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Assessment of the Quantity of Harvested Rainwater in IGAH Communities of Olamaboro Local Government Area of Kogi State, Nigeria

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***Abstract:** This research is aimed at assessing the quantity of harvested rainwater in Igah Communities of Olamaboro Local Government Area of Kogi State, Nigeria. Data were collected through the use of questionnaire, interview and secondary data sources. Stratified random sampling was employed in the sampling of the respondents. Three hundred and ninety five copies of questionnaire were determined using Taro Yammane and administered, while three hundred and seventy two of them were completely returned. The data generated were statistically analysed through the use of descriptive and inferential statistical tools. Principal Component Analysis (PCA) was employed to collapse the various variables responsible for the quantity of rainwater consumed into few underlying dimensions. Results obtained from the statistical analysis revealed that the mean rainwater consumption per person per day of 8.2 litres is far below the WHO recommended standard. Other results revealed that seasonality of rainfall, cost of constructing storage facilities and household size, limited financial capacity and geographical location are responsible for the existing rainwater quantity obtained in the area. Conclusions were drawn from the results, while the major recommendation was on the need for further investigation into water scarcity situation in the study area.*

***Keywords:** rainwater harvesting, rainwater supply, water demand, Principal Component Analysis, Igah communities*

I. INTRODUCTION

Access to safe and sufficient water, sanitation and hygiene (WASH) facilities are crucial to human health and well-being (International Water Association, 2011). As reported by World Health Organization (2014), to have access to adequate WASH services means to have a sufficient and potable water supply, appropriate, safe and secure sanitation facilities and available hand washing equipment with soap and water for use. However, the availability of water as a highly valued resource is increasingly being put at risk as human population is increasing at a rate which is not proportional to the rate for which it is demanded for domestic and economic purposes. Amori and Makinde (2012) argued that the issue of access to potable water supply has been a topical issue of high interest to several individuals, communities, organizations and governments.

In developed countries of the world where there is high satisfaction of WASH services, partly because of the availability of water services, the average domestic use of water including that for all purposes per person is 180–230 litres per day, while in Nigeria, the average domestic consumption by individuals is 2.25 litres per day as against 20 litres per head per day by the World Health Organization (Chima, Nkemdirim and Iroegbu, 2009).

In developing countries, there is lack of access to quality WASH services especially in rural areas where the provision of pipe borne water has not been regular or realized. The lack of pipe borne water or public water system in the rural areas and the inability of water facilities to function effectively especially in towns and cities of Nigeria have made it impossible for most of her population to have access to potable water (Orebiyi *et al*., 2010). As a result, sources such as rivers, boreholes, streams, wells, ponds and rainwater are still very much depended upon to satisfy water needs.

According to United Nations Children's Fund (2015), the total number of people without access to sufficient drinking water and sanitation globally is about 663 million, and nearly half of the people lacking access to adequate water and sanitation live in sub-Saharan Africa and Asia. In Africa, water scarcity is a threat to sustainable development and it has been estimated that by 2030, 75 to 250 million people will be living in water stressed areas. This is also typical in Nigeria, where about 65 million Nigerians have no access to quality WASH and the number rose dramatically to 90 million in 2015 (UNICEF, 2015).

According to Ojo (2014), the scarcity of water in Nigeria is taking a new dimension as residents of many rural areas do not have access to a readily available source of domestic water. The limited access to water supplies by a significant proportion of the Nigerian rural population has been blamed on institutional and socio-economic factors (Ezenwaji, Eduputa and Okoye, 2016).

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Therefore, there is need to solve the crucial problem of water by resorting to unconventional sources. Rainwater source easily available for all seems to be a preferred source in many localities.

