ACCESS TO IMPROVED WATER AND SANITATION IN SELECTED AFRICAN COUNTRIES

Ambrose Nnaemeka Omeje, Ogochukwu Christiana Anyanwu, Augustine Jideofor Mba and Michael Okike Ugwu

Department of Economics, University of Nigeria, Nsukka

ABSTRACT

The problem of water and sanitation globally, has made the governments of different countries, international organizations, non-governmental organizations, and private individuals to raise their consciousness towards surmounting this challenge. Enormous evidence exists on rural-urban and wealth status impacts of access to water and sanitation on the African continent. Therefore, this study utilized a panel of standard Demographic and Health Surveys (DHS) data selected from five (5) African countries and fixed effect model to examine the factors that significantly determine access to improved water and sanitation variations in Africa. It was found, among others, that over the study period, people had more access to improved water sources in Africa was than access to sanitation facilities. While some factors such as household access to electricity, time to get to water source, and location of presence of water negatively and significantly determined access to improved water, other variables of the model positively and significantly determined it. Further, while sharing of toilet with other households, source of drinking water, time to get to water source, sex, age and region negatively determined access to improved sanitation, other variables of the model positively determined access. The study therefore recommended, among others, that African governments and their various agencies on environment should strive more to provide improved water and sanitation to the people. Governments can revive water boards to help provide *reticulated water to all towns and villages to enable them have access to improved water.*

JEL classification: D3, D6, D9, I1, I3, O1, O2, O4, O5, Q2, Q5, R2

1. Introduction

Water is the most precious and valuable natural resource in the world, vital for the growth of any society, economy, agriculture and industry. Access to improved water and sanitation plays an important role in poverty reduction, improved food security, a fall in pervasive underdevelopment, and hence, aids in the realization of the development goals (Bassil, 2012; Abubakar, 2017).

The importance of improved access to water and sanitation cannot be overestimated as access to improved water and sanitation are fundamental to human rights and healthy living of the citizenry (Armah Ekumah, Yawson, Odoi, Afitiri, & Nyieku, 2018). However, in many countries of the world, access to improved water and sanitation are limited, inadequate or lacking. Based on this premise, the Millennium Development Goals (MDGs) and the subsequent Sustainable Development Goals (SDGs, No.6) have been re-echoed to “ensure availability and sustainable management of water and sanitation for all” (United Nations Children Emergency Fund, 2001; Hutton, Haller, & Bartram, 2007; United Nations, 2018). Hence, for a full realization of the SDGs in Africa, access to improved water and sanitation is critical.

In Africa, basic better health determinants like access to safe water and sanitation, still constitute basic problems. Lack or limited access to improved water and sanitation and poor hygiene among households are linked to skin diseases, acute respiratory infections, diarrhoea, malaria, guinea worm, typhoid, cholera, schistosomiasis, trachoma, and dysentery among others. These have implications for improved health and poverty reduction (Ndedzu, Muhoyi, Kunguma & Mavesere, 2012; Twerefou, Tutu, Botchway & Darkwah, 2015; Acey et al., 2019).

Further, African women and children especially, in rural areas, spend considerable amounts of time looking for and fetching the household’s water from different kinds of sources. Most of these households depend on streams, rivers, ponds, among others, for their water needs, while only a few people have access to improved sources like pipe-borne water; public tap, standpipe, tube well, or borehole; hand pump, protected well, or protected spring; and rainwater. Some of these sources dry up during the dry season and the only available sources record great numbers of people trying to fetch water, such as pipe-borne water from a public tap, standpipe, tube well, or borehole. This has implications for productivity as the hours spent could have been employed in income-generating ventures that would fast track economic growth and development (Ishaku, Majid, Ajayi & Haruna, 2011; Hundie & Abdisa, 2016).

However, governments in African countries have initiated several policies, such as the Millennium Development Goals (MDGs) and the more recent one known as the Sustainable Development Goals (SDGs), aimed at increasing access to improved water . Figure 1 shows access to water coverage by wealth quintiles, in urban and rural areas in Africa, based on population-weight averages from 35 countries (percentage).

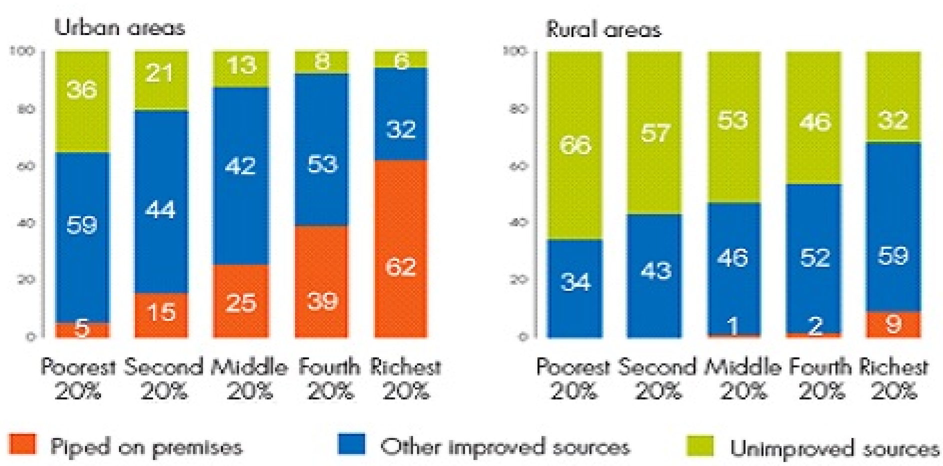

Figure 1. Access to water coverage in Africa by wealth quintiles.
Source: UNDESA, 2015.

Figure 1 indicates that in Africa, 40% of the 1.216 billion people are without access to an improved source of drinking water(United Nations Department for Economic and Social Affairs –UNDESA, 2015). Africa could not meet the

MDG on water access as it recorded just 61% water coverage against the 75% target set for the continent.

Data examined from 35 countries in Africa (representing 84% of the continent's population) indicated the existence of significant difference between the poorest and richest fifths of the population in both rural and urban areas (UNDESA, 2015). Figure 1 shows that in Africa, over 90% of the richest quintile in urban areas use improved water sources, and over 60% have piped water on premises. In rural areas, piped-in water is non-existent in the poorest 40% of households, and less than half of the population use any form of improved source of water.

Africa is also seen to exhibit the least improvement in terms of sanitation (UNDESA, 2015). Irrespective of the fact that the Northern African region had 90% coverage on improved sanitation, sub-Saharan Africa exhibited a surprising 30% coverage on improved sanitation access. This situation raises serious health concern since it comes with the attendant health problems of lack or limited access to basic sanitation such as: wastewater disposal, open defaecation, and solid waste disposal. Open defaecation is the major cause of faecal oral transmission of diseases which makes African children the most vulnerable victims (UNDESA, 2015). Figure 2 is a map of Africa showing countries with improved sanitation.

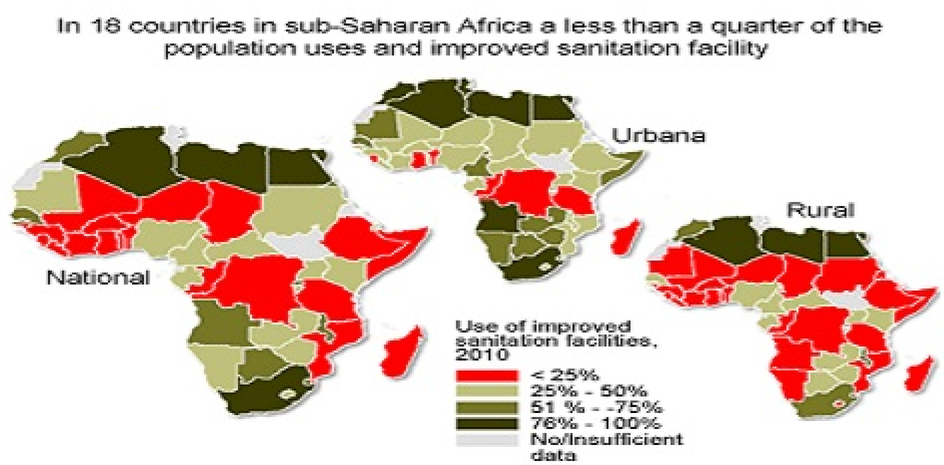

Figure 2. Map of Africa showing use of improved sanitation facilities.

