Jurnal Kejuruteraan 33(3) 2021: 517-530
https://doi.org/10.17576/jkukm-2021-33(3)-13

Community Water Demand and Sustainable Water Supply Planning in Nigeria: A Review

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Received 01 June 2020, Received in revised form 19 October 2020
Accepted 20 November 2020, Available online 30 August 2021

ABSTRACT

The purpose of this study is to review past works in water demands and sustainable water supply planning in Nigeria as reported by many researchers and to determine how to improve the water supply infrastructure sustainably. Nigeria is endowed with abundant surface water and ground water resources. The mean annual rainfall along the coast in the south east is 4 800 mm while it is less than 500 mm in the north east. These water sources are not tapped to the fullest and most of them are polluted and unsafe for use, resulting to scarcity of potable water in most communities. Water crisis is prevalent in most cities and this is further exacerbated by deteriorating infrastructure, political instability, and poorly regulated water laws. The result of the water crisis has led to detrimental consequences for its citizens as child mortality and water-borne disease-related deaths have grown exponentially. Unsuitability of water distribution facilities, quantity of water transported, too much walking distance, long lines at water points, poor maintenance and inadequate bulk water development brought about inefficiency of the facility. The water demand and supply in some countries in the world and many towns in Nigeria were reported. The method adopted in the study involved the use of journals, books and other related literature. The result showed that water supply systems in most places in the country are in poor state, unorganized and incomplete. All countries highlighted showed many problems at various degrees in provision of the facility. Attempt was made to fill some gaps in the literature. Public enlightenment, financing, monitoring, maintenance and juicy annual remuneration packages for best water users are recommended as powerful tools towards sustenance of the water supply infrastructure.

Keywords: Potable water; sustainability; public enlightenment; water pricing; remuneration packages

INTRODUCTION

Nigeria is situated on the west coast of Africa, south of the Sahara, between latitudes 4oN and 15oN, and longitudes 3oE and 14oE, bordering the southern coastal region is the Atlantic Ocean and Niger Republic at the northern border. It is bounded in the west and east by Benin Republic and Cameroon respectively. Nigeria occupies an area of 923 768 square kilometers, having 13 000 square kilometers occupied by water. (CIA 2013). It has a land area of 910.770km2 and a water area of 13 000km2 (Ince et al. 2010). Nigeria is endowed with about 267 billion cubic metres of surface water and about 52 billion cubic metres of ground water annually (Ince et al. 2010). The mean annual rainfall along the coast in the south east is 4 800 mm while it is less than 500 mm in the north east (Nwankwoala 2015). It has abundant surface water and ground water reserves. The rate of urbanization is characterized by high population in Nigeria.

In a study conducted by Nwankwoala (2011), Nigeria is experiencing increase in demands for water resources

as a result of high population growth rate and increasing prosperity. This results in increase in agricultural and industrial activities with environmental pollution and degradation including indiscriminate disposal of all kinds of wastes. All of these pose serious pollution threats which also affects groundwater quality mostly in urban areas (Adelana et al. 2003, 2004, 2005, 2008; Ajala 2005; Ocheri 2006; Eni et al. 2011). The demographic record is that Nigeria's population is estimated at above 140 million people (NPC 2006). As at September 2020, demographic record has it that Nigeria's population is estimated at above 207 million people (Worldometer 2020). The rate of fluctuation yearly is between 1.935% and 2.7% (UNICEF 2010).

According to United Nations General Assembly (2010), drinking water and sanitation is a human right. Today, approximately half of the world's population is without access to freshwater (Clarke & King 2004). Water is derived from various sources such as the ocean water consisting 97% of the earth's water, ice 2%, and 1% of fresh water obtained from rivers, lakes, underground water, the atmospheric and soil moisture (Odey 2010). Water is life. The human body by weight consists of about 70% water and several body functions depend on water (UNDP Human development report 2006). Access to safe water supply has great influence on the health, economic productivity, and quality of life of the people (Ishaku et al. 2011). The increasing demands on water supplies are closely related to population size and more precisely the concentration of human habitation (Kandissounon et al. 2018). Water supply plays a key role towards enhancement of life and development.

Community water demand is of utmost importance for sustainable water supply planning. The objectives of this report are to review community water demands and supply in some cities of the country, including the situation in some countries in developed world as reported in past works. The study also recommended how to optimize water supply to ensure provision of sustainable good quality water to different communities for healthy living. Water is vital for the life and health of people and ecosystems and a basic requirement for the development of countries around the world. Even though it is one of the precious gifts to mankind, lack of access to safe drinking water and basic sanitation is one of the problems affecting billions of people around the world (Hesperian Foundations 2005). Ezugwu (2015) in his work reported that drinking water must attain certain degree of purity, employing water quality standards. At different locations, representative water samples are collected and analysed of physico-chemical characteristics to monitor the groundwater quality (Devendra et al. 2014). African cities have a long history of water supply from surface and groundwater sources. However, due to deteriorating quality and quantity of surface water through increased urbanization and industrialization and high cost of developing new dams, urban groundwater is viewed as a better option (Ocheri et al. 2014).

