



GROUNDWATER RESOURCES AND MANAGEMENT IN NIGERIA

By

Jamiu Alao Alimi

Programme officer (Groundwater)

**Regional Centre for Integrated River Basin Management
National Water Resources Institute, P.M.B. 2309, Kaduna,
Nigeria**

jamiualimi69@yahoo.com; +2348039104697

Geography

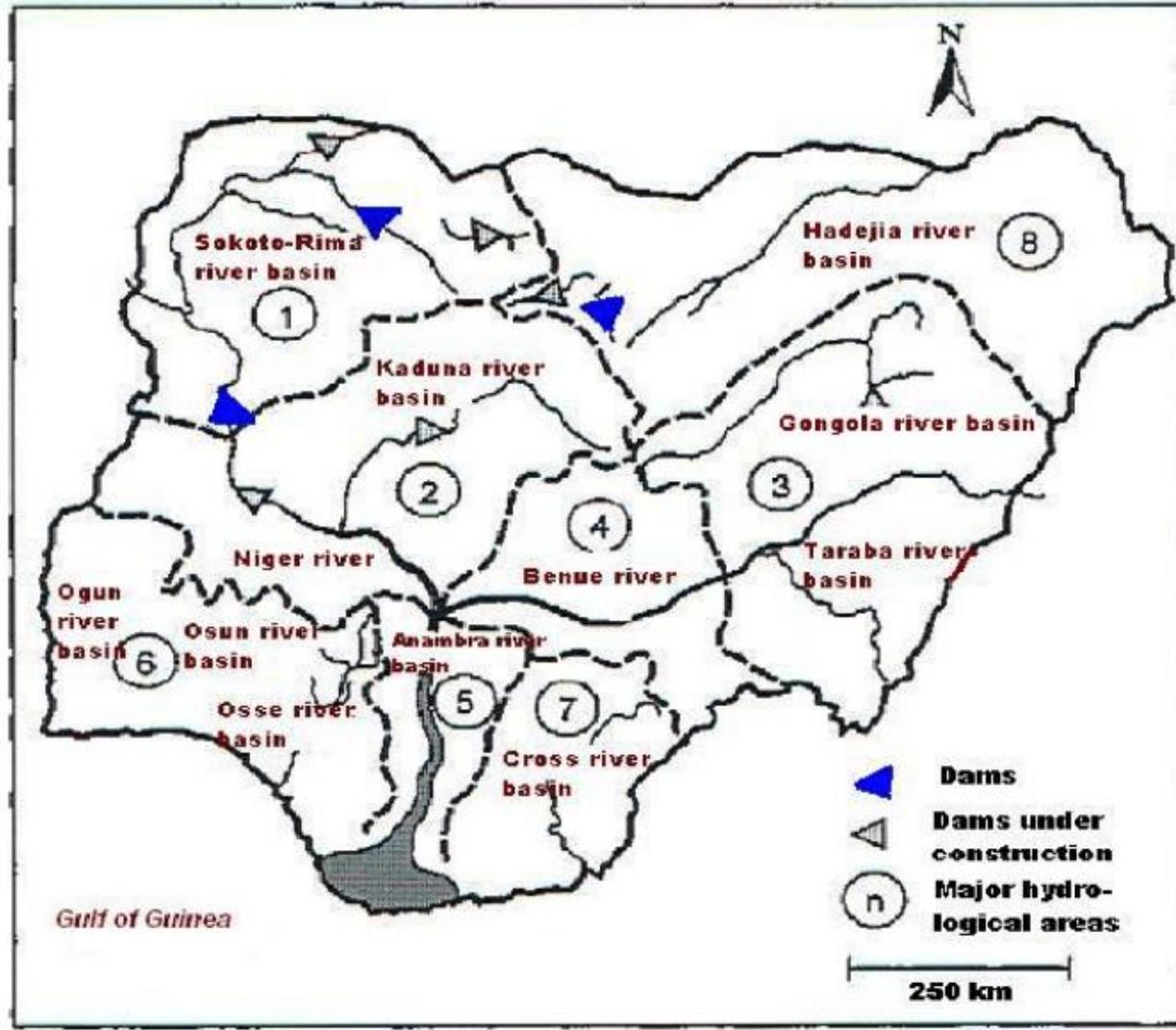
- Nigeria is located on the west coast of Africa, south of the Sahara between latitudes 4° and 14° N and longitudes 3° and 14° E.
- Has a landmass of 923,770 km² (92,377,000 ha).
- It is bordered on the south by the Atlantic Ocean, Niger Republic in the north, and by Benin Republic and Cameroon on the west and east respectively.
- It extends approximately 1,127 km east-west and 1,046 km north-south.
- Nigeria is currently divided into 36 states with Abuja as the federal capital.

