RAINFALL VARIABILITY AND MUNICIPAL WATER SUPPLY IN BOSSO TOWN, NORTH CENTRAL - NIGERIA

[1]OTARU, R. O., [1]OJOYE, S., [1]ADENLE A. A., [2]ADEBOLA, A.O. & [1]YAHAYA T.I.
[1]Department of Geography, Federal University of Technology, Minna, Nigeria.
[2]Department of Remote Sensing and GIS, Federal University of Technology, Akure.
Corresponding E-Mail:dejyojo@futminna.edu.ng

Abstract

The variability of rainfall pattern has a great impact on the hydrological cycle and therefore affects the quality and quantity of water use. The study assessed the effect of rainfall variability on municipal water supply in Bosso town. The aim of the study is to assess rainfall variability and its implications on municipal water supply in Bosso, Nigeria. The study makes use of rainfall data which was collected from NIMET office Minna, municipal water supply data from Niger state water board and responses from structured questionnaire designed for the study. The Standardized rainfall anomaly index revealed that rainfall was variable between 2004 and 2014. The years 2005 and 2013 were moderately dry, years 2006, 2007, 2008, 2009, 2010 and 2014 were near normal while 2011 and 2012 were dry. Simple linear regression revealed a positive and non-significant relationship between rainfall and municipal water supply. This implies that the supply of municipal water in the area is a function of the rainfall received but do not solely depend on the rainfall alone. The questionnaire analysis revealed that the people of the communities buy water to augment the water they get from the State water board, their wells and water harvested from rainfall. On the average, about 8841liters of water is used in the study area, an indication of about 32.39 liters of water per person, a value of which is lower than the recommended WHO standard of 100 liters per person per day. The study recommends that the laws protecting water resources should be enforced and also that research efforts should be intensified in areas of water resource management.

Keywords: Hydrologic cycle, Management, Municipal water, Rainfall, Standardized rainfall anomaly

Introduction

Rainfall is a renewable resource which is highly variable in space and time and is also subject to depletion or enhancement due to both anthropogenic and natural causes. Climate is, with particular reference to rainfall, known to be changing worldwide and there has been growing concern as to the direction and effects of these changes on settlement and infrastructures (Chaponniere & Smokhtin 2006). Thus, hydrological resources such as streams, rivers and ponds that are mainly rain-fed are adversely affected by climate change (Onyenechere Azuwike, & Enwereuzor 2011). Many people, especially in the rural areas of Nigeria, depend on rivers, streams and rainfall harvest for their water supply in the face of infrastructure challenges (Onyenechere, Azuwike, & Enwereuzor, 2011).

Rainfall variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, e.t.c.) of rainfall on all spatial and temporal scales beyond that of individual precipitation events (Odjugo 2010). He further explained that like climate change, variability maybe due to internal or external variables.

Municipal water supply on the other hand means the total amount of metered and estimated non metered, potable and non-potable, water supplied for municipal purposes. The problem of potable water shortage has become a serious matter in the world from a local to a global perspective and has commanded a dramatic attention.

Inadequate water supply has become a major concern in Bosso area of Minna, Niger state, Nigeria. Water supply is said to be adequate in a particular region if it meets the demands of the human, animals and plants within that region. Inadequate water supply poses treat to the stability of health and well-being of human, animals and plant lives. Currently in Bosso, people suffer from inadequate water supply. This is visible from the amount of dried up wells, the reduction in the frequency at which the water board supplies water, and the increase in the price at which water is being sold by water vendors.

