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Increasing Population, Urbanization, and Climatic Factors in Lagos State, Nigeria: The Nexus and Implications on Water Demand and Supply

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Abstract

This study examines the impact of climate, urbanization, and population on water supply in Lagos State. Population baseline data used for this research were based on provisional census data of 1963, 1973, 1991, and 2006. Urbanization assessment were based on multi-temporal imageries from Landsat MSS, TM, NigeriaSat-1, and Landsat ETM+ for 1975, 1995, 2007, and 2015, respectively. Monthly temperature and rainfall data between 1960 and 2015 were collected from the Nigerian Meteorological Agency (NIMET), Oshodi, Lagos, Nigeria, and used for climatic assessment. Information on water production, demand, and supply for this study were gleaned from the Nigerian Bureau of Statistics (NBS), Lagos State Water Corporation reports of various years, and relevant literature on Lagos water supply and demand. The census data revealed that the population of Lagos State increased by about 525.9% between 1963 and 2006 and rose to about 754% in 2015 based on 3.4% growth rate. On the other hand, water demand increased from 172,088m^3/d in 1963 to about 2,392,792m^3/d in 2015 while water supply rose from about 97,377m^3/d in 1963 to about 930,531m^3/d in 2015. Urban land use/build up area increased from 230.8km^2 in 1976 to 805.4km^2 in 2015 while climatic records revealed that temperature and rainfall relatively increased by about 0.0508^{0}C and 0.0159mm respectively for 55 years. The study concludes that there will be more pressure on water as a result of population growth which will further impact the changing functionality in terms of socio-economic and infrastructural development of Lagos State in the near future.

Introduction

Globally, studies have revealed that urbanization, increasing population, and climatic variabilities have a significant impact on water supply particularly in the fast-growing urban centers and/or cities around the world (Ayeni, Soneye, Fasunwon, Miteku, & Djiotang-Tchotchou, 2011; Ayeni, Kapangaziwiri, Soneye, & Engelbrecht, 2015; Tackle, McGranahan, &Satterthwaite, 2015). Studies have revealed that urban bloom will continue for decades why the increase is expected to reach 60% by 2030 as almost half of the world's population currently lives in urban areas (Cohen, 2006; Kamal-Chaoui & Alexis, 2009; UNESA, 2014). For example, the urbanization rate in Lagos State had escalated out of control in that almost 600,000 people are added to the population annually (Fulani, 2012). Remarkably, the urban and peri-urban areas of the world consumed about 75% of commercial energy (UNEP (2015). As a result, almost 80% of global waste and about 60% of greenhouse gas emissions that cause global climate change originate from cities of the world (Kamal-Chaoui & Alexis (2009; El-Sufi, 2010). Oyemade, Bolaji, & Olowa, (2009), Sikder and Xiaoping (2014), and Bhatnagar (2017) observed that the erratic rainfall, temperature, and other climatic variabilities have ensued to continual drought and flood effects at both global, regional, and local scales. More importantly, these have affected water supply. For instance, availability of surface water or shallow groundwater depends on the precipitation (EEA, 2007; IPCC, 2008). To this end, increasing severe weather risk and its threats to human settlements have become a great concern especially in coastal areas like Lagos. Each day, climate refugees from rural areas that have been hit by drought or flooding intensify migration to the cities in search of ways to sustain their livelihoods. Essentially, the most vulnerable groups to the effects of climate change are the majority of rural population who are face poor health conditions, unemployment, or social segregation. As a result, they tend to migrate to cities within or outside their countries e.g., migration from far northern Nigeria States (e.g., Sokoto, Kano, Borno) to Lagos State (DESA, 2011).

Climate change would be one of the major drivers of human migration in the near future as predicted by the United Nation and this will lead to millions of environmental migrants by 2020 (United Nations, 2005; UNESA, 2014). There is no doubt therefore that climate change exists. Due to the fact that availability of improved drinking water is a critical issue for world population, it is important to note that climate change not only affect water resource base vis-à-vis water availability, quantity, quality, timing, and distribution, as well as other watershed services (Abbott, 2011; Ringer, 2008; USDA, 2008), but directly or indirectly it aggravates existing socio-economic and environmental problems particularly pressure on water supply, daily water utilities, and many other unexpected challenges (Arnell, 2004; Morrison, Morikawa, Murphy, & Schulte, 2009, United Nations, 2009). As observed by Pimentel et al. (2004), to some extent these could have resulted from higher temperatures and reduced precipitation levels and could lead to shortages in available fresh water supply owing to reduced availability of surface water as well as slower recharge rates of groundwater. It should be noted that as the supply of fresh water is limited, both the world's population and the demand keep increasing rapidly. Therefore, the implication of pressure on limited fresh resources will not only rest on the world urban poor but the rural population will continue to suffer. The implication will not exempt any part of Lagos State.