Physiography and climate

- Great variety of relief features encompassing uplands of 600 m to 1,300 m on the Jos plateau, the north central and the eastern highlands; and lowlands of less than 20 m in the coastal areas extending as far inland as 60 km from the shoreline.
- Nigeria has a tropical climate, varying from humid in the south to semi-arid in the north. This climate is characterized by hot and wet conditions.
- Mean monthly temperatures during the day is about 36°C, while mean monthly temperatures at night fall below 22°C.
- Rainfall distribution varies spatially and temporally. Rainfall is seasonal with distinct wet and dry seasons.
- Coastal zone in the south experiences all year round rainfall with mean annual rainfall of 4,800 mm
- Less than 500 mm in the north east.
- In the extreme northwest close to the Niger Republic border, approximately 350 mm of rainfall is recorded.

Drainage

- Four major drainage systems:
 - The Niger River Basin Drainage System with its major tributaries of Benue, Sokoto-Rima, Kaduna, Gongola, Katsina-Ala, Donga, Tarabe, Hawal and Anambra Rivers.
 - The Lake Chad Inland Drainage System comprising the Kano, Hadejia, Jama'are Misau, Komadougou-Yobe, Yedoseram and Ebeji Rivers.
 - The Atlantic Drainage System (east of the Niger) comprising the Cross, Imo, Qua Iboe and Kwa Rivers.
 - The Atlantic Drainage System (west of the Niger) made up of the Ogun, Oshun, Owena and Benin Rivers.
- Apart from the Lake Chad Drainage System, the remaining three drainage systems terminate in the Atlantic Ocean with an extensive network of delta channels.



- | | |
|---------------------------|---------------------------|
| 1 Niger North | 2 Niger Central |
| 3 Upper Benue | 4 Lower Benue |
| 5 Niger South | 6 Western Littoral |
| 7 Eastern Littoral | 8 Lake Chad |
- (Source: Taiwo *et al.*, 2012).

Fig.1 Map of Nigeria showing major rivers and hydrological basins

Socio-economic context

- Oil is the major economic mainstay. About one third of Nigerians are employed in agriculture.
- The staple food crops include cassava, yam, corn, coco-yam, cow-pea, beans, sweet potato, millet, plantain, bananas, rice, sorghum, and a variety of fruits and vegetables. The leading cash crops are cocoa, citrus, cotton, groundnut (peanut), palm oil, palm kernel, benniseed and rubber.
- Both manufacturing industry and service sector are growing, particularly telecommunications and financial services. The mining industry is still small even though Nigeria has large mineral resources.
- The GDP per capita in 2017 is USD1, 995.
- The country had a population as at 2015, of **182.2** million out of which **52%** (94,522,000) live in **rural areas** and **48%** (87,680,000) live in **urban areas** (FAO Aquastat).
- According to FAO Aquastat, in 2015, **57.3%** of the rural population had access to safe drinking water, while **80.8%** of the urban population had access to safe drinking water.
- Groundwater is widely used for domestic, agricultural and industrial supplies. Most rural areas and a number of towns and cities depend on groundwater.
- There is renewed effort by the current administration to diversify the economy from being oil dependent to agricultural and other non-oil sectors.

Groundwater resources

Hydrogeology:

- Nigeria's geology is made up of two main rock types: Basement complex and the Sedimentary basins, which are roughly in equal proportions (figure 2). Other minor formations are the volcanic plateau and the River alluvium.
- The major aquifers in Nigeria are **Basement aquifers, Sedimentary basins, Volcanic plateau, and River alluvium.**
- **Basement aquifers** 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 15 m. Boreholes tend to be drilled to depths between 10 and 70 m, depending on local conditions.
- **Sedimentary aquifers** generally consist of thick sequences of sediments with yields between 2 and 60 l/s; water table depth between 10 and 40 m; and borehole depths from 20 m to 150 m. Coastal sedimentary basins have borehole depths between 10m and 800 m and yields between 2 and 60 l/s.

Groundwater resources (Contd)



Fig. 2 Generalized geological map of Nigeria (Source: Adelana *et al.*, 2008)

Groundwater resources (Contd)

- **Volcanic plateau** is found around Jos plateau and Bauchi State of Nigeria
- The rock types are mainly olivine basalts, scoriaceous lavas and tuffs.
- These rocks form typically unconfined aquifers with low to moderate yields, usually below 3 l/s. Aquifer thickness varies substantially.
- Water table depth is less than 5 m. Borehole depths of 15 to 50 m are common.
- **River alluvium aquifers** 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 15 km wide on each side of the river. They are thickest (15-30 m thick) along the rivers Niger and Benue and are largely unconfined with shallow water tables.

