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PROSPECTS AND CHALLENGES OF WATER RESOURCES AND ENVIRONMENTAL MANAGEMENT IN NIGERIA: AN OVERVIEW

Suleiman, Y.M.; Emigilati, M.A.; Abdulkadir, A.¹; Liman, H.M.² and Umar, B.³

1. Department of Geography, Federal University of Technology, Minna, Nigeria

2. Department of Geography, Ibrahim Badamasi Babangida University, Lapai

3. National Weather Forecasting and Climate Research Centre, Abuja, Nigeria
suleym080563@gmail.com

ABSTRACT: Nigeria; located between latitude 4°N and 14°N and longitude 3°E and 15°E is endowed with vast water resources both proven and potential. The country is well drained with a close network of rivers and streams. Some of these, particularly the smaller ones in the north, are seasonal. There are four principal surface water basins in Nigeria; the Niger River, the Lake Chad, the West Coast and the West Central Coast. There is a very large groundwater potential in Nigeria, far greater than the surface water resources, estimated to be 224 trillion l/year (Hanidu, 1990). This picture of availability leads to reckless use of water resources as if the flow will never cease. Both surface and groundwater sources are often polluted through anthropogenic activities. This overview examines the prospects of water resources in Nigeria, the challenges of availability, accessibility and affordability; and environmental management concerns of water resources. The conclusion is that Nigeria as a nation is endowed with huge water resources with the capacity to meet our burgeoning requirements across all facets of life given the requisite resources and a focused plan of action managed by competent and committed professionals within a well orchestrated institutional framework. To mitigate threats to our water resources, government must step up Integrated Water Resources management where all sectors must synergize to achieve results.

Keywords: Water resources, Groundwater, Environment, Prospects, Challenges

1. Introduction

Water resources are sources of water that are useful or potentially useful. Uses of water include agricultural, industrial household, recreational and environmental activities; the majority of human uses require fresh water. 97% of the water on the Earth is salt water

and only three percent is fresh water; slightly over two thirds of this is frozen in glaciers and polar ice caps. The remaining unfrozen fresh water is found mainly as groundwater, with only a small fraction present above ground or in the air (Earth Water Distribution, 2009). Fresh water is a renewable

resource, ground water is steadily decreasing, with depletion occurring most prominently in Asia and North America, although it is still unclear how much natural renewal balances this usage, and whether ecosystems are threatened.

Surface water is water in a river, lake or fresh water wetland. Surface water is naturally replenished by precipitation and naturally lost through discharge to the oceans, evaporation, evapotranspiration and groundwater recharge. Although the only natural input to any surface water system is precipitation within its watershed, the total quantity of water in that system at any given time is also dependent on many other factors. These factors include storage capacity in lakes, wetlands and artificial reservoirs, the permeability of the soil beneath these storage bodies, the runoff characteristics of the land in the watershed, the timing of the precipitation and local evaporation rates (Green facts, 2008). All of these factors also affect the proportions of water loss.

Human activities can have a large and sometimes devastating impact on these factors. Humans often increase storage capacity by constructing reservoirs and decrease it by draining wetlands.

Humans often increase runoff quantities and velocities by paving areas and channelizing stream flow. The total quantity of water available at any given time is an important consideration. Some human water users have an intermittent need for water. For example, many farms require large quantities of water in the spring, and no water at all in the winter. To supply such a farm with water, a surface water system may require a large storage capacity to collect water throughout the year and release it in a short period of time. Other users have a continuous need for water, such as a power plant that requires water for cooling. To supply such a power plant with water, a surface water system only needs enough storage capacity to fill in when average stream flow is below the power plant's need.

Nevertheless, over the long term the average rate of precipitation within a watershed is the upper bound for average consumption of natural surface water from that watershed. Natural surface water can be augmented by importing surface water from another watershed through a canal or pipeline. Humans can also cause surface water to be "lost" (i.e. become unusable) through pollution.

