AN ANALYSIS OF THE STATUS OF PIPE-BORNE WATER DEMAND FOR MALUMFASHI LOCAL GOVERNMENT AREA, KATSINA STATE, NIGERIA

By

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Abstract

A study for Pipe-Borne Water Demand (PBWD) analysis for Malumfashi Local Government Area (LGA), Katsina State Nigeria was carried out in order to analyze the status of pipe-borne water demand for the LGA from 1991 to 2023. The data for the study was obtained from the officials of the State water Board and National Population Commission (NPC). Methods used for investigation are geometric model for estimating population in the future years, trend-based technique for estimating water demand and Linear Regress Model for estimating the direction of trend. Results obtained indicate that population and water demand are increasing steadily. The trend of water demand was increasing at the rate of 17,245M^3/Year and the capacity of the Treatment Water Plant could not meet the pipe-borne water demand of the population. The consequence of this you could see people of the LGA now resort to alternative sources of water supply such as hand-dug wells, water vendors and among others. These predominantly unwholesome sources are variable sources of water borne-diseases. The study thus recommended that Water Board should ensure that pipe-borne water supply meets demand of population in order to avert any possible outbreak of water borne-diseases.

Key words: Analysis, Status, Pipe-borne, Water Demand, Malumfashi LGA

INTRODUCTION

Water demand is the amount of water required for people as a function of their needs. According to the World Health Organisation, (1992), in Ikelegbe and Okuruwa (2007), the daily requirement for the human body is 3-10 litres depending on workload or climate. The use of water for other purposes other than drinking will vary with cultural habits, standard of living, cost of water and its quality (Ikelegbe and Okuruwa, 2007). Water Supplies refers to the various ways urban residents get water for domestic uses as the inability of government to meet the high demand of urban residents has led to provision of water from alternative sources.

With the exception of air, water is the most important natural resource used by man, (Walton, 1970). The average human being has 65% of his total weight in the form of water. Man can exists for several weeks without food, but ten days is about the maximum survival period without water, and it may be less than this in certain parts of the world. Even when man has sufficient water to survive, its availability and quality have profound and continuing implication for general health and well-being. It has been estimated that about two-thirds of the population of the developing world draw untreated water from polluted sources. Diseases, which are either water-borne or water related, are endemic and affect some

500 million people each year, (Walton, 1970). The important of portable water in the daily lives of urban residents in Nigeria has been note (Onokerhoraye, 1984). Consequently, the nation since the colonial era has focused on the improvement of drinking water and plans for public water supplies have been based on projected increase in the total population and the financial allocation to this sector has also increased over the years (Akinola and Areola, 1980); in Ikelegbe and Okuruwa, 2007)

In Nigerian cities, it is common to find commercial, government establishments and high income residential areas with adequate supply of quality water while the densely populated lower income zones are served with few and widely spaced stand pipes which flow intermittently (Ikelegbe and Okuruwa, 2007). Water problems that are observable in most Nigerian cities include the poor distribution in time and space in relation to the needs of urban residents, a lack of adequate planning and management of water resources to ensure that supplies match the ever-growing demand over time and space. Despite the nations continued efforts to develop her vast water resources, the gap between water need and actual supply in urban centres has widened steadily (Oyebande, (1978). Ayoade and Oyebande (1978) attributed the nations water problems to two major factors; the poor distribution of water in time and space in relation to our needs and the lack of adequate planning and management to ensure a temporal and spatial convergence between demand and supplies. Ayoade (1978) stated that water availability and water demand and proper management are essential in other to achieve some convergence in both space and time. He argued that water resource evaluation is done with the primary objective of meeting the demand of various uses and of various users, and as such, evaluation of water resources is therefore not complete without consideration of the demands for water, which are controlled by socio-economic factors.