In 2015, all the United Nations member states adopted the Sustainable Development Goals (also called Global Goals) as a universal call for action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030. The sixth out of seventeen life-changing Sustainable Development Goals (SDGs) is to ensure access to water and sanitation for all (UN General Assembly 2015). This is targeted towards eliminating neglected tropical diseases by promoting good hygiene. Since potable water supply is critical, it is our mandate to provide this resource in sufficient quantity and good quality to users.

Globally, there have been proactive reforms in the entire water sector in the last decade and reforms in policy formulation, law and regulation, technical aspects among others (ADB 2012). Mankind lack access to adequate and safe water to meet their basic needs (WaterAid 2012). It has been reported that about 500 million persons in over 29 countries face water shortage (WHO/UNICEF JMP 2010). Worldwide, problems related to the management of water supply and distribution exists. This is partly due to extensive industrialization, increased population density and present high rate of urbanization (Akpor & Muchie 2011). Over one billion people worldwide do not have access to safe drinking water (USAID 2012). 2.5 billion people, almost 50% of the developing world's population lack enhanced sanitation facilities, and unsafe drinking water sources are used by about one billion people with no safe practice and inadequate service delivery (World Bank Group 2019). About 500 million persons in over 29 countries experience water shortage (Greg 2010). In Africa and particularly Nigeria, the entire water sector law has undergone little growth in the last decade and is in dire need of structural reforms to become aligned with contemporary global trends (World Bank/FGN 2012). Water issues in developing countries include drinking water scarcity, water stress, poor infrastructure for water access, floods and droughts, and contamination of rivers, streams and large dams. Millions of women spend hours every day collecting water, 2.6 billion people lack access to sanitation, and 1.8 million children die each year from diarrhea (Ogbuka 2012).

In most developing countries of the world, water requirements are not investigated accurately, resulting to development of water schemes that are either over-designed or under-designed as a result of poorly estimated population and costing of water facilities. Often times, data for this work is not available and water projects are embarked upon

without carrying out proper engineering economic analysis to ascertain the viability of the project. Water demand and the population it will serve should be provided in a manner to ensure provision of sustainable water system. In a study on sustainability and impact of community water supply and sanitation programmes in Nigeria by Ademiluyi & Odugbesan (2008), it was found that Governments' inability (largely due to lack of resources) to maintain water and sanitation infrastructure has been the major factor leading to the promotion of community participation in water development programmes.

The purpose of this work is to bring together studies carried out in some countries of the world and major towns in Nigeria on community water demand and supply, to ascertain its current status and remedial measures to ensure sustainability. It was observed that even where good quality water is supplied, the facility may crumble due to inefficient maintenance culture and poor financing of the water system.

LITERATURE REVIEW

Journals, books and other related literature were employed in this review of community water demand and sustainable water supply planning in Nigeria. Lacking in the literature are public enlightenment on proper use of water and remuneration packages to best water users to ensure sustainability. This work also tries to address this gap in the literature.

COMMUNITY WATER DEMAND AND SANITATION

Rapid population growth, economic development, urbanization, and industrialization have taken their toll on the country's water services and resource base (Araral & Wang 2013; National Economic Development Authority 2010). Abundant as it may seem, water, in its clean state, is one of the rarest elements in the world (Omole & Longe 2008).

Water as required by a community includes domestic demand (for drinking, bathrooms, cooking, lawns), industrial/commercial, public (including firefighting, etc.), and for wastage and theft. In estimation of water demand for a community, provision is also made for water loss through leakage of pipes and theft so that supply will be sustained throughout the design life of the facility. In water supply systems, these losses can only be reduced but can't be eliminated.

WATER SUPPLY SITUATION IN SOME COUNTRIES

MEXICO

In Mexico City, the water situation is critical and the provision of water services to the population represents a formidable challenge for the city's water utilities (Nolan & Lartigue 2017). Mexico City suffers from multiple and inter-related problems regarding the quality and availability of its water supply, which so far, the Government has failed in addressing adequately (Delgado-Ramos & Carlo 2015; Jimenez & Blanca 2010). The country uses rain water harvesting (RWH) as an alternative means of providing water to households. It was reported that RWH met 88% of household water demand during a six month wet season, also an annual economic saving of 55%. RWH is a viable means of water provision in the south of the city and is recommended to be part of an integrated water management solution (Nolan & Lartigue 2017). Water availability per inhabitant is 4 547 m3 (FCCyT 2012).