2. Water Resources of

Nigeria: Spatial and Temporal Distribution

Nigeria is by far the most populous country in Africa, with its 127 million people accounting for about one-seventh of the total population of Africa's 53 countries (Spon, 1997)). Realizing that the single most important necessity for man is water, the Nigerian Government's priority and investment in water resource development, supply and distribution is borne out of the realization that water is not only a critical human need but also a major factor of socio-economic development. Also, it assists in the eradication of water borne diseases like guinea worm, which has plagued certain areas of the country.

2.1 Surface Water Resources

Nigeria has four large main surface water basins, providing opportunities for irrigated agriculture as well as fisheries. The two largest basins with their tributaries and distributaries are the Niger River Basin and Lake Chad Basin, covering about 83% of the country. Rivers and lakes make up approximately 16% of Nigeria's total surface area. Two surface water systems, the Chad and Niger-Benue complexes dominate the country's Hydrology/Hydrogeology. Nigeria has extensive fadama areas or flood plains found along

the country's rivers, especially the Niger, Benue, Sokoto, Rima, Hadeija/Jamaare, Yobe in the North; and Anambra, Imo, Ebonyi, Cross River, Idemili, Benin, Ogun, Osun etc. rivers in the Southern parts. The fadama areas provide rich grazing and agricultural lands and are internationally important areas for all season farming and biodiversity.

Nigeria has annual internal renewable water resources of 221 cubic kilometers. Sixty-nine percent of water is used for agriculture, 21% for domestic uses and 10% for industries. Potable water supplies are scarce and irregular; in many areas water service is intermittent, sanitation facilities unavailable and water quality is substandard nationwide, suggesting that more than half the population is unable to access sufficient clean water on a regular basis. Nigeria's water resources have been degraded by floods, soil/gully erosion, siltation, salinization, saltwater incursion, pollution and contamination from industrial and agricultural sources, human and animal wastes. Nigeria's rapid population growth has not been accompanied by an increase in the delivery of water supply, sewerage and sanitation services.

The country of Nigeria is well drained with a close network

of rivers and streams. Some of these, particularly the smaller ones in the north, are seasonal. There are four principal surface water basins in Nigeria; the Niger River, the Lake Chad, the West Coast (sometimes referred to as the southwestern littoral basins), and the West Central Coast (also known as the southeastern littoral basins).

The Niger Basin (See Figure 1) has an area of 584,193 km² within the country, which is 63 percent of the total area of the country, and covers a large area in central and north western Nigeria. The most important rivers in the basin are the Niger and its tributaries Benue, Sokoto and Kaduna.

Lake Chad Basin (depicted in Figure 2) located in the northeast with an area of 179,282 km², or 20 percent of the total area of the country, is the only internal drainage basin in Nigeria. Important rivers are the Komadougou Yobe and its tributaries Hadejia, Jama'are and Komadougou Gana.

The West Coast Basin (See Figure 3) has an area of 101,802 km², which is 11 percent of the total area of the country. The rivers originate in the hilly areas to the south and west of the Niger River.

