Rainwater Harvesting in Nigeria: A Survey of Common Water Supply Practices

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Abstract
Rainwater harvesting systems in Nigeria vary in terms of design and operation. To better understand common practice and motivation for collecting rainwater, a questionnaire survey was selected to achieve a representation of the population of Ibadan. A sample size of 1067 was calculated for household respondents (using a population of 2,555,853). 950 households responded to the survey. The survey questions focused on catchment materials, uses for the harvested water, water policy and strategy, water supply and environmental health. Result indicates that corrugated iron sheet is the most commonly used roofing materials for rainwater harvesting (RWH). The most commonly reported use for harvested rainwater was cooking and drinking although greater than 75% of the respondents use their rainwater for potable purposes. 77% of the respondents had no water supply from the public main while less than 25% receive supply. Of the respondents, approximately 61% have a low yield of supply from well sources during the dry season while 39% have supply. Thus, the prevalence of water-borne diseases, in which 61% reported typhoid fever, 19% diarrhea and 17% cholera. Over 60% of the population depend on well water for their supply while 23% rely on borehole and as low as 6.6% harvest rainwater traditionally as a source. In particular, the low reliance on rainwater and the need for an alternative water supply system should be investigated further as the number of RWH systems installed in Nigeria continues to grow.

Keywords: Rainwater Harvesting, Survey, Catchment, Drinking water

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Introduction

There is a challenge of lack of supply of pipe-borne water in Nigeria. Hence, many homes have wells sited around the house some distance from the septic tank. The scarcity of piped water has made communities find alternative water sources; groundwater sources being a ready source. Wells are a common groundwater source readily explored to meet community water requirements or address shortfalls (Adelekan, 2010). The most common cause of pollution is attributed to the close proximity of septic tanks to wells and unhygienic use of wells. For instance, some wells have no cover/lids; they are dirty and unkempt, thus making the water susceptible to infection (Onunkwo and Uzoije, 2011). Groundwater pollution is also caused by the disposal of solid or liquid wastes in pits, abandoned boreholes or even stream channels and landfills (Iyun, 1994). These processes result in the deterioration of the physicochemical and biological properties of water (Orebiyi *et al*., 2010).
The challenges to increasing access to improved drinking water is further complicated by disparities in provision, which may be geographical (between urban and rural); socio-economic (between the poor and more economically disadvantaged) or related to the disproportionate focus on water in comparison with sanitation. For example, compared with 72% of Nigerians in urban areas, only 47% of the rural population has access to improved water sources; whilst the ratio of water access to sanitation is only 2:1 i.e. 58% water to 26% sanitation (WHO/UNICEP 2010). Rainwater harvesting (RWH) is an increasing common practice globally. In Nigeria, population growth, pollution of groundwater caused by poor waste management (Beretta *et al*., 2004) and low yield of wells during the dry season (Lade *et al*., 2012) make harvested rainwater an attractive alternative for potable and non-potable (e.g. irrigation, laundry) uses. There is an increase utilization of rainwater in many parts of the world including, US (Thomas *et al*., 2014), Australia (Huston *et al*., 2012), Bangladesh (Karim, 2010) and Korea (Han and Mun, 2008). Individuals continue to modify their dwellings and devise systems to utilize harvested rainwater due to increase concerns over climate change and stress on water resources (United Nations Environment Programme/SEI, 2009).

Few data on the configuration, operation and maintenance of household RWH system exist. Rodrigo *et al*. (2010) surveyed RWH catchment materials and maintenance practices in Australia, Karim (2010) surveyed RWH catchment materials and cisterns in Bangladesh, Ward *et al*. (2008) surveyed RWH catchment materials and maintenance in UK. To our knowledge, no survey has been conducted in Nigeria. Thus, the objective of our survey was to define the most common water supply system, catchment materials and the need for harvesting RWH in Ibadan. Rainwater is abundant in southern Nigeria. Ibadan city receives heavy rainfall during the rainy season with a mean annual rainfall of 1350 mm. Figure 1 shows rainfall data for Ibadan for the period 1980-2009, indicating that there is ample rainwater. The ponds replenished by rainwater each year are major sources of water supply in rural areas. However, poor waste management and unhygienic practices are increasingly polluting ponds, streams and groundwater (Lade *et al*. 2012). Hence attention and effort are needed to address these unhygienic practices, as they deplete sources of water supply. In addition, more sources of potable water supply are needed to augment current under-supply. In the present context, therefore, RWH is being considered as an alternative option for increasing water supply in Ibadan. Research is being conducted

to evaluate the potential for RWH by conducting a socio-demographic survey in the study area to determine the rate of water consumption and current water sources.

