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DISTRIBUTION OF PUBLIC WATER SUPPLY: ANALYSIS OF POPULATION DENSITY AND WATER SUPPLY IN KEBBI STATE, NORTHWESTERN NIGERIA

Saadu Umar Wali[1],
Sheikh Danjuma Abubakar[2],
Ibrahim Mustapha Dankani[2i],
Murtala Abubakar Gada[2]
[1]Department of Geography,
Federal University Birnin-kebbi,
P.M.B 1157, Kebbi State, Nigeria
[2]Department of Geography,
Usmanu Dan Fodiyo University Sokoto,
P.M.B 2346, Sokoto State, Nigeria

Abstract:
Development and management of an improved water supply system is a great challenge faced by most developing nations. With rapid population growth and urbanization most, states in Nigeria find it difficult to deliver potable water to a substantial number of people who are in dire need for this resource, especially in the Urban areas. In this study, we attempt to relate public water supply to population density in Kebbi State. An inventory of water supply facilities was taken in 21 Local Government Areas (LGAs) in Kebbi State. Census data was collected from the National Population Commission (NPC), Birnin-kebbi. Results showed that, population density correlates very strongly and positively with handpumps (r=0.95), urban schemes (r=0.88), semi-urban schemes (r=0.69) and village scheme (r=0.74). There was a very weak but positive correlation between population density and boreholes (r=<0.001); population density and tabs (r=<0.001). PCA results showed, that the 21 LGAs cluster nicely across a spectrum of public water supply infrastructure. The ratio of persons to water sources is thus: Borehole 1:12794.1; Handpumps 1:7640.2; Taps 1:2821.8; Urban scheme 1:233799.6; Semi-urban scheme 1:63739.7; and Village scheme 1:67245.9. Suggesting that, the existing public water supply facilities are inadequate. More water supply infrastructure is needed to provide people with improved water supply. However, there are no statistics on private boreholes and people depending on them in Kebbi State. An inventory of private water supply sources in Kebbi State is recommended. This will guide policy regarding improved water supply in Kebbi State.

i Correspondence: email imdankani@gmail.com

Keywords: boreholes, hand pumps, taps, urban water scheme, rural water scheme, village water scheme.

1. Introduction

In many developing countries, particularly in Sub-Saharan Africa (SSA), greater attention has been paid to the broader livelihood benefit of improved water supply, especially in rural areas, looking beyond direct links between improved sanitation and water supply to reliable supply of potable water of excellent quality (Ismail, 2014). Improved water supply and sanitation have been one of the priorities of governments at various levels in SSA (Banerjee, 2008). Because sufficient water supply is a prerequisite for a healthy leaving. In many recent campaigns on improved water supply, the importance of community participation is increasingly being acknowledged, especially in rural areas. Because the demand for water supply is localized demands. Therefore, managerial decisions about the level of services locations of water supply facilities as well as cost sharing should be made locally (Ismail, 2014). The key role of higher level government agencies should, therefore, be made to establish institutional rules, regulations, and processes that encourage such decisions (Ismail, 2014). The problems with most developing countries are that public water supply facilities, especially in densely populated regions, are always not available. And where available, the volume of water provided may not be adequate or of excellent quality (Njoku, 2010).

However, the natural distribution of water resources is usually not easily accessible by many people particularly in remote communities (Adedeji, 2014). At least four out of ten people in the world lack access to potable drinking water of excellent quality (Njoku, 2010). However, it is well established that, potable water, is a scarce resource in most developing countries, with rural areas been the most affected. A survey of access to improved water supply and sanitation in thirty-seven (37) small towns (one per state) carried out in Nigeria, revealed that only about 5% of Nigerians had access to water from protected boreholes, and 13% use water from communal wells (Adedeji, 2014). The small towns have been largely ignored by public water supply agencies, and the gap is filled by private, informal arrangements, where individuals pay unit rates for water which is 10 – 20 times higher than those with access to public sector services. In addition, it is estimated that only about 35% of the rural population have access to safe and reliable drinking water supply and improved sanitation (Adedeji, 2014).

Many programs on improving water supply are on track by both governmental and non-governmental agencies in Nigeria and some of these programs have recorded considerable progress in remediating water supply shortages through the provision of boreholes and handpumps in both urban and rural areas (Madu 2010). Despite these efforts, many semi-urban and village water schemes that relied on boreholes and/or handpumps, are not properly maintained. For instance, about 42% of boreholes in

Sokoto state are not in operation, while only 40% of the village water schemes are in full operation. In contrast to these, about 80% of semi-urban water schemes are functioning (Iliya and Gada, 2010). Despite the challenges relating to maintenance of water supply facilities, there are three crucial factors that should be considered in any water supply program meant for improving domestic water supply. These are; location (or accessibility), availability and quality. Where any of the above is lacking, it would be grossly incorrect to say such an area enjoys accessibility to good portable water (Adedeji, 2014).

Many studies on water supply were carried out in Nigeria including Nwagbara et al. (2010), Okereke (2010), Madu (2010), Iliya and Gada (2010), Adedeji (2014) and (Ismail 2014). Most of these studies focused on problems such as impacts of climate change on water supply, the performance of water supply schemes, and the like. A comprehensive study assessing the distribution of public water supply facilities at state levels is mostly carried out by government agencies. And results are often decorated. How the distribution of water supply facilities relates to population distribution is seldom studied. However, in many developing countries especially in SSA, census data are rarely incorporated in designing water supply programs. In addition, politics play important roles in determining where water supply facilities are to be located or constructed. We upscale this study to demonstrate that the setting of public water supply infrastructure was population driven in Kebbi State, Nigeria.

2. The study area

2.1 Location and size

Kebbi state (Figure 1) is situated between latitude 10^0 8′ and 13^0 15′ north of the equator; and between longitude 3^0 30′ E. Kebbi State shares boundary with Sokoto state on the north-eastern axis, Zamfara State in the eastern part, Niger state in the southern part and Republic of Niger on the western part. The state occupies a total land area of about 36,800 km² (Abdulrahim, et al., 2014).