Bosso and its environs are vulnerable to water stress as a result of the variation in the amount of rainfall received which is leading to shortage in water availability and supply, as a result of less ground water recharge, less amount of rain water available for harvest for a long period of time. Water is a basic requirement for people to be able to go about their everyday life. It is used for domestic, commercial, irrigational, industrial purposes. When the amount of water available for use becomes inadequate, it put the inhabitant of that region at risks of various diseases. This research is therefore very important and highly necessary to be carried out as it will tell us the level of water requirement in the study area and when known will be able to inform planners on how to cub or reduce the menace of scarcity. This is the gap this study aims to fill. Due to this, the broad aim of this study is therefore to examine the effect of rainfall variability on municipal water supply in Bosso town, Niger state, Nigeria. In achieving this aim, the objectives are to:

i. assess the variability pattern of rainfall over a period of eleven years (2004-2014).

ii. examine the relationship between rainfall variability and the problems of water supply in the area

iii. examine the adaptation strategies towards a good water supply

The Study Area

Bosso lies between longitudes $6^{0}30'$ and $6^{0}33'$ E of the Greenwich meridian and latitudes 9°7' to 9°41' N of the equator. It covers a total area of about 297.5 km^2 (Amadi & Olasehinde 2010). The area is accessible through Minna-Suleja road and Minna-Tegina road. (Amadi & Olasehinde 2010)

The vegetation is mainly guinea savanna which is characterized by grasses, shrubs and trees. The study area lies within the Middle-Belt of Nigeria which is a transitional zone between the rainforest of Southern

Nigeria and the Guinea Savanna of the Northern Nigeria This area is characterized by tall grasses with light forest, evenly distributed trees along the major river channels. (Amadi & Olasehinde 2010) Bosso is a part of Niger State which has two main seasons. It can therefore be said that the weather and climate of Minna is the same with that of Bosso due to their location. Minna is located in a tropical climatic region which is characterized by two seasons in a year, the wet season and the dry season (Dalil *et al* 2014). The annual rainfall received within the region is less than 1000mm in wet season and it lasts between May and October with a maximum down pour between the months of July and September (Dalil *et al* 2014). The dry seasons lasts between the months of October and March and that temperature varies within the region annually with the dry season having low temperatures because the sun is at the southern hemisphere. In another study, it was revealed that the minimum temperatures of 32^{0}C are recorded during the harmattan period which is late December and January in the following year and its maximum temperatures often do not normally exceed 42 ^{0}C (Musa *et al* 2015). The research further stated that during the wet season, the sun moves northwards from the equator to the tropics of cancer which results in high temperatures because the sun overheads at noon. (Figure 1)

