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PERFORMANCE AND FAILURE OF SOLAR BOREHOLES FOR WATER SUPPLY IN KUMBOTSO LOCAL GOVERNMENT AREA KANO STATE, NIGERIA

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Abstract

Assessment for the performance and failure of solar boreholes was undertaken in Kumbotso local government area of Kano state. This is in line with frequent failures of solar boreholes for effective water supply in the study area. Seven wards were selected for the study. Sample of 151 respondents were interviewed. Data was collected through field observation, use check list, interview and focus group discussion. The data was analyzed using simple statistics such as totals, means, standard deviation and percentages. Likert scale of measurement was also applied in analyzing the responses on performance, failure and level of utilization of boreholes. Student's 't' test was used to find out whether there is significant difference or not between functioning and nonfunctioning borehole in the study area. Chi-square test was also use in the analysis of problems and solutions. Result shows that there are 26 solar boreholes out of which 11 are functioning and 15 are not functioning it is established that there is significant difference among the eight study wards in terms of functioning and non-functioning solar boreholes at 0.05 level of significant. It indicates **that 68 (46%) of the respondents said community members are the major stake holders.** ***The result shows that most of the parameters are fairly satisfactory with means of 0.50 – 1.27. Result also shows*** **that** ***computed means of all the problems facing water supply trough solar boreholes are below the Likert scale of satisfaction of 2.80 – 3.42 and there is no significant association among the problems affecting solar boreholes performance for water supply in the study areas at 0.05 level of significant. Findings shows that provision of full security as a major solution to the problem of solar boreholes performance for water supply with 55 responses (36.45%). Result shows that there is no significant association among the major solutions to the problems. With particular reference to findings of the research it is recommended among other issues that adequate security should be provided to prevent solar panels, sumo and other important components from being stolen for effective performance and water supply.***

Keywords: Solar Boreholes, Performance, Water, Supply, Kumbotso

Introduction

Water is among the major necessities of life. It is the major ingredient of life's need which is a problem to developing countries like Nigeria. Portable water supply is a difficult task for most of the governments in developing regions. Difficulty in water supply is attributed to water shortage to some extend and to water scarcity in the other way round, which are all related to increasing number of human population. In specific areas such as Sahara Desert in Africa, water is scarce, while in other cases, like the river-side areas of Niger Delta regions of Nigeria water is in excess but of poor quality (Orewole*et al*, 2006). Sources of drinking water for both rural and urban communities started from surface to underground whether treated or untreated depending on the stakeholders, availability of water and resources at hand. Water shortage affect not only human health but even time due to distances from water sources. The availability of clean water in rural

communities will not impact positively on the environment but also reduce long distance search for clean water especially from sources that may have been polluted (Nnaji*et al*, 2010).
Pumping water to communities is universally needed and its introduction will enhance provision of water to even remote areas, households, hospitals and other domestic uses. Solar pumps are highly efficient for water supply and are designed directly from solar panels and a wide variety of them are provided by government agencies and private organization. In Nigeria the first solar water pump for domestic water supply was installed in 1982 (Oparaku, 2003). Before that time most of the solar borehole were designed for agricultural purposes. Solar PV (solar photovoltaic) can be used to supply energy to pump water to many water supply project areas (Sambo*et al,* 2014). A lot has been done over time by Nigerian energy commission, other governments and private organizations and individuals to improve water supply through solar powered boreholes but faced with a lot of challenges. Several solar PV projects done in Nigeria failed to meet the minimum lifespan due problems such as poor design, use of substandard components, wrong installation procedure and bad civil engineering work among others (Sambo*et al,* 2014).Apart from these problems there are other problems that causes failure of solar boreholes their less reliability for example Brian (2012) stated that their main constraint is that they cannot pump a sufficient quantity of water from deep boreholes, under cloudy conditions and at night. In some areas problems related to social vices such as thieves of the solar panels and all sorts of vandalism amounted to sets back in water supply trough solar pumps.

