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Analysis of the Impacts of Climate Change and Variability on Water Accessibility and Supply in Yauri, Kebbi State, Nigeria

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Abstract

The study examines the impacts of climate change and variability on water accessibility and supply in Yauri, Kebbi State. Both primary and secondary data were employed for the study. A total of 266 questionnaires were administered to the residents in the study area. Secondary data used include meteorological data (rainfall, minimum and maximum temperature and evaporation) from NIMET, Yauri for the period of 31 years that spanned between1984 to 2014. Also data on quantity of water supplied from Yauri Waterworks were collected. The statistical techniques used include descriptive statistics, Pearson Product Moment Correlation, Multiple Regression Analysis and Trend Analysis. The result from the descriptive statistics revealed that 49.8% of the respondents lack access to water. In the same vein, 38.4%, 31.0% and 18.4% indicated that effects of dry season, climate change/variability and high temperature account for low water accessibility in the study area respectively. Result from Pearson moment correlation revealed a strong positive relationship (0.76) between monthly rainfall and monthly water supply at 0.05 significant levels. The result of multiple regression analysis with four explanatory variables has an R^2 of 0.526 which confirmed that 52.6% of variation in water supply can be explained by climatic factors. Recommendations were made which include; curbing of climate change induced anthropogenic activities, effective water resources management and planning among others.

Key words: Water, Climate Variability, Water Accessibility, *Climate Change.*

Introduction

The earth surface is covered with two thirds (71%) of water (www.universetoday.com) and the human body consist of 65 percent of it (John and Bruce, 2002); therefore, it is evidently clear that water is one of the basic elements responsible for life on earth. Water is one of the most important substances on earth, all plants and animals must have water to live. Apart from drinking it to survive, people have many other uses for water. These include: domestic and industrial uses. Water is also essential for the healthy growth of farm crops and farm stock and is used in the manufacture of many products. However, water seems to be everywhere, yet its accessibility and availability is limited. The Water Project (2015) concludes that "clean, safe drinking water is scarce, today; nearly 1 billion people in the developing world don't have access to water". According to Iweala,(2014) " 47 percent of Nigerians lack access to clean water" It is also reported that the population of Nigeria with access to improved drinking water is less than 64% in the urban area and 42 % in the rural area (Oyebande, 1993; WHO/UNICEF, 2010; World Bank Group, 2015;). One of the factors for the problem of water availability and accessibility is climate change and variability.

Direct impacts of climate Variability and change on the water cycle could mean that some regions will become dryer and turn into arid and semi-arid regions, or even deserts. Changes in water cycles will threaten the survival of fragile ecosystems in these regions, and consequently endanger the lives of people who depend on the natural resources that these ecosystems provide. Already today, more than 40% of the world's land resources are in dry lands (i.e. sub-humid, semi-arid and arid regions) that are threatened by land degradation and desertification. This has a direct

impact on a quarter of a billion people, and an indirect impact on more than a billion people (UNCCD 2008).

Climate variability is the way climate fluctuates yearly above or below a long term average value, this occur over seasons and year. It is also the variation in the mean state and other statistics of climate on all temporal and spatial scales beyond that of individual weather events (Keely, 2011). In the other hand, the most general definition of climate change is a change in the statistical properties of the climate system when considered over long periods of time, regardless of cause. Accordingly, fluctuations over periods shorter than a few decades, such as El Niño, do not represent climate change (Glossary-Climate Change, 2001).

Climate is a major factor in water availability and accessibility on both the earth surface and below the earth surface. Rainfall and other forms of precipitation have great influence on the level of surface runoff through the water cycle which affects water availability. However, water may be available but not accessible to the people due to many climatic factors. The more precipitation and storm events, the more water is available for circulation. Dry spell, Low precipitation and droughts reduce water availability and access to water is drastically hampered.

There are indications that increasing temperature and rainfall variability may result to reduction in stream flows, intense run-off and reduced recharge aquifer, which invariably will lead to drying up of wells and boreholes that are not deep enough. This will eventually make water within the shallow aquifer not accessible.