Statement of Research Problem

According to Biswas (1978) the supply of good quality pipe-bone water in adequate quantity is a vital factor in the determination of health, welfare and productivity of man. In spite of this, however, the existing situation of pipe-borne water in most parts of the world has become in adequate to meet the ever increasing demand. It was also common for piped supplies to be restricted to one part of a town, causing spatial variation of water supply. For instance, in 1937 only one third of Brad ford's population was receiving regular supplies and water carts still provided a door-to-door service in the less fortunate areas (Bradford Cooperation Water Departments, 1955). Ikelegbe and Okuruwa (2007) examined the supply of piped borne water in Benin City in terms of its availability, distribution and accessibility to households. Stratified and systematic sampling techniques were employed in selecting residents for the study, through the use of questionnaires and oral interviews. The results indicated a spatial and temporal variability in piped borne water supply in relation to social class within the city. Also Saleh and Inusa (2015) studied urban water supply and demand analysis for Katsina Urban Area and analyzed the level of adequacy of Pipe-borne water supply to the Urban Area. They used geometric method for estimating population in the future years, trend based technique for estimating water demand and least regress model in their analysis. Results obtained revealed population and water demand is increasing steadily while water demand does not meet the demand of increasing population. This trend holds true in Malumfashi local Area as well. Unfortunately, there is inadequate statistical technique which will make the people aware the cause of this trend. Pipe-borne water supply is scarce in the Local Government Area, in spite of the existing Water Board Authority. It is worse during the dry seasons. Most of the dwellers of the

Local Government Area draw their domestic water from wells and polluted streams, located in different locations in the Local Government Area. There are long hours of dry-taps in most of the distribution areas. People often spent five to seven days without getting water in their taps. The existing distribution network is old. Most of the pipes were installed in 1970. Part of this phenomenon had been studied by Suleiman (2002). On his critical appraisal of water consumption for Malumfashi Metropolis he estimated the average daily per capita water consumption for the area as 80 liters per day (80/pcd). This study focused only Malumfashi Metropolis. It does not focus the entire Local Government Area. That is very nice attempt; however, there are things remains to be studied. Problem of Pipe Borne Water Demand (PBWD), is it increasing or decreasing? What of population, is it increasing or decreasing? What is the source of pipe – borne water supply? Is the need of pipe-borne water demand with respect to time increasing or decreasing? What is it we do not yet know about the pipe-bone water demand in Malumfashi Local Government Area? The contending issues now are? What is the status of the population size of the Local Government Area from 1991 to 2023? What is the status of pipe-borne demand figures from 1991 to 2023? What is the trend of pipe-borne demand from 1991 to 2023? What is the status of future pipe-borne water demand? This study is out to answer these questions.

Aim of the Study

The aim of this study is to analyze the status of pipe-borne water demand in Malumfashi Local Government Area in Katsina State

Objectives of the Study

The aim of the study would be achieved by the following objectives:

i. Analyze the status of the population size of the Local Government Area from 1991 to 2023
ii. Identify the source of pipe-borne water supply in the study area
iii. Analyze the status of pipe-borne demand figures from 1991 to 2023
iv. Determine the trend of pipe-borne demand status from 1991 to 2023
v. Assess the status of future pipe-borne water demand

MATERIALS AND METHOD:

Location of the Study Area:

Malumfashi Local Area locates from Lat.11^0 3`30``N, Lat.$12^0$ 12`0``N, and Long.7^0 25`30``E, Long.$7^0$ 48`0``E. It boarders to the North by Musawa Local Government Area, to the East by Kano State, to the West by Kankara Local Government Area and the South by Kafur and Bakori Local Government Areas (Figure 1). Malumfashi Local Government Area lies in the upper reaches of river Turami, an important' tributary of major River Gagara drainage system. To the east and south-east, the ground rises to latrate capped hills which form a very important watershed between the north-westwards flowing Gagare drainage system, and the east/north-eastwards, flowing Chalwa drainage system, the later into Lake Chad (Saleh and Abdulmalik, 2013)