Advancement in technology over the last decades have made solar water pumping a viable option for potable water service delivery in rural settings. Solar pumping is an attractive alternative when poor groundwater quality or high population density and growth limit the applicability of boreholes fitted with hand pumps (Armstrong, 2015). This is a common phenomenon worldwide. In Kano state and the study area in particular many solar boreholes were installed by various governments and private organization but most of which are not functioning properly due to one reason or another, and these reasons can only be known through studies.

Researches were conducted at different parts of the globe on conditions, performance and failure of solar boreholes. Brian (2012) investigated the challenges of solar boreholes in Turkana area of Northern Kenya and studied the work of Oxfam charity organization. Data was collected using interview and observation. The result shows that solar boreholes were provided in seven villages and are all functioning and provided continuous water supply for domestic uses and gardening. It was deduced from his findings that solar boreholes are better and the failure rate in diesel boreholes is high due to in ability to buy diesel. In another development Ezeomi and Ogonnaya (2013) conducted their study by constructing a one single solar borehole at a particular location and all installations and designed were done by the researchers. Their results revealed that solar borehole is user and environmental friendly, it requires little or no maintenance.

In Nigeria for example Sambo*et al* (2014) conducted studies on the implementation of standard solar PV projects and concluded that most of the projects failed to meet the minimum lifespan due to many factors such as poor construction and maintenance. Oloruntade, Konyeha and Alao (2014) studied sustainability of boreholes in Akoko area of Ondo State, Nigeria. Data was collected through observation, interview, population records and borehole records on yearly basis. Result revealed that in the area all the 110 boreholes were constructed in 1995-2014 and 51 (46%) was constructed in 2005-2009 average 500 people uses them. It is also deduced that 57 are manual hand pumps, 30 are solar and are nonfunctioning and failed between 5-10 years. Mikkel (2016) studied break down of Nigerian solar power failure and attributed that government and agencies planning solar projects lacked awareness of how many people they wanted to reach.

Mogaji, Oloruntade and Afuye (2013) investigated the status of water supply facilities in 24 rural communities of Owo, ondo. They uses former and informer interview, questionnaire and physical assessment. Their work revealed that 86% boreholes fitted with electric failed, 37% hand dung wells failed, 87 hand pumps 38 function the rest not functioning, 24 borehole electric 12 function rest not functioning, hand dung well 882 only 237 function and all solar boreholes not functioning. Manzuma, Abdulsalam and Staley (2015) conducted study on the performance of motorized borehole systems for residential water supply in Zaria. They uses well-structured multiple choice questionnaires and Likert scale of data analysis. Their findings revealed that 14% of the households uses public electricity in pumping water, 86% uses generators 0% uses solar and wind powered pumping systems. Most of these studies focused on the use of motorized boreholes and even those related to solar borehole are faced with a lot of challenges and are outside the study area. That is why this study was initiated with an objective of investigating performance and failure of solar boreholes in relation to mechanized boreholes in the study area for effective water supply and utilization.

Material and methods

The study area

Kumbotso L.G.A is located between latitude $10^{o}55^{I}$N, $12^{o}13^{I}$N and longitude $08^{o}20^{I}$E, $8^{o}20^{I}$E. It has an area of 920 km^2 and population of 295,979 peoples (N.P.C, 2006). The local Government share boarder to the north-west with Dala L.G, Modobi L.G by west, Dawakin kudu L.G.A by the south-east and gezawa local government to the north-east. (Figure; 1). The relief of the study area ranges from plain (500m) to highs of more than (100m) above sea level. The land forms of the area include residual hills and plains with grouped hills, sandy plains and alluvial complexes.

Geologically more than four fifth (4/5) of the study area is underline by quartzite, undifferentiated meta ages climate complex rock of the pre Cambrian and upper Cambrian origin prolonged weathering of the rock produces deep clay rich, regolith which have been subjected to lateralization. It is also reported that the lateriticout crops put the interfluve areas of the upland plain serving as a caps for regolith hill (Olofin, 1984).
In terms of climate, the total rainfall of the study area ranges from 800mm to over 100mm per annum and the rain last for the period of three (3) to five (5) month. The mean temperature ranges from 26^{o}c– 33^{o}c. The hydrology and drainage of the area consist of River Salanta that flows through Sharada industrial area carries industrial effluents passes through Shagari Quarters and Danmaliki among others and drains its water into River Kano which is also part of the study area. The major socioeconomic activities in the area are irrigation farming and commercial activities such as trading.

