Analysis of Sanitation and Waterborne Disease Occurrence in Ondo State, Nigeria

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Abstract

Waterborne diseases are linked to significant disease burden worldwide. Waterborne diarrhoea disease, for example, is responsible for two million deaths each year. Proper household water and sanitation can, however, increase resilience to waterborne disease risks. In view of the foregoing, this work has established a relationship between sanitation and waterborne disease occurrence in Ondo State and between potable water and waterborne diseases in the State by the analysis of the data sourced from the Federal Ministry of Water Resources, Federal Republic of Nigeria. The Ministry has used the stratified sampling procedure to prepare the National Water Supply and Sanitation Baseline Survey Forms that was administered to get information on improved sanitation, potable water supply and waterborne disease occurrence in Ondo State, Nigeria. Three equations were generated to mock the variables of improved sanitation, potable water supply and waterborne disease occurrence and their interdependencies. To predict one variable when the other is known, modelled equations were also validated and returned errors were less than 50% in all cases. It was concluded that since the least average error was generated when the prevalence of waterborne diseases in the State was predicted with information available on improved sanitation, the occurrence of waterborne diseases in the State is due to the unhygienic practices of the people of the State. The study has contributed to the first two goals of SDG 2030 which are: to increase potable water availability and to give access to an improved level of sanitation by the year 2030.

1.0 Introduction

The Sustainable Development Goals, also known as the SDGs, targeted at maintaining the quality of water and hygiene, reducing poverty, protecting biodiversity, and achieving peace and prosperity in the world by the year 2030 were introduced by the United Nations in 2015 [1]. The agenda laid emphasis on the need for potable water and adequate sanitation for human survival. SDG 6, which is one of the 17 set targets of the UN to be reached by 2030, will improve accessibility to basic water and sanitation and reduce the gaps in service delivery.

Even as SDG 6 specifies 8 targets, the primary focus of this paper shall be Targets 6.1: ‘by 2030, achieve universal and equitable access to safe and affordable drinking water for all’ and Target 6.2: “by 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.”

The percentage of people in the world having access to basic sanitation increased from 59% in 2000 to 68% in 2015 [2]. In every ten countries below 95 per cent coverage, only one is in sync with SDG 2030. Moreover, 4.5 million people globally are ill-equipped with a safely managed sanitation in 2015. A safely managed sanitation refers to the situation of bringing about the presence of an improved facility in every household where excreta are disposed safely or transported off-site for treatment.

The human right to sanitation defines sanitation as a process of collecting, transporting, treating, disposing, or reusing human excreta and associated hygiene [3]. People deserve access to a latrine or

toilet so that they would not be victims of unmanaged fecal wastes. The United Nations General Assembly (Human Rights Council) identified access to water and sanitation as human rights that are necessary for maximum comfort in life [4].

The basic needs of man abound in safe water, sanitation, and hygiene (WASH) for his well-being and survival [5]. Deficiency in these vital necessities of life is detrimental to the health of many, especially children [6]. According to the World Health Organization [7], about 1.8 million people in the world are estimated to die from diarrhea-related diseases, most of which were caused by the consumption of unclean water and contaminated foods.

Persons living with one ailment, or the other are even more susceptible to waterborne diseases that are ordinarily harmless to healthy individuals [8, 9]. In the less developed parts of the world, the number of people indulging in the use of undrinkable water has reduced significantly but it is just uncertain if all persons will eventually adopt a potable water [10]. According to [11], 884 million people take water from unimproved water sources.

Again, the global estimate of people without access to clean water is put at 900 million [12]. According to [13], the developing world of about 6 billion has almost half of her population facing the challenge of unimproved sanitation. While 70 percent of people who are deprived access to improved sanitation are found in rural areas, a corresponding proportion of about 80 per cent without access to potable water live in the area [14].

According to [15, 16, and 17], 9% of the world ravaging diseases can be controlled by employing the use of adequate water, sanitation, and hygiene (WASH) facilities. The most susceptible people to disease are the young people who are deprived access to water, sanitation, and hygiene facilities [18]. The spate of death in children below the age five resulting from diarrhea disease is due to a non-compliance with WASH [18, 19].

There is no doubt, adequate WASH facilities will facilitate improvement on people's health status and means of livelihood; but the major concern is the proliferation of these facilities in the rural areas of Nigeria [20–24]; a huge number of people in the rural parts of Nigeria are deprived access to WASH facilities [25]. This trend has left many communities with no other choice than rivers, streams, and ponds to drink from and use for household chores [26] and, sorrily, to aid the act of open defecation [27] and this has resulted into high rate of mortality, sickness, and the proliferation of waterborne diseases [28–30].

Similarly, water which come from improved facilities such as boreholes and wells having hand pumps are quite inadequate such that young people and mothers always travel long distances to harness water. This is much time-consuming and energy-sapping as in the long run, the children's education and the women's livelihood are jeopardized [31]. Again, there is a shortfall in the number of facilities needed to dispose excreta (i.e., toilet) at both household and in public places like schools [32], marketplaces [33] and hospitals [34].

Over the years, people have had no better choice than to defecate openly and/or in water bodies [35], using no soap or disinfection afterwards [36]. Moreover, the case of shared toilet is told, where people use the toilet indiscriminately, giving no special attention to women's needs and integrity [33]. The failure of the government has led to the intervention of UNICEF and WHO responsible for the introduction of WASH to more than a hundred country [37].

Considering the substandard quality of drinking water in Nigeria, most citizens will become disposed to illnesses [38]. Accessibility to improved water in Nigeria has become almost impossible; about 90 million Nigerians are deprived access to safe drinking water and up to 130,000 Nigerian children below the age of five die yearly from waterborne diseases. The most prevalent waterborne diseases in Nigeria are Dracunculiasis, Hepatitis, cholera, and Typhoid [39, 40].