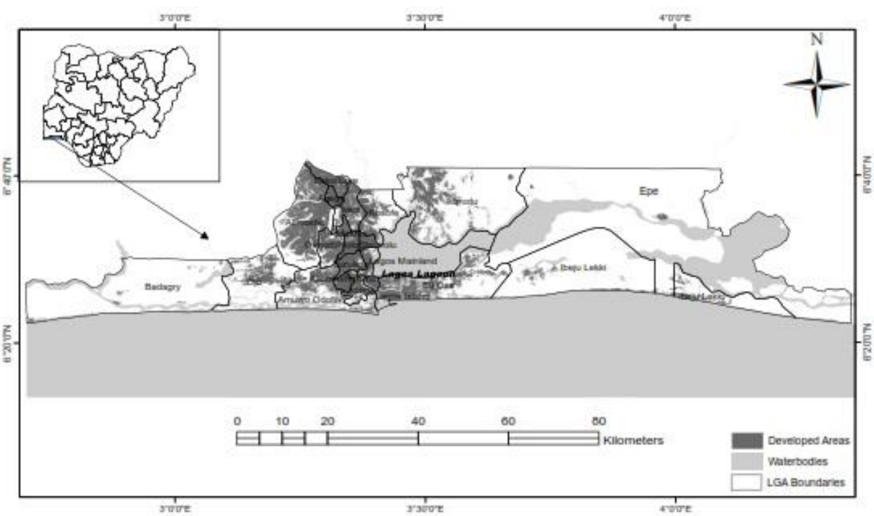
Over the past four decades, the provision of improved and adequate water to the continuous increasing population of Lagos State residents (both rural, sub-urban, and urban) has been a big challenge that should not be under estimated if adequate improved water is to be secured. Historically, the Lagos Water Corporation (LWC) formerly known as the Federal Water Supply (under the federal government) constructed the Iju Waterworks in 1910 with the production capacity of 9,161m^3/d. Iju waterworks undergone series of expansion stages between 1910 and 1985. It was upgraded to 41,640 m^3/d in 1954, 132,489 m^3/d in 1973, and 170,344 m^3/d in 1985 (Olaosebikan, 1999; LWC, 2016). In order to meet the water demand of increasing population of Lagos State which increased from 1.4 million to over 5.7 million between 1963 and 1991, the Ishashi and Adiyaan Waterworks were constructed in 1976 and 1992 with production capacities of 15,142 m^3/d and 264,979 m^3/d, respectively (Olaosebikan, 1999; LWC, 2016). In addition to these three major waterworks, 48 mini/micro waterworks with production capacities of 344,473 m^3/d had been installed across 20 Local Government Areas (LGAs) in order to boost safe water supply for the rapid growing population of the State (Ayeni, 2015; Fasona, Omojola, Odunuga, Tejuoso, & Amogu, 2005; Gideon, 2014; Olaosebikan, 1999; LWC, 2009, 2015, 2016). Nonetheless, there is still wide gap between water demand and water supply in Lagos State.

Various studies have been carried out to address the water supply issues in Lagos State at different times with different objectives (Ayeni, 2015; Fasona et al., 2005; Gideon, 2014; Olaosebikan, 1999; & LWC, 2009). For instance, the study by Ayeni (2015) focused on the challenges of water supply in urban Lagos under increasing climatic variability between 1963 and 2006. It was observed that the preference of climatic variabilities used in the study as the major controlling factors in the future water demand and supply is subjective and therefore could not be used to justify water supply situation in the near future as projected. This therefore, forms the gap that this study anticipates to address. Consequently, this study aims to examine rapid urbanization, increasing population, and climatic variabilities in Lagos State between 1960 and 2015. This is very germane in examining the challenges facing improved water supply in mega city such as Lagos State, Nigeria. This study also underscores the concerted and integrated efforts of Lagos State government over periods of 55 years in safe water provision and various hardships faced by Lagos State water corporation. The paper finally discusses the various future implications posed by rapid urbanization and increasing population to water supply in the face of changing climatic variables in Lagos State.