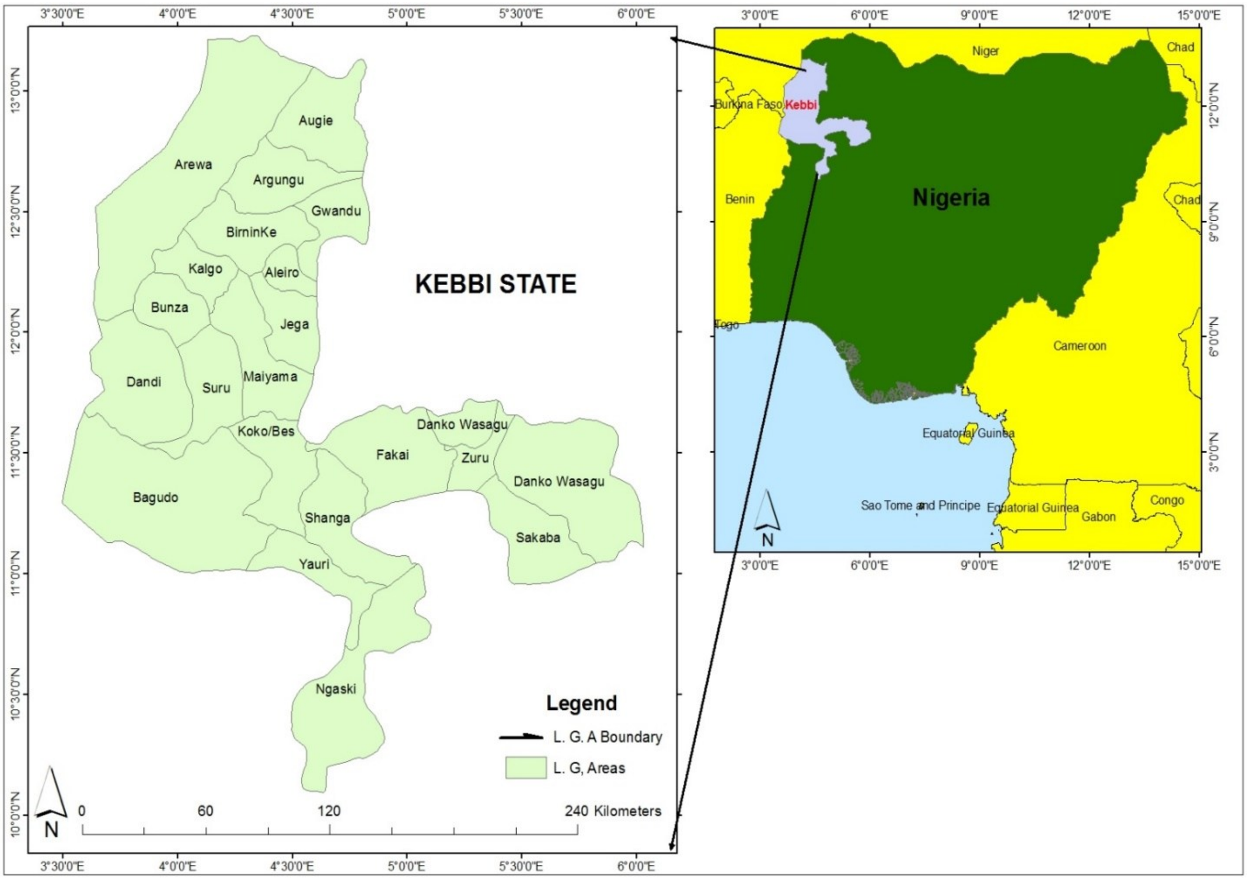

Figure 1: Map of Kebbi state

2.1 Climate

The climate of Kebbi state is hot, semi-arid tropical (AW) in Koppen's classification (Wali et al. 2016). The climate is characterized by a long dry season lasting between the months of October and May with a short but intensive wet season between the months of May and October. The dry season results from a hot continental air mass blowing from the North-west through the Sahara Desert. The rainy season results from humid equatorial maritime air mass blowing from the South-west over the Gulf of Guinea (Wali, 2012). Owing to the position of the state in extreme North-western Nigeria and over 1000km away from the sea, Kebbi state remains largely dry for most periods of the year.

2.2 Hydrology and water resources

In terms of its hydrology, the state falls within the Sokoto basin. The basin is part of an extensive elongated sedimentary formation underlying most of North-western Nigeria and eastern part of Republic of Niger (Kogbe, 1981). The basin is well known for its groundwater potentials (Ofodile, 2002). Despite the potentials presented by groundwater aquifers in Kebbi state, many communities are still struggling with water supply shortages and where water supply is adequate, the water quality and safety for drinking remain largely uninvestigated (Wali and Bakari 2016). Apart from these, the study area is in the semi-arid zone, which is very sensitive to climate change. There have been fluctuations in annual rainfall (Wali et al. 2016). For many years, rainfall short-circuits, even though it intensifies over some years thereby reducing the effects of seasonal droughts (Wali et al. 2016). Where communities rely on surface water bodies such as ponds, lakes, streams or river, these water sources may dry completely during the prolonged dry season, which leads to water shortages in highland areas.

3. Materials and methods

A total of twenty-one (21) local government areas (LGAs) were studied. For each LGA, an inventory of a number of Boreholes, Handpumps, and Taps, in addition to semi-urban, urban and village water supply schemes. However, census data (2006) was collected from the National population commission (NPC). Population figures were projected, thus;

$$Pt = Po \times {}^{e}rt$$

Where; Pt = New Population, Po = Base Population, r = Rate of growth (3.2%) and t = Time

Data obtained was organized and standardized using descriptive statistics (mean, minimum, maximum, and standard error). We further employed Pearson's correlations (*r*) to test the relationship between population and water supply parameters. In addition, we employed Principal Component Analysis (PCA) to calculate the variability between population distribution and public water supply parameters. We used PAST to conduct all the statistical analysis.

