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Factors affecting household access to water supply in residential areas in parts of Lagos metropolis, Nigeria

Isaiah Sewanu Akoteyon[CDFMR]

Lagos State University, Department of Geography and Planning, Ojo P.M.B. 0001, LASU Post Office, Lagos-Nigeria, Mobile number: +2348023161616, email: sewanuakot@gmail.com *(corresponding author)*

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Abstract. Access to water is vital for sustainable human socio-economic development. The study examined factors affecting households' access to water supply in three residential areas in parts of Lagos metropolis, Nigeria. A random sampling technique was employed to administer questionnaires to 200 households. The study area was delineated into residential types using the grid method. The result shows the dominance of improved water sources in the high/medium-income residential areas. Households in the medium-income area recorded the highest access in terms of distance to, and safety of water supply. The factor analysis explains 77.41% of the variance with three components, namely: water access, demographic and economic attributes. The results of the analysis of variance reveal three significant variables, namely: main water source, income and cost, which is significant at $p<0.01$. The regression equation model obtained is given as Y = 2.059 + 0.307MWS + 0.286INM + 0.164CST. The study concluded that main water source, income and cost are the factors affecting access to water supply in the study area. The study recommends investment in water infrastructure, giving a higher priority to low-income residential areas for improved healthy living and sustainable socio-economic development.

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1. Introduction

Nigeria is confronted with many challenges in the water supply sector. Apart from the rapid population growth and urbanisation, rising demand and falling supplies due to overexploitation and anthropogenic impacts remain some of the major challenges in the public water sector. In addition, low budget and poor investment in water infrastructure, poor policy implementation and lack of political will also contribute to the current low access to safe water supply in the country. The provision of potable water supply is one of the vital human needs for healthy living according to the seventh Millennium Development Goal (MDG), which is geared towards reducing the proportion of the population without sustainable access to safe drinking water and basic sanitation. Therefore, it is expected that providing adequate attention to urban water supply be placed on the front burner in urban planning. In Nigeria, for example, the investment in the water supply sector is still low, compared to other infrastructural facilities. Similarly, government policy on water supply has been viewed by many as a free gift that can be used without limit as long as supply lasts (Oyebande, 1978). This perception has changed considerably considering the introduction of the metering system and privatisation or partnership with private investors in the water sector.

The low investment and weak policy in the water sector have been responsible for the country's low performance, below the targets of 75% coverage for safe drinking water in 2015. Available statistics revealed that only 65% and 30% of the population gained access to improved water sources in urban and rural areas, respectively (WHO/UNICEF, 2008). The evolution of water supply in urban areas of Nigeria can be traced to the colonial era. During this era, two principal authorities, namely: the Public Works Department (PWD) and the native administration water schemes, were responsible for water supply (Akpen, 2005). A major challenge in the provision of water supply was mainly attributed to the economic depression of the 1930s, which affected both the planning and funding of water supply schemes. Hence, only cities with financial capability were considered in the provision of water supply schemes (Akpen, 2005).

The inadequacies observed in the Nigerian water supply sector led to the formulation of a National Water Supply Policy (NWSP). The policy is aimed at ensuring the provision of sufficient potable water to all Nigerians in an affordable and sustainable way through participatory investment by the three tiers of: the government, the private sector and the beneficiary. One of the key targets of the policy is to extend service coverage to 100% of the population in the year 2011 and to sustain 100% full coverage of water supply for the growing population beyond the year 2011 (Gbadegesin, Olorunfemi, 2009; FGN, 2011).

Despite government efforts at the federal level and other tiers – as well as international donor agencies – towards improving the water supply situation in Nigeria, the majority of the population is still disenfranchised due to poor access to safe water supply. The current water supply coverage in Nigeria is put at about 58%, representing 87 million people. It is estimated that about half of the Nigerian population, i.e. 70 million people, do not have access to a potable water supply (FGN, 2011). This value represents about 6% of the world's population who lack access to safe drinking water.

2. Literature review

Various studies have been conducted on household access to water supply. For example, Oyebande (1978) assessed urban water supply planning and management in Nigeria and inferred that there is an acute water shortage, with the bulk of the available water supplies unmetered. Where metered, ridiculous rates are charged. He stated the need for a management policy that will enhance financial viability and economic efficiency to meet increasing production and distribution costs. Michael (1985) studied the challenges in urban water management in the United States and infers that the rise in the intensity of water usage in the urban environment of the United States is one of the major challenges for the supply, utilisation and protection of water sources. An integrated management approach was proffered to address the water problems in the urban environment of the United States. The study showed that about 30–60% of the urban population in low-income countries lack adequate housing with sanitary facilities, drainage systems, and piping for clean water (UNCHS, 1996).

Sharma et al. (1996) noted that the major challenges confronting sub-Saharan Africa include: lack of knowledge about the finite nature of water, its scarcity and cost; the impact of deforestation and land degradation on the quantity and quality of water; inadequate capacity building; neglect of traditional knowledge bases; gender issues; fragmentation of water resources management; and weak institutional frameworks. Beukman (2002) noted that, in the urban area of southern African, water supply services are provided through tankers, public standpipes, and yard and private house connections through reticulation networks. He noted that the services are characterised by aging infrastructure and interrupted flows. O&M (2002) identified inefficient organisation as key factors contributing to poor performance of water supply facilities in many metropolitan cities in sub-Saharan Africa. AWDR (2003) reported that unaccounted-for water is a major water supply problem in many African cities.

Akpen (2005) examined temporal variations in electricity and water supply in Makurdi, Nigeria between 1927 and 1960. He argued that there is the absence of both government and native authority in the provision of social services such as water. Gabriel (2005) examines the public–private partnership (PPP) and water-supply provision in urban Africa: a case study of Congo-Brazzaville. The study suggests that to achieve the shift from a supply-driven to a demand-led orientation in water supply, PPPs must take into account the economic and social impacts of diverse consumption patterns, and they must also assess consumers' needs. Three key elements, namely: risk transfer, competition and contestability, are vital to successful PPP's capacity to respond to new urban situations and public needs in relation to water supply.