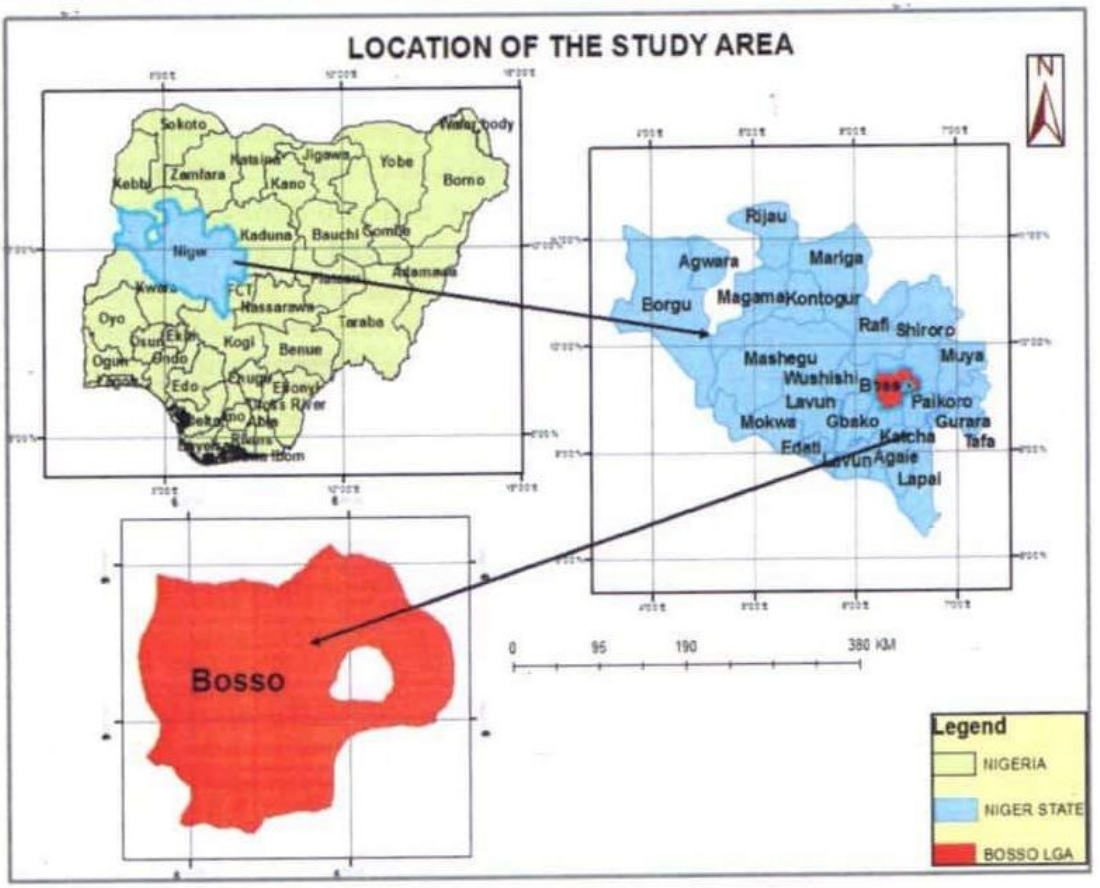

Figure 1: the study area

Geological mapping revealed that the study area is underlain by granite and schist with granite occupying greater portion of the area (Amadi and Olasehinde 2010). The fieldwork shows that the granite did not digest completely the schist through which it intruded, which gives rise to Magmatite (mixed rock) in most locations. The principal joint directions in the area are NE-SW followed by NW-SE direction. (Amadi and Olasehinde 2010) (Figure 2).

