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Water Resources, Pollution, Integrated Management and Practices in Nigeria – An Overview

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ABSTRACT

This paper provides a comprehensive overview of Nigeria's water landscape, focusing on its abundant surface and underground water sources and the agencies responsible for water resources development and management. Findings reveals that the country boasts vast freshwater reserves, encompassing surface and groundwater, intricate river drainage systems, numerous dams, and managed aquifer formations, primarily overseen by River Basin Development Authorities. Despite these resources, Nigeria faces severe pollution challenges, especially in the Niger Delta, resulting from oil-related activities and causing environmental degradation, health crises, and enduring ecosystem consequences. Approximately 13 million barrels of oil spills have adversely impacted coastal wetlands, mangroves, and agricultural lands. Elevated levels of heavy metal pollution, exceeding recommended guidelines, pose significant threats to public health, emphasizing the lasting impact of persistent oil spillage on fishery production and aquatic organisms. River Basin Development Authorities have made substantial contributions, challenges persist in catchment management and the indiscriminate disposal of hazardous substances. The absence of effective environmental policies necessitates urgent, coordinated action from federal and state governments. Nigeria must prioritize integrated water management practices to strike a delicate balance between resource utilization and preservation for the benefit of current and future generations. This manuscript relies on secondary sources, utilizing key search terms such as "water resources in Nigeria," "water pollution in Nigeria," "water supply and demand in Nigeria," "water management in Nigeria," and "integrated water practices in Nigeria." Data were sourced from reputable institutions, including the Federal Ministry of Water Resources, The World Bank, United Nations Environmental Protection (UNEP), USAID's Sustainable Water Partnership, and various scientific publications, ensuring the reliability of the presented data.

INTRODUCTION

Water resources are natural resources of water that are potentially useful for humans, for example as a source of drinking water supply or irrigation water. It plays a major role in the development of any nation most especially in socio-economic development, preservation, and protection of the environment; therefore, its importance is generally well known. However, Nigeria as a nation is rich in natural resources which includes water resources, which is also an important source for its national and economic development. Nigeria as a country is faced with lots of environmental challenges and water pollution is widely among them. It is known that problem of water resources is of three main types: namely too little water, too much water, and polluted water (Adebola, 2001). In Nigeria, the problem of water resources is the availability of good-quality (potable) water because of environmental pollution and degradation (Efe, 2001); beside this, valuable man-hours and resources are spent traveling long distances fetching water of doubtful quality. More so, previous studies have shown that water resources in Nigeria are easily contaminated from anthropogenic activities (Orisakwe *et al.*, 2001; Nduka *et al.*, 2009). Several publications have reported the unregulated discharge of untreated effluents into natural receptors

by industries in Nigeria (Egborge, 2000). The rapid urbanization and industrialization of the Niger Delta Region of Nigeria occasioned by huge crude oil and gas reserves has had its toll on the environment (Nduka *et al.* 2008) most especially on water resources in the entire region. The US Department of Energy estimates that since 1960, there has been more than 4,000 oil spills, discharging several million barrels of crude oil into the ponds, ditches, creeks, beaches, streams, and rivers of the Niger Delta (Amaize, 2007); hence there is need for stringent environmental laws and policy. Majority of Nigeria's environmental problems are because of the ineffective implementation of environmental laws. These challenges range from lack of governmental water supply (availability of freshwater resources, such as rivers, lakes, groundwater, and reservoirs, that can be used for various purposes), infrastructure to properly implement environmental laws, high corruption/poor governance, and lack of maintenance of facilities that aids its implementation. However, the study seeks to explore Nigeria's water resources, pollution sources and types, integrated management, and practices and provide possible suggestions relating to the water problem in Nigeria through secondary data.

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LITERATURE REVIEW

Water Resources in Nigeria

Nigeria is located in Western Africa on the Gulf of Guinea and has a total area of 923,768 km² (356,669 sq mi), making it the world's 32nd-largest country. Nigeria has 36 states, many of which are so rich in water resources, and some of these states were named after rivers. The land area is located within the tropics where its climate is semi-arid in the North gradually becoming humid in the South. However, apart from the surface water found in nearly every part of the country, the country is also endowed with plenty of underground water. With 215 cubic kilometers a year of surface water availability, this amount is much higher than many African countries especially those in the southern and northern regions of the continent. The surface water resources potential of the country is estimated at 267.3 billion cubic meters while the groundwater potential is 51.9 billion cubic

meters (National Water Policy of Federal Republic of Nigeria, 2014). Three broad ecological zones are commonly distinguished in the country:

- i) The northern Sudan Savannah,
- ii) The Guinea Savannah zone or Middle Belt, and
- iii) The southern rainforest zone.

Based on rainfall and temperature, the country is divided into eight agro-ecological zones (FAO, 2016). these zones are presented in a north-south succession, except the mountainous zone which is found at the border with Cameroon and the plateau zone in the center of the country. The peculiar and variable nature of Nigeria in location and climate has given rise to certain water resource issues in the country. These issues range from precipitation to management of these resources. The annual precipitation ranges from 400mm in the North-Eastern part to about 2000mm in the South-Eastern part of the Country (Ishaku & Majid, 2010; FAO, 2016).