Abdul and Sharma (2007) examine the water consumption patterns in domestic households in major cities in India. It is observed that water consumption in Indian cities (more so in large cities) is far lower than the norms laid down by the Bureau of Indian Standards. The lower consumption is mainly because the water supply is not keeping pace with population growth and the problems of industrialisation and alarming pollution of surface and groundwater sources. A comprehensive water policy for cities is recommended. Wahaj et al. (2007) reported that most of the world's 1.2 billion poor people, two-thirds of whom are women, live in water-scarce countries and do not have access to safe and reliable supplies of water for productive and domestic uses. Mwangi (2008) noted that the hydrology of Africa constitutes a significant challenge to water scarcity.

Robert et al. (2010) analysed issues of water supply and contemporary urban society in Greater Amman, Jordan. The study showed an effective ubiquity of access to mains water in the Greater Amman urban area, regardless of income level and geographical area of residence within the city between high- and low-income households. The study argued that the social and economic costs of water rationing and management are high, with much emphasis on water quality as a major concern to all consumers regardless of their socio-economic status. Banerjee and Morella (2011) opined that insufficient production capacity and inefficiencies of service providers hinders households' access to safe water supply in Africa.

Ishaku et al. (2011) noted that the majority of the rural communities in Nigeria lack access to improved water supply. Oftentimes they rely on free water supply sources such as rivers, perennial streams, ponds and unprotected wells, which are susceptible to water-borne diseases.

Fan et al. (2013) examined factors affecting domestic water consumption in rural households in the Wei River Basin, China. The study revealed that *per capita* domestic water consumption per day correlates significantly with water supply pattern and vegetable garden area. A significant negative correlation was also obtained with family size and the age of the head of the household. Hygiene habits, use of water appliances, and preference for vegetable gardening were identified as the dominant behaviours in the villages with access to improved water supply. The study recommended future studies on rural domestic water consumption with an emphasis on user lifestyles and cultural backgrounds in formulating water management schemes for rural areas. Miller et al. (2013) explore modelling for improved water resources management using ordinary regression techniques and mathematical programming for water resources allocation by utilising system dynamics, and noted that it contributes to the understanding of the impact of climate change in a flexible and transparent way.

A study conducted by Naiga et al. (2015) observed that inconsistencies in policy constitute a major factor affecting the local collective action required for sustained access to safe water in rural Uganda. They stated the need to take into consideration the implications of national institutional disturbances on local collective action for long-term access to safe water. Odjegba et al. (2015) reported insufficient water supply due to population pressure and inadequate distribution/coverage of public water supply in Abeokuta Southwest, Nigeria. Akoteyon (2016) examined the pattern of household access to water supply in suburban settlements in parts of Lagos state, Nigeria, and reported poor access to safe water supply in the study area. Galaitsi et al. (2016) examined the causes of intermittent domestic water supply and inferred that water intermittency, particularly when complicated by unreliable supply, jeopardises communities' access to water. They opined that it is an issue that encompasses politics, engineering, human health and social norms. They suggested interdisciplinary studies be undertaken to better characterise the broader context of intermittent water supply's impacts.

Duran-Encalada et al. (2017) examined the impact of global climate change on water quantity and quality in the US–Mexican trans-border region using a conservative model, and noted that the approach has the potential to improve conditions and prevent risks that may lead to social unrest and hinder economic development. Egbinola (2017) examined the trend in access to safe water supply in Nigeria and inferred that poor financing and management, and low capital allocation in the water sector are the major challenges to improved water supply. He stated the need to improve funding for water infrastructure in rural and suburban areas. Angoua et al. (2018) investigated barriers to accessing improved water and sanitation in poor peri-urban settlements of Abidjan and noted that socio-economic status and settlement characteristics are the main indicators of poor access to reliable water and sanitation in peri-urban settlements. They suggested innovative planning approaches that involve local actors, administrative authorities and religious communities, and that are based on the social context of each specific settlement, in order to achieve sustainable access to basic drinking water and sanitation by 2030.

Despite the vast research studies on factors affecting households' access to water supply both at the local and the international level, there is still a gap in knowledge, particularly in varied income residential areas in Lagos metropolis. Thus, this study aimed to examine factors affecting households' access to water supply in varied-income residential areas in parts of Lagos metropolis, with a view to proffering appropriate policies that will enhance access to potable water for improved healthy living and sanitation in the area.

3. The study area

The study areas are located at longitude 3°10'0'E to 3°40'0'E and latitude 6°50'0'N to 6°80'0'N within the metropolitan area of Lagos State, Nigeria (Fig. 1.).

The study area is bounded by the Ibeju-Lekki and Ifako-Ijaiye Local Government Areas (LGA) in the east and north, respectively, while the Atlantic Ocean and Alimosho/Ojo LGAs form the southern and western boundaries. The area occupies about 445.4 km^2 of land. The climate of the study area comprises two major seasons: the dry season from November to March, and the wet season from April to October (Adetoyinbo, Babatunde, 2010). The average temperature is about 27°C, with a mean annual rainfall of about 1,532 mm (Odumosu et al., 1999). The major vegetation consists of tropical swamp forest (fresh waters and mangrove swamp forests and dry lowland rain forest). The drainage system consists of lagoons, occupying almost 22% of the state's total landmass. The area is drained by the Ogun River at the centre, the Osun River to the east and the Yewa River to the west. The population of the area is about 3,057,956, while the density is approximately 140,566/km^2 (NPC, 2006). The provision of public water supply in the study area is through the Lagos Water Corporation (LWC) as far back as the early 20th century.