Source: UNDESA, 2015.

In the regions of Africa, especially sub-Saharan Africa, lack of access to improved water and sanitation has triggered various health issues which have led to deaths, both of adults and children in the region. The West/Central African regions witnessed the highest under-five mortality rates (attributed to issues of water and sanitation) out of all developing regions. They recorded 191 child deaths per 1,000 live births in 2015. In addition, frequent outbreaks of cholera in some of Africa's urban and rural communities confirm the poor state of the African region, given the basic living conditions and improved water and sanitation access (UNDESA, 2015).

Limited access to improved water and sanitation in Africa has been a major challenge facing the continent as rising urbanization and population growth has further compounded the problem (Coster & Otufale, 2014). Based on rising urbanization, migration and population growth, there is increased pressure on the available water and sanitation facilities, which also leads to breakdown of some of the available facilities (Oumar & Tewari, 2013; Akeju, Oladehinde, & Abubakar, 2018). In view of the foregoing, this study examines the factors that significantly affect access to improved water and sanitation in five selected African countries (Congo R, Kenya, Egypt, Nigeria, and South Africa) from the five regions of the continent (East Africa, Middle/Central Africa, North Africa, Southern Africa and West Africa). Unlike previous studies such as Armah et al., (2018), this study utilizes the Demographic and Health Survey (2014) data of all the selected countries and applied the fixed effect model in a bid to examine the factors that significantly affect access to improved water and sanitation in Africa.

1.2 Overview of Water and Sanitation in the Selected African Countries

The African continent has five sub-regions namely: East Africa, Middle/Central Africa, North Africa, Southern Africa and West Africa. This study considered five countries, one for each sub-region, to make sure that each of the sub-regions is represented in the study. The countries selected are: Congo Republic in Middle/Central Africa, Kenya in East Africa, Egypt in the North Africa, Nigeria in the West Africa, and South Africa in the Southern Africa sub-region. These countries were considered based on the fact that they are all developing countries that have recorded fast growth in the last ten (10) years within the sub-region, the size of their economy (population), and above all, data availability. Figure 3 shows the percentage of the population with access to improved water in the selected African countries from 2000 to 2015.

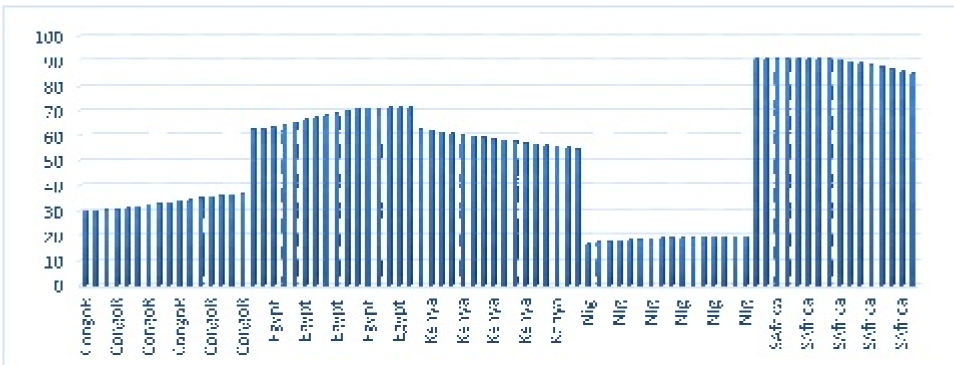

Figure 3. Percentage of Population with Access to Improved Water in Selected African Countries (2000 – 2015).

Source: WDI, 2017.

Figure 3 indicates that the percentage of the population using safely managed drinking water services and/or improved water in South Africa outnumbered the other countries. This was followed by Egypt, Kenya, Congo Republic and lastly, Nigeria. The percentage of the population using at least basic drinking water and sanitation services was also looked at (see figure 4).

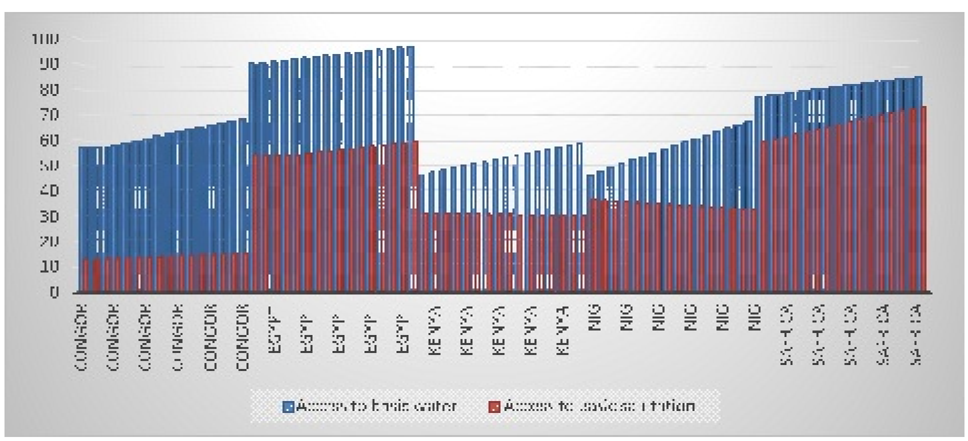

Figure 4. Access to Basic Water and Sanitation in Selected African Countries (2000–2015).

Source: WDI, 2017.

Figure 4 shows that Egypt recorded the highest percentage for population using at least basic drinking water. This was followed by South Africa, Congo Republic, Nigeria and lastly, Kenya. However, for access to basic sanitation services, South Africa recorded the highest percentage of the population using at least basic sanitation services followed by Egypt, Nigeria, Kenya and lastly, Congo Republic.

1.3 Conceptual literature

This sub-section gives a brief description of some terms used in the study to aid understanding of the subject matter. The major concepts looked at are improved and unimproved water and sanitation. These definitions, taken from the WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (2019) report, are given in table 1.

Table 1. Definitions of improved and unimproved water and sanitation

S/N	Services	Improved	Unimproved
1.	Water sources	This incorporates: tube-wells or boreholes, piped water, dug wells that are protected, springs that are protected, packaged or delivered water, and rainwater (Armah et al., 2018).	Found in this area are: dug well and springs that are unprotected, stream, lake, dam, pond, river, irrigation canal and canal.
2.	Sanitation facilities	This among others include: pit latrines or septic tanks; ventilated improved pit toilets/latrines, composting toilets or pit latrines with slabs, and flush/pour flush to piped sewer systems (Armah et al., 2018).	This among others, include: hanging toilets/latrines or bucket latrines/toilets, open defecation, and pit latrines/toilets without a platform or slab.

Source: WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (2019)

2. Literature Review

The literature review of this study is divided into two, viz; theoretical and empirical literature.

2.1 Theoretical literature

The theoretical literature captured in this study are the water supply and access theory and the WASH – water, sanitation and hygiene – theory of change.