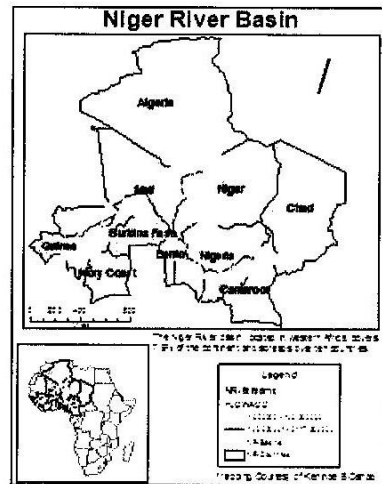


Figure 1: The Niger Basin

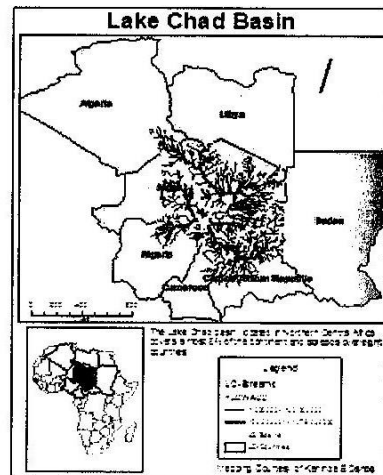


Figure 2: The Lake Chad Basin

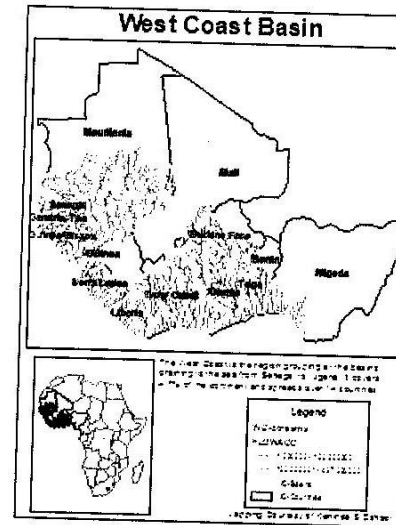


Figure 3: The West Coast Basin

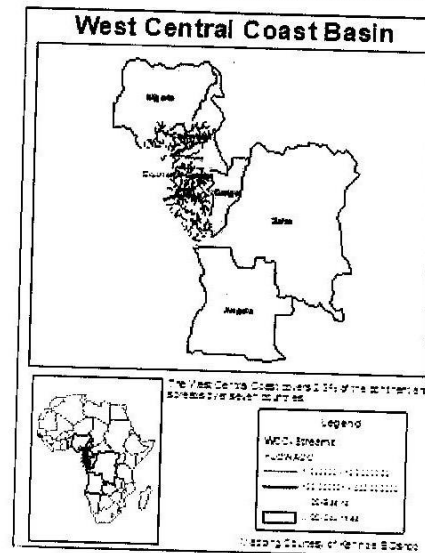


Figure 4: The Central West Coast Basin

The West Central Coast Basin (illustrated in Figure 4) with major water courses being the Cross and Imo Rivers, have an area of 58,493 km², which is 6 percent of the total land area of the country, and receive much of their runoff from the plateau and mountain areas along the Cameroon boarder.

2.2 Ground Water Resources

There is a very large groundwater potential in Nigeria, far greater than the surface water resources, estimated to be 224 trillion l/year (Hanidu, 1990). It is estimated that groundwater resources at 0 to 50 m depth in Nigeria is in the region of 6 × 10 km³. However, from the eight aquifers in Nigeria the Ajali Sandstone aquifer yields 7 to 10 l/s, the Benin formation (Coastal Plain Sands) aquifer yields 6 to 9 l/s, the Upper aquifer 2.5 to 30 l/s, the Middle aquifer 24 to 32 l/s, the Lower aquifer with yields of 10 to 35 l/s (of the Chad formation), the Gwandu formation aquifer with yields of 8 to 15 l/s, the Kerrikerri Sandstone aquifer with yields of 1.25 to 9.5 l/s and the crystalline fluvio-volcanic aquifer with a 15 l/s yield in the Jos Plateau region; groundwater occurrence is not limited to only 50 m b.g.l (below ground level). These eight mega regional aquifers have an effective

average thickness range of 360 m, with a thickness range of 15 to 3,000 m at a depth range of 0 to 630 m b.g.l with an average depth of 220 m. Reserves of groundwater are considerable in large sedimentary basins, which cover some 50% of the country. The potential annual groundwater resources are estimated at $51.93 \times 10^9 \text{ m}^3$, out of which the sedimentary basins account for 67% (FMWRRD, 1995).

The occurrence of groundwater is greatly influenced by the local geological conditions which ultimately control yields. Recharge to aquifers, which influences the safe yields of wells, depends on rainfall over the area. Thus, rainfall ultimately controls the amount of groundwater recovered from wells in any given locality. The amount of

groundwater storage is not yet known, but available records indicate that major aquifers in Nigeria are located in the sedimentary deposit basins which cover about 50% of the nation's land area. The remaining 50% is underlain by crystalline rocks of the basement complex. Aquifers within the basement are limited, their thickness ranges from 16 to 180 m, but depth of hand dug wells and boreholes are therefore seldom more than 60 m with a variable average of static water level between 1 to 45 m below the surface. This shallow depth coupled with the poor hydraulic conductivity, no doubt account for the general low yield of $1.0 \text{ m}^3/\text{h}$ (Nwaogazie, 1995). On the sedimentary deposits, groundwater resources usually occur either as confined aquifers.