Despite the laudable efforts of the Lagos Water Corporation, there is still a very wide variation between the various residential areas in terms of access to water supply. Currently, water supply in Lagos state comes from three main sources, namely: major, mini and micro waterworks. The major waterworks are mainly from a surface water source from Adiyan, Iju, and Isashi with design capacities of 70 million gallons/day (Mgd), 45 Mgd and 4 Mgd, respectively. Unlike the mini/micro waterworks, they are mainly from a groundwater source, tapping from the coastal plain sand (CPS) (Longe, 2011). The mini water works are located in about 23 settlements, with a total design capacity of about 53.2 Mgd, while the micro waterworks are located in about 17 sites, with a total design capacity of about 16.3 Mgd (LWC, 2012). According to LWC

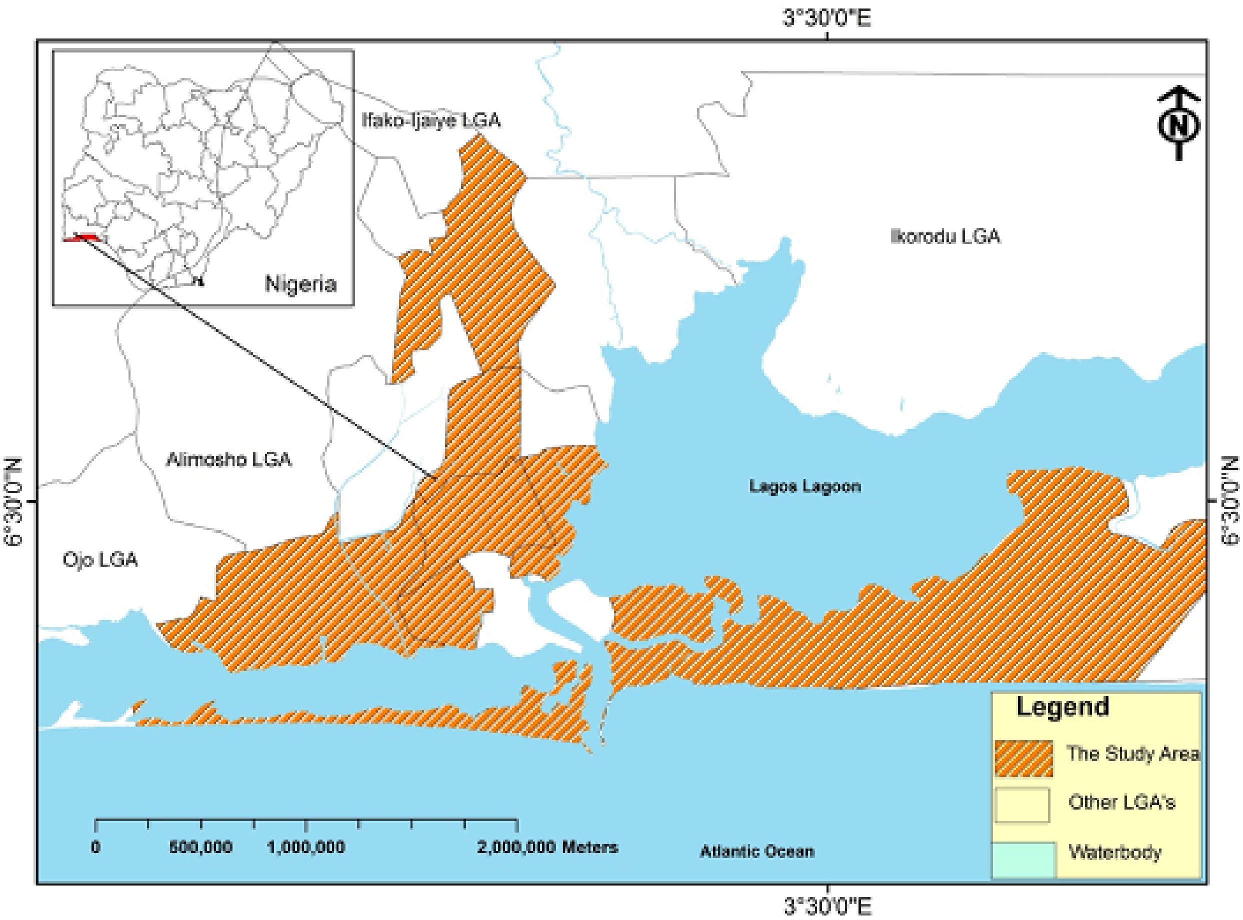

Fig. 1. Study area

(2012), the major, mini and micro-water works account for about 28,070.16 Mgd, 2,797.38 Mgd and 1,208.77, Mgd respectively.

In Lagos state, for example, the high-income residential areas (HIRA) have access to various improved water sources such as boreholes, piped water connections, protected dug wells, public standpipes and rainfall harvesting. This residential area has several water schemes, both public and private, that afford the residents easy access to improved water sources for various uses. Examples of settlements within this area include Ikoyi, Opebi and Victoria Island, among others. In the medium income residential area (MIRA), the water supply provision is similar to what obtains in the HIRA, except that most of the water facilities within the residential area are obsolete and dilapidated. Despite this, most of the residents fall within the middle-income group and have the capacity to pay for water supply. Similar findings have been reported by Obeng-Odoom (2012), Koskei et al. (2013) and Obeta (2017).

Despite the challenges encountered in the zone, the majority of the residents around Ebute-Metta, Festac, Surulere, etc. still have reasonable access to water supply. Unlike the low-income residential area (LIRA), which includes such locations as Ajegunle, Makoko and Mushin, access to water supply is very poor. The dense nature of the population and poor water infrastructure constitute some of the problems of access to improved water supply in this area. Due to the low-income capacity of the residents, the majority obtains or collects water from unimproved sources, such as a stream or river, unprotected dug wells, or vendor-provided water whose quality cannot be guaranteed. In most cases, despite their meagre income, most of the residents in this residential area pay exorbitant fees for their household water consumption on a daily basis. In most cases, they trek for more than 1 km to source water while some spend more than 30 minutes going to and from fetching water. This poor access to water contributes significantly to the man-hour loss and poor hygiene status of the people.

4. Materials and method

The data used for this study was obtained through a survey using a direct questionnaire to obtain information from households with access to water supply across varied residential areas in parts of Lagos metropolis, Nigeria. The survey was conducted between August and September 2012, and covered high-, medium- and low-income residential areas. The grid method, with a grid measuring 10×10 cm representing 1×1 km on the ground (Fadare, Olawuni, 2008), was used to delineate the area into residential types based on household income levels (Balogun et al., 1999). Thereafter, three settlements each were randomly selected from each residential type, e.g. HIRA, MIRA and LIRA, totalling nine settlements in all (Fig. 2). A profile of each residential type is presented in Table 1.