2.1.1 *Water Supply and Access Theory*

This theory, otherwise called the water use plateau theory, was first used in the 1970s. However, Cairncross (1987) formalized the theory. The theory was further developed by Cairncross (1988), Cairncross & Kinnear (1992), and Cairncross & Feacham (1993). This theory was later modified by Environmental Health Group – EHG (2019). The theory looked at the link that exists between the distance travelled by individuals in order to access a water source and the amount of water they consume. This theory states that when sources of water are located more than half an hour's return journey away from home, then bringing water closer to the home would automatically bring about a rise in water consumption, but water sources that are less than a 30-minute round-trip away, will be used for almost the same amount of water, not minding whether the source location is at a distance of 1000 metres or 100 metres. This theory can be presented in the graph given in figure 5.

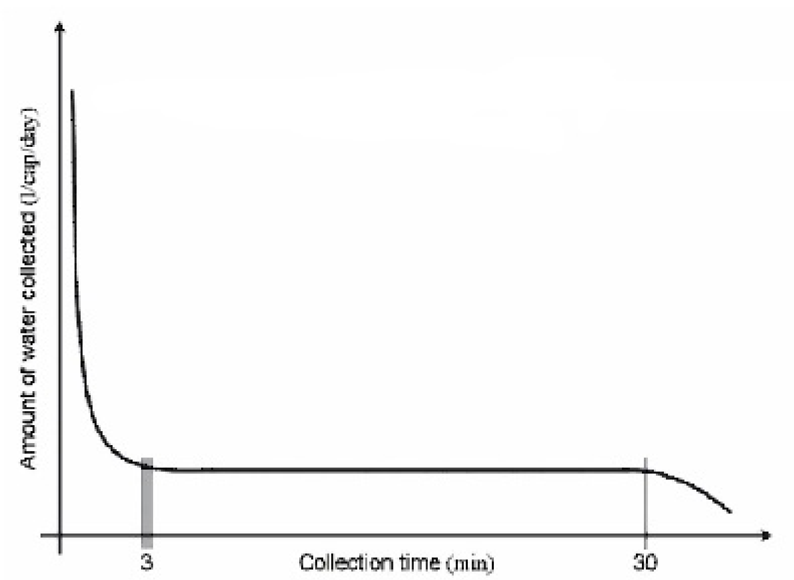

Figure 5. Link between Water Collection Time and Water Consumption.
Source: Environmental Health Group (EHG), 2019.

The water supply and access theory states that irrespective of the demand inelasticity of water, piping water to the house or yard would bring about water access convenience, which would on the average lead to a rise in water consumption by households. Figure 5 shows that any interventions geared towards improving the supply of water in the economy should be targeted at people who lay "off the end of the plateau" (EHG, 2019). This is because, the closer the supply of water and/or access, the more water would be consumed thereby, improving hygiene and sanitation, which in turn brings about health benefits to the people. Hence, with access to improved water, improved sanitation and hygiene would be assured. Further, households lying on the "plateau" require only reticulation and house installation connections which will definitely bring about a rise in water consumption and its attendant health benefits to the people.

2.1.2 *The Water, Sanitation and Hygiene (WASH) – Theory of Change*

The Water, Sanitation and Hygiene (WASH) Theory of Change was developed and applied by international development agencies like the United Nations Children's Fund (UNICEF) (2014), Max Foundation (2015), World Health Organization (WHO) (2018), among others, in the development, updating and dissemination of drinking-water quality and safety, and sanitation and waste water. The WASH model has three main approaches, namely clean and safe drinking water supply, adequate sanitation facilities, and hygiene education (WHO, 2018).

On water, the theory states that inadequate and unimproved water supply, limited sanitation facilities access and poor hygiene are the factors that mainly lead to the spread of diseases (Max Foundation, 2015; WHO, 2018). Tube-well deep water makes water not to be infected. The WASH theory provides that to help tackle the challenges of unimproved water, pipe-borne water supply systems should be installed in rural, hard-to-reach and economically-poor areas where people travel far away from their households to access water (UNICEF, 2014; Max Foundation, 2015; WHO, 2018). For Max Foundation (2015) and WHO (2018), water should be made accessible at individual household level to enable the people utilize it for agricultural and other private purposes. In this way, transportation and storage of water would be safe.

On latrines, the theory posits that instead of defaecating in the open, latrines are the best option for improvement, since open defaecation brings about serious health issues and the spread of dangerous diseases. The theory encourages gender access to (i.e. boys and girls to have separate) latrines both at home and at school.

The view of the theory on hygiene education is that without adequate hygiene information, water access and access to latrines would have no or limited impact in the society. Information on hygiene should therefore be provided to help people prevent water and hygiene-related diseases. For instance, information such as washing of hands after using the toilet and before and after preparing food is very crucial. Therefore, applying all the above combined strategies and approaches would bring about long-term behavioural change among the citizenry.

2.1.3 *Value Chain of Water Supplier Theory and Sanitation*

This theory was first used by Damelin, Shamir and Arad (1972). It was later popularized by Shamir (1981; 2015). The value chain of water supplier theory and sanitation states that many water suppliers are not only responsible for the supply but also for the sanitation sector of the service area. It depicts whole supply chain access to safe drinking water from the water source to the sewage treatment and disposal. The value chain of the water supplier theory is presented in figure 6.

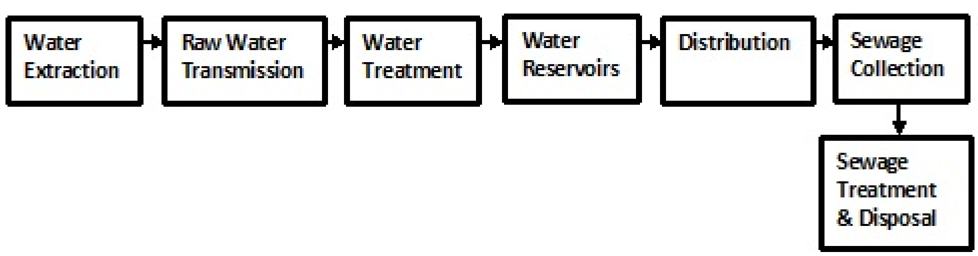

Figure 6. Value Chain of Water Supplier Theory and Sanitation.

It is a known fact that the water source always depends on the geographical and geological environment of the service area of the water utility and therefore is a partly exogenous component. If several sources are available, it is most likely that those sources with the lowest total cost for water withdrawal, transmission, treatment and distribution would be developed and commissioned for use. Apart from the total cost for providing access to improved water, another serious issue of concern with regard to water utility is its operation and maintenance (O & M) which is aimed at preventing water pollution in the supply process (Shamir, 1981; 2015; Kayaga, Calvert, & Sansom, 2003; Echternacht, 2014).

After the people must have used the water, the water is recollected and transmitted to sewage treatment plants (STP). Household reticulate simultaneously the water and sewage connections to help prevent the discharge of wastewater into water drainages, trenches or open places in the environment. The provision of adequate sewerage systems helps to protect the environment and bring about healthy living given that wastewater treatment firms with sufficient capacities exist in the service area and that, appropriate disposal of waste material also exists (Echternacht, 2014; Wang, Pan, Yaya, Yadav, & Yao, 2019).

2.2 Empirical literature

A myriad of literature exists on access to improved water and sanitation in Africa. Some of the literature reviewed in this study can be in the works of Tapela (2012), WHO/UNICEF (2016), Jones (2013), Govender (2014), Wilcock & Townsend (2009), United Nations (2011), Dannenbery, Frumkin & Jackson (2011), Wright, Gundry, & Conroy (2004), Ezeh et al. (2014), Bartram et al. (2014), Hutton & Chase (2016), Kuberan et al. (2015), Sasaki et al. (2008), Kema et al. (2012), and Stephen & Graham (2014).