Rainwater harvesting (RWH) is the human activity involving collection and storage of rainwater in some natural or artificial container either for immediate use or use before its onset in the next season for domestic, agricultural, industrial and environmental purposes (Kun, Linus, William, Mancang and Hui, 2004). Rainwater harvesting which is an age long water sourcing technology is currently making an impact in many countries (especially in the developing world) as an alternative household water supply option. According to Thomas (2009), a number of reasons can be attributed to this resurgence, the more important of which are;

1) Decrease in the quantity and quality of both ground water and surface water.
2) Failure of many piped water schemes to deliver the required amounts to satisfy the consumers due to poor operation and maintenance of the infrastructure.
3) Improvement in roofing material from thatched to more impervious materials like concrete, tiles, corrugated iron sheets and asbestos.
4) Increased availability of low cost rain water harvesting techniques.
5) Shift from more centralized to decentralized management and development of water resources.

Hence there is need for proper investigation on quantity of harvested rainwater consumed by communities relying on the source. In Igah communities, the people heavily rely on this source of water supply which necessitates a closer study with the aim of ascertaining whether its quantity levels satisfy the water supply needs of the people.

II. STUDY AREA

The study was carried out in nine communities of Igah in Olamaboro local government area of Kogi State, Nigeria. The study area in Fig 1 comprises of Igah Agala, Igah Eboyi, Igah Igoh, Igala Ogane, Igah Ojuwo, Igah Ikeje, Igah Ogene, Igah Adumu and Igah Ugbamaka. The population of the study area was obtained using building count method which brought the total estimated population of the study area to 30,200. The climate of the study area is characterized by both the wet and dry seasons. The raining season usually begins by the end of March and lasts till the end of October, while the dry season begins in November and ends early March. The total annual rainfall in the area ranges between 1000 millimeter and 1500 millimeter. Average temperature ranges between 30 degree centigrade and 35 degree centigrade. The type of soil found within the study area is alluvium soil. The alluvial soils along the valleys of the rivers are sandy, while the adjoining lateritic soils are deeply weathered and grey or reddish in colour, sticky and permeable. The vegetation is tropical rainforest with tall trees and undergrowth. The study area is typical of Ajali Formation or the false bedded sandstone and the Mamu Formation. The Ajali consists of thick friable poorly sorted sandstone, typically white in colour but sometimes iron-stained. The study area is drained by the Maboro River and other smaller streams. The streams within the study areas are characterized by a lot of material in suspension and solution within its stream channel.