Observational records and climate projections provide abundant evidence that water resources are vulnerable and have the potential to be strongly impacted by climate variability, with wide-ranging consequences for human societies and ecosystems (Bates *et al.*, 2008). This assertion supports the findings by researchers that

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there is variability in climate condition especially rainfall received in Nigeria (Adefolalu, 1986; Olaniran and Summer 1989; Ati *et al*, 2002; Odjugo, 2005; Ifabiyi, 2011; and Ashaolu, 2013).

Climate change often appears very esoteric in many regions, but in Nigeria it is most evident in extreme variability in rainfall, sea-level increases and a rising number of heat waves. There is a high frequency of coastal erosion and flooding – both climate variability-induced forms of land degradation, droughts and storms are increasing by the day. Declining rainfall in already desert-prone areas in northern Nigeria is causing increasing desertification, the former food basket of central Nigeria is now threatened, and people in the coastal areas who used to depend on fishing have seen their livelihoods destroyed by the rising waters.

Theoretical and Empirical Review

World's fresh water resources is unevenly distributed, thus it varies spatially and temporally. This spatial and temporal variation is largely as a result of climate. Water resource availability also varies with varying population size. Due to the rapid population growth between 1970 and 1994, the potential water availability for the earth's population decrease from 12900m^3 to 7600 m^3 per year per person (Shiklomanov in Lalzad, 2007). The greatest reduction in annual per capita water supply took place in Africa by 2.8 times, Asia and south America by 2.0 and 1.7 times respectively. Therefore the highest per capita water supplies generally occur in countries with most moist climate and low population densities (Cunningham and Cunningham, 2006). For example, Iceland has about 160 million gallons per person per year while Kuwait with high temperature and low rainfall has less than 3000 gallons per person/year.

The humid tropical zones of west and Central Africa have abundant water as a result of frequent rainfall while in sub-Saharan Africa, water availability is highly variable(IPCC,2011). Nigeria is blessed with abundant water as a result of the climatic condition. The total run-off from Nigeria's river basin is 215 km^3 translates to 600 million cubic meters per day or 5700 liters per capita per day (Olasumbo, 2001). This means that Nigeria has a huge water potential, but the level of exploitation is still low thus, leaving most inhabitants without access to adequate water supply.

Climate Variability will affect the water resource base for many water utilities. Higher temperatures and reduced precipitation levels will cause shortages in available supply due to slower replenishment rates of underground water resources and/or reduced availability of surface water. Rising seawater levels and inland flooding will cause land inundation and blockages in natural drainage structures. These effects will be even more difficult to manage for those water utilities that are unprepared and/or financially weak (Danilenko *et al*, 2010).

Climate change is threatening unique biota, as well, their sustainability as the sources of water for municipalities. In India, for example, where most lakes supply water to Indian cities are heavily dependent on monsoon rainfall; this has shown large fluctuations in recent years, even by historical standards. On 7 July 2009, it was reported that authorities in Mumbai had been forced to reduce water supplies by 30% as the city experienced one of the worst water shortages in its history. The cuts affect supplies to hundreds of thousands of households as well as hospitals and hotels. The city corporation urged citizens to save water and use it sparingly as reserves from three lakes are estimated to only contain approximately two and a half months of supply (UN-Water, 2009).

Changes in surface runoffs and groundwater flows in shallow aquifers is part of the hydrological processes that can be linked to climate variability, with implications for permanent and seasonal

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water bodies such as lakes and reservoirs. There is evidence of a broadly coherent pattern of change in annual runoff at the global scale, with some regions, particularly at high altitudes, experiencing an increase while others experience a decrease, for example in parts of Africa (Milly *et al.*, 2005). While lake levels in other parts of the world have risen (e.g. in Mongolia and China) in response to increased snow- and ice melt, lake levels in Africa particularly Lake Chard has declined due to the combined effects of drought, warming and human activities.

Impacts of Climate Variability on Water Resource: The Case of Lake Chad

Lake Chad is a trans-boundary lake that serves four countries, with the biggest share located in Chad, followed by Nigeria, then Niger and Cameroon. This lake was once considered to be one of Africa's largest freshwater lakes but it is now highly decimated. In 1960 it covered 45,000 square kilometers (about 17,000 square miles) but by 1998 it had shrunk to 10,000 square kilometers (about 4,000 square miles). After a particularly dry spell, it covered a paltry 550 square kilometers (see Figure 1) (Associated Press, 2006). The changes that have occurred in Lake Chad from 1963 to 2000 can be watched in a video clip (http://www.youtube.com/watch?v=JXW29zsr6xg).

