

AN EXAMINATION OF URBAN PIPE BORNE WATER SUPPLY AND DEMAND IN SOKOTO METROPOLIS, SOKOTO STATE

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ABSTRACT

While the world's population increased rapidly in the 20th century, the use of renewable water resources has grown six-fold leading to water crisis and stress in Nigeria's major cities. Despite Nigeria's abundant water resources, the Federal Ministry of Water Resources in 2004 noted that less than half of the 85 million people living in urban and peri-urban areas in Nigeria enjoys a reasonable water supply. This paper is aimed at investigating the challenges of sustainable urban water supply in Sokoto metropolis. Both primary and secondary data were obtained through questionnaire administration. The collected data were analyzed using trend based technique as well as Pearson's product moment correlation. The results revealed that there is a good correlation between water supply and demand and that the supply is not keeping pace with the ever increasing demand. This paper suggested a Government-Community based approach towards ensuring adequate water supply. Government should also increase the budgetary allocation of Sokoto State Water Board for maintenance and upgrading of water supply facilities to the required capacity to enhance supply to the growing population in Sokoto Metropolis.

Key words: Sustainable, Urban, Water Supply, Metropolis, Sokoto

1.0 Introduction

The Sub-Saharan Africa is within the arid and Semi-arid part of the continent characterized by limited water resources with increase pressure of accessibility due to expanding urban, industrial and agricultural water requirements. It was reported that globally, over 40% of all people who lack access to drinking water live in Sub-Saharan Africa. The problem persists more in the region because of the slowest and poorest technological advancement, low income and institutional capacity to mitigate the problem (WHO, 2012, Kevin and Nicholas, 2010; MacDonald, 2005).

Water is the major limiting constraints to development in many sub-Saharan African countries. It is one of the critical factors that determine settlement and development of people in Nigeria. As the future water demand is increasing due to modern developments, changing life styles and population growth, the challenges of meeting the increasing demand became necessary for development and economic growth of the region. The United Nation (UN) in 2000 assert that an additional 3.5 billion people would be added the world population of 6.2 billion then by the year 2050

with most of the growth in developing countries that already suffered water shortages (UN, 2000). The higher the population, the higher the demand for water. Population growth and urbanization together with changes in production and consumption have placed unprecedented demand for water resources in the last century.

The World Business Council for Sustainable Development in 2000 also noted that while the world's population increases rapidly in the 20th century, the use of renewable water resources has grown six-fold leading to water crisis and water stress." It applies to situation where there is no enough water for all uses, whether agriculture, industrial or domestic. Defining thresholds for stress in terms of available water per capita is more complex. However, entailing assumption about use and its efficiency have been estimated by the world business council for sustainable development (2000). They proposed that when annual per capita renewable fresh water availability is less than 1,700 cubic meters, countries begin to experience periodic or regular water stress.

Nigeria is well endowed with water resources, and is well drained with a close network of rivers and streams (Ayoade and Bamwo, 2007). Most of the smaller rivers are however, seasonal, especially in the northern part of the country where the rainy season is just for 3-4 months in duration. The expanding population and the threat posed by climate change are putting the water resources under pressure and calling for new approaches for water planning and management. Although water is the most abundant natural resources, the scarcity of treated piped-borne water to settlement all over the world may be due to either or all of misplacement of priorities by government, finance and cost of plumbing installation and water works maintenance, vandalization of plumbing installation, energy source, climatic influence,

political instability, etc (Akintola and Areola, 1980, Buba, 1982).

Nigeria is blessed with abundant water resources estimated at 226 billion m³ of surface water and about 40 billion m³ of ground water. However the Federal Ministry of Water Resources in 2004 noted that out of the 85 million people living in urban and peri-urban areas in Nigeria, less than half have reasonable water supply. It is worth noting that despite the fact that Nigeria is one of the signatories to the United Nations International Drinking Water Supply and Sanitation Decade whose objective was to supply water to all citizens of the country between 1981 and 1990. Despite the efforts of various governments at all levels, the water supply coverage in the country appears to be decreasing and deteriorating. One of the reasons for this deterioration is the enormous socioeconomic rate of development which far outstrips the level of water supply development. Other reasons include low investment in operation and maintenance which accounts for frequent breakdown of the production facilities, and lack of proper management of the nation's water resources (Buba, 1982).

In a bid to effectively manage water resources, there are challenges of poor state of infrastructure, climate change, and intensive cost on investment rapid urbanization process, corrupt practices, and problem of inadequate measures for cost recovery and inability by state, local or community to adequately pay their counterpart funding. Meanwhile the important role water play in the economic, social, recreational and human development and aquatic lives is the basis why emphasis should be laid on the management of this scarce natural resource (UN, 2006).