The principal water-related problems in Mexico are linked to inefficiencies in use. National water allocation gives agricultural sector (77%), of which 67.35% is extracted from surface sources and 32.65% is gotten from underground water source. The industrial sector uses 10% of national water allocations (6.9 km3 annually), 76.8% of which is extracted from surface sources and 23.2% from aquifers (Marco et al. 2016). A major problem in this country is the contamination of catchment area and underground water from residual waste. Great proportion of these waste are discharged into water bodies untreated while little is recovered for treatment. This practice tantamounts to contamination of the water bodies with attendant adverse health implications. Only 0.85 km3 is recovered for treatment, while 4.77 km3 is discharged directly into large bodies of water (CNA 2008). As a result, lack of metering infrastructure, is the cause and consequence of budgetary insufficiencies in the majority of the Potable Water and Sewage Operating Units in the country. The Water Law of 2003, calls for rainwater harvesting to be installed in new buildings and encourages its adoption in existing constructions (Nacionales 2003). One of the most common disadvantages cited globally against RWH is the significant space requirement for the storage tank (Islam et al. 2014). However, in Mexico City where the majority of the population already own a cistern, this is less of an issue and presents the city with a unique, currently unexploited opportunity.

PHILIPPINES

Among the developing countries, the Philippines faces a considerable challenge regarding development due to the continuous increase in electricity demands, with an annual average rate of increase of 4.3% (Ayson et al. 2010). Water resource management is very challenging in the Philippines because of seasonal weather changes (Guiamel & Lee 2020). Increasing block tariff is used by water districts. The underlying principles essentially rely on economic valuation while also balancing affordability, conservation and sustainability. There are about 5 400 water service providers in the Philippines (Llanto 2013; National Economic Development Authority 2010). There are 879 water districts (WD) in existence, 476 of these are registered with the National Water Resources Board (NWRB) and only 511 of them are operational (World Bank 2005). The leading regulatory government agency responsible for ensuring optimum exploitation, development, conservation and protection of the nation's water resources is NWRB. Water demand in water districts is managed by charging for water in proportion to the amount and characteristics of use. Check valves and meters are used to regulate water use. Using metering of service connections is an appropriate economical and equitable method for arriving at suitable water charges. Metering rates are imposed on the basis of the actual volume of water consumed for any given billing period (LWUA 2014).

PAKISTAN

Pakistan has abundant water reservoirs, but still, is experiencing problems in providing safe drinking water due to management of its water resources (Imad et al. 2019). The country has the largest irrigation system in the world but still experiences droughts and floods. Surface water is the main source of water where groundwater is being used in large quantity for both domestic and agricultural uses. Water depletion of the country is traced to over-use of water. Discrepancies in the system include inefficient water policies, unproductive use of water, unpaid and wrongly estimated water bills, among others. The country is experiencing rapid urbanization and it is estimated that by 2025, 50% of the population will live in urban areas (Kugelman 2015). The migration from rural areas to urban areas, on a large scale, poses several challenges and mounts severe pressure on the economy of the country, thereby affecting the basic facilities, water being one of them.

WATER SUPPLY SITUATION IN SOME NIGERIAN CITIES

According to FMWR (2011) report, Nigeria has huge water resources potential estimated at 267 billion cubic meters of surface water and 92 billion cubic meters of ground water. About 47 million Nigerians still rely, exclusively, on surface water sources to meet their domestic needs. Yet, pollution discharge into the surface water by individuals and industries go on unmitigated, unregulated, and unpunished due to weaknesses in the existing laws (Longe et al. 2010). Activities in the water sector are presently being handled by the Federal Ministry of Water Resources at the Federal Level and State Water Board at the State Level (Federal Republic of Nigeria 2000; AFDB/OECD

TABLE 1. Components of the water and sanitation problems in Nigeria

Aspect	Immdiate Problem	Consequences
Water Supply	Distant sources	Much expenditure of time and energy (especially children).
Low levels of water consumption, resulting in water borne disease.		
	Unreliable sources (drought-prone, or poorly engineered or managed)	Time spent queuing and seeking alternative sources
	Poor quality (faecally contaminated) sources	Water-borne disease
Excreta disposal	Lack of safe facilities for disposal of human faeces	Contamination of soil, surface water and ground water
	Little privacy for defecation, and lack of water for anal cleansing and hand-washing	Defecation (by men) in open, often near water (e.g. canal side of river banks); hardship for women for whom public defecation is unacceptable
Wastewater disposal	Engineered facilities for treatment or safe disposal rarely exist	

Source: Adapted from DFID Factsheet (2005).

2007). World Bank estimates that an average of 20 - 50 liters of safe water is needed by an individual for daily metabolism and hygiene. The national water requirements for Nigeria pegs it at 23l/p/d for rural areas and 60l/p/d for urban areas (Ishaku et al. 2011).

Community water supply schemes in Nigeria are marked by lots of ill-conceived, uncoordinated and abandonment of projects. Components of the water and sanitation problems are presented in Table 1.

