CARD International Journal of Science and Advanced Innovative Research (IJSAIR)
ISSN: 2536-7315 (Print) 2536-7323 (Online)
Volume 1, Number 2, September 2016
http://www.casirmediapublishing.com

Water Security and Groundwater Accessibility in Bagwai and Shanono LGAs of Kano State, Nigeria

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ABSTRACT
The Watari region which covers both Bagwai and Shanono among six other local government areas in Kano State is one of the places with the highest availability of both surface and groundwater resources in the state. However, the condition of supply and accessibility particularly in the research's study area is not in conformity with availability. The research used interviews with relevant stakeholders and questionnaire survey for residents to determine domestic water sources and the condition of groundwater and other sources supply, accessibility and security in Bagwai and Shanono Local Governments in Kano State. Borehole yield per minute was also measured. Existing researches on groundwater potential of the area and Kano State as a whole from WRECA, KNARDA and H-JRBDA were studied as well as some GIS-based groundwater assessment researches conducted in the area. The research found out that groundwater potential does not correspond to supply in most of the villages. Water in terms of availability, accessibility and quality was found to be inadequate in most of the villages studied leading the residents to be water insecure. The research recommended the provision of sustainable pipe borne water through the Watari Dam to ameliorate the sufferings of the people in the areas and to ease the pressure on groundwater resources and create room for replenishment in few years.

Keywords: Water Sources, Water Security, Groundwater, Water Supply, Water Accessibility

INTRODUCTION
The importance of water to the sustenance of life on earth cannot be overemphasized. It is one of the most precious gifts with which nature has blessed mankind and it is absolutely vital for the sustenance and maintenance of life. Despite this importance, water supply in many parts of the developing world is faced with many challenges.

Globally, the problem of water has been more of accessibility, quality and management than availability and sustainability. Abdulhamid (2010) argued that water availability is the bedrock of human development and monitoring its state of dynamism is a fundamental requirement for planning and management especially in Northern Nigeria.

Due to the ever increasing population and the need for sustainability, it is realized that the water and land resources need to be developed, used and managed in an integrated and replenishable manner. The key issue of water use revolves around availability, quality, accessibility and sustainability. Water scarcity is said to occur when a country or region's annual water supply is less than 1,000 cubic meters per person per year (ICA, 2012; Adamu and Abdulazeez, 2016 and Shinkafi et al., 2016).

It is believed that, Nigeria is abundantly blessed with groundwater resources, but after almost sixty years of water resources development in the country, it is regrettable that only 60% of the population has access to safe drinking water, and in rural areas less than 50% of the households have access to portable water (Gbadegesin and Olorunfemi, 2009). The cost of constructing boreholes and the unreliability of hand dug open wells combines to make adequate and consistent groundwater accessibility troublesome in many areas.

The concept of water security is used to determine or rate the performance of water supply and quality in relation to demand and availability. WaterAid (2012) noted that there is no single, widely accepted definition of 'water security'. Cook and Bakker (2010) in WaterAid (2012) highlighted that the concept has multiple definitions depending on the definition of need (human and/or environmental)'. Water Security can be defined as the reliable access to water of sufficient quantity and quality for basic human needs, small-scale livelihoods and local ecosystem services, coupled with a well-managed risk of water-related disasters (WaterAid, 2012).

In Kano State, it has been observed that both the urban and rural populace have turned to groundwater for their domestic needs for the past 20 to 25 years (Adamu and Abdulazeez, 2016). This is after the long-time realization that pipe-borne water from government supply is no longer readily available, reliable and sustainable. Public water supply, which depends heavily on surface water sourced from rivers and dams and treated have been abysmal in rural areas. Hence, hand dug wells have been in use for many years and boreholes were only made popular some 15 to 20 years back (Abdulhamid, 2000; Kankara and Adamu 2013; Tanko, 2014).

Significant parts of the study area cover places that are regarded to have one of the highest groundwater potential and yield as well as availability of surface water in Kano State (WRECA, 1985 and 1989). One of the largest reservoirs in Kano state, the Watari Dam is located in the area. However, despite all these, residents of the area are still faced with challenges regarding water security.