The first modern water supply scheme in Nigeria was commissioned in Lagos in 1915. By 1953, there were twenty seven other water

schemes in the country. Only a few of these were wholly financed by the colonial government, the others being partly financed by the Local government authorities, then called the Native Authorities. By 1960, when Nigeria became independent, the number of settlement having modern water supplies had risen to about sixty-seven. The total amount of water consumed also rose from about 62.7 million litres in 1953 to over 295 million litres in 1960. Since then, both the number of water supply schemes and total amount of water consumed per day has been increasing at phenomenal rates. For instance in 1973, there were in old western state alone 59 water supply schemes supplying potable water to 5million people in some 195 towns and villages in the state. In many Nigerian cities, water authorities are finding it increasingly difficult to meet the water demands of the people and industries (Ayoade, 1988).

This study is aimed at examining the urban water supply and demand in Sokoto metropolis, through identification of the various sources of domestic water, examining the present status of water demand and supply and identifying the relationship between the present water supply and demand in Sokoto metropolis.

The research hypothesized that there is no correlation between water supply and demand in the study area.

1.1. The Study Area

1.1.1 Location: Sokoto is the modern day capital of Sokoto state located at the extreme north-western part of Nigeria near the confluence of the Sokoto and Rima Rivers. The city is located on Lat. 13°30' and 14°N, and Long. 5° and 5°25'E (Figure 1) (ESRI, 2008).

1.1.2 Climate: The climate of Sokoto is tropical continental dominated by two opposing air masses, tropical maritime and tropical continental. The tropical maritime is moist and blows from the Atlantic, while the tropical continental air mass is dry, blows from the Sahara and predominates during the dry season. Much of the rains in Sokoto falls between June and September. The annual rainfall is between 500mm and 1300mm.

The state is characterized by hot and the cold seasons with the highest temperatures obtain during the hot season usually experienced in the months of March and April. The Harmattan period starts from November to February and is characterized by cold temperatures and high dusty winds (Jibril, 2004).