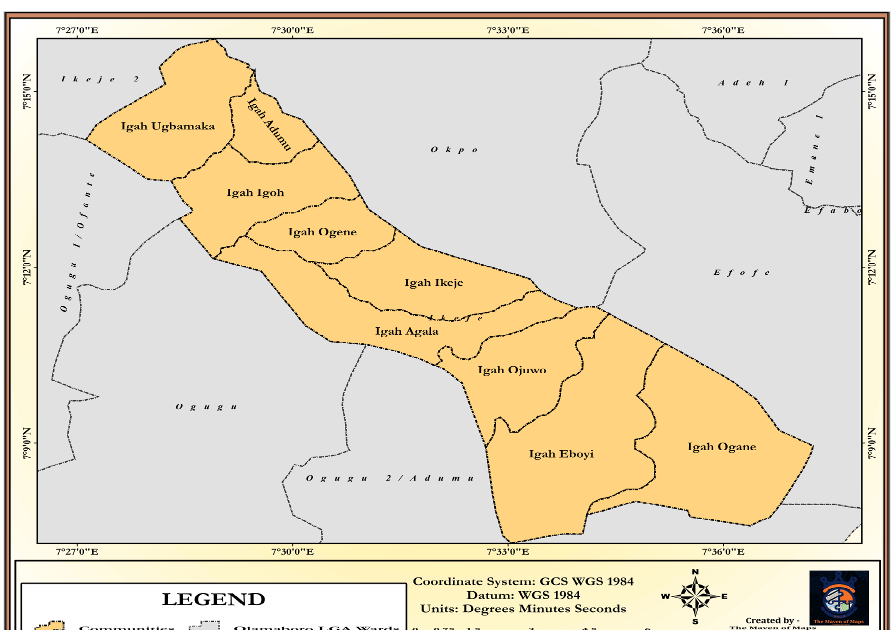

Fig 1: Map of the study area

III. METHODS

Data for this work were collected using structured questionnaire, field observation and oral interview. The sampling method adopted is the stratified random sampling in which every community is a strata while households where sampled randomly within the strata. A total of three hundred and ninety five copies of questionnaire were determined using Taro Yammane and administered, while three hundred and seventy two of them were completely returned. Total rainwater consumption and water demand for the area was calculated using the per capita demand and supply figures of each community and its Population to determine the margin of water deficiency in the area. The data is presented in form of maps and tables to aid discussion and interpretation of results. For data analysis on the factors responsible for quantity of rainwater usage in the area, we employed Principal Component Analysis (PCA) of Statistical Packages for Social Sciences (SPSS) program version 20.0 to combine these factors into a few underlying dimensions. PCA combines large number of indicators into fewer, more analogous groups, each group defining the underlying dimension in the contributing variables forming the group (Anyadike, 2009).

IV. RESULTS AND DISCUSSION

A. *Determination of Quantity of Rainwater used daily by households in Igah Communities*

1) *Quantity of Water Demanded:* The results showed that the mean household water demanded by the communities was found to be 78 litres per household per day (lpd), while the mean daily per capita demand was found to be 10.2 litres per person per day (lpd). The mean domestic demand tends to be similar among the studied communities as a result of a very high degree of social homogeneity exhibited by the people in the study area (Table 1). It can also be deduced that low figures exist for the per capita water demand in all the communities. This could be as a result of factors of relative poverty among the various households, seasonality of rainfall as well as little or no WASH facilities capable of consuming much water. Besides, the people are used to low water use. Generally because they cannot imagine themselves demanding many quantity more than what they consume daily even in the face of adequate supply.

Table 1: Quantity of water demanded

Communities	Mean number of persons per household	Mean quantity of rainwater demanded per household per day (litres)	Mean per capita demand per day (litres)	Population	Total quantity demanded(litres)
Agala	8	83	10.4	3,592	37,356
Eboyi	8	83	10.4	3,208	33,363
Ogane	8	77	9.6	3,424	32,870
Ojuwo	7	70	10.0	2,709	27,090
Ikeje	8	79	9.9	4,016	39,758
Ogene	8	76	9.5	3,176	30,172
Igoh	7	79	11.3	2,422	27,369
Adumu	7	77	11.0	2,772	30,492
Ugbamaka	8	79	9.9	3,752	37,145
Total	69	703	92	30,200	295,615
Mean	8	78	10.2		

Source: field work, 2021

2) *Quantity of Rainwater Supplied:* Results obtained showed that the mean consumption per household was found to be 63.8 litres, while average household per capita water consumption was found to be 8.4 litres per head per day. The mean per household water consumption were highest for Ikeje (72 litres), Ugbamaka (69 litres) and Igoh (67 litres). While Agala (65 litres), Adumu (64 litres), Eboyi (63 litres) and Ojuwo (61 litres) were relatively high. Ogane and Ogene were the lowest with 54 litres and 59 litres respectively. The mean daily domestic per capita consumption of water (8.4 litres) tends to be very low in all the studied communities. And this is far below the WHO recommended standard of 20 litres per head per day (Table 2). Results from Table 3 shows that the extent of rainwater deficiency in Igah communities cannot be overlooked.

Table 2: Quantity of rainwater supplied

Communities	Mean number of persons per household	Mean quantity of rainwater supplied per household per day (litres)	Mean per capita supplied per day (litres)	Population	Total quantity demanded (litres)
Agala	8	65	8.1	3,592	29,095
Eboyi	8	63	7.9	3,208	25,343
Ogane	8	54	6.8	3,424	23,283
Ojuwo	7	61	8.7	2,709	23,568
Ikeje	8	72	9.0	4,016	36,144
Ogene	8	59	7.4	3,176	23,502
Igoh	7	67	9.6	2,422	23,251
Adumu	7	64	9.1	2,772	25,225
Ugbamaka	8	69	8.6	3,752	32,267
Total	69	574	75.2	30,200	241,678
Mean	8	63.8	8.4		