Table 1: Agro-ecological zones in Nigeria

Zone Description	Percentage of country area	Annual rainfall (mm)	Monthly Temperature °C	
			Minimum	Maximum
Semi-arid	4	400-600	13	40
Dry sub-humid	27	600-1000	12	45
Sub-humid	26	1000-1300	14	37
Humid	21	1100-1400	18	37
Very humid	14	1120-2000	21	37
Ultra humid (flood)	2	>2000	23	33
Mountainous	4	1400-2000	5	32
Plateau	2	1400-1500	14	36

(FAO, 2016)

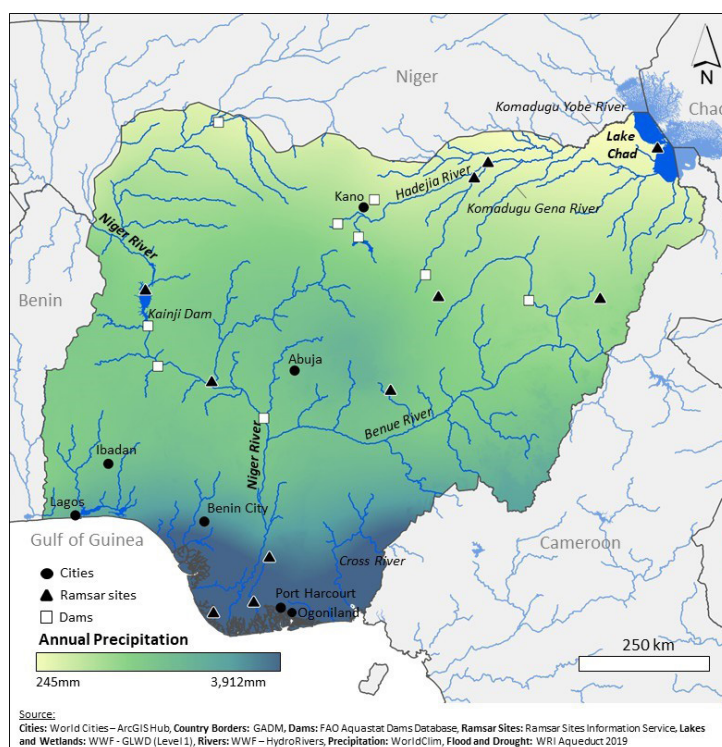


Figure 1: Map of Water Resources

METHODOLOGY

The data and information presented in this manuscript were sourced from secondary sources, including various scientific publications and reputable research institutions. Key search terms and phrases employed to identify these resources encompassed “water resources in Nigeria,” “water pollution in Nigeria,” “water supply and demand in Nigeria,” “water management in Nigeria,” and “integrated water practices in Nigeria.” The majority of the data were acquired from sources such as the Federal Ministry of Water Resources of the Federal Republic of Nigeria, The World Bank, United Nations Environmental Protection (UNEP), and USAID’s Sustainable Water Partnership, among others. Subsequently, the sourced materials were downloaded, thoroughly examined, and appropriately cited.

RESULT AND DISCUSSION

Surface Water Resources In Nigeria

Nigeria’s surface waters primarily drain through the Niger and Lake Chad Basin, in addition to several smaller coastal river basins (Adelodun & Choi, 2018). However, according to Federal Ministry of Water Resources on National Water Resources Policy (2016), Nigeria organizes its basins into eight Hydrological Areas (HA) The Niger North, Niger Central, Niger South, Upper Benue, and Lower Benue HAs formed the lower reaches of the Niger Basin. Nigeria is divided into eight hydrological areas for the purpose of water resources management, considering hydrological and topographical conditions, as shown below.

Table 2: The Eight Hydrological Areas

Hydrological Area		Area (10 ³ km ³)	Mainly related RBDAs	Mainly related states
HA-1	Niger North	135.1	Sokoto-Rima	Katsina, Zamfara, Sokoto, Kebbi
HA-2	Niger Central	154.6	Upper Niger, Lower Niger	Niger, Kwara, Kaduna, Kogi, FCT
HA-3	Upper Benue	156.5	Upper Benue	Adamawa, Taraba, Gombe, Bauchi
HA-4	Lower Benue	74.5	Lower Benue	Plateau, Nasarawa, Benue, Kogi
HA-5	Niger South	53.9	Anambra-Imo, Niger Delta	Bayelsa, Delta, Edo, Kogi, Anambra, Rivers
HA-6	Western Littoral	99.3	Ogun-Osun, Benin-Owena	Lagos, Ogun, Oyo, Osun, Ondo, Edo, Ekiti
HA-7	Eastern Littoral	57.4	Cross River	Abia, Anambra, Imo, Enugu, Ebonyi, Cross River, Akwa Ibom, Rivers
HA-8	Lake Chad	178.5	Hadejia-Jama'are, Chad	Kano, Jigawa, Yobe, Borno, Bauchi, Adamawa, Plateau

Adopted from Ibrahim et al. (2021)

Collectively, they drain almost two-thirds of the country and account for about 60 percent of total runoff (Idu, 2015). The Niger River originates in Guinea and outlets to the Gulf of Guinea through the Niger Delta, which is the third largest delta in the world covering 70,000 km² and containing seven percent of the world’s mangroves (Linden and Palsson, 2013; FAO, 2020) The Benue River is the largest and most important tributary of the Niger River in Nigeria. The North-eastern Lake Chad HA drains the western limits of the Lake Chad Basin, which spans eight countries and forms Lake Chad along the border between Nigeria, Chad, and Cameroon. The largest river in the Chad Basin HA is the Komadougou Yobe which has a number of seasonal tributaries, including the Hadejia, Jama’are, and Komadougou Gena ((FAO Aquastat, 2016). Water availability in the Lake Chad HA has declined due to the recession of Lake Chad because of drought and overexploitation. In the 1960s, Lake Chad spanned 25,000 km² and had roughly one-quarter of its surface within Nigeria. During this time, demand for water increased significantly from agricultural communities around the lake Joint Environmental Audit, 2015; Vivekananda *et al.*, 2019). Major Sahelian droughts reduced Lake Chad’s coverage by 90 percent to 2,000 km², however, the lake’s coverage has somewhat recovered to

14,000 km². The Western Littoral HA has relatively low runoff, whereas the Eastern Littoral HA, which includes the Cross and Imo Rivers, has high precipitation and generates about 30 percent of national runoff (Idu, 2015; Pharm-Duc *et al.*, 2020).