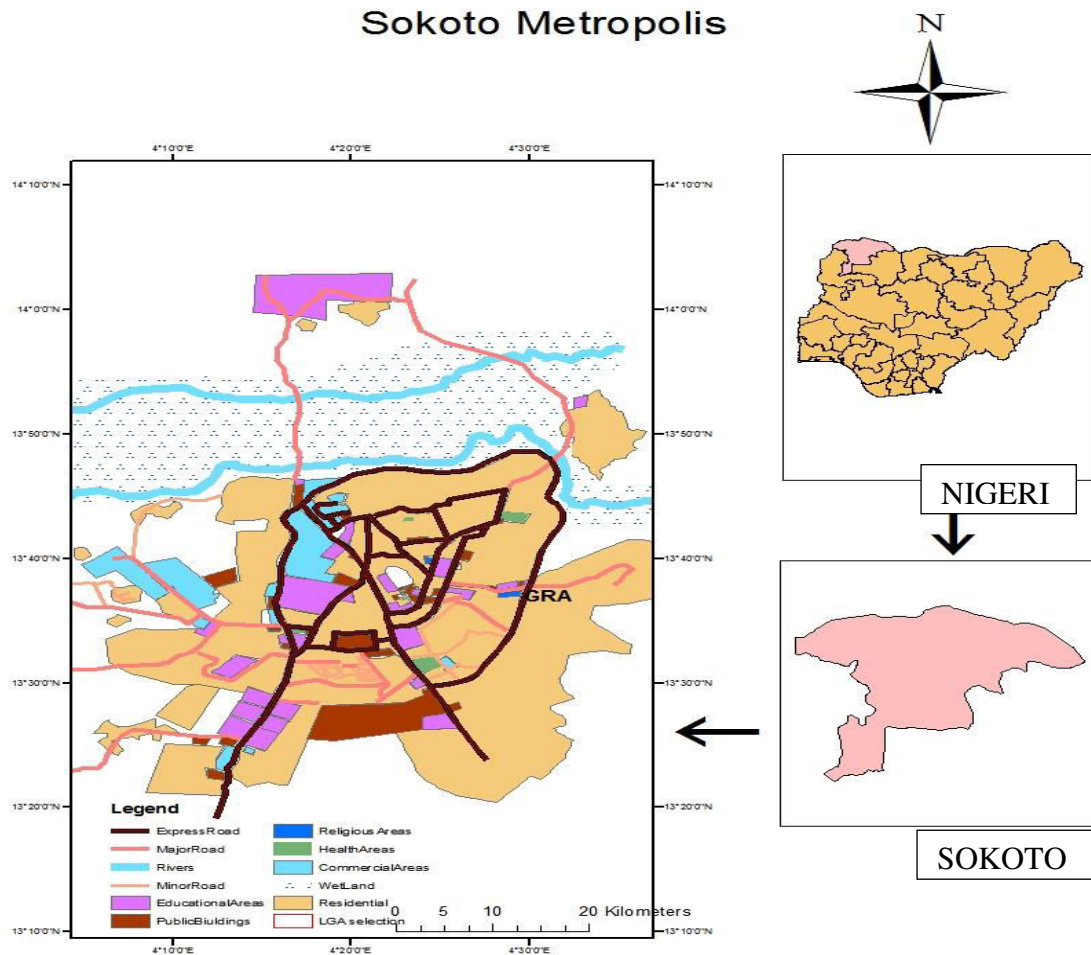


Fig 1: Sokoto Metropolis
Source: Modified from ESRI, 2008

1.1.3 Geology and Hydrogeology: Sokoto State falls within the Iullemeden basin and is covered by a series of sedimentary rocks which have been deposited over the basement complex rocks. These sediments range from continental to marine in origin and are classified under four major categories. The Gundumi formation is the oldest sedimentary rock in the state directly overlying the basement complex. It is made up of sandstones and clays, all of continental origin. The sandstone portion of the formation contains a lot of water and is currently being harnessed through boreholes.

The Rima group formations overlay the Gundumi and consists of three distinct marine sediments, namely, the Taloka, Dukamaje and Wumo formations. The Taloka is the oldest formation in the Rima group and consists of multiple layers of sandstones and shales. The sandstones contains water in appreciable quantity. The Dukamaje is shaly, non-aquiferous and serve as a confining layer to Taloka. The Wumo formation is the top layer in the group and consist of sandstone which is also aquiferous.

The Sokoto group formations are the third category of sedimentary rocks in Sokoto State

and is of marine origin overlying the Rima group. It consists of three main formations the Dange, Kalambaina and thin Gamba formations. The Dange formation consists of clays and shales, while the Kalambaina overlying the Dange, is made up of limestones. The Gamba is not so pronounced in some areas and is also shaly. The Limestones in the Kalaambaina has high water potential and serve as the main water source to Sokoto metropolis. The fourth category of sedimentary rocks in the State is the Gwandu formation which occurs in the north western and southern parts of the state. This formation consists of clays and sandstones and is the most prolific aquifer with high potential for groundwater (Kogbe, 1979; Oteze, 1979).

1.1.4 Soil and Vegetation: Sandy topsoil with clayey subsoil are common, except along plains of river valleys where alluvial soils predominate to the north of the state, especially along the border with Niger Republic, the undulating plains are covered by Aeolian deposits of variable depth (HWSD, 2012).

The State falls within the Sudan Savannah type of vegetation characterized by thorny species with a scatter of acacia tree species. The river courses are lined with dum-palms, which are interspersed with herbaceous cover of annual grasses (Eyre, 2013).

1.1.5 Water Supply Situation: Major sources of water supply in Sokoto metropolis include both the surface sources such as the rivers Sokoto and Rima and ground sources through boreholes and hand-dug wells. The Sokoto State Water Board supply pipe-borne water to the metropolis after series of treatment processes of raw water taken from the intake plant of Rima River.

Other important pumping and distribution areas are Asare Water Plant, Old Water Works, Treatment Plant, Bi-Water Plant,

numerous Boreholes, and Gwiwa Water Plant. Together, these plants have a total water supply volume of 117,347.79 m³ per day which represents the current water supply of the study area. This implies that annual pipe borne water supply is 42,831,943 m³ per year.

The nature of water pumping and distribution points in Sokoto Metropolis are as follows:

- Asare Plant pumps water to Arkilla hills storage tanks which later pump water down and distributes to Arkilla, Gwiwa, Bado, some part of Wamako areas, Gumbi, Kaura, Barkeji, Kalambaina, Bakin Kusu, Gidan Fulani, Gidanganau and some part of Bahuri area.
- Old market water works pumps water to Mabera including Ali-Akilu road, some part of the main town or heart of Sokoto, Minannata, GRA, Government House, Gawon-Nama, Polo Club, Sama Road, Old Airport, Dange-Shuni.
- Bi-Water plant however distributes to kware.
- Boreholes are scattered everywhere in the whole of Sokoto metropolis to supplement the supply in case of failure from the main tanks.

The quality of water supplied is continuously assessed through laboratory analysis every day at water board using qualified personnel. This research therefore seeks to answer the following questions:

- i. What is the quantity of pipe-borne water demanded in the study area?
- ii. What is the quantity of water supplied to the people in the metropolis?
- iii. Is the quantity of pipe-borne water supplied enough to meet the demand?
- iv. What alternative sources of water supply is available to people in the study area?

2.0 Materials and Methods

Types of Data: Both primary and secondary data were used for this research. The primary data were collected through a structured questionnaire administered to the people living in the study area. The secondary data includes the population figures obtained from the National Population Commission (NPC), Sokoto Office, annual water supply figures from Sokoto State Water Board office, written documents, journals and other printed materials.

