FEDERAL REPUBLIC OF NIGERIA

FEDERAL MINISTRY OF WATER RESOURCES

NIGERIAN INTEGRATED WATER RESOURCES MANAGEMENT COMMISSION

DEVELOPMENT OF SUSTAINABLE WATER FOOTPRINT IN NIGERIA

FINAL REPORT

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TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 BACKGROUND

Nigeria Integrated Water Resources Management Commission has commissioned JIL Engineering Associates Ltd to Develop a Sustainable Water Footprint In Nigeria.

This project is being implemented by the federal ministry of water resources through the Nigeria Integrated Water Resources Management Commission.

The earth's freshwater resources are subject to increasing pressure in the form of consumptive water use and pollution (Postel, 2000; WWAP, 2003, 2006, 2009). Until recently, issues of freshwater availability, use and management have been addressed at a local, national and river basin scale. The recognition that freshwater resources are subject to global changes and globalization have led a number of researchers to argue for the importance of putting freshwater issues in a global context (Postel et al., 1996; Vörösmarty et al., 2000; Hoekstra and Hung, 2005; Hoekstra and Chapagain, 2008; Hoff, 2009). Appreciating the global dimension of freshwater resources can be regarded as a key to solving some of today's most urgent water problems (Hoekstra, 2011).

In formulating national water plans, governments have traditionally taken a purely national perspective, aiming at matching national water supplies to national water demands. Governments have looked for ways to satisfy water users without questioning the total amount of water demands. Even though governments nowadays consider options to reduce water demands, in addition to options to increase supplies, they generally do not consider the global dimension of water demand patterns. Since production processes in a global economy can shift from one place to another, water demands can be met outside the boundaries of a nation through the import of commodities. All countries trade water-intensive commodities, but few governments explicitly consider options to save water through import of water-intensive products or to make use of relative water abundance to produce water-intensive commodities for export. In addition, by looking at water use within only their own country, governments do not have a comprehensive view of the sustainability of national consumption. Many countries have significantly externalized their water footprint without looking at whether the imported products are related to water depletion or pollution in the producing countries. Knowledge of the dependency on water resources elsewhere is relevant for a national government, not only when evaluating its environmental policy but also when assessing national food security.

Understanding the water footprint of a nation is highly relevant for developing well-informed national policy.
Conventional national water use accounts are restricted to statistics on water withdrawals within their own territory (Van der Leeden et al., 1990; Gleick, 1993; FAO, 2010b). National water footprint accounts extend these statistics by including data on green water use and volumes of water use for waste assimilation and by adding data on water use in other countries for producing imported products as well as data on water use within the country for making export products (Hoekstra et al., 2011).

Quantifying and mapping 'national water footprints' is an evolving field of study since the introduction of the water footprint concept in the beginning of this century (Hoekstra, 2003). The first global study on the water footprints of nations was carried out by Hoekstra and Hung (2002); a second, much more comprehensive study, was done by Hoekstra and Chapagain and reported in a number of subsequent publications: Chapagain and Hoekstra (2004, 2008), Chapagain et al. (2006) and Hoekstra and Chapagain (2007a, 2008).

The water footprint is an indicator of water use that includes both direct and indirect water use of a consumer or producer. The water footprint of an individual, community or business is defined as the total volume of freshwater that is used to produce the goods and services consumed by the individual or community or produced by the business. Water use is measured in water volume consumed (evaporated) and/or polluted per unit of time. A water footprint can be calculated for any well-defined group of consumers (e.g. an individual, family, village, city, province, state or nation) or producers (e.g. a public organization, private enterprise or economic sector).

The water footprint is a geographically explicit indicator, not only showing volumes of water use and pollution, but also the locations. However, the water footprint does not provide information on how the embedded water is contributing to water stress or environmental impacts.

A water footprint consists of three components: the blue, green and grey water footprint. The blue water footprint is the volume of freshwater that evaporated from the global blue water resources (surface water and ground water) to produce the goods and services consumed by the individual or community. The green water footprint is the volume of water evaporated from the global green water resources (rainwater stored in the soil as soil moisture). The grey water footprint is the volume of polluted water that associates with the production of all goods and services for the individual or community. The latter can be estimated as the volume of water that is required to dilute pollutants to such an extent that the quality of the water remains at or above agreed water quality standards.

1.2 Concept of Water Footprint

Water footprint (WF) is a new concept which allows quantification of freshwater appropriation. The main goal of WF is quantifying and mapping of indirect water use in the relevance of involving producers and consumers along chosen supply chain. This helps by sustainable water resource management and planning.

The importance of environmental protection in supply chain management leads to solutions for water resources. Life cycle assessment (LCA) also takes into account the importance of water use and included impacts related with water use in research with life cycle approach.

The water footprint methodology was introduced by Hoekstra as an indicator of freshwater appropriation, with the aim to quantify and map indirect water use and show the relevance of involving consumers and producers along supply chains in water resources management. LCA community developed comprehensive methodologies to include environmental impacts related to water in LCA studies and started to frame the main concepts in the forthcoming international standard on water footprint (ISO 14 046). A water footprint is the amount of water used to produce a product. To complete a full water footprint, it is necessary to include direct and indirect water usage. Direct use is water that physically is used during a process, while indirect use is water needed to create something used in the process. So the water footprint is an indicator of freshwater use (direct and indirect) in production or consumption.

Cradle-to-grave analysis is used to break down the total production, from raw materials to final product, into individual processes.

1.3 PROJECT OBJECTIVE

The project is aimed at developing an effective, efficient and sustainable water footprint of selected products with emphasis on bulk raw water use e.g. in irrigation schemes, hydropower, industries, bottling companies, water boards, oil companies, thermal power stations and NIPP projects with a view to ascertaining the volume/quantity of the bulk raw water use in such facilities in order to improve on the revenue generation for effective governance.

1.4 SCOPE OF WORK

The scope of the project shall include but not limited to the following:

a. Review and complete the balance of work from inception report submitted in 2017 which include the following;

i. Document the major river systems and abstraction points across the country and undertake the following;

- ❖ The water footprint of electricity and tariffs.
- ❖ The crude oil and gas water footprints and tariffs
- ❖ The domestic water footprints and biofuel water footprint and tariffs
- ❖ The industrial water footprints and tariffs
- ❖ Agricultural water footprint and tariffs

ii. Specifically develop a sustainable water tariff system which shall include but limited to the following;

- ❖ Review of existing water tariff structure
- ❖ Establish methodology for tariff setting
- ❖ Profile affordability index
- ❖ Develop cost recovery mechanism
- ❖ Justification of established parameters
- ❖ Draft water tariff structure for the country

2.0 PROJECT AREA

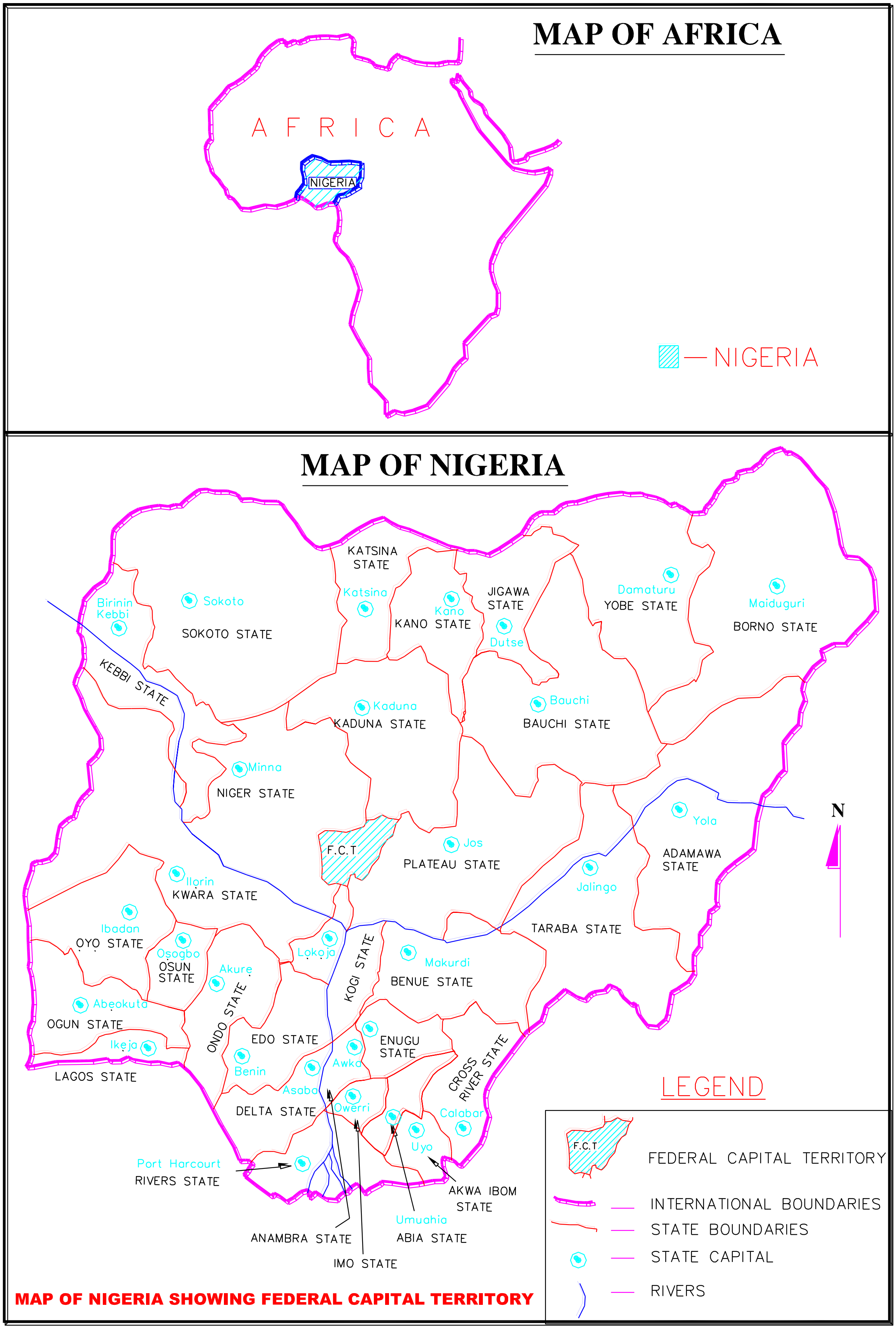

Fig 2.1: Map of Nigeria Showing the 36 States and the FCT

Fig. 2.2: hydrological Areas in Nigeria

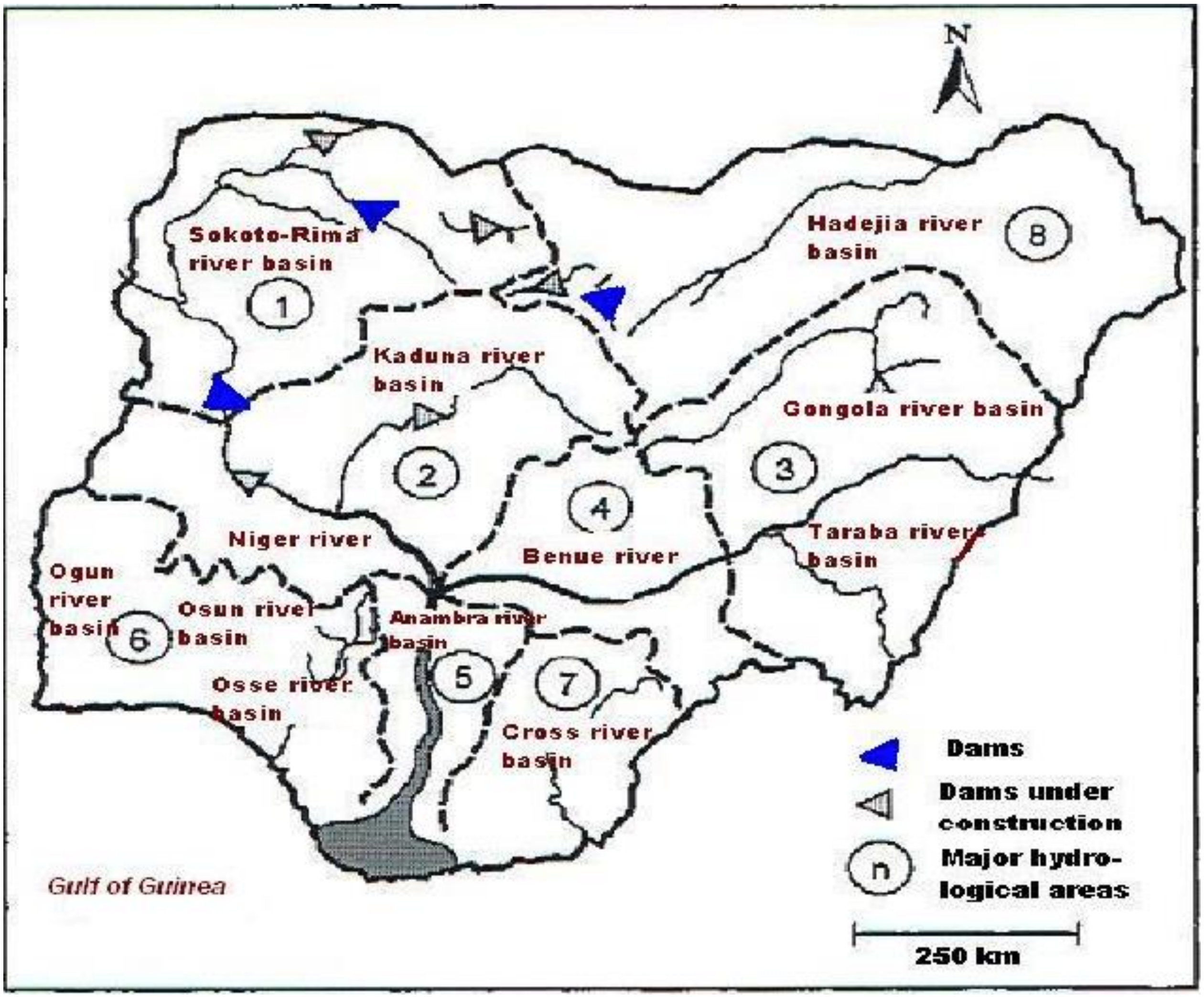

Fig.2.3: Map of Nigeria showing major rivers and hydrological basins: 1 Niger North, 2 Niger Central, 3 Upper Benue, 4 Lower Benue, 5 Niger South, 6 Western Littoral, 7 Eastern Littoral, 8 Lake Chad (WHO/UNEP, 1997).

2.1 Physical Characteristics

2.1.1 Location and Climate

Nigeria lies south of the Sahara within West Africa, with the Atlantic Ocean bordering the southern coastal region. The entire country lies on longitudes 2°50" to 14°20"E and from latitudes 4°10" to 13°48"N, occupying a land area of 923,768km^2, Covering an average distance of 1120 km from south to north.

Nigeria displays physiographic regions of varying characters in relief, nature and spatial distribution. Nigeria is the most populous country in Africa with a population of over 180 million. Just over half of the population (52%) is rural (WHO/UNICEF, 2007).
Annual demographic growth rate currently exceeds 3%.

The climate in Nigeria is semi-arid in the north, and humid in the south. Due to its location, Nigeria has a tropical climate characterized by the hot and wet conditions linked with the movement of the Inter-Tropical Convergence Zone (ITCZ) north and south of the equator. The country experiences consistently high temperatures throughout the year. There are, however, wide diurnal ranges in temperature particularly in the very hot months. The mean monthly temperatures during the day sometimes exceed 36°C while monthly average temperatures at night fall below 22°C. Since temperature varies only slightly, rainfall distribution, over space and time, becomes the single most important factor in differentiating the seasons and climatic regions. Except for the coastal zone, where it rains all year round, rainfall is seasonal with distinct wet and dry seasons. The mean annual rainfall along the coast in the southeast is 4800 mm while it is less than 500 mm in the northeast (although there are considerable spatial and annual variations to the long-term mean (Goni, 2002; Adelana et al., 2003a).

2.1.2 Geology and Hydrogeology

The geology of Nigeria, as detailed in Kogbe (1989), is made up of three main rock groups: mainly Precambrian basement crystalline metamorphic-igneous-volcanic rocks; Mesozoic to Tertiary sediments, granites and volcanics; and Quaternary alluvial deposits(Figure 2.4).

2.1.2.1 Precambrian Basement Complex Rocks

Precambrian Basement Complex rocks underlie three areas of Nigeria: North-central area including the Jos Plateau; South-west area adjacent to Benin; and south-east area adjacent to Cameroon. The rocks of the North-central area are composed of gneisses, migmatites, granites, schists, phyllites and quartzites. The narrow, tightly folded north-south trending schist belts of north-western Nigeria include igneous rocks, pelitic schists, phyllites and banded ironstones. The migmatite-gneiss complex of amphibolites, diorites, gabbros, marbles and pegmatites form a transition zone between the schist belt of NW Nigeria and the granites of the Jos Plateau to the east. There, extensive Precambrian age Older Granites crop out extensively. These have been intruded by Jurassic age Younger Granites that form characteristic ring complex structures. The Precambrian Basement rocks of south-western Nigeria, as found in the Dahomey (Benin) Basin, consist of migmatites, banded gneisses and granite gneisses, with low grade meta-sedimentary and meta-volcanic schists, intruded by Pan-African age granites and charnockites (Oyawoye, 1972). The migmatites and gneissic metasediments are often intruded by pegmatite veins and dykes (Oluyide et al., 1998). Older granites, granodiorites and syenites, with dolerite dykes, also form part of the Precambrian basement of SW Nigeria. The Precambrian Basement rocks of south-eastern Nigeria occur in three blocks along the border with Cameroon (Figure 2.4). The crystalline basement rocks include biotite-hornblende gneiss, kyanite gneiss, migmatite gneiss and granites and are well fractured (Ekwueme, 1987).