The Study Area

Lagos State is the smallest state and formal capital of Nigeria. It is located along the narrow coastal plain of the Bight of Benin on longitude 2^{0}42'E and 3^{0}22'E and Latitude 6^{0}22'N and 6^{0}42'N (Fig. 1). The state has a total area of about 3,577 square kilometers including water bodies and bounded to the north and east by Ogun State, and bounded to the south and west by the Coast of the Atlantic Ocean and the Republic of Benin, respectively. The dominant vegetation of Lagos State is the tropical swamp forest consisting of fresh water and mangrove swamp forests. These two sub vegetation types are influenced by the double rainfall pattern. The annual rainfall of the state generally ranges between 1400 millimeters and 1800 millimeters with a short August break. Two climatic seasons vis-à-vis the dry season (from November to March) and the wet season (from April to October) dominate the state. The air temperature is averagely high and ranges between 30° Celsius and 38^0 Celsius (Daejeon, 2004; Louche & Keep, 2002). The major water bodies are the Lagos and Lekki Lagoons, and the Yewa and Ogun Rivers. Others are Ologe Lagoon, Kuramo Waters, Badagry, Five Cowries, and Owu. Politically, Lagos State is divided into 20 local government areas (LGAs) with 16 LGAs in the metropolitan area while the remaining four are recognized as sub-urban LGAs (Table 1). The state had a population of about 9.01 million in 2006, which accounted for 6.44% of the Nigeria total population figure 140.003 million in the 2006 Census (NBS, 2007). However, the UN study and the State Regional Master Plan estimated the population of Lagos State to be about 12 million as at 2006 (Fulani, 2012).

Figure 1: The Study Area



Source: Compiled by author

Table 1: The Twenty Local Government Areas of Lagos State, 2006

LGAs		Area (km^2)	2006 Census Figure
Metropolitan Areas	Agege	11	459,939
	Alimosho	185	1,277,714
	Ifako-Ijaiye	27	427,878
	Ikeja	46	313,196
	Kosofe	81	665,393
	Mushin	17	633,009
	Oshodi/Isolo	45	621,509
	Shomolu	12	402,673
	Apapa	27	217,362
	Eti-Osa	192	287,785
	Lagos Island	9	209,437
	Lagos Mainland	19	317,720
	Surulere	23	503,975
	Ajeromi/Ifelodun	12	684,105
	Amuwo/Odofin	135	318,166
	Ojo	158	598,071
Sub-urban Areas	Badagry	441	241,093
	Ikorodu	394	535,619
	Ibeju-Lekki	455	117,481
	Epe	1,185	181,409
Total		**3,474**	**9,019,534**

Sources: National Bureau of Statistics, 2007.

Methodology

The population baseline data used for this research were based on provisional census data of 1963, 1973, 1991, and 2006. The data were collected from the National Bureau of Statistics, Abuja-Nigeria. Information on water production, demand, and supply for this study were gleaned from the Nigerian Bureau of statistics (NBS), Lagos State Water Corporation reports of different years (LBS, 2010; Olaosebikan, 1999; LWC, 2008; Olukoju, 2003; Oteri & Ayeni, 2014) and other literature related to Lagos state water supply and demand. Using population projection, the data for 1963, 1973, 1991, 2006 were projected appropriately for the subsequent years till 2015 based on each census annual growth rate. For 20 years

(2036) projection from 2016, the 2006 figure growth rate was used. The projection was based on the below formula:

$$PO = Pa\,(1 + r)^{n},$$

where:

PO is the projection
Pa is the actual population to be projected
r defined as $\frac{\text{Growth rate}}{100}$
n is the number of year

The land-use/land-cover (LULC) classification for urbanization assessment for this study were based on imageries from Landsat MSS, TM, NigeriaSat-1, and Landsat ETM+ for 1975, 1995, 2007, and 2015, respectively. The classified maps of 1976, 1995, and 2007 were sourced from the work carried out by SEDEC Associates (2008). Using ENVI version 5.3, the standard procedures for LULC classification (Ayeni, Cho, Mathieu, & Adegoke, 2016; Chander, Markham, & Helder, 2009; de Vries, Danaher, Denham, Scarth, & Phinn, 2007) was adopted for 2015 land use analysis.

Based on the scope of this study, monthly temperature and rainfall for 55 years (1960 to 2015) were collected and used for climatic finding. The data which were originally generated from the three synoptic stations in Lagos (Ikeja, Island, and Oshodi) on a daily basis were collected from the Nigerian Meteorological Agency (NIMET), Oshodi, Lagos, Nigeria. For trend analysis and a 20-year projection of climatic and water variables, linear regression analysis was adopted using the formula:

$$y = a + bx$$

where:

y is the dependent variable
x is the independent variable
a is the intercept (i.e. value of when x = 0)
b is the slope

The rainfall and temperature projection of Building Nigeria's Response to Climate Change Project (BNRCC) (2011) for Lagos State up to year 2046–2065 (Oteri & Ayeni, 2014) was used for this study. It should be noted that the projections baseline data were in line with the climatic data used for this study.