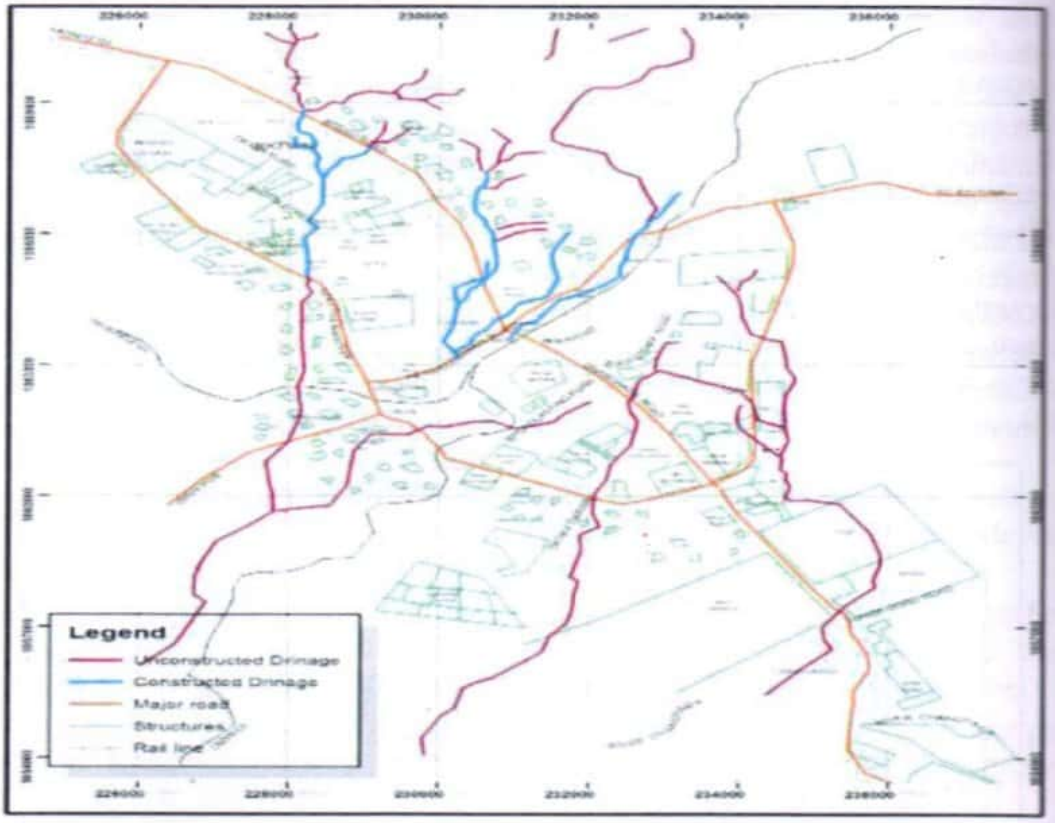

Figure 2: Constructed and Unconstructed Drainage in Minna
Source: Dalil *et al,* 2014

Bosso area has a fairly flat-lying terrain with few gentle hills and drained by River Chanchaga (Amadi and Olasehinde 2010). River Chanchaga takes its source from the north central highlands and there after flowing towards the western lowlands before meeting river Kaduna at appoint west of Minna (Dalil *et al,* 2014). The main tributaries include river Wana, Shaho, Godina, and Dunalape, which are flowing from their respective highlands and isolated compounds such as Gwam, Kpewi, Zuru, and Tsauran Nabi hills).

Materials and Methods

The data used for this work was obtained from variety of sources which includes primary and secondary sources. The primary data used were oral interview and questionnaire which revealed direct field information concerning residence perception of

water supply issues as well as the variation in rainfall pattern over the study period and also obtained information on the quantity of water used by the residence in the study period. The secondary data used while embarking on this research work includes; weather data and water supply data.

Descriptive statistics was employed in analyzing the data using standardized rainfall anomaly index (SRAI), linear regression and EXCEL in order to provide thorough mean variations in rainfall, show relationship between rainfall variability and water supply within the periods of (2004 to 2014). Random sampling method was employed to administer the questionnaires and oral interview of the residents in order to find out how much water an individual consumes daily per household and also to be able to quantify, how much water they get from other sources in order to augment what they receive from the state water board. The drought index called standardized rainfall anomaly index (SRAI) adapted from Ifabiyi and Ojoye, (2013) was used. The formula is given as

$$SRAI = \frac{X - \bar{X}}{SD} \quad (1)$$

Where X is the annual rainfall total

$\overline{X}$ is the mean of the entire series

SD is the standard deviation from the mean of the series

Positive SRAI values indicate greater than median precipitation and negative values indicate less than normal precipitation (Table 1)

Table 1: Climatic Index Values and Range

Values	Range
2.0	Extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
-0.99 to 0.99	Near normal
-1.0 to -1.49	Moderately dry
-1.5 to -1.99	Severely dry
-2.0 and less	Extremely dry

Source: Ifabiyi & Ojoye, 2013

The standard rainfall anomaly index revealed that rainfall was variable between 2004 and 2014. In the year 2005 and 2013 was moderately dry, years 2006, 2007, 2008, 2009, 2010 and 2014 was near normal while 2011 and 2012 were severely dry (Figure 3).

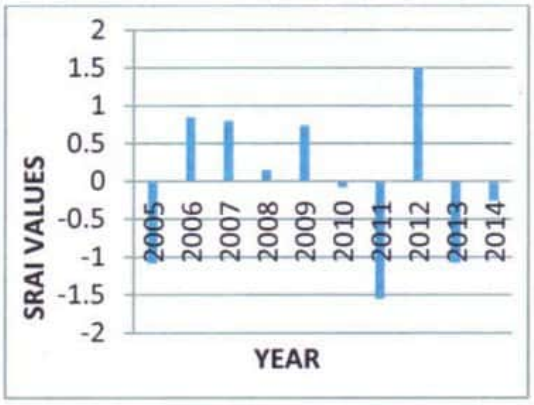

Figure 3: Rainfall Pattern in Bosso (2004-2014)