According to [41, 42, 43], there have been incident reports about infections arising from the drinking of contaminated water in many towns. Outbreaks of waterborne diseases occur when surface water containing enteric pathogens is adopted for home and sporting purposes [44]. In Sokoto, Shunni and Tambuwal towns, the drinking water sampled had *Salmonella, E. coli, Shigella* and *Vibrio* species that were more than WHO's tolerance for potability [45].

There is paucity of data on the spread of waterborne diseases in Ondo State, especially, and in Nigeria at large. Whereas data is a major prerequisite in developing the preventive measures and the policies to hinder spread. This study, therefore, on establishing a relationship between potable water, improved sanitation, and waterborne diseases in Ondo State, Nigeria, enumerates that the spread of waterborne diseases can be prevented, as it is dependent on every household behaviour.

Impacts of Water Supply, Sanitation and Waterborne Diseases on the Economy, the Individual, and the Government

Many researchers have demonstrated a significant correspondence between non-potable water, sanitation, and maternal mortality [46, 47]. The most susceptible age group to diseases are the children below the age of five. A frequent exposure to fecal matters causes nutritional deficiencies, leading to growth stunting and mental retardment [48, 49].

According to [50], a significant reduction in the distance of travel to get water bears a direct impact on the prevalence of diarrhea, healthy diet, and low death rate in children under five years. This encourages better hygiene practices [51, 52, 53] and time availability for child-care, personal growth, and investment [54] thus encouraging the birth of healthy children.

Inadequate water available for consumption leads to dehydration which affects both mental and physical functions of the body [55]. According to [56], oral rehydration salts is premised upon the use of safe drinking water. In the use of groundwater that contains deleterious elements like arsenic, 226 million people have died in more than hundred different countries [57].

According to [58], poor water and sanitation is responsible for 0.9 percent of global disability-adjusted life years (DALY) or 300,000 mortality per year. Also, 842,000 deaths worldwide are due to the prevalence of diarrhea disease [59] and of which 43 percent constitutes children below the age of five. According to [60], about 2.9 million cases of deaths were due to cholera and its prevalence in 69 countries.

Thus, when water supply and sanitation are improved, they offer comfort, safety, convenience, status, and dignity to people and optimally influences their habitat [61]. All these are particularly beneficial to women [62]. Although water availability does not automatically translate into women employment [63], it has been proven to reduce time spent on water collection by women and thus promoting gender equity [64].

On-slot sanitation lessens the prevalence of crimes and assault on women especially in the night or in secluded places [46]. The adoption of improved latrines is safer as they are less susceptible to collapse and are easily accessible to small children. In India, a government programme geared towards the establishment of toilet facilities brought an 8 percent increase to pubescent-age boys and a 12 percent increase to the enrollment of younger children [65].

2.0 Materials And Methods

2.1 Description of the Study Area

Ondo State that is dubbed as “Sunshine State” was created in 1976 by the defunct Western Region. Before emergence, it belonged to the old province of the old Western Region. The State has a land mass of 14,793 km^2 and its capital town is Akure. The last census conducted in Nigeria in 2006 put the population of the State at 3.4 million people. The State has eighteen local governments as shown in Fig. 1, and it is richly blessed with diverse ethnic groups; predominant of which are the Yorubas. There are about seven subgroups within the Yoruba entity which include Akoko, Ikale, Akure, Ilaje, Oke-Igbo, Owo and Ondo.

The State is popular for being host to the largest number of public schools (about 880) in the country. Bounded by Ekiti and Kogi States in the North, Edo State in the East, Osun and Ogun States in the West and the Atlantic Ocean in the South, the State completely lie within the tropics. Ondo State is favoured by varying degrees of ecology and climate as its vegetation transverses from mangrove swamps to rainforest and to the derived savannah that is mostly prevalent in the northern part of the State. The southern part of the State supports the growing of cash crops such as cashew, oil-palm, cocoa, cashew, teak etc.

Ondo State has two tropical climates: rainy season (that occurs between April and October) and dry season (occurring between November and March). The range of temperature within an annual period is between 21˚C and 29˚C and humidity is predominantly high. Rainfall improves from the northern parts of the State to the southern part, having values between 1,150mm and 2,000mm. There are quite some rivers in the State such as Ala, Oni, Ose, Owena, Ogbese and Awara. The topography of the land slopes

from the north to the creeks of the south. This descriptive was obtained from the State's official website (www.ondostate.gov.ng).

2.2 Sampling and Sampling Procedures

The sampling procedure that has been adopted by the Federal Ministry of Water Resources, Federal Republic of Nigeria and used to prepare the National Water Supply and Sanitation Baseline Survey Forms administered to collate the data used in this study is the stratified sampling procedure. Stratified sampling procedure is the most effective method of sampling when a researcher wants to get a representative sample of a population.

It involves categorizing the members of the population into mutually exclusive and collectively exhaustive groups. An independent simple random sample was then drawn from each group. Stratified sampling techniques can provide more precise estimates if the population under survey is more heterogeneous than the categorized groups. In Ondo State, for example, where the survey forms that are employed for this study were administered, there are varying types of sanitation facilities. They cut across rural, small towns and urban areas. The main advantage of the stratified sampling technique is that it can give the most representative sample of a population.

The objective of this assignment is to document the proportion of Nigerians that have access to safe water and sanitation facilities and those who, on the other hand, are deprived access to them. In line with the definition of sanitation i.e., the availability of improved disposal facilities of human wastes that can effectively prevent human, animal and insect contact with the human wastes, forms were used as tools supplying information about the location, types, and conditions of sanitation facilities. The forms specified the types of healthcare facilities available in Urban, Small Towns, and the rural areas of Ondo State.

It as well captured the incidence of the cases of diseases that are caused by lack of access to safe water, contaminated water, poor sanitation, and exposure to water-based disease vectors. In other parts of the form, the types of toilet facilities used in some selected households were investigated. And this had informed the kind of sanitation, improved or unimproved, in the households. The part C of the forms used stated the probable diseases challenging each of the household.