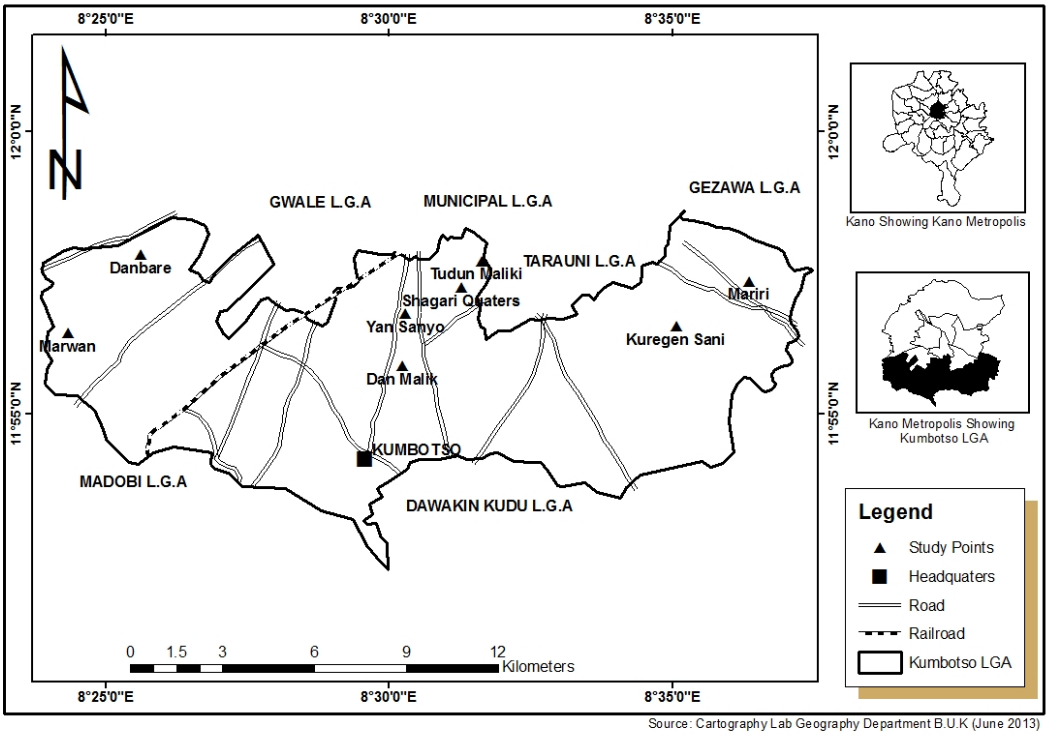

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Figure 1 Map of the Study Area
Source: Cartography Lab Bayero University, Kano

Methods of Data Collection

The total population of the study areas is 295,979(N.P.C, 2006) out a sample of 0.051% was selected(Arlosorof*et al*, 1987) and Krejcie, and Morgan (1970).i.e 151 people approximately to represent the entire population. The study area has about eight wards where there are solar boreholes. The eight wards were purposively selected, which are Kuregen–Sani, Dan-Maliki, Dan- Bare, Shagari-Quarters, Marwan, Yan-sanyo, Tudun-maliki and Mariri. In each of the ward nineteen (19) respondents were interviewed with exception of Marwan with eighteen respondents (18) because of its least population. For the selection of respondents systematic random sampling was adopted using list of households based on streets as a sampling frame (Krejcieand Morgan, 1970)

Data for the study was generated through field observation for inventory of borehole, use of check list for determining functioning and nonfunctioning solar boreholes, interview and focus group discussion were used for determining responses on water supply solar borehole in the areas as adopted from Mogaji, Oloruntade and Afuye (2013), Oloruntade, Konyeha and Alao (2014) and Manzuma, Abdulsalam and Staley (2015).

