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Population Growth and Pipe-Borne Water Supply in Calabar Metropolis: Finding the Balance

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Abstract: *This study focused on finding the balance between population growth and pipe-borne water supply in Calabar, Cross River State, Nigeria between 2007 to 2015. Secondary data was collected from Cross River State Water Board Limited (CRSWBL) and the National Population Commission. Analysis of data using the Pearson Correlation Coefficient showed that there is positive relationship between population growth and pipe-borne water supply (r=0.818, n= 1, p = 0.007<0.05), implying that as the population increased volume of water supplied also increased, although the accompanying increase in supply is not commensurate with water needs of the populace. This is buttressed by further results which revealed insufficiency in volume supplied in the area considering the World Health Organization (WHO) and Cross River State Technical Unit (CRSTU) criteria. The Independent Sample t-Test showed there was statistical significant difference (t (12.4) = 6.84, P= 0.0 < 0.05) for the WHO criteria and otherwise (t (9.72) = 0.174, P= 0.866 > 0.05) for the CRSTU, as the mean difference of water supplied by CRSWBL during the period and water demand of the populace was significantly low for the former (108561.66m^3) and high for the latter (4632857.4m^3) More so, as deduced, the average quantity of water availed an individual in the Metropolis per day in 2015 was 13 litres, way lower than the 30 litres stipulated by CRSTU and 50 litres by the WHO. It was thus recommended that CRSWBL increases the volume of water supplied, with consideration to the water needs of the people and keep pace with the teeming population. Also, the pipe-borne water providers should use the WHO 50 litres standard as its yardstick for measuring its progress on efficient service delivery as the CRSTU 30 litre criteria is not universal and would give room to ineffectiveness.*

Keywords: *Population growth, pipe-borne water supply, water needs, water demand.*

1. Introduction

Population growth is a major contributor to water scarcity. The global population is expanding by 80 million people annually, increasing the demand for freshwater by about 64 billion m^3 a year (Population Institute, 2010). Rapid population growth and urbanization could expose more people to water shortages, with negative implications for livelihoods, health, and security. These demographic trends, coupled with increasing per-capita water consumption, will be a huge development challenge (Bates, Kundzewicz, Wu and Palutikof, 2008). Growth in population implies mounting demand and competition of water for domestic, industrial, and municipal uses (Population Action International, 2011). At the household level, demand for water is determined by demographic factors including household size, composition, and age structure. Population growth leads directly to increases in overall water demand, while other demographic factors such as population distribution and age structure modifies the pattern in demand and determines increases in household water demand. Overall, the amount of water each person uses is expected to increase as incomes grow and consumption increases (UN-Water and FAO. 2007).

Evidences are ample that there is an explosion in the population of cities in Nigeria (Eja, Inah, Yaro and Inyang, 2011; Nwosu, 2013). The effect of the rapid urban population growth is noticeable through the provision of municipal services such as pipe-borne water. Expectations of the populace on the activities of policy makers for the supply of water are quite high. Urban and population expansion has been seen to offset the gains made by the government in her effort to provide water (Sule, 2008). Water supply is still considered primarily as a State responsibility and the government in Cross River State actualizes this through the CRSWBL. In 2015, CRSWBL recorded an average monthly water supply of 573,981 m3, with a laudable graduation in volume supplied as the average monthly supply in 2007 was 360,738 m3 (CRSWBL, 2015)

Water can be said to be adequate when an individual is availed a quantity of at least 50 litres per day (World Health Organization, 2003) and according to CRSTU (2009), at least 30 litres is suitable per person per day. This research critically examined the dynamism in population of the city vis-à-vis volume of water supplied by CRSWBL at different temporal scales. Specific objectives of the study were to assess the relationship between population growth and pipe-borne water supply in the Metropolis over a period of 9 years (2007 to 2015) and to compare the volume of water supplied with the actual water needs of the residents within the area over the same period.