3) *Margin of Deficiency in Rainwater Supply in Igah Communities:* Results obtained in Table 3 showed that only about 241,678 litres of rainwater were consumed, whereas about 295,615 litres of water were demanded with a margin of deficiency of 53,937 litres. Although there is no much difference between quantity supplied and quantity demanded. This could be attributed to the nature of the study which emphasized more on rainwater harvested as there are other sources of water which can to some extent supplement insufficient rainwater in the area. Besides, from oral interview conducted in the study area, it was obvious that communities in Igah suffer from a certain measure of water inadequacy. And thus need more water supplies to avoid health issues of WASH related diseases and other negative socio-economic effects of water inadequacy. Fig 1 and Fig 2 present the map of the study area indicating the level of water demanded and level of rainwater consumed respectively. While Fig 3 presents the degree of water deficit in the area.

Table 3: Margin of deficiency in rainwater supply in Igah communities

Communities	Quantity supplied (Litres)	Quantity demanded (Litres)	Deficiency (Litres)
Agala	29,095	37,356	8,261
Eboyi	25,343	33,363	8,020
Ogane	23,283	32,870	9,587
Ojuwo	23,568	27,090	3,522
Ikeje	36,144	39,758	3,614
Ogene	23,502	30,172	6,670
Igoh	23,251	27,369	4,118
Adumu	25,225	30,492	5,267
Ugbamaka	32,267	37,145	4,878
Total	241,678	295,615	53,937

Source: field work 2021

4) *Determination of factors Responsible for the Existing Quantity of Rainwater used in the Study Area:* From the questionnaire responses a total of 9 variables were isolated. The responses were sorted and tabulated. The identified factors were labeled and coded while the data were subjected to PCA to determine the dominant factors affecting the quantity of available rainwater harvested in the study area. Table 4 shows the field data of the 9 perceived harvested rainwater quantity determinants in the study area which were properly coded to ensure easy handling of data for PCA analysis as presented in Table 5 which reveals a fairly weak association between variables which indicates the presence of serial autocorrelation as most of the perceived determinants provided showed weak correlation with each order. For example, Y_2 is weakly correlated with Y_3, Y_4 and Y_6.

Furthermore, Y_4 is very weakly correlated with Y_5 and Y_7. With this sort of outcome that characterizes the data, Principal Component Analysis (PCA) was employed to properly explain the data. The PCA analysis was able to collapse the 9 variables into significant and orthogonal components that explained the variables in the observed data. When PCA was transformed, the primacy of four components manifested (Table 6). From Table 6, it is clear that the four components explained 86.787% of the variance while all the four components had eigen values greater than 1.00. The percentage of explanation to the variations observed in the dataset as regards perception of respondents on factors determining quantity of harvested rainwater in the study area is provided by the components. For example, component 1 with eigen value of 2.247 explains 24.966% of the variations in quality of harvested rainwater in the study area, followed by component II which explains 22.581 % of the variance.

Table 4: Coding and Labeling of the Factors Responsible for the Existing Quantity of Rainwater in the Study Area

VARIABLE CODE	NAME OF VARIABLE	LABEL CODE
Y1	Seasonality of rainfall	SR
Y2	Size of storage infrastructures/cisterns	SSI
Y3	Long distance to stream	LDS
Y4	Cost of constructing storage infrastructures/cisterns	CCSI
Y5	Household size	HS
Y6	Limited financial capacity	LFC
Y7	Absence of water storage infrastructures	AWSI
Y8	Geographical Location	GL
Y9	Variations in quantity of rainwater supplied	QS

Table 5: Correlation Matrix of Perceived Factors Responsible for the Existing Quantity of Rainwater in the Study Area

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9
Y1	1.000								
Y2	.180	1.000							
Y3	.679	.567	1.000						
Y4	.107	.547	.096	1.000					
Y5	.377	.364	.390	.538	1.000				
Y6	-.024	.569	.285	.356	-.122	1.000			
Y7	-.310	.211	-.207	.535	.171	.323	1.000		
Y8	.082	-.286	-.533	.221	-.208	.028	.263	1.000	.065
Y9	.570	-.007	.300	-.328	.203	.095	-.482	.065	1.000

Table 6: Varimax Rotated Component Matrix of the Variables for Rainwater Quantity