2.1.2.2 Mesozoic to Tertiary Rocks

Tertiary age olivine basalts, trachytes, rhyolites and tuffs, overlying or interbedded with coarse grained alluvial sediments, occur in the Jos Plateau and adjacent plateau areas. The surfaces of these volcanic lava flows have been weathered to form succession of laterite palaeosols on the Jos Plateau related to the uplift of the plateau. (Farnbauer & Tietz, 2000).The Mesozoic and Tertiary strata, of the Sokoto part of the Illummeden Basin in NW Nigeria, comprise interbedded sandstones, clays, and limestones that dip to the north-west. These formations are capped by laterite. The sedimentary sequence includes the late Jurassic to early Cretaceous Illo and Gundumi Formations, the Maastrichtian Rima Group, the late Paleocene Sokoto Group and the Eocene-Miocene Gwandu Formation.These were deposited during a series of overlapping marine transgressions. Over 1250m of sediments occur in the down-warped Sokoto Basin, unconformably overlying Precambrian Basement rocks. Quaternary age alluvial deposits occur along the course of the River Sokoto. In the Chad Basin of NE Nigeria, Cretaceous sediments include the Albian-Cenomanian Bima Sandstone Formation continental poorly sorted and thickly bedded feldspathic sand-stones and conglomerates to fluviatile and deltaic sediments. The early Turonian age Gongila Formation, up to 500m thick, includes marine limestones, sandstones and shales. The Senonian-Maastrichtian age Fika shale Formation, 100 to 500m thick, consists of gypsiferous shales and limestone of marine and continental origin. The Maastrichtian age Gombe Sandstone Formation consists of estuarine and deltaic sediments, deposited upon marine shales with sandstone/shale intercalations. The lower deposits of siltstone, mudstone and ironstone are overlain by well-bedded sandstones and siltstones. The upper formation contains coals and cross-bedded sandstones. The Cretaceous ended with a period of uplift and erosion. The Palaeocene age Kerri-Kerri Formation consists of lacustrine or fluvio-lacustrine loosely cemented cross-bedded coarse- to fine-grained sandstones, with locally occurring claystones, siltstones, ironstones, lignites and conglomerates. The Kerri-Kerri Formation rests unconformably on the Gombe Sandstone Formation and thickens towards the basin center where it is overlain by Chad Formation. The Pleistocene age Chad Formation (up to 840m thick) consists of poorly sorted fine to coarse-grained sand, with sandy clay, clay and diatomite. The southern Nigeria sedimentary basin includes the Lagos-Osse and the Niger Delta Basins that are separated by the Benin Hinge Line (the Okitipupa ridge). These basins have a common basal formation of marine Albian age, arkosic, gravelly, poorly-sorted, cross-bedded sandstones and sandy limestones. The Lagos-Osse Basin, the eastern sector of the Benin Basin, underlies the western low-lying coastal zone, where rock exposures are poor due to thick soil cover. The Tertiary geology of the area comprises the basal Araromi/Ewekoro Formation, consisting of shelly and sandy black shale with thin sandstones and limestones that is overlain by the Palaeocene age Imo Shale Formation (Okosun, 1998). These are overlain by the Oshosun Formation of shales, clays and sandstones. The succeeding Miocene age Benin Formation consists of up to 200m of sands with shales, clays and lignite. The near surface Quaternary geology includes recent littoral sandy alluvium and lagoon/coastal plain sands (Jones & Hockey, 1964; Longe et al., 1987). In the Niger Delta Basin, Quaternary age sediments underlying the Delta Plain consist of coarse to medium grained unconsolidated sands and gravels with thin peats, silts, clays, and shales, forming units of old deltas. The underlying Miocene age Benin Formation is composed of gravels and sands with shales and clays. This multi-aquifer system formation crops out to the northeast of the coastal belt. The Cretaceous sediments of the down faulted and failed rift that is the Benue Trough occur in a series of sedimentary basins that extend north east of the confluence of the Niger and Benue Rivers, bounded by the Basement Complex strata to the north and south of the Benue River (Figure 2) (Reyment, 1965). The Lower Benue Basin consists of shales, silts and silty-shales with subordinate sandstones and limestones intruded by dolerite dykes. The Upper Benue Basin consists of a thick succession of continental sandstones overlainby marine and estuarine deposits (Carter et al., 1963). The basal formation is the Bima Sandstone. The Bida Basin runs north west from the confluence of Niger and Benue rivers from the Anambra Basin in the southeast and to the northwest towards the Sokoto Basin (Figure 2).The basin contains Cretaceous age mainly continental sandstones, siltstones, claystones and conglomerates. The Middle Niger Basin at the confluence of the Niger and Benue rivers, contains 500 to 1000m of increasingly marine sediments (Ladipo, 1988). The main unit, the Lokoja Formation, consists of alluvial to deltaic coarse to medium-grained cross-bedded to massive sandstones with subordinate siltstones, kaolinitic claystones and shales indicate. Quaternary to Recent age alluvial deposits occur along the main river valleys. These deposits range from thin discontinuous sands to thick alluvial deposits up to 15 km wide and 15 to 30 m thick along the Niger and Benue rivers. The alluvial deposits include gravel, coarse and fine sand, silt and clay. Thin deposits of unconsolidated and mixed sands and gravels occur along the courses of ephemeral fadamas in northern Nigeria.

2.1.2.3 Summary of Hydrogeology of Nigeria

Groundwater constitutes an important source of water for domestic supply and agriculture in Nigeria. The distribution and flow of groundwater is controlled by geological factors such as the lithology, texture and structure of the rocks; and also hydrological and meteorological factors such as stream flow and rainfall. Occurrence of groundwater varies with the geology of the area. In the Basement Complex terrain, groundwater occurs in the weathered regolith and in fractures in the fresh crystalline rocks.

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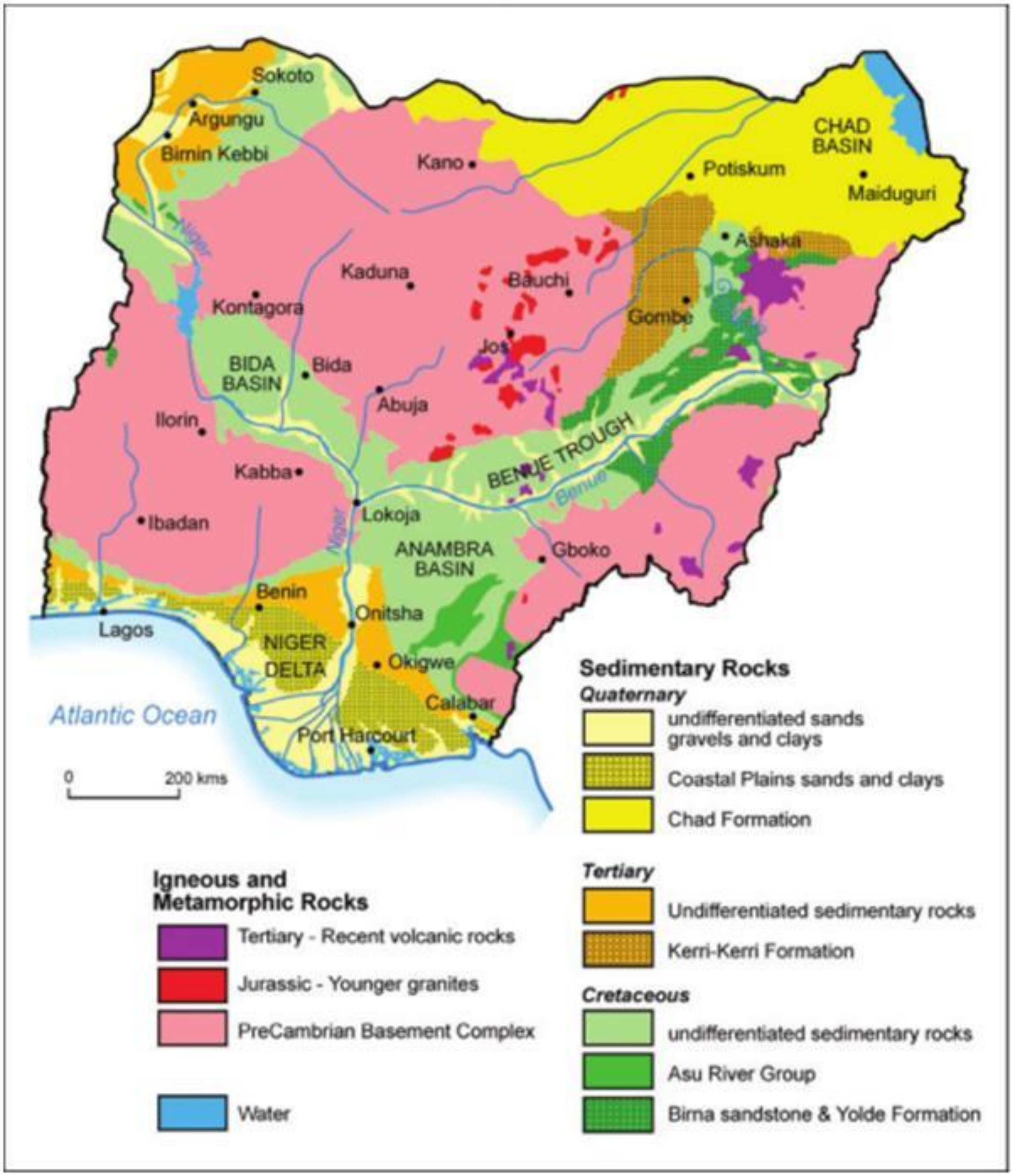


Fig 2.4: Generalized geological map of Nigeria (from MacDonald et al., 2005).

Generally, aquifer distribution in Nigeria is categorized into two systems: basement fluviovolcanic aquifers and sedimentary aquifers. The availability of groundwater in areas underlain by crystalline basement rocks depends on the development of thick soil overburden (overburden aquifers) or the presence of fractures that are capable of holding water (fractured crystalline aquifers). The storage of groundwater is confined to fractures and fissures in the weathered zone of igneous, metamorphic and volcanic rocks, the thickness of which range from <10 - 60 m in arid and humid rain forest. The groundwater resources here are usually limited (Eduvie, 2006).

Similarly, groundwater found in sedimentary deposits is mainly the pore-type, so also the one found in alluvial deposits where Aeolian and fluvial sediments are found, which collectively form primary aquifers because the water is contained in their primary pore spaces. The several sedimentary formations of variable age, mineralogical and geochemical character found in Nigerian basins, affect the quantity and quality of water found in them (Eduvie, 2006). These basins include Chad, Sokoto and Benue Trough, among others. The biggest water bearing units in Nigeria include: Chad, Kerri Kerri, Nsukka, Benin and Abeokuta Formations. This is because they are largely formed from sandstones, alluvial deposits and other related arenaceous sedimentary rocks. Shales, clays, and limestones are generally poor aquifers due to their argillaceous nature. There is little groundwater in them, the one found is only confined to their fracture and weathered zones. These rocks only help to confine an aquifer.

Groundwater tapped from confined aquifers is sometimes artesian in nature. Details of the various hydro-geological basins are presented in Offodile (1992) and Akujieze et al. (2003). According to Jim (2008), Nigeria has extensive groundwater resources, located in eight recognized hydro-geological areas together with local groundwater in shallow alluvial (Fadama) aquifers adjacent to major rivers thus;

i. The Sokoto Basin Zone (yield range from below 1.0 to 5.0 liters per second L/s).
ii. The Chad Basin Zone (yields are about 1.2 to 1.6 L/s from the Upper unconfined aquifer and 1.5 to 2.1 L/s from the Middle aquifer).
iii. The Middle Niger Basin Zone (yields between 0.7 and 5.0 L/s and in the Niger valley is between 7.5 and 37.0 L/s).
iv. The Benue Basin Zone (yields between 1.0 and 8.0 L/s).
v. The South-western Zone comprises sedimentary rocks bounded in the south by the coastal Alluvium and in the north by the Basement Complex.
vi. The South-Central Zone (yields are from 3.0 to 7.0 L/s.)
vii. The South-eastern Zone comprises Cretaceous sediments in the Anambra and Cross River basins.
viii. The Basement Complex (yields between 1.0 and 2.0 L/s).

Various authors, Adeyemi (1987 and 1988), Sule (2003), Sule & Okeola, (2010), Maduabuchi, (2004), Hanidu, (1990), Rijswlk (1981), Akujieze, et al., (2003), and Goni, (2006) gave empirical figures which suggest high groundwater resources potential for Nigeria. Groundwater potential in Nigeria is far greater than the surface water resources, estimated to be 224 trillion l/year (Hanidu, 1990). Rijswlk (1981) estimated groundwater resources at 0-50m depth in Nigeria to be 6 x 10km3 (6 x1018m3). However, from the eight aquifers in Nigeria (Akujieze, et al., 2003), the Ajali Sandstone aquifer yields 7 - 10 l/s, the Benin Formation (Coastal Plain Sands) aquifer yields 6 – 9 l/s, the Upper aquifer 2.5 – 30 l/s, the Middle aquifer 24 – 32 l/s, the Lower aquifer with yields of 10 – 35 l/s (of the Chad Formation), the Gwandu Formation aquifer with yields of 8 – 15 l/s, the Kerri-kerri Sandstone aquifer with yields of 1.25 – 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 50m b.g.l (below ground level).

These eight mega regional aquifers have an effective average thickness range of 360m, with a thickness range of 15 – 3,000m at a depth range of 0 – 630m b.g.l with an average depth of 220m (Akujieze et al., 2003). Reserves of groundwater are considerable in large sedimentary basins, which cover some 40% of the country. The potential annual groundwater resources are estimated at 51.93 x109m^3 , out of which the sedimentary basins account for 67% (FMWRRD, 1995). From National Water Resources Master Plan completed in 1995, surface water is about 267 billion cubic meters with groundwater resources estimated at 52 billion cubic meters of replenishable yield per year.

The sedimentary basins generally form the most prolific aquifers. The depth of the water table in unconfined parts of the Sokoto basin is typically 15 -75 m (Adelana and Vrbka, 2005). Artesian conditions occur in confined aquifers at 75 - 100 m depth at the eastern edge of the basin especially around Argungu but with piezometric levels going down further west to about 50 m below surface (Adelana et al., 2002, 2003, 2006a). Significant groundwater ages (in excess of 3000 years) have been found for some confined groundwaters from the Sokoto basin (Geyh and Wirth, 1980; Oteze, 1989a,b, 1991; Bassey et al., 1999).

Artesian conditions also exist in the Chad basin, where three main aquifers have been identified:

i. an upper aquifer at 30-100 m depth,
ii. a middle aquifer (eastern part of the basin) some 40-100 m thick occurring from 230 m depth near Maiduguri and
iii. a lower aquifer consisting of 100 m of medium to coarse sands and clays at a depth of 425-530 m.

The upper and middle aquifers are exploited intensively in the Maiduguri area (UN, 1988). Overexploitation of the aquifers in the Chad basin has led to a recent decline in groundwater levels and has necessitated drilling to greater depths in order to tap the lower aquifer (Goni, 2008).

Isotopic evidence suggests that groundwater from the middle and lower aquifers are old (20,000 years or more) and are not being actively replenished by modern recharge (Maduabuchi et al., 2003; Edmunds et al., 2002).

In the Anambra basin south east of Lokoja, coarse Cretaceous sandstones form a good aquifer which is largely unconfined in its northern part but becomes artesian further south (UN, 1988). Groundwater levels are typically 60-150 m deep. Prolific aquifers are also present in the Tertiary and Quaternary sediments of the southern coastal areas, the best being the Tertiary 'Illaro Formation' composed of sands with occasional beds of clay and shale. An unconfined shallow aquifer also exists at less than 30 m in much of the area near the coastal area (UN, 1988). Table 2.1 shows the regional aquifer systems and yields in Nigeria while Table 2.2 shows the hydro-geological Areas of Nigeria.