The summary of the instruments used in gathering information for this study includes Form 01 (Sanitation Facility Survey) used in capturing the location, types, and conditions of sanitation facilities; Form 02 (Water-Related Diseases Survey) used in collecting data on reported cases of water-related diseases from health institutions; Form 03 (Household Survey) used while capturing data on the proportion of households that have access to safe drinking water and sanitation facilities and the prevalence of water-related diseases in each community. Forms were randomly administered by trained enumerators to a minimum of fifteen households in each political council ward.

2.3 Data Preparation and Analysis Methods

The collected secondary data were processed following some established methods as described in the following sub-sections. The percentage access to potable water, improved sanitation, and waterborne diseases in the study area were estimated using the expressions in the Equations 1–3. Different water-related diseases were sampled. They include Diarrhoea, Guinea worm, Dysentry, Typhoid fever, Malaria, Scabies, Ring worm, Cholera, Trachoma, Hepatitis B, Streptococci and Onchocerciasis

2.3.1 Data Preparation

Estimation of the Percentage of People with Access to Potable Water

In Ondo State, there was more than one source of potable water. The various means through which potable water was made available to the people of the State are represented in Eq. 1. This equation is like that used in a study by [66] for estimating the percentage access to potable water supply in Oyo State, Nigeria.

$$APW = H + B + M + W + P + R + S \quad \text{Eq. 1}$$

Where:

APW = Total percentage access to Potable Water

H = Percentage of people with access to House connection

B = Percentage of people with access to Hand-Pump borehole

M = Percentage of people with access to Motorized borehole

W = Percentage of people with access to Dug well

P = Percentage of people with access to Standpipe

R = Percentage of people with access to Rain

S = Percentage of people with access to spring

Estimation of the percentage of People with Access to Improved Sanitation

In Ondo State, there was more than one means of access to Improved Sanitation. The various means through which improved sanitation are made available to the people of the State are those represented in Eq. 2.

$$A_{IS} = SL + LS + VIP + WC + HW + SS + PS + SD + SW \quad \text{Eq. 2}$$

Where:

A_{IS} = total percentage access to Improved Sanitation

SL = percentage of people with access to Simple Latrine

LS = percentage of people with access to Latrine Sanplat

VIP = percentage of people with access to Latrine VIP

WC = percentage of people with access to Water Closet

HW = percentage of people with access to Hand Wash

SS = percentage of people with access to Septic System

PS = Percentage of people with access to Public Server

SD = Percentage of people with access to Sullage Disposal

SW = Percentage of people with access to Storm Water

Estimation of the percentage of People with Various Waterborne Diseases

Similarly, there was more than one waterborne disease occurrence. The various waterborne diseases among the people of the State are represented in Eq. 3.

$$T_{WBD} = DI + GW + DY + TY + MA + SCH + SCA + RW + TR + HE + ST + ON + OWD \quad \text{Eq. 3}$$

Where:

T_{WBD} = Total percentage affected with waterborne disease occurrences

DI = Percentage of people with Diarrhea

GU = Percentage of people with Guinea worm

DY = Percentage of people with Dysentery

TY = Percentage of people with Typhoid fever

MA = Percentage of people with Malaria

SCH = Percentage of people with Schistosomiasis

SCA = Percentage of people with Scabies

RW = Percentage of people with Ringworm

TR = Percentage of people with Trachoma

HE = Percentage of people with Hepatitis B

ST = Percentage of people with Streptococci

ON = Percentage of people with Onchocerciasis OWD = Other waterborne diseases

2.3.2 Statistical Analysis

This study used both Correlation and regression analyses as the statistical methods to analyze the data for this work. They were successful in showing the relationship existing between sanitation and disease occurrences in Ondo State, as well as the relationships that exist between other similar variables. In the correlation of the percentages of people with access to potable water and the percentages of people with various waterborne diseases in Ondo State, the percentages of people with access to potable water served as the predictor (or the independent) variable while the percentages of people with waterborne diseases served as the dependent variable.

Meanwhile, in the correlation of the percentages of people with waterborne diseases and the percentages of people with improved sanitation in Ondo State, the percentages of people with improved sanitation were the independent variable and the percentages of people with waterborne diseases was the dependent variable. Also, in the correlation of the percentages of people with access to potable water and the percentages of people with improved sanitation, the percentages of people with access to potable water was the independent variable and the percentages of people with improved sanitation was the dependent variable.

To determine the strength of the relationships between the variables, Guilford's rule of thumb with the following statistical ranges $r < 0.2$ (almost negligible relationship); $0.2 < r < 0.4$ (low correlation; definite but small relationship); $0.4 < r < 0.7$ (Moderate correlation; substantial relationship); $0.7 < r < 0.9$ (High correlation; marked relationship), and $r > 0.9$ (very high correlation; very dependable relationship) were used.

2.3.3 Relationship Equation Development & Validation

Relationship Development

To establish the relationship between the three variables, the linear regression model was used, and the modeled equations were developed using SPSS version 25. About twelve LGAs data were used for relationship equations modeling, and it comprises of the first 12 Local Governments of Ondo State as they come in alphabetical order (Akoko N/W, Akoko N/E, Akoko S/E, Akoko S/W, Akure North, Akure South, Ese Odo, Idanre, Ifedore, Ilaje, Ile-Oluji/Okeigbo and Irele).