On ethical consideration, approval was obtained from the ethics committee of the Lagos State University. The respondents were informed that participation in the survey was purely voluntary and that they were free to decline to provide the researcher information at any time without providing justification. Consent for data gathering was also obtained before the administration of questionnaires. A total sample size of (n=200) was designed across the residential areas (RAs) according to Yamane (1967). The Yamane formula is given in Equation 1.

$$\mathbf{N/1+N(e)2} \tag{1}$$

Where: n is the sample size; N is the finite population; e is the level of significance (or limit of tolerable error) (0.05); 1 is unity (a constant).

Based on the uneven distribution of population across the RAs, a proportional method was employed for the sample size (Kothari, Garg, 2014). Thus, a total of 40, 60 and 100 questionnaires, totalling two hundred, were administered to household heads representing high-, medium- and low-income residential areas, respectively. The survey was conducted to collect information on household access to water supply sources in the study area. Prior to the survey, a pilot study was conducted to ensure that the issues raised were relevant to the study rationale. The survey questionnaire consists of four sections: sociodemographic variables of households,

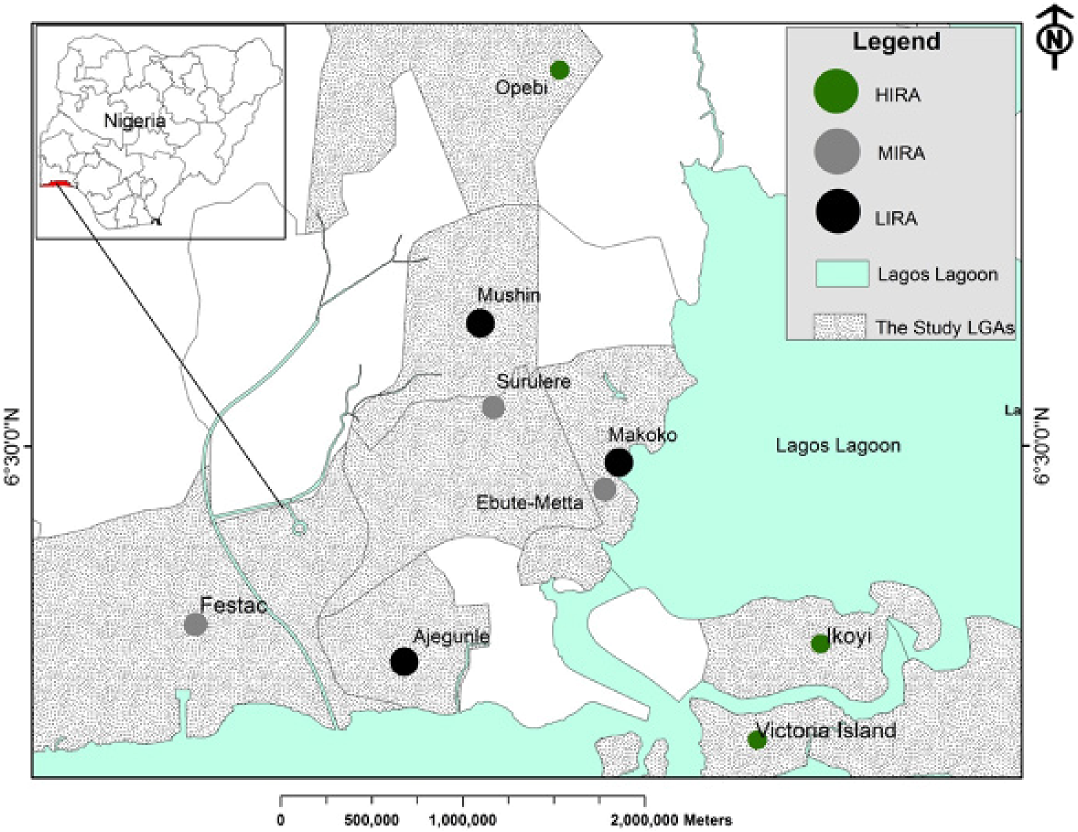

Fig. 2. Residential types in the study area

Table 1. Profile of residential types

s/n	Residential types	Settlements	Characteristics
1	HIRA	Ikoyi, Opebi and Victoria Island	Has well-defined road/drainage networks and street layout plan. Patches of natural vegetation and landscaping are prominent. Most buildings are well spaced with adequate open spaces for recreation. A large number of the residents are high-income earners.
2	MIRA	Ebute-Metta, Festac town and Surulere	Parts of this area falls within the old colonial master's residential area (Ebute-Metta) and government housing estate (Festac town). The area has well-defined road/drainage networks and a well-defined street layout plan. The presence of natural vegetation cover is scanty, while the level of landscaping is relatively high. The majority of residents are middle-income earners.
3	LIRA	Ajegunle, Makoko and Mushin	The area lacks well-defined road/drainage networks. There is a lack of clearly defined street layout. Most buildings are clustered, without adequate ventilation. There are no open spaces and the area is devoid of natural vegetation cover and landscaping. The majority of residents are low-income earners.

sources of water, access to water sources, and water source attributes (i.e. distance to water source, time taken to obtain water, and quantity of water consumed per person per day).

The term "sources of water" used in this study includes both the improved and unimproved sources of water available for the household for various uses. The improved sources used in this study are: borehole (BH), piped water connection (PWC), public standpipe (PS), protected dug well (PDW) and rainwater harvesting (RWH). The unimproved sources consist of: unprotected dug well (UDW), stream/river and vendor-provided water (VPW), such as sachet water, bottled water and cart/truck water vendors (WHO, UNICEF, 2014).

Household access to water supply sources in this study was measured using attributes of water access based on WHO, UNICEF (2014) maximum benchmark. The attributes are:

Distance of dwelling to and from the water source. The scale of the distance ranges from "within household" to "above 2 km". The WHO, UNICEF (2014) maximum benchmark is 1 km.

Time spent to fetch water from the source back to the dwelling. The scale range from less than 10 minutes to 1 hr. The prescribed maximum benchmark is 30 minutes.

Daily water consumption per person. The scale ranges from less than 20 litres to above 80 litres. Daily water consumption per person/day below 20 litres implies a lack of access to water.