Table 2.1: Regional aquifer systems and yields in Nigeria (after Akujieze et al., 2003)

S/N	Main aquifers	Yield (L s-1)
1	Ajali Sandstone aquifer	7 – 10
2	Benin Formation (coastal plain sands) aquifer	6 - 9
3	The Upper aquifer (Chad Formation)	2.5 – 30
4	The Middle aquifer (Chad Format ion)	24 – 32
5	The Lower aquifer (Chad Format ion)	10 – 35
6	Gwandu Formation aquifer	8 - 15
7	The Kerr ikerri Sandstone aquifer	1.25 - 9.5
8	Crystalline fluvio–volcanic aquifer	15

Table 2.2: Hydro-geological Areas of Nigeria (Source: FMWRRD, 1995)

S/N	Region	Area (km^2)
1	Sokoto Basin Area (Sokoto Sedimentary Area)	63,700
2	Chad Basin Area (Chad Sedimentary Area)	120,400
3	Niger Basin Area (Upper Niger Sedimentary Area)	38,300
4	Benue Basin Area (Benue Sedimentary Area)	116,300
5	South Western Area (Ogun / Osun Sedimentary Area)	
6	South Central Area (Lower Niger Sedimentary Area)	110,300
7	South Eastern Area (Cross River Sedimentary Area)	29,700
8	Basement Complex Area (Crystalline Rock Area)	445,100`
	Total	**923,800**

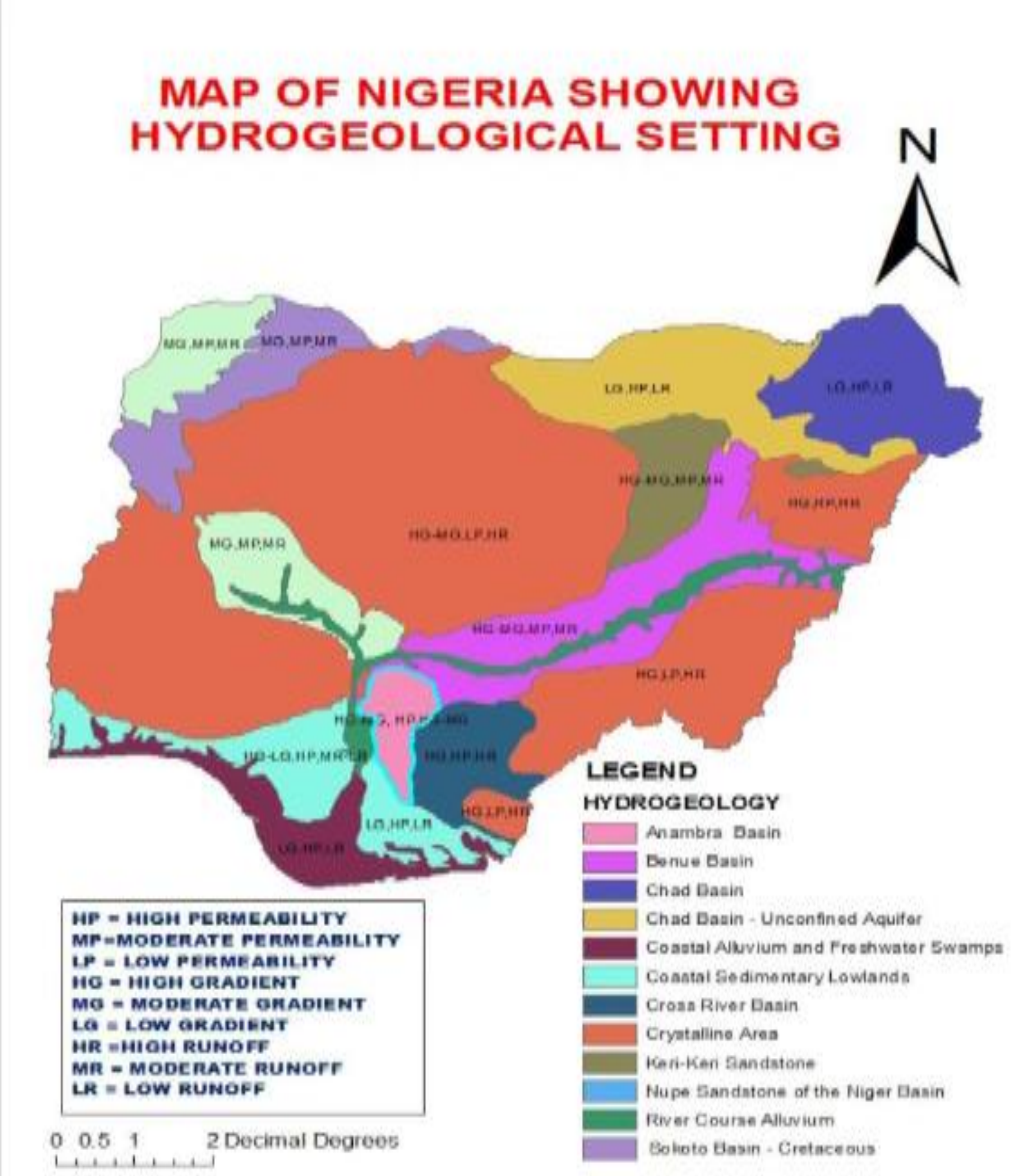


Figure 2:5 Hydrogeological Setting Depicting Relative Permeability and Runoff Potential

2.1.3 Vegetation

Nigeria is a large country with varying vegetation belts. The variations are found from North to South with the belts running from East to West. Climatic factors such as rainfall, temperature, and relative humidity account for these variations, other factors include topography and human activities on land. The type of agricultural activities to be engaged in a particular area depends on the environment. Vegetation belts in Nigeria reflect the tight link between the vegetation and the country's climate:

- Rainforest;
- Fresh Water Swamp;
- Sahel Savanna;
- Short Grass Savanna;
- Guinea Savanna;
- Woodland;
- Marginal Savanna;
- Mangrove;
- Montane;
- Sudan Savanna.

There are two major types of vegetation in Nigeria. These are the;

1. Forest zones
2. Savanna zones

2.1.3.1 Forest Zones

The forest vegetation is found in the southern part of the country and comprises of:
a. Mangrove forest
b. Rain forest

Mangrove Forest: It is found around swamps of the coastal creeks, estuaries and lagoons of southern Nigeria. Trees found there are: red and white mangroves, palm and lianas (climbing and twining plant). Animals found there are: fish, crocodiles, snakes and birds.

Rain Forest: This area is characterized with rainfall of about 1500mm-2000mm within 8-9 months of rainfall. They are found around Ogun ,Oyo , Ondo, Delta, Anambra, Akwa Ibom. Some of the trees found in this area are oil palm ,iroko, mahogamy, rubber, walnut, obeche and animals found in this area are, monkeys, antelopes, wart-hogs, snails, grasscutters etc.

2.1.3.2 Savanna Zones

This covers as much as 80% of the country from the northern edge of the rain forest to the southern edge of the Sahara desert. The savanna zone is subdivided into:
a. Derived savanna
b. Guinea savanna
c. Sudan savanna

d. Sahel savanna

Derived Savanna: In this zone, farming activities have combined to degrade the original forest vegetation, leaving behind some fire-tolerant savanna species and a few forest trees. Animals found in the derived savanna include antelopes, giant rats, monkey etc.

Guinea Savanna: This is the largest vegetation belt in Nigeria: It covers the sparsely populated areas of the middle belts. This region is characterized by natural grassland, sparse woodland or trees. This region is dominated by tubers and grain crops. Animals found here include large animals like buffaloes, elephant, lions kept in game reserve, while smaller animals like giant rats, rabbits and wild cats etc. move about freely.

Sudan Savannah: This area is characterized by sparsely distributed short trees, with short and seasonal grass cover. Rainfall in this area last only 2-3 months and relative humidity is low. It has long and more severe dry season or period than the guinea savanna. Feathery grasses and give a continuous land cover. Common plant found is baobab and shea butter. Animals found are similar to those of the guinea savanna but fewer in number due to lack of food (pasture)

Sahel Savannah: This is the most northern vegetation zone, found in the Eastern corners of Kano and Borno states. It is characterized with: Barely 500mm of rainfall annually with about 9-10 months of dry season. Very sparse vegetation, with sparse thorny trees plants found, varying from low growing shrubs in some part, trees varieties include raphia palm, acacia and the major crops are millet and sorghum, while vegetables and sugar cane are grown along the river bed.
Note: irrigation is widely practised in this area due to the inadequate water supply.

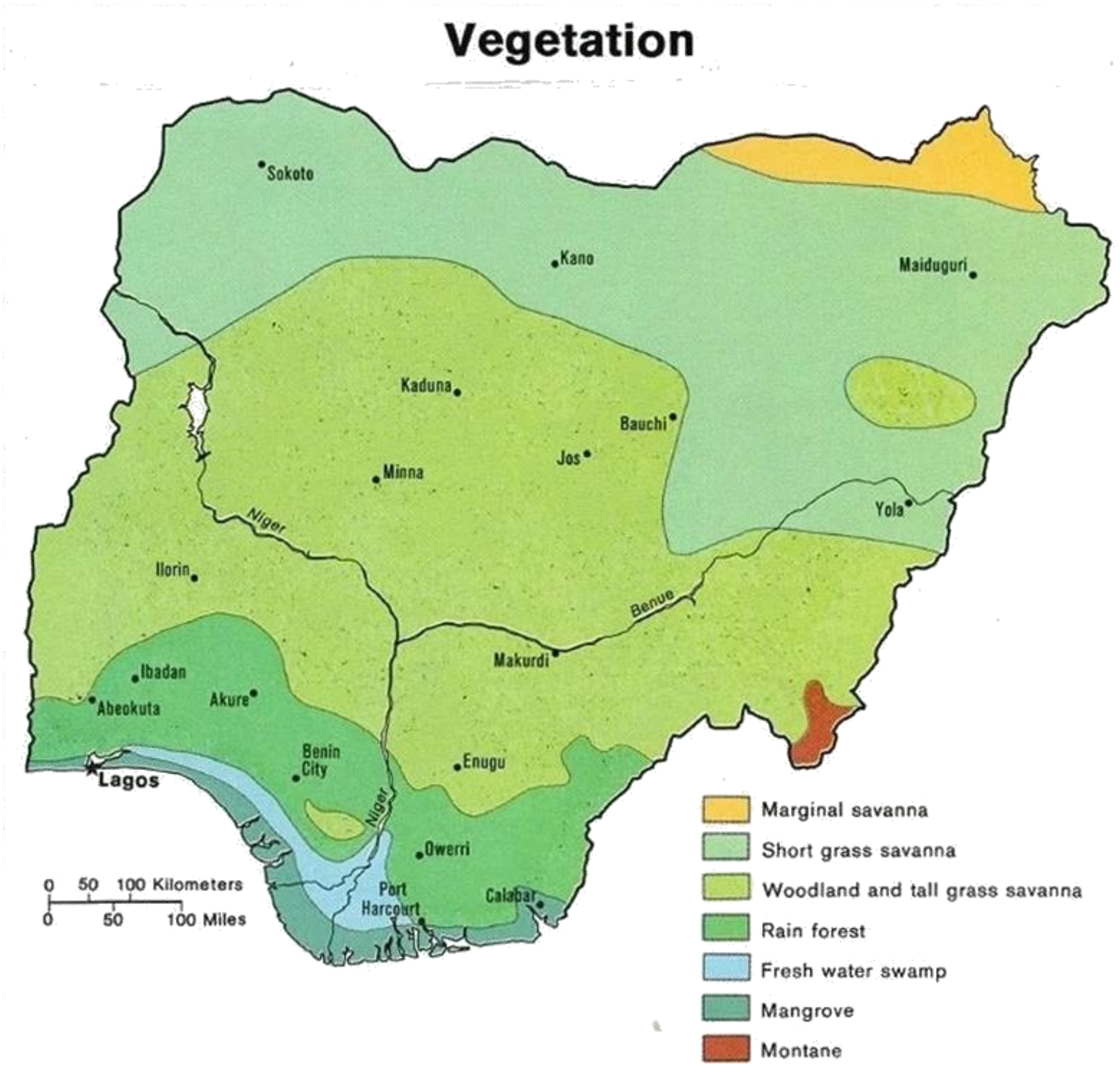


Fig. 2.6: Map Vegetation Zones of Nigeria

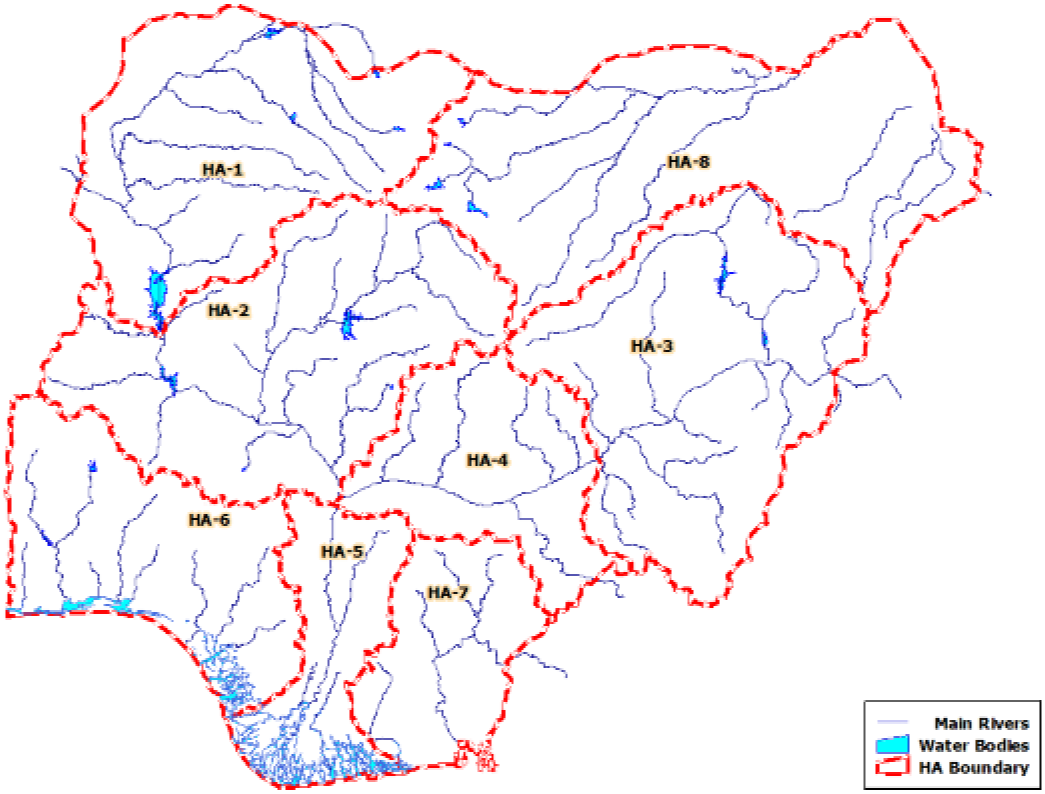
2.1.4 Hydrology

On the basis of JICA report, the meteorological and hydrological data during the last 40 years (1970-2009), it is estimated that about 24% of the total precipitation are runoff while the remaining is lost though evapotranspiration and others. The water resources potential within the territory of Nigeria is estimated at 287BCM/year. Adding water resources flows into Nigeria from outside the country, the total water resources potential would become 375BCM/year. Among the total water resources potential, 88BCM is from outside the country. It can be said that about 24% of the total water resources relies on contribution from neighbouring countries. The groundwater resources potential as renewable resources is estimated at 156BCM/year Associated with precipitation pattern in the country, there are unevenly distributed water resources: 25mm/year on water resources (500mm/year in average precipitation and 5% in runoff rate) in the northern area, 1,000mm/year on water resources (2,000mm/year in average precipitation and 50% in runoff rate) in the southern area.

There is a unique hydrological regime in the Niger River, which is influenced by the upper reach of the Niger River. The Niger River originated from the Guinean high land and flows toward an inland delta in Mali. In the inland delta, the flow is retarded very much and almost half of the flow is lost by evaporation in the wetland area. Because the inflow to Nigeria is influenced by the retarding and loss in the inland delta, the peak inflow discharge appears around March to April, which shows almost half year delay from the precipitation event in the upper reach of the Niger River. On the other hand, the runoff in the lower reach of the Niger almost coincides with the precipitation event, which brings about the peak runoff at round August and September. The discharge in the lower reach of the Niger River is determined by the combination of the inflow to Nigeria and the runoff in the lower reach. It should be also noted that the contribution from Benue river basin to the total runoff volume in the Niger River is relatively large compared to its drainage area.

2.1.4.1 Hydrological Areas

As shown in Figure 2.7 below, Nigeria is divided into eight hydrological areas for the purpose of water resources management, considering hydrological and topographical conditions.



Hydrological Area		Area ($10^3 km^2$)	Precipitation (mm/year)	Mainly Related RBDAs	Mainly Related States	Population (2010) (10^6)	Population (2030) (10^6)
HA-1	Niger North	135.1	767	Sokoto-Rima	Katsina, Zamfara, Sokoto, Kebbi	17.1	27.2
HA-2	Niger Central	154.6	1,170	Upper Niger, Lower Niger	Niger, Kwara, Kaduna, Kogi, FCT	17.0	31.5
HA-3	Upper Benue	156.5	1,055	Upper Benue	Adamawa, Taraba, Gombe, Bauchi	12.2	19.4
HA-4	Lower Benue	74.5	1,341	Lower Benue	Plateau, Nassarawa, Benue, Kogi	8.3	13.9
HA-5	Niger South	53.9	2,132	Anambra-Imo, Niger Delta	Bayelsa, Delta, Edo, Kogi, Anambra, Rivers	19.6	31.1
HA-6	Western Littoral	99.3	1,541	Ogun-Osun, Benin-Owena	Lagos, Ogun, Oyo, Osun, Ondo, Edo, Ekiti	35.9	57.8
HA-7	Eastern Littoral	57.4	2,106	Cross River	Abia, Anambra, Imo, Enugu, Ebonyi, Cross River, Akwa Ibom, Rivers	20.8	32.6
HA-8	Lake Chad	178.5	610	Hadejia-Ja'mare, Chad	Kano, Jigawa, Yobe, Borno, BAuchi, Plateau, Adamawa	27.4	44.4

Source: JICA Project Team

Fig.2.7: Hydrological Areas in Nigeria (JICA REPORT)

3.0 SITE VISITS

3.1 Site Visit/Consultations

The consultant had started with initial consultations with some stakeholders among which is the client (Nigeria integrated water resources management commission). The meetings held with the client representatives resulted in collecting some available documents relevant to the project. Also, at the meeting, the client made available some copies of letters introducing the consultant to the selected bulk water users as well as the Catchment Management offices of the Nigerian Integrated Water resources Management Commission.

Armed with the letters and other necessary information, the consultants commenced the Site Visits to the bulk water users and catchment offices on the 28th of June, 2019. A total of 72 bulk water users' sites were visited cut across the 8 hydrological areas, with at least three (3) states per Hydrological Area (HA).

A table showing the bulk water users sites visited with the corresponding states and HAs is shown below.