Study Area

In context, Nigeria has a land mass of 923,768km^2; Oyo is one of these states located in the South-western axis. Ibadan is the capital of Oyo state with an estimated population of 2,559,853 in 2007 [19] and a projected population of 7,656,646 by 2015. Ibadan is located in south-west Nigeria (longitude $3^0$45'-$4^0$00'E, latitude $7^0$15'-$7^0$30'N and is reputed to be the largest indigenous city in Africa, South of Sahara (Figure 2). It is the second largest city in Nigeria in terms of land mass; consisting of 11 Local government areas (Figure 3).

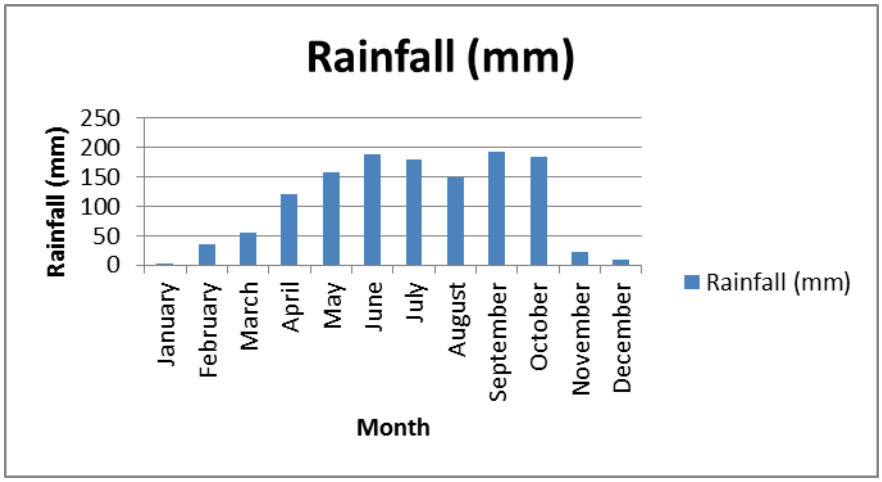

Figure 1 Mean rainfall for Ibadan City for the period 1980-2009 Source (DMS, 2010)

Methodology

Questionnaire survey and target population

A questionnaire survey was designed for householders and tenants. The questionnaire is designed to generate data and consist of closed-ended questions (respondents choose from a given set of answers) and/or open-ended questions (respondents record their views and opinions in full). In order to determine a suitable sample size, a sample size calculator provided by Research Information (2008) was utilised. By using a City population of 2,555,853 (National Population Commission 2006), and a confidence level of ($p < 0.05$) (after Munn and Drever, 1990), a sample size of 1067 was calculated for household respondents. A total of 1067 householders participated in the survey, with 950 completing it in its entirety, for an 89 % completion rate.

Questionnaire methodology and weighting of results

The first question asked all respondents to describe their demography: (1) population in the home and (2) local government area of residence. The survey consisted of 33 questions for the household respondents. Statistical analysis such as descriptive and inferential statistics were carried out on the data collected from the questionnaire survey. Since the nature of the variables administered in the questionnaire is univariate, which implies that frequency distribution is required (De Vaus, 2002).

Inferential statistic (chi-square test) is used to estimate how likely the sample pattern will hold in the population.

Results and Discussion

Respondents' population distribution
Figure 4 reveals that 10.8% of the sampled households are two persons. About 14.9% of the households have three persons in them while 12.4% of the households have more than six persons living in them. A percentage as low as 4.8% have one person, which implies that about 69.3% of the population have four or more people living in them.

Respondents' local government area
Figure 5 shows the local government area of the respondents. About 11.4% of the respondents reside in Egbeda and 20.9% reside in Ibadan North, this group represents the largest proportion of the respondents. Those residing in Ido, Ibadan South-west, Ibadan North-west, Ibadan South-east and Ibadan North-East make up the lowest percentage with 3.8%, 2.8%, 5.3%, 3.9% and 4.9% respectively.