Tapela (2012) looked at lack of access to water and inadequate sanitation using time series data and descriptive statistics. The study found that limited access to water and inadequate sanitation were major problems people faced in Africa and this has brought about violence and turbulence among different communities. The study therefore recommended, among others, more government intervention in the area. WHO/UNICEF (2016) also assessed how to improve water and sanitation in urban and rural areas since these are seen as fundamental human rights and many people do not have access to them because of the difference in the topography of different countries in Africa. The study recommended improved water sources and improved sanitation to help reduce water-borne diseases in Africa. In a related study, Jones (2013) also found, using descriptive statistics and time series data, that the disabled in Africa have low access to water supply, low income, and also low access to water and sanitation. As a result of this inadequate access, they used less water and were at high risk of disease infection from unimproved sources.

Govender (2014), in a similar study, stated that people in the rural areas in South Africa, particularly those that were bedevilled by poverty, were vulnerable to disease as a result of poor water supply services. Wilcock and Townsend (2009) also supported this view. In their study, they found that limited water access can be a barrier to meaningful occupation for a lot of reasons. The United Nations (2011), in a similar study reported that there has been progress made in increasing and improving access to drinking good water, however, efforts in rural areas in Africa need to be intensified. Dannenbery, Frumkin and Jackson (2011) looked at sanitation and found that it is one of the factors that militate against improved access to water. The water sanitation problem tends to reduce access to water and it is as a result of poor sewage and water pollution among others.

Wright, Gundry and Conroy (2004), in their research found that investment in research cannot actually reduce the level of diseases caused by drinking bad water and poor sanitation. In a related but different study, Ezeh et al. (2014) looked at the risk of lack of good water supply to children. They found that inability to access water leads to neonatal, post-natal and child mortality and this risk of mortality, given unsafe water and poor sanitation, is very high. Bartram et al. (2014) also found that high death rate among children under five years is as a result of poor water and poor sanitation. Limited access to improved water which causes disease and thus absenteeism from work affects both individual and community productivity. According to Hutton and Chase (2016), improved access to water is limited in some countries more than in others. Kuberan et al. (2015) on their part found that limited access to water leads to poor disposal of solid waste, which also contaminates surface and ground water. They therefore recommended that access to water and solid waste disposal must be guided.

Sasaki et al. (2008) looked at high death rate and high cholera rate in Ghana, Senegal and Zambia, in relation to poor access to water and sanitation. It was observed that limited access to improved water was common in urban centres where waste disposal was not controlled and this resulted in high cholera outbreak in some Africa countries such as Ghana and Zambia. Kema et al. (2012), in a similar study, examined the motivation to improve sanitation and access to facility. It was found that access to facility significantly encouraged improved sanitation. Stephen and Graham (2014), in their study enquired into how livestock activities such as poultry, piggery and fishery can have improved sanitation. It was found that siting of livestock houses, both in urban and rural areas, derails improved sanitation. The study therefore recommended among others, improved access to water and more sanitation facilities in rural areas.

3. Methodology

This study adopted the water supply and access theory and applied the fixed effect model given a panel of five (5) selected African countries standard DHS data (2014). In other words, the empirical fixed effect model is anchored on the water supply and access theory.

The fixed effect model is therefore specified as follows:

$$aipw_{it} = \alpha_{it}X'_{it} + \Upsilon_i + \varepsilon_{it} \quad (1)$$

where:

$aipw_{it}$ is the dependent variable (access to improved water and sanitation (aips))

X'_{it} is a k-vector of regressors (windex, sex, edu, region, sector, haelectr, swater, tgwater, lpwater, watertbb, watertbblc, watertbstc and watertbwf)

ε_{it} are the error terms for $i = 1, 2, \ldots, M$ countries observed for dated periods

$t = 1, 2, \ldots, T$. ??$_i$ ($i = 1 \ldots. n$) represents the unknown intercept for each country (n country-specific intercepts) otherwise known as the country-specific fixed effects.

The individual coefficients are estimated together with the vector of coefficients, α_{it}.

However, the Hausman model selection test was adopted by the study in order determine which model, fixed or random effect model would best ascertain the significant factors that determine improved access to water and sanitation in the selected African countries.

Hence, the fixed effect given in equation (1) above is asymptotically consistent with the normal estimator of the vector of coefficients (Wooldridge, 2010; Pforr, 2014) for explaining the factors that would determine access to improved water and sanitation in selected African countries. Therefore, itemizing the variables of the model and re-specifying them in estimable functional form to capture access to improved water and sanitation in the selected African countries yields equations (2) and (3):

$$aipw = f(windex, sex, edu, region, sector, haelectr, swater, tgwater, lpwater, watertbb, watertbblc, watertbstc, watertbwf) \qquad (2)$$

$$aips = f(stwoh, phwhand, pwwp, itpsd, lpwater, swater, tgwater, windex, sex, age, edu, mstatus, region, sector) \qquad (3)$$

where the variables are as defined in table 2.

Table 2. Definition of Variable Names in the Model

Variable Names	Definitions	
aipw	**Access to improved water**	**Equation (6) Variables**
windex	Wealth index	
sex	Sex of household members	
edu	Highest educational level attained	
region	Geopolitical region of residence	
sector	Sector of residence (that is, whether urban or rural)	
haelectr	Household access to electricity	
swater	Source of drinking water	
tgwater	Time to get to water source	
lpwater	Location of presence of water	
watertbb	Water usually treated by boiling	
watertbblc	Water usually treated by adding bleach/chlorine	
watertbstc	Water usually treated by straining through a cloth	
watertbwf	Water usually treated by use of water filter	
aips	**Access to improved sanitation**	**Equation (7) Variables**
stwoh	Share of toilet with other households	

Variable Names	Definitions
phwhand	Place where households wash their hands
pwwp	Presence of water at washing place
itpsd	Items present such as soap and detergent
lpwater	Location of presence of water
swater	Source of drinking water
tgwater	Time to get to water source
windex	Wealth index
sex	Sex of household members
age	Age of household members
edu	Highest educational level attained
mstatus	Marital status
region	Geopolitical region of residence
sector	Sector of residence (that is, whether urban or rural)

3.1 Data sources

The data used in this study came from selected African countries' Standard Demographic and Health Surveys (SDHS) (2014). The SDHS surveys are nationally representative household survey data and as such come from secondary sources that are made available through many indicators for monitoring and impact assessment in the areas of population, health, and nutrition. The SDHS data are an open source and can be accessed on the DHS website (www.dhsprogram.com). The SDHS are done in a manner that ensures comparability across countries' populations over time. The data incorporate demographic, social, wealth and health characteristics. Household level water and sanitation data are also incorporated in the SDHS data. All the variables used in the study are adequately captured by the SDHS data.

The selection criteria for the countries in the study were that: the selected countries, that is, Congo DR, Kenya, Egypt, Nigeria, and South Africa, must represent the five regions of the continent (that is, East Africa, Middle/Central Africa, North Africa, Southern Africa and West Africa); and must have recent standard DHS data phase six (6) or seven (7). Unlike previous studies such as Armah et al. (2018), this study utilized the standard Demographic and Health Survey (2014) data of all the selected African countries and applied the fixed effect model in a bid to examine the factors that significantly affect access to improved water and sanitation in Africa. The motivation for the choice of variables used in the study is that all the variables were adequately captured and the SDHS data for each country also incorporated at the household level, the sources of drinking water and type of toilet facilities in the selected countries. Further, the rationale for the choice of sampled countries in this study was based on population; the country with the highest population in each of the five regions of the continent was selected. This population consideration stems from the fact that population matters for access to water and sanitation. Increased population can put more pressure on the available water thereby limiting access. A rise in population can also deteriorate improved sanitation.