Although Nigeria is blessed with abundant water resources, government at all levels (federal, state and local) have not been able to successfully harness these resources to ensure a sustainable and equitable access to safe, adequate, improved and affordable water supply, and sanitation to the population (Muta'a 2012). Water problems experienced are multi-faceted depending on the population, standard of living, industrialization, and urbanization. Nigeria depends on groundwater as their greatest source of water supply for more than 20 years now. Groundwater sources of water includes springs, hand-dug wells, boreholes/tube-wells. About 100 million Nigerians get their source of water from groundwater. Nigeria has recorded a reduction in water supply in urban areas since 1990 (Olajuyigbe 2010).

Water as required by a community includes domestic demand (for drinking, bathrooms, cooking, lawns), industrial/commercial, public (including firefighting, etc.), and for wastage and theft. In estimation of water demand for a community, provision is also made for water loss through leakage of pipes and theft so that supply will be sustained throughout the design life of the facility. In water supply systems, these losses can only be reduced but can't be eliminated.

YENAGOA

Yenagoa, capital of Bayelsa State, in spite of the proliferations of wells and boreholes, and short distances to places of major water supply, 29.28% of sampled respondents used below 20 litres of water per capita per day (Ohwo & Abotutu 2014). This falls quite far below acceptable standard. This is due to high cost of water supply at N4 500 per month in average, considering the minimum wage of N30 000 per month for civil servants prevalent in the country.

NNEWI

Nnewi, a foremost industrial and commercial town in Anambra state, has most households depending on boreholes, well water, and sachet water as major potable water sources (Ifenna & Chinedu 2012). Akunyili (2003) asserted that there is need to support production of packaged water (bottled and sachet water) as a good programme for poverty mitigation. This is informed by the fact that with access to good quality water there will be improvement in public health which will boost the economy. Nnewi has surface water called "Mmiri Ele" but this is not used as a source of water supply since the water is being polluted by untreated industrial wastewater discharged into the stream by many industries in the town. Investigation into the degree of pollution of this stream by these pollutants is lacking. Most of the boreholes here are private and about 75% of water users access water through buying from commercial tankers that make their purchases from boreholes owned by individuals or industries in the area. Public water supply system is available but not functional in the town.

IBADAN

Ibadan, south west of Nigeria, does not have adequate water supply. According to Adeniji (2012), less than 30% of her residents obtain their water from public water system. They rely on sachet water as alternative water source, basically for drinking. Water for other domestic purposes like bathing, cooking, etc. are obtained from streams and water vendors. In a study in Ibadan by Adeyemi & Temowo (2010), in a hydrogeological investigation of waste dumps, it was observed that the concentration levels of electrical conductivity, total dissolved solids, sodium, potassium, magnesium, nitrate, and chloride were higher in water samples collected near the dumpsite than those far away. This is traced to leachate from dumpsite. Consequently, waste dumpsites should not be located close to water sources to avoid contamination.

LAGOS

Nigeria's largest city Lagos, is located in Lagos State in southwest Nigeria. It is the country's most populated city with a population estimated at 21 million people in 2014 (Jideonwo 2014). Lagos State lies within latitude 6°22'N and 6°52'N, and longitude 2°42'E and 3°42'E, being surrounded by water from the sea and lagoon. The commercial hub of Nigeria is facing major water crisis. Despite being rich in water resources, access to water within the state is dreadfully slow and a major public health threat (Adaure 2018). The population in the city of Lagos grows at an annual rate of 5.5 % and is accounted for by rural-urban migration mostly (Jideonwo 2014; LWC 2010). Its clean water supply in the city is about 81.32% (Lagos Water Corp 2012). As a result of pollution of the raw water, it gets its water from Ogun and Owo rivers. The city's oldest

water treatment plant, located in Iju on the Ogun River, was built in 1910 (Lagos Water Corp 2012). This was expanded in stages to 45 million gallons per day. The biggest plant so far was commissioned in 1991 in Adiyan with a capacity of 70 million gallons per day (Lagos Water Corp 2012). The Lagos Water Corporation states that the water produced in the plant meets the highest standards, and that it supplies "safe drinking water in sufficient and regular quantity to over 12.5 million people in Lagos State". Dwindling electricity supply to the area makes treatment plants not to function in full capacity resulting to insufficient water supply to the town. Data from the 2006 census in Nigeria showed that only 26% of the residents of the metropolitan area were using piped water (Acey 2010). This resulted to many residents using private wells, boreholes with other water sources which may be detrimental to human health, being below acceptable standards. In Lagos, the growth of urban population and climate change are not the main reasons militating against potable water supply, but the use of obsolete infrastructure which cause leakages and waste intrusion in the pipe borne water.