Implication of this is that the amount of rainfall received over the study period between 2004 and 2014 is insufficient. When rainfall is insufficient, recharge of streams and rivers would be reduced. This would bring about a reduction in well water as well as dam capacity which would then give rise to water shortage in the community. Linear regression revealed a positive and non-significant relationship between rainfall and municipal water supply. While correlation showed a positive correlation between the variables which indicates a tendency that an increase in rainfall will be followed by an increase in municipal water supply and vice versa an indication that the municipal water supply in the study area is due to insufficient rainfall received during the period 2004 to 2014. The questionnaire analysis showed that the communities buy water to augment the water they get from the state water board, their wells and rain. The water vendors buy their water from the borehole sunk by individuals within the communities. Findings also revealed that the average daily water of about 8841.804 litres is used by the respondents. This implies that about 32.39 litres of water is used per person per day in Bosso area. The result shows that the communities in the study area are living below the recommended WHO standard of 100 litres per person per day.

Summary of Linear Regression Analysis

It was observed from the regression analysis that there exist a weak, positive and non-significant relationship between rainfall and municipal water supply. The coefficient of determination (R^2) value observed was 0.7% implying weak relationship and the correlation coefficient (R) observed was 8.5% indicating weak degree of association between the variables.

The positive correlations observed between the variables indicate a tendency that an increase in rainfall will be followed by an increase in municipal water supply and vice versa. (Figure 4)