2.1 Methods of Data Collection

Apart from Sokoto North and Sokoto South local governments, the metropolis also comprises of some parts of Kware, Bodinga, Dange-Shuni and Wamako local governments. One hundred and sixty (160) copies of the questionnaire were administered to selected individuals within the study area. Forty (40) respondents were taken from each of the above mentioned local governments within the metropolis, giving a total of 160 respondents.

Households were selected using systematic random sampling along selected streets where every 4th house along respective sampling division was selected and given a copy of the questionnaire to fill.

2.2 Techniques of Data Analysis

The analytical techniques used for data collection are:

2.2.1.1 Trend-Based Technique for Forecasting Water Demand (Sharp, 1967)

This technique involves the use of past-trend of per capita consumption and project into future. Estimates of future population are used to obtain total water demand and the future water demand.

The reason for the trend based technique is to justify the high demand for water especially

where the supply is inadequate to satisfy the demand. There is the need to know what the demand is, so this technique was used to calculate the actual water demand of the study area. The formula is in form of the product of the population figure and average daily per capita water consumption.

$$D_w = P \times (W_c/pd \times 365)$$

Where D_w = demand for water

P = population

W_c = water consume per day

For instance, if a person consumes 80 liters of water per day, then in a year, he consumes (80 × 365) liters per year, = 29,200 liters/per year 29.2cubic meter/year

Water demand = Estimated population figure × 29.2m³

2.2.2 Correlation Analysis

The study of the relationship that exists among two or more random variables (like demand and supply) is the main objective of the correlation analysis. Pearson's product moment correlation denoted by the letter r is used to test the hypothesis because it gives the intensity of a linear relationship between the two variables.

$$r = \frac{n \sum xy - (\sum x)(\sum y)}{\sqrt{[(n \sum x^2 - (\sum x)^2)(n \sum y^2 - (\sum y)^2)]}}$$

Where by:

x = the water supply

y = the water demand

n = number of years (8)

The value of r lies between -1 and +1. A positive value of r indicates a positive relationship and a negative value indicate a negative relationship. If $r = +1$ we say the relationship is perfect and positive and if r is -1, it indicates a perfect negative relationship.

3.0 Results and Discussion

Responses to the nature of resident of the study area is calculated and shown in Table 3.1.

Table 3.1: Residential Types

Types of Residence	Frequency	Percentages
Compound	50	32%
Private/Personal	80	50%
House	23	14%
Shop/Commercial	07	4%
Others		

Source: Fieldwork 2015

From the result in Table 3.1 above, 32% of the population resides in compound houses and about half (50%) of the population resides in private/personal houses. This result indicates that majority of the people in Sokoto metropolis use private/personal house e.g. Flats houses.

The proportion of houses connected with pipe borne water and those without tap water are presented in figure 3.1.

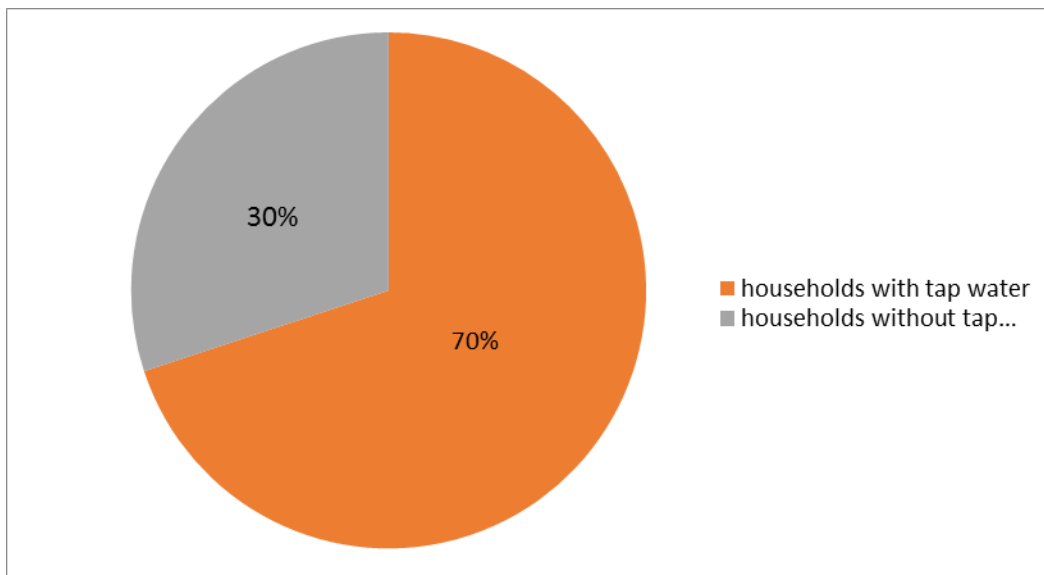


Figure 3.1: Proportion of residents with and without tap water connected to their houses.