Groundwater systems:

- Aquifer distribution in Nigeria is categorized into two systems: basement fluvio-volcanic aquifers and sedimentary aquifers.
- There are eight major regional aquifer systems, 30 local and minor aquifers and 36 aquicludes, aquitards, and aquifuges in Nigeria (Adelana, 2012).
- These eight mega regional aquifers have an effective average thickness of 360 m; with a range of 15–3,000 m. Yields from major aquifers in range between 1.25 and 32 l/s. The sedimentary basins generally form the most prolific aquifers.
- Olorunfemi and Fasuyi (1993) identified five aquifer types in the Basement Complex as :
 - the weathered aquifer;
 - the weathered/fractured (unconfined) aquifer;
 - the weathered/fractured (confined) aquifer;
 - the weathered/fractured (unconfined)/fractured (confined) aquifer; and
 - the fractured (confined) aquifer
- Mean groundwater yield for the aquifer types varies from 0.83 l/s to 3 l/s.
- An optimum borehole depth for the typical basement complex is 60-70 m.

Aquifer yield, recharge and groundwater potential:

- The crystalline basement of Nigeria generally represents the deeper, fractured aquifer and is noted as a poor source of groundwater.
- Basement complex aquifers have low to moderate yields (0.83 to 3 l/s).
- Yields between 1–2 l/s in the Nigerian basement rocks are considered good enough for the installation of motorized submersible pumps, while values of borehole yield <0.5 l/s are still adequate for hand pumps .
- Groundwater recharge into the Basement aquifers is mainly through direct infiltration from rainfall.
- Generally, Basement aquifers have low groundwater potential because groundwater occurs in thin, localized and disconnected aquifers.
- Major aquifers in the coastal zone of western Nigeria have thicknesses ranging between 100 and 250 m with mean groundwater storage of 2.87×10^3 m³ .
- The surface water resources potential of the country is estimated at 267.3 billion cubic metres while the groundwater potential is 51.9 billion cubic metres (National Water Policy, 2004).

Table 1 Yields from major aquifers in Nigeria (Akujize *et al.*, 2003).

MAIN AQUIFERS	YIELD (LS⁻¹)
Ajali Sandstone aquifer	7-10
Benin Formation (Coastal plain Sands) aquifer	6-9
The upper aquifer (Chad Formation)	2.5-30
The Middle aquifer (Chad Formation)	24-32
The Lower aquifer (Chad Formation)	10-35
Gwandu Formation aquifer	8-15
The Kerrikerri Sandstone aquifer	1.25-9.5
Crystalline fluvio-volcanic aquifer	15

Table 2 Estimated groundwater recharge at a regional level across Nigeria (JICA, 2014)

Region	Estimated Groundwater Recharge (BCM/year)
Niger North (Northwest Nigeria)	5.0
Niger Central (West-central Nigeria)	20.5
Upper Benue (East-central Nigeria)	19.3
Lower Benue (East Nigeria)	18.6
Niger South (South-central Nigeria)	31.9
Western Littoral (Southwest Nigeria)	23.4
Eastern Littoral (Southeast Nigeria)	32.8
Chad Basin (North-east Nigeria)	4.2

Groundwater quality

- Generally, groundwaters in most of the aquifers in Nigeria are fresh with low concentrations of total dissolved solids ($< 500 \text{ mg L}^{-1}$).
- With respect to agricultural and irrigation purposes the groundwaters are excellent.
- However, groundwater is exposed to active pollution in major cities and rural communities of Nigeria due to increased urbanization, indiscriminate waste disposals, intensive agricultural practices and industrial activities.
- There are reports of metals contamination of groundwater from mining activity; and sea water intrusion into southern coastal aquifers due to lowering of groundwater levels following over-abstraction (Ministry of Water Resources 2013).