4. Results and Interpretations

The results of the study first of all analysed the descriptive statistics of the data before examining the factors that significantly determine access to improved water and sanitation.

4.1 Descriptive statistics

The frequency, percentage and cumulative frequency of respondents by country are presented in table 3. Nigeria had the highest frequency and percentage of respondents, followed by Kenya, Egypt, Congo DR, and lastly, South Africa. The data also shows that the standard DHS data (2014) of all the countries have the same phase six (6), except for South Africa which was started in phase six (6) but was completed in phase seven (7).

Table 3. Distribution of the Frequency, Percentage and Cumulative Frequency of Respondents by Country

Country Code and Phase	Respondents Frequency	Percent	Cum. Freq.
Congo – DR CD6	95,949	16.32	16.32
Egypt – EG6	120,276	20.46	36.78
Kenya – KE6	153,840	26.17	62.96
Nigeria – NG6	178,894	30.43	93.39
South Africa – ZA7	38,850	6.61	100
Total	**587,809**	**100**	

Source: Selected African Countries Standard DHS Data, 2014.

Further, the distribution of the sources of improved and unimproved water access by country is provided in figure 7. Egypt had the highest distribution of piped water into dwelling places followed by South Africa, Kenya, Nigeria and lastly, Congo DR. However, Kenya had the highest distribution of piped water to yard/plot followed by South Africa, Congo DR and lastly Nigeria. On public tap/standpipe, Kenya again had the highest distribution, followed by Nigeria, Congo DR, South Africa and Egypt at last. On distribution of tube wells or boreholes, Nigeria came first, followed by Kenya, Congo DR, South Africa and lastly Egypt. With regard to protected wells, Nigeria again had the highest distribution, followed by Kenya, Congo DR, Egypt and lastly South Africa. For protected springs, Kenya has the highest distribution, followed by Congo DR, Nigeria, South Africa and lastly Egypt.

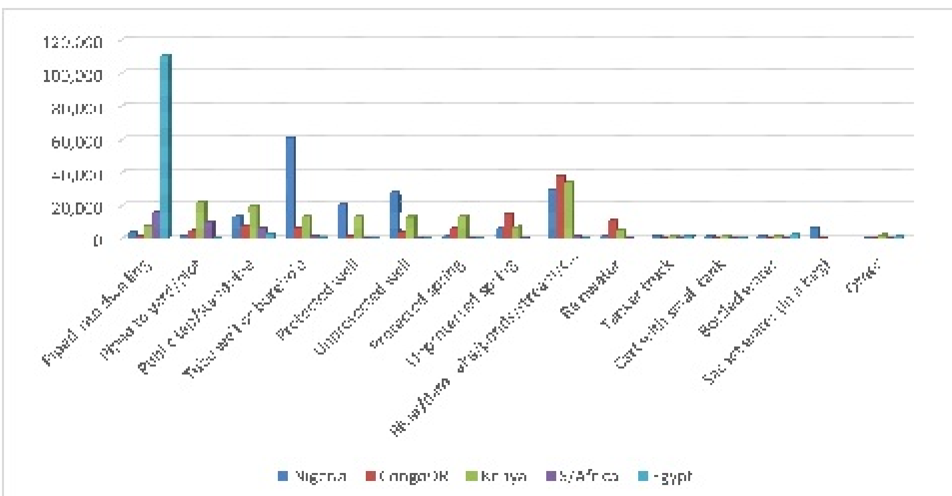

Figure 7. Distribution of Source of Improved and Unimproved Water Accessed by Country.

Source: Authors' computation from the selected countries' DHS data, 2014.

For unprotected wells, Nigeria was first, followed by Kenya, Congo DR, South Africa and lastly Egypt. For unprotected springs, Congo DR had the highest distribution followed by Kenya, Nigeria, South Africa and lastly Egypt. Congo DR had the highest distribution of rivers/dams/lakes/ponds/streams, followed by Kenya, Nigeria, South Africa and lastly Egypt. With regard to rain water, Congo DR was again first, followed by Kenya, Nigeria, South Africa and lastly Egypt. Egypt had the highest for tanker truck delivered water source, followed by Nigeria, Kenya, South Africa and lastly Congo DR. Nigeria had the highest distribution of people using a cart with a small tank and sachet water, but Egypt came first in terms of the distribution of bottled water, followed by Nigeria, Kenya, Congo DR and lastly South Africa. For other sources, Kenya had the highest distribution, followed by Egypt, Nigeria, Congo DR and South Africa.

Improved sanitation access takes another dimension in Africa and is seen in terms of access to toilet facility, The distribution of types of toilet in the selected countries in Africa is shown in figure 8.

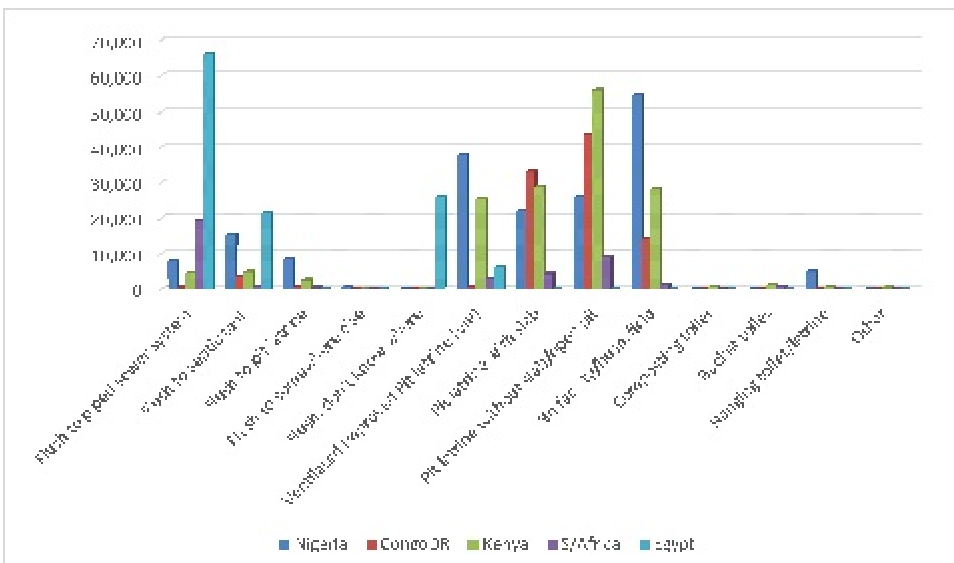

Figure 8. Distribution of Type of Toilet Facility Accessed by Country.

Source: Authors' computation from the selected countries' DHS data, 2014.

The figure shows that Egypt had the highest distribution of flush to piped sewer system. This was followed by South Africa, Nigeria, Kenya and Congo DR. Egypt also had the largest distribution of flush to septic tank system. After Egypt came Nigeria, Kenya, Congo DR, and lastly, South Africa. However, Nigeria had the highest number of flush to pit latrine followed by Kenya, Congo DR, South Africa, and lastly, Egypt. With respect to flush to somewhere else toilet, Nigeria had the highest distribution, but Egypt had the greatest number and/or distribution of flush, don't know where toilets. On ventilated improved pit latrine, Nigeria had the highest distribution followed by Kenya, Egypt, South Africa, and lastly, Congo DR. For pit latrine with slab, Congo DR recorded the highest distribution, then Kenya, Nigeria, South Africa, and Egypt followed suite in that order. Kenya, on the other hand, had the greatest number of people using pit latrines without slab/open pit, followed by Congo DR, Nigeria, South Africa, and Egypt. On distribution of people with no facility/bush/field defaecation, Nigeria had the highest, followed by Kenya, Congo DR, South Africa, and lastly, Egypt. However, composting toilet, bucket toilet and other types of toilet recorded low distribution in all the selected African countries. However, with respect to hanging toilet/latrine, Nigeria was the only country out of the five selected that recorded a noticeable number in terms of people with this type of toilet system.

