Vol. 1, No. 1 (June 2020)
Journal of Applied Sciences, Information, and Computing
School of Mathematics and Computing, Kampala International University

ISSN: 1813-3509 https://jasic.kiu.ac.ug

Geologic Factor and Domestic Water Scarcity in Rural Nigeria

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Abstract

As climate change and population explosion impacts access to adequate water supply in developing countries, attention has been shifted to the examination of economic and socio-demographic differentials, mostly in urban settings, in relation to water demand and supply chain. Thus, this study examined (i) the extent of rural households' vulnerability to domestic water scarcity; and (ii) the impact geologic differentials on water scarcity in the rural setting of Yobe State, Nigeria. It adopted the geologic divisions of the area as study zones and applied a two-stage sampling approach. Firstly, nine village units were purposively selected; and secondly, respondents were drawn using systematic-random sampling approach. Descriptive statistics show that overwhelming majority of the households (63.4%) relied on unimproved water sources; trek an average distance of 1.5km per round trip of water collection; an average household barely access 50% of its daily water demand. The descriptive and inferential statistics revealed further that an average person in the study area access only 52.6% of his/her daily water demand. It also found that the disparities in the per capita water accessibility varied by 12 litres between KKF and CDF, 5 litres between FKS and both KKF and CDF respectively. The study concluded that the pattern of water scarcity is tied to the spatial geologic differentials. Therefore, the study recommends the integration of geologic factor into rural water policy formulation; and an increase in budgetary allocations to water supply sector to achieve target 6.1 of the SDGs.

Keywords: Geology, Households, Scarcity, Water

1.0 Introduction

Affordable access to water supply constitutes a huge challenge to developing countries despite being a human right, its spatial distribution and accessibility which is projected to grow by 1% annually, are closely linked to socio-economic development with attendant effects on public health and poverty reduction (Al-Amin & Mahmud, 2011; Ngohi, 2011; Mohammed, 2016; WWAP, 2018). The situation in rural places is more worrisome, as the public sources appear to be dotted, sometimes poorly function, breeding high competition over the resource followed by attendant consequences such as scarcity, high energy and time expenditure, violence against young girls and women. Survey of available literature on water supply (Omeje, 2012; Ibrahim, 2012; Oke, Adeyeni, Adesina & Ajibade, 2013; Inkani, 2015; Adams, Boateng, & Amoyaw, 2015; Mashi & Inkani, 2016; Chukwuma, 2017; Abubakar, 2018; Fagan, Etango, Zerihun & Tafere, 2019) shows biases towards urban and peri-urban settings, climatic change and variability, water infrastructure and tariff, households' socio-economic and demographic characteristics, whereas rural disparity and physical or geologic condition of the environment in question, remained ignored.

However, yields from both surface and groundwater sources, on which major domestic water needs are met, are determined by the interactions between rock fractures in the aquifer. For instance, Tukur et al (2018) described Chad Basin which the study area is part of, as one of the largest accessible stores of groundwater, exploited through the construction of boreholes and hand-dug wells, principally for domestic water supply. Similarly, the variation in groundwater table has been attributed to geologic characteristics, which consequently determines the quantity of water accessible for domestic uses (Fagoyinbo, 2015). As such, groundwater exploration and exploitation has been a top priority of households because of its cheapness, freshness, portability and purity (Hamidu et al., 2017). These facts, coupled with the depressing water service level in developing countries such as Nigeria, are evident, as poor households continue to struggle to meet-up their daily water demand.

The scenario of rural communities in Yobe region of Nigeria has not been studied and documented, as available literature has shown, creating huge data gaps for public water supply policy formulation and other development needs. Therefore, this study examined the extent of households' vulnerability to domestic water scarcity; geologic differentials and its impact on households' access to domestic water supply in rural communities of Yobe State, Nigeria.

2.0 Materials and Methods

2.1 Study Area Setting

The Fune Local Government Area which is one of the rural geo-political units in Yobe State has a projected population of 388,771, landmass of 4,985km² and a population density of 78 persons/km² (NPC, 2017). It falls within the Nigerian arm of the Chad Basin, dominated by three geologic units namely Fika Shale (FKS), Kerri-Kerri Formation (KKF) and Chad Formations (CDF). The soil of the area is classified as Typic Alfisols according to the USDA Soil Taxonomy and are described generally as loose and sandy (and hence highly erodible) supporting the cultivation of crops such as millet, sorghum, beans and groundnut as well as livestock rearing. Characterized with climate simply identified as 'AW' using Koppen's climatic classification, the area lies within the dry Sudano-Sahelian savanna climatic belt, with an annual rainfall that ranges between 600 – 800mm. The semi-arid region is an area of natural water scarcity – with low and highly erratic rainfall with an annual average of 250mm and a continuous decline in water availability due to lacks adequate water supply infrastructure and increasing human and animal populations leading to a complex water scenario.