4. Results and Discussion

4.1 Distribution of public water supply infrastructure

Table 1 summarizes total population, land mass and population density in Kebbi State. Also, contained in the table is a summary of boreholes, handpumps, taps, urban, semi-urban and village water supply schemes. Human population (mean ± standard error) was 208501.00±16416.63 and ranged from 89195.00 to 362904.00 in Kebbi State. Population distribution is highly variable reflecting geographical, socio-economic, historical and political factors. Birnin-kebbi the state capital constitutes ~8.3% of the state's population, followed by Suru LGA (8.2%). Bagudo has ~7.3%, Argungu ~6.0%, Gwandu ~6.0%) and Arewa ~5.7% (Figure 2A). These are LGAs with fertile soils, rich groundwater aquifers and the longest history of human settlement. Aleiro LGA has the lowest population (2.04%) in Kebbi State. However, land mass (mean ± standard error) was 8857.76±5333.42 (sqkm) and ranged from 503.00 to 8595.00 sqkm. (Figure 2B). Arewa LGA constitutes ~11.3%, of the state's landmass. Bagudo has ~11.5% and Danko-wasagu ~11.6 %. These are the largest LGAs in Kebbi State (Figure 1). The three LGAs put together, constitutes about 32% of total land mass of Kebbi State. LGAs that are very small in size are Argungu (1.6%), Bunza (1.4%) and Kalgo (1.2%). However, they represent LGAs with high population density (Figure 2C). Population density (mean ± standard error) was 129.52±19.39 and ranged from 26.00 to 308.00 persons per sqkm. Kalgo has the highest population density (308 persons/sqkm), followed by Argungu (292 persons/sqkm) and Birnin-kebbi (281 persons/sqkm). Apart from these, all the remaining LGAs in Kebbi State have less than 220 persons per square kilometer (Figure 2C). Arewa, Gwandu, Kalgo, and Danko-wasagu represent LGAs with very low population density.

Table 1: Summary of population, land mass, population density and public water supply facilities in Kebbi State

Parameters	Minimum	Maximum	Mean	Standard error
Population	89195.00	362904.00	208501.00	16416.63
Landmass	503.00	108595.00	8857.76	5333.42
Density	26.00	308.00	129.52	19.39
Boreholes	10.00	54.00	19.24	2.52
Handpumps	10.00	115.00	42.90	6.20
Taps	0.00	5338.00	422.10	254.42
Urban Schemes	0.00	1.00	0.43	0.11
Semi-urban Schemes	1.00	11.00	5.05	0.63
Village Schemes	0.00	21.00	4.52	1.03

While population density and landmass were highly variable in Kebbi State, water supply facilities are also highly variable reflecting water supply characteristics of underdeveloped communities of SSA. More than half of LGAs in Kebbi State, do not have urban water supply scheme (Figure 3A). LGAs with the urban scheme are Arewa, Argungu, Bagudo, Birnin-kebbi, Dandi, and Jega. However, LGAs without urban water scheme are Aleiro, Augie, Bunza, Danko-wasagu, Fakai, Gwandu, Kalgo, Maiyama, Ngaski, Sakaba, Shanga and Suru LGAs (Figure 3A). Semi-urban schemes were available in virtually all the 21 LGAs (Figure 3B). Aleiro LGA constitutes ~10.4% of the semi-urban scheme in Kebbi State. Argungu has ~9.4%. Birnin-kebbi, Arewa, and Danko-wasagu have ~8.5%, ~7.5% and ~7.5% respectively. Koko-Besse and Zuru LGAs have a very sparse number of semi-urban schemes (1.4%). Except for Zuru and Yauri, all the LGAs in the Kebbi State have village schemes (Figure 3C). Birnin-kebbi and Zuru LGAs have more boreholes compared to the remaining LGAs in Kebbi State. About 13.3% of boreholes in the study area, are in Birnin-kebbi LGA, followed by Zuru LGA (~10.6%).

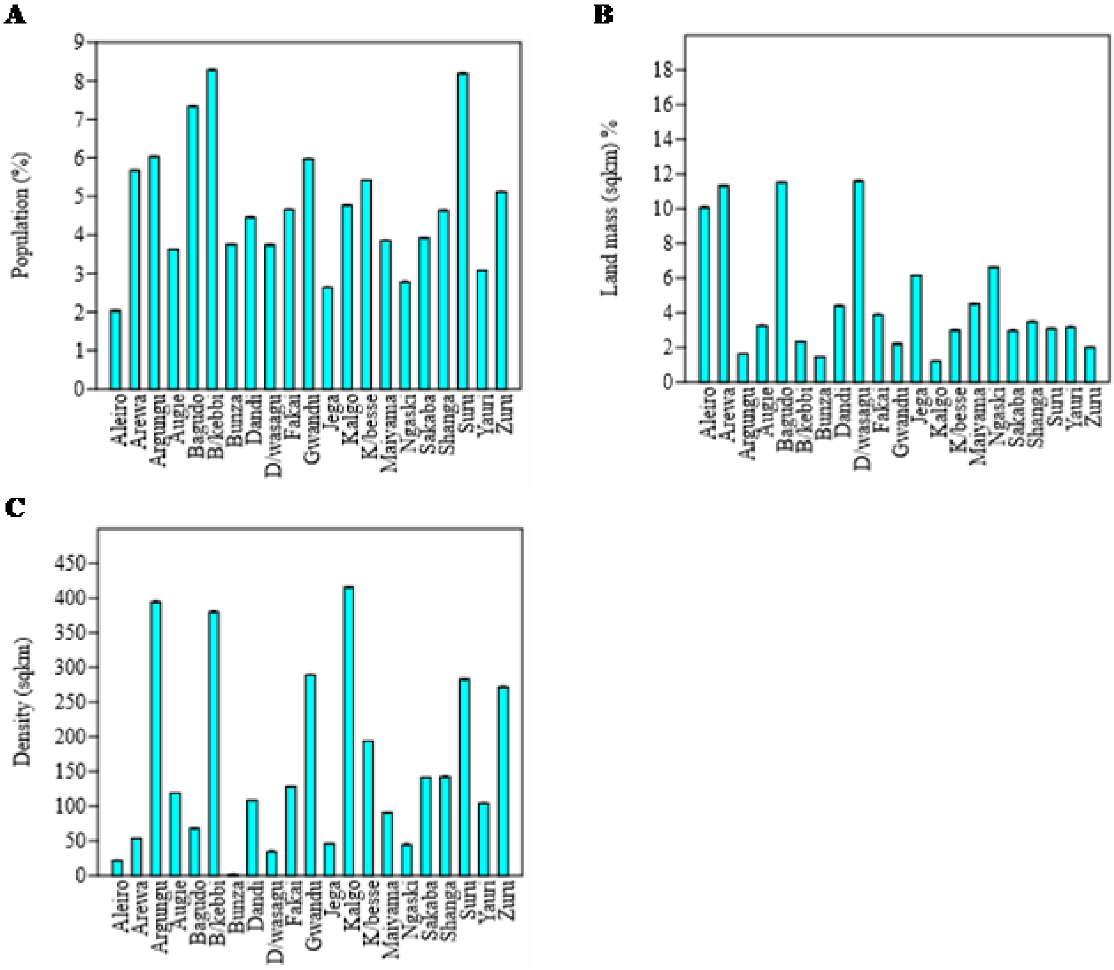

Figure 2: Variability of Geographical factors (A) Population,
(B) Landmass and (C) Population density