Groundwater Resources

Groundwater resources are controlled by hydrogeology of the country and follow the pattern of occurrence of the aquifers, aquitards or aquicludes (Idu, 2015). There are four major aquifers in Nigeria according to Adelen, (2012) reports, these are;

Basement Aquifers

These consist of crystalline and coarse-grained rocks and argillaceous meta-sedimentary rocks. Generally, have low yields. Thickness varies from 10 to 25 m; with water table depth varying from about 5 to 15m. Depending on local conditions, boreholes tend to be drilled to depths between 10 and 70m.

Sedimentary Aquifers

They generally consist of thick sequences of sediments with yields between 2 and 60l/s; water table depth between 10 and 40m; and borehole depths from 20m to

150m. Coastal sedimentary basins have borehole depths between 10m and 800m and yields between 2 and 60l/s.

Volcanic Plateau

It is found around Jos plateau and Bauchi State of Nigeria. The rock types are mainly olivine basalts, coriaceous lavas and tuffs. These rocks form typically unconfined aquifers with low to moderate yields, usually below 3l/s. Aquifer thickness varies substantially. Water table depth is less than 5m. Borehole depths of 15 to 50m are common.

River Alluvium Aquifers

It occur along the valleys of major rivers and streams ranging from the thin discontinuous sands occurring in the smallest streams to the thick alluvial deposits of rivers Niger and Benue. They may occupy strips of country up to 15km wide on each side of the river. They are thickest (15-30m thick) along the rivers Niger and Benue and are largely unconfined with shallow water tables.

However, most of Nigeria's groundwater exists in basement complexes or sedimentary basins. Alluvium aquifers are less common but are the most productive groundwater systems. Groundwater recharge rates

are lowest in the northwest (estimates from 4-28mm/year) and highest in the southeast (estimates from 281-1,047mm/year) (Adelana, 2012). Basement complexes cover 60 percent of Nigeria and are located throughout the southwest, in the central region, and along the eastern border with Cameroon. Most of these groundwater systems have shallow depths to the water table (5-15m) and low to moderate well yields (FAO Aquastat, 2016). Sedimentary aquifers underlay most of the northeast and northwest, and along the upper reaches of the Niger and Benue Rivers. The best-yielding aquifers are in the northwest, northeast, and central regions. Aquifers in the northern sedimentary basin typically have both confined and unconfined layers. Unconfined aquifer depths range between 15-75m in the northwest and 30-100m in the Northeast. Alluvium aquifers broadly follow the paths of the Niger and Benue Rivers in relatively narrow bands and underlie most of the Niger Delta. In these aquifers, groundwater can be easily accessed at shallowest depths (0-10m) with high yields (FAO Aquastat, 2016; Earthwise accessed 2024). Nigerian groundwater can be best divided into three hydro-meteorological areas based on its availability (Idu, 2015) and presented in Table 3;

Table 3: Hydro-meteorological Areas of Nigeria's Groundwater

	Hydro-meteorological Areas	Related River Basins	Characteristics
1	Sahel zone	Sokoto, Hadejia-Jama'are-Yobe and the South-East Chad	Low annual precipitation of 500-750mm
2	Guinea savannah zone	Kaduna, Benue (upper and lower), and the Niger (Upper and lower)	Mean annual precipitation of 1000-1250 mm
3	Tropical rain forest zone	Anambra, Cross River, Kwa-Iboe, Niger Delta and the Southwestern Coastal	Heavy precipitation from 1250mm-4000mm

Source: Idu, (2015)

However, around three-quarters of all irrigation withdrawals are from groundwater through traditional, dry-season flood plain irrigation known as fadama (National *et al.* Plan, 2013). Groundwater is also the main domestic water source for approximately 60 percent of the population in rural and urban areas. However, data on groundwater use and sustainability is limited and requires more systematic monitoring. Average water levels in shallow aquifers in the northeast have declined over 13 meters (Gronwall *et al.*, 2010; Yusuf *et al.*, 2018 and Cobbing, 2020). Groundwater is generally available at lower depths; however, deeper wells are more expensive (Adelana, 2012; Adeyeye, 2020). Recharge rates have declined significantly as dams have reduced the extent of wet season inundation of flood plains (Joint Environmental Audit, 2015). Research and systematic monitoring of groundwater levels throughout southern Nigeria is lacking, although there is some indication that over- pumping is contributing to subsidence (land sinking) in coastal cities such as Lagos. Additionally, groundwater demand is high in the northern Kano region, which is home to one-third of the total population. Despite above average precipitation in recent years, groundwater levels

across the Kano metropolitan area are declining, largely due to over-abstraction and urbanization which reduce recharge (Abdulhamid *et al.*, 2014; Mahmud *et al.*, 2016; Tukur *et al.*, 2018).

Climatic Condition and Water Resources in Nigeria

Nigeria is characterized by three distinct climate zones, a tropical monsoon climate in the south, a tropical savannah climate for most of the central regions, and a Sahelian hot and semi-arid climate in the north of the country. This leads to a gradient of declining precipitation amounts from south to north. The southern regions experience strong rainfall events during the rainy season from March to October, with annual rainfall amounts usually above 2,000 mm and can reach 4,000 mm and more in the Niger Delta. The central regions are governed by a well-defined single rainy season (April to September) and dry season (December to March). The Harmattan wind from Sahara influences the dry season. Coastal areas experience a short, drier season, with most rain occurring from March to October. Annual rainfall can reach up to about 1200 mm. In the north, rain only falls from June to September in the range of 500 mm to 750 mm. The rest of the

year is hot and dry. Northern areas have a high degree of annual variation in its rainfall regime, which results in flooding and droughts (World Bank Group Climate Change Knowledge Portal, 2020).