Figure 2: Map of the States of Nigeria

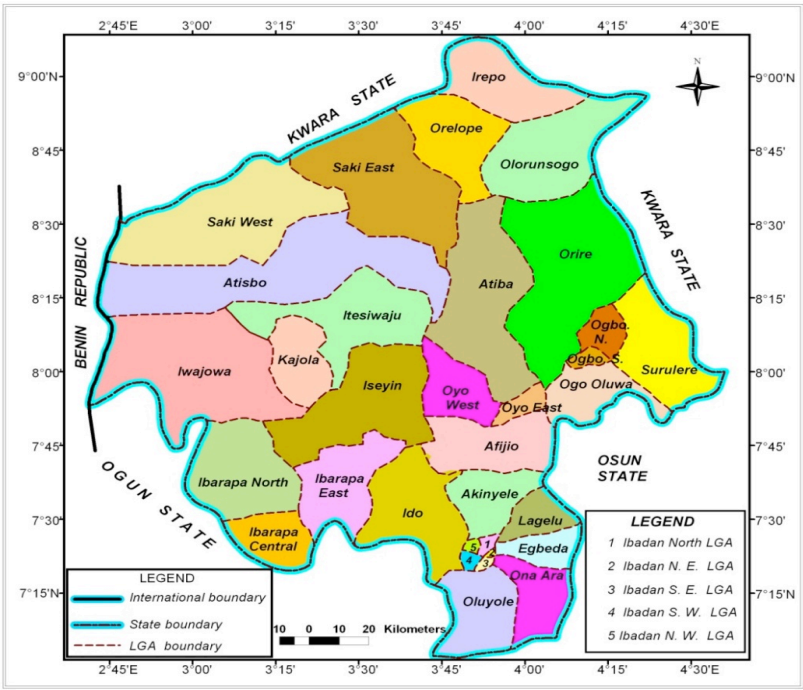

Figure 3: Map of Oyo State showing Ibadan (source: DG 2012)