All household members who trekked more than 1 km, spent above 30 minutes in collecting water and consumed below 20 litres of water per person/day were considered as not having access, even if they were using improved sources.

Two field assistants were trained to administer the questionnaires in the study areas while the researcher cross-checked for errors or inadequacy in the administered questionnaires after each field survey so as to guarantee quality control of data generated from the questionnaires. The survey questionnaires were coded 1–40, 41–100 and 101–200 representing low-, medium- and high-income residential areas, and thereafter were inputted into the Statistical Package for Social Sciences (SPSS) version 17.0 for analysis. Descriptive, bivariate and multivariate statistical techniques were all employed for the data analysis. ArcMap 10 software was employed to generate a map of the study area/residential types while Excel software (2003 version) was adopted to plot the gender distribution, sources of water and households' access to water in the study area.

Descriptive statistics was used to examine the measure of location, and bivariate statistics helped to establish the interdependence of the variables, while multivariate statistics, i.e. Factor Analysis (FA), was employed to explain factors affecting household access to water supply in the study area. Nine variables affecting household access to water supply were subjected to Principal Component Analysis (PCA) using the Kaiser–Meyer–Olkin measure (KMO) and Bartlett's sampling adequacy test (Kaiser, 1974). Linear Regression Analysis (LRA) was used to examine the effects of the contributions of each of the factors affecting household access to water supply. The independent variables used for the LRA are: sex, age, education, occupation, income, household size, main water source and cost expended on water consumption/day by household (HH). Daily water consumption (Lpcd) was used as the dependent variable. The coding used for the analysis is presented in Table 2.

Before the analyses, the model variables were checked for collinearity. Also, the correlations between variables included in the model were checked to ensure that the independent variables had some degree of relationship with the dependent variable above 0.3 (Pallant, 2010). The correlation analysis shows that all variables (sex, age, education, occupation, income, household size, main source and cost correlate significantly with the dependent variable, DWC.

5. Results and Discussion

5.1. Sociodemographic characteristics of households

The distribution by sex and occupation of households is shown in Fig. 3. Approximately 74.0% are females, while the remaining 26.0% are males. This confirms the role of the female in sourcing and handling water in households in most developing countries. Regarding occupation, trading activities predominate, representing 37.5%. About 26.5% accounts for other categories of occupation such as retirees, religious leaders and traditional healers, among others.

Other sociodemographic attributes of the household are presented in Table 3. The result indicates that more than three-quarters of the households interviewed are married. The dominant age groups are 31–35 and above 35, each representing 40.5%. The result confirms the targeted group being the household head or their representative who can provide adequate information on household access to water. Approximately half of the households interviewed had a tertiary education, while about 41.0% had a secondary education. This proportion indicates that the households interviewed have a basic understanding of issues relating to access to water supply.

This result further supports the information deduced from the marital status and age of the household in the study area. Therefore, the data collected in this survey are reliable. On household income, the majority representing 42.5% earn above NGN 35,000/month (USD 177.7), while 27.0% earn between NGN 10,000 and NGN 20,000/month. Though it was observed that quite an appreciable proportion of the households earn above NGN 35,000/month, it is evident that the purchasing power of the households in the study area – and the quantity of water they consumed – may be affected based on their income level. Regarding the household size, the result shows that 49.0% and 45.0% contain 6–10 and 1–5 persons per household, respectively. Only 3.0% of the households declined to give information on their household size. This might be attributed to their cultural belief, as this is common in most African countries.

Based on the chi-square test, significant variations exist between the educational status of the households and the residential types, obtained as ($\chi 2=82.69$, $df=6$, $p<0.01$). Similarly, income and HHS showed a dependent relationship ($\chi 2=141.23$, and $\chi 2=24.36$) at $p<0.01$ respectively. The result implies that the RAs have an influence on education, income, and HHS in the study area.

5.2. Sources of water and household access to water

The sources of water available for household uses and household access to water in the study area are presented in Figs 4 and 5, respectively. The result shows that piped water connections and borehole are the major sources of water, representing 43.5% each in HIRA. In MIRA, the major sources of water include; public standpipe, piped water connections and borehole, accounting for 100%, 53.3% and 41.9%, respectively. It was observed that less than one-quarter of the households rely on vendor-provided water for various uses in this zone. Unlike the LIRA, the major sources of water are; unprotected dug well, rainwater harvesting, protected dug well and vendor-provided water.

Household access to water shows that 40.4% and 31% of the households in HIRA have access to piped water connections and borehole, respectively. In MIRA, approximately 90.5%, 57.6%, and 43.7%

Table 2. List of variables and coding

Variables	coding
Time to main water source	TSMWS
Distance to main water source	DMWS
Income	INM
Time taken to fill container	TTFC
Main water source	MWS
Number of trips to main water source	NTMWS
Household size	HHS
Cost	CST
Daily water consumption (lpcd)	DWC