The Local Government Area is wholly underlain by rock belonging to pre- Cambrian Basement complex rock. Three major units of basement complex rocks can be identified within the area. These are:

i. Gneisses- this is hard banded, coarsely crystalline rock.
ii. Granite- Intrusive into gneisses and metasediments, consisting of hard crystalline igneous rock. Metasediments do not show the banded nature of gneisses, but they often jointed and fractured along a systematic pattern.
iii. Metasediments:- These are fine to medium grained rocks often showing a fine foliation, more massive types (quazites) form ridges 2-3 km east of Malumfashi Local Government Area (Saleh and Abdulmalik, 2013)

The climate of the area appears to be the same with Sudan type of climate. The present climate is wet and dry type of climate coded AW, according to Kopper's classification. Rainfall lasts from May to October, and dry season lasts from November to April. High temperatures within the area are recorded from the month of March to October (Saleh and Abdulmalik, 2013)

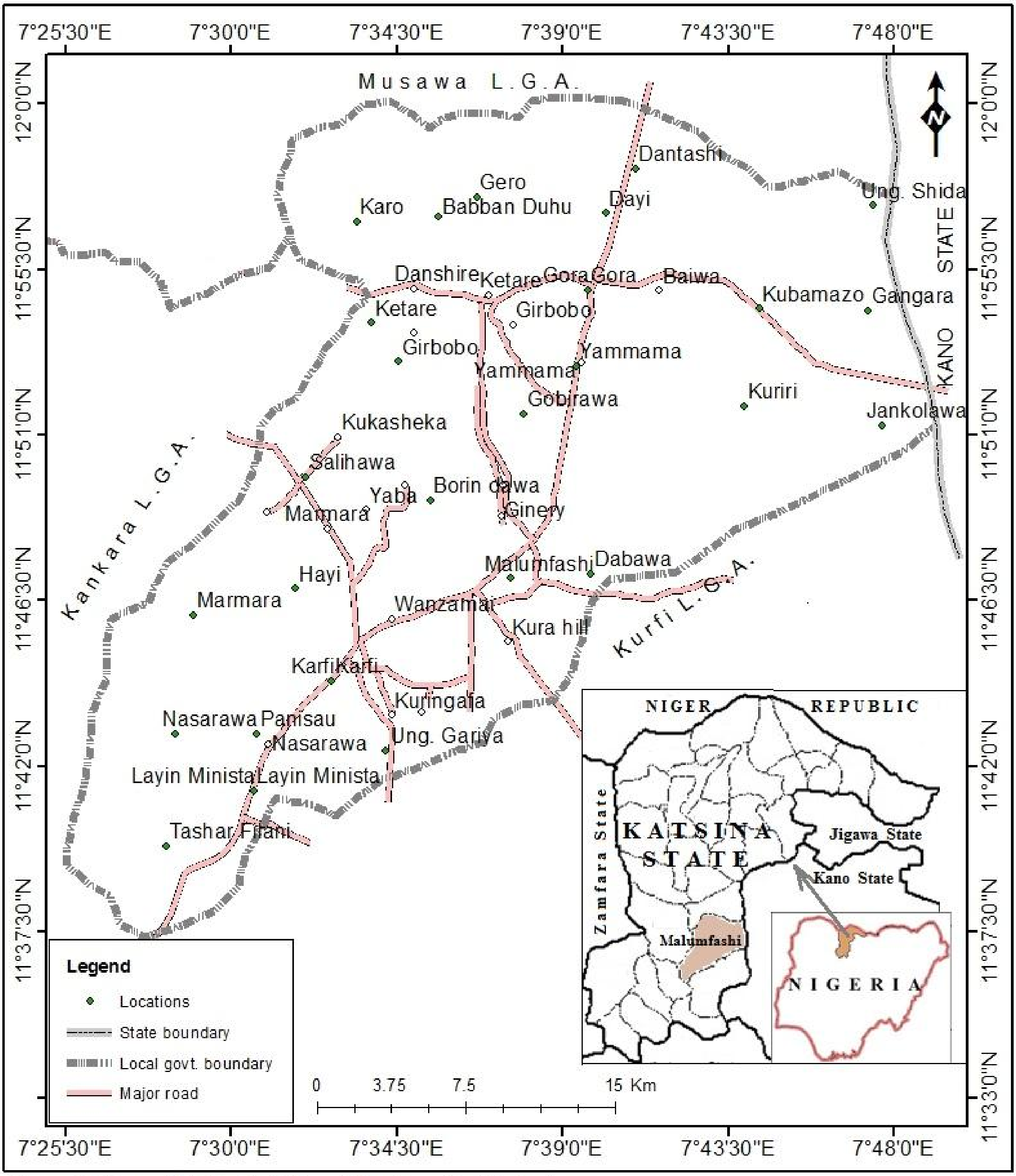

Figure 1: Map of Malumfashi Local Govt. as the Study Area
Source:- Extracted from Katsina State Administive map 2023

Methodology

The data for the study was obtained from the officials of the State water Board and National Population Commission (NPC). Three types of data were analyzed in this study. The first one was

1991 population census data which was obtained from National Population Commission Malumfashi Local Area office, second was annual estimated population data from 1992 to 2023, and the last one was the annual estimated pipe-borne water demand data from 1991 to 2023. Population growth data from 1992 to 2023 was estimated using geometric method after Kpedekpo (1982). The basis of using this method was based on the fact that Malumfashi Local Area has a high population growth potential. In addition, the method gives a higher population estimate than any other method of estimating population growth. This method was presented by the following equation:

$P_1 + n = P_1 (1+r)^n$ whereby:

$P_1 + n$ is the population at time ($P_1 + n$), a future data

r is the rate of growth per unit time

P_1 is the population at time t

n is the length of time for projection.