$$Y = 4822.322 + 0.807\ water\ supply \quad (2)$$

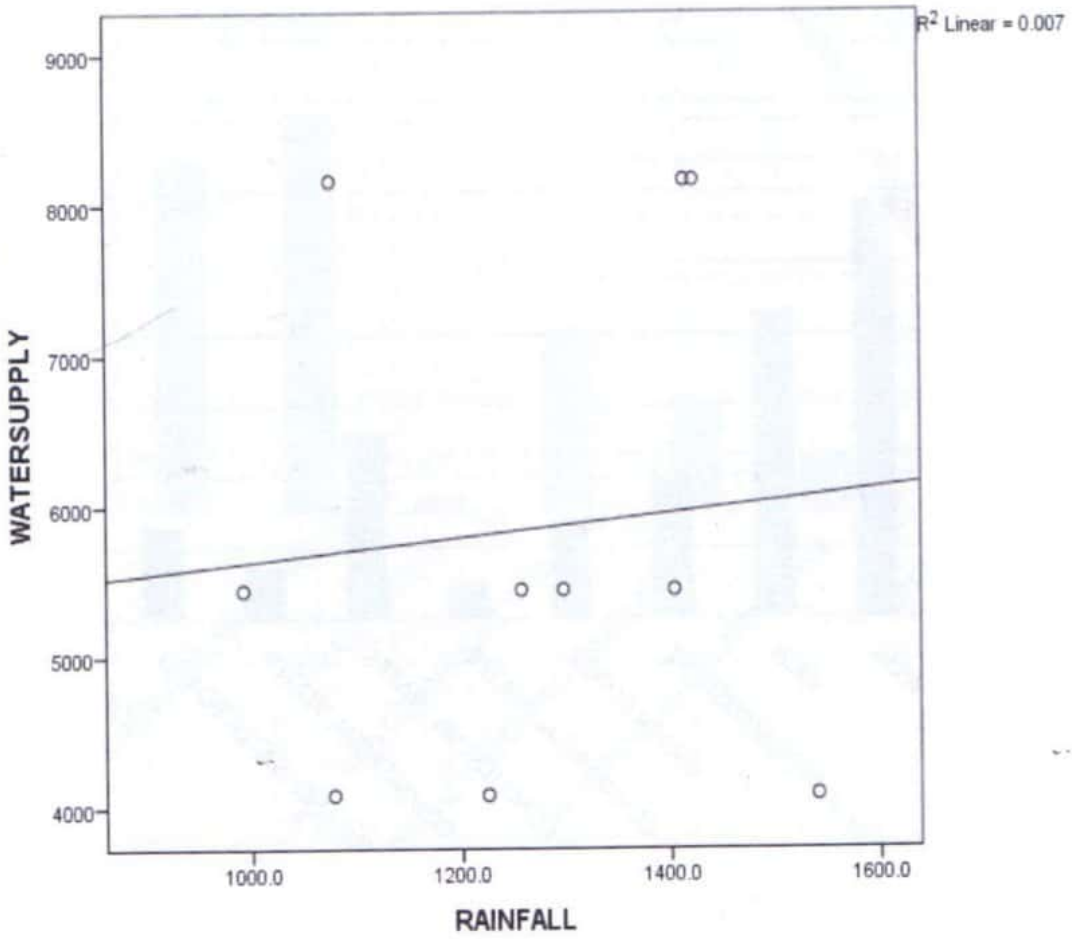

Figure 4: Relationship between Rainfall and Municipal Water Supply in Bosso

Summary of Respondents' Coping Strategies with Water Supply in Bosso town.

The study revealed that during the rainy season, 29 percent of the respondents get their water from well, 10 percent gets their water from commercial water (Mairuwa), 7 percent get water from the states water board, 3 percent harvest rainfall, 13 percent get water from wells, about 4 percent of them get from well and commercial sources, 7 percent of them get from well, commercial sources and water board and about 6 percent of the respondents get their water from other combination of water source.(figure 5)