Table 1: Distribution of Annual Average yield of Surface and Groundwater in Nigeria

Hydrological Area	Average Surface water annual yield $10^9 \text{ (m}^3\text{)}$	Average Groundwater annual yield $10^9 \text{ (m}^3\text{)}$
Chad Basin	8.2	5.6
North West	22.4	4.3
Upper/ Lower Benue	83.0	11.4
West Littoral	35.4	9.0
Niger	85.9	13.4
North Central	32.4	8.2
Total	267.3	51.9

Source: Martins (2001)

Groundwater resources are controlled by the hydrostratigraphy of the country and follow the pattern of occurrence of the aquifers, aquitards or aquicludes. More than half of the country is made up of igneous and metamorphic rocks which make up the basement complex. Even though these hard rocks are essentially non-water bearing (aquiclude) there are areas of weathered basement rocks which have acquired secondary porosity due to weathering over geologic time. These areas furnish moderate to marginal water yields at depths of 20-100 m. normally, weathering and compaction processes are followed by fracturing which is a major factor of incompetent rocks at depths.

These secondary aquifers are characterized by their non-extensive nature, susceptibility to anthropogenic pollution and climatic vagaries. As one proceeds towards the south, The prospects of good aquifers increase. Thus within the Anambra basins and Niger delta basins ground water yield becomes extensive to the extent that free flow conditions occur in confined areas.. Unlike surface water that cuts across geographical boundaries, the occurrence of groundwater in

terms of quantity and quality displays spatial variability being driven by the geology and climate.

On this premise, we can chronicle the availability based on three hydro-meteorological areas: **The Sahel Region:** Although the Sahel region comprises areas above latitude 11° , there is gradual southward advancement of the Sahara to now cover areas down to 10° latitude. As a result, three River basins are considered to lie within the Sahel; the Sokoto basin, the Hadejia-Yobe basin and the South-east Chad basin. The main characteristics of the area are low annual precipitation of 500-750 mm. The region is also associated with greater extremes of temperature as high as 44°C before the onset of the rains or drop to as low as 6°C during the cool harmattan air around December to February. The Sokoto basin is drained by the River Sokoto with the Ka, Zamfara and Rima as tributaries. The groundwater resources are furnished by the fractured meta-sediments within the basement complex. Boreholes in these meta-sediments are shallow (30-40 m). Borehole yields are low (0.5-0.8 lit/sec), with steep drawdown. The Gundumi and Illo Formations are aquiferous but occasionally deeply confined.

Yields of 8 lit/sec and transmissivity of up to 978 m²/day have been reported at Gusau-Sokoto road by Anderson et al. (Anderson, 1973). Another borehole in the same town (Bakura Farm) was 85 m deep and gave 3 lit/sec. The Rima group comprising the Taloka (poor aquifer) and Dukamaje (aquiclude) Formations are not impressive hydrogeologically. The Wurno Formation is a moderate water yielding aquifer in the Sokoto basin. The thickness varies from 5-30 m and the recharge is restricted to only 330 km² (Ofordile, 2002). The Sokoto Group consists of the Dange (aquitard), the kalambiana (perched aquifer, furnishing water seasonally) and the Gwandu Formation (best known aquifer in the Sokoto basin). The Gwandu consists of two main aquifers-an upper sandy aquifer and a lower confined sandy aquifer.

For the water table aquifer, water levels average 21 m, though in the uplands, near the Niger border, depths of 100 m can be recorded. Further west, and down dip, the aquifer is confined by 20 m of clay and lignite, giving rise to artesian conditions. The aquifer itself varies in thickness from 13-60 m. The Hadejia-Yobe basin is drained by the Hadjia-Yobe River. The tributaries rise from Kano,

Katsina and the Jos Plateau, with relatively higher rainfall than the rest of the region. The rivers flow from the area of high rainfall in the Southwest to the area of lesser rainfall towards the Lake Chad. The geology of the basin comprises (from the oldest to the youngest); the basement complex, the younger granite complex, the Gundumi Formation, the Kerrikerri Formation and the Chad Formation.