		INTAKE COORDINATES (DD MM SS.S)							
S/No.	LOCATION	NORTHINGS (m)	EASTINGS (m)	ELEVATION (m)	SECTOR	TOWN	STATE	CATCHMENT AREA	SOURCE OF ABSTRACTION
1	COSCHARIS FARM	6 26 39.9	6 54 34.7	36	AGRICULTURE/IRRIGATION	ANAKU	ANAMBRA	NIGER SOUTH/EASTERN LITTORIAL	SURFACE WATER
2	INTERNATIONAL BREWERIES	6 07 36.2	6 45 47.2	18	INDUSTRIAL (BREWERY)	ONITSHA	ANAMBRA	NIGER SOUTH/EASTERN LITTORIAL	SURFACE WATER
3	GUBI DAM	10 25 06.1	9 52 36.4	571	AGRICULTURE/IRRIGATION	GUBI	BAUCHI	UPPER BENUE	SURFACE WATER
4	STOWA				DOMESTIC WATER	BAUCHI	BAUCHI	UPPER BENUE	UNDERGROUND
5	BAUCHI STATE URBAN WATER				DOMESTIC WATER	BAUCHI	BAUCHI	UPPER BENUE	
6	BAUCHI STATE RUWASA				DOMESTIC WATER	BAUCHI	BAUCHI	UPPER BENUE	UNDERGROUND
7	BENUE STATE WATER BOARD	7 44 44.7	8 31 56.1	76	DOMESTIC WATER	MAKURDI	BENUE	LOWER NIGER	SURFACE WATER
8	BENUE STATE RURAL WATER				DOMESTIC WATER	MAKURDI	BENUE	LOWER NIGER	UNDERGROUND
9	BLUE ROSE WATER FACTORY	4 57 56.1	8 20 01.5	26	INDUSTRIAL (BOTTLE WATER)	CALABAR	CROSS RIVER	EASTERN LITTORIAL	UNDERGROUND
10	LAFARGE INDUSTRIAL (CEMENT)	5 04 05.6	08 30 44.5	23	INDUSTRIAL (CEMENT)	MFAMOSING	CROSS RIVER	EASTERN LITTORIAL	UNDERGROUND
11	ARCH O. VENTURES				INDUSTRIAL (BOTTLE WATER)	CALABAR	CROSS RIVER	EASTERN LITTORIAL	UNDERGROUND
12	ALEX EKWUEME UNIVERSITY NDUFU ALIKE				DOMESTIC WATER	IKWO	EBONYI	EASTERN LITTORIAL	UNDERGROUND
13	EBONY AGRO INDUSTRIES	6 05 06.7	8 08 46.0	66	AGRICULTURE/IRRIGATION	IKWO	EBONYI	EASTERN LITTORIAL	UNDERGROUND
14	NIGERIA BOTTLING COMPANY	6 22 47.2	5 42 35.8	106	INDUSTRIAL (SOFT DRINKS)	BENIN	EDO	NIGER SOUTH	UNDERGROUND
15	GUINESS NIG. LTD	6 20 54.6	5 39 53.5	72	INDUSTRIAL (BREWERY)	BENIN	EDO	NIGER SOUTH	UNDERGROUND
16	CWAY INDUSTRIAL (BOTTLE WATER)	6 12 31.8	5 38 30.4	34	INDUSTRIAL (BOTTLE WATER)	BENIN	EDO	NIGER SOUTH	UNDERGROUND
17	SEVEN UP BOTTLING CO.	6 26 41.3	5 35 49.1	138	INDUSTRIAL (SOFT DRINKS)	BENIN	EDO	NIGER SOUTH	UNDERGROUND
18	NESTLE WATER	8 31 44.1	6 55 49.1	170	INDUSTRIAL (BOTTLE WATER)	ABAJI	FCT ABUJA	NIGER CENTRAL	UNDERGROUND
19	GURARA DAM	9 38 46.4	7 43 58.3	595	HYDRO ELECTRIC/WATER SUPPLY	GURARA	FCT/KADUNA	NIGER CENTRAL	SURFACE WATER
20	GOMBE STATE WATER BOARD				DOMESTIC WATER	GOMBE	GOMBE	UPPER BENUE	
21	GOMBE STATE RUWASA				DOMESTIC WATER	GOMBE	GOMBE	UPPER BENUE	UNDERGROUND
22	SHEMAR'S RUWAN DADI WATERS				INDUSTRIAL (BOTTLE WATER)	DUTSE	JIGAWA	LAKE CHAD	UNDERGROUND
23	JIGAWA STATE WATER BOARD				DOMESTIC WATER	DUTSE	JIGAWA	LAKE CHAD	
24	OLAM GRAINS	10 13 47.2	7 20 49.1	627	INDUSTRIAL (GRAINS BAGGING)	KADUNA	KADUNA	NIGER CENTRAL	RAIN HARVEST/UNDERGROUND
25	KRPC	10 24 54.7	7 29 06.5	617	INDUSTRIAL (OIL AND GAS REFINERY)	KADUNA	KADUNA	NIGER CENTRAL	SURFACE WATER
26	NORTHERN NOODLES	10 26 18.8	7 30 17.2	636	INDUSTRIAL (PASTERS PRODUCTION)	KADUNA	KADUNA	NIGER CENTRAL	UNDERGROUND
27	NIGERIA EAGLE FLOUR MILL	10 28 24.3	7 23 29.7	590	INDUSTRIAL (FLOUR MILLS)	KADUNA	KADUNA	NIGER CENTRAL	SURFACE WATER
28	NIGERIA BREWERIES PLC	10 28 43.3	7 24 46.4	599	INDUSTRIAL (BREWERY)	KADUNA	KADUNA	NIGER CENTRAL	SURFACE WATER
29	KADUNA STATE WATER CORPORATION	10 30 15.084	7 26 51.504	250	DOMESTIC WATER	KADUNA	KADUNA	NIGER CENTRAL	SURFACE WATER
30	TAMBURAWA WATER PLANT	11 50 52.6	8 30 47.6	447	DOMESTIC WATER	TAMBURAWA	KANO	LAKE CHAD	SURFACE WATER
31	SEVEN UP BOTTLING CO.	11 53 33.4	8 32 31.4	467	INDUSTRIAL (SOFT DRINKS)	KANO	KANO	LAKE CHAD	UNDERGROUND
32	NIGERIA BOTTLING COMPANY				INDUSTRIAL (SOFT DRINKS)	CHALLAWA	KANO	LAKE CHAD	SURFACE WATER
33	KANO STATE WATER BOARD				DOMESTIC WATER	KANO	KANO	LAKE CHAD	SURFACE WATER
34	ROYAL CERAMICS	7 26 31.1	6 40 46.5	73	INDUSTRIAL (TILES PRODUCTION)	AJAOKUTA	KOGI	NIGER CENTRAL	SURFACE WATER
35	GEREGU POWER PLC	7 28 16.1	6 39 32.6	110	HYDRO ELECTRICITY	AJAOKUTA	KOGI	NIGER CENTRAL	SURFACE WATER
36	GREATER LOKOJA WATER	7 44 01.1	6 44 47.0	47	DOMESTIC WATER	LOKOJA	KOGI	NIGER CENTRAL	SURFACE WATER
37	OLAM RICE	7 55 09.3	8 19 12.6	83	AGRICULTURE/IRRIGATION	RUKUBI	NASARAWA	LOWER NIGER	SURFACE WATER
38	NASARAWA STATE WATER BOARD				DOMESTIC WATER	LAFIA	NASARAWA	LOWER NIGER	
39	JEBBA DAM (MAINSTREAM ENERGY LTD.)	9 08 23.61	4 47 20.1	98	HYDRO ELECTRICITY	JEBBA	NIGER	NIGER CENTRAL	SURFACE WATER
40	SHIRORO DAM (NORTH SOUTH POWER LTD	9 58 22.4	6 50 03.3	289	HYDRO ELECTRICITY	SHIRORO	NIGER	NIGER CENTRAL	SURFACE WATER
41	KAINJI DAM (MAINSTREAM ENERGY LTD.)	9 51 45.0	4 36 45.0	124	HYDRO ELECTRICITY	KAINJI	NIGER	NIGER CENTRAL	SURFACE WATER
42	SUNTI JAAGI	9 05 59.3	5 13 36.1	66	INDUSTRIAL (FLOUR MILLS)	JAAGI	NIGER	NIGER CENTRAL	
43	DUFIL	6 41 06.9	3 13 07.0	84	INDUSTRIAL (PASTERS PRODUCTION)	OTA	OGUN	WESTERN LITTORIAL	UNDERGROUND
44	BELLS UNIVERSITY WATER	6 41 03.4	3 10 21.9	72	INDUSTRIAL (BOTTLE WATER)	OTA	OGUN	WESTERN LITTORIAL	UNDERGROUND
45	COVENANT UNIVERSITY WATER	6 40 09.8	3 09 29.0	61	INDUSTRIAL (BOTTLE WATER)	OTA	OGUN	WESTERN LITTORIAL	UNDERGROUND
46	ILESHA BREWERIES	7 37 30.9	4 46 57.6	429	INDUSTRIAL (BREWERY)	ILESHA	OSUN	WESTERN LITTORIAL	UNDERGROUND
47	TUNS FARM	7 50 32.6	4 36 38.8	381	AGRICULTURE/IRRIGATION	OSOGBO	OSUN	WESTERN LITTORIAL	UNDERGROUND
48	LASDOL TABLE WATER				INDUSTRIAL (BOTTLE WATER)	OSOGBO	OSUN	WESTERN LITTORIAL	UNDERGROUND
49	ESSENCE TABLE WATER	7 46 52.7	4 32 58.8	310	INDUSTRIAL (BOTTLE WATER)	OSOGBO	OSUN	WESTERN LITTORIAL	UNDERGROUND
50	UNIVERSITY OF IBADAN WATER	7 25 58.5	3 53 43.4	236	DOMESTIC WATER	IBADAN	OYO	WESTERN LITTORIAL	
51	FAN MILK	7 24 38.0	3 52 06.3	212	INDUSTRIAL (DIARY PRODUCTS)	IBADAN	OYO	WESTERN LITTORIAL	UNDERGROUND
52	SEVEN UP BOTTLING CO.	7 21 22.6	3 50 51.4	176	INDUSTRIAL (SOFT DRINKS)	IBADAN	OYO	WESTERN LITTORIAL	UNDERGROUND
53	PROCTER AND GAMBLE	7 21 23.4	3 51 00.1	168	INDUSTRIAL (HOUSEHOLD ITEMS)	IBADAN	OYO	WESTERN LITTORIAL	UNDERGROUND
54	RELIANCE CHEMICAL LTD	7 21 23.4	3 51 00.1	168	INDUSTRIAL (DISTILLATION)	IBADAN	OYO	WESTERN LITTORIAL	UNDERGROUND
55	OYO STATE WATER CORPORATION				DOMESTIC WATER	IBADAN	OYO	WESTERN LITTORIAL	
56	ZARTECH LTD.				INDUSTRIAL (POULTRY DRUGS)	IBADAN	OYO	WESTERN LITTORIAL	UNDERGROUND
57	BARKIN LADI DAM	9 45 56.5	8 58 23.4	1241	DOMESTIC WATER	JOS	PLATEAU	LOWER NIGER	SURFACE WATER
58	NASCO	9 52 30.6	8 52 22.8	1292	INDUSTRIAL (HOUSEHOLD ITEMS)	JOS	PLATEAU	LOWER NIGER	UNDERGROUND
59	LIBERTY DAM	9 53 34.3	8 55 30.5	1281	DOMESTIC WATER	JOS	PLATEAU	LOWER NIGER	SURFACE WATER
60	PRUWASA				DOMESTIC WATER	JOS	PLATEAU	LOWER NIGER	UNDERGROUND
61	DADIN KOWA DAM	10 19 15.2	11 28 43.8	262	DOMESTIC WATER	JOS	PLATEAU	LOWER NIGER	SURFACE WATER
62	SPDC	4 50 00.5	7 01 48.5	20	INDUSTRIAL (OIL AND GAS REFINERY)	PORT HARCOURT	RIVERS	NIGER SOUTH	UNDERGROUND
63	PH WATER	4 50 11.4	7 00 21.7	15	DOMESTIC WATER	PORT HARCOURT	RIVERS	NIGER SOUTH	UNDERGROUND
64	PABOD BREWERY				INDUSTRIAL (BREWERY)	PORT HARCOURT	RIVERS	NIGER SOUTH	UNDERGROUND
65	SOKOTO WATER BOARD	13 04 33.8	5 15 23.9	288	DOMESTIC WATER	SOKOTO	SOKOTO	NIGER NORTH	
66	INDUSTRIAL (CEMENT) CO. NORTHERN NIG	13 03 50.9	5 10 27.4	262	INDUSTRIAL (CEMENT)	SOKOTO	SOKOTO	NIGER NORTH	
67	BAKOLORI DAM	12 30 43.7	6 10 58.0	290	AGRICULTURE/IRRIGATION	BAKOLORI	ZAMFARA	NIGER NORTH	SURFACE WATER
68	FEDERAL UNIVERSITY GUSAU	12 07 42.1	6 46 52.3	468	DOMESTIC WATER	GUSAU	ZAMFARA	NIGER NORTH	UNDERGROUND
69	GUSAU DAM	12 08 48.5	6 40 21.1	449	DOMESTIC WATER	GUSAU	ZAMFARA	NIGER NORTH	SURFACE WATER
70	HAMSTORE INTEGRATED SERVICES				INDUSTRIAL (BOTTLE WATER)	GUSAU	ZAMFARA	NIGER NORTH	UNDERGROUND
71	ZM RUWASA				DOMESTIC WATER	GUSAU	ZAMFARA	NIGER NORTH	UNDERGROUND
72	ZAMFARA STATE WATER BOARD				DOMESTIC WATER	GUSAU	ZAMFARA	NIGER NORTH	

4.0 WATER FOOTPRINT

4.1 MAJOR RIVER SYSTEMS IN NIGERIA AND ABSTRACTION POINTS

The table 4.1 below shows may **Rivers Systems** in Nigeria.

S/N	NAME OF MAJOR RIVER	TRIBUTARIES	DISTRIBUTARIES
1	Kwa Ibo River		
2	Cross River	Akwayafe River Great Kwa River Calabar River Asu River Aboine River Anyim River	
3	Bonny River		
4	Imo River	Aba River Otamiri River	
5	Oli River		
6	Malendo River		
7	Sokoto River	Ka River Zamfara River Gaminda River Rima River Goulbi de Maradi River Gagere River Bunsuru River	
8	Gurara River		
9	Kaduna River	Mariga River Tubo River Galma River	
10	Benin River		
11	Osse River		
12	Niger River		Escravos River Forcados River Chanomi Creek Nun River New Calabar River

13	Anambra River		
14	Osun River	Erinle River Otin River Oba River Omi Osun	
15	Ona River	Ogunpa River	
16	Ogun River	Oyan River Ofiki River	
17	Ouémé River	Okpara River	
18	Benue River	Okwa River Mada River Katsina Ala River Menchum River Ankwe River Donga River Bantaji River (Suntai River) Wase River Taraba River Kam River Pai River Hawal River Faro River	
19	Moshi River	Teshi River	
20	Yobe River	Komadugu Gana River	
21	Jama'are River (Bunga River	Katagum River	
22	Hadejia River	Chalawa River Kano River Watari River	
23	Ngadda River		
24	Yedseram River		
25	Gongola River		

Map showing some of the Major River systems in Nigeria *(source: mapsofworld.com)*

4.2 Abstraction Points

The abstraction points on the major rivers in Nigeria and the corresponding company taking water from such rivers are shown in the table 4.2 below with coordinates of the intake locations.