LGAs with sparse number of boreholes are Augie (~2.5%), Jega (~2.5%), Koko-besse (~2.5%), Maiyama (~2.5%), Ngaski (~2.5%) and Yauri (~2.7%). However, Danko-wasagu and Birnin-kebbi LGAs have the highest allocation of handpumps (Figure 3E). The two LGAs joint together constitutes >23% of handpumps in Kebbi State. LGAs with the moderate allocation of handpumps are Ngaski (8.7%) and Zuru (8.1%).

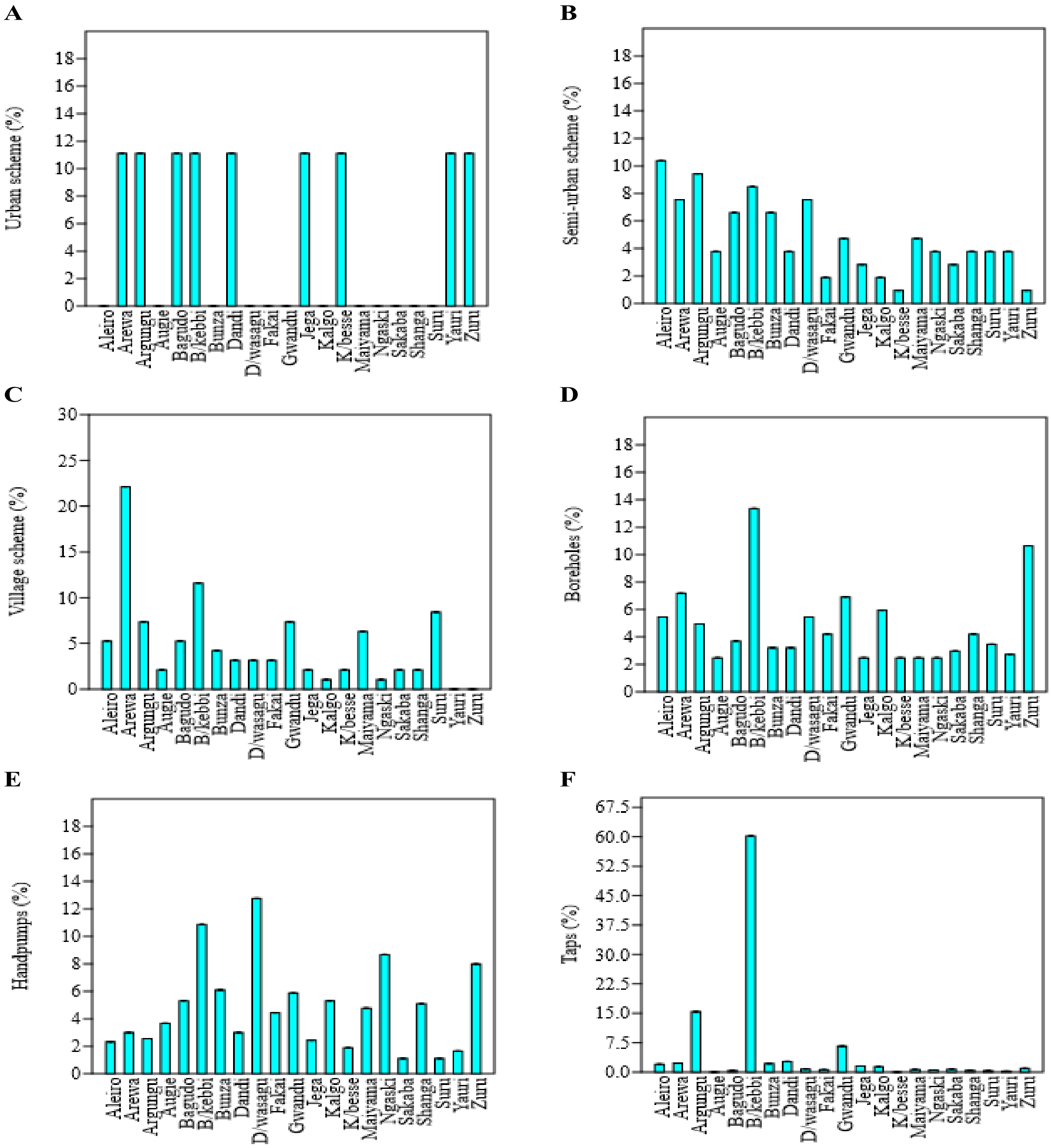

Figure: 3 Public water supply facilities (A) Urban water scheme (B) Semi-urban scheme (C) Village scheme, (D) Boreholes (E), Handpumps and (F) Taps

However, the relative percentage of handpumps was 5.3%, 5.9%,5.1% and 4.4% in Bagudo, Gwandu, Shanga, and Fakai LGAs respectively. However, LGAs with the very low allocation of handpumps are Sakaba (~1.1%), Suru (1.1%) and Yauri (1.6%).

4.2 Correlations between population density and public water supply infrastructure

Table 2: Correlations between population density and public water supply.
Values in bold are significantly related

Pearson's Correlation (*r*)	Population	Landmass	Density	Boreholes	Handpumps	Taps	Urban Schemes	Semi-urban Schemes	Village Schemes
Population		0.25624	0.020386	0.026458	**0.66159**	0.018997	0.18886	**0.6357**	0.024419
Landmass	-0.25936		**0.82101**	**0.64918**	**0.84552**	**0.75747**	0.28153	0.1417	**0.99147**
Density	0.50206	-0.052556		0.009682	**0.94812**	0.019529	**0.87747**	**0.686**	**0.74453**
Boreholes	0.48329	-0.10545	0.55068		0.011924	0.00031611	0.23263	0.22666	0.077714
Handpumps	0.10149	0.045268	0.015124	0.53776		0.069528	**0.57782**	**0.38389**	**0.91321**
Taps	0.50697	-0.071689	0.50506	0.70947	0.40373		0.17747	0.056621	0.09928
Urban Schemes	0.29842	-0.24644	0.035826	0.27218	-0.12883	0.3059		**0.81741**	**0.34942**
Semi-urban Schemes	0.10978	0.33182	0.093771	0.27555	0.20035	0.42214	0.053629		0.009487
Village Schemes	0.48917	0.0024843	0.075639	0.39335	-0.025332	0.36947	0.21495	0.55192	