Findings and Discussions

Population

The population rose from about 1.44 million in 1963 to about 9.2 million in 2006 and to 12.3 million in 2015 (projected based on 3.4% growth rate) representing an increase of about 754% within 55 years, i.e., between 1960 and 2015 (Table 2).

Contrary to this projection, the United Nations noted that Lagos is one of the fastest growing mega cities in the world and as a result estimated 23.2 million people to be in Lagos State for 2015 (United Nations, 1999). As compared to other mega cities in the world, the growth rate of 3.7% between 2000 and 2015 was the highest and has continue to contribute to rapid population growth (Oteri & Ayeni, 2014). The rapid population growth is the major factor responsible for the urban expansion and the associated pressure on different land use as well as pressure on available water resources.

Table 2: Population trends in Lagos State for census years and 2015 projection

Year	Population (Census & Projected)	Remarks
1963	1,440,000	Census
1973	2,470,000	Census
1991	5,725,116	Census
2006	9,013,534	Census
2015	12,343,176	Projection

Sources: National Bureau of Statistics, 1963-2007.

As shown in Figures 6 and 7, there is an increase in both temperature and rainfall trends between 1960 and 2015. Observations from previous studies confirm the increase in temperature and evidence of urban thermal discomfort in Lagos in the last few decades due various urbanization characteristics including high traffic, housing congestions, and industrial activities as well as the level of heat stress (Abotutu & Ojeh, 2013; Ayeni, 2015; Oluwafemi, Akande, & Adebamowo, 2010; Sawka & Montain, 2001; Sangowawa, Adebamowo, & Godwin, 2008). The consistent increase in temperature since 1999, increased in population and rapid urbanization have been noted to be responsible for a wider gap between water demand and supply in recent years (Akinrotimi, Abu, & Aranyo, 2011; Economist Intelligence Unit and GlobeScan (2007); Mirkin, 2010).

Urbanization and Land Use Assessment.

Studies have revealed that water challenges in most world's urban centers are accompanied with population growth and rapid urbanization (Tackle, McGranahan, & Satterthwaite, 2015). Lagos State is not an exception, and it could not be over emphasized as most of land use types have experienced changes in terms of area expansion. Though the changes which is meant to improve the living standard of the population and strengthening urban Central Business Districts (CBDs) is not rather intensifying urban water supply problems. The data on land use show that the urban land use/built up area increased from 230.8km^2 in 1976 to 805.4km^2 in 2015 (Table 3, Figures 2 through 5). This represents an increase of about 249% in 39 years. This could be attributed to intensive residential built-up since Lagos State encourages individual building mostly developed for residential and commercial purposes. Most of these buildings are bungalows particularly in the suburban and rural areas. Patches of high rise building are only conspicuous in few places in the metropolitan Lagos. If this trend continues, urban slum is expected to increase while there will be serious congestion in the suburban areas of Lagos State vis-à-vis Badagry, Epe, Ibeju-Lekki, and Ikorodu areas. As a result, both metropolitan and suburban areas will be more vulnerable to environmental hazards, e.g., flooding if proper adherence to land use acts/regulations is not enforced.

Table 3: Urban Land-use Change in Lagos between 1976 and 2015

Land use	1976 (km^2)	%	1995 (km^2)	%	2007 (km^2)	%	2015 (km^2)	%
Agriculture	1138.4	31.5	903.9	24.9	86.4	2.4	164.8	4.6
Forest	232.0	6.4	6.0	0.2	501.2	14.2	271.0	7.6
Urban	***230.8***	***6.4***	***583.2***	***16.1***	***620.3***	**17.6**	***805.4***	***22.6***
Water	743.4	20.6	824.0	22.7	1033.8	29.3	980.9	27.6
Wetlands	1268.7	35.1	1290.6	35.5	1221.8	34.6	1168.1	32.86
Others	-	-	24.9	0.6	69.6	2.0	169.6	4.8
Total	**3613.3**	**100**	**3632.6**	**100**	**3533.06**	**100**	**3533.06**	**100**

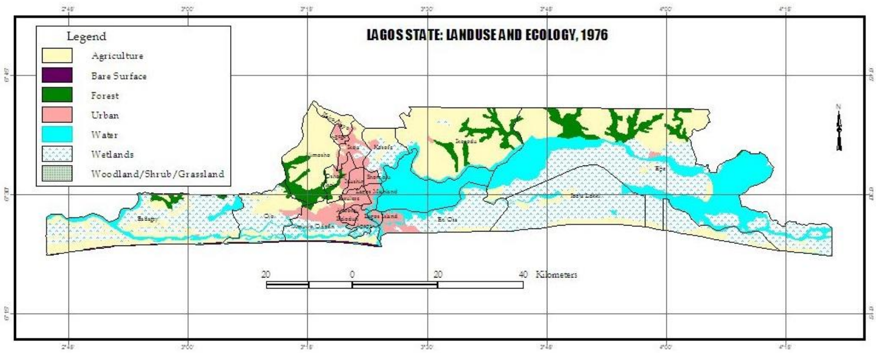
Source: SEDEC Associates, 2008; Other years by author.

