance, especially as Water Fowl Habitat, 1971. Some national environmental legislation for sustainable biodiversity convention include the Forestry Ordinance of 1937, National Parks Act 1979, 1991 and 1999, Wild

Animal Preservation Laws of 1926, The Endangered Species (Control of International Traffic) Act of 1983, Sea Fishing Act 1971 and listing regulation of 1972, Environmental Impact Assessment Act 86 of 1992 and Federal Environmental Protection Agency Act 1988.

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Conflicts of interest

Author declares that there is no conflict of interest.

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