Source: Fieldwork, 2015

Information in Figure 3.1 indicates that 70% of the sampled respondents have tap water connected to their houses, while about 30% are not connected with tap water from water board. This shows that 30% of the population in the study area are living without pipe-borne water supply and have to resort to alternative sources such as hand dug wells or water vendors, which may be unclean and unhealthy for consumption.

Table 3.2 shows an estimated annual water supply by the Water Board from 2007-2014. From the table, it can be seen that Sokoto metropolis received the highest total annual water supply in

the year 2010 and the lowest supply total in 2013. The highest and lowest values are 12,792,678m³ and 9,496,154m³ respectively.

Table 3.2: Estimated Annual water Supply for Sokoto Metropolis (2007-2014)

Year	Water supply (m ³)
2007	9,984,128.2
2008	10,382,713.1
2009	10,984,186.4
2010	12,792,678.3
2011	10,497,685.1
2012	10,496,660.9
2013	9,496,154
2014	11,450,992.3
TOTAL	86,085,198.3

Source: Sokoto State Water Board, 2015

From the result of Table 3.2 above, water supply in Sokoto metropolis for the past 8 years has not been uniform. There is variability in the total amount supplied from one year to another with the highest supply in the year 2010 and lowest in 2013. This according to water board officials is due a number of challenges faced by the board every year, ranging from erratic power supply, poor maintenance and rapid increase in demand due to continuous population increase in the metropolis etc.

It is important to state here that the Water Board have two sources of water viz: surface and ground water sources. The surface water is from river Rima and river Sokoto, while the ground water are sourced from numerous boreholes within the metropolis, strategically located to boost or compliment supply from the main water plants. Responses to the sources of domestic water supply is shown in table 3.3.

Table 3.3: Sources of Domestic Water Supply

Different sources of pipe-borne water supply	No. of households that responded	Percentage
Water board	76	47
Water tanker	19	12
Others	65	41
Total	160	100

Source: Fieldwork, 2015

From table 3.3, most of the sampled dwellers in the study area (47%) depend on water board as their major source of pipe-borne water. While about 41% also depends on Water Board supplies usually conveyed through other sources (e.g. fetched from taps outside their residences etc.). Respondents were asked whether the water supplied by water board is adequate or not to meet their demand. The responses are shown in figure 3.2.

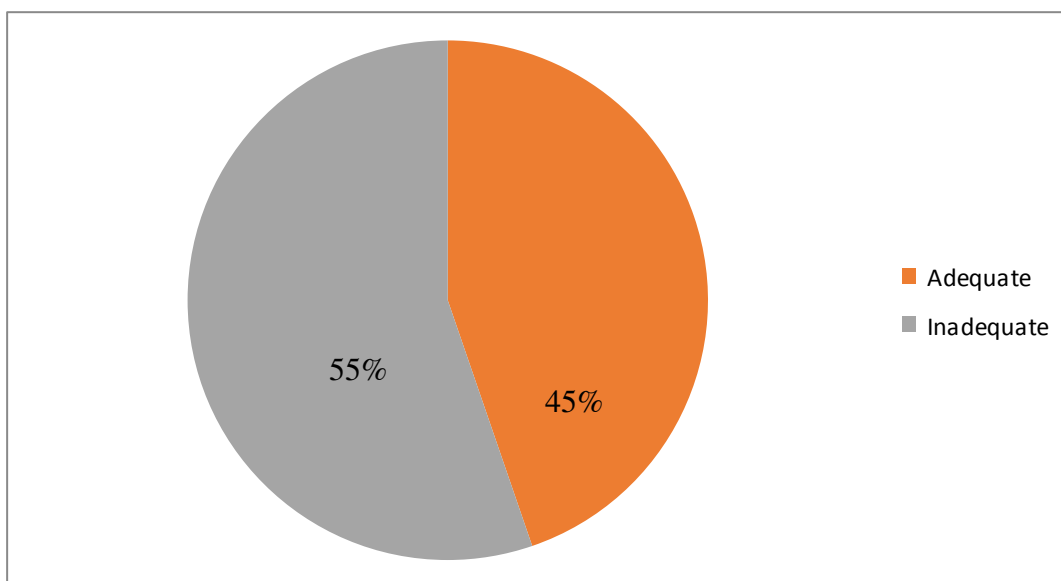


Figure 3.2: Adequacy of pipe born water in the study area

Source: Fieldwork, 2015

From figure 3.2, it is evident that large proportion of respondents (55.2%) are faced with inadequate pipe-borne water supply and only about 45% get adequate pipe-borne water supply. This means that majority of the residence had to resort to alternative sources to meet up with their water demand. The available alternative sources of water are presented in Table 3.4 as given by the respondents.