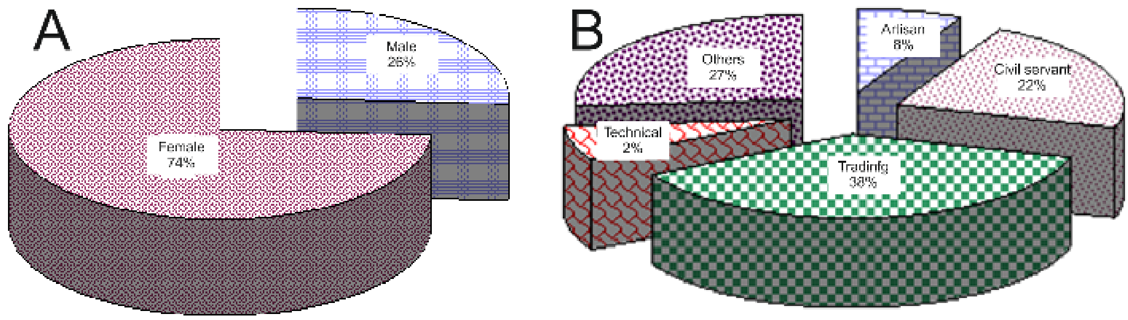

Fig. 3. A - Sex of household, B - Occupation of household

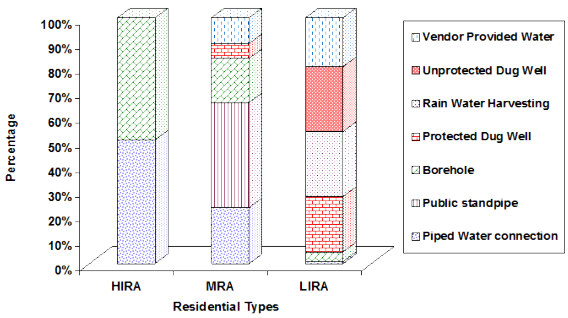

Fig. 4. Sources of water

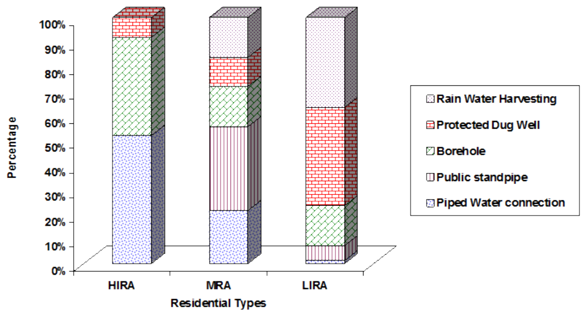

Fig. 5. Household access to water sources

have access to the public standpipe, piped water connections and borehole, respectively. Household access in LIRA revealed that about 62.5% and 57.1% have access to a protected dug well and rainwater harvesting. A similar result was reported by Tadesse et al. (2013) and Mahama et al. (2014). Access to safe water (piped water connections and public standpipe) indicates that MIRA, comprising Ebute-Meta, Festac town and Surulere, recorded the highest access. The observed highest access recorded in the area can be attributed to the presence of waterworks that are located within the zone. For example, a major waterworks (surface water source) with a projected capacity of 4 Mgd deriving its source from the Owo River in Ogun state was established at Isashi in 1977 to provide water to the residents in Festac town and its surroundings. The water scheme was also designed to serve the delegates that participated in the Festival of Arts and Culture in Festac town, which is hosted by Nigeria. Similarly, the location of the mini waterworks at Surulere which taps from the Coastal Plain Sand (CPS) aquifer, a groundwater source, serves as the major source of water supply in Lagos State and its environs (Longe, 2011). In addition, Ebute-Meta is one of the major settlements in Lagos state, where the colonial administrators resided. The area is well planned, with a dense system of water trucks that serves the people.

5.3. Water access attributes

5.3.1. Distance to water source

Household access to public standpipe based on distance shows full access in MIRA and LIRA, while access to a protected dug well recorded full access across the three residential areas. Access to borehole based on distance is shown to be available to 98.4% of households in the study area. A similar result was reported by Obeta (2017) in his study on the rural communities in Enugu, Nigeria. The variations across the residential type revealed that only 6.1% of the households in the LIRA do not have access. It is curious to note that distance to an

Table 3. Descriptive analysis of the sociodemographic characteristics of households

Variables		HIRA	MIRA	LIRA	Total
Marital status	Single	6(15.0)	11(18.3)	8(8.0)	25(12.5)
	Married	28(70.0)	44(73.3)	84(84.0)	156(78.0)
	Divorced	5(12.5)	0(0.0)	6(6.0)	11(5.5)
	Others	1(2.5)	5(8.3)	2(2.0)	8(4.0)
Age	20–25 years	0(0.0)	2(3.3)	2(2.0)	4(2.0)
	26–30 years	3(7.5)	9(15.0)	22(22.0)	34(17.4)
	31–35 years	18(45.0)	26(43.8)	37(37.0)	81(40.5)
	Above 35 years	19(47.5)	23(38.3)	39(39.0)	81(40.5)
Level of education	Primary	0(0.0)	0(0.0)	12(12.0)	12(6.0)
	Secondary	3(7.5)	15(25.0)	64(64.0)	82(41.0)
	Tertiary	37(92.5)	44(73.3)	19(19.0)	100(50.0)
	Others	0(0.0)	1(1.7)	5(5.0)	6(3.0)
Income (NGN)	10,000	0(0.0)	0(0.0)	19(19.0)	19(9.5)
	10,000–20,000	0(0.0)	1(1.7)	53(53.0)	54(27.0)
	20,000–30,000	1(2.5)	6(10.0)	16(16.0)	23(11.5)
	Above 30,000	40(100)	35(58.3)	10(10.0)	85(42.5)
	No response	4(10.0)	13(21.7)	2(2.0)	19(9.5)
Household size	1–5	23(57.5)	32(53.3)	35(35.0)	90(45.0)
	6–10	14(35.0)	23(38.3)	61(61.0)	98(49.0)
	11–15	0(0.0)	1(1.67)	2(2.0)	3(1.5)
	Above 15	0(0.0)	1(1.67)	2(2.0)	3(1.5)
	No response	0(0.0)	5(8.3)	1(1.0)	6(3.0)

unimproved source, e.g. unprotected dug well and vendor provided water, in the study area were within the World Health Organisation (WHO) benchmark, with the exception of MIRA, where only 6.5% of households exceeded the maximum benchmark (WHO, UNICEF, 2014). The exposure of households in the MIRA and LIRA to unimproved water sources might pose some health challenges, including water-borne diseases such as cholera and typhoid.

5.3.2. Time spent fetching water

Household access to water source based on time taken from and to the dwelling in order to obtain water revealed that households have access to water, since the majority obtains water within the maximum WHO benchmark of 30 minutes. This result corroborates the findings of Mahama et al. (2014). Only 1.1% of the households in the LIRA exceeded 30 minutes based on the time taken to obtain water from vendor-provided sources. The relationship between the residential types and sources of water shows that there is a dependent relationship in the sources of water for piped water connection, public standpipe and borehole. Concerning specific sources, HIRA recorded the highest proportion for PWC and BH.