Most of Nigeria experiences distinct wet and dry seasons, which are known to cause high seasonal variability in water supply. The wet season is shorter (May- September) in the north compared to the south where it lasts at least 9 months (March-November). Climate change has caused average temperatures to increase by 0.8°C between 1960 and 2006, with a particularly steep increase since 1980, while annual precipitation has decreased (USAID, 2019; Butu and Emeribe, 2019). Between 1971 and 2012, heat waves have increased in the Guinea and Sahel regions. Dry seasons have become longer, and wet season rainfall variability has increased. Droughts are also more frequent and affect larger areas, while extreme flooding has increased. In northern Nigeria, rainfall has declined by 25 percent in the past 30 years. Climate change is projected to further increase temperatures by 1.9-3.7°C, while total precipitation may increase slightly. Total water availability is projected to decrease due to increased evaporation (Abatan *et al.*, 2016; Elisha *et al.*, 2017; Shiru *et al.*, 2018; Haider, 2019). Sea levels may rise between 1.5- 3 feet, potentially submerging more than 11,000 square miles, where many of the most densely populated cities and towns are located, including Lagos (King, 2017).

Reports has it that an estimated 20 percent of the population face flood risks. However, flood risks are highest in riverine communities in the downstream reaches of the Niger, Benue, and Cross Rivers, and Lagos State.

The lower basin states throughout southern Nigeria have experienced a 20 percent increase in recorded volumes of torrential rains in the past 40 years. This has accelerated gully erosion in the southeast where many riverbanks have collapsed. In 2012, widespread flooding affected almost every Nigerian state, damaging, or destroying 600,000 houses, displacing over 2 million people, and causing almost USD \$17 billion in losses to the economy (Relief Web, 2012; Cirella and Iyalombe, 2018; UNFCCC, 2020; Njoku *et al.*, 2020). Climate change will continue to lower rainfall in northern Nigeria and increase the frequency of severe droughts. Desertification will worsen these risks. In addition to drought, desertification is driven by poor water resources management and land use changes, overgrazing, and deforestation. Between 50-75 percent of the land in the 11 northernmost states are impacted by desertification. Desertification is progressing southward at a rate of 0.6 kilometers per year and has contributed to the loss of nearly half the vegetation in the northernmost states between 1984 and 2016 (Toye, 2002; Haider, 2019; Nwilo *et al.*, 2020). A growing number of sand dunes have threatened oases and buried water points, and significantly reduced wetland coverage (Adepelumi *et al.*, 2009).

Water Availability and Regulation: Supply, Demand and Management

The Federal Ministry of Water Resources (FMWR) is the foremost agency for water, sanitation, and hygiene (WASH) activities in Nigeria. The ministry works with the National Task Group on Sanitation (NTGS), and development partners on sanitation and hygiene issues.

Table 4: Statutory Bodies for Water Regulation in Nigeria

No.	Statutory body	Key provision
1.	The Oil in Navigable Waters Act, 1968	Prohibits water pollution by oil spillage
2.	The Petroleum Act, 1969	Covers prevention of pollution by inland waters, rivers, lakes, and watercourses
3.	The River Basin Development Authority (RBDA) Decree 25 of 1976 (repealed by No. 87 of 1979 and also latter by the RBDA Act, Decree 35 of 1987, i.e. Cap 396)	In its present form Cap. 396 spells out diverse functions and objectives for these authorities to ensure a Pan-Nigerian programme for water resources development
4.	The Environmental Impact Assessment (EIA) Decree, No. 86 of 1992	This law seeks to protect the physical and aquatic environment
5.	Water Resources Decree, No. 101 of 1993	Vests the right to use and control all surface waters and groundwater and of all water in any watercourse affecting more than one state in the Federal Government, with provisions that any person may take water without charge for his domestic or livestock watering purposes (in any watercourse to which the public has free access)
6.	The 1999 Constitution of the Federal Republic of Nigeria	The Constitution puts in the Exclusive Legislative List (ELL) shipping and navigation on the River Niger and its affluent and on any such other inland waterway as may be designated by the National Assembly to be an international waterway or to be an interstate waterway. The ELL also includes water from such sources as may be declared by the National Assembly to be sources affecting more than one state

Adopted from Balogun and Redina (2019)

Table 5: List of other Regulations bearing on Water Resources in Nigeria

No.	Statutory body	Key provision
1.	National Policy on Environment 1989	Protection of the environment
2.	National Guidelines and Standards for Environmental Pollution Control in Nigeria 1991	Pollution control in watercourses as part of the environment
3.	National Effluent Limitation Regulation 1991	Control of discharge of industrial waste and sewage into watercourses
4.	Pollution Abatement in Industries and Facilities Generating Wastes Regulation 1991	Control of industrial pollution
5.	Waste Management Regulation 1991	Waste management

Adopted from Balogun and Redina (2019)

The national standards and targets being followed are as stated in the 2010 Water Sector Road Map, Vision 20:2020, the Millennium Development Goals (MDGs), and the African Water Vision (WHO, 2013).