Table 3.4: Other Sources of Water Supply

Types of sources	Frequency of Respondents	Percentage (%)
Water vendors	55	34
Borehole	40	25
Well	45	28
Others (river, rain etc.)	20	13

Source: Fieldwork, 2015

This result indicates that 34% of the sampled respondents in the study area obtain their alternative water from water vendors, followed by about 28% households who uses dug wells as their alternative sources. Small proportion (13%) of the respondents confirmed using other sources such as river Sokoto or rain water catchment in the rainy season as their alternatives.

This research revealed that the supply of pipe-borne water in the study area is usually just for few hours every day. The water board confirmed that the only way they can supply water to the whole population in the metropolis is through rationing. The responses to the supply duration of pipe-borne water is presented in figure 3.3.

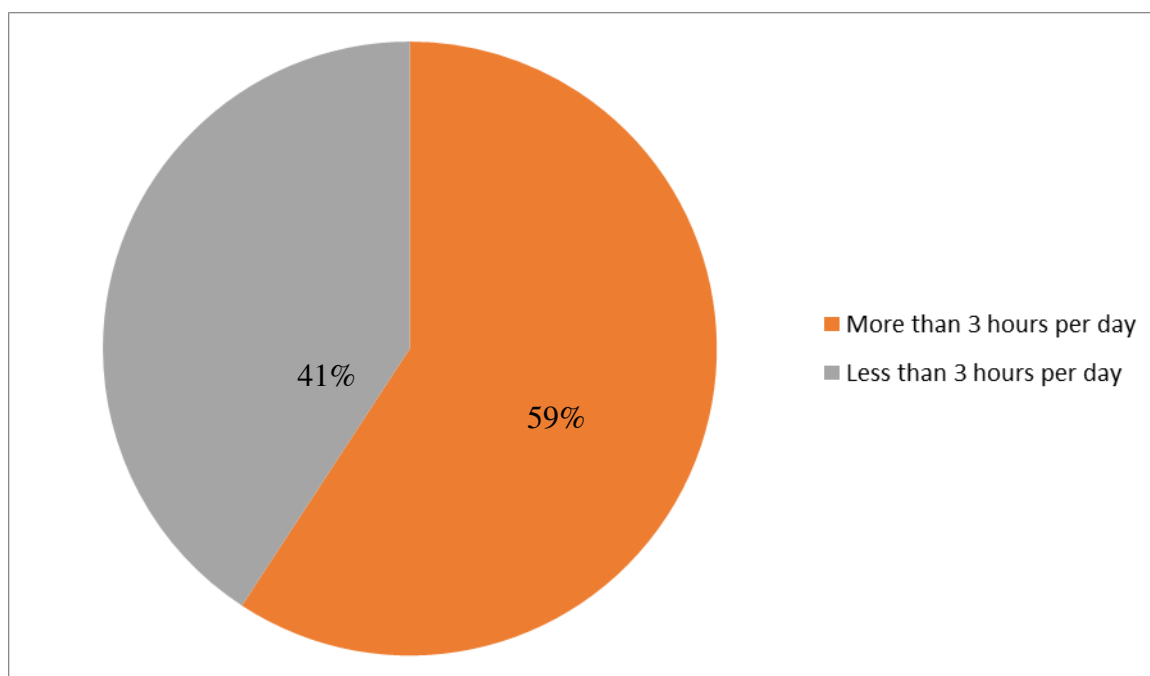


Figure 3.3: Water supply duration of tap water to the people in the study area

Source: Fieldwork, 2015

The result shows that only about 59% of the sampled respondents are supplied with tap water from water board for more than 3 hours and the remaining 41% are supplied for less than 3 hours. This result justifies that 41% of the population get their water from other sources such as wells, boreholes and water vendors etc. This necessitates the respondents to seek for alternative water supply.

3.1 Water Demand

In order to obtain the actual water demand for the study area, the projected population was multiplied by the trend based technique (Sharp, 1967). The results of the estimates are shown in Table 3.5.

Table 3.5: Estimated annual water demand for the study area from 2007-2014

Year	Population	Water demand(m ³)
2007	439,737	12,840,320.4
2008	445,049	13,199,830.8
2009	464,707	13,569,444.4
2010	477,719	13,949,394.8
2011	491,095	14,339,974
2012	504,845	14,741,474
2013	518,981	15,154,245.2
2014	533,513	15,578,579.6
TOTAL		113,373,263.2

Source: Fieldwork, 2015

From Table 3.5, the expected population estimates for 2015 is calculated as 548,451 and the water demand for that year was 16,014,769m³. Responses to the amount of water consumed per day was also calculated and presented in figure 3.4.