2.2 Sample Size and Sampling Procedure

Literature survey of sample size determination methods shows the existence of many such as Cochran,1963; Yamane, 1967; Scheaffer et al, 1996, Inkani (2015) revealed. These were employed by a community of researchers (Israel, 1992; Evans et al, 2000; Dell et al, 2002; Sincich et al, 2002; Särndal et al, 2003; Mora and Kloest, 2010), she maintained. To correct the weakness of Cochran, Yamane proposed the following formula, meant to estimate the upper limit of the sample size:

$$n = \frac{N}{1+N\,(e^2)} \quad \text{……………………} \text{ Eq.(1)}$$

Where 'n' is the sample size; 'N' is the population size and 'e' is the error precision level. Household sizes of the communities in the study area as established by 2006 human population headcount was adopted and updated during the reconnaissance survey. Thus, the application Yamane method of sample size determination appeared to be quite suitable for this study.

However, drawing 225 samples, 25 each from the nine sampled village units, necessitated the employment of mixed sampling approach. Firstly, three communities from each zone were purposively selected; and secondly, household heads were drawn for in-depth interviews using a systematic random sampling technique. While some studies (Fan et al., 2013; Inkani, 2015; Irianti, 2016; Ahmad, 2017; Abubakar, 2019; Fagan et al., 2019) used rainfall data, socio-economic and demographic status, occupation and geopolitical division to stratify the study population, this study employed geologic map of Nigeria in the delineation of the area into the different physical zones and adopted same as study zones.

2.3 Data Sources and Analyses

The data for the study were collected through in-depth interviews, Focus Group Discussions and desk review of relevant literature. However, basic descriptive statistics of tabulations and charts and t-test model of inferential statistics were employed to ascertain the differences in mean water availability and demand across the geologic zones at both household and per capita levels. The model assumed that:

$$t = \frac{x - \mu_o}{\frac{s}{\sqrt{n}}} \quad \text{..} \text{ Eq.(2)}$$

Where, x = sample mean, μ_o = population mean, s = sample standard deviation, n = sample size.

3 Findings of the Study

3.1 Water Sources

The primary sources of water supply relied upon for domestic water supply in the study area are boreholes (11.3%, 45.1% and 52.8% in CDF, KKF and FKS respectively), hand-dug wells (29.8%, 39.8% and 33.8% in CDF, KKF and FKS respectively) and surface waters (58.9%, 14.3% and 13.4% in CDF, KKF and FKS respectively), see Figure 1. The means that only 36.4% access water from a source defined as improved, leaving behind 63.6% to the hands of conventionally unimproved water sources, based on WHO/UNICEF (2006) classification as cited by Obeta and Chikwu (2013). It was revealed in FGDs that 'those relying on surface waters which barely last few weeks after the rainy season, were resorting to the use of shallow wells in the dry period'.

3.2 Spatial Distance to Water Sources

Descriptive analyses as shown in Figure iii.ii indicates that 67.5% of the households' trek about 1.5km per round-trip of water collection. This may invariably affect their household chores, farm labour inputs and other incomegenerating activities which consequently livelihood system. There was consensus in FGDs that 'the frequencies of water collection trips, time expenditure and coverage increases in the dry season, since the surface waters quickly dried up and water table drops – leading to long hours of trekking to reach alternative sources in addition to competition'.