Table 2 presents correlation analysis between population density and boreholes, Handpumps, tabs, urban, semi-urban and village water supply schemes. Population density correlates very strongly and positively with hand pumps (*r*=0.95) and urban water supply schemes (*r*=0.88). There was a strong correlation between population density and semi-urban water supply schemes (*r*=0.67). Village water supply scheme also correlates strongly (*r*=0.74) with population density in Kebbi State. There was a very weak positive correlation between population density and boreholes (r=0.009), population density and taps (*r*=0.018). The observed positive correlation between population density and public water supply amenities is an indication that public water supply services are population driven in Kebbi State (Figure 4).

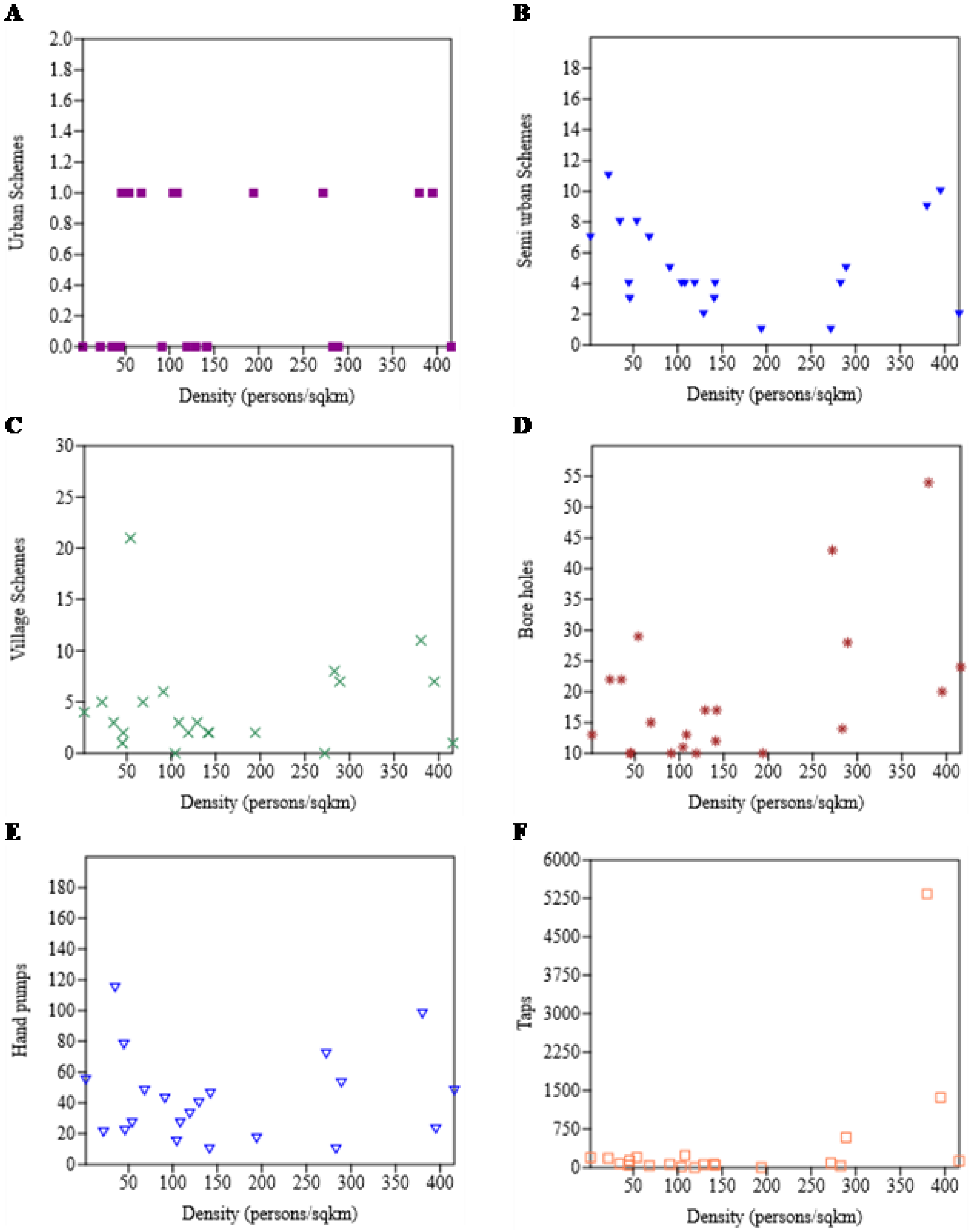

Figure 4: Scatter plots of population density and water supply (A) Urban scheme, (B) Semi-urban scheme), (C) Village scheme, (D) Boreholes, (E) Hand pumps and (F) Taps

Table 3 presents the proportion of people to water supply in Kebbi State. Suru, Koko-besse, and Bagudo have a high proportion of persons per borehole. This implies that for every borehole in Suru LGA there are 25611 persons to fetch water from it. In Koko-besse LGA, there were 23753 people depending on a borehole.

Table 3: Ratio of persons to boreholes, handpumps, and taps

LGAs	The ratio of persons to boreholes (0:000)	The ratio of persons to handpumps (0:000)	The ratio of persons to taps (0:000)	The ratio of persons to Urban scheme (0:000)	The ratio of persons to semi-urban scheme (0:000)	The ratio of persons to village scheme (0:000)
Aleiro	4054	4247	496	*	8109	17839
Arewa	8580	9215	1244	248809	31101	11848
Argungu	13209	11486	194	264186	26419	37741
Augie	15857	4805	0	*	39643	79286
Bagudo	21435	6699	9187	321529	45933	64306
Birnin-kebbi	6720	3703	68	362904	40323	32991
Bunza	12632	2986	855	*	23459	41054
Dandi	15004	7224	830	195057	48764	65019
Danko wasagu	7449	1425	2341	*	20485	54626
Fakai	12010	5104	3712	*	102089	68059
Gwandu	9336	4932	447	*	52282	37345
Jega	11546	5248	837	115465	38488	57732
Kalgo	8710	4355	1659	*	104514	209029
Koko-besse	23753	13972	*	237527	237527	118764
Maiyama	16868	3923	2811	*	33737	28114
Ngaski	12159	1559	2702	*	30399	121595
Sakaba	14325	17190	2645	*	57300	85951
Shanga	11948	4415	5078	*	50778	101555
Suru	25611	35855	11952	*	89639	44819
Yauri	12264	8993	6745	134899	33725	*
Zuru	5205	3109	2633	223820	223820	*