4.2 Results of the fixed effect model

In order to determine the significant factors that affect improved water and sanitation in the selected African countries, the study utilized the standard DHS data and panel fixed effect model. The utilization of the fixed effect model was possible since the Hausman test confirmed that the random effect model was inappropriate for the model. The Hausman test conducted on the two models, indicates that the Prob>chi2 is less than 0.05 (Prob>chi2 =0.0000 < 0.05). This therefore implies that it is statistically significant at 5% level of significance thereby, making the study to adopt the fixed effect model as the best model that can be utilized to determine the significant factors that affect water and sanitation in selected African countries. Hence, under H1; that the fixed effects is the preferred model, the fixed effect model is consistent and efficient. The study therefore presents the fixed effect model on access to improved water.

4.2.1 *Access to Improved Water Results*

The results of the panel fixed effect model for access to improved water are presented in table 4 and thereafter discussed.

Table 4. Summary Results of the Panel Fixed Effect Model for Access to Improved Water

aipw	Coef.	Std. Err.	t	P>t
windex	0.020622	0.0004091	50.41	0.000
sex	0.002391	0.0008215	2.91	0.004
edu	0.007241	0.000423	17.12	0.000
region	0.008012	0.0001886	42.48	0.000
sector	0.020368	0.0010385	19.61	0.000
haelectr	-0.03776	0.0010621	-35.56	0.000
swater	0.000596	0.0000289	20.59	0.000
tgwater	-0.000013	0.0000010	-13.00	0.000
lpwater	-0.00567	0.0011497	-4.93	0.000
watertbb	0.567809	0.0016813	337.72	0.000
watertbblc	0.623868	0.0015874	393.00	0.000
watertbstc	0.013673	0.0027876	4.90	0.000
watertbwf	0.21047	0.0028033	75.08	0.000
_cons	-0.03254	0.0045152	-7.21	0.000
sigma_u	0.064036			
sigma_e	0.259976			
rho	0.057201			
	(fraction of variance due to u_i)			

F test that all u_i=0: F(13,400550)=107843.59, Prob > F = 0.0000, corr(u_i, Xb) = 0.1296

The results of Corr(u_i, Xb) show that errors, ui, in the fixed effects model are correlated with the regressors. In addition, the F-test results depict that all the coefficients in the model are statistically different from zero. The reason here is that the probability of F, Prob > F = 0.0000, is < 0.05. Therefore, the model is good and as such, has a good fit. The intra-class correlation (rho) further shows that about 5.72% of the variances occur due to differences across selected African countries in the study (i.e. across panels).

The fixed effect model results therefore show that when wealth index (windex) increases by 1%, access to improved water in selected African countries (aipw) would rise significantly by about 2.1%. This result is expected since the wealthier a country is, the more it would be capable to provide improved water for its citizenry.

When sex changes in favour of males by 1%, access to improved water in selected African countries (aipw) would rise significantly by about 0.24%. The implication here is that the higher the number of males in a country, the more likely the country would be able to provide improved water for its people.

A rise in the level of educational attainment (edu) by 1%, would on the average lead to a significant rise in access to improved water in the selected countries (aipw) by about 0.724%. The implication here is that with higher level of educational attainment, people are likely come out of poverty, and would likely provide more improved water for themselves and the people around them.

Movement from one geopolitical region to the other would on the average lead to a rise in access to improved water in the countries (aipw) by about 0.801%. The implication here is that regions that have higher water tables would spend less in providing improved water than those that have to drill very deep boreholes before they can have access to improved water.

Being in a given sector (urban or rural) would also on the average lead to a rise in access to improved water in the selected African countries (aipw) by 2.04%. The implication here is that sectors that are more developed would have more access to improved water than those that are less developed.

Household access to electricity (haelectr) has significant negative impact on access to improved water by 3.78%. This means that having electricity does not guarantee improved access to water since electricity supply all over Africa is epileptic.

Source of water (swater) has significant positive impact on access to improved water by about 0.060%. The implication here is that when the source of water is close to the people, there is every tendency that they will keep it clean and improve on it unlike when it is far away.

When the time to get to water source (tgwater) increases by 1%, access to improved water would diminish by 0.0013%. The implication is that when people spend a lot of the time to get to the water source, it has a negative impact on them, both in terms of the time used to trek to the water source and the economic activities that they would have engaged in during the waiting time to access improved water from a distant place.

Location of presence of water (lpwater) has significant negative impact on access to improved water by about 0.057%. The implication here is that when the location of presence of water is far, there is every tendency that people will not have easy access to the water, let alone improving on it unlike when it is located close by.

The results show that when treating water either by boiling (watertbb), adding bleach/chlorine (watertbblc), straining through a cloth (watertbstc) or by using a water filter (watertbwf) increases by 1%, access to improved water in the selected African countries (aipw) will rise significantly by 56.78%, 62.39%, 1.37% and 21.05% respectively This means that the more people treat water, the more likely they are to have access to improved water.

4.2.2 *Access to Improved Sanitation Results*

This section presents the results of the panel fixed effect model for access to improved sanitation (see table 4 for summary).

Table 5. Summary Results of Panel Fixed Effect Model for Access to Improved Sanitation

aips	Coef.	Std. Err.	t	P>t
stwoh	-1.545791	0.048654	-31.77	0.000
phwhand	1.257905	0.16897	7.44	0.000
pwwp	0.21867	0.061646	3.55	0.000
itpsd	0.70141	0.066269	10.58	0.000
lpwater	0.792766	0.069135	11.47	0.000
swater	-0.00139	0.001369	-1.01	0.311
tgwater	-0.000511	0.000122	-4.18	0.000
windex	1.65035	0.026239	62.90	0.000
sex	-0.05924	0.053637	-1.10	0.269
age	-0.00854	0.001779	-4.80	0.000
edu	0.17998	0.024412	7.37	0.000
mstatus	0.035587	0.025975	1.37	0.171
region	-0.0072	0.012604	-0.57	0.568
sector	0.735986	0.065902	11.17	0.000
_cons	19.71113	0.345821	57.00	0.000
sigma_u	3.9413			
sigma_e	5.230207			
rho	0.362188 (fraction of variance due u_i)			

F test that all u_i=0: F(14,39841) = 851.28, Prob > F = 0.0000, corr(u_i, Xb) = 0.0565

The results of Corr(u_i, Xb) show that errors, ui, in the fixed effects model are correlated with the regressors. In addition, the F-test results depict that all the coefficients in the model are statistically different from zero. The reason is that the probability of F, Prob > F = 0.0000, is < 0.05. Therefore, the model is good and as such, has a good fit. The intra-class correlation (rho) further shows that 36.22% of the variances occur due to differences across the selected African countries in the study (i.e. across panels).

The fixed effect model results therefore show that if households sharing toilets with others (stwoh) increases by 1%, access to improved sanitation in the selected African countries (aipw) would fall significantly by 154.6%. This result is expected since the more people use the toilet, the more dirty it will be and the more likely that people would get infected with diseases hence, leading to unimproved sanitation.

Similarly, a rise in the provision of places where households wash their hands (phwhand) by 1%, would on the average lead to a significant rise in access to improved sanitation in the selected African countries (aipw) by 125.79%. The implication of this is that the higher the provision of places where households wash their hands, the more conscious people are likely to be of basic hygiene, which would lead to improved sanitation.

An increase in making water available at washing places (pwwp) by 1%, would on the average lead to a significant rise in access to improved sanitation in the selected African countries (aipw) by 21.87%. The higher the provision of water at washing places, the more likely that people will use water more to clean their environment, thereby bringing about improved sanitation in their areas.