3.3 Impact of Geology on Vulnerability to Water Scarcity

Descriptive analyses as shown in Figure 2, revealed that an average household in FKS was accessing only 190 litres of water daily, which is only 40.5% of the daily water demand, indicating a deficiency of 257 litres. On the other hand, an average household in KKF manages to use 172 litres of water (50%) of the daily water demand (344 litres); whereas in CDF their daily water accessible by an average household was 171 litres, 47.1% of the daily water demand, running short of 192 litres. These differences in both water availability and vulnerability to scarcity can be tied differentials in geologic characteristics of the environment. Further analyses in Figure 3, of the per capita water availability with the UNDP (2006) standard of 38 litres of water per head daily, revealed that an average person accesses 24 litres, 16 litres and 19 litres in CDF, KKF and FKS respectively. This means an average person in the study area only 20 litres of water daily, running short 18 litres relative to the benchmark. It also indicates that the proportion of persons who access sufficient water supply were only 12.3%, 5.3% and 8.5% in CDF, KKF and FKS. This generally implies that in the study area only 8.7% of the studied population access the required quantity of water, leaving behind highly 91.3% vulnerable to the incidence of scarcity. Moreover, the per capita water variability model shows that there are statistical mean differences of 12 litres of between KKF and CDF; 5 litres between FKS and KKF; and also 5 litres between FKS and CDF (see Table 3.1). The demonstrated variation scenarios are in tune with the difference in a geologic formation, because the most dominant source of water in CDF is surface water which quickly dried up, and combination of both groundwater and surface are used in both KKF and FKS, though boreholes are predominantly used in the later zone.