Note: * No data

Bagudo has 21435 persons to borehole (Figure 5A). LGAs that have the lowest ratio of persons to boreholes are Aleiro (1:4054), Zuru (1:5205) and Birnin-kebbi (1:6720). The proportion of persons to handpump was greater in Suru (1:35855), Sakaba (1:17190) and Koko-besse (1:13972). LGAs with less than 10000 persons per handpumps are Aleiro, Augie, Bagudo, Danko-wasagu, Fakai, Gwandu, Jega, Kalgo, Maiyama, Ngaski, Shanga, and Zuru (Figure B). However, Suru LGA has the highest proportion of persons to tabs (Figure 5C). For every single tab in Suru LGA, there are 11952 persons to fetch water from it. In Sakaba the ratio was 1:2645 and in Bagudo for each 1 tab, there are 9187 persons to fetch water from it. LGAs with less than 1000 persons to tab are Aleiro Augie, Birnin-kebbi and Koko-besse (Figure 5C).

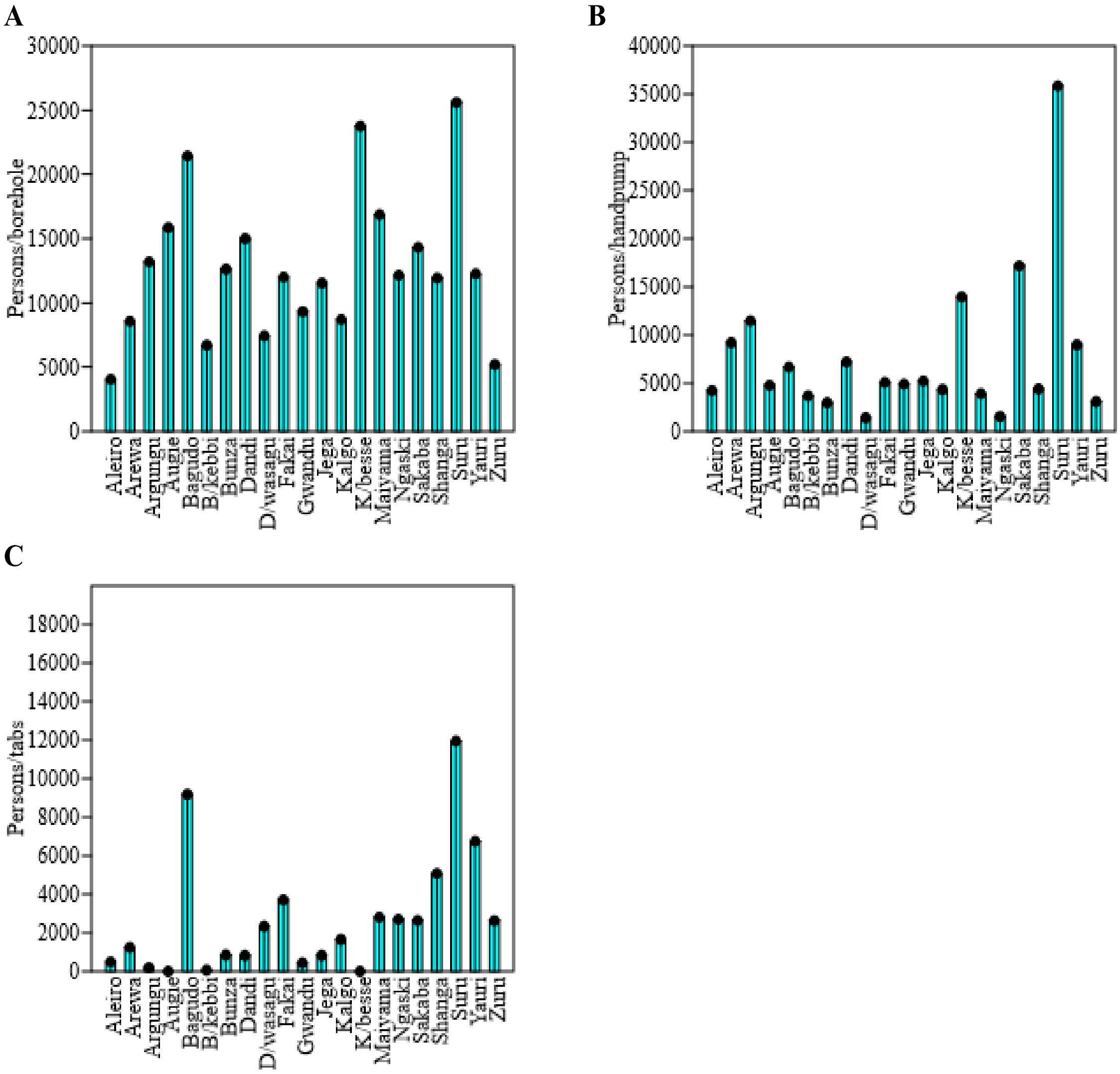

Figure 5: The ratio of persons to sources of water supply (A) Boreholes, (B) Handpumps and (C) Taps

Overall, there was an uneven distribution of public water supply facilities in Kebbi State. While the distribution of water supply amenities was highly variable, water supply facilities correlate very strongly and positively with population density. Even though the ratio of persons to boreholes, handpumps, and tabs was relatively high, the distribution of water supply in Kebbi State can say to be population driven.