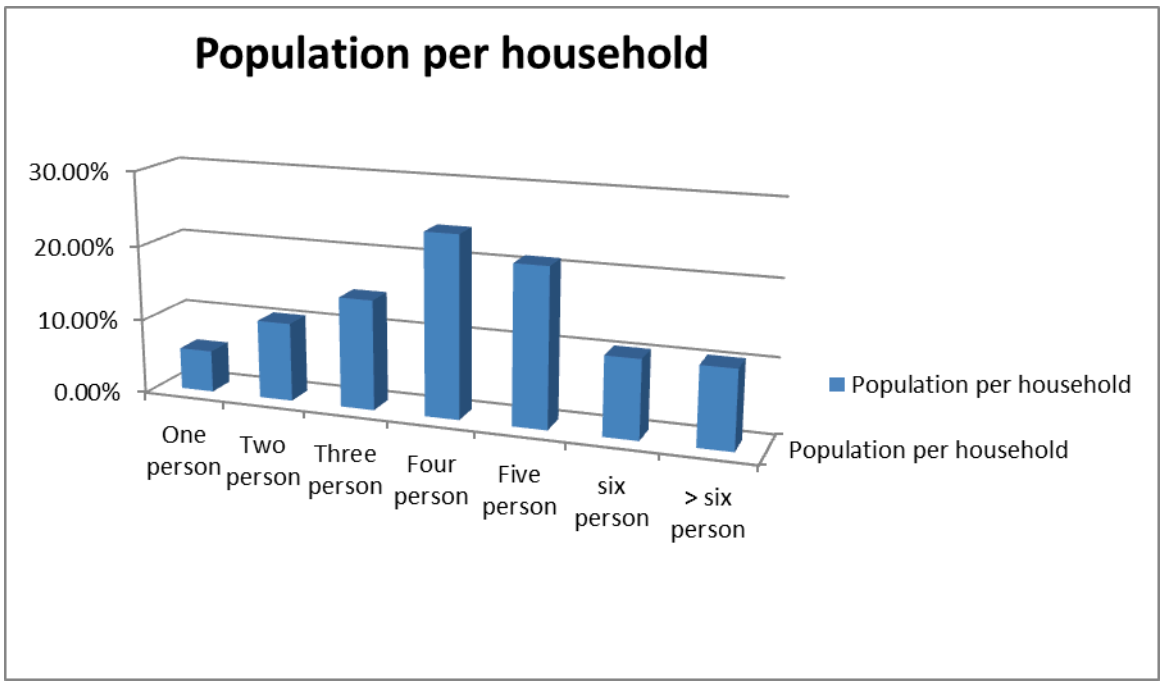

Figure 4: Respondent population distribution

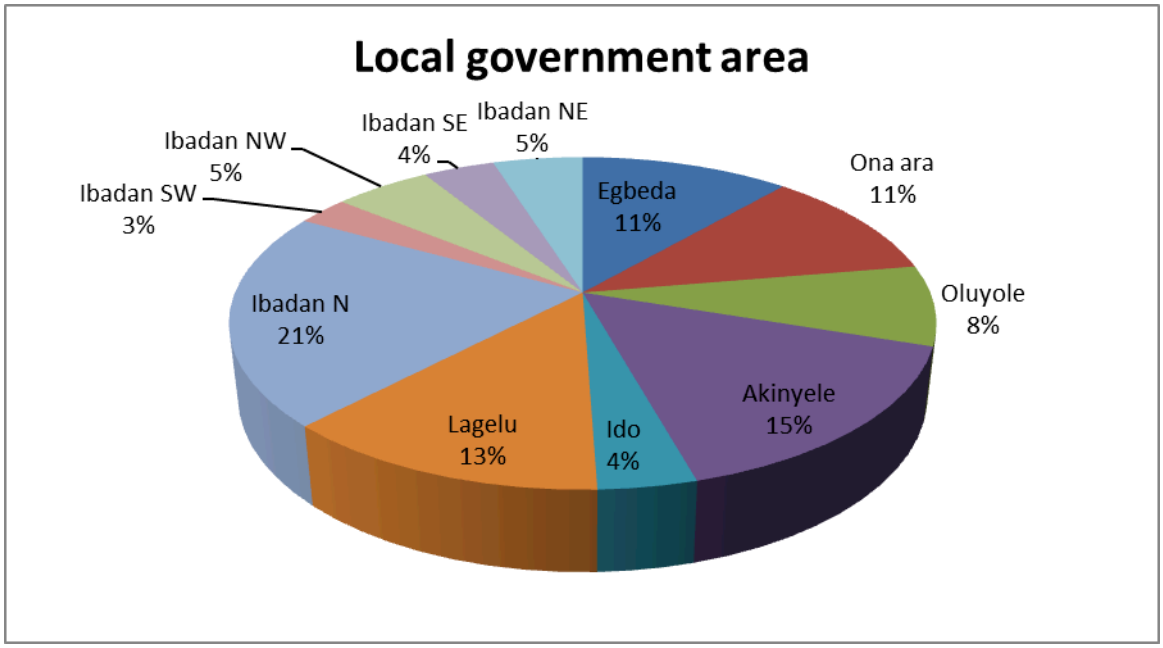

Figure 5: Respondent Local Government areas

Major system components

Figure 6 presents respondents' type of roofing materials. As the roofs are prone to corrosion, the harvested water needs filtration and purification with chlorine to make it potable. Table 1 represents a cross tabulation of the type of roofing materials with household income range. Some 32 and 33% of low income earners use roofing tiles and cement concrete materials, respectively, for their roofs. Some 38% of mid-income earners used roofing tiles and 11% of high income earners used cement concrete. This indicates that people with low income used high quality materials for their roofs, which is expected as people usually take loans from banks and co-operative societies to build larger houses. A chi-square test was carried out to determine the degree of association between type of roofing material and household income (Table 2). This result shows a strong, statistically significant, relationship between the two variables ($p < 0.05$).

Harvested water usage

In terms of the use that people would be willing to consider RWH for, Figure 7 illustrates that the most widely accepted would be (in order of popularity) drinking, cooking, toilet flushing, washing clothes. Few would be willing to use it for bathing animals, car washing, personal washing, garden watering and general outdoor use, respectively.