Two analytical techniques were used to analyze the data collected. The first was the trend-based technique by Sharp (1967), for forecasting water demand. This technique involves the use of past-trend of per capita water consumption and project into the future. Estimates of future population are then used to obtain total water demand. The second technique is the Linear Regress Model for estimating the direction of trend. Data for pipe-borne water demand figures were subjected into this technique. The end product for Linear Regression Modal is an equation mathematically expressed after David (1977) in the form of:

Y = bx + a whereby:

Y is the predicted value for dependent variable

X is the value of independent variable.

a and b are the coefficients of the regression equation.

The coefficients are calculated by the following equations:

i. S.D of X, Sx = $\sqrt{\frac{\sum x^2}{n} - \bar{x}^2}$ - - - - - 1.1

ii. S.D of y, Sy = $\sqrt{\frac{\sum y^2}{n} - \bar{y}^2}$ - - - - - 1.2

iii. Covariance of S_{xy} = $\sum xy / n - \bar{X}\,\bar{Y}$ - - - - 1.3

iv. Coefficient of a = $\bar{Y}$ - b$\bar{x}$ - - - - - - 1.4

v. Coefficient of b = $\frac{\sum xy}{\sum x^2} - \frac{nxy}{n\bar{x}^2}$ - - - - - 1.5

vi. Correlation coefficient (r) = $\frac{Sxy}{SxSy}$ - - - - - 1.6

Whereby: X is the population figures at time – t (years)

Y is annual water demand figures

$\bar{X}$ is the mean value of population figures at time- t(years)

$\bar{Y}$ is the mean value of annual water demand figures

n is the numbers of pairs of measurement

Derivation of the Status of Annual Population Figures (1991- 2023)

The estimated population of Malumfashi Local Government Area according 1991 population was 158, 338. The population was growing at rate of 2.5%. The population figure of 1992 was estimated using geometric model after Kpedekpo (1982) as follow:

The geometric model is expressed as:

$P_1 + n = P_1 (1+r)^n$ whereby:

$P_1 + n$ is the population at time ($P_1 + n$), a future data

r is the rate of growth per unit time

P_1 is the population at time t

n is the length of time for projection

1991Pop= **158,338**

1992Pop= 158,338(2.5% + 1)^1 = **162,296**

1993Pop = 158, 338(2.5+1)^2 = **166,345**

The rest of population figures from 1994 to 2023 were estimated using similar method.