Relationship Validation

This study validated the modeled equations by estimating the mean errors (MEs) and Nash-Sutcliff Efficiency (NSE) using the modeled and observed values as the inputs with Equations 5 and 6 respectively. The last six LGAs of Ondo State, however, were used, and this includes Odigbo, Okitipupa, Ondo East, Ondo West, Ose and Owo. The data from these LGAs were used to check for the model equations appropriateness to know if they were fair representations of the relationship that exist between the variables involved.

$$ME = \frac{MeasuredValue - ModeledValue}{\overline{MeasuredValue}} * 100 \qquad \text{Eq. 4}$$

$$NSE = 1 - \left(\frac{\left[\left(\sum_{i=1}^{n} (\text{MeasuredValue} - \text{ModeledValue}) \right)^2 \right]}{\left[\sum_{i=1}^{n} (\text{MeasuredValue} - \overline{\text{MeasuredValue}}) \right)^2]} \right) \qquad \text{Eq. 5}$$

3.0 Results And Discussion

Summaries of the results of the access to potable water, improved sanitation, and the occurrences of the waterborne diseases are shown in Figs. 2–5. These results are the plots of the comparisons among the access to potable water (%), improved sanitation (%), and waterborne diseases (%) by pairing each variable.

Figure 2 shows the percentages of people with access to a potable water supply in Ondo State estimated using Eq. 1. It can be inferred from the Table that Irele and Ese Odo LGAs have the highest and lowest accesses of about 80% and 23% respectively to Potable Water amongst all the sampled population within the LGAs of Ondo State. Also, the percentages of the sampled population with the occurrence of water-borne diseases were estimated using Eq. 3, and the results were shown in Fig. 2.

Again, from Fig. 2, Ese Odo and Ondo West LGAs have the highest (452%) and the least (108%) occurrences of waterborne diseases. It is important to note that some of the sampled populations have had one or more waterborne infections. Therefore, the percentages of diseases are more than 100%. For example, while the sampled population in Akoko LGA is 295, the occurrence of waterborne infection has been more than 295 because some of the sampled populations have had multiple and different infections.

From Fig. 2, it is understood that access to potable water supply is inversely proportional to the level of waterborne disease (%) in Ondo State. As seen in Fig. 2, Ese Odo LGA has the highest percentage of the

sampled population affected by waterborne disease (about 453%) with the corresponding lowest access to potable water supply (about 23%).

Similarly, using Eq. 2, the access to improved sanitation was estimated as shown in Fig. 3. So, from Fig. 3, Okitipupa and Ilaje LGAs have the highest (about 84%) and the least (about 5%) accesses to Improved Sanitation in the sampled population of the LGAs of Ondo State. It can thus be seen that the majority of the LGAs in Ondo State have access to Improved Sanitation. As seen in Fig. 3, it is safe to conclude that access to water supply in about 85% of the LGAs in Ondo contributed to having an improved sanitation facility.

Statistical Analysis

As it was stated earlier, the data of the first twelve LGAs of Ondo State is as contained in Table 1 which summarizes the information regarding the access to Potable Water, Improved Sanitation and Waterborne Disease occurrences that were considered for modeling of relationship equations. The results are, thus, presented in Tables 2.

Table 1
Summary of the Study Variables for the Statistical Analysis

S/N	LGA NAME	% Potable Water Access	% Improved Sanitation	% Waterborne Disease
1	Akoko N/W	53.6	24.1	170.2
2	Akoko N/E	44.5	30.9	304.6
3	Akoko S/E	50.5	26.6	243.4
4	Akoko S/W	66.8	28.5	139.0
5	Akure North	68.0	22.0	159.9
6	Akure South	56.2	71.4	135.7
7	Ese Odo	22.9	17.5	452.2
8	Idanre	74.0	59.7	164.3
9	Ifedore	71.0	16.3	234.0
10	Ilaje	38.3	5.0	395.8
11	Ile-Oluji/Okeigbo	58.5	60.5	155.1
12	Irele	79.4	19.9	294.4
13	Odigbo	37.8	61.0	332.6
14	Okitipupa	46.8	83.5	165.4
15	Ondo East	50.5	4.7	195.7
16	Ondo West	58.3	60.8	107.8
17	Ose	45.3	31.2	189.4
18	Owo	45.0	30.6	265.7

Table 2
Correlations amongst the Study Variables

		APW (%)	WBD (%)	IS (%)
APW (%)	Pearson Corr.	1	– .678*	0.249
	Sig. (2-tailed)		0.015	0.435
WBD (%)	Pearson Corr.	– .678*	1	– .623*
	Sig. (2-tailed)	0.015		0.03
IS (%)	Pearson Corr.	0.249	– .623*	
	Sig. (2-tailed)	0.435	0.03	1
*. Correlation is significant at the 0.05 level (2-tailed).				

Table 2 shows that there exists a *Negatively Moderate correlation*: *substantial relationship* between the access to a potable water supply (APW) (%) with the water-borne diseases (WBD), and waterborne diseases (%) with Improved Sanitation (IS) (%) in Ondo State. However, it is safe to infer that there exists a Low Correlation, definite but small relationship between the percentages of people with access to a potable water (APW) (%) to those with Improved Sanitation (IS) (%) in Ondo State.

Table 3
Models Summary amongst the Study Variables

Change Statistics									
Modes	**R**	**R^2**	**Adjusted R^2**	**SE Estimate**	**R^2 Change**	**F Change**	**df_1**	**df_2**	**Sig. F Change**
APW (%) & IS (%)	.249[a]	0.062	-0.032	20.92523	0.062	0.663	1	10	0.435
WBD (%) & IS (%)	.623[c]	0.389	0.328	86.257	0.389	6.358	1	10	0.03
WBD (%) & APW (%)	.678[e]	0.46	0.406	81.04883	0.46	8.528	1	10	0.015
a. Predictors: (Constant), Percentage with Potable Water Access (APW)									
b. Dependent Variable: Percentage with Improved Sanitation (IS)									
c. Predictors: (Constant), Percentage with Improved Sanitation (IS)									
d. Dependent Variable: Percentage with Waterborne Diseases (WBD)									
e. Predictors: (Constant), Percentage with Access to Potable Water (APW)									
f. Dependent Variable: Percentage with Waterborne Diseases (WBD)									

From Table 3, the R^2 values for the three scenarios were generally low with the magnitudes of *6.2%, 38.9%, and 46%*. Hence, it can be said that the movement of the outcome (dependent) variables were explained by the movement of the predictors (independent) variables by 6.2%, 38.9%, and 46% respectively.