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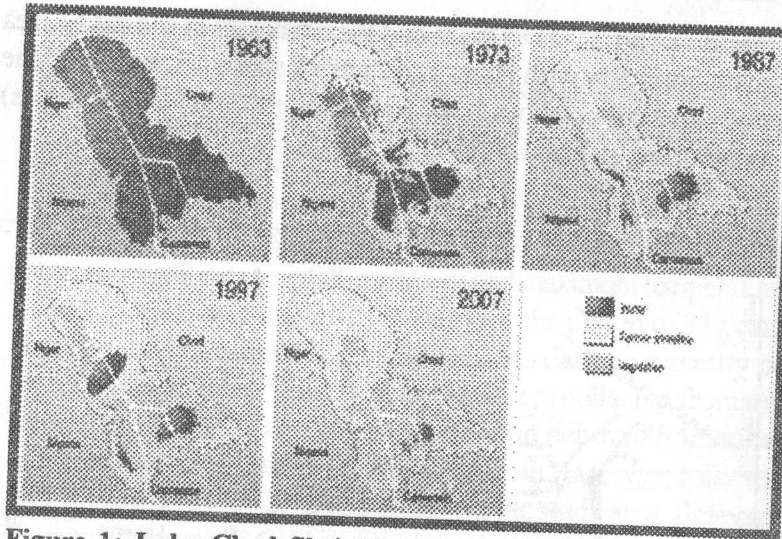

Figure 1: Lake Chad Shrinking Water Body
Source: NASA, 2011

Chadian government officials insist the lake is disappearing solely because of global warming/climate change, with severe droughts since the 1970s and temperatures rising up to 50ºC, which causes large volumes of water to evaporate. But international experts say other factors have also contributed (Associated Press, 2006). Some of these factors may include: population pressure in the surrounding countries which has led to heavy irrigation for farmland, the demand for power which has seen many rivers dammed for hydroelectric schemes, and human mismanagement of the natural resource (Somerfield, 2010).

Study Area

Yauri Local Government is located southward on the eastern bank of the famous River Niger at about 200 kilometers away from Birnin Kebbi, Kebbi state capital. It falls within latitudes 10º and 30ºN of the equator and longitudes 3º and 6º W of the Greenwich

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meridian (fig.2). The South and Western part of the study area share boundary with Niger and Zanfara states respectively. The study area covers about 3,380 square kilometers (1,306 sq. miles) as reported by Frank (1980).

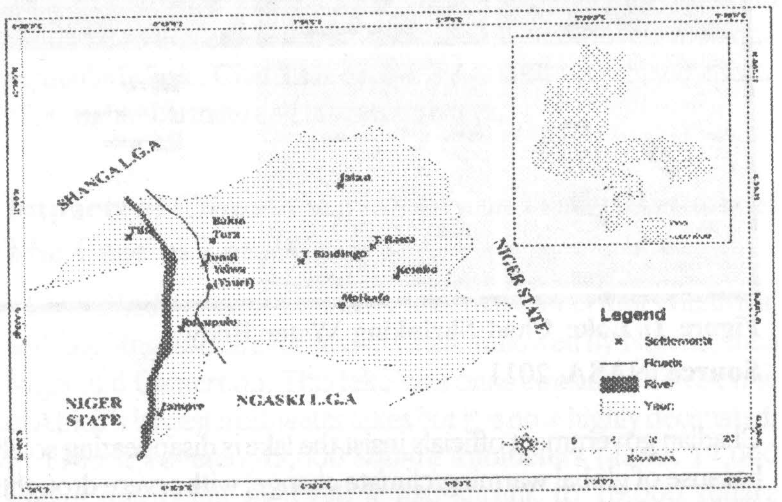

Figure 2: Map of the study area,

Yauri enjoys a Tropical Continental type of climate of which according to Köppen-Geiger climate classification is 'Aw'. This is largely controlled by two air masses, namely Tropical Maritime and Tropical Continental, blowing from the Atlantic and the Sahara Desert respectively. These air masses determine the two dominant seasons - wet and dry. The wet season lasts from April to October; while the dry season lasts for the remaining period of the year. Mean annual rainfall is about 900mm. Temperature is generally high with mean annual temperature of about 27.5°C in all locations (Minka *et al*, 2013).