Methods of Data Analysis

The data was analyzed using simple statistics such as totals, means, standard deviation and percentages. Likert scale of measurement was also applied in analyzing responses on performance, failure and level of utilization of boreholes and problems as adopted from Manzuma, Abdulsalam and Staley (2015). Student's 't' test was used to find out whether there is significant difference or not between functioning and nonfunctioning borehole in the study area. Chi- Square was also used in establishing level of associatin among problems and solutions of solar boreholes in the study area as adopted from Sambo*et al,* (2014).

Level of problem and performance were analyzed using weighted average formula which is

$$\dot{c}_\chi = \sum fx / \sum f \quad (1)$$

Where $\dot{c}_\chi$ = point on Likert scale, f = choice of each point on Likert scale as adopted from Manzuma, Abdulsalam and Staley (2015).

Results and discussions

Results from field observation indicates that in the study area there are 26 solar boreholes out of which 11 are functioning and 15 are not functioning (Figure 2). It can be seen from the 't' test analysis that there is significant difference among the eight study wards in terms of functioning and non-functioning solar boreholes since P value is 9.45, t stat is 5.545953 and critical t is 2.160369 at 0.05 level of significant two tail with standard error of 1.278281 (table 1). This shows that there is high level of damage regarding solar boreholes in the study area. This finding is similar to that of Mogaji, Oloruntade and Afuye (2013) in Awo Ondo where all the solar boreholes are not functioning.

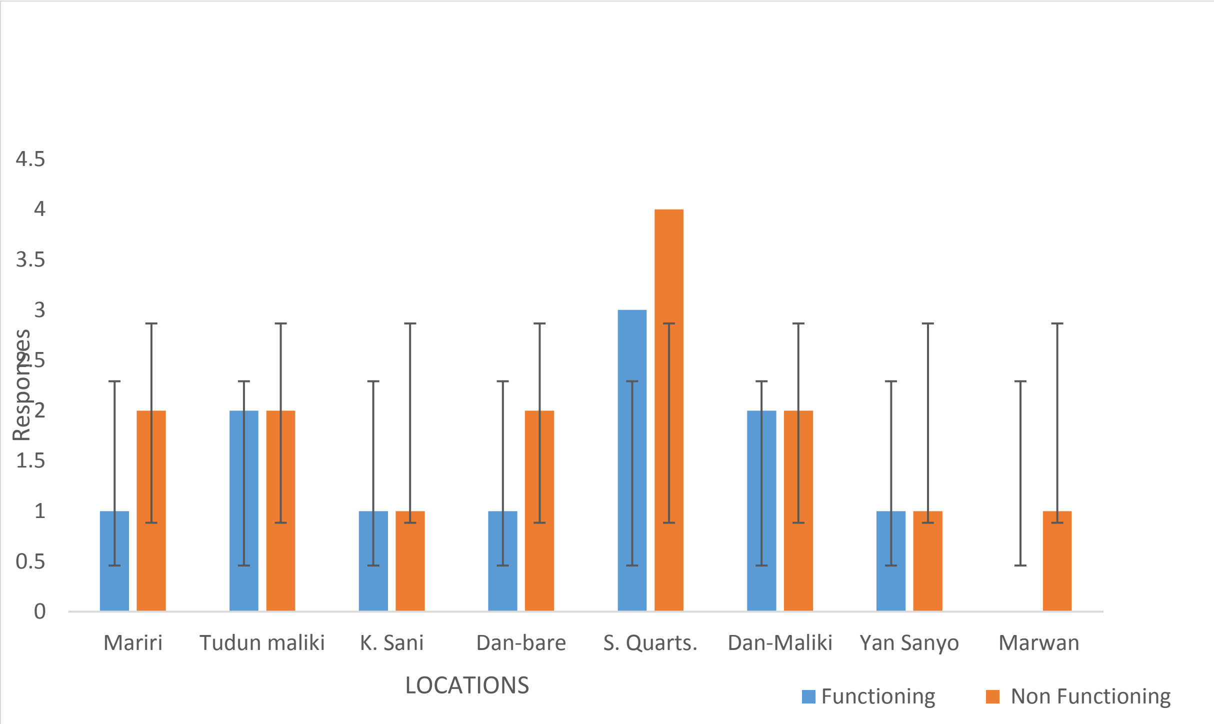


Figure 2 Functioning and Non-Functioning Solar Boreholes
Source: Data Analysis, 2014