STUDY AREA

Location and Size

Bagwai (having an area of 405km^2) and Shanono (having an area of 607km^2) lie between Latitudes 11° 93′ 22″ and 12 ° 31′ 38″N and between longitudes 7° 81′42″ and 8° 26′26″ E. The study area is bordered to the East by Dawakin-Tofa, Tofa and Rimin-Gado Local Governments, to the South by Gwarzo and Kabo Local Governments, to the North by Tsanyawa and Bichi Local Governments all in Kano State. However, to the West, it is bordered by Musawa and Kankia Local Governments in Katsina State (Fig 1).

Source: Modified from Kano State Ministry of Lands

Fig 1: Map of Bagwai and Shanono indicating sampled areas.

METHODOLOGY

Questionnaire and Interviews

Questionnaire was used to determine the level of water demand, supply, quality and accessibility among the people in the study area as well as the seasonal changes in groundwater. Interviews were used to tap into the experience and knowledge of local communities (especially local well drillers) which played an integral part in understanding of water challenges in their villages.

The study systematically sampled and selected three households, whom questionnaires were administered to from each of the 20 purposively selected areas, making a total of 60.

Borehole Yields Measurement

Using availability sampling, four boreholes each were selected from groundwater potential zones; very good, good, moderate, low and poor potential zones (Table 1). For each hand pump borehole, a timer was set at 0.00 and one person begins to pump the water into a container while another holds and starts the timer. The time keeper asks the pumper to stop when it is exactly 60 seconds and thereafter the water in the container was measured in litres. This was done for 20 (4 each for every potential zone) sampled boreholes. This enabled the testing of groundwater yield with groundwater potential and also accounted for variations within each zone.

Table 1: Sampling for Borehole Yield determination

SN	POTENTIAL	*EXPECTED OUTPUT	SAMPLES	LOCATIONS
1	Very Good	100-120 L/Min	4	Daddauda, Kiyawa
2	Good	80-100 L/Min	4	Wurobagga, Janmaza
3	Moderate	60-80 L/Min	4	Kokiya, Kariya
4	Low	30-60 L/Min	4	G/Dutse, Gogori
5	Poor	0-30 L/Min	4	Gadanya, Jobe

*Borehole yields were assessed in litres per minute and expected values according to groundwater potential were computed after Solomon (2003); WaterAid; FAO (1994).

Statistical Analyses

Statistical tools like the mean, Analysis of Variation (ANOVA), frequency calculation, percentages, pie charts and bar charts were used in this research for data analysis and presentation. Other statistical methods used include totals, mean deviations and standard deviations.

RESULTS PRESENTATION

Water Sources in Bagwai and Shanono

Generally, three sources of water were identified to exist in Bagwai and Shanono; these are groundwater, surface water and treated pipe-borne water. Groundwater sources existed in both villages of Shanono and Bagwai but surface water source was prominent and significant only in Bagwai because of the presence of the Watari Dam. Some other surface water sources like ditches, sand mining valleys, eroded gullies and river channels are mostly seasonal, dirty and unreliable (Plate 1) and therefore not used for many purposes. It was noticed that waters from such sources were used mostly for mud blocks construction and other uses other than household uses.

Pipe-borne water from taps was only found in certain areas of Bagwai like the main Bagwai town, Kiyawa, Daddauda and some villages between Bagwai and Bichi and those along Bagwai to Dawakin-Tofa road. This shows that the water treatment plant in Bagwai which sources its water from the Watari Dam does not effectively serve Shanono, even though many broken and dilapidated water pipes were noticed on Bagwai to Shanono road.

Plate 1: One of sources of water for non-regular uses in the outskirts of Bagwai

From the 60 questionnaires used for this research, 30 each were administered in the two major towns and in the villages of Bagwai and Shanono; all the questionnaires were administered to household heads as shown in table 2 below.