Within the basement complex and younger granite complex areas, boreholes are shallow (20-35 m), Specific capacity of about 8-9 lit/m/min have been recorded (Ofordile, 2002). In the overlying Gundumi Formation borehole depths average 45 m with maximum yield of 6.25 lit/sec and average of 3.2 lit/sec. The Kerrikerri Formation of thickness of up to 200 m is considered to be unpredictable and inadequately explored. It is however associated with deep water levels (165 m Southeast of Bauchi). It appears to belong to the same hydrostratigraphic unit with the Chad Formation which overlies it. The Chad basin sediments are reported to be 132 m at Gumel, 115 m at Nguru, and 132 m at Marguba. Yields of 3.3-5 lit/sec have been recorded. The separation of the Chad Formation

into an upper, middle and lower aquifer cannot be defined in this part of the basin. The upper 20-30 m of the alluvial sands of the Hadejia-Yobe basin, holds a lot of water as bank storage, directly recharged from river flows. The Chad basin is described as the largest area of inland drainage basin in Africa and occupies parts of Nigeria, Chad, Central Africa Republic and the Cameroon. Most of the rivers flowing into lake Chad rise from the watershed areas of the Jos plateau and the Adamawa highlands. The rivers include the Hadejia-Yobe, Alo and yedsaram from the southwest, and the Bambassa, Chari, Illi and lagone from the south east. The rivers Yedseram-Ngadda flow from the south to the northwest, and with all the minor tributaries and rivulets empty into Lake Chad. The Hadejia-Yobe, the Yedseram and all the other tributaries are seasonal. The yedseram with its smaller catchment area, starts to flow a little later, after the beginning of the rainy season, than the Hadejia-Yobe drainage system. There is practically no surface flow from the more arid regions of the north (Ofordile, 2002).

Two Formations are important, hydraulically, in the Chad basin. These are the kerrikerri and the Chad

Formations. While the kerrikerri is too deep to be of general hydrogeological interest, the Chad formation is well explored and demarcated into upper, middle and lower aquifers. In Maiduguri, the upper aquifer has a depth limit of 105 m. The aquifer consists of lenses of fine to very coarse, often, pebbly sands alternating with clays and sandy clays. The aquifer may be either water table or semi confined. The water levels vary from 10 m to 15 m in wells tapping the aquifer with yields ranging from 2.5 lit/sec to 30 lit/sec. The middle zone aquifer is separated from the upper by about 150 m of plastic clays. It has a thickness of 300 m and is underlain by another 120 m of clay and shale. It is thus highly confined. The recharge areas of the middle confined aquifer all fall outside the geographical boundaries of Nigeria, making it a trans-boundary aquifer.

The Guinea Savannah Zone:

This zone covers the area with mean annual precipitation of 1000-1250 mm and about 80 to 60 days of rainy days northwards. About five River basins fall within this zone, namely; the Kaduna River basin, the Benue River basins(upper and lower), the Upper and lower Niger Basins. The Kaduna River basin is drained

by the River Kaduna and its tributaries. The River has its headwaters at the Jos Plateau. The climate is typical of most northern areas of Nigeria, except areas bordering the Jos Plateau which feature the orographic influence of highland areas of the Plateau. The temperature shows a mean annual of 24 °C to 30 °C. Precipitation shows a mean of 1120 mm but attain 1500 mm around the plateau area. Over 80% of the Kaduna basin is underlain by basement complex rock with shallow well yields of 0.2-1 lit/sec. The rest of the basin is underlain by the Nupe sandstone and alluvial deposits [4]. The Nupe sandstone underlies most of the southeast including Kontagora,, Mokwa and Bida areas. It consists of slightly cemented fine to coarse sandstones and siltstones with interbedded thin beds of carbonaceous shale and clays. Yields of 1.8-4 lit/sec have been reported in the Nupe sandstone (Du Preeze, 1965).