Table 1 T TEST Equal Variances

Alpha 0.05

	std err	*t-stat*	*df*	*p-value*	*t-crit*	*lower*	*Upper*	*Sig*	*effect r*
One Tail	1.278281	5.545953	13	4.72E-05	1.770933			Yes	0.838397
Two Tail	1.278281	5.545953	13	9.45E-05	2.160369	4.327728	9.850844	Yes	0.838397

The research findings on stakeholders of solar boreholes in the study area indicates that 68 (46%) of the respondents said community members are the major stake holders, 56 (38%) said it is the local government responsible for taking care of solar boreholes, 13 (7%) are of the opinion that it is trough constituency projects, 6 (4%) attest that Federal government is the major stake holder and 6 (4%) said NGOs are the major stakeholders taking care of solar boreholes in the study locations (table 2). This indicated that members of the community are responsible for the repairs and maintenance of solar boreholes in the area. This is substantiated by the findings of Brian (2012) in Turkana Kenya most of the solar boreholes are controlled by community.

Table: 2 Stake holders on borehole

S/N	STAKE	RESPONSES	PERCENTAGE
1	Community	68	46%
2	Local Govt.	56	38%
3	Constituency	13	07%
4	Federal Govt.	8	05%
5	NGO'S	6	04%
	TOTAL	151	100%
	MEAN	30.2	20%
	S.D.	26.3	18.2

Source: Field Survey, 2014

The result shows that the computed mean of availability of components and spare parts is satisfactory since it is within the satisfactory scale of Likert of mean 2.80 – 3.42 satisfactory while all the rest of the parameters are fairly satisfactory as they are neither within the satisfactory or non-satisfactory (0.50 – 1.27) range of the Likert scale (table 3). This indicates that the performance of solar boreholes in water supply at the study areas is fairly satisfactory. This result is in line with that of Ezeomi and Ogonnaya (2013) who stated that water supply by solar boreholes is not satisfactory due to the influence of cloud cover and other problems. It is contrary to the acertion of Arnstrong (2015) that solar boreholes are the best options for water supply.

Table 3 Rating of Solar Boreholes Performance Parameters

	Scale						
Parameters	1	2	3	4	∑f	∑fx	Mean
Adequacy of water	3	5	3	4	15	38	2.53
water pressure	8	5	11	8	32	83	2.59
Availability of components and spare parts	5	4	6	10	25	71	2.84
Affordability of components and spare parts	8	5	5	9	27	69	2.56
Cost of maintenance	6	7	5	5	23	55	2.39
Overall Performance	12	4	7	6	29	65	2.24

Scales

1=Very unsatisfactory 2=Unsatisfactory 3=Satisfactory 4=Very satisfactory

The outcome of field observation attributed that in the study area there are 26 solar borehole and 112 mechanical borehole (non-solar boreholes) (table 4). From the't' test analysis it is indicated that P value is 9.85, t stat is 6.715472 while critical't' is 2.144787 with standard error of 1.600718. This indicated that there is significant difference between solar and other forms of boreholes for water supply in the study area at 0.05 level of significant (table 5). This indicated that solar boreholes are not adequate in the area. This result is substantiated by the work of Mogaji, Oloruntade and Afuye (2013) in Ondo where there are 86 boreholes, 87 hand pumps and only 12 solar borehole which are not functioning at all.

Table 4 Solar and non-solar Boreholes

S/N	Location	Solar	Non Solar
1	Mariri	3	12
2	Tudunmaliki	4	15
3	K. Sani	2	11
4	Dan-bare	3	16
5	S. Quarts.	7	20
6	Dan-Maliki	4	19
7	Yan Sanyo	2	10
8	Marwan	1	9
	Total	26	112

Source: Field Survey, 2014

Table 5 t test result of solar and non-solar boreholes

				Alpha	0.05				
	std err	*t-stat*	*df*	*p-value*	*t-crit*	*lower*	*Upper*	*Sig*	*effect r*
One Tail	1.600781	6.715472	14	4.93E-06	1.76131			Yes	0.873558
Two Tail	1.600781	6.715472	14	9.85E-06	2.144787	-14.1833	-7.31667	Yes	0.873558