Table 2: Groundwater and other sources of water in Bagwai and Shanono Areas

SN	GROUNDWATER SOURCE	BAGWAI	SHANONO	TOTAL (%)
1	Hand-Dug wells only	9	15	24 (40.0%)
2	Borehole only	2	3	5 (8.3%)
3	Hand-Dug wells and borehole	5	8	13 (21.7%)
4	Other non-groundwater source only	7	0	7 (11.7%)
5	Hand dug wells with other source	6	2	8 (13.3%)
6	Boreholes with other source	1	2	3 (5.0%)
TOTAL		30	30	60 (100%)

Source: Questionnaire Survey, 2015

It is clear from table 3 that hand-dug wells are still the most popular means of groundwater extraction in the rural areas constituting 40% of the respondents with more than 60% from this amount coming from Shanono. Another 35% of the people use hand-dug wells along with other sources of water. The table also shows that boreholes and other sources like pipe borne water are still a luxury in the areas with only 8.3% solely depending on boreholes for source of water and others depending on pipe-borne water only as a complementary source.

Water Demand and Supply

The mean daily water demand and mean water supply from groundwater and other sources for four communities (two each from Bagwai and Shanono) was compared to determine how water supply fairs with demand. The households were categorized into 3; small households with between 2 to 4 people, medium households with between 5 to 7 people and large households with 8 people to above; over-sized extended family houses were not considered. Initially, data was generally collected for all households before sub-categorizing the data based on households' sizes. The arithmetic means were used because data was analysed from 10 households each from the four communities and the different categories of households did not get equal representation which the mean took care of.

Table 3: Mean daily water demands and supplies in litres for 4 communities in Bagwai and Shanono

HOUSEHOLDS	COMMUNITIES' DAILY WATER DEMAND AND SUPPLY (LITERS)											
	GOGORI			KOKIYA			FARIN-RUWA			BAGWAI		
	DD	SS	DF	DD	SS	DF	DD	SS	DF	DD	SS	DF
Small household	80	77	-3	91	93	+2	102	87	-15	87	102	+15
Medium household	167	158	-9	161	142	-19	192	190	-2	177	240	+63
Large household	251	255	+4	289	205	-84	312	208	-104	248	412	+164

Source: Interviews and Questionnaire survey, 2015

KEY: DD= Demand, SS=Supply and DF=Difference between Demand and Supply

From table 3, it is clear that some households are over supplied with water while others are undersupplied. Those over supplied are example of households who claim to have enough water that exceeds their daily need and they end up either doing some things that are not necessary with it or keep it for future use. Those undersupplied are example of those households who have shortages and have to forfeit some needs like bathing and washing and leave it for other days when they have enough water.

Table 4: ANOVA Test Results for Water Supply and Demand.

SUM OF VARIANCE	SUM OF SQUARES	DEGREE OF FREEDOM	ESTIMATION OF VARIANCE	F
SST (TOTAL)	49650.00	12-1 = 11		9273.11
SSC (VARIANCE)	27819.33	4-1 = 3	27819/3 = 9273.11	2728.83
SSE (ERROR)	21830.67	12-4 = 8	21830/8 = 2728.83	= **3.3982**

Source: Statistical Analysis

An Analysis of variation, at 0.05 Level of significance, for the data in table 3 produced a computed value of 3.3982 and a critical value of 9.28 (Table 4). This shows that the amount of water supply has no adequate correspondence with demand in Bagwai and Shanono Local Government Areas.

Meanwhile, many of the boreholes found in the 20 sampled areas were found to be failed, non-functional and half functional due to poor maintenance. Another parameter used to determine groundwater supply was the daily withdrawal rates of open hand-dug wells.