The observed high proportion of these sources attests to the fact that households living in the HIRA, such as Ikoyi, Victoria Island and Opebi, are high-income group earners who have the financial capability to provide their own private borehole with a piped water connection within their dwellings. These findings have been established by Obeng-Odoom (2012), Koskei et al. (2013) and Obeta (2017). In MIRA, PS is the most prominent source. Residential areas in this area are characterised by the medium-income class, such as: Surulere, Ebute-Meta and Festac. A major feature of this residential area is that public water facilities such as public standpipes are readily available to the residents. In LIRA, the availability of PWC and PS is very low. Areas within this residential zone comprise low-income earners who neither have the financial capability to drill their own private BH nor have a piped water connection within their dwelling. Examples of settlements within this area are Mushin, Ajegunle and Makoko.

The relationship between education and water usage shows that there is a dependent relationship in the sources of water for PWC, BH, UDW, VPW and stream. The result implies that the choice of source(s) of water is dependent on the educational status of the households. It is believed that literate people are very much concerned with the quality of the water they consume because of the health consequences. In contrast, the illiterate and low-income earners often rely on traditional beliefs common among African nations. Concerning specific source, households with tertiary education have the highest proportion for PWC and BH. Based on water quality for human consumption, PWC and BH are considered as an improved source (WHO/UNICEF, 2014) (provided there is no anthropogenic influence on it), as compared to sources such as UDW, VPW and a stream, which are regarded as unimproved water sources. The result indicates that households with primary and secondary educational background use unimproved water sources. The result of the correlation analysis between DWC (lpcd) and MWS ($r=0.509$), INM ($r=0.506$), education ($r=0.351$) and CST ($r=.300$) show significant relationship at $p<0.01$.

5.4. Factors affecting household access to water supply

The suitability of the dataset for factor analysis based on the KMO measure of the sampling adequacy value was 0.701 (Table 4). The value exceeds the recommended value of 0.6 (Kaiser, 1974). Bartlett's test of sphericity was found to be statistically significant ($p<0.01$) (Table 4), thus supporting the factorability of the correlation matrix.

The PCA extracted four main components with eigenvalues exceeding 1, explaining 77.41% of the variance from the nine variables in the dataset. Component 1 accounts for 35.9%, while components 2, 3 and 4 contribute 17.2%, 12.9% and 11.4%, respectively (Table 5).

The pattern and structure coefficients matrix and communalities are presented in Table 6. The oblimin rotation indicates high loadings on four variables on component 1. This component indicates the dominance of the TSMWS, DMWS and TTFC water access attributes. As indicated in the pattern coefficient, an increase in component 1 shows a corresponding decrease in the water access attributes. This implies that reducing time spent, distance and time taken to fill the water container will result in an increase in household access to water supply. The time and distance from the dwelling to an improved water source and back are vital in gaining access to water. Component 2 also shows a similar attribute of water access with high loadings on MWS and NTMWS.

Component 3 has high loadings on HHS, which represents a demographic attribute. In any social survey on domestic water use, the HHS is very important because it determines the domestic water demand and the consumption pattern. Studies have shown that HHS to a large extent determines domestic water demand (Ayanshola et al., 2010; Keshavarzi et al., 2006). This result is further supported by component 4 having high loadings on CST and DWC, which represent an economic attribute. As indicated in Table 6, the increase in component 4 results in high CST incurred on sourcing for water, and also an increase in DWC. This implies that the greater the quantity of daily *per capita* water consumption, the higher the cost expended on water provision in the household. This result agrees with the findings of Olajiyigbe (2010). Regarding INM, the result shows that this variable accounts for the highest communality. This implies that the higher the income of a household, the greater the access to an improved water source.

The result of the linear regression analysis shows that the overall value of the R square change is obtained as 0.259. This implies that the main water source explains an additional 0.26% of the variance. This value indicates a significant contribution as revealed by the Sig. F change value (Table 7). Further,

Table 4. The KMO and Bartlett's Test of the data set

Kaiser–Meyer–Olkin Measure of Sampling Adequacy.		0.701
Bartlett's Test of Sphericity	Approx. Chi-Square	79.600
	df	36
	Sig.	0.000

Table 5. Total Variance Explained

Component	Initial eigenvalues			Extraction Sums of Squared Loadings			RotationSums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	3.230	35.884	35.884	3.230	35.884	35.884	3.027
2	1.546	17.177	53.062	1.546	17.177	53.062	1.588
3	1.163	12.923	65.984	1.163	12.923	65.984	1.183
4	1.028	11.421	77.406	1.028	11.421	77.406	1.551
5	.676	7.516	84.921				
6	.573	6.369	91.291				
7	.427	4.742	96.032				
8	.241	2.683	98.716				
9	.116	1.284	100.000				

Extraction Method: Principal Component Analysis.
a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Table 6. Pattern and structure matrix with Oblimin Rotation of factor analysis

Variables	Pattern coefficients				Structure coefficients				Communalities
	1	2	3	4	1	2	3	4	
TSMWS	**-0.923**	-0.104	-0.04	0.114	**-0.911**	-0.19	-0.085	-0.076	0.772
DMWS	**-0.872**	-0.312	0.03	-0.013	**-0.900**	-0.388	-0.007	-0.181	0.804
INM	**0.789**	-0.065	-0.156	0.247	**0.827**	-0.003	-0.108	0.414	0.908
TTFC	**-0.578**	0.446	-0.313	-0.055	**-0.567**	0.408	-0.358	-0.203	0.856
MWS	0.009	**0.813**	-0.041	0.302	0.142	**0.800**	-0.061	0.262	0.760
NTMWS	0.306	**0.722**	0.13	-0.333	0.305	**0.762**	0.121	-0.303	0.633
HHS	-0.009	0.000	**0.890**	0.105	0.061	-0.034	**0.891**	0.115	0.734
CST	-0.019	0.135	0.358	**0.774**	0.175	0.084	0.363	**0.768**	0.767
DWC(lpcd)	0.371	-0.092	-0.334	**0.654**	0.483	-0.082	-0.302	**0.732**	0.733

Table 7. Model Summary of the factors affecting household access to water

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics R Square Change	F Change	df1	df2	Sig. F Change
1	.509[a]	.259	.255	1.07075	.259	69.089	1	198	.000
2	.570[b]	.325	.318	1.02438	.066	19.332	1	197	.000
3	.591[c]	.350	.340	1.00783	.025	7.522	1	196	.007

a. Predictors: (Constant), MWS
b. Predictors: (Constant), MWS, INM
c. Predictors: (Constant), MWS, INM, CST

the ANOVA result test (Table 8) shows that the entire model consists of three variables and is statistically significant [F (3, 196) = 35.159, $p<.000$].