Derivation of the Status of Annual Pipe- borne Water Demand Figures (1991- 2023)

Trend-based technique for estimating water demand after Sharp (1967) and Suleiman (2002) for estimating the average daily per capita water consumption of 80 litres per day (80/pcd) were adopted and derived the status of annual pipe-borne water demand. This is obtained by finding the product of population figure and average daily per capita water consumption. If a person consumes 80 litres of water per day, then in a year he consumes (80 x 365) litres/year, which is equal to 29,200 litres/year or 29.2m^3/year. Using this method the status of 1991 pipe-borne water demand (PBWD) figure was derived as follow:

1991(PBWD) = 1991Pop. Figure x 29.2m3/year = **4, 623469.9m^3**

1992(PBWD) = 1992Pop. Figure x 29.2m^3/year = **4,739,043.2m^3**

The rest of PBWB figures from 1993 to 2023 were estimated using similar method.

RESULTS AND DISCUSSION

The results of this study were presented and discussed according the set of objectives of the study as follows:

Status of Population Size of Malumfashi Local Government Area (LGA) from 1991 To 2023

Results of the status of population size of Malumfashi LGA are determined and presented in Table 1: It could be seen the results revealed temporal variation of the status of population size of Malumfashi LGA from 1991 to 2013. For instance in 1991 population census, the population was 158,338. It increased to 162,296 in 1992, 166,354 in 1993, 170,513 in 1994, and 174,776 in 1995 and among others. These findings indicated annual increase of population size in the study area. Meaning the status of population size increased with respect to time in year. This finding was in line with the work of Saleh and Inusa (2015) that studied water supply and demand analysis for Katsina Urban Area and revealed that the population of the study area was increasing with respect to time at an average growth rate of 2.88% per annum.

Table 1: Status of the Population Size of Malumfashi LGA (1991 -2023)

Years	Population Figures
1991	158,338
1992	162296
1993	166354
1994	170513
1995	174776
1996	179145
1997	183624
1998	188214
1999	192,919
2000	197742
2001	202,686

2002	207,753
2003	212,947
2004	218,271
2005	223,727
2006	229,321
2007	235,054
2008	240,925
2009	246,949
2010	258,127
2011	259,455
2012	265,942
2013	272,590
2014	279,405
2015	286,390
2016	293,550
2017	300,889
2018	308,411
2019	316,121
2020	324,024
2021	332,125
2022	340,428
2023	348,938

Source: Data Survey, 2024

Source of Pipe-Borne Water Supply in the Study Area

Pipe-borne water to Malumfashi LGA is supplied by the Malumfashi Water Board Authority. The source area comes from the earth dam constructed in 1983 by the former Kaduna State Government during Second Republic. The dam locates along River Tura, an important tributary of river Gagare, about 12km north of Malumfashi town (Figure 2). The Dam is named Tura Dam. Table 2 described the dimensions of the Dam, its reservoir Storage Capacity; Reservoir area and the capacity of Water Treatment Plant (WTP)