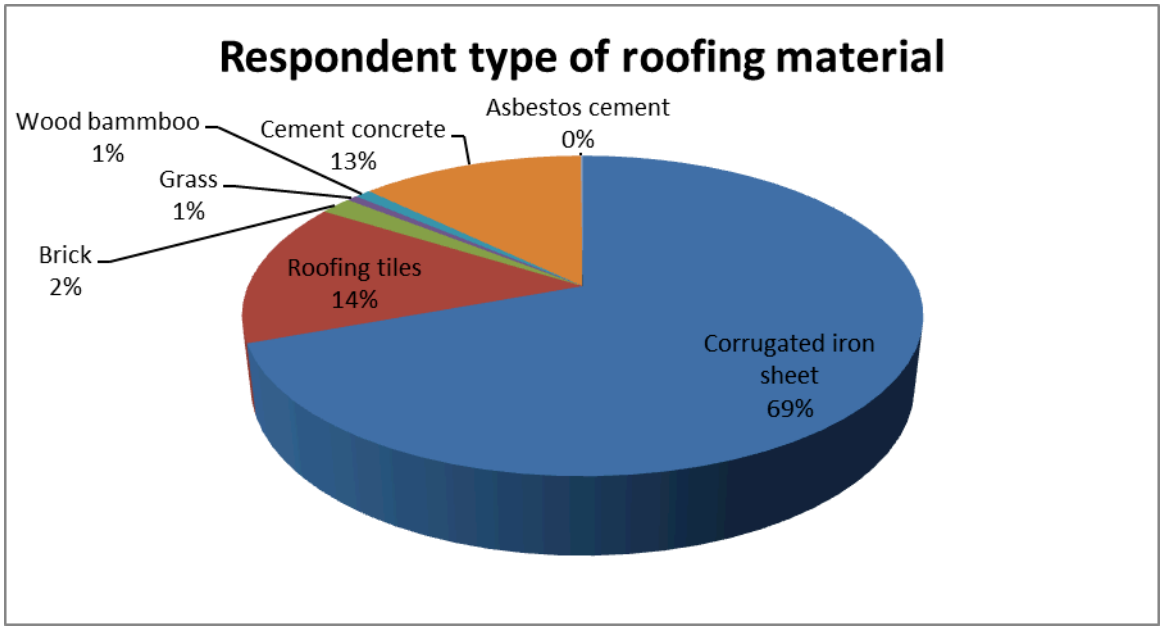

Figure 6: Respondents type of roofing materials

Table 1: Type of roofing material cross tabulation with monthly income range

Respondent Type of Roofing Material	Respondent Monthly Income Range (Naira, 000)						
	<10	10-30	31-100	101-150	151-200	>200	Total
Corrugated iron sheet	216	190	172	50	20	10	658
Roofing tiles	33	46	38	8	9	4	138
Brick	5	4	3	3	2	0	17
Grass	1	0	3	3	2	0	6
Wood bamboo	3	1	2	0	2	1	9
Cement concrete	32	39	23	7	9	11	121
Asbestos cement	0	0	0	0	0	1	1
Total	290	280	241	69	43	27	950

Individual satisfaction with public main supply

Figure 8 reveals that 70% of the respondents chose unsatisfactory with the level of main water supply from Water Corporation of Oyo State (WCOS), while 29.9% of respondents were satisfied. This implies that the WCOS is not providing adequate water supply for the community.

Table 2 Chi-Square tests for relationship between roofing material and monthly income range

	Value	Df	Asymp. Sig. (2-sided) (P)
Pearson Chi-Square	91.788[a]	30	<0.001
Likelihood Ratio	56.567	30	0.002
Linear-by-Linear Association	15.269	1	<0.001
N of Valid Cases	950		

a. 24 cells (57.1%) have expected count <5. The minimum expected count is 0.03.

Current supply sources

Figure 9 shows a low proportion of respondents chose main supply confirming inadequate supply of main water supply in the study area. Few respondents chose stream/river; tank/truck vendors and rainwater. This also confirms that RWH technology is yet to be tapped as an alternative source of supply in the area. Some 579 (60.9%) of respondents depend on well water and 22.9% of respondents depend on boreholes. This indicates that 83.8% of respondents depend on ground-water as their main source of supply. This implies that a large proportion of households possibly have water supply from unhealthy and untreated sources.