Table 3 Groundwater quality in Nigeria (Modified after Edet *et al.* 2011)

Parameter *	Min	Max	Mean	WHO MPL (2012)
pH	6.04	7.05	6.58	6.5-8.5
Conductivity ($\mu\text{S cm}^{-1}$)	30.16	635.36	270.63	1, 000
Dissolved Solids	10	413.92	164.83	500
Sodium	0	202.09	30.35	200
Potassium	0.02	52.29	8.07	12
Calcium	1.04	55.6	20.16	75
Magnesium	0.2	46.01	9.98	30
Chloride	0.87	82.55	25.34	200
Bicarbonate	4.64	237.79	71.5	250
Sulphate	0	87.38	21.03	250
Nitrate	0	97.22	18.38	50
Iron	0.04	12.01	1.28	0.3
Manganese	0.05	0.58	0.2	0.2

*All units are in mg L^{-1} except pH or unless indicated

WHO MPL= World Health Organization Maximum Permissible Level (2012)

Groundwater Development and Utilization

Groundwater abstraction

- Groundwater in Nigeria is abstracted through hand dug wells and drilled boreholes
- In 2013 there were around 65,000 boreholes or other groundwater points in Nigeria, extracting an estimated total of 6,340,000 m³/day (Ministry of Water Resources 2013; JICA 2014).
- Rural water supply boreholes are usually installed with hand pumps, which have a maximum pumping capacity of 10 m³/day.
- More than 2, 000 private sector drilling companies in Nigeria.
- Average cost of drilling a 60 m-deep borehole in the Basement complex areas of Nigeria ranges between 450, 000 and 550, 000 Nigerian Naira (1, 232.87 and 1, 506.85 USD) while in the sedimentary areas the average cost of drilling ranges between 700, 000 and 1, 500, 000 Nigerian Naira (1, 917.81 and 4, 109.59 USD) depending on local conditions.

Groundwater Development and Utilization (Contd)

- JICA study(2014) identified issues that were affecting both yield and quality of groundwater in Nigeria as:
 - Over abstraction leading to water level decline and boreholes drying up;
 - Contamination of groundwater resulting from sea water intrusion and infiltration of domestic and industrial contaminants.
- The study suggested the following measures to increase resilience to climate change in Nigeria's groundwater supply:
 - Future boreholes should be drilled 20 m deeper;
 - Pumps should be positioned at greater depth (20 m deeper than present).

Groundwater utilization:

- Groundwater is widely used in Nigeria for domestic, agricultural and industrial purposes.
- With a population of 182.2 million in 2015, the per capita water availability was 1,536 m³/year and is expected to drop to 1,175 m³ in year 2025 with a projected population of 238.4 million people.
- A 1996 survey by the Ministry of Water Resources found only 63% of Nigerian boreholes were in working order, with many out of action due to pump failure.
- For domestic water supply, one borehole could serve 230- 500 people living within 500 m radius of the water point.
- Given that 52 percent of the population lives in rural areas, which are to be served with hand-pump boreholes, Nigeria will need at least 190,000 boreholes to serve its 95 million people living in rural areas alone.

Institutional and Legal Framework

- Many bodies are responsible for groundwater management in Nigeria.
- These include:
 - Nigeria Hydrological Services Agency (NIHSA)
 - Nigeria Integrated Water Resources Management Commission (NIWRMC)
 - The state Ministries of Water Resources and their Rural Water Supply and Sanitation Agencies (RUWATSSAN)
 - The National Water Resources Institute
 - All the River Basin Development Authorities
 - The Nigerian Association of Hydrogeologists (NAH)

Institutional and Legal Framework (Contd)

- The National Water Resources Master Plan recognises current problems in the effective acquisition and management of groundwater data, and recommends strategies for improving this situation (Ministry of Water Resources 2013).
- The 2004 National Water Policy aimed to decentralise management of water to the most local government unit possible and to maximise user participation in planning and management, with central government retaining overall control of water governance.
- Legislation has been developed, including the Water Resources Decree 101 promulgated in 1993 (now referred to as Water Resources Act 100), but is under review and awaiting enactment.

Conclusions

- With many of the surface water now polluted, focus on the importance of groundwater as a drinking water source has to increase.
- Groundwater is generally taken as been the ‘free gift from God’. Therefore, those exploiting this natural resource have taken no action to protect its quality as well as ensuring its sustainable management.
- While regional plans and rules exist to protect surface waters, legislation for groundwater protection is in its infancy in Nigeria and requires much improvement.
- Much of the water legislation in Nigeria is use-oriented without much focus on scientific research such as groundwater pollution vulnerability.

Recommendations

- Land use should be controlled and managed in terms of effluent discharge and waste management.
- National assessment of vulnerability of aquifers to pollution should be carried out. Local and municipal governments should also design or approve similar projects based on the resources available to them.
- Simple and manageable groundwater protection zones based on aquifer pollution vulnerability and source protection parameters could be established.
- Scientific research-oriented, in addition to use-oriented legislation on groundwater management and aquifer protection should be enacted to ensure long-term sustainable use of groundwater in future generations.



THANK YOU FOR LISTENING