MAKURDI

In Makurdi, the capital of Benue State, only about 25% - 30% of the population is served by a crumbling network and inhabitants fetch raw water in buckets from the polluted Benue River (USAID 2012). As of 2012, a water treatment plant was under construction as part of the Greater Makurdi Waterworks Project. According to Nat Apir, an independent water consultant, the lack of a modern distribution network will result to bursting of pipes, and the capacity of the plant is at risk of not being fully utilized (USAID 2012). Amadi et al. (2010) in a study examined the effect of urbanization on groundwater quality of Makurdi metropolis. Results of analysis show water samples collected within the vicinity of dumpsite have low pH, higher concentration of iron, manganese, calcium and total dissolved solids and total coliform when compared to those far away from the dumpsite, suggesting leachate influence. Makurdi, the capital of Benue state has extensive water resources (Ahol et al. 2016). It is situated on the banks of River Benue which is one of the two largest rivers in Nigeria. It is expected that with the availability of the river, there should be no scarcity. But only a small fraction of residents have access to pipe born water, households are forced to resort to unsafe alternative sources of water supply from the shallow hand dug wells, which are highly polluted from physical, chemical and bacteriological sources (Mile et al. 2012). In a study by Apeh & Ezugwu (2017), it was observed that sources of pollution of River Benue include feaces from humans defecating directly into the river, waste from animals and human waste from land to the river as well as fertilizers and other chemicals applied to crops that are usually grown at the river banks.

ABUJA

Nigeria's capital, Abuja, receives part of its drinking water from the Lower Usuma dam (Oluwaseyi 2014). The Guara dam, which was under construction in 2012, was aimed at increasing water supply to Abuja and to mitigate against the risk of drought in the territory.

Longe et al. (2010) in a study discloses that households in Nigeria have water sources from surface water (34%), hand-dug well (28%), pipe borne (24%), boreholes (12%), and vendors (2%). See Figure 1. The quality of water from these sources should be investigated and treated where necessary.

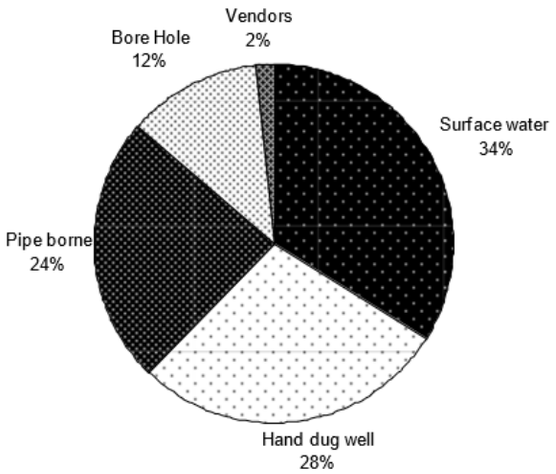

FIGURE 1. Nigerian household distribution by source of water supply

Source: Longe et al. (2010)

MUBI

A lot of people dwelling in the town of Mubi in Adamawa State saying they have no access to good quality water provided by public water works (Okoro et al. 2015). In this area, water users buy water from water vendors or other unapproved water sources. They also get water from free sources, including rivers, streams, water ponds, open wells, etc., that are prone to water borne diseases, like malaria parasites, typhoid fever, cholera, dysentery, and others. According to Okoro et al. (2015), Adamawa State as a whole lacks sufficient water facility in spite of supports from federal, state, local and donor agencies.

ENUGU

Ezenwaji et al. (2016) reports that residents in Enugu urban area access water from the Greater Enugu water supply scheme in an irregular manner due to lack of maintenance culture on the equipment at the head works, water sources and channels being silted up, and significant water losses along the transmission lines. Enugu state is comprises of seventeen Local Government Areas, having Enugu as its capital city. Anejionu & Okeke (2011) presents map of the seventeen local government areas of Enugu State, as in Ukabia (2010). See Figure 2. Presently, residents of Enugu access water mainly through wells dug in private residences and sachet water sources.

PRIVATE-PUBLIC-PARTNERSHIPS (PPPS) IN WATER SUPPLY AND SANITATION SECTOR

Public-Private Partnerships (PPPs) are defined as: “the combination of a public need with private capability and resources to create a market opportunity through which the public need is met and a profit is made” (UN 2005). The public sector might not be able to cope with the challenges regarding sanitation and water management and therefore cooperates with the private sector through a "partnership". Public Private Partnerships (PPPs) are partnerships between the public and the private sector for the purposes of designing, planning, financing, constructing and/or operating projects, which would be regarded traditionally as falling within the remit of the public sector (INWRDAM 2010). The public and private sectors should partner by way of providing human and financial resources to enhance effectiveness and sustainability of the project (Ezugwu 2006). Individuals are to participate in the water infrastructure development through community participation programmes. People are encouraged to donate money for this project to make it sustainable. Levies are placed on the community to raise money towards achieving this goal. Community groups are formed for the planning and implementation of this agenda. PPP is one of the mechanisms set up to help the government fund a much-needed investment to usher technological advancement