The contributions of the independent variables included in the model were also examined to see which of them contributed to the prediction of the dependent variable (Table 9). The equation model indicates three strong predictors of access to water supply in the study area. The predictors are: main water source, income and cost (Equation 1).

$$Y = 2.059 + 0.307_{MWS} + 0.286_{INM} + 0.164_{CST.}$$

Where: Y is the predicted daily water consumption (lpcd); MWS is the main water source; INM is income; and CST is cost. The results indicate that MWS, INM and CST have strong contributions in explaining the dependent variable, DWC (lpcd).

The result agrees with the findings of Ezenwaji et al. (2016). Other variables such as sex, age, education, occupation and HHS were not statistically significant. Therefore, these variables do not contribute significantly to explaining the dependent variable. The coefficients for the main water source indicate that, on average, about 0.3 litres of more water *per capita* per day will be required. Therefore, households that use the main source of water supply were found to have 0.3 litres more daily *per capita* water consumption than households that use other sources as the main water source. This is due to the fact that it is a more reliable improved source for various uses. INM has a beta value of 0.3, indicating that a one-unit increase of (₦1,000) in the monthly INM of the HHS results in a 0.3-litre increase in the amount of daily *per capita* water consumption

Table 8. ANOVA of the factors affecting household access to water

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	79.211	1	79.211	69.089	.000[a]
	Residual	227.009	198	1.147		
	Total	306.220	199			
2	Regression	99.497	2	49.749	47.409	.000[b]
	Residual	206.723	197	1.049		
	Total	306.220	199			
3	Regression	107.137	3	35.712	35.159	.000[c]
	Residual	199.083	196	1.016		
	Total	306.220	199			

a. Predictors: (Constant), MWS
b. Predictors: (Constant), MWS, INM
c. Predictors: (Constant), MWS, INM,CST
d. Dependent Variable: DWC(lpcd)

Table 9. Coefficients of the regression analysis of the factors affecting household access to water

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	2.059	0.171		12.071	0.000	1.723	2.396
	MWS	0.465	0.056	0.509	8.312	0.000	0.354	0.575
2	(Constant)	1.487	0.209		7.124	0.000	1.075	1.899
	MWS	0.296	0.066	0.323	4.486	0.000	0.166	0.425
	INM	0.328	0.075	0.317	4.397	0.000	0.181	0.475
3	(Constant)	1.040	0.262		3.966	0.000	0.523	1.557
	MWS	0.280	0.065	0.307	4.307	0.000	0.152	0.408
	INM	0.296	0.074	0.286	3.984	0.000	0.149	0.443
	CST	0.239	0.087	0.164	2.743	0.007	0.067	0.411

a. Dependent Variable: DWC(lpcd)

of the households in the study area if the influence of other variables in the model is controlled. The result agrees with the findings of Kithinji (2015) and Ezewanji et al. (2016).

6. Limitations

The interview only covers some parts of Lagos metropolis and may not be used for generalisation to other parts of Lagos state, Nigeria. The search identified limited literature on the subject, hence an indication of the limited research in this area. Also, the delineated RAs may not reflect a clear-cut scenario due to the inter-connectivity and intertwined nature of the metropolis. The scope of the study did not cover the impacts of the climate change phenomenon. Future study will be required to examine the impacts of climate change on water supply and demand and its socio-economic and health implications for achieving sustainable development.

7. Conclusion

The study examined factors affecting households' access to water supply in varied income residential areas in parts of Lagos metropolis, with a view to proffering appropriate policies that will enhance access to potable water for improved healthy living. The findings show that improved water sources are dominant in HIRA and MIRA, while in LIRA, unimproved sources predominate. Regarding household access to safe water supply, MIRA recorded the highest access, while access based on distance shows that MIRA and LIRA recorded full access. The study inferred that households are prone to water-borne diseases based on proximity in terms of distance to unimproved source in MIRA and LIRA. The time spent to obtain water indicates that the majority of the households obtain water within the stipulated WHO maximum benchmark. A significant relationship was established between DWC (lpcd) and MWS (r=0.509), INM (r=0.506), education (r=0.351) and CST (r=.300) at p<0.000.

The extracted four components explain 77.41% of the variance. Component 1 accounts for 35.9%, while components 2, 3 and 4 contribute 17.2%, 12.9% and 11.4%, respectively. Component 1 indicates the dominance of water access attributes with TSMWS, DMWS and TTFC, and has implications for an increase in household access to water supply. Component 2 also represents an attribute of water access, with high loadings on MWS and NTMWS. Component 3 has high loadings on HHS representing a demographic attribute, while component 4 represents an economic attribute, with high loadings on CST and DWC. This component implies that the more the quantity of daily *per capita* water consumption, the higher the cost expended on water provision in the household.

The LRA revealed that the overall R square change is 0.259, indicating that the main water source explains an additional 0.26% of the variance with a significant contribution of the Sig. F change value. The ANOVA showed that the model comprises three variables and is statistically significant at (F [3, 196] = 35.159, p<.000). The equation model ($Y = 2.059 + 0.307_{MWS} + 0.286_{INM} + 0.164_{CST}$) indicates three strong predictors, namely MWS, INM, and CST, as the major factors affecting household access to water supply in the study area. This implies that MWS, INM and CST have strong contributions in explaining the dependent variable, DWC (lpcd). The regression coefficients for the main water source show that, on average, about 0.3 litres more water *per capita* per day will be required. Therefore, households that use the main source of water supply were found to have 0.3 litres more daily *per capita* water consumption than households that use other sources as their main water source.

The study concluded that three major factors, namely main water source, income and cost, are the major factors affecting household access to water supply in the study area. The study also revealed that households in the low-income residential area rely more on unimproved water sources and have poor access to a safe water supply. The study recommended that policymakers and relevant agencies should invest more in water infrastructure, giving a higher priority to low-income residential areas so as to improve their well-being and quality of life for sustainable socio-economic development.

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