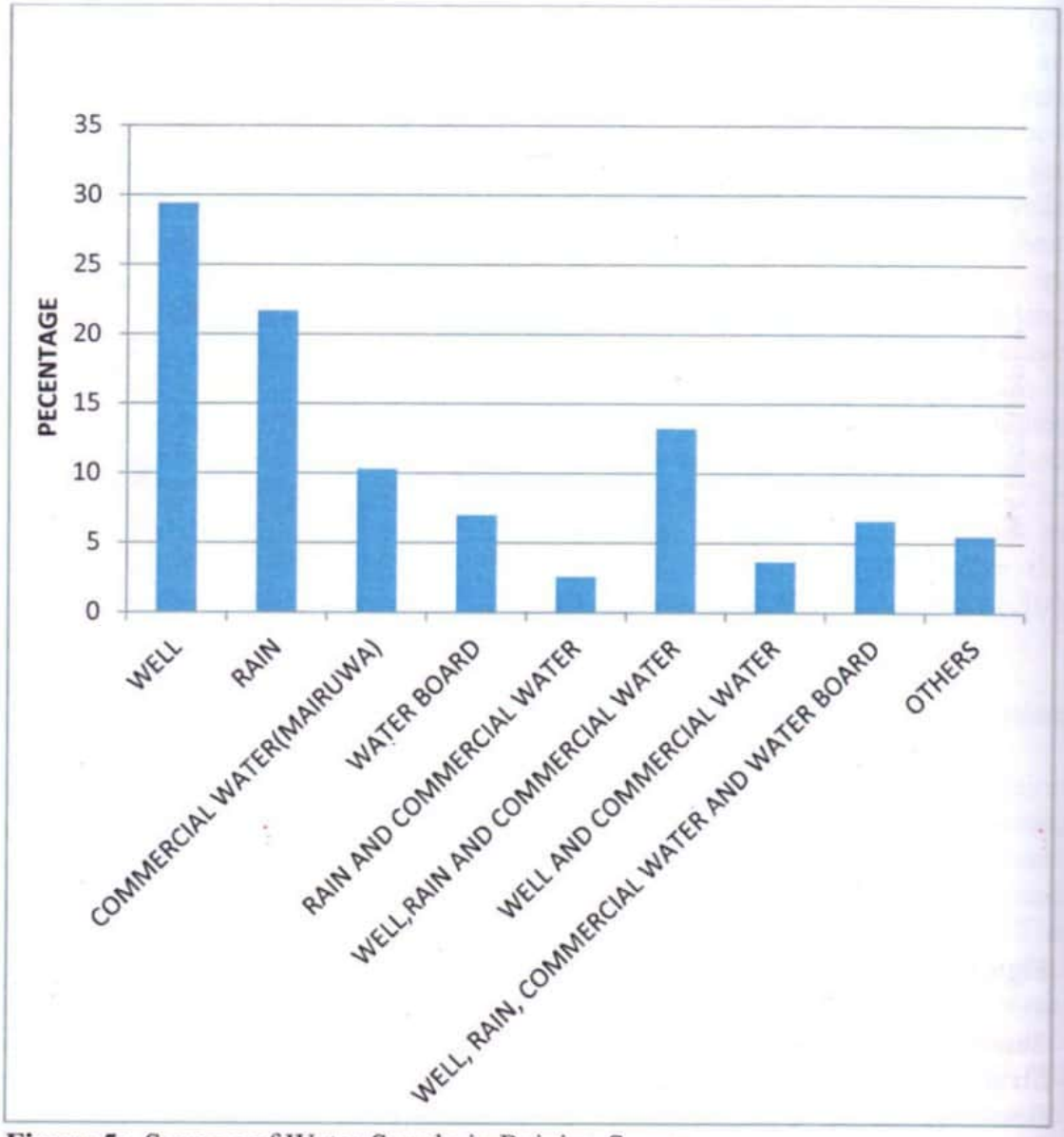

Figure 5: Sources of Water Supply in Raining Season

In dry season, 39 percent of the respondents get water from well only, 34 percent gets water from commercial water (*mairuwa*) only, one percent of them gets water from the state water board only, 10 percent gets water from well and commercial water, 10 percent of them gets from commercial water and water board, 7 percent gets water from well, commercial water and water board and about 4 percent of the respondents gets their water from other combination of water source. (Figure 6)