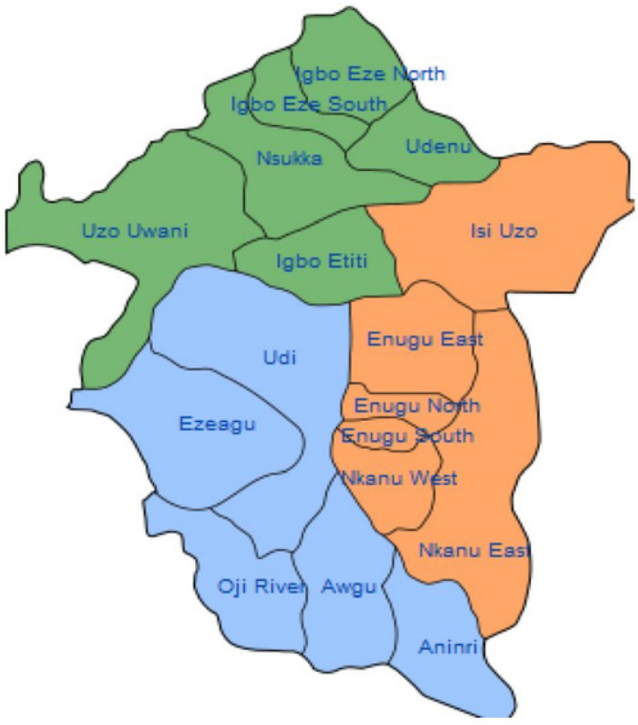

FIGURE 2. Map of Enugu State showing the locations of the 17 local government areas.

Source: Anejionu and Okeke (2011).

and efficiency that can improve the financial suitability of the sector. Private sector organizations and Donor-aid agencies are charged with the function of releasing funds to communities to construct locally fabricated water facilities (Asabia 2008). This money should be released to the agency charged with the management of the facilities. Communities are encouraged to form community development associations (CDAs) to ensure project ownership. At post-construction, this association now hands the facility to somebody or group to manage the facility. At this stage, water is made available to all households and other water users.

SDC (2005) outlines the common actors in the PPPs as Contracting parties (local service operators), key stakeholders strongly influencing the PPP (all contracting parties, national and municipal governments, investors, regulators, donors, trade unions, consumers, NGOs), and stakeholders affected by the PPP (all above, households, community and gender groups, beneficiaries, etc.). Agencies for PPPs might also be helpful to make the implementation process of a PPP easier, to delegate a function and therefore make sure the PPP is going to work well (SDC 2005).

The spheres of each actor involved in a PPP overlaps with the spheres of the others as shown in Figure 3. We have the stakeholders, which includes all people that are interested or affected in the PPP project. Then, within the stakeholders we have those that are heavily involved and the contracting parties that are makers of the PPP contract.

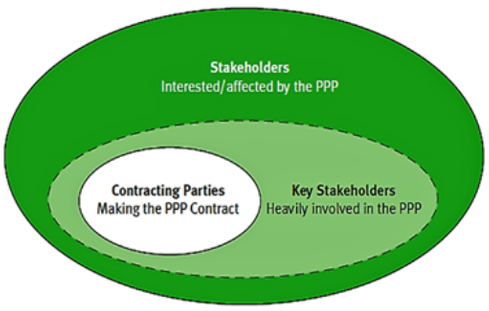

Figure 3. Examples of Actors in a Given PPP
Source: SDC (2005).

Community participation (CP) in rural water supply is widely considered as a very crucial strategy for efficient and sustainable operation of rural water supply systems (RWSS); and no rural water supply system can be truly successful without the support of the host community (Imoro & Fielmua 2011). There is need for the public and private sectors to partner, pulling their human and financial resources together to put up water supply system that will be sustainable and efficient.

In PPP programmes, policy makers in governments, donor agencies, e.g., World Health Organization (WHO), World Bank (WB), United Nations Educational, Scientific and Cultural Organization (UNESCO), etc., and communities, including other stakeholders' partner to provide improved water and sanitation services to the area. According to Philippe (2009), the main focus of PPP in water sector should include attracting direct private investment, and using private operators to enhance the service quality and efficiency. Public Private Partnership is not without problems. Its projects have been seen to be controversial in the water sector arising from lack of reliable data on the population served and on the quality of service delivery. All these have led to difficulty in assessing the overall contributions of projects in Nigeria and other developing countries of the world. It is remarkable that out of 65 developing countries that embarked upon water PPPs in the last two decades, not less than 41 still had private water operators, and 84% awarded contracts was still in operation by 2007 ending (Philippe 2009). Some water PPPs experience conflicts which led to termination of the contract.

PRICING FOR WATER

Pricing of water is seen as an economic tool for enhancing water use efficiency and securing financial sustainability (Ricato 2019). Placing some charges on the usage of water is similar to pricing other economic goods, which is an important factor for infrastructural development and demand management policies, which controls misuse of good and helps in conservation of natural resources (OECD 2009). Another issue relevant to water use and management in the urban public sector is the lack of accurate water metering. In many countries of the world, consumers pay too little for water service and some do not pay at all. Payments for water use depends on demand, and the availability of alternative water sources decreases incentives for payment (Koehler et al. 2015). Revenue acquired from these services is used for the maintenance and repair of the water infrastructure to enhance sustainability.