The unavailability of water in required proportion for man's use has assumed global crises dimension. According to the Population Institute (2010), only 20 percent of the global population has access to running water and over 1 billion people do not have access to clean water. The Population Institute noted further that with a projected population of the world to expand to 9 billion people by 2050, it is estimated that 90 percent of the additional 3 billion people will be living in developing countries, many of which are already experiencing water stress or scarcity. In Calabar, the situation is dire and similar to what is obtainable in other Nigerian cities as noted by Krebs (2010), Ohwo and Abotutu (2014), Lawal and Bashorun (2015), etc. A preliminary survey by the authors in Calabar revealed that institutional and physical problems have diminished the availability of the essential commodity, forcing residents to resort to construction of boreholes in their compounds and where a borehole is not present in the residence, women, young men and children are seen spending reasonable time carrying buckets and other containers to and from other water supply sources. CRSWBL thus appears to be overwhelmed by the rising demand for portable water by the teeming population in the Metropolis. As the population of the city grows, the water board is pressured to act correspondingly. Demand for the service increases and where supply is not commensurate as observed from the preliminary survey, a vacuum is created which would require extra efforts to fill.

Calabar Metropolis is the capital city of Cross River State, in the southern region of Nigeria. The city lies between Longitudes 8°18'00''E to 8°24'00''E and Latitudes 4°54'00''N to 5°04'00''N, sandwiched in between Odukpani LGA to the north, the Calabar River to the west, Great Kwa River to the east and the creeks of the Cross River as it empties into the Atlantic Ocean in the South. The Metropolis covers a land area of 137.039 square kilometers (sqkm) and had a population of 328,878 in 1991 and 375,196 in 2006 according to the National Population Commission (NPC).With a growth rate of 2.54 (World Bank, 2015) and continued development of the City, the projected population for 2015 is given as 529362. The population density of the city is mapped in Figure 1.