The state and local governments under the umbrella of the State's Water Corporation are primarily responsible for the provision of municipal and domestic water supply. However, the Federal Government often intervenes to increase access to meet these targets. Even though monitoring and evaluation of water supply and regulation are not taken seriously enough, some agencies monitor activities in the WASH sector. However, effective legislation could not be made to ascertain the quality of water supply and management. In compensation with the lack of insufficient quality water supply to the citizen, Alternative market of water production by the private owners (traditional well water and borehole) took over the supply of water in the country. Furthermore, there are three major level of government that share responsibility

for the delivery of water supply services which are the federal, state, and local government. In some rural area or rural communities' water and sanitation committees (WASCOs) are formed to operate and maintain water facilities. These committees are tasked with the duty of collecting water tariffs from inhabitants of these communities. Donors such as the African Development Bank have set a requirement that at least 30% of members of WASCOs must be women (African Development Bank, 2012). In 1993 the government committed itself to reinforce community participation in rural water supply in a policy document which as of the year 2000 but the policy had not been dispersed or administered in all government or donor-financed programs. Individual water supply services also known as alternative water supply system; mostly everywhere in the country, the residents practice or are engaged in this part of water supply service due to the shortcoming of water supply from the governmental water supply services.

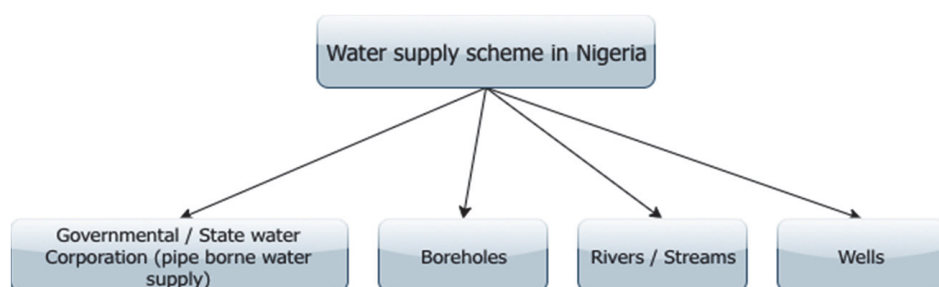


Figure 2: Major water supply sources in Nigeria

Source: Balogun and Redina (2019)

Nigeria's 2013 National Water Resources Master plan projects that total surface water demand will more than triple by 2030. The largest increases will be in the Upper Benue, Lake Chad, and Western Littoral HAs due to growing demand for irrigation. Municipal demand is concentrated in the Niger Central and Western Littoral HAs whereas agricultural demand is concentrated in the Lake Chad and Niger North Has. Nigeria also has over 200 dams (Adelodun & Choi, 2018). The Kainji, Shiroro, and Jebba Dams in the Niger Basin account for 70 percent of Nigeria's total dam storage capacity (JICA, 2014).

Around 70 percent of all livestock is in northeastern Nigeria. Major droughts in the 1970s killed 13 percent of the region's livestock and cut the agriculture sector's contribution to the GDP by more than half (Eze, 2018; Adeyeye, 2020). Key dams on the Hadejia and Komadugu-Yobe River have significantly reduced the coverage of key wetlands, especially Hadejia-Nguru wetlands and reduced Lake Chad's coverage and surrounding pastures (Pearce 2018; World *et al.* al., 2020).

Lake Chad has high inter-annual and inter-seasonal rainfall variability. As a shallow lake, its coverage

fluctuates greatly with rainfall patterns, affecting the extent and viability of pastures, croplands, and fisheries (Pearce, 2018; Vivekananda *et al.*, 2019). High poverty rates and unequal access to land and water resources amplify existing socio-economic tensions among ethnic and religious groups (Anderson, 2019; Adeyeye, 2020). Food and water insecurity in northern Nigeria have been important factors in helping Boko Haram recruit fighters while violent clashes between pastoralists and farmers are partly attributed to water scarcity and desertification (Audu, 2014; Muhammed *et al.*, 2015; Piesse, 2017). Approximately 30 percent of Local Government Areas (LGAs) have medium to high flood risk. The highest risks are around the Niger Delta, along the Niger, Benue, and Cross Rivers, and in Lagos State (Njoku *et al.*, 2020). Poor urban planning and enforcement of existing zoning regulations has led to uncontrolled development in coastal zones and flood plains. Lagos City is one of the largest and fastest growing cities in the world, and over two-thirds of its population reside in low lying flood plains (Stark & Terasawa, 2013; Raji *et al.*, 2014). Stormwater infrastructure and drainage systems cover less than half of Lagos, and most are not maintained. Further, many drainage systems are uncovered channels and are commonly used as dump sites for solid waste, which increases surface water contamination and health risks during floods (Lucas, 2021).

Water Pollution in Nigeria

Water pollution is a change caused in the chemical, physical or biological properties of the water that has the capacity of hurting the living organism. However, water pollution is another key aspect of environmental pollution and the main type of water pollution in Nigeria especially in the riverine areas as oil pollution (Astegbua, 2003). In relation to this, Owa (2013) stated that water is polluted if some substances or conditions are present to such a degree that the water cannot be used for specific purpose. Damilola (2012) also defines water pollution as the contamination or change in the quality of water that has a harmful effect on any living thing that drinks, uses, or lives in it. Abimbola (1999) also posits that as a result of oil losses, vast tracks of agriculture have been laid waste, thus becoming unproductive, and surface water and river courses are invariably contaminated and polluted, rendering the water undrinkable. The result is great hardship for the inhabitants who become impoverished and deprived.

Nigeria is the 10th largest oil producer in the world due to the rich oil deposits in the Niger Delta (Imoobe & Tanshi, 2009). Oil spills have discharged an estimated 13 million barrels of crude oil into the environment and destroyed coastal wetlands and mangroves, degraded agricultural lands, and created widespread public health crises (King, 2017). Oil spills have contributed to high concentrations of heavy metals such as cadmium, chromium, and lead in numerous watercourses, particularly in Rivers and Delta States. Pollution from cadmium and lead is the most severe,

with their maximum concentrations found over 100 times the WHO guideline values for drinking water (Nduka & Orisakwe, 2011; WHO, 2017). While environmental and social impact assessments are required in Nigeria, local compliance and enforcement of environmental regulations are often lacking (Imoobe & Tanshi, 2009). The impacts of these spills threaten public health and can devastate ecosystems and biodiversity. Fishery production and populations of key aquatic organisms are declining in the Niger Delta due to oil spillage. Despite cleanup efforts, contaminants from an oil spill from over 40 years ago have persisted in the Ogoniland area, demonstrating the long-term consequences that these events can have (UNEP, 2011; Osuagwu & Olaifa, 2011; Ogunlade & Olaifa, 2018).