Climatic Factors

The years 1986 and 2006 recorded the minimum and maximum temperature of 20.71^0 Celsius and 32.02^0 Celsius, respectively with the average annual temperature of 29.55^0 Celsius for the studied 55 years (Figure 6). The 55-year trend shows a slight increase of 0.0508^0 Celsius. The increase could be attributed to the variation in emissions particularly urban heat from urban congestion and industries as well as high volume of vehicular and generator emissions. On the other hand, the 55-year rainfall records revealed that years 1998 and 2014 recorded the minimum and maximum rainfall of 69.89 millimeter and 227.43 millimeter, respectively with the average annual rainfall of 141.36 for the studied 55 years (Figure 7). The 55-year rainfall trend indicates an insignificant increase of 0.0159 millimeter between 1960 and 2015.

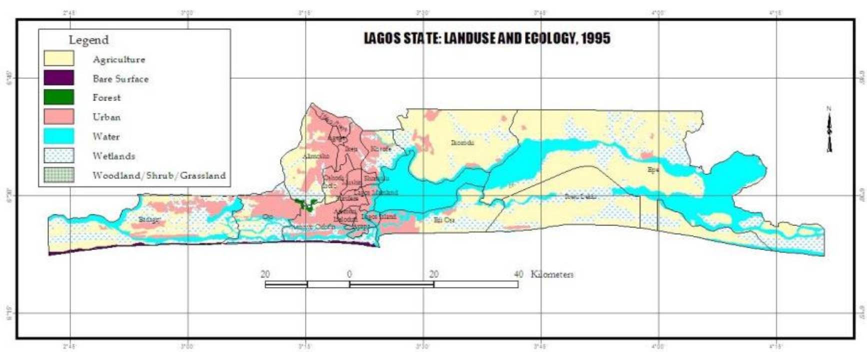
BNRCC (2011) projection adopted for this study revealed a 2^o Celsius rise in temperature in the 2046 to 2065 while increase in rainfall will about 2 millimeters in monthly rainfall in the 2046 to 2065. This means that significant population of Lagos State will be affected if the quantity and quality of water and/or its accessibility change as a result of climate change.