Table 5: Daily Withdrawal rates of Hand-dug wells in Bagwai and Shanono households

SN	OUTPUT DAILY RATES	BAGWAI	SHANONO	TOTAL (%)
1	Less than 150 litres	8	10	18 (30.0%)
2	150-200 litres	2	4	6 (10.0%)
3	201-250 litres	5	6	11 (18.3%)
4	251-300 litres	4	3	7 (11.7%)
5	Above 300 litres	1	2	3 (5.0%)
6	Don't use hand dug wells	10	5	15 (25.0%)
TOTAL		30	30	60 (100%)

Source: Questionnaire survey, 2015

Out of 60 respondents, 15 (8 from Bagwai and 5 from Shanono) do not use hand dug wells, but 45 (20 from Bagwai and 25 from Shanono) use hand dug wells either as their first or second choice. Most of the wells with less than 150 litres daily withdrawal rates are either personally owned or non-adequately productive. This result shows more pressure on hand dug wells in Bagwai than in Shanono explaining the non-dependability of hand-dug wells for water in Bagwai because of many other alternatives like pipe-borne water and surface water.

Most respondents whose wells yield between 251 to 300 litres to above daily withdrawal rates were found in Bagwai while 10 respondents' wells in Shanono had less than 250 litres daily withdrawal rates due mainly to poor yield.

Water Accessibility

In assessing water accessibility, groundwater and other forms of water supply in the areas were analysed using a horizontal and vertical approach. The horizontal analysis has to do with the availability of groundwater and other forms of water extraction sources and their functionability across the areas. In this analysis, attention was focussed on number of wells, taps and boreholes; distance and time covered to obtain water. The vertical analysis has

to do with the depth of the wells and frequency of dredges, withdrawal rates and visible quality of the waters.

Efforts towards Groundwater Accessibility

Groundwater accessibility analysis was carried out in relation to the time and distance it takes to source groundwater. Table 6 presents the time it takes for people in the area to source groundwater.

Table 6: Time spent to source groundwater

SN	TIME SPENT	BAGWAI	SHANONO	TOTAL (%)
1	Less than 30 mins	18	9	24 (40.0%)
2	30 mins - 1 hour	2	3	5 (8.3%)
3	1 -2 hours	2	11	13 (21.7%)
4	Above 2 hours	1	7	8 (13.3%)
5	None	7	0	7 (11.7%)
TOTAL		30	30	60 (100%)

Source: Questionnaire survey, 2015

It takes many well owners less than 30 minutes to fetch groundwater while those who mostly depend on boreholes with large queues take up to two hours and above to source groundwater. Those who fall under the 'none' category are those who claimed not to use groundwater at all; they depend on surface water and pipe-borne water from taps and all of them are from Bagwai.

Table 7: Distance Covered to Source groundwater

SN	DISTANCE (Meters)	BAGWAI	SHANONO	TOTAL (%)
1	Less than 100	6	6	12 (20.0%)
2	100 – 300	11	9	20 (33.3%)
3	301- 500	5	10	15 (25.0%)
4	501 – 1000	1	2	3 (5.0%)
5	Greater than 1000	0	3	3 (5.0%)
6	None	7	0	7 (11.7%)
TOTAL		30	30	100%

Source: Questionnaire survey, 2015

It takes all the well owners less than 100 meters to fetch groundwater as their wells are mostly located in their houses or in their backyards. Trekking long distances often at night to fetch groundwater is more common in Shanono town, Sha-kogi, Kan-dutse and Dan Bakoshi, all in Shanono. Some respondents who trek between 100 to 300 meters to fetch groundwater from boreholes do so to avoid the stress involved in drawing water from hand-dug wells.