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Materials and methods of study

Primary and secondary data were employed in this study. A total of 266 questionnaires were administered to the residents in the study area. Systematic random sampling technique was used to administer the questionnaires. In all, 255 questionnaires were returned while 11 got missing. Secondary data used include meteorological data (rainfall, minimum and maximum temperature and evaporation) from NIMET, Yauri for the period of 31 years that spanned between1984 to 2014. Also data on quantity of water supplied from Yauri Waterworks were collected from the period of 1989 to 2014(26years). Data on depth of functional and dried wells dug by individual households in Yauri were collected by measuring randomly selected wells in the study area. Relevant literatures, journals and internet materials were consulted. The statistical techniques used include descriptive statistics, Pearson Product Moment Correlation, Multiple Regression Analysis and Trend Analysis.

Results and Discussions

The presentation in table 1 reveals that 20.8% of the residents in Yauri access water through well dug in the house, 19.2% got their water from borehole, while 10.2% of the respondents accessed water supplied from Yauri Waterworks. However, 12.2% and 11.4% accessed water from well and Water Vendor, as well as Yauri Waterworks and well respectively. It is noted from the analysis that greater numbers of the residents get their water needs supplied by water Vendors (23.1%). This implies that the public water supply from Yauri Waterworks is not sufficient for the residents of the study area. Furthermore, the wells and boreholes dug in individual houses do not provide enough water for the people, thus the option to patronize water Vendor becomes imperative. From the analysis, the various ways of accessing water in Yauri is identified and the two major ways are water vendor and well dug in the house.

Table 1: Opinions of Respondents on Ways of Accessing Water in Yauri.

Access To Water	Frequency	Percentage (%)
Well in The House	53	20.8
Borehole	49	19.2
Water Vendor	59	23.1
Yauri Waterworks	26	10.2
River Niger and Others	8	3.1
Well and Water Vendor	31	12.2
Well and Yauri Waterworks	29	11.4
TOTAL	255	100

Source: Author's Field Survey, 2016

Problems and Difficulties of Access to Water in Yauri

Table 2 shows the opinions of respondents on the difficulty faced in accessing water in the study area. Out of 255 respondents, 81 representing 31.8% expressed difficulty in reaching water vendor to supply water. This is followed by the problems of dried wells and water yield going down beyond reach in the wells during dry season (65 respondents representing 25.5%). Long distance within the neighborhood/Yauri Waterworks and difficulty in getting water supplied from Yauri waterworks account for 24.3% and 13.7% respectively. Only 4.7% of the respondents have financial constraint, while no respondent (0%) attest to not having any problem or difficulty in accessing water in Yauri.

Table 2: Access to Water in Yauri

Problem of Access To Water	Frequency	Percentage (%)	Accessibility Indicator
Difficult to get Water Vendor(DWV)	81	31.8	Accessible
Difficult to get Water from Yauri Waterworks (DYWWs)	35	13.7	Accessible
Long Distance to Access Water in the Neighborhood/Yauri Waterworks(LDYWW)	62	24.3	Not Accessible
Financial Constraint(FC)	12	4.7	Accessible
Dry up of Well/Water go Down Beyond Reach/Well not Yielding Adequate Water (DWBR)	65	25.5	Not Accessible
No Problems/Difficulty in Accessing water in Yauri(NP)	0	0.00	Nil
TOTAL	255	100	

Source: Author's Field Survey, 2016

The table (table 2) also shows that 49.8 %(i.e. the addition of 24.3 %(LDYWW); and 25.5 %(DWBR)) of the respondents don't have access to water. This assertion is based on the WHO/ UNICEF (2010) benchmark of access to safe drinking water which states that the source of water most be less than 1 kilometer or 200 meters away from source and the possibility of obtaining at least 20 liters per member of a household per day is achieved.

The water accessibility indicator on table 4.3 shows that long distance to get water in the neighborhood/ Yauri Waterworks

(LDYWW) account for 24.3% indicating non accessibility of water. This implies that 24.3% of the respondents travel beyond the required 1 km distance benchmark by WHO/UNICEF (2010) to access water. Also 25.5% of the respondents in table 4.3 shows that dry up of wells/water go down beyond reach and well not yielding adequate water (DWBR) lacks access to water according to WHO/UNICEF (2010) water accessibility benchmark. This indicates that 20 liters of water per member of a household per day is not achieved. Therefore, the addition of these two figures (24.3% and 25.5%) gives a total of 49.8% of respondents without access to water in the study area.