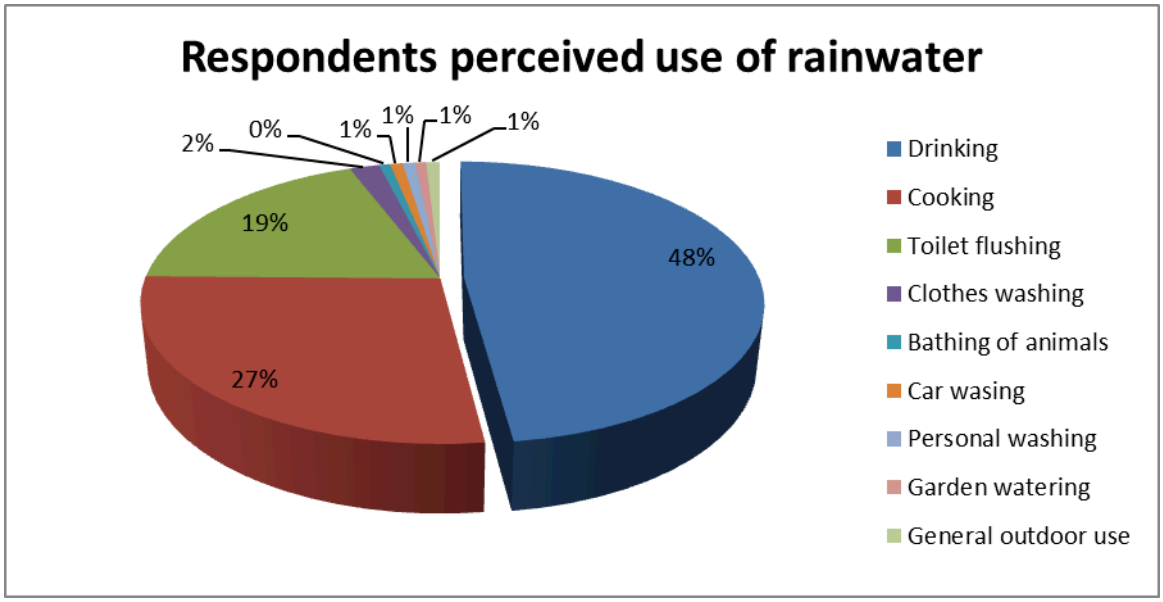

Figure 7: Respondents perceived use of rainwater

Well water yield

Figure 10 reveals 50.7% of respondents said their wells dried up during the dry season; 39.1% said their wells do not dry up and 10.2% are unsure. This indicates over 60.9% experience water shortage during the dry season.