Table 4
Coefficients for predicting *dependent variables in each model scenario*

		Unstandardized Coefficients		Standardized Coefficients		
Models	**Constants**	**B**	**Std. Error**	**Beta**	**T**	**Sig.**
1	**(Constant)**	486.537	88.47		5.499	0
	APW (%)	-4.373	1.498	-0.678	-2.92	0.015
2	**(Constant)**	338.816	47.311		7.162	0
	IS (%)	-3.183	1.262	-0.623	-2.521	0.03
3	**(Constant)**	13.933	22.841		0.61	0.555
	APW (%)	0.315	0.387	0.249	0.814	0.435
a. Dependent Variable: Percentage with Waterborne Diseases						
b. Dependent Variable: Percentage with Waterborne Diseases						
c. Dependent Variable: Percentage with Improved Sanitation						

Since an unscattered plot was obtained from the output of the SPSS that generated Table 4, it can be explained that there is a linear relationship between access to a potable water supply and the occurrences of waterborne diseases in Ondo State. These linear relationships can be represented by Equations 6–8.

$Y = -4.373X + 486.537$	**Eq. 6**
$P = -3.183Q + 338.816$	Eq. 7
$L = 0.315M + 13.933$	Eq. 8

Where Y = Waterborne Disease occurrences in Ondo State (Outcome Variable); X = Access to Potable Water in Ondo State (Predictor Variable); Slope of the straight line (-4.373); Intercept or constant on the vertical axis (486.537); P = Water-borne Disease occurrences in Ondo State (Outcome Variable); Q = People with Improved Sanitation in Ondo State (Predictor Variable); Slope of the straight line (-3.183); Intercept or constant on the vertical axis (338.816), and L = people with Improved Sanitation in Ondo State (Outcome Variable) M = Access to Potable Water in Ondo State (Predictor Variable); Slope of the straight line (0.315); Intercept or constant on the vertical axis (13.933).

It follows that it might be possible to predict the level of occurrences of waterborne diseases in Ondo State if information is available on the access to potable water supply using Eq. 6. Similarly, it is possible to predict Water-borne Disease occurrences in Ondo State if the information on people with Improved Sanitation is available while using Eq. 7. Also, it is possible to predict improved sanitation in Ondo State if information is available on people with potable water while using Eq. 8.

Modeled Relationship Equations Validation

In the eighteen LGAs of Ondo State, while the first twelve were selected for training, the remaining six were used for validation. Modelled equations 6–8 were used for validations with the information available for their predictor variable while generating their outcome variables. The outcome variables were compared with the original measured outcome variables (obtained for the same set of data) and the errors and average errors found were recorded in Table 5.

'A' represents the errors obtained when the measured results of waterborne diseases were compared with the modelled results of waterborne diseases predicted using Eq. 6 and information available on access to potable water.

'B' represents the errors obtained when the measured results of waterborne diseases were compared with the modelled results of waterborne diseases predicted using Eq. 7 and information available on improved sanitation.

'C' represents the errors obtained when the measured results of improved sanitation were compared with the modelled results of improved sanitation predicted using Eq. 8 and information available on access to potable water.

Table 5
Model Validation: Summary of errors

LGAs	A	B	C
Odigbo	3.8	56.5	57.4
Okitipupa	70.3	56.6	65.7
Ondo East	34.2	64.8	83.3
Ondo West	115.7	33.4	47.5
Ose	53.3	27	9.3
Owo	8.9	9.8	9.3
Mean Error (%)	**47.7**	**41.4**	**45.4**

$$NSE_A = 1 - \left(\frac{44308.6}{198915.4}\right) = 0.78 = 78\%$$

$$NSE_B = 1 - \left(\frac{64785.0}{198915.4}\right) = 0.67 = 67\%$$

$$NSE_C = 1 - \left(\frac{5701.6}{34633.2}\right) = 0.84 = 84\%$$

Since the MEs are less than 50% and the NSEs are all greater than 50% in all cases, it can be said that the modeled equations are very good in predicting past and future waterborne diseases and improved sanitation facilities in Ondo State, Nigeria. Thus, with good quality raw data, it is possible to reduce these error values. However, it is reasonable to conclude that the various models can achieve their purposes in Ondo State.

4.0 Conclusions

The level of access to Potable Water in Ondo State has less significance on the prevalence of Waterborne Diseases when compared to the impact of improved sanitation on the diseases in the State. Waterborne diseases in Ondo State are best attributed to unhygienic practices by the people of the State since the least average error was generated when the prevalence of diseases in the State was predicted with information available on Improved Sanitation.

This study may be adopted for future planning and implementation of SDG 6, Target 1: i.e., by 2030, we may come to achieve universal and equitable access to safe and affordable drinking water for all' having helped in identifying the problem of water accessibility in Ondo State. Since this study has helped to enumerate and distinguish between improved and unimproved sanitation and has also identified the necessary parameters of assessments, SDG 6, Target 2 which specifies that 'by 2030, we may come to achieve access to adequate and equitable sanitation and hygiene for all…,' will become easily achievable.

A linear relationship has been established between access to potable water and waterborne disease occurrence; between improved sanitation and waterborne disease occurrence; and between access to potable water and improved sanitation in Ondo State. It is now possible to predict any of the observed parameters (i.e., access to potable water, waterborne disease occurrence and improved sanitation) if one of them is known in Ondo State. The prediction or modelling of each of the identified variables i.e., improved sanitation, access to potable water and waterborne diseases with another variable that the study has adopted will become useful in identifying one parameter (say potable water access) once the other (say improved sanitation) is known, hence saving time and energy needed for data sourcing.

Declarations

ETHICAL APPROVAL

The authors of this work ensured that all ethical standards were complied with throughout the duration of the work and no human or animal rights was violated.

CONSENT TO PARTICIPATE

All author (s) and co-authors who collaborated in the project have consented to participate in the work.