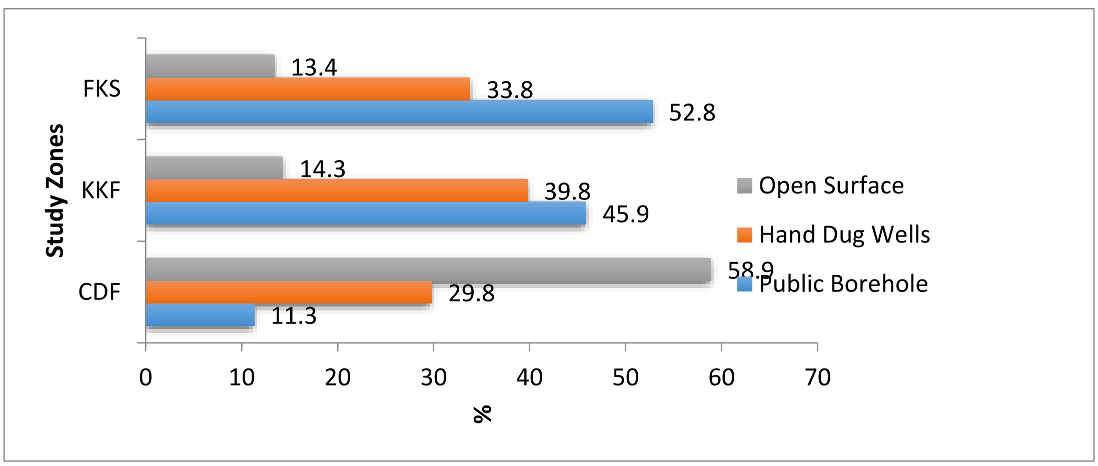

Figure 1: Domestic Water Sources

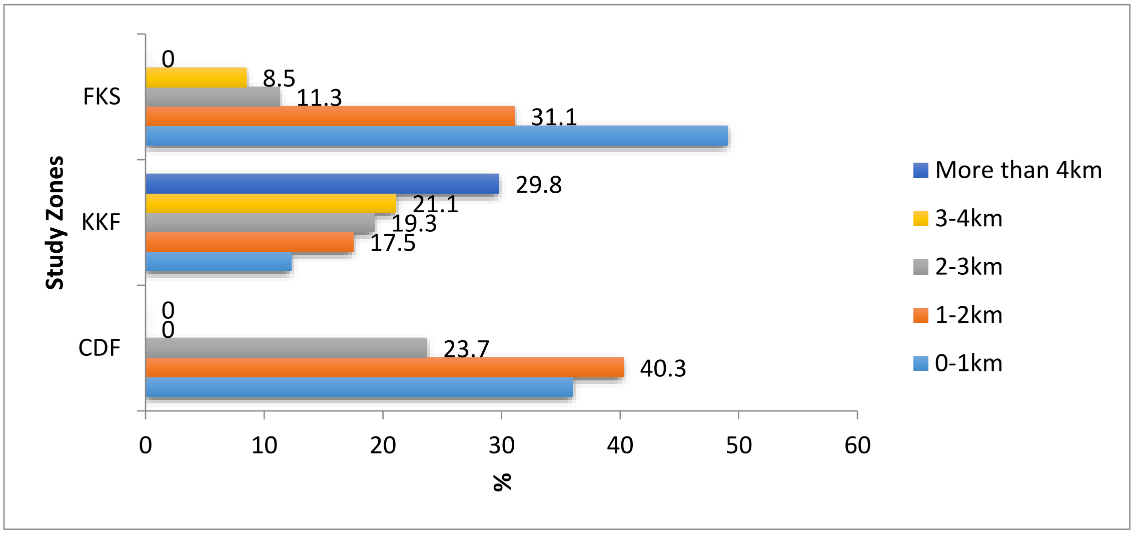

Figure 2: Distance to Water Sources

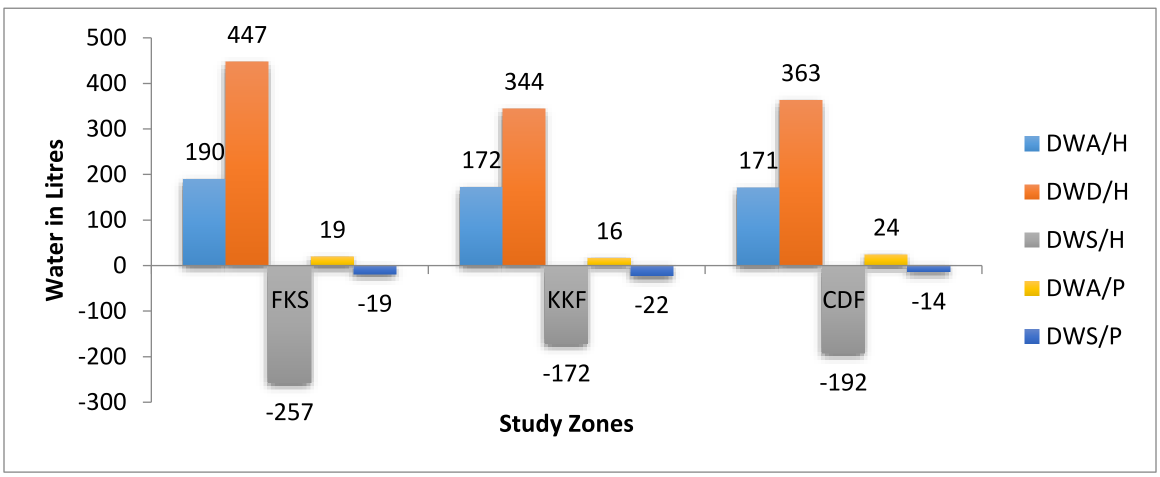

Figure 3: Average Water Availability, Demand and Vulnerability to Scarcity
DWA/H = Daily Water Available per Household; DWD/H = Daily Water Demand per Household; DWS/H = Daily Water Shortage per Household;
DWA/P = Daily Water Availability per Person; DWS/P = Daily Water Shortage per Person
Source: Researcher's Fieldwork, 2019

Table 3.1 Difference Influence of Geology on Water Availability

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	KKF WA/H - CDF WA/H	-11.5418354	39.1204348	5.1816282	-21.9218839	-1.1617868	-2.227	56	.030
Pair 2	KKF WA/H - FKS WA/H	-5.1900585	29.6982214	3.9336255	-13.0700573	2.6899403	-1.319	56	.192
Pair 3	FKS WA/H - CDF WA/H	5.2993469	35.7749696	3.4747722	-1.5904845	12.1891783	1.525	105	.130

KKF = Kerri-Kerri Formation; CDF = Chad Formation; FKS = Fika Shale; WA/P = Water Availability per Head

4.0 Discussions

The study findings are consistent with those of Obeta and Chikwu (2013); and Sule et al. (2016) in terms of water sources of rural areas in Nigeria, since the overwhelming majority of households in this study area (63.6%) defend heavily on unimproved water sources, particularly hand-dug wells and surface waters, while more than 20% still defecate in the open. These findings eroded the so-called achievement of the water component of the Millennium Development Goals (MDGs) which claimed to have halved the proportion of without access to improved water supply and threatens the attainment target 6.1 of SDGs as well as the African Water Vision by 2025. Though it also agreed with WHO/UNICEF JMP (2015) as quoted by Fagan et al. (2019) that 844 million people had lacked access to basic drinking water service, 159 million people are still collecting drinking water directly from surface water bodies, 58% of whom live in sub-Saharan Africa. It similarly reputed the finding of Fagan et al. (2019) that the global population using surface waters decreased from 4% in 2000 to only 2% (159 million) in 2015, as 147 million of them lives in rural areas. This is because more than half of the surface water using households are living in sub-Saharan Africa, which the study is part of. The study findings also confirmed the inability of relevant public institutions in providing adequate water supply service to the growing rural population. On the other hand, the study findings contradict the reports by UNDP (2012) and WHO/UNICEF (2012) that 61% of households in sub-Saharan Africa have access to improved water supply sources. It’s also a negation of the expected 91% target coverage in rural water supply in the year 2018 of the Yobe State Rural Water Supply and Sanitation Policy paper.