Figure 2: Lagos State Land Use, 1976



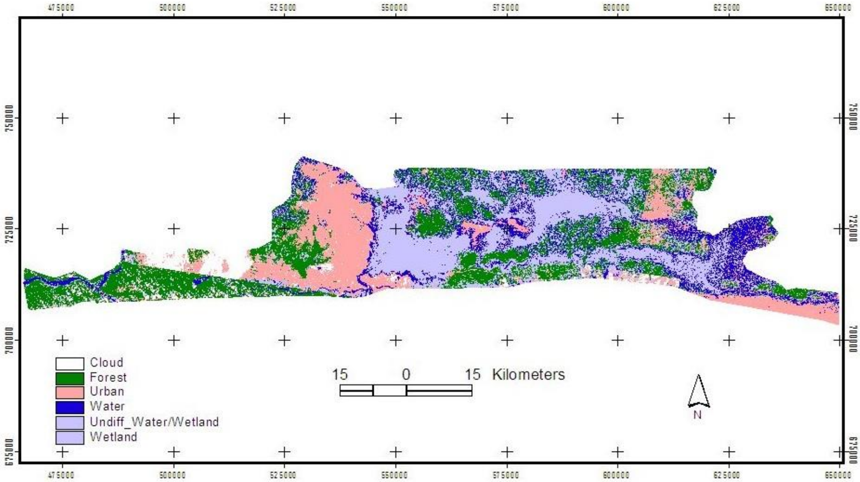
Source: SEDEC Associates, 2008

Figure 3: Lagos State Land Use, 1995



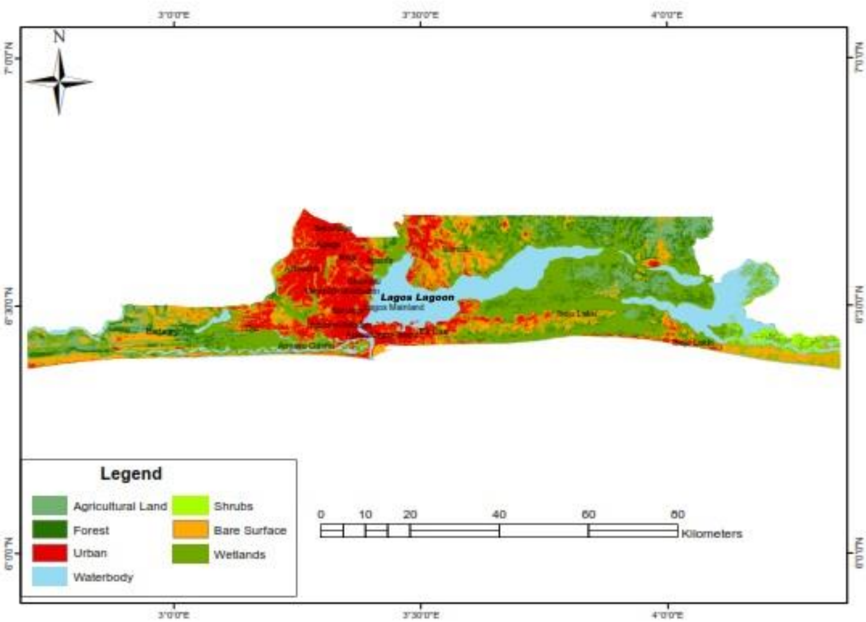
Source: SEDEC Associates, 2008

Figure 4: Lagos State Land Use, 2007



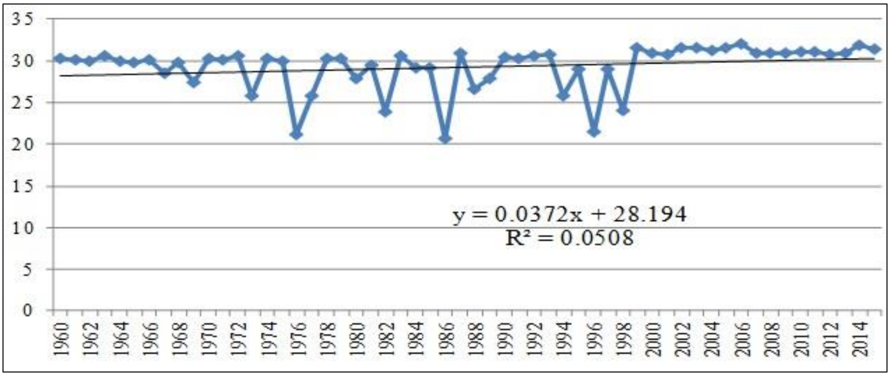
Source: SEDEC Associates, 2008

Figure 5: Lagos State Land Use, 2015



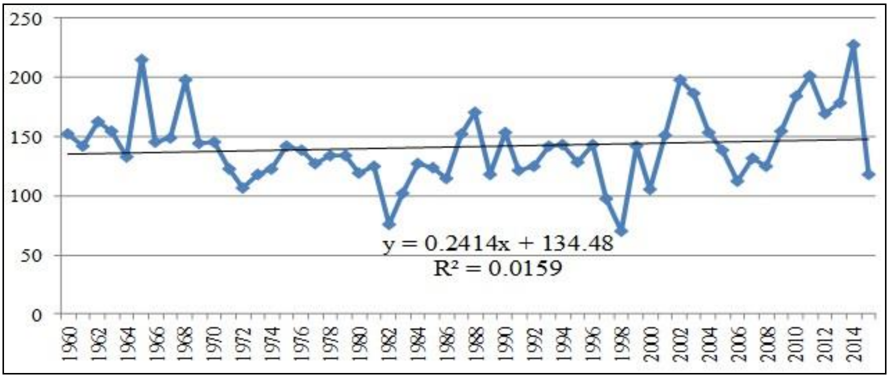
Source: by author, 2016

Figure 6: Average Annual Temperature (ºC)



Source: Figure developed by author.

Figure 7: Average Annual Rainfall (mm)



Source: Figure developed by author.

Water Supply and Demand

Using census data of 1963 and per capita water demand at different times as baseline information for water demand, the study reveals that the estimated water demand increased from about 172,088m^3/d to about 2,392,792m^3/d in 1963 and 2015, respectively indicating an increase of about 1290.5%. Based on the information from Lagos Water Corporation (2008) and Lagos Bureau of Statistics (2010), safe water supply rose from about 97,377m^3/d in 1963 to about 712,900m^3/d in 2006 (Table 4), which indicate an increase of 632.1%. As at 2015, the production from all water production sources (both surface and groundwater) was about 39% of the total water demand in the State. This translates to an estimate of about 930,531m^3/d representing percentages of increase of 855.6% and 30.5% from 1963 and 2006, respectively (Table 4).