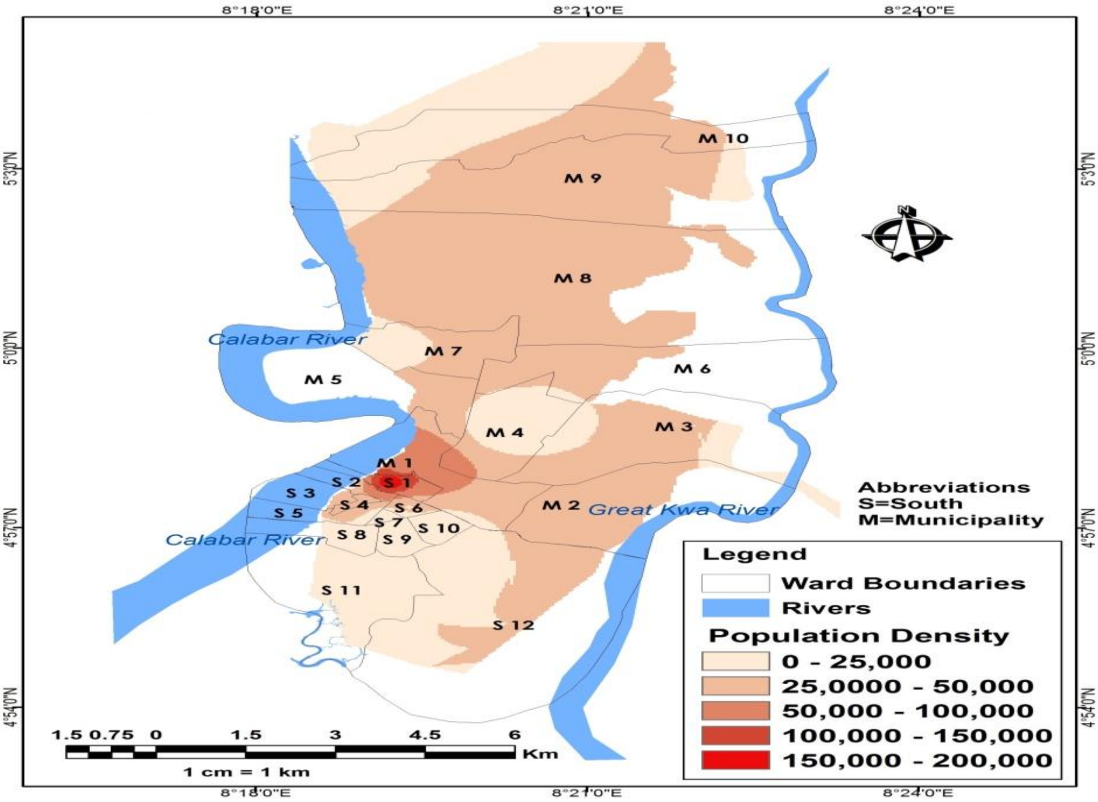

Figure2. *2015 Population density map of Calabar Metropolis [Source: Authors, (2016)]*

2. LITERATURE REVIEW

The ability of the human populace to have sufficient provision of water has been acknowledged in different literatures, a few of which are reviewed in this study. Ishaku, Majid, Ajayi, and Haruna (2011) in their work observed that access to safe water supply has great influence on the health, economic productivity and quality of life of the people. Abaje, Ati and Ishaya (2009) studied the nature of portable water supply and demand in Jema LGA of Kaduna State, Nigeria. They deduced that most of the people that have pipe-borne water in their houses are not satisfied with the water supply due to its insufficiency and intermittency. Also, Ezenwaji, Eduputa and Ogbuozobe (2015) in their work proposed employing water demand management option for the improvement of water demand supply and sanitation in Nigeria. The strategy is demand driven as against the supply approach and recommends that consumers should be motivated to regulate the amount and manner in which they access, use and dispose water to avoid waste.

Roudi-Fahimi, Creel and De-Souza (2001), attempted to find equilibrium between population and water scarcity in the Middle East and North Africa (MENA). They reaffirmed that Population growth usually increases demand for water in all sectors of the economy and divulged that MENA's population more than doubled between 1970 and 2001, rising from 173 million people to 386 million people, reducing the average amount of fresh water available per capita by more than half, to 1,640 cubic meters per person per year. They thus proposed the following sustainable measures to balance water scarcity and supply/demand in the MENA countries; Qanats (chain wells) and rainwater harvesting, sequential water use, desalination, water reallocation, conservation, etc.

The micro determinants of the demand for public pipe-borne water in Ilorin, Nigeria was assessed by Ijaiya and Abdul-Rahman (2012). The study emphasized on whether factors such as education, occupation, household size, income, price of water, perceived quantity, quality and reliability of water, existence of alternate water sources and distance travelled to same, etc. are the significant factors that determine the demand for pipe-borne water at household level in Ilorin. Their findings showed that variables like the income of the people, the quality of water supply, the reliability of supply and the price of water never influenced the demand for pipe-borne water in the area. Also, Saleh and Sada (2013) in their work on pipe-borne water supply in Malumfashi Town, Katsina State proved empirically that there were shortages and spatial variations of pipe-borne water supply, due to inadequacy of supply, relief factor, population growth and the nature of water system.

Considering social and demographic factors such as gender, marital status, number of persons in households, socio-economic background and geographical locations, Amori and Makinde (2012) studied the significant differences in perception of the people in two major Nigerian cities. They revealed that there were no significant differences in the way populace views the issue of access to safe and potable water supply as the respondents acknowledged, in the course of the study, that even though they were connected to water supply, yet supply potable water was irregular and also compounded by the problem of acquiring water from alternative means due to the long distance separating them from public taps or disconnection from public source due to inability to pay water levies or poor distribution system on which water supply is based.