Source: Data Analysis, 2015

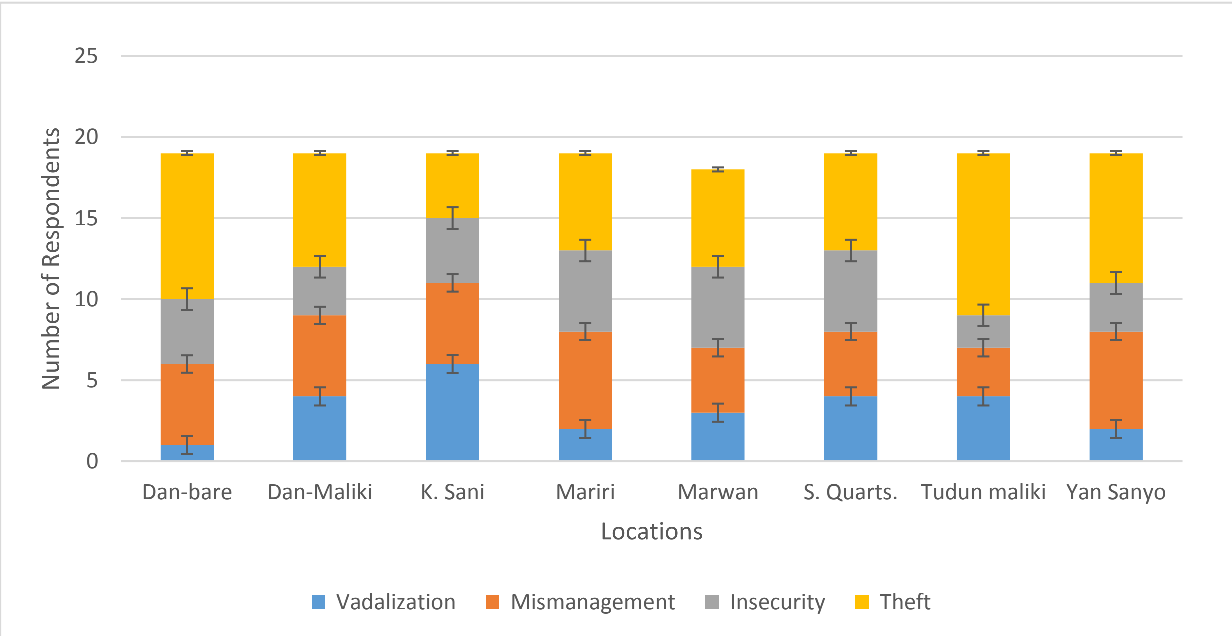
It is established from the research findings that computed means of all the problems facing water supply trough solar boreholes are below the Likert scale of satisfaction of 2.80 – 3.42. For this all the problems are considered to be serious. But theft of solar panels and other components is considered to be the major problem facing water supply by solar boreholes because of its highest mean and highest responses followed by mismanagement (table 6 and Figure 3). It can also be seen from the chi-square (X^2) analysis that there is no significant association among the problems affecting solar boreholes performance for water supply in the study areas at 0.05 level of significant. This is so because Chi-square value is 12.86, P value is 0.91, critical chi is 32.67 (table 7). This result is in line with that of Oloruntade, Konyeha and Alao (2014) who established that theft of solar panels among other issues is the major problem of water supply by solar PV. The findings are contrary to the assertions of Samboet *al* (2014) that failure in solar PV in Nigeria is attributed to poor construction and maintenance.