Table 4: Population and Water Supply and Demand Trends in Lagos State

Year	Population (Census & Projected)	Water Supply (m^3/d)	Water Demand (m^3/d)
1960	364,000	-	43,500
1963	1,440,000 [C]	97,377	172,088
1973	2,470,000 [C]	159,000	-
1991	5,725,116 [C]	241,500	-
2006	9,013,534 [C]	712,900	1,747,324
2015	12,343,176	930,531	2,392,792

Sources: LBS, 2010; Olaosebikan, 1999; LWC, 2008; National Bureau of Statistics, 1960-2007; Olukoju, 2003. Note: [C] = Census figures.

On the whole, the three major water sources vis-à-vis the Adiyan, Iju, and Ishashi rivers account for about 47.6% of the total water production distributed across Lagos with production capacities of 264,979 m^3/d, 170,343 m^3/d, 15,142 m^3/d from Adiyan, Iju, and Ishashi water works, respectively (LWC, 2015, 2016). The rest of the water is being sourced from 48 mini/micro water works through boreholes distributed around 20 LGAs in the state and contribute about 344,473m^3/d (Fasona et al., 2005; Gideon, 2014; LWC, 2015, 2016). In addition, majority of residents also rely on other sources provided by an informal private water sector and vendors (Gideon, 2014). These other sources include the commercial water tankers, the *mairuwas* (the Migrant Hausa water vendors), commercial boreholes and wells (popularly known as *Konga dero*), and sachet water (popularly known as *pure water*).

It is important to note that the overstretched of the potential of Iju production and distribution plant as a result of continuous/rapid population growth and the growth of the industrial and commercial sectors influx in Lagos in the 1970s resulted into the continuous constructions of additional water works since 1977 (Olaosebikan, 1999). These water works/plants include Ishashi (1977) and Adiyan (1992), and several mini/micro water works between 1991 and till date (Lagos State Government, 1987; LWC, 2015).

The Nexus and Expected Future Implications

Studies have revealed that population, urbanization, and climatic variables have direct and indirect links with water demand and supply. Increase in population and urbanisation require increasing volumes of water to be extracted from source and transported to point of use (Hunt and Watkiss, 2011; Buytaert and De Bièvre (2012). Population growth is a major contributor to water scarcity and limits the amount of water available per person, drives people into regions (e.g. cities) which are already water stressed (Mogelgaard, 2011). As the population of people living on earth continue to increase and grow, the demand for water mounts and exacerbates pressure on finite water resources, and consequently mounting demand and competition on water for domestic, industrial, agricultural etc (United Nations, 2007; Mogelgaard, 2011). Continuous urban growth increases water pollution as rain water picks up heavy metals, toxic anthropogenic substances, chemicals and other waste materials and discharge them in large, concentrated amounts into nearby water sources, such as a river, stream, lake, pond etc. (Bhatta, 2010; McDonald, 2011) and consequently, subjected the available water sources to pollution and/or contamination. On the other hand, it is obvious that increases in temperature will lead to increased evapotranspiration and therefore less runoff and recharge of groundwater resources while increase and/or prolonged rainfall produces very large volumes of surface water which can easily overwhelm drainage system, and could therefore result to flooding risks in urban centres (Pimentel et al., 2004; Hunt and Watkiss, 2011). Water supply abstraction and treatment plants located beside rivers may be the first objects of infrastructure to be affected by floods and may therefore intensify water shortages in the affected area (IPCC 2007; Satterthwaite, 2008).

Estimates suggest that as a result of increase in population, more people will be living in the urban city centers particularly the megacities and fewer people will be in rural areas by 2025 (UNESA, 2014; UNFPA, UNISDR, & ONU-Habitat, 2014). As stated in UNFPA, UNISDR, and ONU-Habitat (2014) report, it is therefore very germane to plan adequately for this growing population over the next 15 years as changes in the spatial distribution of population will pose a great challenge on policy and sustainable development in cities' infrastructures particularly water supply infrastructure due to a narrow error margin of a population projection over a 5- to 10-years scenario. This will maximize impacts on available water production and demand in the near future as its lies in the relative inertia of what is available today.