Table 4.2: Bulk Water Users Visited and Their Abstraction Points

		INTAKE COORDINATES (DD MM SS.S)							
S/No.	LOCATION	NORTHINGS (m)	EASTINGS (m)	ELEVATION (m)	SECTOR	TOWN	STATE	CATCHMENT AREA	SOURCE OF ABSTRACTION
1	COSCHARIS FARM	6 26 39.9	6 54 34.7	36	AGRICULTURE/IRRIGATION	ANAKU	ANAMBRA	NIGER SOUTH/EASTERN LITTORIAL	SURFACE WATER
2	INTERNATIONAL BREWERIES	6 07 36.2	6 45 47.2	18	INDUSTRIAL (BREWERY)	ONITSHA	ANAMBRA	NIGER SOUTH/EASTERN LITTORIAL	SURFACE WATER
3	GUBI DAM	10 25 06.1	9 52 36.4	571	AGRICULTURE/IRRIGATION	GUBI	BAUCHI	UPPER BENUE	SURFACE WATER
4	STOWA				DOMESTIC WATER	BAUCHI	BAUCHI	UPPER BENUE	UNDERGROUND
5	BAUCHI STATE URBAN WATER				DOMESTIC WATER	BAUCHI	BAUCHI	UPPER BENUE	
6	BAUCHI STATE RUWASA				DOMESTIC WATER	BAUCHI	BAUCHI	UPPER BENUE	UNDERGROUND
7	BENUE STATE WATER BOARD	7 44 44.7	8 31 56.1	76	DOMESTIC WATER	MAKURDI	BENUE	LOWER NIGER	SURFACE WATER
8	BENUE STATE RURAL WATER				DOMESTIC WATER	MAKURDI	BENUE	LOWER NIGER	UNDERGROUND
9	BLUE ROSE WATER FACTORY	4 57 56.1	8 20 01.5	26	INDUSTRIAL (BOTTLE WATER)	CALABAR	CROSS RIVER	EASTERN LITTORIAL	UNDERGROUND
10	LAFARGE INDUSTRIAL (CEMENT)	5 04 05.6	08 30 44.5	23	INDUSTRIAL (CEMENT)	MFAMOSING	CROSS RIVER	EASTERN LITTORIAL	UNDERGROUND
11	ARCH O. VENTURES				INDUSTRIAL (BOTTLE WATER)	CALABAR	CROSS RIVER	EASTERN LITTORIAL	UNDERGROUND
12	ALEX EKWUEME UNIVERSITY NDUFU ALIKE				DOMESTIC WATER	IKWO	EBONYI	EASTERN LITTORIAL	UNDERGROUND
13	EBONY AGRO INDUSTRIES	6 05 06.7	8 08 46.0	66	AGRICULTURE/IRRIGATION	IKWO	EBONYI	EASTERN LITTORIAL	UNDERGROUND
14	NIGERIA BOTTLING COMPANY	6 22 47.2	5 42 35.8	106	INDUSTRIAL (SOFT DRINKS)	BENIN	EDO	NIGER SOUTH	UNDERGROUND
15	GUINESS NIG. LTD	6 20 54.6	5 39 53.5	72	INDUSTRIAL (BREWERY)	BENIN	EDO	NIGER SOUTH	UNDERGROUND
16	CWAY INDUSTRIAL (BOTTLE WATER)	6 12 31.8	5 38 30.4	34	INDUSTRIAL (BOTTLE WATER)	BENIN	EDO	NIGER SOUTH	UNDERGROUND
17	SEVEN UP BOTTLING CO.	6 26 41.3	5 35 49.1	138	INDUSTRIAL (SOFT DRINKS)	BENIN	EDO	NIGER SOUTH	UNDERGROUND
18	NESTLE WATER	8 31 44.1	6 55 49.1	170	INDUSTRIAL (BOTTLE WATER)	ABAJI	FCT ABUJA	NIGER CENTRAL	UNDERGROUND
19	GURARA DAM	9 38 46.4	7 43 58.3	595	HYDRO ELECTRIC/WATER SUPPLY	GURARA	FCT/KADUNA	NIGER CENTRAL	SURFACE WATER
20	GOMBE STATE WATER BOARD				DOMESTIC WATER	GOMBE	GOMBE	UPPER BENUE	
21	GOMBE STATE RUWASA				DOMESTIC WATER	GOMBE	GOMBE	UPPER BENUE	UNDERGROUND
22	SHEMAR'S RUWAN DADI WATERS				INDUSTRIAL (BOTTLE WATER)	DUTSE	JIGAWA	LAKE CHAD	UNDERGROUND
23	JIGAWA STATE WATER BOARD				DOMESTIC WATER	DUTSE	JIGAWA	LAKE CHAD	
24	OLAM GRAINS	10 13 47.2	7 20 49.1	627	INDUSTRIAL (GRAINS BAGGING)	KADUNA	KADUNA	NIGER CENTRAL	RAIN HARVEST/UNDERGROUND
25	KRPC	10 24 54.7	7 29 06.5	617	INDUSTRIAL (OIL AND GAS REFINERY)	KADUNA	KADUNA	NIGER CENTRAL	SURFACE WATER
26	NORTHERN NOODLES	10 26 18.8	7 30 17.2	636	INDUSTRIAL (PASTERS PRODUCTION)	KADUNA	KADUNA	NIGER CENTRAL	UNDERGROUND
27	NIGERIA EAGLE FLOUR MILL	10 28 24.3	7 23 29.7	590	INDUSTRIAL (FLOUR MILLS)	KADUNA	KADUNA	NIGER CENTRAL	SURFACE WATER
28	NIGERIA BREWERIES PLC	10 28 43.3	7 24 46.4	599	INDUSTRIAL (BREWERY)	KADUNA	KADUNA	NIGER CENTRAL	SURFACE WATER
29	KADUNA STATE WATER CORPORATION	10 30 15.084	7 26 51.504	250	DOMESTIC WATER	KADUNA	KADUNA	NIGER CENTRAL	SURFACE WATER
30	TAMBURAWA WATER PLANT	11 50 52.6	8 30 47.6	447	DOMESTIC WATER	TAMBURAWA	KANO	LAKE CHAD	SURFACE WATER
31	SEVEN UP BOTTLING CO.	11 53 33.4	8 32 31.4	467	INDUSTRIAL (SOFT DRINKS)	KANO	KANO	LAKE CHAD	UNDERGROUND
32	NIGERIA BOTTLING COMPANY				INDUSTRIAL (SOFT DRINKS)	CHALLAWA	KANO	LAKE CHAD	SURFACE WATER
33	KANO STATE WATER BOARD				DOMESTIC WATER	KANO	KANO	LAKE CHAD	SURFACE WATER
34	ROYAL CERAMICS	7 26 31.1	6 40 46.5	73	INDUSTRIAL (TILES PRODUCTION)	AJAOKUTA	KOGI	NIGER CENTRAL	SURFACE WATER
35	GEREGU POWER PLC	7 28 16.1	6 39 32.6	110	HYDRO ELECTRICITY	AJAOKUTA	KOGI	NIGER CENTRAL	SURFACE WATER
36	GREATER LOKOJA WATER	7 44 01.1	6 44 47.0	47	DOMESTIC WATER	LOKOJA	KOGI	NIGER CENTRAL	SURFACE WATER
37	OLAM RICE	7 55 09.3	8 19 12.6	83	AGRICULTURE/IRRIGATION	RUKUBI	NASARAWA	LOWER NIGER	SURFACE WATER
38	NASARAWA STATE WATER BOARD				DOMESTIC WATER	LAFIA	NASARAWA	LOWER NIGER	
39	JEBBA DAM (MAINSTREAM ENERGY LTD.)	9 08 23.61	4 47 20.1	98	HYDRO ELECTRICITY	JEBBA	NIGER	NIGER CENTRAL	SURFACE WATER
40	SHIRORO DAM (NORTH SOUTH POWER LTD	9 58 22.4	6 50 03.3	289	HYDRO ELECTRICITY	SHIRORO	NIGER	NIGER CENTRAL	SURFACE WATER
41	KAINJI DAM (MAINSTREAM ENERGY LTD.)	9 51 45.0	4 36 45.0	124	HYDRO ELECTRICITY	KAINJI	NIGER	NIGER CENTRAL	SURFACE WATER
42	SUNTI JAAGI	9 05 59.3	5 13 36.1	66	INDUSTRIAL (FLOUR MILLS)	JAAGI	NIGER	NIGER CENTRAL	
43	DUFIL	6 41 06.9	3 13 07.0	84	INDUSTRIAL (PASTERS PRODUCTION)	OTA	OGUN	WESTERN LITTORIAL	UNDERGROUND
44	BELLS UNIVERSITY WATER	6 41 03.4	3 10 21.9	72	INDUSTRIAL (BOTTLE WATER)	OTA	OGUN	WESTERN LITTORIAL	UNDERGROUND
45	COVENANT UNIVERSITY WATER	6 40 09.8	3 09 29.0	61	INDUSTRIAL (BOTTLE WATER)	OTA	OGUN	WESTERN LITTORIAL	UNDERGROUND
46	ILESHA BREWERIES	7 37 30.9	4 46 57.6	429	INDUSTRIAL (BREWERY)	ILESHA	OSUN	WESTERN LITTORIAL	UNDERGROUND
47	TUNS FARM	7 50 32.6	4 36 38.8	381	AGRICULTURE/IRRIGATION	OSOGBO	OSUN	WESTERN LITTORIAL	UNDERGROUND
48	LASDOL TABLE WATER				INDUSTRIAL (BOTTLE WATER)	OSOGBO	OSUN	WESTERN LITTORIAL	UNDERGROUND
49	ESSENCE TABLE WATER	7 46 52.7	4 32 58.8	310	INDUSTRIAL (BOTTLE WATER)	OSOGBO	OSUN	WESTERN LITTORIAL	UNDERGROUND
50	UNIVERSITY OF IBADAN WATER	7 25 58.5	3 53 43.4	236	DOMESTIC WATER	IBADAN	OYO	WESTERN LITTORIAL	
51	FAN MILK	7 24 38.0	3 52 06.3	212	INDUSTRIAL (DIARY PRODUCTS)	IBADAN	OYO	WESTERN LITTORIAL	UNDERGROUND
52	SEVEN UP BOTTLING CO.	7 21 22.6	3 50 51.4	176	INDUSTRIAL (SOFT DRINKS)	IBADAN	OYO	WESTERN LITTORIAL	UNDERGROUND
53	PROCTER AND GAMBLE	7 21 23.4	3 51 00.1	168	INDUSTRIAL (HOUSEHOLD ITEMS)	IBADAN	OYO	WESTERN LITTORIAL	UNDERGROUND
54	RELIANCE CHEMICAL LTD	7 21 23.4	3 51 00.1	168	INDUSTRIAL (DISTILLATION)	IBADAN	OYO	WESTERN LITTORIAL	UNDERGROUND
55	OYO STATE WATER CORPORATION				DOMESTIC WATER	IBADAN	OYO	WESTERN LITTORIAL	
56	ZARTECH LTD.				INDUSTRIAL (POULTRY DRUGS)	IBADAN	OYO	WESTERN LITTORIAL	UNDERGROUND
57	BARKIN LADI DAM	9 45 56.5	8 58 23.4	1241	DOMESTIC WATER	JOS	PLATEAU	LOWER NIGER	SURFACE WATER
58	NASCO	9 52 30.6	8 52 22.8	1292	INDUSTRIAL (HOUSEHOLD ITEMS)	JOS	PLATEAU	LOWER NIGER	UNDERGROUND
59	LIBERTY DAM	9 53 34.3	8 55 30.5	1281	DOMESTIC WATER	JOS	PLATEAU	LOWER NIGER	SURFACE WATER
60	PRUWASA				DOMESTIC WATER	JOS	PLATEAU	LOWER NIGER	UNDERGROUND
61	DADIN KOWA DAM	10 19 15.2	11 28 43.8	262	DOMESTIC WATER	JOS	PLATEAU	LOWER NIGER	SURFACE WATER
62	SPDC	4 50 00.5	7 01 48.5	20	INDUSTRIAL (OIL AND GAS REFINERY)	PORT HARCOURT	RIVERS	NIGER SOUTH	UNDERGROUND
63	PH WATER	4 50 11.4	7 00 21.7	15	DOMESTIC WATER	PORT HARCOURT	RIVERS	NIGER SOUTH	UNDERGROUND
64	PABOD BREWERY				INDUSTRIAL (BREWERY)	PORT HARCOURT	RIVERS	NIGER SOUTH	UNDERGROUND
65	SOKOTO WATER BOARD	13 04 33.8	5 15 23.9	288	DOMESTIC WATER	SOKOTO	SOKOTO	NIGER NORTH	
66	INDUSTRIAL (CEMENT) CO. NORTHERN NIG	13 03 50.9	5 10 27.4	262	INDUSTRIAL (CEMENT)	SOKOTO	SOKOTO	NIGER NORTH	
67	BAKOLORI DAM	12 30 43.7	6 10 58.0	290	AGRICULTURE/IRRIGATION	BAKOLORI	ZAMFARA	NIGER NORTH	SURFACE WATER
68	FEDERAL UNIVERSITY GUSAU	12 07 42.1	6 46 52.3	468	DOMESTIC WATER	GUSAU	ZAMFARA	NIGER NORTH	UNDERGROUND
69	GUSAU DAM	12 08 48.5	6 40 21.1	449	DOMESTIC WATER	GUSAU	ZAMFARA	NIGER NORTH	SURFACE WATER
70	HAMSTORE INTEGRATED SERVICES				INDUSTRIAL (BOTTLE WATER)	GUSAU	ZAMFARA	NIGER NORTH	UNDERGROUND
71	ZM RUWASA				DOMESTIC WATER	GUSAU	ZAMFARA	NIGER NORTH	UNDERGROUND
72	ZAMFARA STATE WATER BOARD				DOMESTIC WATER	GUSAU	ZAMFARA	NIGER NORTH	

Table 4.3: Abstraction Points (Surface Water Only)

S/No.	LOCATION	INTAKE COORDINATES (DD MM SS.S) NORTHINGS (m)	EASTINGS (m)	ELEVATION (m)	SECTOR	TOWN	STATE	CATCHMENT AREA	SOURCE OF ABSTRACTION
1	COSCHARIS FARM	6 26 39.9	6 54 34.7	36	AGRICULTURE/IRRIGATION	ANAKU	ANAMBRA	NIGER SOUTH/EASTERN LITTORIAL	SURFACE WATER
2	INTERNATIONAL BREWERIES	6 07 36.2	6 45 47.2	18	INDUSTRIAL (BREWERY)	ONITSHA	ANAMBRA	NIGER SOUTH/EASTERN LITTORIAL	SURFACE WATER
3	GUBI DAM	10 25 06.1	9 52 36.4	571	AGRICULTURE/IRRIGATION	GUBI	BAUCHI	UPPER BENUE	SURFACE WATER
4	BENUE STATE WATER BOARD	7 44 44.7	8 31 56.1	76	DOMESTIC WATER	MAKURDI	BENUE	LOWER NIGER	SURFACE WATER
5	GURARA DAM	9 38 46.4	7 43 58.3	595	HYDRO ELECTRIC/WATER SUPPLY	GURARA	FCT/KADUNA	NIGER CENTRAL	SURFACE WATER
6	KRPC	10 24 54.7	7 29 06.5	617	INDUSTRIAL (OIL AND GAS REFINERY)	KADUNA	KADUNA	NIGER CENTRAL	SURFACE WATER
7	NIGERIA EAGLE FLOUR MILL	10 28 24.3	7 23 29.7	590	INDUSTRIAL (FLOUR MILLS)	KADUNA	KADUNA	NIGER CENTRAL	SURFACE WATER
8	NIGERIA BREWERIES PLC	10 28 43.3	7 24 46.4	599	INDUSTRIAL (BREWERY)	KADUNA	KADUNA	NIGER CENTRAL	SURFACE WATER
9	KADUNA STATE WATER CORPOR	10 30 15.084	7 26 51.504	250	DOMESTIC WATER	KADUNA	KADUNA	NIGER CENTRAL	SURFACE WATER
10	TAMBURAWA WATER PLANT	11 50 52.6	8 30 47.6	447	DOMESTIC WATER	TAMBURAWA	KANO	LAKE CHAD	SURFACE WATER
11	NIGERIA BOTTLING COMPANY				INDUSTRIAL (SOFT DRINKS)	CHALLAWA	KANO	LAKE CHAD	SURFACE WATER
12	KANO STATE WATER BOARD				DOMESTIC WATER	KANO	KANO	LAKE CHAD	SURFACE WATER
13	ROYAL CERAMICS	7 26 31.1	6 40 46.5	73	INDUSTRIAL (TILES PRODUCTION)	AJAOKUTA	KOGI	NIGER CENTRAL	SURFACE WATER
14	GEREGU POWER PLC	7 28 16.1	6 39 32.6	110	HYDRO ELECTRICITY	AJAOKUTA	KOGI	NIGER CENTRAL	SURFACE WATER
15	GREATER LOKOJA WATER	7 44 2.51	6 44 58.55	47	DOMESTIC WATER	LOKOJA	KOGI	NIGER CENTRAL	SURFACE WATER
16	OLAM RICE	7 55 09.3	8 19 12.6	83	AGRICULTURE/IRRIGATION	RUKUBI	NASARAWA	LOWER NIGER	SURFACE WATER
17	JEBBA DAM (MAINSTREAM ENEF	9 08 23.61	4 47 20.1	98	HYDRO ELECTRICITY	JEBBA	NIGER	NIGER CENTRAL	SURFACE WATER
18	SHIRORO DAM (NORTH SOUTH P	9 58 22.4	6 50 03.3	289	HYDRO ELECTRICITY	SHIRORO	NIGER	NIGER CENTRAL	SURFACE WATER
19	KAINJI DAM (MAINSTREAM ENEI	9 51 45.0	4 36 45.0	124	HYDRO ELECTRICITY	KAINJI	NIGER	NIGER CENTRAL	SURFACE WATER
20	SUNTI JAAGI	9 05 59.3	5 13 36.1	66	INDUSTRIAL (FLOUR MILLS)	JAAGI	NIGER	NIGER CENTRAL	SURFACE WATER
21	BARKIN LADI DAM	9 45 56.5	8 58 23.4	1241	DOMESTIC WATER	JOS	PLATEAU	LOWER NIGER	SURFACE WATER
22	LIBERTY DAM	9 53 34.3	8 55 30.5	1281	DOMESTIC WATER	JOS	PLATEAU	LOWER NIGER	SURFACE WATER
23	DADIN KOWA DAM	10 19 15.2	11 28 43.8	262	DOMESTIC WATER	JOS	PLATEAU	LOWER NIGER	SURFACE WATER
24	INDUSTRIAL (CEMENT) CO. NOR	13 03 50.9	5 10 27.4	262	INDUSTRIAL (CEMENT)	SOKOTO	SOKOTO	NIGER NORTH	SURFACE WATER
25	BAKOLORI DAM	12 30 43.7	6 10 58.0	290	AGRICULTURE/IRRIGATION	BAKOLORI	ZAMFARA	NIGER NORTH	SURFACE WATER
26	GUSAU DAM	12 08 48.5	6 40 21.1	449	DOMESTIC WATER	GUSAU	ZAMFARA	NIGER NORTH	SURFACE WATER

Figure 4.1: Satellite Imagery of The Bulk Water Users Locations

4.3 Water Footprint Assessment

Water is used for a variety of purposes in our daily lives: for drinking, bathing, washing our clothes, etc. Water is also required to produce nearly everything we use and consume, from the food we eat, the drinks we consume, and the clothes we wear to the technological devices that are integral to our modern society. In the production of goods, the water use may be indirect as compared to the direct water consumption understood by an average layman. Because this indirect water isn't visible in the product, it is also often referred to as "embedded," "embodied," or "virtual" water. A full measure, therefore, of the water footprint of an individual, industrial sector, or society is the combination of direct water use and the water used indirectly to provide or produce the goods and services consumed. The water footprint shows the extent of water use in relation to consumption of people.

As pressures on water resources intensify globally, there is growing interest in evaluating the complex ways in which every day human activities impact the world's water resources.

Consumptive and non-consumptive uses of water occur at almost every step along the supply chain of a product. The water footprint concept has been developed to estimate the amount of water consumed in the production of goods and services. The production of goods is often much more water-intensive than services, and water footprints have been calculated for a range of goods, from food to drinks, to agriculture/irrigation, to energy.

Simply put, the volume of water consumed to produce a cup of coffee is far more than the volume of the cup of coffee. For example, an average 35 gallons of water is consumed to produce a cup of coffee (including the water required to grow the coffee crop). Likewise, the water footprint of a cotton shirt includes the water for growing cotton, processing and dyeing fabric, and various finishing procedures.

The water footprint of a country is defined as the volume of water needed for the production of the goods and services consumed by the inhabitants of the country. Again, the water footprint of a nation can be defined as the total volume of freshwater that is used to produce the goods and services consumed by the people of the nation. Since not all goods consumed in one particular country are produced in that country, the water footprint consists of two parts: use of domestic water resources (Internal water footprint) and use of water outside the borders of the country (external water footprint). The internal water footprint is the volume of water used from domestic water resources; the external water footprint is the volume of water used in other countries to produce goods and services imported and consumed by the inhabitants of the country. Past studies have shown that the global average water footprint is 1240 m3/cap/yr.