Table 6 Rating Problems of Solar Boreholes Performance and water supply

	Scale						
Problems	0	1	2	3	∑f	∑fx	Mean
Vandalization by users	4	5	10	7	26	46	1.77
Mismanagement	8	9	10	11	38	62	1.63
Insecurity	6	10	3	12	31	52	1.68
Theft	10	11	10	25	56	106	1.89

Scales 0 = Not a problem, 1 = a problem 2 = Serious Problem 3 = Very serious problem

Figure 3 Responses on problems facing Performance of Solar Boreholes



Source: Data Analysis, 2015

Table 7 Chi-square for the Problems

	chi-sq	*p-value*	*x-crit*	*sig*	*Cramer V*
Pearson's	12.86807	0.913175	32.67057	No	0.168542
Max likelihood	13.416	0.893355	32.67057	No	0.172093

Source: Data Analysis, 2015

Research findings shows that in most of the wards provision of full and adequate security is the major solution to the problems solar boreholes performance for water supply in the study areas. In Mariri full security recorded 10 responses out of 19, in Tudun-Maliki 8 responses out of 19, in kureken-Sani 7 responses out of 19, in Danbare Full security and proper management 5responses each out 19, in Shagari Quarters 5 responses each out of 19 for full security and construction of more solar boreholes, in Danmaliki full security and public enlightenment recorded 6 responses each out of 19, in Yansanyo full security recorded 8 responses out of 19.

In Marwan with 18 respondents' full security recorded 6 and public enlightenment recorded 5 responses. In the whole wards provision of full security as a major solution to the problem of solar boreholes performance for water supply 55 responses (36.45%), followed by Public enlightenment 32 (21.19%), proper management 25 responses (16.56%) construction of more solar boreholes 20 responses (13.25%) and regular service with 19 responses (16.56%) (table 8). This shows that provision of full security to prevent solar panels, sumo and other important components of solar boreholes from been stolen is the major solution to the problems for effective water supply in the study areas.

From the chi-square analysis value of chi is 20.06, critical chi is 41.34, P value is 0.85, and this shows that there is no significant association among the major solutions to the problems of solar boreholes performance in the study locations (table 9). This result is supported by that of Ezeomi and Ogonnaya (2013) who stated that solar borehole is user and environmental friendly, it requires little or no maintenance particularly if there is adequate security for the solar components. This result is contrary to the believe of Mikkel (2016) who attributed that once population is considered while constructing solar PV all problems are solved regarding water supply using solar boreholes. It can be seen that security challenge is the major problem facing water supply through solar boreholes in the study areas.

Table: 8 Solutions to the Problems

S/N	Location	Proper management	Regular service	Full security	Public enlightenment	Construction of more
1	Mariri	1	3	10	3	2
2	Tudunmaliki	4	2	8	4	1
3	K. Sani	6	1	7	4	1
4	Dan-bare	5	3	5	4	2
5	S. Quarts.	2	3	5	4	5
6	Dan-Maliki	3	2	6	6	2
7	Yan Sanyo	3	3	8	2	3
8	Marwan	1	2	6	5	4
	Total	25	19	55	32	20
	Percentage	16.56%	12.58%	36.42%	21.19%	13.25%

Source: Field Survey

Table 9 Chi-square for Solutions

	chi-sq	*p-value*	*x-crit*	*Sig*	*Cramer V*
Pearson's	20.06013	0.862263	41.33714	No	0.182242
Max likelihood	20.438	0.847979	41.33714	No	0.18395

Source: Data Analysis, 2015

Conclusion and Recommendations

It can be concluded that there is high level of damage regarding solar boreholes in the study area because non-functioning boreholes outnumber the functioning ones. It was established that there is significant difference between solar and other forms of boreholes for water supply in the study area and solar boreholes are not adequate in the study area for effective water supply. It was discovered that the performance of solar boreholes in water supply at the study areas is fairly satisfactory. It is part of the conclusion that it is determined there is no significant association among the problems affecting solar boreholes performance for water supply in the study areas.

The study revealed that water supply in the study area using solar borehole is not very effective because of government negligence, low NGO concern, poor management, over reliance on community service and low security among others. The major way of improving or solving solar boreholes problem is by provision of adequate security.

Reference to findings of the research it is strongly recommended that

- Proper and adequate security should be provided to reduce the problem of stealing of expensive solar components particularly solar panels and sumo.
- More solar boreholes are to be constructed trough constituency projects, by all levels of governments and non-governmental organizations for effective water supply and management in the areas.
- Damaged solar boreholes are to be repaired as they are cost effective and demands no fuel unlike mechanical boreholes.

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