A rise in making items such as soap and detergent present (itpsd) by 1%, would on the average lead to a significant rise in access to improved sanitation in the selected African countries (aipw) by 70.14%. The implies that the higher the provision of soap and detergent, the more likely that people will use them to wash hands and clothes, and clean their houses and other things washable in a bid to improve their sanitation habits.

The location of presence of water (lpwater) has significant positive impact on access to improved sanitation by 79.28%. When the location of presence of water is close to the people, they are likely to have easy access to water and be encouraged to wash a lot of things, thereby improving their sanitation habits, unlike when it is far from them.

Source of water (swater) has insignificant negative impact on access to improved sanitation by 0.139%. The implication is that when the source of water is far from people's residences, they are unlikely to have easy access to water, making it difficult for them to have improved sanitation unlike if it is close to their abode.

The model results further show that if the time to get to water source (tgwater) increases by 1%, access to improved sanitation would diminish by 0.051%. This means that when the time spent to get to water source is high, it would have a negative impact on the people, both in terms of the time spent to trek to the water source and the economic activities they would have engaged in the waiting time to access improved water from a distant place.

The results also indicate that when wealth index (windex) increases by 1%, access to improved sanitation in the selected African countries (aipw) would rise significantly by 165.03%. This result is expected since the wealthier the people of a country are, the more they would be capable to improve their sanitation, since they would have the resources to access improved basic facilities and can employ cleaners to take care of their environment.

When sex changes in favour of males by 1%, access to improved sanitation in the selected African countries (aipw) will fall, though insignificantly, by 5.92%. The implication here is that the higher the number of males in a given household, the more likely that the household would not be able to adequately take care of sanitation. The reverse is the case with more females.

Further, the results show that an increase in the age of the people by 1% would on the average lead to a significant fall in access to improved sanitation in the selected countries (aipw) by 0.854%. What this implies is that the higher the number of aged people, the higher the probability that people will be less capable of taking appropriate care of themselves. This may require employment of house helps who would take care of these aged people and keep them and their environments clean.

However, a rise in the level of educational attainment (edu) by 1%, would on the average lead to a significant rise in access to improved sanitation (aipw) by 17.99%. The implication here is that with higher level of educational attainment, people would be more informed about the dangers of an unclean environment and the risk of getting infected or contracting diseases if they do not keep their environment and themselves clean. This would no doubt ensure improved sanitation among them and the people around them since they would also educate them on these dangers.

Marital status (mstatus) has insignificant positive impact on access to improved sanitation by 3.56%. This means that being married can guarantee improved access to sanitation since the wife would always make sure that the house is kept in order, even when the husband is not around.

Movement from one geopolitical region to the other would on the average lead to a fall in access to improved sanitation in the selected countries (aipw) by 0.72%. The implication here is that when one moves from a region that has more access to water to one that has less access to water, the tendency is that level of sanitation will decrease.

Being in a given sector (urban or rural) would also on the average lead to a rise in access to improved sanitation in the selected countries (aipw) by 73.60%. The implication here is that sectors that are more developed and have access to improved water would on the average have more improved sanitation than those that are less developed and have less access to improved water.

5. Conclusion and Recommendations

This study tried to examine the significant factors that determine improved water and sanitation in selected countries in Africa using the fixed effect model and standard DHS data (2014) from the sampled countries. It was found that the majority of the captured variables in the study significantly determine improved water and sanitation.

While some factors such as household access to electricity (haelectr), time to get to water source (tgwater), and location of presence of water (lpwater) negatively and significantly determine access to improved water, other variables of the model positively and significantly determine access. Further, while sharing of toilet with other households (stwoh), source of drinking water (swater), time to get to water source (tgwater), sex, age and region negatively and significantly determine access to improved sanitation, other variables of the model positively determine it.

The study therefore recommends, based on its findings, that African governments and their various agencies on environment should strive more to provide improved water and sanitation for the people. Governments can revive water boards to help reticulate water to all towns and villages to enable them have access to improved water. Non-governmental organizations, wealthy private philanthropists and other well-meaning Africans interested in water and sanitation can also help to provide some of these water and sanitation facilities to the public, and to schools in urban and rural areas, among others, to help remedy the water and sanitation situation across Africa. The Federal Ministry of Environment and its counterparts at both state and local government levels should also intensify their efforts towards creating drainage channels that would allow for free flow of water along the roads and water ways, clear wastes that block these water ways at least every week, carry out advocacy to every nook and cranny of these countries on the need for good sanitation habits, and monitor the agencies responsible for environmental hazards. This will definitely bring about a clean environment, healthy lives, poverty reduction and economic growth and development in the African continent and the world at large.

References

Abubakar, I.R. (2017). Access to sanitation facilities among Nigeria households: Determinants and sustainability implications. *Sustainability*, (9): 577.

Acey, C., Kisiangani, J., Ronoh, P., Delaire, C., Makena, E., Norman, G., Levine, D., Khush, R., & Peletz, R. (2019). Cross-subsidies for improved sanitation in low income settlements: Assessing the willingness to pay of water utility customers in Kenyan cities, *World Development,* (115): 160-177.

Akeju, T.J., Oladehinde, G.J., & Abubakar, K. (2018). An analysis of willingness to pay (WTP) for improved water supply in Owo Local government , Ondo state Nigeria, *Asian Research Journal of Arts & Social Sciences*, 5(3): 1-15.

Armah, F, A., Ekumah, B., Yawson, D.O., Odoi, J.O., Afitiri, A., & Nyieku, F.E. (2018). Access to improved water and sanitation in a quarter century. *Heliyon*, (4): 11.

Bartram, J., Brocklehurst, C., Fisher, M.B. Luyendijk, R., Hossain, R., Wardlaw, T. & Gordon, B. (2014). Global monitoring of water supply and sanitation: History, methods and future challenges, *Int. J. Environ. Res. Public Health*, (11): 8137-8165, Doi:10.3390/ijerph110808137

Bassil, Y. (2012). The socioeconomic water problems & challenges in the Middle East, *Advances in Applied Economics and Finance (AAEF),* 3(3): 599-610, ISSN 2167-6348, World Science Publisher, United States, Available Online At: www.worldsciencepublisher.org

Cairncross, S. (1988). *Domestic water supply in rural Africa. In: Rural Transformation in Tropical Africa*, in D. Rimmer, ed. London: Belhaven Press.

Cairncross, S. (1987). The private sector and water supply in developing countries: Partnership or profiteering? *Health Policy and Planning*, 2(2): 180?182.

Cairncross, S. & Feacham, R. (1993). *Environmental Health Engineering in the Tropics,* 2nd ed., Chichester, U.K.: John Wiley & Sons.

Cairncross, S. & Kinnear, J. (1992). Elasticity of demand for water in Khartoum, Sudan, *Social Science and Medicine*, 34 (2): 183-189.

Coster, A. S. & Otufale, G. A. (2014). Households' water-use demand and willingness to pay for improved water services in Ijebu Ode, Ogun State, Nigeria, *Journal of Environment and Earth Science*, 4(17): 166 – 175, ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)

Damelin, E., Shamir, U., and Arad, N. (1972). Engineering and economic evaluation of the reliability of water supply, *Water Resources Res,* 8(4): 97-384.