The four major direct factors determining the water footprint of a country are: volume of consumption (related to the gross national income); consumption pattern (e.g. high versus low meat consumption); climate (growth conditions); and agricultural practice (water use efficiency).

Water abstraction and use traditionally is either for domestic, agricultural and industrial sector usage. Based on these, we have also presented the bulk water usage according to the basic use of the bulk users as shown in the table below"

4.3.1 Water Footprint of Nations - Arjen Hoekstra (University of Twente)

The water footprint concept has been developed in order to have an indicator of water use in relation to consumption of people. The water footprint of a country is defined as the volume of water needed for the production of the goods and services consumed by the inhabitants of the country. Closely linked to the water footprint concept is the virtual water concept. Virtual water is defined as the volume of water required to produce a commodity or service. International trade of commodities implies flows of virtual water over large distances. The water footprint of a nation can be assessed by taking the use of domestic water resources, subtract the virtual water flow that leaves the country and add the virtual water flow that enters the country.

The internal water footprint of a nation is the volume of water used from domestic water resources to produce the goods and services consumed by the inhabitants of the country. The external water footprint of a country is the volume of water used in other countries to produce goods and services imported and consumed by the inhabitants of the country.

The use of domestic water resources comprises water use in the agricultural, industrial and domestic sectors. The total volume of water use in the agricultural sector is calculated based on the total volume of crop produced and its corresponding virtual water content. The virtual water content (m^3/ton) of primary crops is calculated based on crop water requirements and yields. The crop water requirement of each crop is calculated using the methodology developed by FAO. The virtual water content of crop products is calculated based on product fractions (ton of crop product obtained per ton of primary crop) and value fractions (the market value of one crop product divided by the aggregated market value of all crop products derived from one primary crop).

The virtual water content (m^3/ton) of live animals is calculated based on the virtual water content of their feed and the volumes of drinking and service water consumed during their lifetime. The calculation of the virtual water content of livestock products is again based on product fractions and value fractions. Virtual water flows between nations are derived from statistics on international product trade and the virtual water content per product in the exporting country.

The global volume of water used for crop production, including both effective rainfall and irrigation water, is 6390 Gm^3/yr. In general, crop products have lower virtual water content than livestock products. For example, the global average virtual water content of maize, wheat and rice (husked) is 900, 1300 and 3000 m^3/ton respectively, whereas the virtual water content of chicken meat, pork and beef is 3900, 4900 and 15500 m^3/ton respectively. However, the virtual water content of products strongly varies from place to place, depending upon the climate, technology adopted for farming and corresponding yields. The global volume of virtual water flows related to the international trade in commodities is 1625 Gm^3/yr. About 80% of these virtual water flows relate to the trade in agricultural products, while the remainder is related to industrial product trade.

The global water footprint is 7450 Gm^3/yr, which is 1240 m^3/cap/yr. The differences between countries are large: the USA has an average water footprint of 2480 m^3/cap/yr, while China has an average footprint of 700m^3/cap/yr. The four major factors determining the water footprint of a country are: volume of consumption a (related to the gross national income); consumption pattern (e.g. high versus low meat consumption); climate (growth conditions); and agricultural practice (water use efficiency).

The countries with a relatively high rate of evapotranspiration and a high gross national income per capita (which often results in large consumption of meat and industrial goods) have large water footprints, such as: Portugal (2260 m^3/yr/cap), Italy (2330 m^3/yr/cap) and Greece (2390 m^3/yr/cap). Some countries with a high gross national income per capita can have a relatively low water footprint due to favourable climatic conditions for crop production, such as the United Kingdom (1245 m^3/yr/cap), the Netherlands (1220 m^3/yr/cap), Denmark (1440 m^3/yr/cap) and Australia (1390 m^3/yr/cap). Some countries can exhibit a high water footprint because of high meat proportions in the diet of the people and high consumption of industrial products, such as the USA (2480 m^3/yr/cap) and Canada (2050 m^3/yr/cap).

International water dependency is substantial. An estimated 16% of the global water use is not for producing domestically consumed products but products for export. With increasing globalisation of trade, global water interdependencies are likely to increase.

4.3.2 Virtual Water and Water Footprint - by Environmental Justice Organisation, Liabilities and trade

Humans consume water directly for drinking, cooking and washing, but much more for producing commodities such as food, paper, cotton clothes, etc. The amount of water that is used in the production processes of commodities during their entire life cycle is referred to as the virtual water contained within them (Hoekstra, 2003). Virtual water can be further divided into 'blue' water (which evaporates from rivers, lakes or aquifers in production processes such as irrigation), 'green' water (rainfall that evaporates during crop growth), and 'grey' water (polluted after agricultural, industrial and household use).

The water footprint of an individual, community or business is defined as the total volume of freshwater that is used to produce the goods and services consumed by that individual or community or produced by the business. Some sample water footprints are set out below (Source: www.waterfootprint.org):

- The production of 1 kilogram of beef requires 16,000 litres of water.
- To produce one cup of coffee we need 140 litres of water.
- The water footprint of China is about 700 m3 per year per capita. Only about 7 percent of the Chinese water footprint falls outside China.
- Japan with a footprint of 1,150 m3 per year per capita, has about 65 percent of its total water footprint outside the borders of the country.
- The US water footprint is 2,500 m3 per year per capita.

Since the per capita consumption of virtual water contained in our diets varies according to the type of diet (from 1 m3/day for a survival diet, to 2.6 m3/day for a vegetarian diet and over 5 m3/day for a US-style meat-based diet) it is clear that the moderation of diets (reducing meat consumption) can have a big impact on virtual water use. However, the precise impact of a water footprint depends entirely on where water is taken from and when. An increased footprint in an area where water is plentiful is unlikely to have an adverse effect, but an increase in an area experiencing scarcity could result in the drying up of rivers, the destruction of habitats and livelihoods, and the extinction of species – in addition to affecting agricultural prices, supplies and local economies. Some proponents of virtual water argue for the need for a labelling scheme,

with the water footprint of a product clearly set out so as to encourage demand management. This would help consumers and policy-makers recognize links between production and consumption.
On the policy level, a water-scarce country can import products that require a lot of water in their production (import of virtual water) to relieve pressure on its own resources. This is a strategy first adopted by Israel, which imports almost all cereals. Conversely, arguments are made that dry countries such as Spain should not be exporting tomatoes with a high virtual water content to wet Northern Europe. Exports of paper pulp, soybeans or ethanol from Latin America to Europe or China imply large exports of virtual water. This type of global virtual water trade has geopolitical implications: it induces dependencies between countries.

Virtual water proponents believe insufficient attention is placed on demand management in comparison to supply management. In their opinion, consumer demand management through education/information, labeling schemes has been overlooked, because consumers and policy-makers do not recognize links between production and consumption. One problem with virtual water labeling is that water content should be considered bearing in mind its geographical and temporal importance (50 litres of water taken from England is not the same as from the Sahara, or from Valencia in summer – high tourist season when water is scarce). Similarly, an agricultural product grown with rainwater is not comparable with one grown with irrigated water extracted from non-renewable ground water. Thus, virtual water gives no indication if water is being used within sustainable extraction limits, which can change annually based on rainfall. Finally, the virtual water argument can also have consequences politically, particularly regarding equity. Water released from one use will not necessarily be used more efficiently, or distributed more equitably. If water is released from agriculture, and farmers grow lower-value crops with less water requirements, the released water could easily be absorbed by urban users, or by the industrial sector instead of being distributed more equitably among the rural poor.

4.4 Methodology

To effectively carry out the water footprint for Nigeria, the consultant used the following methods to gather information which served as basis for the production of this report:

1. Site visits and on-spot information collection
2. Structured questionnaire (used especially in situations where on-spot information could not be collected, and for states/HAs that could not be visited
3. Review of existing documents

4.5 Water Use by Sectors and Tariff

JIL Engineering Associates Limited was to determine the bulk water use or footprint and tariff paid by the following sectors:

- The water footprint of electricity and Tariffs
- The water footprint of Crude Oil and Gas Water Footprint and Tariffs
- The Domestic water footprint and Biofuel Water Footprint and Tariffs
- The Industrial Water Footprint and Tariffs
- Agricultural Water Footprint and Tariffs

A tabular presentation of the water use of various sectors as obtained from the bulk water users visited is shown below in table 4.4.

It is very evident from the table that information on water use and tariff were not given for many of the establishments visited across the sectors.
The consultant covered all the hydrological areas and visited all the companies as listed in the table.

A major challenge encountered by the consultant in obtaining the water footprint of the sectors as demanded in the project terms of reference is unavailability of data.
Almost all the bulk water users visited had no systematic way of keeping record of their water abstraction and use and this made the consultants work very difficult.

We inferred that either these records were not there or that there was no willingness to give such information to us or that they do not pay anything for the water they use in their activities.

From the table below, it is obvious that some bulk users pay very high for a cubic meter of water, while others pay very low. This is assuming that information given were correct. The highest tariff was paid in the industrial sector by NASCO (N900/Cu.m) followed by Northern Noddles (N100/Cu.m). The lowest tariff was paid by the Kaduna refinery despite being one of the highest bulk water users (0.01k/Cu.m). the consultant finds this ridiculous.

Table 4.4: Water Use by Sectors and Tariff

S/No.	LOCATION	SECTOR	TOWN	STATE	CATCHMENT AREA	QUANTITY ABSTRACTED PER DAY (liters)	QUANTITY ABSTRACTED PER DAY (CU.M/DAY)	QUANTITY ABSTRACTED (CU.M/MONTH)	TOTAL TARIFF PAID/MONTH (N)	TARIFF/CU.M (N)
1	COSCHARIS FARM	AGRICULTURE/IRRIGATION	ANAKU	ANAMBRA	NIGER SOUTH/EASTERN LITTORIAL					
2	GUBI DAM	AGRICULTURE/IRRIGATION	GUBI	BAUCHI	UPPER BENUE	53,645,000	53,645	1,609,350		
3	EBONY AGRO INDUSTRIES	AGRICULTURE/IRRIGATION	IKWO	EBONYI	EASTERN LITTORIAL					
4	OLAM RICE	AGRICULTURE/IRRIGATION	RUKUBI	NASARAWA	LOWER NIGER					
5	TUNS FARM	AGRICULTURE/IRRIGATION	OSOGBO	OSUN	WESTERN LITTORIAL					
6	BAKOLORI DAM	AGRICULTURE/IRRIGATION	BAKOLORI	ZAMFARA	NIGER NORTH					
7	STOWA	DOMESTIC WATER	BAUCHI	BAUCHI	UPPER BENUE					
8	BAUCHI STATE URBAN WATER	DOMESTIC WATER	BAUCHI	BAUCHI	UPPER BENUE					
9	BAUCHI STATE RUWASA	DOMESTIC WATER	BAUCHI	BAUCHI	UPPER BENUE					
10	BENUE STATE WATER BOARD	DOMESTIC WATER	MAKURDI	BENUE	LOWER NIGER	16,800,000	16,800	504,000		
11	BENUE STATE RURAL WATER	DOMESTIC WATER	MAKURDI	BENUE	LOWER NIGER	31,500,000	31,500	945,000		
12	ALEX EKWUEME UNIVERSITY NDUFU ALIKE	DOMESTIC WATER	IKWO	EBONYI	EASTERN LITTORIAL					
13	GOMBE STATE WATER BOARD	DOMESTIC WATER	GOMBE	GOMBE	UPPER BENUE	189,270,589.2	189,271	5,678,118		
14	GOMBE STATE RUWASA	DOMESTIC WATER	GOMBE	GOMBE	UPPER BENUE					
15	JIGAWA STATE WATER BOARD	DOMESTIC WATER	DUTSE	JIGAWA	LAKE CHAD					
16	KADUNA STATE WATER CORPORATION	DOMESTIC WATER	KADUNA	KADUNA	NIGER CENTRAL					
17	TAMBURAWA WATER PLANT	DOMESTIC WATER	TAMBURAWA	KANO	LAKE CHAD					
18	KANO STATE WATER BOARD	DOMESTIC WATER	KANO	KANO	LAKE CHAD					
19	GREATER LOKOJA WATER	DOMESTIC WATER	LOKOJA	KOGI	NIGER CENTRAL	60,000,000	60,000	1,800,000		
20	NASARAWA STATE WATER BOARD	DOMESTIC WATER	LAFIA	NASARAWA	LOWER NIGER					
21	UNIVERSITY OF IBADAN WATER	DOMESTIC WATER	IBADAN	OYO	WESTERN LITTORIAL					
22	OYO STATE WATER CORPORATION	DOMESTIC WATER	IBADAN	OYO	WESTERN LITTORIAL					
23	BARKIN LADI DAM	DOMESTIC WATER	JOS	PLATEAU	LOWER NIGER					
24	LIBERTY DAM	DOMESTIC WATER	JOS	PLATEAU	LOWER NIGER	48,454,860	48,455	1,453,646		
25	PRUWASA	DOMESTIC WATER	JOS	PLATEAU	LOWER NIGER	1,400,000	1,400	42,000		
26	DADIN KOWA DAM	DOMESTIC WATER	JOS	PLATEAU	LOWER NIGER					
27	PH WATER	DOMESTIC WATER	PORT HARCOURT	RIVERS	NIGER SOUTH					
28	SOKOTO WATER BOARD	DOMESTIC WATER	SOKOTO	SOKOTO	NIGER NORTH					
29	FEDERAL UNIVERSITY GUSAU	DOMESTIC WATER	GUSAU	ZAMFARA	NIGER NORTH	150,000	150	4,500	80,000.00	17.78
30	GUSAU DAM	DOMESTIC WATER	GUSAU	ZAMFARA	NIGER NORTH	13,800,000	13,800	414,000		
31	ZM RUWASA	DOMESTIC WATER	GUSAU	ZAMFARA	NIGER NORTH	432,000	432	12,960		
32	ZAMFARA STATE WATER BOARD	DOMESTIC WATER	GUSAU	ZAMFARA	NIGER NORTH					
33	GURARA DAM	HYDRO ELECTRIC/WATER SUPPLY	GURARA	FCT/KADUNA	NIGER CENTRAL					
34	GEREGU POWER PLC	HYDRO ELECTRICITY	AJAOKUTA	KOGI	NIGER CENTRAL					
35	JEBBA DAM (MAINSTREAM ENERGY LTD.)	HYDRO ELECTRICITY	JEBBA	NIGER	NIGER CENTRAL					
36	SHIRORO DAM (NORTH SOUTH POWER LTD	HYDRO ELECTRICITY	SHIRORO	NIGER	NIGER CENTRAL					
37	KAINJI DAM (MAINSTREAM ENERGY LTD.)	HYDRO ELECTRICITY	KAINJI	NIGER	NIGER CENTRAL					
38	KRPC	OIL AND GAS	KADUNA	KADUNA	NIGER CENTRAL	17,997,000	17,997	539,910	2,700.00	0.01
39	SPDC	OIL AND GAS	PORT HARCOURT	RIVERS	NIGER SOUTH					
40	BLUE ROSE WATER FACTORY	INDUSTRIAL (BOTTLE WATER)	CALABAR	CROSS RIVER	EASTERN LITTORIAL					
41	ARCH O. VENTURES	INDUSTRIAL (BOTTLE WATER)	CALABAR	CROSS RIVER	EASTERN LITTORIAL					
42	CWAY INDUSTRIAL (BOTTLE WATER)	INDUSTRIAL (BOTTLE WATER)	BENIN	EDO	NIGER SOUTH	22,000	22	660		
43	NESTLE WATER	INDUSTRIAL (BOTTLE WATER)	ABAJI	FCT ABUJA	NIGER CENTRAL	600,000	600	18,000	30,000.00	1.7
44	SHEMAR'S RUWAN DADI WATERS	INDUSTRIAL (BOTTLE WATER)	DUTSE	JIGAWA	LAKE CHAD					
45	BELLS UNIVERSITY WATER	INDUSTRIAL (BOTTLE WATER)	OTA	OGUN	WESTERN LITTORIAL					
46	COVENANT UNIVERSITY WATER	INDUSTRIAL (BOTTLE WATER)	OTA	OGUN	WESTERN LITTORIAL					
47	LASDOL TABLE WATER	INDUSTRIAL (BOTTLE WATER)	OSOGBO	OSUN	WESTERN LITTORIAL					
48	ESSENCE TABLE WATER	INDUSTRIAL (BOTTLE WATER)	OSOGBO	OSUN	WESTERN LITTORIAL					
49	HAMSTORE INTEGRATED SERVICES	INDUSTRIAL (BOTTLE WATER)	GUSAU	ZAMFARA	NIGER NORTH	6,143	6.14	184.3		
50	INTERNATIONAL BREWERIES	INDUSTRIAL (BREWERY)	ONITSHA	ANAMBRA	NIGER SOUTH/EASTERN LITTORIAL					
51	GUINESS NIG. LTD	INDUSTRIAL (BREWERY)	BENIN	EDO	NIGER SOUTH					
52	NIGERIA BREWERIES PLC	INDUSTRIAL (BREWERY)	KADUNA	KADUNA	NIGER CENTRAL	120,000	120	3,600		
53	ILESHA BREWERIES	INDUSTRIAL (BREWERY)	ILESHA	OSUN	WESTERN LITTORIAL					
54	PADOL	INDUSTRIAL (BREWERY)	PORT HARCOURT	RIVERS	NIGER SOUTH					
55	LAFARGE INDUSTRIAL (CEMENT)	INDUSTRIAL (CEMENT)	MFAMOSING	CROSS RIVER	EASTERN LITTORIAL					
56	INDUSTRIAL (CEMENT) CO. NORTHERN NIG	INDUSTRIAL (CEMENT)	SOKOTO	SOKOTO	NIGER NORTH					
57	FAN MILK	INDUSTRIAL (DIARY PRODUCTS)	IBADAN	OYO	WESTERN LITTORIAL					
58	RELIANCE CHEMICAL LTD	INDUSTRIAL (DISTILLATION)	IBADAN	OYO	WESTERN LITTORIAL					
59	NIGERIA EAGLE FLOUR MILL	INDUSTRIAL (FLOUR MILLS)	KADUNA	KADUNA	NIGER CENTRAL					
60	SUNTI JAAGI	INDUSTRIAL (FLOUR MILLS)	JAAGI	NIGER	NIGER CENTRAL					
61	OLAM GRAINS	INDUSTRIAL (GRAINS BAGGING)	KADUNA	KADUNA	NIGER CENTRAL					
62	PROCTER AND GAMBLE	INDUSTRIAL (HOUSEHOLD ITEMS)	IBADAN	OYO	WESTERN LITTORIAL					
63	NASCO	INDUSTRIAL (HOUSEHOLD ITEMS)	JOS	PLATEAU	LOWER NIGER	3,000	3	90	81,000.00	900
64	NORTHERN NOODLES	INDUSTRIAL (PASTERS PRODUCTION)	KADUNA	KADUNA	NIGER CENTRAL	400,000	400	12,000	1,200,000.00	100.00
65	DUFIL	INDUSTRIAL (PASTERS PRODUCTION)	OTA	OGUN	WESTERN LITTORIAL					
66	ZARTECH LTD.	INDUSTRIAL (POULTRY DRUGS)	IBADAN	OYO	WESTERN LITTORIAL					
67	NIGERIA BOTTLING COMPANY	INDUSTRIAL (SOFT DRINKS)	BENIN	EDO	NIGER SOUTH					
68	SEVEN UP BOTTLING CO.	INDUSTRIAL (SOFT DRINKS)	BENIN	EDO	NIGER SOUTH					
69	SEVEN UP BOTTLING CO.	INDUSTRIAL (SOFT DRINKS)	KANO	KANO	LAKE CHAD					
70	NIGERIA BOTTLING COMPANY	INDUSTRIAL (SOFT DRINKS)	CHALLAWA	KANO	LAKE CHAD					
71	SEVEN UP BOTTLING CO.	INDUSTRIAL (SOFT DRINKS)	IBADAN	OYO	WESTERN LITTORIAL					
72	ROYAL CERAMICS	INDUSTRIAL (TILES PRODUCTION)	AJAOKUTA	KOGI	NIGER CENTRAL					

5.0 WATER TARIFF

5.1 INTRODUCTION

Water systems in developing countries must (1) provide services that are safe, desirable, and affordable to consumers; and (2) ensure an institutional and commercial system capable of actually recovering costs (Stalker and Komives, 2001). These often-conflicting goals have significant political and economic implications. The effort to balance them is particularly challenging in developing countries and can lead to the implementation of price structures that do not help meet either goal and, in fact, have an adverse impact on poor consumers (Whittington, Boland, and Foster, 2002).