Invariably, it means that reliance on these water sources means an increase in time expenditure for water searching, decline in productivity and income levels and consequently exposure to poverty and violence against girls and women (who are the primary water collectors). The study findings further portrayed that it is not only the attainment of goal six of the SDGs is at stake but also goal one (which aimed to end poverty in its all forms), three (focused on ensuring healthy lives while promoting well-being for all at all ages) and the gender equity and equality component of the SDGs are threatened by the use of unimproved water sources.

On the rate of open defecation, the finding demonstrated that more commitments are required to actualized the open-defecation-free (ODF) Nigeria by 2025. This is because, about 50 million Nigerians continue to defecate in the open and about 68 million are likely to be added between now and 2030, and the country loses about ₦455 billion ($3.6 billion) in addition to childhood malnutrition and over 87,000 diarrhoea-related under-five deaths (Adedoyin, Emmanuel & Ohunene, 2019). It may be argued it is either difficult for Nigeria to realize the ODF target by 2025. These facts also placed Nigeria high in the statistical graph of the global child mortality rate. These did not only erode the so-called progress recorded in access to the domestic water supply and sanitation but posed a huge challenge to achieving the many goals of sustainable development.

Due to the seasonality and climate change factors which alters the water yields from these sources, households’ water collectors travel a long distance in search of water, especially in the dry season when the water table drop. For example, 67.5% of the studied households cover about 1.5km per round-trip of water collection, higher above the WHO (2010) recommended maximum distance of 1km per round trip with 30 minutes. The finding agreed with Fagan et al. (2019) who cited WHO/UNICEF JMP 2015 report that 263 million people spend over 30 minutes per round trip of water collection. It may similarly mean that the more water source is spatially distant away from dwelling place the more likelihood of alternating the source with insecure or contaminated one increases, despite the potential health risks therefrom. In traditional Nigerian setting, especially poor and rural households, girls and women are the primary water and wood collectors, in addition to farm labour. However, as water fetching involves long-distance trekking and several trips, this folk of the population loses schooling hours, their performance lowered and school-age enrolment discouraged – further increasing the out-of-school population and male dominance in the education sector among other labour industries.

However, the variability in average water availability and demand at the households and per capita levels, across the study zones, points to the influence of geologic differentials at a play. For example, an average households were accessing only 40.5%, 50%, 47.1% of their daily water demand in FKS, KKF and CDF respectively. These differences in both water availability and vulnerability to scarcity can be tied differentials in geologic characteristics of the environment. This means in the study area, an average household manage to use only 45.9% of its expected sufficient water supply daily. As household struggle to access less than half of its water demand, many socio-economic consequences are likely to follow up. These may include vulnerability to poverty, and water-related diseases such as typhoid, dysentery, diarrhea. It on the other hand, means time and financial must have to be committed to the treatment of these potential diseases.

Using UNDP (2006) standard of 38 litres of water per head daily in Nigeria, it was found that only 8.7% of the studied population access the required quantity of water, leaving behind 91.3% vulnerable to the incidence of scarcity. This suggested that nine in every ten persons in the area was short of the expected to water sufficiency, reflecting mirror reflection of the situation at the household level. Moreover, the statistical differences of water per head between the zones, were not surprising since surface water is the dominantly used by households in CDF and though involves less human energy and time expenditure, especially in the rainy season as against the boreholes and wells used by households in KKF and FKS. The situation of those in FKS for instance, differed and might not be unconnected with the aquifer behaviour and depth of the water table of the area. These brought the argument that geology was not only a significant factor determining water availability, vulnerability to water scarcity in the study area, but also reflects the tendency to have water scarcity fluctuating with geologic characteristics of the areas in question.

5.0 Conclusion and Policy Recommendations

Domestic water supply in rural Nigeria falls far below the demand, exposing households varying degree of vulnerabilities including but not limited to poverty. The emerged pattern of the vulnerabilities to water scarcity in the study area was neither primarily caused by water governance crises nor by household characteristics, rather by the spatial differentials in the geology of the environment. Therefore, the study recommends the integration of geologic factor into the rural water policy formulation – in an attempt to reduce the existing inequities in access to water at both household and per capita levels. The study also recommends an increase in budgetary allocations to domestic water supply sector and prioritized attention to the achievement of human development agenda such as the SDGs.

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