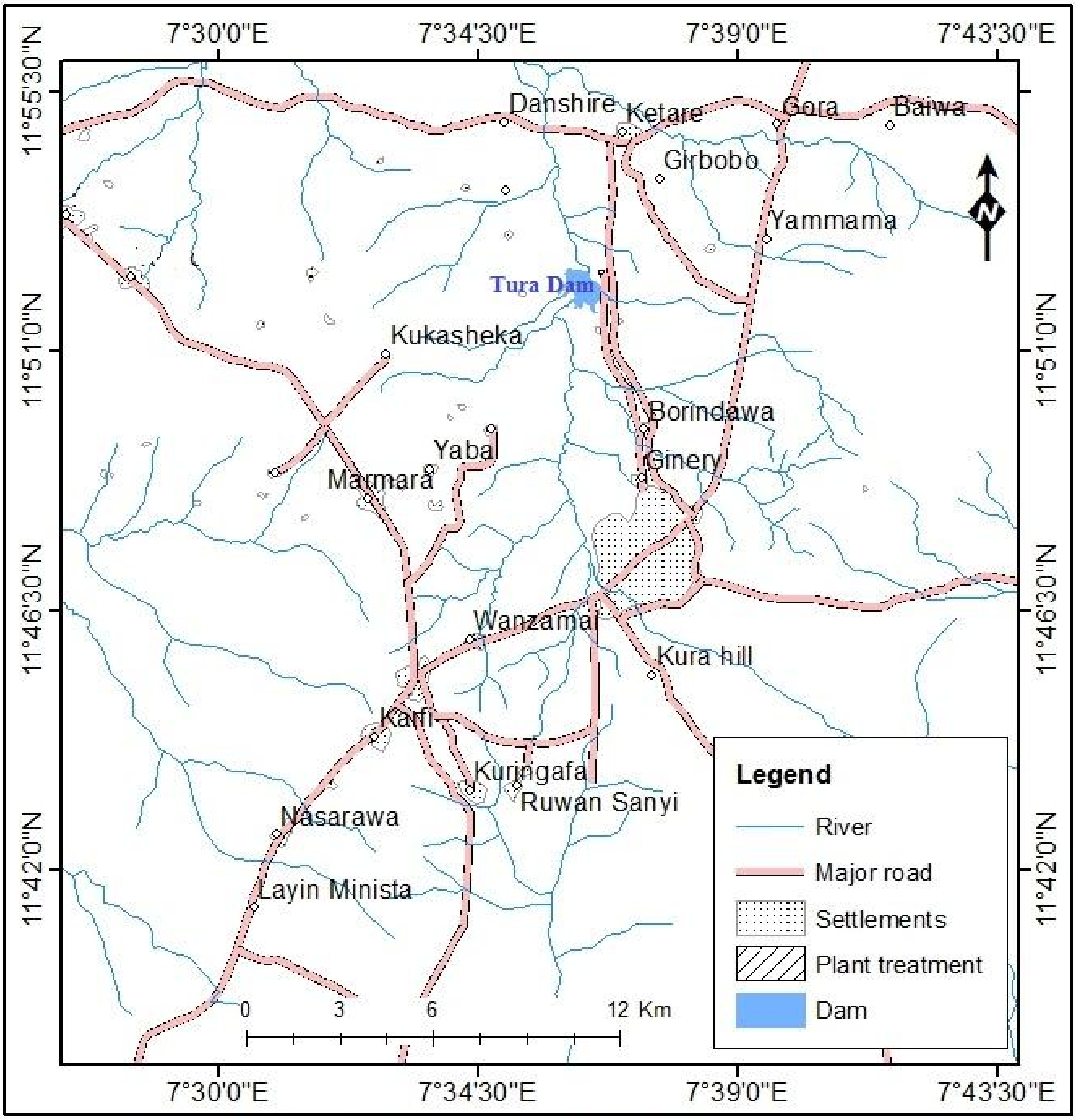

Figure 2: Location of Tura Dam in Relation to Malumfashi.
Source:- National Aeronoutic and Space Administration Spot Image 2024.

Table 2: Dimensions of Tura Dam, Reservoir and Water Treatment Plant (WTP) Capacity

Dam Height	Length of Dam	Reservoir Storage	Reservoir Area	WTP Capacity
9.60m	122,008m	4410^6m^3	120hectares	$6,300m^3$/day($2,299,500m^3$/yr)

Source: Malumfashi Water Board Authority, 2024

Status of Pipe-Borne Water Demand Figures

Results for the status of Pipe-borne water demand figures from 1991 to 2023 are presented in Table 3. The data presented indicated the status of pipe-borne water demand figures and they were varied with respect time in years. For instance in 1991 the pipe- water demand figure was $4,623,469.6m^3$, in 1992, it was $4,739,043.2m^3$, and in 1993 it was $4,857,536.8m^3$ and among others. Each water demand figure obtained in Table 3 is the function of population figure (Table 1). Comparing with the water treatment plant capacity of $2,299,500m^3$/Year with annual pipe-borne water demand figures in Table 3, it could be seen the supply do not meet with ever increasing population of the Local Government Area. This finding was in line with the work Saleh and Inusa (2015) who studied urban water supply and demand analysis for Katsina Urban Area and revealed that pipe-borne water supply do not meet with increasing population of the Urban Area. The finding was also in line with the work of Saleh (2006) who studied Water Supply and Demand Analysis for Malumfashi Town and also revealed water supply do not meet the demand of the population.