Like any business, utilities must recover their costs if they are to sustain their operations. Tariffs are the most common way of doing so. Water tariff here refers to the price charged by the water utility on consumers who obtain water from the urban water supply network operated by the utility. But tariffs serve other goals beyond raising revenues to cover all or part of costs. They also are used to ensure access across socioeconomic groups, to send price signals to users about the relationship between water use and water scarcity, and to ensure fairness in water service delivery (Cardone and Fonseca, 2003).

In developing countries, tariffs are controversial for many reasons. For policy makers, one objective can be more important than another, which can lead to the adoption of different tariff structures. The impact of such structures on consumers is ambiguous. Despite recent advances, policy makers are not sufficiently informed of the effects on consumer behaviour. A lack of competition in the water market implies that policy makers do not have a market test of whether a tariff structure is functioning effectively, with consumers unable to reject a tariff structure that is negatively impacting them (Whittington, Boland, and Foster, 2002).

In most developing countries, prices are usually set below full cost recovery for historical and political reasons, and there are implicit and explicit subsidies associated with the tariff structure. That is the conventional wisdom, but there has been insufficient focus on Africa to evaluate whether its water tariffs are meeting the desired goals.

Water tariff structures are measured against the criteria of cost recovery, efficiency, and equity. Questions include: do tariffs recover costs? are customers metered? are there cross subsidies between large and small consumers, public stand posts, and private residential consumers? are water usage charges equitable, and are water connection charges fair?

5.2 BASIC MODELS OF TARIFF STRUCTURES

There are several different tariff structure models occurring in practice that we present bellow – the objective is to select the most appropriate model for the country. These are, for example:

- Single unit price of a m^3 of water, paying according to volume of water used without a fixed charge;
- Single unit price of a m^3 of water, paying according to volume of water used with a fixed charge;
- Single unit price of a m^3 of water for all consumers;
- Flat tariff;
- Marginal cost tariff;
- Tariff structure with two or more block tariffs.

We shall attempt to describe each of the model stated above as follows:

Single unit price of a m3 of water, paying according to volume of water used without a fixed charge

This relates to tariff set per unit of the consumed water volume (KM/m^3) where the unit price does not depend on the total volume of water consumed (every m3 of water has equal price for the same consumer category). The tariff per m^3 still can be (but does not have to be) different for different categories of consumers. It includes specific consumer's costs such as meter maintenance or meter reading and billing. This method does not include fee for recovery of costs not depending on the delivered volume of water (consumer's costs). It is simple to analyse and apply and easily understandable for service users.

Single unit price of a m^3 of water, paying according to volume of water used with a fixed charge

This differs from the previous structure in a way that, along with the volumetrically set charge, the fixed charge is added, which does not depend on the volume of water consumed. The two variants of this tariff structure relate to fixed charge which includes only specific consumer's costs, i.e. the fixed charge including, along with consumer's costs, also a certain volume of water consumed. In this case, the price per m^3 can (but does not have to be) different for different categories of consumers too.

In the former case, therefore, the fixed charge primarily concerns the specific costs of maintenance and replacement of meters, meter reading and billing, with possible adding of the (small) amount related to maintenance of the operational network. In the latter case, even a relatively small volume of water is included in the fixed charge (usually 5%-15% of the average consumption in this category); the volume of water included in the fixed charge should not be large, because in that case the fixed charge could turn into a flat rate. The estimate of the volume of water to be included in the fixed charge can be conducted based on the minimum volume of water delivered to that category of consumers during the year. All other consumption above this volume that enters the fixed charge is calculated per m^3 with equal unit price within the same category, and independently on the volume of water consumed. In this case, the price per m^3 can (but does not have to be) different for different categories of consumers too.

Single unit price of a m^3 of water for all consumers

A single price per m^3 is set regardless of the category of consumers, irrespective of the volume of water consumed. A unit price per m^3 is calculated by simple dividing of the total required revenues with the total estimated water consumption. This is mostly used in practice in the small systems where consumers have similar requirements. Specific consumer's factors such as inequality of consumption or the size of meters are not taken into account when setting the price.

Flat tariff

This type of the tariff structure is mostly used when water consumption is not metered, mainly in the category of households. This structure is not cost-effective and should be avoided whenever possible.

It is usually based on the number of household members, which may seem logical (although it is not always simple to obtain the updated information on the number of members, particularly in terms of seasonal, e.g. students' holidays), but in case of individual dwelling units this principle does not take into account the consumption of water for purposes such as watering the garden, washing and cooling terraces, etc. In practice, it is even possible to see the principle of the flat rate per household, regardless of the number of the household members, or even the dwelling size, which obviously has nothing to do with real consumption and puts consumers of services in unequal position.

Marginal Cost Tariff

This tariff model is based on marginal costs related to production of the additional product unit. The prices are, thus, related to the costs of the required enhancement of the total water supply capacity, namely development of additional infrastructural facilities needed for the increased production driven by the increased demand. This way, an adequate signal on the real water price is sent to consumers. The application of this tariff structure is not practical for water supply and sewerage services.

Tariff Structure with Two Or More Block Tariffs

The structure with two or more block tariffs can have increasing or decreasing character. A distinctive market approach to sale appears when the unit price of a product or a service decreases with the quantity of order - in this case, this means that the unit price decreases as the consumption grows, within the given framework (e.g. the first 5 m^3 of consumption are billed at one price per m^3, then the price decreases for consumption of 6-10 m^3, then the price decreases again, etc.). In principle, this tariff structure makes sense, since most of the costs incurred by service provision are captured by assuring the basic consumption; thereby the unit costs of users with lower consumption are higher. Nevertheless, increasing block tariff is used more frequently – when the unit cost per m^3 of water increases with higher consumption. This is primarily used to stimulate water saving. After adopting the block tariff ceilings, it should also be checked whether the adopted elements create sufficient revenues to recover all related costs (for each of the categories of consumers).

5.3 REVIEW OF EXISTING WATER TARIFF STRUCTURE

Many bulk water users visited agree that they pay for bulk water abstraction of raw water supplied to them. However, only 5 bulk users provided information on the amount they pay and to which government agency. Regrettably, none of the users visited confirmed that they pay to NIWRMC as they have limited information on the commission. Payments are made to various federal and state government agencies such as National Inland Water Authority (NIWA), State water corporations.

From information gathered, the table below shows the bulk water users that actually pay for bulk water use, the amount they pay, and the relevant agency they pay to:

S/No.	LOCATION	SECTOR	TOWN	SOURCE OF ABSTRACTION	QUANTITY ABSTRACTED PER DAY	UNIT	QUANTITY ABSTRACTED PER DAY (CU.M/DAY)	TARRIFF PAID (₦)	UNIT	TARRIFF PAID PER MONTH		QUANTITY ABSTRACTED PER MONTH	Naira/Cu.m	
1	NESTLE WATER	INDUSTRIAL (BOTTLE WATER)	ABAJI	UNDERGROUND	600000	LTRS	600	30,000.00	MONTH	30,000.00	NAIRA/MTH	18,000.00	1.67	
2	KRPC	INDUSTRIAL (OIL AND GAS REFINERY)	KADUNA	SURFACE WATER	17.997	ML	17997	90.00	DAY	1,980.00	NAIRA/MTH	539,910.00	0.004	
3	NIGERIA BREWERIES PLC	INDUSTRIAL (BREWERY)	KADUNA	SURFACE WATER	120000	LTRS	120	100.00	CU.M	19,591.00	NAIRA/MTH	3,600.00	100.00	
4	NASCO	INDUSTRIAL (HOUSEHOLD ITEMS)	JOS	UNDERGROUND	30000	LTRS	30	81,000.00	MONTH	81,000.00	NAIRA/MTH	900.00	90.00	
5	FEDERAL UNIVERSITY GUSAU	DOMESTIC WATER	GUSAU	UNDERGROUND	150000	LTRS	150	20,000.00	WEEK	80,000.00	NAIRA/MTH	4,500.00	17.78	
													41.89	Average Naira/Cu.m

From the table above and based on analysis, the highest amount paid as tariff for bulk water use per cubic meter is about N100.00, while the lowest is N0.004, with an average of N41.89 per cu.m.

Comparing the result of the analysis to that of other countries (as obtained from the NIWRMC document: A Report on Water Tariff setting, as shown below, it can be said that water Tariff in Nigeria is still very low. The current 0.25k/cu.m of water in Nigeria is substantially low and therefore not sustainable.

S/N	COUNTRY BY RANK	COST US¢/1m3	NAIRA CONVERSION (₦)
1	Germany	178.1	641.16
2	Denmark	172	619.2
3	United Kingdom	123.2	443.52
4	Netherlands	113.8	409.68
5	France	108.3	389.88
6	Belgium	101.9	366.84
7	Italy	72.7	261.72
8	Spain	71.2	256.32
9	Finland	64.3	231.48
10	Sweden	61.5	221.4
11	Australia	54.7	196.92
12	United States	54.3	195.48
13	South Africa	42.8	154.08
14	Ghana	39.11	140.79
15	Canada	37.6	135.36
16	Kenya	33.65	121.15
17	Algeria	7	25.2
18	Egypt	4	14.4
19	Nigeria	0.07	0.252

* CBN Exchange rate of USD = ₦360

5.4 Methodology for Tariff Setting

This one, and partly the following chapter present proposal of tariff setting methodology for water. All proposals are based on previously presented information.

5.4.1 Criteria for Tariff Setting

It is important to highlight that water supply services are of public interest with multiple aspects affecting the tariff setting – such as:

- Economic aspect;
- Social aspect; and
- Political aspect

In practice, political aspect sometimes plays a dominant role, although disguised by public emphasis of the social aspect. Namely, the low approved price is publicly justified by poverty of local population (social aspect), without any differentiation of the poverty level so, in fact, even the richest get subsidised.

The Consultant proposes that the methodology should primarily focus on the economic aspect, with consistent and full compliance with the affordability principle, which would actually incorporate the social aspect as well.

5.4.2 Methods for Achieving the Set Principles

In this chapter, the consultant, presented several key principles to be taken into consideration when setting the price for water supply. The following is the Consultant’s proposal for achieving these principles in Nigeria.

Principle Consumer Pays

In line with considerations above, the Consultant suggests to equalise water price for all consumer categories. Such an approach will simplify calculation of tariff, which will assume only total consumption instead of consumption classified per categories of consumers.

Principle of Equity and Equality

UN Resolution 64/292 of 28th July 2010 recognised the human right to water as essential for the realisation of all other human rights. It is defined as the right of everyone to sufficient, safe, acceptable and physically accessible and affordable water for personal or domestic uses. This principle leads to responsibility of the local community to assure water under equal conditions for its entire population, which is currently not the case in many parts of Nigeria since it is assured only in core urban area through the so-called central water supply system, whereas other systems outside this area are mainly out of control and local community management.

Principle of affordability

This principle is directly related to the previous one, and only together they fulfil the goals of the UN Resolution on the human right to water. It determines the highest possible price that an average family can monthly pay from its income and the average consumption per person.

Although in practice, the real problem is the assessment of a family’s overall monthly income in the relevant local community. Namely, this income does not include only wages earned in public and private sector, but also direct or opportunity income from agriculture, tourism, small services, residential and commercial rentals, etc., for which good quality inputs cannot be obtained.

Principle of Conservation of Natural Resources

Principle of conservation of natural resources or the Principle of environmental efficiency is to some extent already in use through application of the defined water fees such as special water fees for use of surface and groundwaters, water protection fees, extraction of materials from watercourses, etc.

The other options pertain to those local communities with scarce water sources and insufficient quantities to meet all the stated needs without full exhaustion of natural resources. In those cases, the Consultant does not suggest introduction of additional general fees, but rather the application of the increasing block tariff models (can be on a seasonal basis, in case of uneven water scarcity), where any excessive consumption will be discouraged by higher price compared to basic consumption. Specifically, for such cases the block tariff model is proposed with the unit price covering the basic costs to the full amount for the first 5 m^3 of water consumed per person, increased by 50% for the subsequent 5m^3 consumed, and increased by 100% for each subsequent m^3. In case when the application of this tariff brings higher revenues than the respective costs, it is suggested to earmark them into activities of reducing losses in the network, or general improvement of service quality.

Full Recovery of Costs
This principle is extremely important, while a baseline for its consistent application is full understanding of all costs pertaining to water supply services.

Principle of Economic Efficiency
The Consultant finds that this principle is extremely important for enhancing the Nigerian water supply sector performance.

5.4.3 Tariff Structure Proposal and Method of Price Calculation

The most common model in Nigeria practice is the model of unit price per m^3 of water, paying according to water consumed, i.e is uniform volumetric tariff as practiced in Lagos state for example.
The Consultant suggests the application of the model of single unit price per m^3 of water with paying according to volume of water used with a fixed charge, where the tariff per m^3 is equal for all categories of consumers, with the following instructions on the price calculation method:

Fixed charge: A very important aspect of the efficient water system management is metering. It assumes measuring of water production, flow (and pressure) as well as metering the consumption of users served. In the current practice, this function is not understood and implemented in a way that corresponds to its importance, and it is quite often the case that there are meters or water intake meters at all to check the quantity of water taken from our water resource by the bulk water users.

It is also proposed not to include any volume of water in the fixed charge; i.e. fixed charge should assume 0 m^3 of consumption, while every m^3 of water consumed should be calculated per unit price as explained bellow. Namely, the essential goal of the fixed charge introduced in this proposal is to make up revenue loss due to poor metering.

Unit water price per m^3: This proposal to be equal for all consumer categories and should be charged in addition to the fixed charge.

5.5 Affordability Index

Affordability is a function of both ability and willingness to pay. Subject to a budget constraint, the ability to pay refers to whether consumers can purchase goods or services given the prevailing prices. The amount that can be consumed is therefore constrained by the income available to the consumer. Willingness to pay refers to the maximum amount an individual is willing to sacrifice to acquire a good or receive a service. It therefore emphasises the consumer's preferences and taste.

In the case of willingness to pay, affordability considerations refer to the acceptability of prices. A good or service set above the maximum price a consumer is willing to sacrifice to acquire it will thus be unacceptable (Pontius, 2003).

Two prevalent approaches to measuring affordability from an ability to pay perspective are the affordability ratio and the residual income approaches. These have been applied to varying degrees in the water services sector with affordability ratios having clear dominance. A third and alternative approach combines both methods and calculates the ratio of water services expenditure to residual income where residual income is household income less food expenditure.

Affordability Ratios: What proportion of household income is allocated to water services?

The most common and popular measure of affordability of water services is affordability ratios. These ratios indicate what proportion of household income is spent on water services. The Organization for Economic Cooperation and Development (2003) differentiate between macro-affordability ratios and micro-affordability ratios. The former calculates average national water services expenditures divided by average household income and the latter does the same but for different subgroups such as income groups, family type and composition and geographic region (Cruz et al., 2015). Macro-affordability ratios are what Gawel et al. (2011) refer to as Conventional Affordability Ratios (CAR). The calculated ratio is compared to a pre-defined threshold. Prices are considered affordable where the ratio is below the threshold and considered to be creating a financial burden where it is above the ratio (Hutton, 2012).

$$\textit{Affordability ratio (index)} = \frac{\textit{Expenditure on Water Services}}{\textit{Total Household Income or Expenditure}} \; x \; 100$$

In trying to profile the affordability index for Nigeria, we adopt a per capita demand of water of 120liters/person/day as given by Nigerian Standard for Drinking Water Quality. We also adopt the current minimum wage in Nigeria as the total household income.