	I	II	III	IV	h^2
Y1	*.873	.309	.023	-.032	.859
Y2	.058	.436	.706	-.377	.834
Y3	.544	.254	.351	-.637	.890
Y4	-.182	*.825	.378	.188	.891
Y5	.257	*.862	-.140	-.233	.883
Y6	.010	-.038	*.966	.055	.938
Y7	-.555	.477	.333	.328	.754
Y8	.082	.049	.014	*.974	.958
Y9	*.878	-.166	.030	.061	.803
Eigen value	2.247	2.032	1.830	1.701	
% of var. explained	24.966	22.581	20.339	18.902	
Cumulative % explained	24.966	47.547	67.886	86.787	

Source: Field Survey, 2021

In the Principal Component Analysis, it was clearly established that two of the perceived determinants affecting quantity of rainwater harvested loaded highly on component 1. This implies that seasonality of rainfall affects the available quantity of harvested rainwater in the study area. In components 2, 3 and 4, one variable each loaded highly as follows; *cost of constructing storage facilities and Household size*, limited financial capacity and geographical location respectively. Consequently, it is clear based on the foregoing that the quantity of available harvested rainwater in the study area is greatly determined by:

1) Seasonality of rainfall
2) Cost of constructing storage facilities and Household size
3) Limited financial capacity
4) Geographical location

Seasonality of rainfall was identified as one of the important factors responsible for rainwater quantity used. During the rainy season, there is abundant rainfall while in the dry season, the revise is the case. Stored rainwater is not usually enough to sustain households throughout dry season. Woltersdolf, Licher and Doll (2015) noted that the quantity of rainwater harvested depends on monthly precipitation, roof catchment area and roof run off coefficient.

Moreover, the increasing size of family members was identified by the communities as one of the factors responsible for quantity of rainwater used. 84.2% of the respondents confirmed that household size largely influence the quantity of rainwater used. One may not be too amazed at this finding considering the fact that population is growing rapidly. Consequently, there is pressure on the available stored rainwater and the resultant effect is water scarcity. Glass (2010) noted that the combination of high population growth and exhaustion of water has contributed to a severe water crisis in Yemen.

Besides, the cost of constructing rainwater storage facilities was also identified by the communities as one the important factors responsible for the quantity of rainwater used. 56.74% of the respondents attested to this. The construction processes ranges from excavation of the soil, purchasing of materials and other accessories and finally labour. From personal interview carried out within the study area, it was observed that due to exorbitant nature of goods in the market, many households were compelled to borrow money with high interest rate just to construct cisterns in their homes.

In addition, limited financial capacity was identified in the study area as one the contributing factors affecting rainwater quantity. This is confirmed by 72.6% of the respondents. The majority of the people in the study area are poor and economically not empowered. They are mostly farmers with low level income to construct rainwater cisterns which are capital intensive. According to FAO (2012), finance instability causes a major setback to water development in developing countries.

Furthermore, the study area is located in an area where climatic condition did not favour rainfall for all the months of the year. In the rainy season (April - September), there was abundant rainfall and rainwater is harvested for domestic and other purposes. However, during dry season (October - March), the opposite is the case. 76.7% of the respondents affirmed this. The situation is typical of the tropical wet and dry climate of the humid tropics (Whol et al., 2012).

V. CONCLUSION AND RECOMMENDATIONS

Sufficient water, sanitation and hygiene are crucial for human well being. The study however, found that the quantity of rainwater consumed per person per day which is 8.2 litres is far below the recommended standard of 20 litres as put forward by World health organization. The study further revealed that factors such as seasonality of rainfall, cost of constructing storage facilities and household size, limited financial capacity and geographical location are responsible for the existing quantity of rainwater consumed. The researchers therefore, recommend that to alleviate water scarcity situations, the communities are encouraged to have a sizeable rainwater storage facilities to store water for use especially during the dry season. It is also recommended that government should provide and locate water supply projects in each of the communities. The communities should also be sensitized on the need for adequate water supply as well as the concomitant effects of inadequate water supply and health consequences of using unsafe and untreated water for domestic activities.

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