More so, in Nigeria, less than 10 percent of industrial effluent is treated, thereby leading to contamination from heavy metal pollution, mostly lead and chromium, in addition to oil and grease, high turbidity, and high biological/chemical oxygen demand (BOD/COD) are widespread (Idu, 2015). High BOD/COD levels can kill aquatic species and disrupt ecosystems. Water quality risks from industry are especially high in the southwest near the Lagos and in the north near Kano (Wakawa & Kagbu, 2008; Taiwo *et al.*, 2012; Lohdip & Gongden, 2013). Apart from Abuja and Lagos, functional wastewater treatment plants are limited. Additionally, excess fertilizer use, poor land use planning, and dams are increasing eutrophication in rivers, lakes, and reservoirs, destroying ecosystems and inhibiting recreational use of surface waters. Algal blooms have been observed in Rumuji Lake in the Niger Delta region (Nweze, 2010; Megbo, 2010; Erhumwunse *et al.*, 2013 and Kayode *et al.*, 2018).

Research has shown that, naturally high fluoride levels contribute to widespread fluorosis in some parts of Nigeria. Fluoride concentrations are higher in central and northern Nigeria, with one national survey showing that 30 percent of groundwater sources exceed the WHO guideline value for drinking water for fluoride (Lar *et al.*, 2014; Malago, 2017; Cobbing, 2020). Heavy metals such as lead, cadmium, arsenic, and selenium have been detected in groundwater in the southwestern city of Ibadan, although contamination from antimony is highest and most widespread and likely derives from natural and anthropogenic sources (Etim, 2017; Ganiyu *et al.*, 2021). Similarly, lead pollution from industrial and municipal waste is widespread in shallow and deep wells in Lagos. Additionally, inadequate sanitation systems in many cities, including Lagos, have led to high concentrations of *E. Coli* and nitrates in shallow wells (Yahaya *et al.*, 2020; Healy *et al.*, 2020). Groundwater resources used for drinking supply in the coastal area of Lagos and in communities in Delta State and in Ondo State have been affected by saltwater intrusion. Groundwater monitoring wells are lacking in Lagos, although some studies have found saline intrusion in wells as far as 3km inland (Oteri & Atolagbe, 2003; Adepelumi *et al.*, 2009; Aladejana *et al.*, 2021). Rising sea levels from climate change and land subsidence in

coastal cities will increase saline intrusion. Groundwater sampled in areas with a history of oil spillage have shown high turbidity, low pH, and low dissolved oxygen at levels that may not be suitable for human consumption. In Ogoniland, one water quality study closes to an oil pipeline found an 8 cm layer of refined oil floating on the groundwater table which serves community wells (UNEP, 2011; Nwachukwu & Osuagwu, 2014).

The nation's water sources are under serious threat from inadequate catchment management and widespread pollution, including the indiscriminate disposal of hazardous substances. The oil-producing region of Nigeria, the Niger Delta, suffers a lot from the improper implementation of environmental policies and activities associated with petroleum exploration, development, and production. They have been experiencing a wide range of environmental degradation and pollution and are at high risk of health hazards and socio-economic problems (Ite *et al.*, 2016). These regions often must deal with oil spillage in their rivers from oil and gas industries thereby causing serious damage to aquatic life and plant as well. Since the environmental policies in Nigeria are not very effective, these communities must deal with these situations by themselves most of the time.

Consuming water and plants contaminated with oil is dangerous to health. Over the years, threats to the nation's water resources are because of poor and uncoordinated management of the resource. Federal and state governments have a much bigger role in the overall management of the nation's water resources. In most cases, stakeholders are not consulted or otherwise involved in planning, development and management of the nation's water resources (Adegoroye, 1994).

Integrated Water Management System in Nigeria

Historically, beginning from colonial Nigeria, the Water Works Acts, 1915 is the only pan Nigerian law passed specially to keep water from being polluted. It bans the pollution of water works in Nigeria by noxious or harmful matter or substances. However, in 2017, a comprehensive national water resources bill was proposed to consolidate and clarify existing

laws, centralize water resources management through a national council, and establish a regulatory framework for water resources. The bill has been controversial due to its provisions for privatization of water service delivery and consolidation of water management responsibilities within the central government. Approval of the law remains pending (Ogunmupe, 2020). Further, technical capacity is often low; and one assessment of the Cross River Basin Development Agency highlighted the lack of key technical staff, including geographic information system and remote sensing expertise, hydrologists, and water resources managers (Ngene *et al.*, 2019). Capacity issues are compounded by inadequate data, and poor data management systems. NESREA struggles to fulfill its mandates due to technical capacity constraints, in addition to a lack of transparency and autonomy from political interests, fragmented environmental laws, lack of public participation, and limited enforcement of permits (Cobbing, 2020; Stewart, 2011).

Presently, the Federal Ministry of Water Resource (FMWR) is responsible for large water resources development projects and water allocation between states (Idu, 2015). FMWR has sixteen (16) parastatals and agencies made up of twelve (12) River Basin Development Authorities (RBDAs), Nigeria Hydrological Services Agency (NIHSA), Nigeria Integrated Water Resources Management Commission (NIWRMC), Gurara Water Management Authority (GWMA), and the National Water Resources Institute (NWRI).