Dannenbery, A.L., Frumkin, H. & Jackson, R.J. (2011). *Making Healthy Places: Designing and building for health, well-being, and sustainability.* Island Press: USA

Demographic and Health Survey – DHS (2014). Standard Demographic and Health Survey Data, Available online At: https://www.dhsprogram.com

Echternacht, L. (2014). Pricing Urban Water: Evaluation of Economics in the Water Sector of Hyderabad and Varanasi (India), *Business & Economics, Springer Science & Business Media*, Available Online At: https://books.google.com.ng/books?isbn=3319041908

Environmental Health Group – EHG (2019). Water supply and access, *London School of Hygiene & Tropical Medicine*, Available Online At: https://ehg.lshtm.ac.uk/water-supply-and-quality/

Ezeh, O.K., Agho, K.E., Dibley, M.J., Hall, J., & Page, A.N. (2014). The impact of water and sanitation on childhood mortality in Nigeria: Evidence from demographic and health surveys, 2003–2013. *Int. J. Environ. Res. Public Health*, (11): 9256–9272.

Govender, P. E. (2014). Water is life, Sanitation is dignity: Accountability to people who are poor, Report on the right to access sufficient water and decent sanitation in South Africa: 2014, *South African Human Rights Commission*. Available Online At: https://www.sahrc.org.za/home/21/files/FINAL204th20Proof20420March2020Water2020Sanitation20low20res%20(2).pdf

Hundie, S. K. & Abdisa, L.T. (2016). Households' willingness to pay for improved water supply, *The Romanian Economic Journal*, (62): 1-9.

Hutton, G. & Chase, C. (2016). The knowledge base for achieving the sustainable development goal targets on water supply, sanitation and Hygiene, *International Journal of Environment Resources and Public Health*, 13(6): 536.

Hutton, G., Haller, L. & Bartram, J. (2007). Global cost-benefit analysis of water supply and sanitation interventions, *Journal of water and Health*, 5(4):481-502.

Ishaku, H., T., Majid, M. R., Ajayi, A. P., & Haruna, A. (2011). Water supply dilemma in Nigerian rural communities: Looking towards the sky for an answer, *Journal of Water Resource and Protection* (3): 598-606.

Jones, H.E. (2013). Mainstreaming disability and ageing in water, sanitation and hygiene programmes: A mapping study carried out for WaterAid, UK. London, UK: WaterAid Publications.

Kayaga, S, Calvert, J., & Sansom, K. (2003). Paying for water services: effects of household's characteristics, *Utilities policy*, 11(3): 123-132.

Kema, K., Semali, I., Mkuwa, S., Kagonji, I., Temu, F., Ilako, F. & Mkuye, M. (2012). Factors affecting the utilisation of improved ventilated latrines among communities in Mtwara Rural District, Tanzania, *Pan African Medical Journal*, 13(1): 4.

Kuberan, A., Singh, A.K., Kasav, J.B., Prasad, S., Surapaneni, K.M., Upadhyay, V., & Joshi, A. (2015). Water and sanitation hygiene knowledge, attitude, and practices among household members living in rural setting of India, *Journal of Natural Science, Biology and Medicine*, 6(Suppl 1): S69–S74, Doi: 10.4103/0976-9668.166090

Max Foundation (2015). What we do, our interventions: Theory of change, Available Online At:http://www.maxfoundation.org/files/downloads/05-opmaak-flyer-theory-of-change.pdf

Ndedzu, D., Muhoyi, E., Kunguma, I., & Mavesere, I. M. (2012). Household demand for improved water supply services in high density urban areas, *Journal of Strategic Studies*, 3(1).

Oumar, S., B. & Tewari, D.D. (2013). The Evolution of Access to drinking water and sanitation coverage in urban centers of selected African countries, *Mediterranean Journal of Social Sciences*, 4(6): 747 – 756.

Pforr, K. (2014). Femlogit—implementation of the multinomial logit model with fixed effects, *The Stata Journal: Promoting Communications on Statistics and Stata,* 14(4): 847–862 Available Online At: https://journals.sagepub.com/doi/abs/10.1177/1536867X1401400409

Sasaki, S., Suzuki H., Igarashi, K., Tambatamba, B. & Mulenga, P. (2008). Spatial analysis of risk factors of cholera outbreaks for 2003 – 2004 in a peri-urban area of Lusaka, Zambia, *American Journal of Trop. Med. Hyg.*, 79(3):414 – 421.

Shamir, U. (1981). Water supply reliability theory, *Research and Technology Journal,* (2): 387-384, DOI: 10.1002/j.1551-8833.1981.tb04736.x

Shamir, U. (2015). Water supply reliability theory, *Journal - American Water Works Association,* (1): 387 – 384, DOI: 10.1002/j.1551-8833.1981.tb04736.x

Stephen, S. & Graham, J. (2014). Ending open defecation in rural Tanzania: Which factors facilitate latrine adoption? *International Journal of Environmental Research and Public Health*, (11): 9854-9870.

Tapela, B.N. (2012). Social water scarcity and water use, Water Research Commission, 11(1): 1940, Available Online At: https://www.researchgate.net/publication/291206060_Social_Water_Scarcity_and_Water_Use

Twerefou, D.K., Tutu, K.A., Botchway, E. & Darkwah, S. (2015). Willingness to pay for potable water in the Accra-Tema Metropolitan Area of Ghana, *Modern Economy*, 6(12): 1285-1296.

United Nations (2018). The Sustainable Development Goals Report 2018, *United Nations Publications,* Available online At: https://unstats.un.org/sdgs/files/report/2018/TheSustainableDevelopmentGoalsReport2018-EN.pdf

United Nations (2011). The Millennium Development Goals Report 2011, *United Nations Publications,* New York, Available online At: https://www.un.org/millenniumgoals/pdf/(2011_E)%20MDG%20Report%202011_Book%20LR.pdf

United Nations Children Emergency Fund (2001). The state of the world's children 2001, *UNICEF Publication*, Available online At: https://www.unicef.org/sowc/archive/ENGLISH/The%20State%20of%20the%20World%27s%20Children%202001.pdf

United Nations Children's Fund (UNICEF) (2014). Water, Sanitation and Hygiene (WASH) Annual Report 2013, Available Online At: https://www.unicef.org/wash/files/WASH_Annual_Report_Final_7_2_Low_Res.pdf

United Nations Department for Economic and Social Affairs – UNDESA (2015). International decade for Africa 'water for life' 2005-2015, *UNDESA Publication*, Available Online At: http://www.un.org/waterforlifedecade/africa.shtml

Wang, C., Pan, J., Yaya, S., Yadav, R.B., & Yao, D. (2019). Geographic inequalities in accessing improved water and sanitation facilities in Nepal, *International Journal of Environmental research and public health*, (16): 1269, Doi:10.3390/ijerph16071269

WHO/UNICEF (2016). The state of the world's children 2016, WHO/UNICEF Publications, Available Online At: https://www.unicef.org/publications/files/UNICEF_SOWC_2016.pdf

WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (2019). Estimates on the use of water, sanitation and hygiene by country (2000-2017), Available Online At: www.washdata.org

Wilcock, A.A. & Townsend, E.A. (2009). *Occupational Justice*. In Crepeau, E.B. Cohn, E.S. &Boyt Schell, B.A. (Eds.), Willard & Spackman's Occupational Therapy (11th ed.), Baltimore: Lippincott Williams & Wilkin, Pp.193–199.

Wooldridge, J.M. (2010). *Econometric Analysis of Cross Section and Panel Data*. 2nd ed., Cambridge, MA: MIT Press.

World Health Organization (2018). WHO Water, Sanitation and Hygiene strategy 2018-2025. *Geneva: (WHO/CED/PHE/WSH/18.03)*. *Licence*: CC BY-NC-SA 3.0 IGO.

Wright, J. Gundry, S. & Conroy, R. (2004). Household Drinking water in developing countries: A systematic review of microbiological contamination between source and point-of-use, *Tropical Medicine and International health,* (9): 106 – 117.