Table 8: Range of Well depths in selected locations

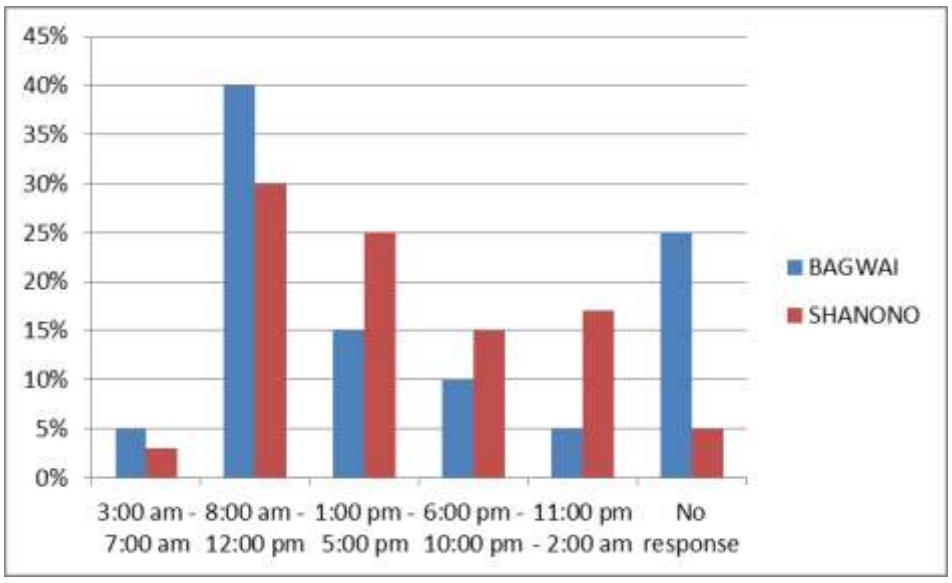
Gaba is a local measurement that roughly converts to 1.5 meters. From the interviews with well diggers in the areas, this research can reveal that wells can range in depth from about five meters deep, to deep wells of over 15 meters deep. Wells with depths of over 20 meters are sometimes constructed to exploit a known aquifer.

SN	LOCATION	LGA	ESTIMATED DEPTH	CONVERSION (m)
1	Kwajale	Bagwai	*Gaba* 4-5	5-7m
2	Gada	Bagwai	*Gaba* 3-4	4-6m
3	Bagwai	Bagwai	*Gaba* 3-5	4-7m
4	Farin-ruwa	Shanono	*Gaba* 5-8	7-12 m
5	Kadamu	Shanono	*Gaba* 4-6	5-9m
6	Shanono	Shanono	*Gaba* 8-14	11-20m

Source: Interview with Local Well-drillers, 2015

Times of Fetching Groundwater

Periods of fetching groundwater in study area was found to be significantly influenced by well yield changes between day and night. Many residents explained that during the day, there is huge pressure on groundwater extraction causing the yield to drop down drastically. However, during the night the yield increases. This is why a substantial number of people fetch groundwater at night or very early in the morning (Fig 3).



Source: Interviews and Questionnaire survey, 2015

Fig 3: Bar Chart showing time of fetching groundwater in Bagwai and Shanono

Frequency of Well Dredges and Groundwater Quality

As the research did not intended to carry out detailed laboratory tests for chemical groundwater quality, some visible physical quality-detecting parameters like colour, odour, taste and turbidity were observed and analysed. Another parameter used was the dredging frequency of wells not only to test the reliability and functionability of the wells but to see how they affect groundwater quality.

Table 9: Frequency of Hand dug wells dredges

SN	DREDGES	BAGWAI	SHANONO	TOTAL (%)
1	Once a year	2	13	15 (25.0%)
2	Twice a year	0	3	3(5.0%)
3	Once in two years	3	2	5 (8.3%)
4	Once in three years	9	4	13 (21.7%)
5	Twice in three years	2	2	4 (6.7%)
6	Once in four years	2	0	2 (3.3%)
7	No dredging at all	0	0	0 (0.0%)

8	No well	10	5	15 (25.0%)
9	No response	2	1	3 (5.0%)
TOTAL		30	30	60 (100%)

Source: Questionnaire survey, 2015

It was noted that wells that are dredged once in four years and those dredged once and twice in three years have far much better clear waters than those dredged once in two years. Wells dredged once a year and those dredged twice a year were observed to have earth-coloured, dirty and in some instances murky waters. Such wells exist in Sare-sare and 'Yar Tofa in Bagwai while they are found in 'Yar Kurciya, Rinji and Jigawa all in Shanono.