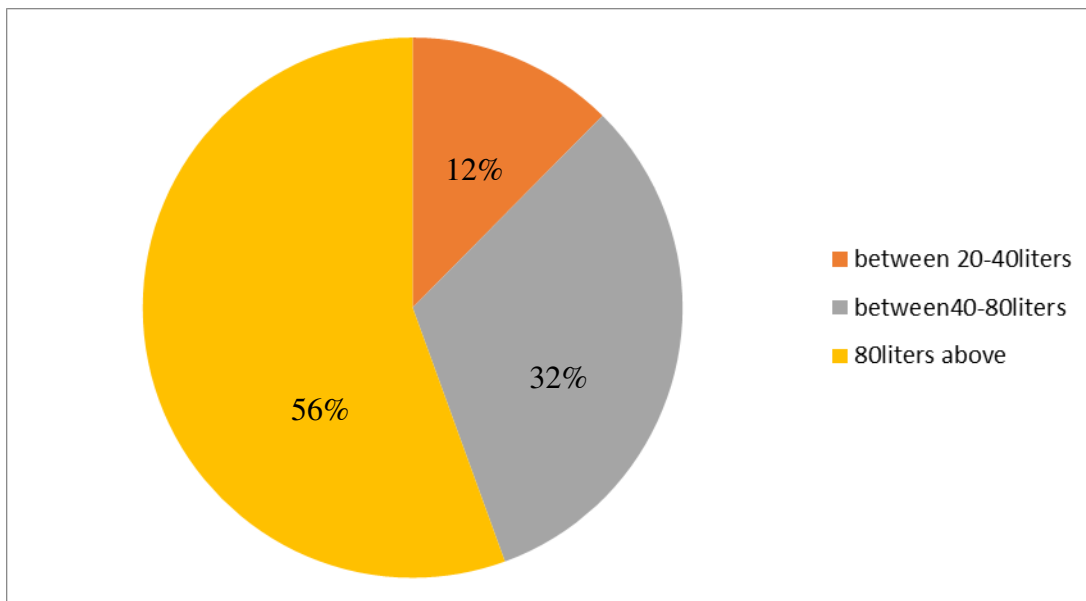


Figure 3.4: Quantity of water (litres) used by individuals per day for the study area
Source: Fieldwork, 2015

The results indicated that the minimum quantity of water used by most respondents (56%) in the study area is 80 litres and above, while others (32%) used between 40-80 litres. Only few respondents (12%) used between 20-40 litres per day. This shows the importance of pipe-borne water for everyday usage in the metropolis. If not available, it may cause serious problem to the inhabitants.

The research found that people in the study area uses water not only for domestic consumption but also for different purposes as presented in Table 3.6.

Table 3.6: Household Uses of Pipe-Borne Water

Types of uses	Frequency	Percentage (%)
Domestic use	122	77
Commercial use	31	19
Gardening use	07	4
Others	0	0
Total	160	100

Source: Fieldwork, 2015

In Table 3.6, domestic usage of pipe water carries the largest proportion of water utilisation (77%). It means that majority of the people uses tap water for domestic purposes. This is followed by commercial uses (19%) where few people engaged in packaging of water supplied by the state water board and sell as sachet water.

3.1.1 Comparison between Water Demand and Supply

Comparing supply and demand from Table 3.2 and 3.5 indicates that there are differences between supply and demand in all the years (2007 – 2014). The differences in terms of deficits are computed and shown in table 3.7. The expected water supply for the year 2015 according to the Sokoto State Water Board is estimated as 12,910,384.7m³, further confirming that the actual water supply will not be able to meet the estimated water demand for that year.

Table 3.7: Comparison of Estimated Annual Water Supply and Demand (2007-2014)

Years	Water supply(m ³)	Water demand(m ³)	Water supply deficit(m ³)
2007	9,984,128.2	12,840,320.4	2,356,192.2
2008	10,382,713.1	13,199,830.8	2,817,117.7
2009	10,984,186.4	13,569,444.4	2,585,258
2010	12,792,678.3	13,949,394.8	1,156,716.5
2011	10,497,685.1	14,339,974	1,547,295.7
2012	10,496,660.9	14,741,474	4,244,813.1
2013	9,496,154	15,154,245.2	5,658,091.2
2014	11,450,992.3	15,578,579.6	4,127,587.3
TOTAL	86,085,198.3	113,373,263.2	24,493,071.7

Source: Fieldwork, 2015

3.1.2 Correlation between Water Demand and Supply in the Study Area

The Table 3.7 shows the nature of water supply and demand for the past 8 years. This data was correlated using Pearson's Product Moment Correlation statistical method as follows.