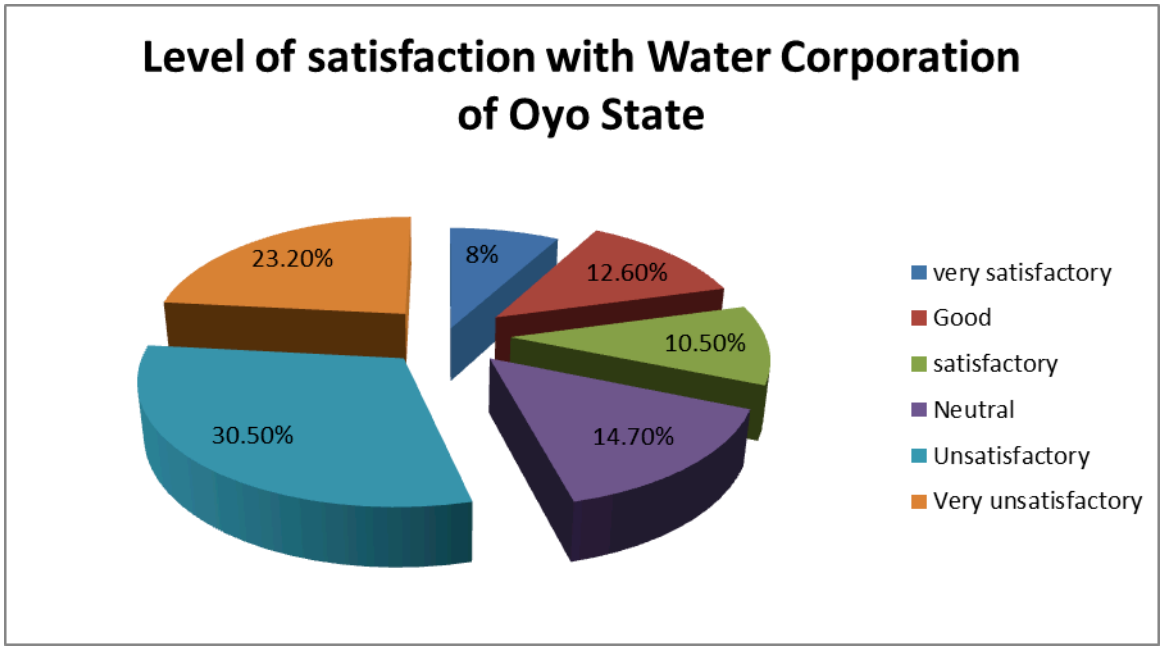

Figure 8: Respondents level of satisfaction with Water Corporation of Oyo State

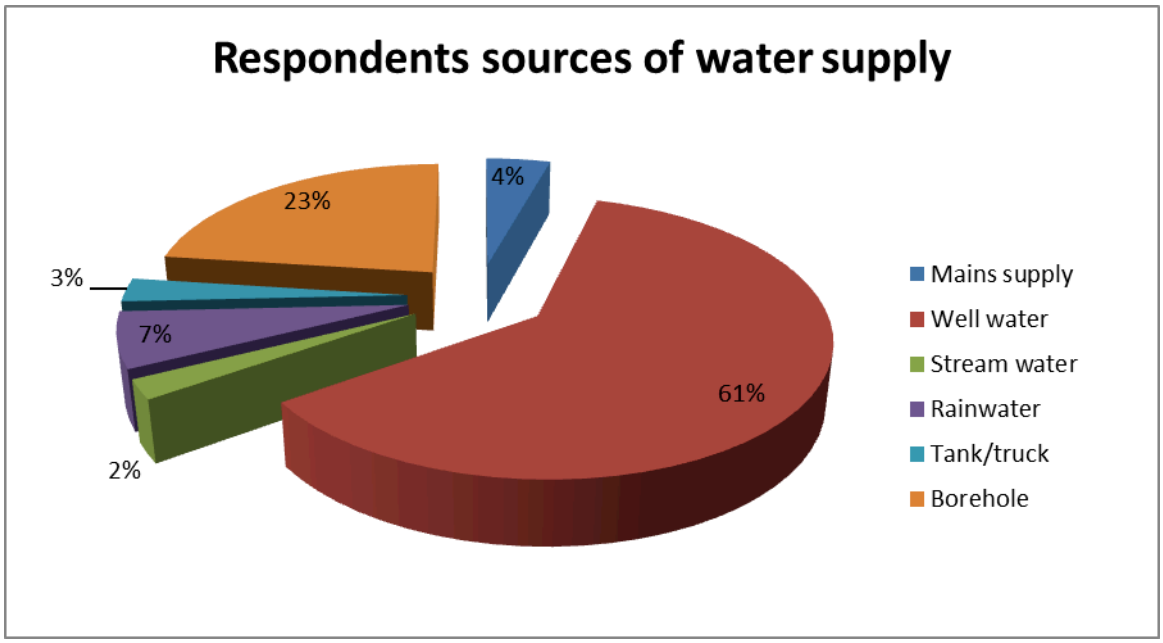

Figure 9: Respondents sources of water supply

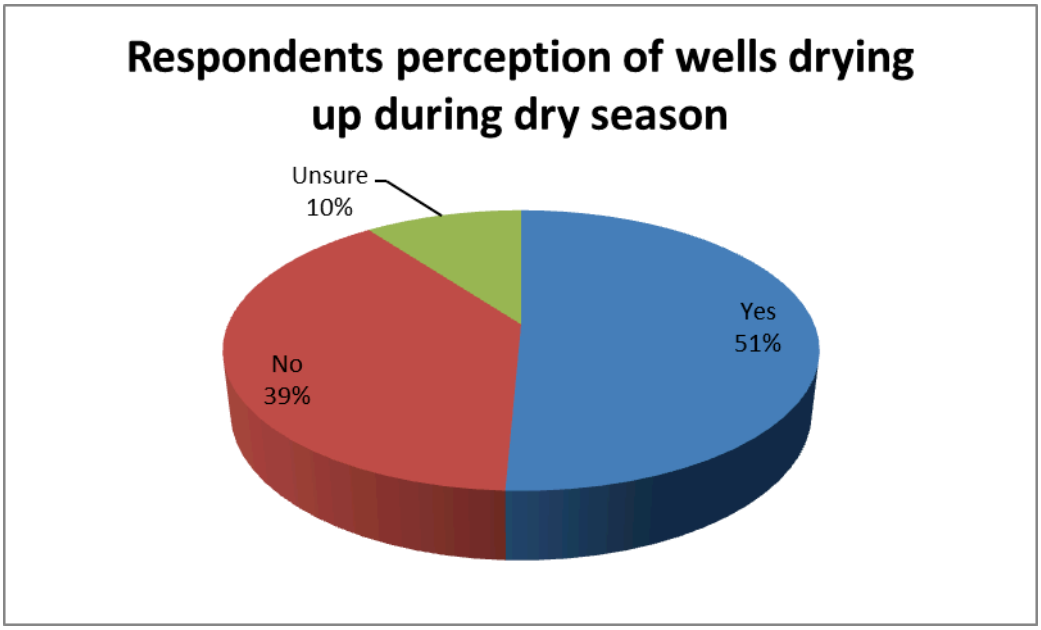

Figure 10: Respondents perception of wells drying up during dry season

Health hazard with drinking contaminated water

Figure 11 shows a larger proportion (581), of respondents, chose prevalence of typhoid fever; some have a prevalence of diarrhoea, while few of respondents water source is free from water-borne disease. This indicates that there is a prevalence of 97.8% of water-borne disease in the study area. This is quite alarming; hence, an alternative source of potable water is urgently needed.

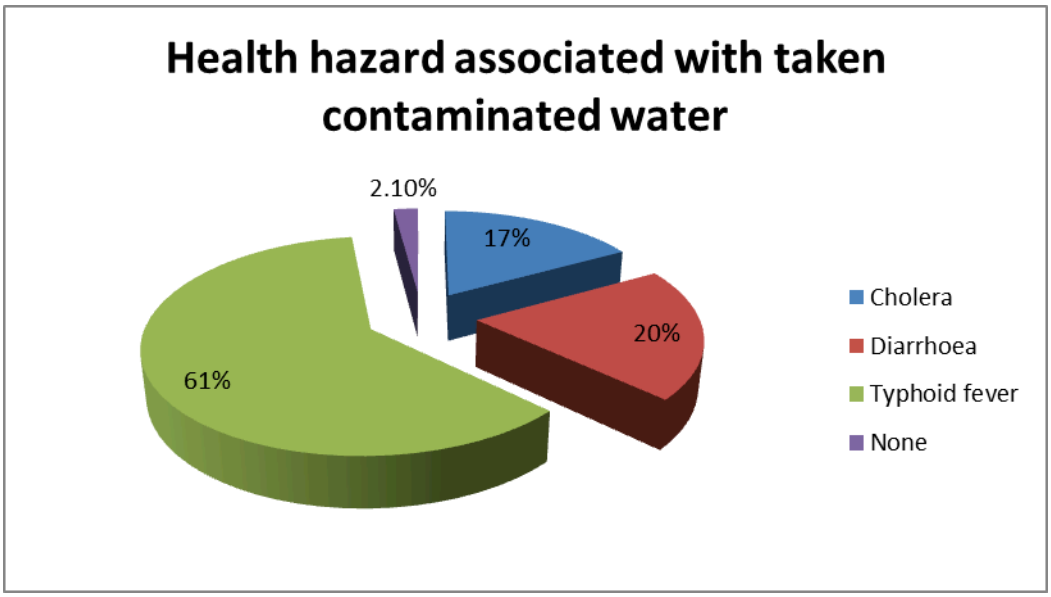

Figure 11: Respondents major health hazard associated with taken contaminated water

Conclusions

A survey was conducted to investigate the most common system set up, catchment materials and the need for rainwater harvesting in Nigeria. Our goal was to identify common water supply systems and the need for alternative source of supply. Householders and tenants were surveyed and responses were obtained. The survey had 89 percent response rate, indicating their willingness to utilize rainwater for domestic purposes. Result indicates that corrugated iron sheet is the most commonly used roofing materials for rainwater harvesting. The most commonly reported use for harvested rainwater was cooking and drinking although greater than 75% of the respondents use their rainwater for potable purposes. 77% of the respondents had no water supply from the public main while less than 25% receive supply. Of the respondents, approximately 61% have a low yield of supply from well source during the dry season while 39% have supply. Thus, the prevalence of water-borne diseases, in which 61% reported typhoid fever, 19% diarrhea and 17% cholera. Over 60% of the population depend on well water for their supply while 23% rely on borehole and as low as 6.6% harvest rainwater traditionally as a source. In particular, the low reliance on rainwater and the need for an alternative water supply system should be investigated further as the number of RWH systems installed in Nigeria continues to grow.

This survey provides essential data about current water supply practices in Nigeria. The result can be used to understand current practice as well as to guide further research into harvesting rainwater for domestic consumption. Further surveys of this type could be conducted with different population by utilizing Nigeria Society of Engineers Forums and groups. In addition, surveys of householders in more remote areas and in the Northern part of Nigeria could provide valuable information on RWH practices for individuals.

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