Table 10: Physical groundwater qualities of selected hand dug wells

PARAMETER	NO. OF WELLS				
	POOR	GOOD	BETTER	EXCELLENT	TOTAL
Odour	2	3	8	7	**20**
Colour	4	5	6	4	**20**
Taste	3	2	2	13	**20**
Turbidity	6	7	1	6	**20**

Source: Fieldwork, 2015

From the samples collected from 20 open wells, table 10 shows that only relatively few samples fall within the 'poor' category in terms of odour, colour, taste and turbidity. Most of the samples fell within the 'better' or the excellent category. The well waters in the study area mostly have an excellent taste.

Groundwater Potential Zones in Relation to Supply

Borehole yield was used to test for the different groundwater potential zones to find out if groundwater yield actually corresponds to potential. Borehole yields were assessed in litres per minute and were compared against expected standard values computed after Solomon (2003), FAO (1994) and Water-Aid (2012). Three boreholes'

yield samples were used and the average was taken for each groundwater potential area.

Table 11: Groundwater yield from boreholes in different potential zones

SN	POTENTIAL ZONE	EXPECTED OUTPUT	AVERAGE YIELD
1	Very Good	110 Litres/Min	97 litres/Min
2	Good	90 Litres/Min	71 litres/Min
3	Moderate	70 Litres/Min	63 litres/Min
4	Low	45 Litres/Min	41 litres/Min
5	Poor	15 Litres/Min	17 litres/Min

Source: Fieldwork, 2015

From table 11, it can be noted that none of the average borehole yield was able to actually meet up with the expected standard output of each groundwater potential zone. It was observed that most of the boreholes are in poor condition and lack adequate maintenance. Therefore, even when an area is a zone of high groundwater potential, the poor condition of the boreholes caused by poor maintenance in the area may not allow them to yield the expected output.

DISCUSSION OF RESULTS

Questionnaire survey and interviews were used to determine the level of water supply and usage among the residents of Bagwai and Shanono Local government Areas. In assessing this, the research focused on water sources, accessibility, physical quality, supply and reliability of sources with a bias towards groundwater. The multiple sources of water; surface, ground and pipe-borne in Bagwai make water availability not to be a significant issue in most parts of the area, even as it constitutes a major problem in some others. However many parts of Shanono depend only on unreliable groundwater sources. The research concentrated on physical quality of groundwater only and from the 20 samples observed from different hand-dug open wells, most of the water were between good to excellent in terms of colour, odour, taste and turbidity. In terms of

water accessibility, distance covered and time taken to obtain groundwater were analysed. It was noted that differences in groundwater potential played no significant role on distance, but it did on time. For instance some residents in the very good potential zones areas trekked long distances to fetch water because of lack of water facilities. Likewise people who own wells in their homes can access water easily than others who don't. However time mattered much because in low and poor groundwater potential zones, residents spent hours on queues waiting to fetch water and in some cases in the middle of the night.

In Bagwai and Shanono, groundwater is being extensively used to cater to the needs of the people. Groundwater withdrawal is increasing year after year due to population increase, erratic rainfall and unreliable surface water bodies, resulting in the drying-up of dug and bore wells. To help to overcome this situation, remedial measures have to be implemented by imposing restrictions on the construction of water harvesting structures for argumentation of groundwater resources and also through the implementation of proper best management practices for watershed throughout the area.

CONCLUSION AND RECOMMENDATIONS

The inadequacy of groundwater exploring facilities like boreholes and the poor condition of existing ones are contributing towards denying people within very good potential zones the opportunity to have available and accessible water. Despite both Bagwai and Shanono directly and indirectly falling within the Watari Region or basin, it is unfortunate that problems associated with domestic water sourcing and consumption is still a problem in these areas. With proper maintenance, the Watari Dam in Bagwai alone is more than capable of supplying the two local governments with consistent, reliable and hygienic water for a long period of time. If such was the case, these areas need not to mount unnecessary pressure on depleting and apparently migrating groundwater resources.

Since the supply of pipe borne water to all villages and settlements in Bagwai and Shanono is not beyond the capacity of local and state authorities, it is advisable that such should be done as soon as possible. Alternatively, this can be jointly done by local and state governments especially in providing pipe-borne water. This will ease the pressure on groundwater resources and create room for replenishment in few years.

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