Opinions of Respondents on Factors Responsible for Dry wells/boreholes in Yauri

Opinions of respondents on factors responsible for dry wells and boreholes were sought in the study area. Various reasons responsible for the drying up of both wells and boreholes were provided by the respondents. Majority of the opinions linked up drying of wells and boreholes with climate. For instance, 31%, 18.4% and 38.4% believed that climate change/ variability, high temperature and dry season effects are responsible for dry well and boreholes. However, 12.2% held on to superstitious beliefs that dry well and boreholes are caused by unseen forces in the spirit realm. No respondent (0%) expressed "no idea" to the factors responsible for dry well/boreholes. This is evidence that the people of Yauri have a wealth of knowledge about the changes going on in the environment.

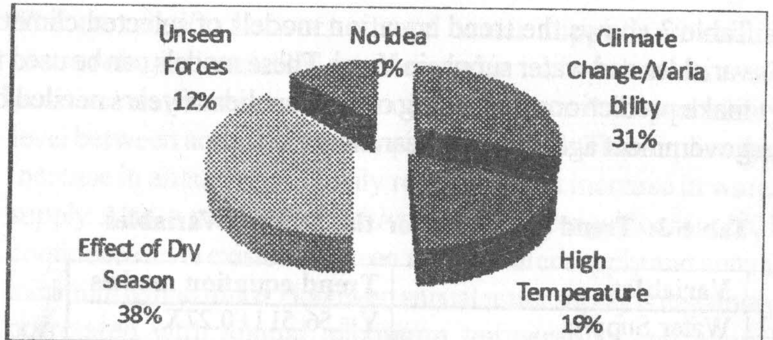

Figure 3: Factors Responsible for Dry Wells/Boreholes in Yauri.

Trend Analysis of Water Supply in Yauri

In order to show the variation in quantity of water supplied in Yauri during the period of study, water quantity supplied were plotted against years. A graph with positive trend line was obtained (see figure 4.19). It is observed that water supply increase with time. However, the trend line equation shows that water supply increase at 0.30 million cubic meters (m^3) every year over the period of study. Many factors adduced to this increase in water supply like increase in population as a result of economic development and migration, lack of access to water as indicated by the opinion of respondents (49.8% lack access to water(table 4.3)) among others, in the study area.

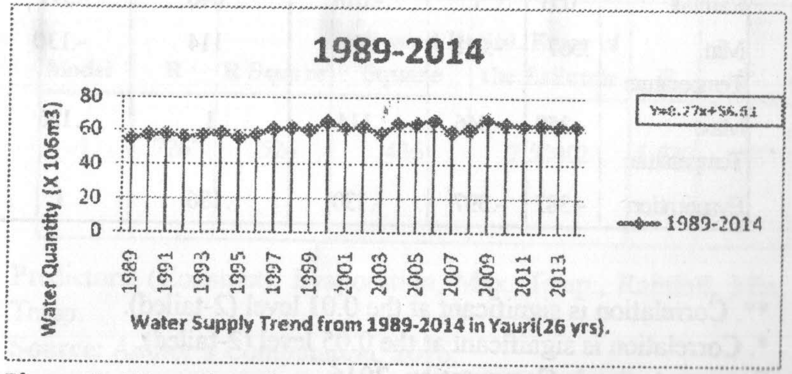

Figure 4: Water Supply Trend from 1989-2014 in Yauri

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Table 3 shows the trend equation models of selected climatic variables and water supply in Yauri. These models can be used to make predictions depending on the number of years needed by government agencies or researchers.