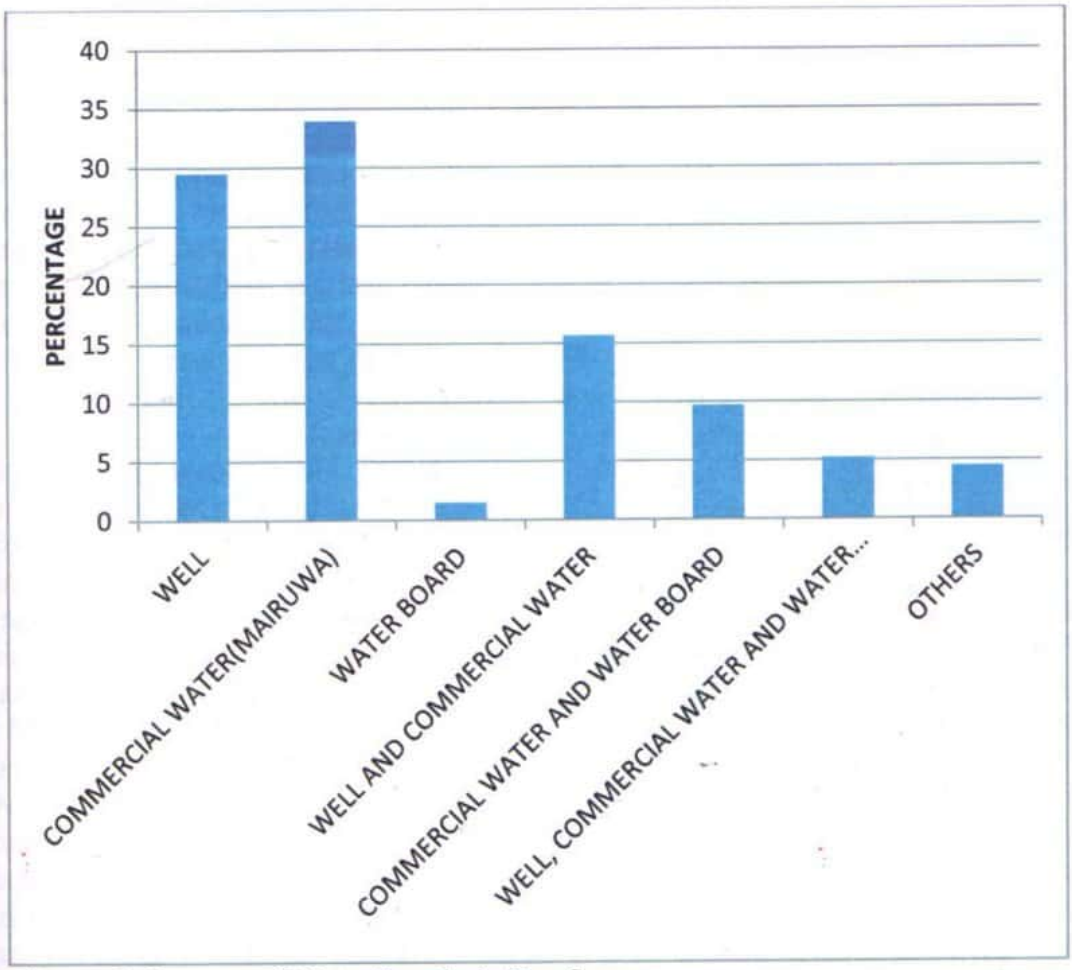

Figure 6: Sources of Water Supply in Dry Season

Respondent's Usage of Water

The containers in which the respondents use in collecting their water are buckets, bowl, Jerry can, drum and tank. Some respondent use only one out of the containers, while others use a combination of some or all of the containers in varying sizes. The most frequently used type of container in collecting water in Bosso area is Jerry can have a percentage of about 47 percent.

Some people refill their containers daily, weekly or monthly. Majority of the people refill their containers weekly and monthly and having the highest percentage form analysis respectively. Findings revealed that an average of 8, 841,804 litres per day of water are used by the respondents. With a population of 272, 979 people it implies that about 32.39 litres of water is used per person per day in Bosso area. The result shows that the communities in the study area are living below the recommended WHO standard of 100 litres per person per day.

Table 4.1: Average Water Consumption/ person/Day

	Daily	Weekly	Monthly	Others
Bucket	2502	1500	265	233
Bowl	541	1158	285	0
Jeri cans	4257	6484	300	1135
Drum	4580	7325	1325	1140
Tank	11150	23480	91500	1000
Total	23030	39947	93675	3508
Daily:	23030	5706.714	3122.5	3508
	Daily ave:	8841.804		
Average per respondent:			32.39	

Source: Author's Work, (2015)

Conclusion

Rainfall was variable between 2004 and 2014 while years 2005 and 2013 were moderately dry, 2006, 2007, 2008, 2009, 2010 and 2014 was near normal, 2011 and 2012 were severely dry. There is a positive correlation between the rainfall and water supply variables which indicates a tendency that an increase in rainfall will be followed by an increase in municipal water supply and vice versa. The communities within Bosso town buy water (commercial sources) to augment the water they get from the state water board, wells and rainfall. Also, it was revealed by the study that averagely about 8841.804 litres of water is used by the respondents on daily basis, an implication that about 32.39 litres of water is used per person per day in Bosso area. The supply of water from various sources show a deficit from the minimum approved water supply by World Health Organization. These findings thereby concluded that there is an acute shortage of domestic water in Bosso town. In order to improve the adequacy of water supply in the study area, the study recommends that the laws protecting water resources should be enforced, greater efficiency in water use should be promoted, research efforts should be intensified in area of water supply and management and that government should partner with the people to protect and maintain existing watersheds among others.

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