The Benue River is a continuous elongated geological structure, conveniently subdivided into Upper, Middle and lower basins. The upper Benue River basin occupies the upper reaches of the Benue valley. Its main drainage network

comprises numerous streams and rivers flowing into the River Benue from the north and South. The major river systems include the Gongola, Kilunga, and Pai to the north and the Faro and Taraba from the south of the River Benue. The temperature in the Benue valley is relatively high. It is typified by the recording from Yola where the mean daily maximum ranges from 29°C to 32°C in May to October, 32°C to 40°C in October to April. The highest mean maximum temperatures, of 38°C to 40°C, are recorded in February to April. The mean minimum ranges from 18°C to 21°C from November to February. Rainfall is limited, with a mean annual of 750 mm to 1000 mm. The Upper Benue basin is underlain by patches of the basement complex rocks, including a number of volcanic plugs, basaltic flows, and sedimentary rocks of cretaceous age. The geological sequence comprises the basement overlain by the thick sequence of shale of the Asu River group, continental sandstones of the Bima sandstone and shale, clays and limestone. The upper Benue is separated from the Chad basin by the Z a m b u k r i d g e . Of hydrogeological interest are the weathered basalts in Biu, Longuda and Sugu plateau areas.

Of more hydrogeological interest is the Bima sandstone outcropping in Yola, Jimeta,, Dabore areas. It is essentially feldspar sandstone with grit, pebbles and clay beds. It is highly cemented and behaves like crystalline rocks, hence its constraints hydrologically. Yields of 2 lit/sec to 8 lit/sec have been recorded. The Lower Benue River basin includes the lower reaches of the Benue valley, stretching from about river Wase down to the confluence of the Benue and Niger to the south. This part is drained by a number of River systems, including the River Wase, Shemankar, Dep and Mada, flowing northeast wards and the Donga, Bantaji and Katsina Ala drainage network flowing in the opposite direction, all the river systems emptying into the River Benue.

The climate is characterized by high temperature regimes, like in the upper Benue, ranging from between 27°C as mean annual. The altitude influences the situation in Jos. Rainfall is moderate with a range of 1120-1500 mm on the Plateau. The geology of the Lower Benue is related to the Upper Benue with close similarity in lithology of the geological formations. These include the Interbedded Sandstones of the Awe Formation,

the Sandstones of the Makurdi and Ezeakku Formation, sandstones of the Awgu Formation and the basal sandstones of the Lafia Formation. A number of boreholes have been drilled into the Makurdi Formation with varying degree of success. Yields of 2.5 lit/sec 8.7 lit/sec have been reported. A borehole of about 150 m drilled into the Awgu formation furnished artesian flow at Assakio, north of Lafia. The Lafia formation has highly permeable sandstone of thickness 10-150 m and gives rise to various springs at the contact with underlying Awgu formation.

The Niger Basin consists of the broad valley of the River Niger, from the confluence of the Rivers Niger and Benue to the north western border with Benin Republic. The Basin is subdivided into Upper and Lower Niger Basins. The Upper Basin represents the upper arm of the drainage area of the River Niger covering an area of about 116,300 km². The River Niger, in the upper Niger Basin of Nigeria, is charged with water, from mainly, the Sokoto-Rima and Kaduna River systems. Responsibility for potable 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, and in some states also for rural water supply. As of 2000, 22 States had separate State Rural Water and Sanitation Agencies (RUWASSA), mostly set up to implement a UNICEF programme. The 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 address the problem. The most important external partners in the Nigerian water supply and sanitation sector are the African Development Bank, the European Union, Japanese JICA, UNICEF, USAID, the NGO WaterAid and the World Bank. The African Development Bank and the World Bank provide loans to the government; the European Union, JICA and USAID provide grants to the government; UNICEF and WaterAid receive grants from governments and donations from the public to implement their projects in cooperation with, but not through the government. Water policy