In spite the effort of Lagos State to efficiently and effectively improved water demand of ever-increasing population, various factors still significantly responsible for the wide gap between water supply and demand in the State. Since the supply capacity of Lagos State from all sources can only meet about 39% of the total water demand, the potential water supply is put at 930,531 m^3/d in 2015 as against actual water demand of 2,392,792m^3/d accounting for a demand gap of 1,462,261 m^3/d. In other to improve the water supply system and provide pipe borne water for every citizen in the state, the Lagos State Water Corporation inaugurates three master plan phases via-a-vis short term, medium term, and long term (LWC, 2016). The short term phase was a plan designed to be achieved between 2010 and 2013 while the medium term and long term was set to achieve effective water production that will address the demand gap of 2014-2017 and 2018-2020, respectively (LWC, 2016). To meet the projected water demand of 2,774,707m^3/d for the Lagos megacity in

2020 the state will strive to achieve the projected production capacity of 2,820,132m^3/d based on LWC, 2010 estimated 136.2lcpd (Gideon, 2014; LWC, 2016).

Aside from the continuous increase in population, more concerns are that industrialization and urban agriculture activities are also growing rapidly with existing poor water infrastructures in the state. Though some old water pipes are recently replaced in some areas of metropolitan Lagos, but the major problem lies in the suburban areas where water infrastructure layout is virtually absent or inadequate. Improved water supply target may not likely be met in the future if this is not well addressed soon. Presently, about 55% population of the Lagos rural and suburban areas mainly depend on shallow wells for their domestic water. In addition, unsafe surface waters like ponds, springs, and lagoons are the major sources of domestic water of some rural areas of Badagry, Epe, Ibeju-Lekki, and Ikorodu LGAs. The location of the state is another factor that cannot be overemphasized. The state is located on a complex interlock of lagoons and creeks that cause albedo to increase as one moves towards city island (Haider, 1997). This may also result to high evaporation and evapotranspiration rate in the city (Appah-Dankyi & Koranteng, 2012). Excessive heat may therefore cause the daily body fluid requirements to be varied from two liters per day to 16 liters per day depending on the locations and the nature of urban characteristics (Gisolfi, 1993). The implication of this is that people may likely subjected to profuse sweating that can cause high rate of water consumption to avoid dehydration. Without a doubt and if this situation continues, water shortage will become more severe in the future as increase in population will result to more water consumption; there will more pressure on available water sources, deterioration of public water infrastructure, and poor management in the water supply sector as well as an increase in vandalization and illegal connection. More so, more people will be “water poor” (i.e., the water poverty index will likely decrease below 25 in 2026). Furthermore, the percentage of residents that were not connected to public pipe borne water in Lagos State was about 55% in 2008 (Ohwo and Abotutu, 2014) and this is likely to go beyond 65% in the near future if water borne pipe lines are not extended to most part of rural and suburban areas. In order to address this sustainably, the wide gap between water supply and demand in Lagos State needs to be bridged. For instance, the population of Lagos State is estimated to reach 19.8 million in 2026 and correspondingly, improved water demand is expected to increase to about 3,213,058m^3/d. In order to meet this expected demand, Lagos State will need between US $1.8 billion and $5.2 billion (Vanguard, 2004; Environmental Rights Action, 2016). For Lagos State to achieve this, private sector involvement will be required through injection of more capital to improve the efficiency of existing state-owned water asset (Premium Times, 2016).

Conclusion and Suggestions

There is no doubt that the rapid urbanization and population growth in Lagos State has had a great impact on water supply patterns. This portends the dangerous trend that pressure on water will pose on population growth and the changing functionality of Lagos State in the near future. In addition, climate change is becoming more threatening to the natural environment and socioeconomic activities of Lagos State. It should be noted that such changes can intensify the problem facing improved water provision and supply in regions with rapid urbanization and increasing population.

There is an urgent need for effective policy formulation in the State to strengthen and train planners and related professionals in the modern techniques of improving water resources such as efficient waste water management and water harvesting as well as effective management and control of the available water resources infrastructure. Various options for increasing water supply and capacity as well as reducing greenhouse gas emissions will have to be adopted. More water supply infrastructure should be planned and developed for future generations. This can be achieved by developing a highly efficient water supply scheme, encouragement of community water development, and management strategies that will take cognizance of the increasing variability in the climatic conditions of the state. Also, strategies to protect and restore threatened natural resources should be established and global laws that protect them should also be enforced in Lagos State.

Furthermore, in as much the driving forces of future urbanization is still the demographic changes, economic growth, and technological development, and therefore, land use change, urban sprawl and land conversion will be inevitable in Lagos State. As a result, gradual land use change should be enforced and well guided in various developmental activities and properly monitored by the monitoring agencies involved.

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