To proffer workable solution to the deficit in water supply in Calabar, Njoku, Okon, Okpiliya, Agbor and Ekwok (2017) adopted Epanet spatial modelling tools to perform real-time simulation of the hydraulic behaviour within the CRSWBL pipe networks. The analysis assessed the movement and performance of water within the distribution system in an extended period simulation of 6:00 am, 12:00 noon and 6:00pm times of the day. Based on universal standards, locations with pressures and flow-rates that fell short of the standards were identified. The height of the elevated water tanks (EWTs) and pipe junctions above mean sea level (AMSL) proved to significantly influence water pressure which in turn influences the availability of water for household use. The authors recommended a reassessment of the existing pipe-borne water network to enable equitable water supply for the Calabar populace.

World population has continued to grow throughout history. While the human demand for fresh water has risen steadily, since 1940 the global water withdrawals have risen even faster than the rate of population growth (PCJP, 2003). It is correct to deduce that more people need more water. However, to attribute to population growth a disproportional role misrepresents the true picture. The ever growing concentration of a very high percentage of the world's population in large urban areas, especially in mega-cities propose new challenges for water management, which will seriously impact the short and long-term local demand for water (PCJP, 2003). Previous studies have not widely assessed the lapses in water supply for the populace considering global best practices, especially in Calabar as well as the balance between water supply and demand. However, the authors in the reviewed literatures revealed that population growth was a major factor the influenced deficits in volume of water availed to the people. In Nigeria however, the deficit was not blamed on only population expansion, but also on the inefficiency of the municipal water agencies to produce and distribute sufficient amounts of water.

3. Materials and Methods

Data for this study was acquired mainly from secondary sources such as existing official and unofficial statistics from publications including journals, articles, theses, books, conference papers and reports of renowned organizations from both paper and virtual platforms. The 1991 and 2006 census data from the NPC and CRSWBL monthly data of volume of water supplied to the Metropolis from 2007 to 2015 were also adopted. To derive the population of the area for the periods not provided by the NPC, a growth rate of 2.54 given for the area by World Bank (2015) was adopted for projecting the population using the following formula:

$P_n = r/100xP_o + P_z$……………………… Equation (i)

Where P_n = Population of year to be projected to

P_o = Base year population

r = Growth rate

P_z = Previous year

For Calabar Metropolis, in the years under study, the EWD was calculated based on the CRSTU standard of 30litres of water per individual daily and the WHO specification of 50litres per person per day, using a mathematical linear equation given as:

$\mathbf{EWD_n = Sta \times DY_n \times P_n}$,..Equation (2)

Where:

EWD_n = Expected Water Demand for the specific(n) year.

Sta = Minimum volume of water that should be used daily per person (volume according to standards).

DY_n = Number of days in the specific (n) year and P_n = Population of the specific (n) year.

This linear equation was developed from the Washington State Department of Health's (2001) water systems design manual equation for calculating residential water demands. In the manual, water demand was calculated by multiplying the 'per unit' demand by the total number of residential units in the area. In this case, however, the minimum volume of water that should be used daily per person was multiplied by the number of days in a year and the population of the year under consideration. Because the standard used was in litres, the result derived was as well in litres, was and was converted to cubic meter, the unit for volume of water supplied by the board. This was to ensure standardization. The local (CRSTU) and international (WHO) standards were adopted so that comparisons can be made from the results obtained. The Independent Sample t-Test was then used to test the significance of the relationship between means of water supplied and EWD for 9 years in the Metropolis considering the WHO and CRSTU standards separately. The relationship between population growth and pipe-borne water supply in the Calabar Metropolis between 2007 and 2015 was also assessed using the Pearson Product-Moment Correlation coefficient.

4. Results and Discussions

4.1. Population Growth and Pipe-Borne Water Supply in Calabar Metropolis

The relationship between population growth and pipe-borne water supply in the metropolis from 2007 to 2015 was studied empirically. The monthly volume of water supplied by the water board for the period under review and the projected population is shown in Table 1 which reveals a gradual increase in the volume of water supplied from 4328865 m^3 in 2007 to 9655066 m^3 in 2014. The Metropolis however experienced a drastic shortfall in supply in 2015 when the volume supplied reduced to 6887782 m^3. Also, based on a projection of the population of the Metropolis, the population of the area in 2007 stood at 462534 and 529362 in 2015.