Nigeria's National Water

Supply and Sanitation Policy, approved in 2000, encourage private-sector participation and envisages institutional and policy reforms at the state level. However, little has happened in both respects. As of 2007, only four of the 37 states - Lagos, Cross River, Kaduna and Ogun States - began to introduce public-private partnerships (PPP) in the form of service contracts, a form of PPP where the responsibility of the private sector is limited to operating infrastructure without performance incentives. While the government has a decentralization policy, little actual decentralization has happened. The capacity of local governments to plan and carry out investments, or to operate and maintain systems, remains low despite efforts at capacity development. Furthermore, the national policy focuses on water supply and neglects sanitation.

In 2003 a "Presidential Water Initiative (PWI): Water for People, Water for Life" was launched by then President Olusegun Obasanjo. The initiative had ambitious targets to increase access, including a 100 percent water access target in state capitals, 75 percent access in other urban areas, and 66 percent access in rural areas. Little has been done

to implement the initiative and targets have not been met. In 2011 the government voted in the United Nations in favour of a resolution making water and sanitation a human right. However, it has not passed legislation to enshrine the human right to water and sanitation in national law. With the above scenario, it is doubtful if the country will be able to attain the Millennium Development Goal for water and sanitation.

3. Water Resources and Environment: Challenges and Prospects

Water resources development includes the Construction, harnessing, distribution and protection of both surface and groundwater infrastructures for the domestic, agricultural and industrial needs of the society. The exploitation of Nigeria's water resources has progressively increased with the return to civil rule. Despite the progress that has been made in water supply development since the first waterworks in Nigeria was commissioned in Lagos in 1915, many Nigerians still have inadequate access to modern water supply. Water shortages exist periodically in almost every major town and are present in many rural areas of the country. Areas that are provided with

water more often than not revert to water distress due to the unsustainable nature of the infrastructures, making statistics of access unreliable. The turning point for water resources development and management in Nigeria occurred after the severe drought of the 1960s. The Government's response to the catastrophe was the initiation of strategies for co-ordinated and effective water resources development, culminating in the mid-1970s in the creation of the Federal Ministry of Water Resources and the River Basin Development Authorities. The activities of these institutions were further strengthened in 1981 by the establishment of the National Committee on Water Resources, and by the Water Boards at the state level. Later the National Water Resources Institute (NWRI), the Nigerian Hydrological Services Agency (NIHSA), the Rural Water Supply and Sanitation Agencies (RUWASSA) were added. These bodies were charged with taking an inventory, and ensuring rational and systematic planned management and conservation, of the country's water resources. This is further boosted by the various interventions by government, donor agencies and

(c) Indiscriminate disposal of industrial effluents into Surface water bodies

Studies carried out in most cities in Nigeria had shown that industrial effluent is one of the main sources of surface water pollution in Nigeria (Ekiye, 2010). Industrial effluents when discharged directly into the rivers without prior treatment have capacity of Increasing water quality parameters. Dada (1997) indicated that less than 10 % of industries in Nigeria treat their effluents before being discharged into the rivers. This has led to high load of inorganic metals such as Pb, Cr and Fe in most of water bodies (Ahmed, 2000; Wakawa, 2008).

The poorly managed drainage system in the country had caused the surface water impairment due to erosions during rainfall. Rainfall runoff carries all sorts of pollutants from houses, industries, farmland and dumping sites. Industries are the major sources of pollution in all environments. Based on the type of industry, various levels of pollutants can be discharged into the environment directly or indirectly through public sewer lines.

Wastewater from industries

includes employees' sanitary waste, process wastes from manufacturing, wash waters and relatively uncontaminated water from heating and cooling operations. High levels of pollutants in river water systems causes an increase in biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), total suspended solids (TSS), toxic metals such as Cd, Cr, Ni and Pb and faecal coliform and hence make such water unsuitable for drinking, irrigation and aquatic life. Industrial wastewaters range from high biochemical oxygen demand (BOD) from biodegradable wastes such as those from human sewage, pulp and paper industries, slaughter houses, tanneries and chemical industry.