Using PCA, the 21 LGAs cluster nicely across a spectrum of public water supply infrastructure (Figure 5). Total population, population density, semi-urban scheme, village scheme, handpumps, boreholes, and taps are closely and positively related in Kebbi State (Figure 5A). Water supply infrastructure and population correlate negatively with landmass (Figure 5B). The result of the PCA indicates that component 1 explained ~37% of the observed variability between population density and water supply infrastructure. Component 2 also explained ~23% of the observed variability. Component 1 and 2 together explained ~60% of the observed variability, meaning that components 3-9 explained the remaining ~40% of the variability, and thus it is not clear which of these latter components is important (Figure 5A). Our analysis, therefore, suggests that most of these parameters we considered (population, land mass, density, water supply infrastructure) to some degree influence water supply in Kebbi State. The presence of large population, disproportionate sizes of LGAs together with the uneven distribution of water supply infrastructure, together explained most of the variability of water supply in Kebbi State, and the variability between LGAs was largely responsible for heterogeneity of population ratio to water supply sources in Kebbi State.

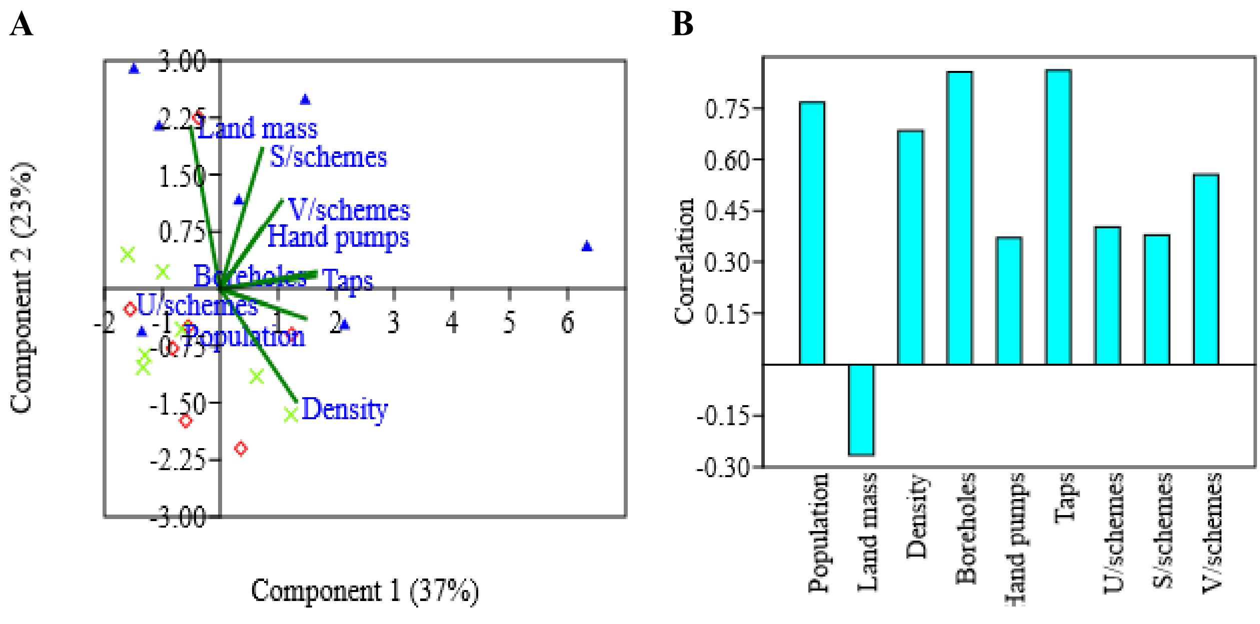

Figure 6: Principal component analysis (A) scatter plot and (B) Correlation

4.2 Comparison with some states in Nigeria

In Kebbi State, there was an uneven distribution of public water supply facilities and at the same time, the existing water supply infrastructure is inadequate. However, there were positive correlations between population density and water supply facilities. Implying that the location of water supply infrastructure was based on population density. The ratio of persons to sources of water supply is quite large, and figures obtained showed that public water supply sources are not enough to provide the teaming population with adequate water supply. Based on the survey of literature this was expected an outcome, and the result is likely due to the inability of the government to allocate the needed resources to improve public water supply in Kebbi State. This characterized nearly all the states in Nigeria as well as some countries in SSA.

Our analysis showed the distribution of public water supply infrastructure in Kebbi State was population driven, even though the ratio of persons to sources of water supply was relatively high in nearly all the 21 LGAs. For the first time, we relate public water supply infrastructure to population density in Kebbi State. While this study demonstrated that public water supply was population driven, the ratio of persons to boreholes was very high, implying that the majority of people in Kebbi State do not have access to public water supply. Our finding agrees with Ishaku et al. (2011). Their analysis of rural water supply in Nigeria showed that the public water supply sector was not successful in meeting water supply needs by population especially in rural areas. In addition, about 50% of urban and semi-urban dwellers in Nigeria have no access to reliable water supply (Ishaku et al. 2011). In Owerri (Southern Nigeria), most residents relied on commercial boreholes and water tankers for supplies (Onyenechere and Osuji 2012). Overall, the number of boreholes reported by this study was higher compared to Iliya and Gada (2010). Similarly, a number of boreholes in Kebbi State were higher compared to Imo, Delta, and Osun States (Table 4).

Table 4: Reported water supply infrastructure in literature

States	Boreholes	Reference	Handpumps	Reference	Rural water scheme	Source
Kebbi	404	This study	160445	This study	95	This study
Imo	58	(Okereke, 2010)	2521	Ndububa (2014)	14	(Okereke, 2010)
Delta	13	(Okadigwe and Efe 2010)		-	13	(Okadigwe and Efe, 2010)
Sokoto	150	(Gada and Iliya 2010)	-	-	04	(Ezenwaji, 2010)
Osun	33	(Felix and Olushola 2016)	-	-	189	(Iliya and Gada, 2010)
Kano	300	(Nuratu, 2014)	-	-	-	-
Bauchi	110	(Ndububa, 2014)	608	(Ndububa, 2014)	-	-
Benue	34	(Ndububa, 2014)	341	(Ndububa, 2014)	-	-
Jigawa	111	(Ndububa, 2014)	1174	(Ndububa, 2014)	-	-
Katsina	206	(Ndububa, 2014)	340	(Ndububa, 2014)	-	-
Anambra	108	(Ezenwaji, 2010)	-	-	-	-

This implies that many people in Nigeria do not have access to improved water supply. The ratio of persons to boreholes was very high in Kebbi State (Table 3, Figure 5) and ranged from 4054 to 25611 persons per borehole. These figures are lower compared to Sokoto State where the ratio of persons to borehole ranged from 68414 to 249051 (Iliya and Gada 2010). However, a number of handpumps in Kebbi State are higher compared to values reported in the literature (Table 3). There was only one urban scheme in each of the nine LGAs in Kebbi State. This is characteristic of urban water supply in most cities and large towns in Nigeria (Nwankoala, 2014). Semi-urban water supply scheme in Kebbi State (95) compares very well with Sokoto State (Iliya and Gada 2010). Their assessment of rural water supply in Sokoto State showed that the state has 97 semi-urban water supply schemes. However, in Jigawa, there were 300 semi-urban water schemes (Vanguard, 2005). Village water scheme in Kebbi State is comparable to many states in Nigeria (Table 3). Overall, the distribution of public water supply in Kebbi State is like most of the states in Nigeria. What is apparent is that the existing public water supply facilities in Nigeria, even though they vary by states, these facilities are comparably inadequate to provide sufficient quantity of water supply required by teaming population.