Table 3: Status of Pipe-Borne Water Demand Figure (1991 -2023)

Years	PBWD(M^3)
1991	4,623,469.6
1992	4739043.2
1993	4,857536.8
1994	4978979.6
1995	5103459.2
1996	5231034
1997	5361820.8
1998	5495848.8
1999	5633234.8

2000	5774066.4
2001	5918431.2
2002	6066387.6
2003	6218052.4
2004	6373513.2
2005	6532828.4
2006	6696173.2
2007	6863576.8
2008	7035010
2009	7210910.8
2010	7537308.4
2011	7576086
2012	7765506.4
2013	7959628
2014	8158626
2015	8362588
2016	8571660
2017	8785958.8
2018	9005601.2
2019	9230733.2
2020	9461500.8
2021	9698050
2022	9940497.6
2023	10188989.6

Source: Data Survey, 2023

Trend of Pipe-Borne Water Demand Status from 1991 to 2023

The trend of pipe-borne water demand status was determined and presented in Figure 3.

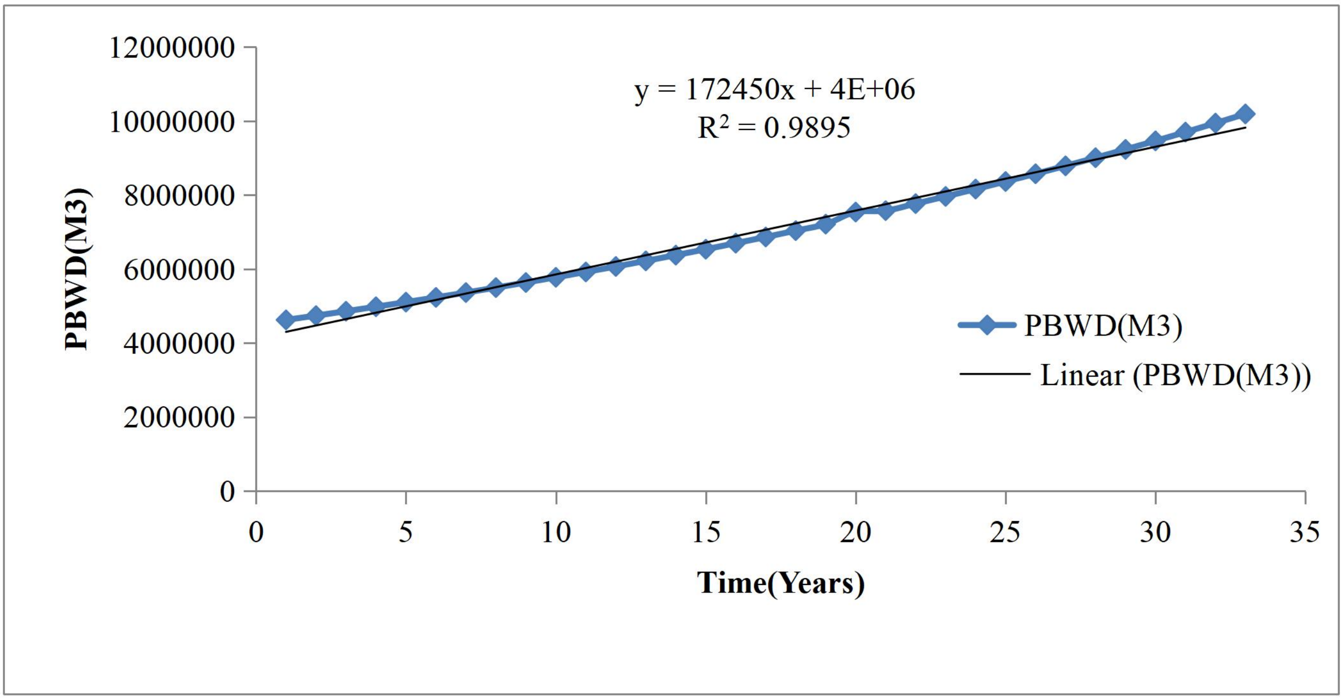

Figure 3: Trend of Pipe-borne Water Demand (1991 -2023)