CONSENT TO PUBLISH

The permission to publish this article has been sought and obtained from all contributing authors.

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AVAILABILITY OF DATA AND APPROVAL

The datasets analyzed during the current study are available from the corresponding author upon reasonable request

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COMPETING INTEREST

The authors declare no competing interest in this research paper.

Authors' Contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by H.A. Adegoke, H. Soliu and S.O. Bilewu. The first draft of the manuscript was written by H.A. Adegoke; data used was sourced and made available by S.O. Bilewu and data was analyzed by H. Solihu. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Figures

Figure 1: Map of Ondo State Showing the Eighteen Local Government Areas in the State (Developed by the Author)

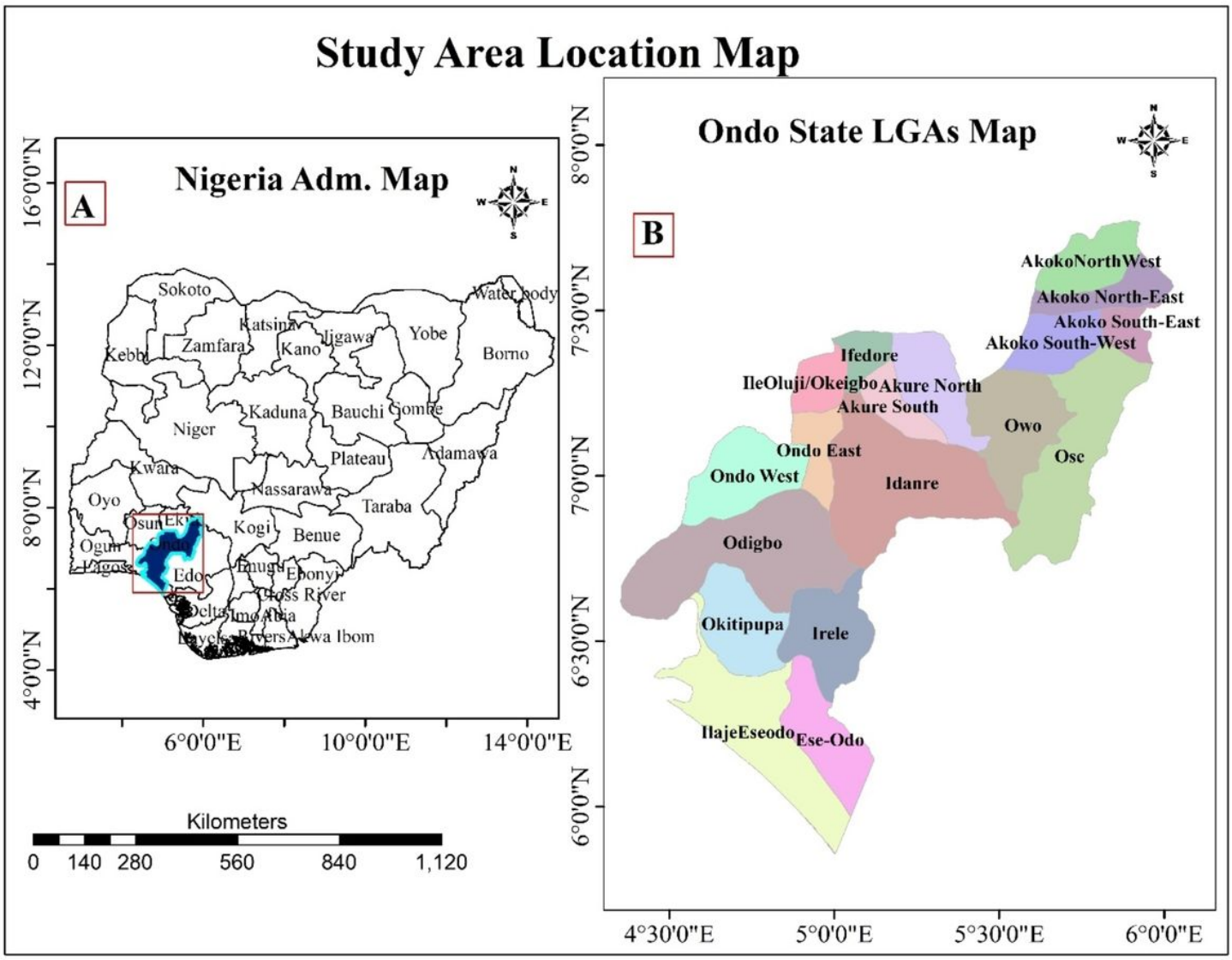

Figure 1

Map of Ondo State Showing the Eighteen Local Government Areas in the State (Developed by the Author)