The Pearson Product–Moment Correlation coefficient was executed to determine the relationship between the annual volume of water supplied by CRSWBL and the population of the metropolis from 2007 to 2015. The data showed no violation of normality, linearity or homoscedasticity. The output in Table 2 shows that there was a positive correlation (r=0.818, n= 1, p = 0.007<0.05) between population growth and pipe-borne water supply in the Metropolis.

Table1. *CRSWBL volume of water supplied and projected population from 2007 to 2015.*

Month	**Volume Per Year (M^3)**								
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
January	349664	494315	510270	437297	542747	581845	728294	831277	818594
February	329474	495'395	491490	362450	484048	495566	581204	831820	578639
March	393853	505061	510109	431190	554674	690063	792608	806671	470985
April	329623	452347	487720	396117	557189	700997	703970	783611	369343
May	295'377	487'003	413082	471742	521838	697504	489888	977945	373505
June	324858	454562	422708	388343	534136	692442	670199	884880	306523
July	332523	390054	390780	432578	526442	716089	627657	768970	663608
August	373627	391030	357441	448647	544847	686973	698328	680504	686610
September	366693	425009	365647	435794	555253	685275	769068	634963	663608
October	389740	511233	405555	471529	598046	696050	792434	791008	555676
November	376660	462861	389752	443934	560857	729891	748592	696184	724115
December	466773	553199	410755	503635	641378	778351	853844	967233	676576
Total	4328865	5622069	5155309	5223256	6621455	8151046	8456086	9655066	6887782
Population	462534	470888	479241	487595	495948	504302	512655	521009	529362

Source: *CRSWBL 2015, NPC 1991 and Authors field work, 2016.*

Based on the result returned by the correlation analysis, the alternate hypothesis is accepted and the null rejected that there is significant relationship between population growth and pipe-borne water supply in the Calabar Metropolis between 2007 and 2015. This denotes that as population increased over time, volume of water supplied by the board increased as well. The Water Board no doubt understands the need to increase water supply to meet up with the growing population. Where the population grew from 462534 to 529362, the volume of water supplied increased as well from 4328865m^3 in 2007 to 6887782 m^3 in 2015 with fluctuations in between within the period. The volume increase in water supply between the initial year (2007) and 2015 was 2558917m^3 and the number of persons added to the population within same period was 66828. This accompanying increase in supply does not however commensurate with water needs of the populace considering the WHO stipulated standard of water needed by an individual in a day. Within the period, the mean of water supplied was 6677881.6m^3 and water demand, 11310739m^3 as illustrated on Table 6.

Table2. *Correlation result of water supplied and population growth*

		Water supplied over the years	Population Growth
Water supplied over the years	Pearson Correlation	1	.818**
	Sig. (2-tailed)		.007
	N	9	9
Population Growth	Pearson Correlation	.818**	1
	Sig. (2-tailed)	.007	
	N	9	9

***. Correlation is significant at the 0.01 level (2-tailed).*

Source: *Authors field work, 2016*

4.2. Pipe-Borne Water Supply and Water Needs in Calabar

The volume of water supplied versus the water needs of the residents from 2007 to 2015 was also examined. Table 3 shows the annual volume of water supplied by CRSWBL and the EWD. This table is based on CRSTU standard of 30 litres per individual in a day and the WHO standard of 50 litres. The assessment was done to find out if the volume of pipe-borne water supplied by CRSWBL has been sufficient for service demands of the population over a period of 9 years. The volume of water supplied with the water needs of the residents in the Metropolis would be compared firstly using the CRSTU standard and secondly with the WHO standard.