The first two RBDAs - Chad Basin Development Authority (CBDA) and Sokoto-Rima River Basin Development Authority (SRRBDA) were created in 1973, through the Decree Nos. 32 and 33 of 1976. In 1976, based on the Decree No. 25 of 1976, nine (9) additional RBDAs were established, and as a result, the number of RBDAs becomes 11. In 1984, with separation of Niger River Basin Development Authority into two RBDAs – such as Upper Niger River Basin Development Authority (UNRBDA) and Lower Niger River Basin Development Authority (LNRBDA), the number of RBDA became 12 and these RBDAs long continue with the operation to date (JICA, 2014).

Table 6: River Basin Development Authority

S/N	RBDA	Area of Operation	Office
1	Anambra-Imo River Basin Development Authority (AIRBDA)	Abia, Anambra, Ebonyi, Enugu and Imo States	Oweri
2	Benin Owena River Basin Development Authority (BORBDA)	The regions of River Benin and Owena and a senatorial district in Delta State	Benin-City
3	Chad Basin Development Authority (CBDA)	Borno, Yobe State and northern part of Adamawa State	Maiduguri
4	Cross River Basin Development Authority (CRBDA)	Akwa Ibom and Cross River States	Calabar
5	Hadejia Jama' are River Basin Development Authority (HJRBDA)	Kano, Jigawa States and North and central parts of Bauchi Sate	Kano
6	Lower Benue River Basin Development Authority (LBRBDA)	The catchment states of Benue, Plateau, Nassarawa States and Kogi State East of the River Niger	Makurdi

7	Lower Niger River Basin Development Authority (LNRBDA)	Entire geographical boundaries of Kwara State and a part of Kogi State, West of the River Niger	Ilorin
8	Niger Delta Basin Development Authority (NDBDA)	Delta and Bayelsa States	Port-Harcourt
9	Ogun-Osun River Basin Development Authority (OORBDA)	Lagos, Ogun, Oyo and Osun States	Abeokuta
10	Sokoto-Rima River Basin Development Authority (SRRBDA)	Katsina, Zamfara, Sokoto and Kebbi States	Sokoto
11	Upper Benue River Basin Development Authority (UBRBDA)	Gombe, Taraba, two senatorial districts of Adamawa State and one senatorial district of Bauchi State	Yola
12	Upper Niger River Basin Development Authority (UNRBDA)	Niger, Kaduna States and the FCT	Minna

Source: Federal Ministry of Water Resource (FMWR)

The Federal Ministry of Water Resources (FMWR) has authority over all the formulation of national policy and strategy advice for the public provision of water. However, it is up to each state to adopt and implement national legislation and policy and decide on the institutional framework for delivering services. While the local governments water sectors take all formulations of policies on managements from their state governments. The National Council on Water Resources (NCWR) is the highest water resources policy formulating body, overseen by the FMWR and with representatives from the Federal

Ministry of Environment and all commissioners for state governments. State Ministries of Water Resources are responsible for policy, regulation, and monitoring which are passed down to control the local governments even though not all states have a stand-alone ministry of water resources (e.g., the Rivers State Ministry of Water Resources and Rural Development – RSWRRD – in Rivers State). Thus, while certain structures and policies related to water supply prevail throughout the country, there is a great deal of variation in the management and provision of water across jurisdictions (WHO, 2013).

Table 7: Key Laws, Policies, and Plans

Name	Year	Purpose
National Water Resources Policy	2016	Originally drafted in 2004, the National Water Policy was approved in 2016. The policy establishes that all water is a national asset and defines planning and development through an integrated water resources management framework.
Water Resources Master Plan	2013	Assesses water resources supply and demand from 2010 to 2030 and defines basin development priorities and risks.
Minerals and Mining Act	2007	Grants Ministry of Mines and Steel Development (MMSD) water use permitting rights when they concern mining exploration and operation.
The National Inland Waterways Authority (NIWA) Act	1997	Established NIWA and defines its responsibilities towards river navigability, riverbank stabilization, and dam development.
Water Resources Act	1993	Established the Federal Ministry of Water Resources as the lead institution in charge of water resources development, licensing, planning, and use.
River Basins Development Authority Act	1990	Established 12 River Basin Development Agencies (RBDA) that are responsible for developing surface and groundwater resources, prioritizing water use for domestic and agricultural purposes. The act was originally enacted in 1976 but has been revised several times.

Adopted from USAID's Sustainable Water Partnership

Water management responsibilities do not consistently follow hydrological or administrative boundaries. This leads to overlapping responsibilities between institutions and undermines basin management approaches. For example, RBDAs follow state administrative, rather than hydrological, boundaries. RBDAs within the same basin and HA often do not coordinate and instead prioritize irrigation expansion within their administrative

jurisdiction. This can impact water availability and water quality for downstream states (Irokalibe, 2008). Within the Niger Basin, there is limited coordination between the six RBDAs responsible for planning, design, and operation of key hydraulic infrastructure (Gana, 2019). The NBA lacks funding and commitment from member states. Inflows to Nigeria's Kainji Reservoir have been decreasing for decades, possibly from over abstraction in upper basin

states. Uncontrolled and uncoordinated management in the Lake Chad Basin leads to over-exploitation of Lake Chad and has reduced lake coverage and pastures in Nigeria. Poor management of Cameroon's Lagdo Dam

has led to reduced flows on the Benue River, and Nigeria claims that uncoordinated floodgate releases have caused major flooding in downstream villages (Golitzen *et al.*, 2005; Joint *et al.*, 2015 and Ewepu, 2019).