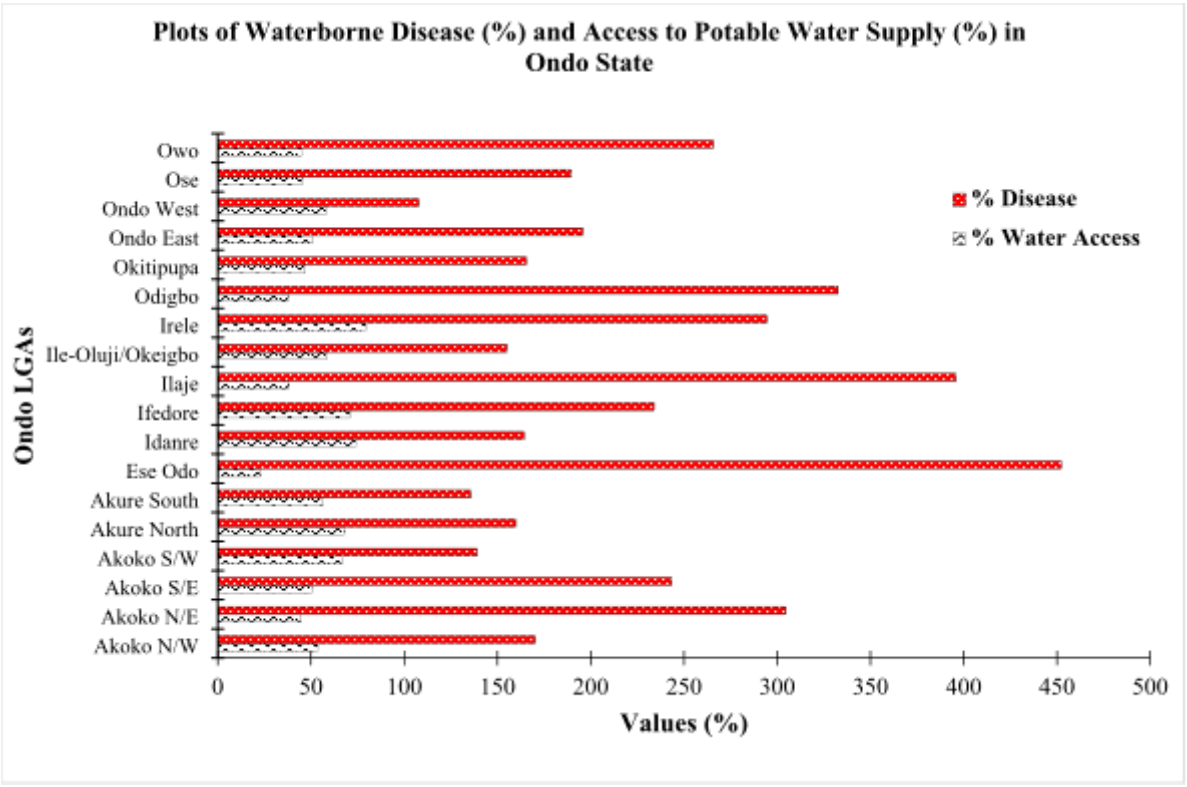

Figure 2

A Clustered Bar Chart Showing the Plots of Access to Potable Water (%) and Waterborne Disease (%) in Ondo State

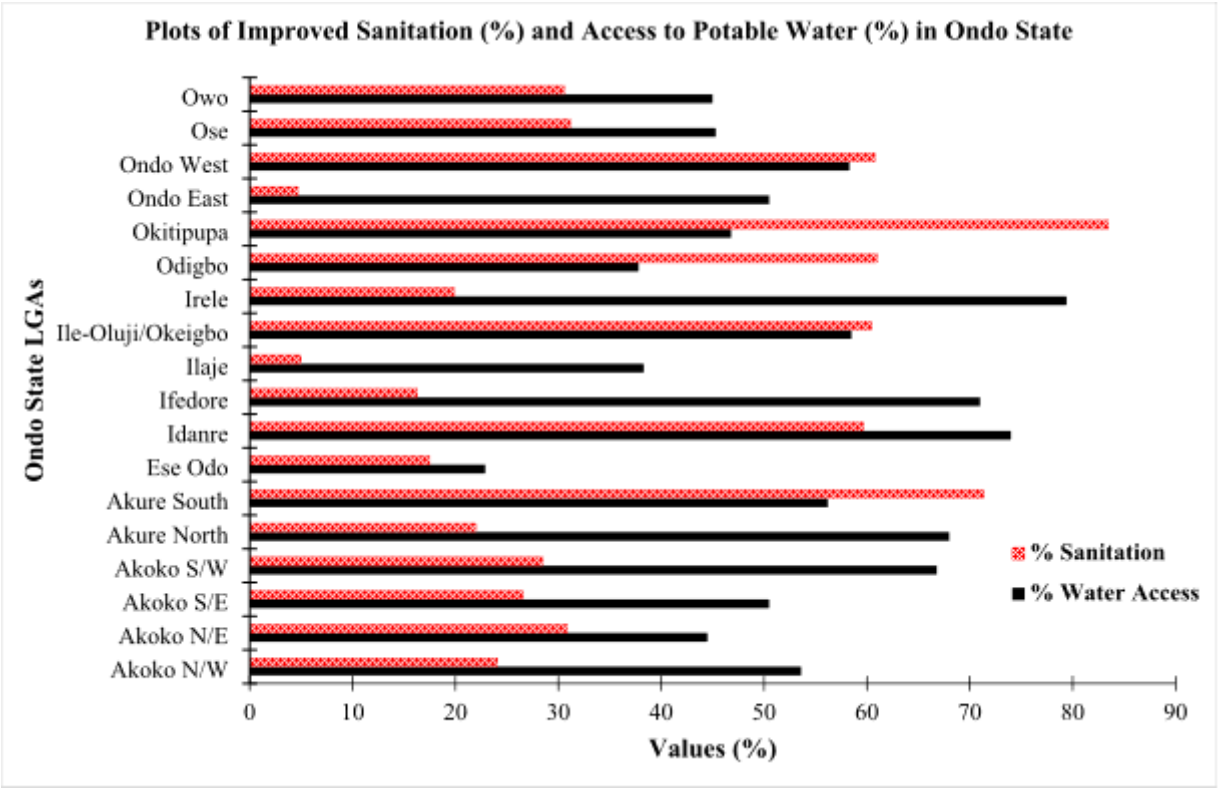

Figure 3

A Clustered Bar Chart Showing the Plots of Access to Potable Water (%) and Improved Sanitation (%) in Ondo State