The linear trend line equation y = 17245x +4E+06 presented in Figure 3 indicted an increasing trend in respect to pipe-borne water demand in the study area. This is because the slope of the linear trend line equation indicated positive direction. It also indicated very strong positive correlation (R^2= 0.989) between pipe-borne water demand and time in year. Meaning that as population increase with respect to time in year, demands of pipe-borne water also increase. Pipe – borne water demand in the area increased at rate of 17,245M^3/Year**.** This finding was also in line with the work of Saleh (2006) who reported an increasing trend in respect to water supply and demand for Malumfashi Town in Katsina State, Nigeria.

Status of Future Pipe-Borne Water Demand

An estimated status of future pipe-borne water demand figures for Six years after 2023 were determined for the study area. The water demand figures were derived using Trend-based technique for estimating water demand after Sharp (1967) and Suleiman (2002) for estimating the average daily per capita water consumption of 80 litres per day (80/pcd). Results for the five years period; 2024, 2025; 2026; 2027 and 2028 pipe-borne water demand are presented in Table 4

Table 4: The Status of Five Years Future Pipe-Borne Water Demand (PBWD) (2024-2028)

Years	Estimated Population Figures	PBWD(M^3)
2024	357686	10,444,431.2
2025	366,552	10,703,318.4
2026	375,736	10,971,491.2

2027	385,236	11,248,891.2
2028	395,212	11,540190.4

Source: Data Survey, 2024

Data presented in Table 4 indicate that as annual population increased, annual demand of pipe-borne water also increased. In 2024, the presence year, estimated population figure was 357,686 and the PBWD was 10,444,431.2m^3. For the next year, 2025, the estimated population figure was 366,552 and the PBWD was 10,703,318.4m^3 and among others. These findings indicate that future growth of population has a direct relationship with the PBWD in the study area.

Conclusion and Recommendations

The analysis of the status of pipe-borne demand for Malumfashi Local Area Katsina State, Nigeria presented in this paper revealed very important facts. The findings have shown the increasing trend of pipe-born water demand from 1991 - 2023. It was also observed water demand is a function of time. Based on this trend linear regression model of pipe-borne water demand for the area was derived and expressed as y = 17245x +4E+06. This equation was used to determine trend direction of pipe-borne water demand; which was an increasing trend. Pipe-borne water demand in the study period increased at the rate of 1724m^3/year. It observed that there was very strong relationship between pipe-borne demand water demand and time (R^2 = 0.989). The status of future pipe-borne water demands for five years beyond the study period was also determined. In the present year 2024, for instance, the PBWD was estimated as 10,444,431.2m^2, 2025 was 10,703,318.4m^3 and among others. It empirically observed that annual pipe-born water supplied by the Water Board Authority from 1991 to 2023 does not meet the annual demand. It concluded that the consequence of this you could see people of the LGA now resort to alternative sources of water supply such as hand-dug wells, water vendors and among others. These predominantly unwholesome sources are variable sources of water borne-diseases

Based on these findings the study thus recommended that Water Board should ensure that pipe-borne water supply meets demand of population in order to avert any possible outbreak of water borne-diseases. Water Board officials and the Government and at large should use trend-based technique for estimating water demand after Sharp (1967) and Suleiman (2002) for estimating the average daily per capita water consumption of 80 litres per day (80/pcd to estimate the present and future status of pipe-borne water in the area. Government should drill boreholes in different locations in the Local Government Area. There should be private participation in water supply system. This should involve the establishment of individual or cooperative water supply industries. Finally reduction of water loss through leakages should be checked. This could be achieved by carrying out repairs on all damaged pipes and fittings as well as providing high capacity.

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