$$r = \frac{n \sum xy - (\sum x)(\sum y)}{\sqrt{[(n \sum x^2 - (\sum x)^2)(n \sum y^2 - (\sum y)^2)]}}$$

$$r = \frac{(8(12.24514793 \times 10^{14})) - ((86,085,198.3)(113,373,263.2))}{\sqrt{(8 \times 9.335019461 \times 10^{14}) - (86085.198.3)^2)((8 \times 1.466755759 \times 10^{14}) - (11373263.2)^2}}$$

$$r = \frac{(9.796118344 \times 10^{15}) - (9.759759844 \times 10^{15})}{\sqrt{((7.468015569 \times 10^{15}) - (7.410661366 \times 10^{15}))((1.293404607 \times 10^{15}) - (1.273511150 \times 10^{15}))}}$$

$$r = \frac{3.6358 \times 10^3}{\sqrt{(5.7354203 \times 10^{13})(1.9893449 \times 10^{13})}}$$

$$r = \frac{3.63585 \times 10^{13}}{3.377829055 \times 10^{13}}$$

$$r = 1.07638662$$

$$r = 1.076$$

The correlation value r is equal to 1.076. This correlation indicates that the two variables (i.e. water supply and demand) are correlated. The correlation is mainly due to the fact that the water supplied is based on the increasing population resulting to increase in demand. This however does not mean that increase in supply is adequate enough to equate the increase in demand.

The Null hypothesis is therefore rejected, and the alternative is retained. This means there is correlation between water supply and demand in the study area.

4.0 Summary, Conclusion and Recommendation

4.1 Summary

This research examined the nature of urban water supply and demand in Sokoto metropolis. The research identified that the agency responsible for water supply to the metropolis is the state water board. Due to inadequate supply to meet the actual population demand however, people had to look for alternative sources of water supply through direct purchase from water vendors or construction of boreholes and/or hand dug wells.

The results generally found out that the average daily per capita water consumption is 80 litres per day which was used to compute the successive water demand for the area. The data for the estimated water supply and demand was computed and compared against

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each other from 2007-2014. The results revealed that there is a correlation ($r = 1.076$) between water supply and demand in the study area and that the water supplied is grossly inadequate to meet the continuous demand increase.

Recommendations

Based on the findings presented in this research, it is recommended that:

- There is the need for improved water supply capacity for the metropolis, considering the fact that the water supplied is always short of the water demand for all the years considered in this research.
- Additional water intake, treatment plant and pumping station capable of supplying water to equate the demand of the population should be put in place; or,
- Drilling of additional boreholes or water wells in different locations to supplement the existing supplies.
- Adequate funding to the Sokoto State Water Board should be a priority of government to ensure continuous maintenance and management of water supply facilities in the metropolis.
- Integrated Water Resource Management should be adopted and encouraged. There should be private participation in water management. This involves establishment of individuals or cooperative groups as stakeholders in water supply activities.

References

- Akintola and Areola, (1980). *Domestic Water Consumption in Urban Area*. Published by federal Department of Water Resources, Lagos, Nigeria.
- Ayoade, J. O. (1988). *Tropical Hydrology and Water Resources*. Pg. 209-219
- Ayoade J.O, Bamwo Y. (2007). Changes in Annual Rainfall Characteristics in Nigeria between 1931-1960 and 1961-1990. *The International Journal of Meteorology*, Vol. 32, No. 318
- Buba, A. (1982). *The problem of water in Kano city*. Unpublished Thesis, Dept of Geography, A.B.U Zaria.
- Eyre, SR (2013) *Vegetation and Soils: A World Picture*, 2nd edition, Edward Arnold books.google.co.uk/books?isbn=1412851009
- Jibril, Y.H (2004): *Philosophy among the Sokoto Scholars*, Benchmark Publishers, Kano Nigeria.
- Japan International Cooperation Agency (JICA), (1990) *The Study for Groundwater Development in Sokoto State*, *Unpublished Report Vol. II*, Federal Ministry of Water Resources and Rural Development, Nigeria
- Kogbe CA (1979) Cretaceous and Tertiary of the Iullemeden Basin in Nigeria. In: C.A. Kogbe (eds), *Geology of Nigeria*, 2nd edition. Rock View, Jos
- Kevin, C.N., O. Nicholas, 2010. Impacts of climate change on water resources in Africa: The role of adaptation. *African technology policy studies network (ATPS)*
- MacDonald AM (2005) *Developing groundwater: a guide for rural water supply*, ITDG Publishing, <http://www.developmentbookshop.com>
- Oteze GE (1979), *The Hydrogeology of North-Western Nigeria Basin*, In: Kogbe CA (ed), *Geology of Nigeria*, 2nd edition. Rock View, Jos
- Sharp, R (1967) "Estimation of future demand on water resources in Britain." *Journal of institution of water engineers*, Vol. 21, No 3 pg.23-249
- UNICEF and WHO (2008) *Joint Monitoring programme for Water Supply and Sanitation, Progress in drinking water and sanitation: (MDG Assessment report, 2008)* pg 2-25.
- United Nations, 2006. *Water, a shared responsibility*. The United Nations World water Development Report.
- WHO and UNICEF (2012) *Progress on sanitation and drinking water; 2012 update*. Joint monitoring programme for water supply and sanitation, New York, NY: UNICEF and WHO