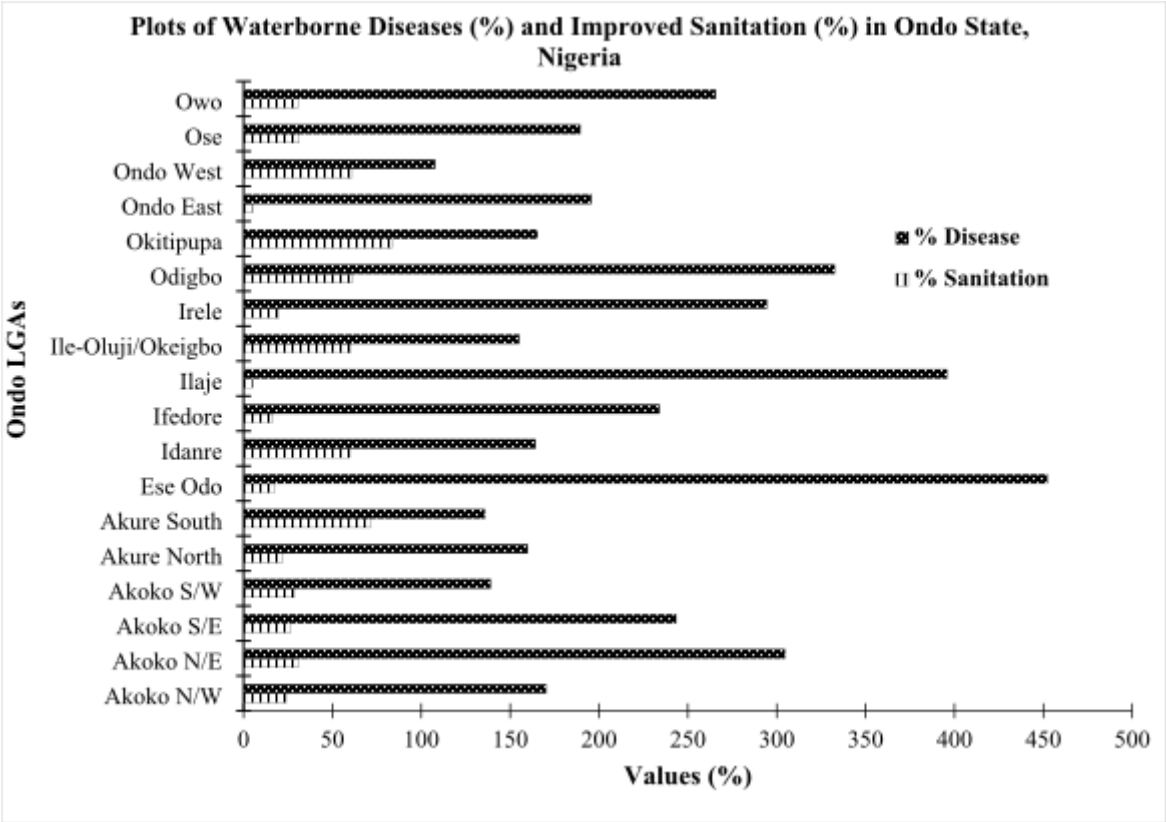

Figure 4

A Clustered Bar Chart Showing the Plots of Access to Potable Water (%) and Improved Sanitation (%) in Ondo State

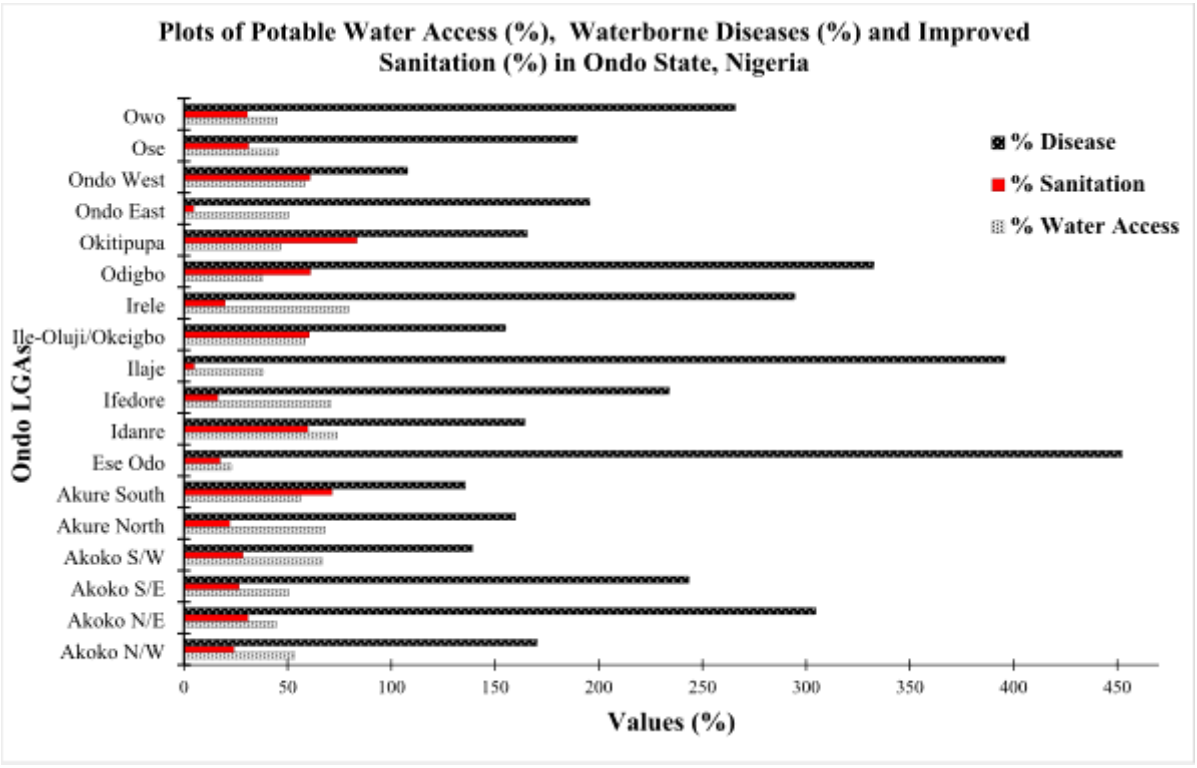

Figure 5

A Clustered Bar Chart Showing the Plots of Access to Potable Water (%), Improved Sanitation (%), and Waterborne Diseases (%) in Ondo State