Table 3: Trend Equation for the Studied Variables

Variables	Trend equation models
Water Supply	Y= 56.511+0.27X
Rainfall	Y= 80.40+0.37X
Minimum temperature	Y= 20.73+0.05X
Maximum temperature	Y= 34.48-0.07X
Evaporation	Y= 13.45-0.19X

Source: Author's Computation, 2016

Table 4: Result of Correlation Coefficients between Annual Mean Meteorological Variables and Annual Water Supply

	Water Supply	Rainfall	Min. Temperature	Max. Temperature	Evaporation
Water Supply	1	.053	.567**	-.358	-.387
Rainfall	.053	1	-.018	.046	-.397*
Min. Temperature	.567**	-.018	1	.114	-.130
Max. Temperature	-.358	.046	.114	1	.186
Evaporation	-.387	-.397*	-.130	.186	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).
Source: Author's Computation, 2016

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The correlation between annual water supply and annual meteorological variables as presented in table 4 shows a weak positive relationship which is not significant at 0.05 probability level between annual water supply and rainfall. This implies that increase in annual rainfall only result in slight increase in water supply. Also, a moderate, positive relationship significant at 0.01 confidence level existed between annual water supply and annual minimum temperature. However, annual water supply is negatively correlated with annual maximum temperature and annual evaporation. This relationship is not significant at both 0.01 and 0.05 probability levels. Annual rainfall and annual evaporation are negatively correlated at 0.01 probability level. This implies that increase in annual rainfall brings about decrease in evaporation rate.

Result of Multiple Regressions between Climatic Variables and Water Supply Variability.

The results of the multiple regression analysis are shown on table 5 and 6.

Table 5: Model Summary of Water Supply and Climatic Variables

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	F	P
1	.726a	.526	.436	2.50402	5.835	.003

Predictors: (Constant), Evaporation, Max. Temp., Rainfall, Min. Temp.
Source: Author's Computation, 2016.

Table 5 shows multiple linear regression model, with four predictors, and it has R^2 value of 0.526. This result shows that 52.6% of the variation in water supply can be explained by this model. In other word, the selected climatic variables are able to explain 52.6% variability observed in water supply. Thus to elucidate on other factors affecting water supply in the study area, the opinions of the people of Yauri was sought for using questionnaire and the results discussed(see table 4.17 and figure 4.23).

Table 6 indicates that for every 1% increase in rainfall and minimum temperature, there is 0.014% and 1.680% increase in water supply respectively. Also, for every 1% decrease in maximum temperature and evaporation, there is -0.128% and -0.265% decrease in water supply respectively. The result implies that increase in rainfall brings about significant increase in water supply while slight decrease in maximum temperature and evaporation has no significant impact on water supply.

Table 6: Relative Contribution of Each Climatic Variable to Water Supply Model

Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	29.990	12.053		2.488	.021
	Rainfall	.014	.035	.064	.408	.687
	Min. Temp	1.680	.480	.560	3.501	.002
	Max. Temp	-.128	.049	-.405	-2.616	.016
	Evaporation	-.265	.280	-.156	-.946	.355

a. Dependent Variable: Water Supply
Source: Author's Computation, 2016.

Conclusion

Access to water is a problem in Yauri due to climate variability and other factors. Climate variables like rainfall, temperature and others play important role in water availability, accessibility and supply especially in semi arid region with high incidence of excessive anthropogenic activities which are climate change induced factors. Climate variability can affect both surface and underground water resources, thus impacting negatively on rivers, lakes, streams and water recharge aquifer.

It is indicated that 49.8% of the people in the study area lack access to water and the selected climatic variables examined in this study contributed more than 50% to the variability in water supply in Yauri. This implies that one of the major reasons for inadequate access to water may be variability in climate. This assertion is supported by the fact that many respondents agreed that climate variability causes their well not to yield adequate water or dry up completely in seasons. Therefore, since climate variability does not contribute 100% to the problems of water accessibility and supply, it means other factors contributed to inadequate access and supply of water in the study area. These factors may include poor water resources management and planning, inadequate infrastructures and facilities for effective distribution and supply of water, obsolete equipments, wastage, abject poverty and poor water governance among others.

Findings revealed that the supply of water to the community by Yauri waterworks is hampered by damages on supply lines due to road construction. Therefore, government should replace the damaged pipelines with new ones, with strict demarcation from areas of potential road construction activities. This action will increase access to water tremendously.

Climate change induced anthropogenic activities like deforestation, bush burning, over grazing and burning of fossil fuel among others should be discouraged or reduced to the minimum through proper sensitization programs and policy advocacy. This will curb excessive release of greenhouse gasses that are inimical to stratospheric ozone layer.

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