Table3. *CRSWBL volume of water supplied and expected demand from 2007 to 2015*

CRSWBL Volume of Water Supplied and Expected Demand (Cubic Meter) from 2007 to 2015									
Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Volume of Water Supplied	4328865	5622069	5155309	5223256	6621455	8151046	8456086	9655066	6887782
EWD (CRSTU 30 litres standard)	5961070	6151819	6348678	6551833	6761493	6999765	7201158	7431589	7670584
EWD (WHO 50 Litres Standard)	9935117	10253032	10581131	10919723	11269156	11666276	12001930	12385983	12784307
Population (Projected)	462534	470888	479241	487595	495948	504302	512655	521009	529362

Source: *CRSWBL, 2015, NPC 1991 and Authors field work, 2016*

4.2.1. CRSTU Standard

To compare the volume of water supplied to the residents of the Metropolis and their water needs over the period, the EWD formula was used to calculate the expected water demand of the populace based on the CRSTU standard (Table 3). The Independent Sample t-Test was adopted. Tables 4 and 5 display the results of the analysis. There were no outliers in the data, as assessed by inspection of a boxplot. The volume for actual water supplied and expected water demand were normally distributed as assessed by Shapiro-Wilks test (P > 0.05). Homogeneity of variances were violated as assessed by Levene's Test of Equality of variances (P= 0.010), so separate variances and the Welch-Satterthwaite correction were used. Although, the expected volume of water demand (M= 6786443.22 m3, S.D= 585950.54 m3) was more than the actual water supply (M= 6677881.56 m3, S.D= 1778688.967 m3), there was no statistical significant difference (t (9.72) = 0.174, P= 0.866 > 0.05).

From the foregoing, considering the CRSTU standard, it is fit to reject the alternate hypothesis and accept the null that the actual volume of water supplied to the residents of the Metropolis and the EWD of residents from 2007 to 2015 does not differ significantly. This is visible from the mean of the two variables where the difference between the EWD and water supplied is 108561.66 m3 (Table 4). For pipe-borne water to be sufficient in the Metropolis, the difference between the two variables has to be substantial with the mean of water supplied significantly greater than that of the EWD. An insignificant difference in this scenario implies the provided water would not be sufficient for the residents of the area. This connotes a huge deficit in the resident's accessibility to portable water for their household uses and would no doubt tell negatively on their quality of life and health outcomes.

Table4. *Group statistic for CRSTU Standard*

	Water Supply	N	Mean	Std. Deviation	Std. Error Mean
Volume of water supplied	Actual Water Supplied	9	6677881.56	1778688.967	592896.3222
	Expected Water Demand	9	6786443.22	585950.5351	195316.845

Source: *Author's field work, 2016*

Table5. Independent samples t-test for CRSTU Standard

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Volume of water supplied	Equal variances assumed	8.615	0.01	0.174	16	0.864	108561.67	624239.31	1431890	1214767
	Equal variances not assumed			0.174	9.72	0.866	108561.67	624239.31	1504981	1287858

Source: *Author's field work, 2016*

4.2.2. WHO Standard

On the other hand, comparing the actual volume of water supplied to the residents of the Metropolis and the EWD of residents over the period using the WHO standard, an Independent Sample t-Test was again adopted. Table 6 is the group statistics showing the mean and standard deviation of the variables, while Table 7 displays the results of the test. There were no outliers in the data, as assessed by inspection of a boxplot. The volume of water for actual and expected water supplied were normally distributed as assessed by Shapiro-Wilks test ($P > 0.05$). Homogeneity of variances was once again violated as assessed by the Levene's Test of Equality of variances ($P= 0.09$), so separate variances and the Welch-Satterthwaite correction were used. Here, the expected volume of water demand (M= 11310739.44 m3 S.D= 976584.247 m3) was largely more than the actual water supply (M= 6677881.56 m3, S.D= 1778688.967 m3), and there was statistical significant difference ($t (12.4) = 6.84$, $P= 0.0 < 0.05$).