If we apply the Nigeria minimum wage of N30,000, as the total household income per month, then we arrive at 3.6% affordability index.

To identify a state of (un)affordability a target ratio is set normatively. Prominent are the target ratios 3-5% set by the World Bank (see table below), which is applied by various studies of water affordability (e.g. Bayrau 2005 and Smith/Green 2005). Accordingly, the Conventional Affordability Ration identifies problematic situations for households whose affordability index is above the world bank target of 5%.

Table 5.1: Affordability Ratio

Source	Target Ratios for Water
World Bank	3-5%
UK Government	3%
US Government	2,5%
Asian Development Bank	5%

Table 1: CAR benchmarks for measuring water-affordability (in per cent of total household income/expenditure). Source: *Fankhauser/Tepic* (2007: 1040).

From the formula given above based on Nigerian Minimum wage of N30,000.00, and using a proposed water tariff of N300/m^3, the affordability index is 3.6%. Since it is below the world bank bench mark of 5%, it therefore could be said to be affordable.

5.6 Cost Recovery Mechanism

5.6.1 Introduction

The production and provision of clean water to consumers entails a cost both in terms of initial capital outlay and in ongoing operation, maintenance, management and extension of services. However, because of poor planning for cost recovery, a lack of government funding and inadequate tariff rates, the ability of the sector to recover costs is often limited even for routine operation and maintenance. This has led to problems in providing sustainable water supplies.

Cost-recovery and application of water charges is a very political issue as many consumers have been used to provision of water supply as a free service or one for which only nominal payment is made. There is still a widely held view (in developed countries as well as less developed countries) that water is ‘free’ and that water supply should remain a free social service.

To a certain extent this concept is correct in that if a person wishes to collect untreated water they can often do so at no cost, apart from their time and potentially their health. However, water supply treated so as to represent no health risk, is not a free service and the cost of water supply largely reflects the ‘added value’ cost of treatment and delivery. It is essential for long-term sustainability of the sector that costs are recovered by some mechanism, whether through application of full cost-based charges to consumers or by Government support to the sector.

Where cost recovery and sector funding has been ignored, the effect has been a deterioration of infrastructure which eventually leads to the breakdown of systems, absence of an adequate water supply and an increased public health risk. It is essential that the profile of the need to pay for water supplies amongst consumers is maintained at a high level. Unless consumers are convinced of the need to pay for services, cost recovery will remain problematic and the long-term sustainability of the drinking water provision will be compromised. However, this also means that service quality needs to be sufficiently good to encourage payment and that water suppliers are seen to be responsive to the demands of consumers.

The consultant proposes the following as cost recovery mechanisms:

5.6.2 Willingness to Pay

Willingness to pay Willingness to pay (WTP) is an expression of the demand for a service, and it is a strong pre-requisite for cost recovery because it is a measure of user satisfaction of a service and of the desire of users to contribute to its functioning.

It is therefore necessary to determine the conditions affecting demand and willingness to pay. Direct techniques for the estimation of WTP are based on the observation of what people actually do in order to ensure water provision, including how much money they have to pay for it. Indirect ways draw conclusions from users' responses to hypothetical questions about their willingness to pay for water and sanitation (W&S) services. WTP studies are carried out to understand what level of W&S services people want, why and how much they are willing to pay for it. If people would be happy to pay more for a better service, or are not willing to pay because the existing service does not match their expectations, this information can be used to find ways to improve the service and increase revenue

Another way to improve willingness to pay is to improve relationships between consumers and the organisation managing the water supply service. Increased mutual trust and confidence that the service will be delivered as promised can be achieved through better information and communication. This often has a positive influence on a user's satisfaction and willingness to pay, as is found by numerous urban utilities. Social marketing strategies and techniques can help to forge better relationships between service providers and consumers in urban areas. Social marketing is less frequently applied in the context of rural and low-income urban water and sanitation provision. It is, nevertheless, sometimes feasible to introduce some basic concepts of social marketing to improve relationships between community organisations and users. As Yakubu (1997) pointed out, marketing and total customer service can be effective ways to recognise customer needs and to stimulate willingness to pay.

5.6.3 Setting Up an Adequate Institutional Framework/Capacity Building

Appropriate management capacity and skills are required to run a service efficiently, especially those skills related to budgets, organising bills, collection, recording expenses and revenue, monitoring, and applying sanctions. An assessment of the management capacity of the agency supplying the water is therefore crucial. If capacity building activities are too complex to organise for a given technology, it might be necessary to consider another technology that requires fewer management skills. The management structure will influence the way that cost recovery is going to be organised.

Training water managers, in financing and other issues is very important to sustain services. In the case of communities, training needs to be adjusted to ensure it is not too far from the community, it is not too long, and it matches the appropriate level of education for community members. These issues, and others, are especially important to ensure that women as well as men are trained.

In many cases, water managers need training on bookkeeping and financial management.

Training might also be needed for project staff, who often see cost recovery as secondary to technical issues. They will need to be aware that cost recovery is a key factor in sustainable water supplies and that it needs to be planned for right from the start. This implies that some provision has been made by support organisations for training and capacity building, in order to achieve sustainable cost recovery.

5.6.4 Setting an Appropriate Tariff

Although tariffs cannot remedy all financial deficiencies and ensure complete viability of a water system, they do go a long way to achieving financial sustainability" WASH (1991). The use of tariffs as a mechanism to cover the cost of water supply services has increased in rural and low-income areas, mainly due to the following factors:

- an acknowledgement that the service of water should be paid by users,
- the general and progressive implementation of new development models, whereby communities are responsible for and own, (or are co-responsible for and co-own) their water supply scheme,
- the trend towards decentralizing the management of public services,
- decreases in government recurrent costs funding.

A tariff is the price a user is expected to pay for a service. It should preferably meet all costs, or at least cover operation and maintenance costs, depending on the chosen strategy. A tariff is also a mechanism used to regulate demand by, for instance, discouraging wasting water. It can also be used to promote the supply of water for the poor, by applying a 'social' price. It can further be used as a tool to protect the environment by including, for instance, a pollution penalty, or the costs of environmental protection and conservation. Finally, water tariffs are often used as a political tool in local communities, which can create a situation where they are no longer realistic, and do not meet all costs. It is therefore important to sensitise local politicians to the importance of tariffs that are able to cover costs.

5.6.5 Optimising Costs

To arrive at this situation, costs must be identified, a decision made on which cost should be recovered, estimate them, analyse them, and finally find ways to minimise them. As Evans (1992) points out, "too often the real cost of water and sanitation improvements are unknown or inadequately recorded". There are many reasons for this. First, agencies are, in the main, accustomed to financing investment costs, so they have little reliable cost data about operation and maintenance. Second, there is a lack of adequate mechanisms for data collection and data is not compiled in standardised format (Katko, 1989, citing a Bates and Wyatt, 1987). Third, costs differ widely between countries, and even within them, because they are influenced by a broad set of factors, such as the choice of technology, levels of service, the project strategy and by management and administrative procedures.

An important aspect of optimising costs is reducing O&M costs. These can be significantly reduced in the following way:

- ❖ Choosing a technology with low cost spare parts or low-cost operation and maintenance costs.

- Economies of scale can make an expensive water supply system more attractive financially, where costs can be spread over a large number of actual or potential users.
- One way to reduce costs is to monitor with care changes in variable costs such as energy, consumables, maintenance and repair. Unusual increases in these costs should swiftly alert the organisation managing the service to possible misuse or mismanagement.
- Fixed costs cannot normally be reduced. However, like all costs, at times they can be subject to variations. One way to protect a project from unpredictable increases is to fix them in a contractual agreement between personnel and the organisation.
- Planners should try, where possible, to reduce dependence on chemical use, using for example alternative water treatment technology such as a multi-stage filtration system.
- Reduce dependence on fuel or electric consumption, by using solar, gravity, or wind energy.
- Try to firmly install a maintenance culture amongst professional staff to keep the service in good working condition and so increase the life cycle of the equipment.
- Organise preventive maintenance activities involving the users, helping to increase their sense of responsibility, and involve them in constant monitoring of the system, which leads to better functioning and may reduce expenditures on repairs.
- Install proper administrative and financial control mechanisms to avoid mismanagement of funds.

5.6.6 Increasing Connections

Access should be given to more customers to water supply. A policy that will encourage this can be formulated by water managers.

5.6.7 Strict and Efficient Project Implementation Approaches

The Project Implementation Unit (PIU) should be staffed with very competent staff, who work hand in hand with consultants to ensure cost-effective and efficient implementation of capital projects to avoid shoddy work and future high O&M costs. In addition, the PIU team guards against cost and time over-runs, which are the usual causes of high project costs that result into high depreciation. After project completion, efforts should be made so that projects return immediate benefits through aggressive marketing efforts to increase new customer hook-ups and related timely billings. In so doing, revenues are realised immediately, which in turn enhances the cost recovery situation.

5.7 Development of Water Tariff Structure

5.7.1 Basic Considerations

In water tariff design, cost recovery with consideration of social equity and affordability concerns has received much attention in the design of water pricing strategies and the allocation of user charges. The following elements shall be considered in tariff design:

Objectives

- Revenue sufficiency (i.e. cost recovery),
- Economic efficiency,
- Equity and fairness,
- Income redistribution, and
- Resource conservation.

Considerations

- Public acceptability,
- Political acceptability,
- Simplicity and transparency,
- Net revenue stability, and
- Ease of implementation.

A key element in tariff design is to safeguard essential services in the interest of public health, and to protect a fragile natural environment and increasingly scarce water resources. Attention should be given to social acceptability issues that arise when water pricing structures are adapted to more accurately reflect environmental externalities and resource cost. Social water pricing can satisfactorily combine economic efficiency, resource conservation, and equity goals.

In trying to come up with appropriate water pricing policy, international trends and best practice with the aim of developing a water pricing methodology consistent with social equity, ecological and financial sustainability and economic efficiency principles shall be considered. The recommendations shall underline the high priority given to social protection objectives in the Nigerian context:

- Tariff should be fair in that customers in the same circumstances are treated consistently.
- Tariffs and subsidies should be clear and easy to understand.
- Tariff enforcement should be guided by fairness and consistency.
- Tariff reform should yield a positive cost-benefit ratio.
- Tariffs should promote revenue stability and predictability.
- Consumers should have easy access to relevant information.

5.7.2 Tariff Structure

Tariff structures can be described as a set of procedural rules used to determine the conditions of service and monthly bills for water users in various categories or classes. A tariff structure should allow service providers to comfortably recover operation and maintenance costs. It should further enable debt servicing and support development plans. Beyond this, tariff structures can be designed to achieve a number of social and environmental objectives. For instance, tariff structures can have a function of providing low lifeline rates for low consumption and a penalty rate for high consumption.

In its simplest form, a water tariff is a *fixed monthly charge* levied on the customer. Alternatively, the user fee can be linked with *volumetric consumption*. *Multi-part tariffs* are obtained by combining fixed, volumetric and/or other charge components (such as annual charges based on property values or minimum usage fees). Metered (volumetric) water charges may be priced at a *uniform rate*, but there are a variety of *variable rates*. Most common is the *increasing block tariff* (IBT), with progressively increasing charges associated with a number of discrete blocks. Alternative options are *decreasing block tariffs* (DBTs), *mixed block tariffs* (MBTs) featuring a combination of the two, and *increasing block rates*. Similarly, to the IBT, the increasing block rate is a progressive tariff structure, but whilst for IBTs the monthly user fee is calculated by applying the appropriate rate to water consumption in each block, monthly bills under an increasing block rate tariff are determined by total monthly consumption, according to which the applicable rate is selected and multiplied by total use in that particular month.

A move towards volumetric pricing is considered to be more efficient, as metering discourages the wasteful consumption patterns promoted by fixed charges. Metering has significant benefits, including providing customers with a sense of equity in that they pay according to their measured consumption. High fixed charges reduce customers' ability to influence the size of their water bills, while low fixed charges create revenue uncertainty for water companies.

5.7.3 Tariff Structures in Some African Countries

Like the majority of countries worldwide, many African countries have switched to increasing block tariffs in recent years. Table 5.2 below, presents a summary of tariff structure information extracted from the available literature on tariff.

Table 5.2: Tariff Structures in Use in Some African Countries

Country	Tariff Structure	Differentiation
Algeria	domestic: IBT (4 blocks) flat rate (others)	consumer groups: domestic, institutions, service enterprises, tourism regional differentiation under consideration
Benin	IBT	
Burkina Faso	IBT	
Botswana	IBT (4 blocks – 4th band for peri-urban areas only, equals equivalent urban bulk rate)	area: major villages/rural villages/urban areas, urban areas further differentiated by supply areas business tariff under consideration
Cote d'Ivoire	IBT	uniform across the country
Ghana	IBT	
Guinea	IBT	
Kenya	IBT	
Madagascar	IBT	(2 blocks) consumer groups: small users, administration, special users
Morocco	IBT	
Namibia	fixed + volumetric, some IBT (4	individual tariffs for each municipality

	blocks)	special tariff for mining industry
Senegal	IBT	
Nigeria	flat rate (domestic) metered (industry & commerce)	several domestic customer categories (single tap – 1 family, single tap – multiple families, house with water system reticulation, high cost residential areas)
Sudan	flat rate MBR (3 blocks) for metered residences and industries	differentiated by size of property by region
Tanzania	uniform rate (volumetric)	consumer groups: domestic, institutions, commercial, industries, agriculture, expatriates
Tunisia IBT	(5 blocks), including wastewater component	consumer groups: domestic, standpipes, industry, tourism
Uganda	unmetered domestic: flat rate based on number of taps IBT (3 blocks): major industry & commerce uniform rate: all others (metered)	consumer groups: public standpipes, domestic, institutions, government, minor industry and commerce, major industry and commerce
Zambia	IBT	
Zimbabwe	fixed charge + volumetric rate	

Source: Collignon (2002), Dinar & Subramanian (1997), Franceys & Gerlach (2008), Nyoni (1999), Plummer (2003)

Note: IBT = Increasing Block Tariff

5.7.4 Comparison of Different Tariff Structures

Comparison of various tariff structures are given below as adopted from African Development Bank Guidelines for User Fees and Cost Recovery for Urban, Networked Water and Sanitation Delivery

Table 5.1: Comparison of Different Tariff Structures

Tariff Structure	Cost Recovery	Objectives		Affordability
		Economic Efficiency	Equity	
Fixed Charge	***Adequate*** Provides stable cash flow if set at appropriate level, but utility may be vulnerable to resale of water and spiralling consumption.	***Poor*** Does not send a message the cost of use of additional water.	***Poor*** People who use large quantities of water pay the same as those who use little.	***Adequate*** If differentiated by ability to pay, but households are unable to reduce their bills by economizing on water use.
Uniform Volumetric Charge	***Good*** If set at appropriate level, moreover revenues adjust automatically to changing consumption.	***Good*** If set to or near marginal cost of water.	***Good*** People pay according to how much they actually use.	***Good*** Can be differentiated by ability to pay, and people can limit their bills by reducing consumption.
increasing (rising) Block Tariff	***Good*** But only if the size and height of the blocks are well designed.	***Poor*** Typically, little water is actually sold at marginal cost.	***Poor*** People do not pay according to the costs their water use imposes on the utility.	***Poor*** Penalizes poor families with large households and/or shared connections.
Decreasing Block Tariff	***Good*** But only if the size and height of the blocks are well designed.	***Poor*** Typically, little water is actually sold at marginal cost.	***Poor*** People do not pay according to the costs their water use imposes on the utility.	***Poor*** Penalizes poor families with low levels of consumption.

Source: Whittington et al. (2002)

5.7.5 Recommended Tariff Structure

JIL has tried to apply the best approach in the development of the tariff structure. The methods applied elsewhere among developing countries have been studied for application as shown in the table 5.1 above. However, while developing the tariff structure, the following factors were considered among others:

- Cost of electricity generation (gas purchase etc.)
- Wage fund of the personnel engaged at the enterprise
- Costs of, Producing, Pumping, Treatment, Transportation of drinking water to customers
- Cost of materials and chemical agents used during the process of wastewater discharge
- Cost of quality control of drinking water and waste water
- Cost of acquisition of water from underground and surface water sources
- Technological costs
- Personnel costs
- Rent for the leased tangible and intangible assets used in the regulated activity.

JIL engineering shall also review the existing water tariff structure in Nigeria as well as other advanced and developing countries.

Premised on the foregoing and based on the analysis in table 5.2, we hereby recommend the uniform volumetric tariff system plus a fixed charge that increases with according to range of water consumption (**Table 5.3**).
In a uniform volumetric charge, or constant volumetric tariff, all water units are priced the same independent of the use, and consumers pay proportionally to their water consumption. With this type of tariff, all consumers (domestic, industrial and commercial) pay the same unit rate, and their water bill corresponds directly to the quantity of water consumed. Prerequisite for setting a uniform volumetric charge is that consumers have a metered connection to the water system.

We also recommend that a fixed charge be combined with the actual bill on water use.

Volumetric price schemes present several advantages: first of all is easy to understand for consumers - because it is how most other commodities are priced – furthermore it sends a clear signal to the consumers about the cost of supplying them with additional water. Moreover, the tariff incorporates the concept of water conservation as the water bill increases with consumption.

5.7.5.1 Price per Cubic Meter of Water

Having discussed the inadequacy of the current tariff structure in the country, we hereby recommend the use **₦300/cu.m** as the new tariff structure with fixed charge as indicated in the table 5.3 below:

Table 5.3: Recommended Tariff Structure

S/N	WATER USAGE IN M^3/MONTH	FIXED CHARGE ₦/MONTH	PRICE PER M^3
	< 2	50.00	300.00
	$\geq 2 < 6$	100.00	300.00
	$\geq 6 < 10$	300.00	300.00
	$\geq 10 < 15$	350.00	300.00
	$\geq 15 < 20$	420.00	300.00
	$\geq 20 < 25$	1000.00	300.00
	≥ 25	5000.00	300.00