4.3 Implications for public water supply in Sub-Saharan Africa

The ratio of people to public water supply in Kebbi State is characteristics of the water supply situation in Sub-Saharan Africa (SSA). Nigeria is the most populous nation in SSA and a signatory to the UN declaration of Right to Water. As a result, every Nigerian is entitled to adequate and affordable water of excellent quality. A survey by National population commission (NPC, 2008) indicates that only 12.7% of urban dwellers in Nigeria have access to public tab/standpipe water supply. In rural areas, only 4.1% have access to public water supply. This implies that public water supply is grossly inadequate in meeting the public demand. As a result, most urban dwellers have to resort to private boreholes/wells which are often poorly constructed and protected. In addition, water quality test is seldom conducted after borehole/well construction. Many urban dwellers in Nigeria obtained drinking water from unprotected sources (NPC, 2008). Demographic and health survey results showed that about 14.6% of urban dwellers in Nigeria, obtain water from a non-improved source (NPC, 2008). The situation is more pronounced in rural areas where 53.4% fetch water from non-improved sources of water supply. However, water treatment prior to drinking is carried out by 6.6% of urban dwellers, and the remaining proportion of urban dwellers used untreated water. In rural areas, water treatment prior to drinking is carried out by only 2.4% of rural dwellers. The percentage of Nigerians using an appropriate treatment method is 12.9% in urban areas and 8.9% in rural areas (NPC, 2008). Overall, Kebbi State and Nigeria at large, are short of adequate public water supply schemes. While the water supply sources are inadequate, they are at the same time short of many requirements for domestic water quality (Madu, 2010).

In some parts of SSA, the situation is so critical and water supply have reached a crisis level. Although the global water crisis tends to be viewed as a water shortage problem, water quality is increasingly being acknowledged as a central factor (Somaya, 2011). The fact that some five million people, mainly children, and infants, die annually from water-borne diseases in developing countries, especially in SSA and South-east Asia, is sufficient to rally both national and global action about improved sanitation and water supply. The water supply situation in SSA, like in most developing countries, is highly variable, reflecting social, economic and physical factors as well as the level of technological advancement. While not all parts of SSA are facing water shortages, all have to a greater or lesser extent serious problems associated with reliable water supply, particularly in rural areas (Somaya, 2011). Assessments of public water supply in SSA, by Banerjee et al. (2008), showed declines in the percentage of the urban population accessing various water supply (Table 5).

Table 5: Percentage of urban dwellers accessing various water supply sources in SSA

Decades	Piped water	Stand posts	Wells/boreholes	Surface water	Vendors
1990-1995	50	29	20	6	3
1996-2000	43	25	21	6	2
2001-2005	39	24	24	7	4

Source: Banerjee et al. (2008).

The situation of water supply in SSA is not completely ugly. Some countries, are making remarkable progress in providing improved water supply to its citizens. Ethiopia has taken the lead in expansion and development of improved water supply, reaching about 5 % of its population each year with piped water. In Ivory Coast, about 4% is added annually through piped water (Table 6). Uganda has recorded the fastest expansion (4.67%) of public stand posts annually, followed by Burkina Faso (4.00%). Nigeria has recorded the most rapid increase in wells and boreholes, reaching about 4% of its population each year, even as coverage of piped water and stand posts declines (Table 5). Uganda and Ethiopia appeared to be the most successful countries in reducing dependence on surface water (Table 6).

Table 6: Percentage of annual growths in urban water supply accessibility from various sources

Country	Piped water	Country	Public stand posts	Country	Boreholes	Country	Surface water
Ethiopia	4.77	Uganda	4.67	Nigeria	3.99	Uganda	-98
Ivory Coast	3.81	Burkina Faso	4.00	Malawi	3.10	Ethiopia	-1.08
Benin	3.58	Tanzania	3.91	Rwanda	3.03	Lesotho	-0.66
Burkina Faso	3.40	Rwanda	3.67	Ghana	2.65	Madagascar	-0.41
Mali	3.00	Malawi	3.01	Mozambique	2.31	Ghana	-0.21

Source: Banerjee et al. (2008).

It is apparent that the existing public water supply services in Kebbi State are too inadequate to provide the teaming population with sufficient water supply. However, it is important to note that most of the high-medium income households in Kebbi State have private boreholes/wells which fill the existing gap in the public water supply. In addition, many low-income households in the state also obtained water from private boreholes/wells from their neighborhood. Therefore, knowing the actual proportion of citizens without improved water supply is very difficult, as it is a tradition in the state for high-income households to provide at least one stand post, outside their houses, which can be freely accessible to all who may need the water within the neighborhood. However, the statistics of private owned boreholes/wells and people depending on them is lacking, making it very difficult to relate non-public water supply to population density. This could only be revealed by future studies, which relate public and private water supply sources to the population in Kebbi State.

5. Conclusion

Analysis of public water supply infrastructure in Kebbi State showed water supply sources correlates strongly and positively to population density, except for land mass. What is apparent is that the public water supply is not adequate to meet the current demand for water supply in the state. And this characterized public water supply in most countries in SSA. The ratio of persons to public water supply sources is so large and without private water sources in both urban and rural areas, many people will find it very difficult, to obtain sufficient water supply required for everyday activities. What we do not know is the proportion of people depending on private water sources, in the state. Some rural communities in the state relied entirely on communal water sources, mostly hand-dug shallow wells. This study, therefore, creates an opportunity for future studies that compare both public and private sources of water supply with a population in Kebbi State.

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