The result after adopting the WHO standard depicts significant statistical difference between volume of water supplied and the EWD of the populace from 2007 to 2015. Thus, enough evidence to reject the null and accept the alternate hypothesis that the actual volume of water supplied to the residents of the Metropolis and the EWD of residents over a period of 9 years differs significantly. Thus, going by the WHO criteria, water supply to residents in the Metropolis can be said to be grossly inadequate. The WHO comparison depicts a direr situation that calls for urgent attention with a deficit of 4632858 m3 in the mean of the volume supplied and demanded. This tells on the quality of access to water in the area which undoubtedly would be unsatisfactory in the city.

A comparison of results obtained considering both CRSTU and WHO standards reveal insufficiency in volume of water supplied in the area, in as much as the relationship was not significant for the latter and significant for the former. A calculation of the average quantity of water availed an individual in the Metropolis in 2015 based on the volume supplied and the projected population showed that on average, an individual is provided with only 13 litres of water per day. This Figure is way lower than the 30 litres stipulated by CRSTU and 50 litres by the WHO. The result exposes the lapse in the local standard which allows for laxity on the part of the service providers. The WHO 50 litre per-person-per-day standard is more universal and should be the benchmark which the CRSWBL would aim and work to attain.

Table6. *Group statistic for WHO Standard*

	Water Supply	N	Mean	Std. Deviation	Std. Error Mean
Volume of water supplied	Actual Water Supplied	9	6677881.6	1778688.97	592896.322
	Expected Water Demand	9	11310739	976584.248	325528.083

Source: *Author's field work, 2016*

Table7. *Independent samples t-test for WHO Standard*

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Volume of water supplied	Equal variances assumed	3.3	0.09	6.849	16	0	4632858	676383.5	6066727	3198989
	Equal variances not assumed			6.849	12.421	0	4632858	676383.5	6101044	3164672

Source: *Author's field work, 2016*

5. Conclusion

In this research, the relationship between population growth and pipe-borne water supply in Calabar Metropolis was holistically studied adopting spatial and statistical techniques at sampling and data analyses stages respectively. The problem of inadequacy in supply was pointed out and data were acquired from a field survey and secondary sources to aid in the analyses to achieve desired results and make recommendations. Two research objectives and two hypotheses were formulated to give direction to the work and facilitate scientific deductions within an epoch of 9 years (2007 to 2015), using mainly secondary data sources.

The Pearson Product-Moment Correlation coefficient and the Independent Sample t-Test specifically were adopted. A summary of the results showed that population and water cannot be separated. A probe of the prevailing relationship between population growth and pipe-borne water supply depicted a positive relationship. This denotes a significant relationship between both variables over time. Also, after considering both local (CRSTU) and international (WHO) stipulated standards for the least volume of water that should be availed an individual in a day and the volume supplied by the Board over the years, inferences revealed that the volume of water supplied by CRSWBL was not commensurate with the water needs of the populace within the period studied.

RECOMMENDATIONS

As a follow-up to the findings of this research, it is recommended that the CRSWBLincrease in the volume of water supplied in line with the needs of the resident. Having identified all the problems that cause insufficiency in the volume of water supplied, the government still cannot negotiate on the need to upsurge the volume of water it disburses to the populace. The reasons are not far-fetched. The lapse in meeting up with local and international standard stipulated for the quantity of water necessary for the well-being of an individual daily is one reason while the evident increase in population of the area is another. When this is done, the end of the problem of in-accessibility to pipe-borne water in the area comes to sight.

Also, the result of the analysis on the volume of water supplied and demanded for exposed the lapse in the CRSTU local standard which allows for laxity on the part of the service providers. The WHO 50 litres standard is more universal and should be the yardstick which the CRSWBL would aim and work to accomplish. Municipal water administrators should likewise attempt to deduce the deficits in the volume of water supplied with frequent assessment of population dynamics and consideration of global best practices in volume availed to an individual not only in Calabar, but beyond.

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