Table 8: Water Resources Management Entities

Mandate	Institution	Roles and Responsibilities
Transboundary	Niger Basin Authority (NBA)	Commissioned in 1980, the NBA's nine member states are Niger, Benin, Chad, Guinea, Côte d'Ivoire, Mali, Nigeria, Cameroon, and Burkina Faso. Supports integrated basin development related to energy, water resources, agriculture, animal husbandry, fisheries, forestry, and transportation.
	Lake Chad Basin Commission (LCBC)	Established in 1964, members include Cameroon, Niger, Nigeria, Chad, the Republic of Central Africa, and Libya to coordinate the sustainable development and equitable use of Lake Chad, regional peace and security, and environmental conservation.
National	Federal Ministry of Water Resources (FMWR)	Lead governmental entity in charge of water management and allocation between states. Oversees all 12 RBDAs, in addition to other water sector entities such as the Nigeria Hydrological Services Agency (NIHSA), the Nigeria Integrated Water Resources Management Commission (NIWRMC), and the National Water Resources Institute (NWRI).
	Nigeria Integrated Water Resources Management Commission (NIWRMC)	Overseen by the FMWR, the NIWRMC is the central coordinating body for Catchment Management Offices (CMO). Manages water use regulations and licensing, strengthens CMO capacity, and formulates Catchment Management Plans based on stakeholder consultation.
	National Environmental Standards and Regulations Enforcement Agency (NESREA)	Housed within the Federal Ministry of the Environment, NESREA is responsible for issuing environmental permits, including for effluent discharge, and monitoring compliance of permit holders.
	National Council on Water Resources (NCWR)	Formulates and approves water sector policy, laws, strategy, master plans, and the development and implementation of large infrastructure.
Sub-national	River Basin Development Authorities (RBDA)	

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Federal Government

The Nigeria Federal Ministry of Water Resources, was part of the Ministry of Agriculture until 2010, is responsible for large water resources development projects and water allocation between states of the federation. There are 12 River Basin Development Authorities under this Ministry, responsible for planning and developing water resources, irrigation work, the collection of hydrological and hydro-geological data, and providing water in bulk to cities from dams (The World Bank Group, 2000).

State Government

Responsibility for portable water supply is entrusted to State Water Agencies (SWAs) or state water departments in the 36 Nigerian states. The SWAs are responsible to their state governments, generally through a State Ministry of Water Resources. SWAs are responsible for

urban water supply, they are also responsible for rural water supply. As of 2000, 22 states had separate state-maintained rural water and sanitation agencies, mostly set up to implement a UNICEF program (The World Bank Group, 2000).

Local Governments

The country's Local Government Authorities (LGAs), of which there are 774, are responsible for the provision of rural water supplies and sanitation facilities in their areas although only a few have the resources and skills to handle the problem. Only few LGAs have rural water supply divisions.

Water Pollution Mitigation Proposal in Nigeria

CMOs (Catchment Management Offices) are broadly responsible for monitoring water quality within their

respective HAs and maintaining databases for all hydrological and hydrogeological information (Federal Ministry of Water Resources, 2016). The Federal Ministry of Health (FMoH) and the FMWR (through its Department of Water Quality Control and Sanitation) are responsible for monitoring drinking water quality, but they both lack funding and technical capacity, and there is a lack of coordination (SON, 2015). Most surface and groundwater quality studies have been carried out by researchers at universities, research institutes, and government institutes (Taiwo *et al.*, 2012; Standard Organization of Nigeria, 2015 American Chemical Society, 2015).

- The most effective way to reduce water pollution is to treat some of the water before it is reintroduced into the waterways.

- This is a highly effective solution because wastewater treatment facilities can remove nearly all pollutants in wastewater via a chemical, physical, or biological process.

- Water resources law and environmental management strategy must be backed by effective regulation, enforcement, and implementation in the field.

- Laws and regulations should be put in place to prevent, reduce, and control pollution emanating from exploration and production of oil in the Niger Delta Area of Nigeria.

- Pollution of the water in the coastal areas should be viewed as crime against humanity, therefore a violation of human rights; this is because people living in the coastal areas depend on the waters for drinking, bathing, and fishing which is their major source of livelihood. Therefore, companies and individuals should be held liable for water pollution.

- An active oil industry bill is required to protect and improve Nigeria's coastal waters and the environment as stipulated under Section 20 of the Constitution of the Federal Republic of Nigeria. This provision should be made justiciable.

- The legislature, judiciary, and the various agencies charged with safeguarding the environment must be ready to do all that is required to enhance sustainable practices and manage the environment today and for the future.

Water Supply Mitigation Problem in Nigeria

- Regular updates of water regulation laws and policies should be in place;

- Provision of constant water supply;
- Provision of standard infrastructure and water treatment facilities;

- Incorporating a standard method of water treatment using the international treatment guidelines;

- Enforcing strict compliance to environmental law;

- Implementation of new law to reduce the amount of alternate water supply (Balogun and Redina, 2019)

CONCLUSION

The provided overview offers a comprehensive depiction of Nigeria's water landscape. Abundant water resources,

including surface and groundwater, are distributed across diverse ecological zones. The country boasts large freshwater reserves, featuring four river drainage systems, numerous dams, and four major aquifer formations spread across eight hydrological areas spanning the thirty-six states. Although River Basin Development Authorities have contributed to water resource development, catchment management inadequacies and indiscriminate disposal of hazardous substances persist as significant challenges. Problems of flooding in the Middle Belt, inadequate water distribution and supply to rural areas, most especially in the Northern region, and pollution in the Niger Delta have been major problems in Nigeria. Addressing these issues requires crucial stakeholder involvement and consultation in planning, development, and water resource management. Coordinated efforts are imperative to protect the environment, ensure sustainable practices, and safeguard communities' health and socio-economic well-being. In navigating these challenges, Nigeria must prioritize integrated water management practices, striking a balance between resource utilization and preservation for both current and future generations.

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