Others include those from plating shops and textiles, which may be toxic and require on-site physiochemical pre-treatment before discharge into municipal sewage system. Research has shown that some of the water quality parameters of both ground and surface water often rise up during rainfall with high values of turbidity, solids and anionic species often been recorded (Taiwo, 2011; Jaji, 2007; Taiwo, 2010; Mustapha, 2008 & Izonfuo, 2001).

Agricultural run-

off of pesticides, plant and animals wastes is also a major contributing source of organic pollution to water bodies in Nigeria. Agricultural run-off of pesticides, plant and animals wastes is also a major contributing source of organic pollution to water bodies in Nigeria. The work of Mustapha (2008) had Linked the periodic eutrophication of Oyun Reservoir in Offa, Kwara state to run-off of phosphate fertilizers from nearby farms in addition to cow dung washing from the watershed into the Reservoir. Water pollution through surface run-off has been reported in Literatures with subsequent effects on nutrient enrichment, water quality impairment, marine lives spawning ground destruction and fish kill (Izonfuo, 2001 & Martins, 1998).

(d) Threats to existing water infrastructures from erosion and contamination of water pipelines

Due to regulation lapses and mining is a common business in eastern Nigeria. These activities often lead to severe erosion of the pipelines leading to excavation and collapse of the pipelines (Figure 8). Effluents from industrial and domestic activities usually enter the network through

the joints of the collapsed pipes. The situation is further aggravated by the activities of cattle men who take advantage of the leakages from the pipes to provide water for their herds. Unfortunately these activities take place in areas far from residential areas such that detection may take months to occur.

4 Conclusion and Recommendations

The Nigeria Water Sector has significant potentials to contribute to the development of the economy. The provision of potable water for cooking and drinking; and the construction of dams for hydro-electricity are all relevant for economic development while irrigation facilities across the country have helped the nation to support its growing population without solely depending on rain-fed agriculture. Additionally, the existence of dams and irrigation schemes has contributed to suburban development of several communities and induced socio-economic improvement of the residents. Clearly, the Water Sector has a major role to play in the sustenance and further development of the nation's industrial sector especially in food and beverages, textile, pharmaceutical among others.

The supply of potable water holds the key to the elimination of water-related diseases such as cholera, typhoid, dysentery, river blindness and malnutrition.

Fortunately, Nigeria as a nation is endowed with huge water resources with the capacity to meet our burgeoning requirements across all facets of life given the requisite resources and a focused plan of action managed by competent and committed professionals within a well orchestrated institutional framework. This will require significant capital to transform the stated objectives and requirements into available water resources for domestic and industrial consumption. The amount of resources required to maintain the dams and irrigation facilities as well as keep the taps running would require the private sector participation.

In view of these considerations, Government needs to take the first step of articulating a holistic roadmap for the development and management of the nation's water resources towards the actualization of the sector's potentials. We believe that with the support of private sector investors and other key stakeholders, focused implementation of the roadmap will facilitate the achievement of

water target objectives and create the enabling environment to attract private investments in this sector. To mitigate threats to our water resources, government must step up Integrated Water Resources management where all sectors must synergize to achieve results.

The Federal Ministry of Environment must strengthen the present environmental laws such that the polluters of water bodies could be prosecuted. Industrial and agricultural sectors should also be compelled to treat their wastes before being discharged into the water bodies. Drastic measures must be taken by all authorities concerned to minimize children morbidity and mortality due to poor sanitation and water quality problems. The threats to water resources are variable and many. The variation in water quality experienced in Nigeria reflects differences in land management and the physical environment. These differences occur both as a result of natural variability, societal development and pollutant inputs. In addition, water quality in the vicinity of urban areas is influenced by industrial and urban development. Understanding the condition of rivers and streams and their relation to ground water

is critical to effective mitigation of threats to water development.

The River basins and Research Institutes must evolve custom mitigation measures suitable for the hydro meteorological environment. Education of the benefitting masses is also likely to help in reducing anthropogenic threats to our water bodies. The Ministry of Environment should take up the challenge by stepping up regulations.

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