Reliable and fast maintenance as well as repair services are important to ensure steady user payments (Sustainable WASH Systems Learning Partnership 2020). The plan should be to price water reasonably to raise enough funds for sustenance of the water system. At the same time, it should be such that users will be able to pay. There should be an Agency charged with the responsibility of creating awareness on this, and collecting the funds from water users. Water obeys the law of demand and supply. The mathematical expression for quantity of water demanded

in relation to price of water can be expressed as:

$$Q = ap^b \quad (1)$$

where, Q, p and a are quantity of water demanded, price of water per litre, and a constant (price of elasticity coefficient) respectively.

$$b = \frac{\frac{\Delta Q}{Q}}{\frac{\Delta P}{P}} \quad (2)$$

where Q (m3/s) is the demand at price P(N) per unit of consumption.

The coefficient b measures the sensitivity of water use to price changes, being negative value always, since price increase leads to reduction in demand. This enables knowledge of how water users respond to every change in price. For instance, if there is an increase of cost and it is seen that water users decline to buy water, then it is the responsibility of the water administrators to review the price downwards to encourage people to buy water.

For years i and j, with corresponding water demand Q_i and Q_j, and pricing for the years, P_i and P_j, we have the following relationship:

$$Q_j = Qi \left(\frac{Pj}{Pi}\right)_a^b \quad (3)$$

Equation (3) is used to study the effects of price changes on quantity of water demanded.

Pricing of water brings fund for infrastructural development. A water tariff is the price assigned to water supplied by a public water utility generally for both freshwater supply and wastewater treatment. Tariff setting prices vary around the world, and there appears to be no consensus on which tariff structure best fits into the objectives of the utility, consumers, and society (Whittington 2002). The gains of tariff include generating revenue to enable recovering of operation and maintenance costs, reduction of quantity of water used by water users, generate funds for other infrastructural development and wastewater treatment to ensure protection of water quality. Most times, consumers pay a very small amount for water they use, so it does not serve the purpose of its being used sufficiently for maintenance, etc.

This work suggests subsidizing tariffs for low income groups to ensure that those that are poor can have access to water. Water tariffs are a powerful management tool used to achieve various objectives in water and sanitation systems. Sometimes, setting tariffs serve as a political tool. In occasions like this, free water is used as political divided, but unfortunately such projects don't last since these politicians sink shallow boreholes that do not bear sufficient water. Consequently, these boreholes run out of water and are not sustained.

SUSTAINABLE APPROACH TO WATER SUPPLY INFRASTRUCTURE

Water is at the core of sustainable development (Sodoware & Ortigara 2017). If good quality and quantity of water is supplied steadily, we will be able to shift the world on to a sustainable and resilient path. All the 17 sustainable development goals of the United Nations in 2015 deal on sustainability. Sustainability is about whether or not water and sanitation services and good hygiene practices continue to work over time (Abebe et al. 2013). This report sets out to achieve sustainability of the water supply infrastructure through public enlightenment, financing, monitoring, maintenance, and remuneration packages for best water users.

The water supply system is designed to last throughout the project life span. The design life of the water supply facility is determined and demographic data on population for the area obtained from a government designated area. The most appropriate method for population forecasting is used to estimate population for the design period. Water supply facility is usually designed to serve throughout the facility's life span. According to Sodowale & Ortigara (2017), water resources, and the range of services they provide, underpin poverty reduction, economic growth and environmental sustainability. From food and energy security to human and environmental health, water contributes to improvements in social well-being and inclusive growth, affecting the livelihoods of billions.

PUBLIC ENLIGHTENMENT

In existing literature, there is lack of adequate measures to ensure sustainability in the area of public enlightenment. There should be adequate public enlightenment in print and mass media periodically to inform water users on the importance of good quality water. They should be educated on the implications of drinking water that falls below water quality standards which can trigger up water-borne diseases that may assume fatal dimensions. An agency should be set up by the government to be in charge of this. Their function among other things, should include educating water users on the uses and importance of good quality water to curtail incidences of water borne diseases, employing mass and print media.

REMUNERATION PACKAGES

Government should set up agencies charged with the responsibility of providing remuneration packages for best water users for the year. These packages should be made attractive to encourage more people to do the needful as stipulated by law. Also, those that pollute our water sources should be punished to minimize incidence of defecating in water bodies, discharging industrial wastes into our water bodies, putting all manner of solid wastes into our waters, etc. Moreover, people that break water supply pipes to steal water should be charged to court, and appropriate punishment meted on them as spelt out by law.

REGULAR MAINTENANCE CULTURE

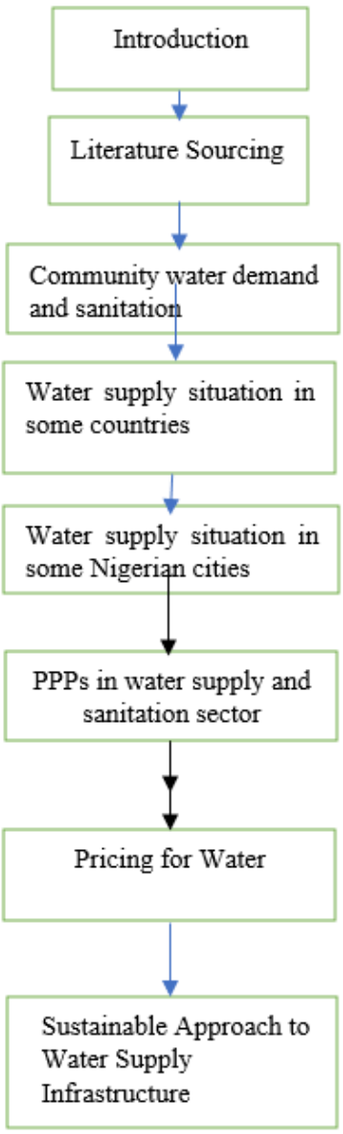

FIGURE 4. Flow Chart of the Review Methodology

Availability of good quality water in sufficient quantity improves upon the socioeconomic and environmental status of a town. The water when provided should be used cautiously with adequate maintenance culture to avoid wastage. This could be achieved by supplying good quality water in a sustainable manner by building water infrastructure like dams to provide in their reservoir's erosion mitigation and control, sanitation, recreation, wildlife development, and so on. Water supply information on specific towns in Nigeria are structured to make it sustainable. In the present context, the test for sustainability is whether water continues to be abstracted at the same rate and quality as when the supply system was designed, whether the excreta and wastewater disposal systems continues to function and be used as planned, and whether environmental quality continues to improve (Ademiluyi & Odugbesan 2008). According to Nanan et al. (2003), inadequate water and sanitation services adversely affect the health and socioeconomic development of communities. Lack of safe sanitation is the world's biggest cause of infection. To ensure sustainability, a sound maintenance structure should be put in place to see that distribution networks, etc., will be monitored and maintained as situations arise. The methodology of the review is presented in Figure 4.

RECOMMENDATIONS

There should be adequate funding, utilization of latest technology, empowerment of experienced professionals in water resources for the development of water supply infrastructure. Active community participation in project initiation and management is key to generate favorable conditions for sustainability of the water schemes. Water tariffs which are powerful management tools should be used to achieve various objectives in water and sanitation system. However, it is suggested that water tariffs be subsidized to enable low income groups pay for the water they use. Public enlightenment on water use, regular maintenance works and remuneration packages for best water users as highlighted in this study should be integrated into the water supply system to ensure its and sustainability. Provision of adequate and steady power is a necessity to ensure that the water supply is sustained. There should be great involvement of private sector in water supply and distribution through innovative approaches like public-private partnership (PPP). The involvement of private ownership and franchise in water provision will improve efficiency and reduces government financial risks. Moreover, there is an urgent need for the government of the day to embark on awareness campaign, organization

of workshops, use of the print media as well as radio and television jingles to sensitize the people on the need to boil their water before drinking and treating them by adding alum to remove the sediments. Equally to ensure sustainability of water by ensuring proper payment of revenue as well as maintaining and reporting damage water pipes promptly and also to ensure genuine public participation in water supply planning and effective sanitary environment. Future work should be carried out on investigating the functionality of public water systems in different parts of the country to determine their present states and remedial measures in order to put up water supply systems that will be comprehensive and sustainable. Also, there should be future research on public enlightenment methods to encourage usage of good quality water.

The federal government should put in place a functional water supply system in each state of the federation to ensure sustainable water supply infrastructure. Public water works should be reinvigorated to curb unending water crisis in the country. Public enlightenment, maintenance works and remuneration for best water users should be integrated into the water supply infrastructure to ensure comprehensiveness, efficiency and sustainability. Finally, all water facilities throughout the country should be monitored periodically for optimal performance.

CONCLUSION

All countries studied suffer one form of water crisis or another. Inefficiency of the water supply system in different cities in Nigeria borders on mainly poor management of the water system. Maintenance of the facility is poor due to lack or absence of revenue derived from water users, making the system to be unsustainable. Acceptable quality of the water in sufficient quantity must be provided to impart positively on the health, economic, social, and environmental status of a community. Developed countries are not left out in this issue of water crisis. They suffer from one form of water problem to another. Lagos and Abuja, the commercial and administrative capitals of the country respectively also have water issues. We have worse cases in Yenagoa, Ibadan, Enugu, and Makurdi, Kaduna, etc. Water supply services is more organized and of high efficiency in countries like Mexico, Philippines and Pakistan than in Nigeria. Moreover, dwindling power supply in most parts of the country hamper water delivery and efficient functioning of the water system, since electricity is of utmost importance.

ACKNOWLEDGEMENT

The authors would like to thank Alex Ekwueme Federal University Ndufu Alike for their encouragement and financial support towards carrying out this research work.

DECLARATION OF COMPETING INTEREST

None.

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