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Bridging the Gap between Rural Water Supply and Demand using Harvestable Rainwater: A Case Study of Adansi-Fumso

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Abstract

Rainwater harvesting has several benefits including providing a valuable alternative source of water for households, reduction in flood flow to storm drains and settlement erosion as well as health benefits. The research aimed at assessing and confirming the available renewal water sources, determining the cost of developing a rainwater harvesting system and assessing the potential of rainwater as a supplement to water supply at Fumso. Using a systematic random sampling technique and a sample size of 100 respondents, it was discovered that rainwater harvesting in Adansi Fumso has the potential to conserve on-site potable water use, protect water quality and reduce the risk of flooding within the community. Rainwater was preferred by the community due to its easy accessibility, nature (clean, pure, healthier and tastier), cost and quality. An examination of the rainfall records at AngloGold Ashanti weather station at Obuasi revealed an average annual rainfall of 1449.2 mm with the drier months (November, December, January and February) receiving only a quarter of the average monthly rainfall. The relatively high rainfall means that rainwater harvesting system designs need to be taken as a priority in addressing the water shortage situation in the community. Geometrically uniform building shapes and the local hydrology can provide sufficient rainwater to serve buildings in the community. The cost of the proposed rainwater harvesting system is GH ¢ 389.00 ($256.00). Reasons have been given for the need for this project and recommendations made for its implementation at Adansi Fumso as the best alternative source of water to the fewer boreholes in the community.

Introduction

Water scarcity is recognised as one of the root causes of poverty (Martinson and Thomas, 2003). Water is indeed recognised as the key factor in changing the fundamental conditions for the existence and development of poorer areas. The supply of water which is easily available, potable and affordable is also prerequisite for good hygiene and sanitation and hence central to the general welfare of a household. In Ghana, the challenges posed by dry wells, as well as excessive levels of contaminants especially minerals in the groundwater resources of some geological formations make harnessing of rainwater for household use unavoidable according to Siabi *et. al* (2005). Whilst researchers are looking for efficient ways of dealing with contaminants associated with these water sources, focus is gradually shifting to the development of enhanced methods for rainwater harvesting as a complement to conventional sources. Thus, small communities are increasingly accepting rainwater harvesting as a technology choice capable of meeting their water demands. If rainwater resources are managed well, emerging phenomena like flooding and erosion in communities could be contained. The resource if properly harnessed has benefits, which would contribute to meeting the millennium development goals (MDG) on water and environmental sanitation by the year 2015 in Ghana (Siabi *et. al,* 2005).

Rainwater harvesting is simply gathering or accumulating and storing rainwater. Rainwater harvesting in Ghana has gone through several stages of development ranging from the use of very basic techniques (including bamboo and raffia fronds with collectors normally household equipment of different capacities) to modern techniques using aluminium gutters, P.V.C pipes with galvanized steel, ferrocement, metal as well as plastic tanks as rainwater cisterns/reservoirs. Several works have been done and documented globally especially in developing countries, however, little work has been done concerning the implementation of a formal domestic rainwater harvesting system as well as policies regarding domestic rainwater harvesting at Adansi Fumso in Ghana in particular. Averagely, Ghana receives adequate rainfall even though the resource is unevenly distributed geographically and seasonally. Adansi Fumso enjoys substantial amount of rains (about 1,449 mm) throughout the year with 7-8 wet months but has a rainwater harvesting efficiency less than 1%. This indicates that very little quantities of water are harvested during the rainy season and the various households are not able to store enough water for daily and future usage due to the absence and cost of larger storage facilities.

This paper has its prime aim as increasing the rainwater harvesting awareness in the community by encouraging the use of feasible rain gutters and larger storage facilities to store enough harvested water. This aim could be achieved by: examining the efficacy of rooftop water harvesting for meeting the water deficit at Fumso, determining the average per capita consumption of water in the community, determining the average rain roof catchment area for rainwater harvesting and designing a rain gutter for optimal rainwater harvesting and determining their cost implications.

Materials and methods

The research was based on an integrated and an interdisciplinary approach consisting of two main interactive phases. Primary data were collected through an interview schedule, using a formal questionnaire as the main research instrument. The interviews sampled a total of 100 respondents in the community using a systematic random sampling technique. The collected data were analysed by the computer based Statistical Programme for Social Scientists (SPSS) version 11. Secondary data (sources) consisting of literature studies of published materials and data from decentralised offices, corporate agencies, non-governmental organisations and scientific journals in the area of interest were consulted for the study. Field surveys were also carried out which helped in determining the optimal size of a gutter required for harvesting rain and determining the average rain roof catchment area for rainwater harvesting through measuring dimensions of sampled houses in the study area. The research was carried out at Fumso in the Adansi-North District of Ashanti.

Fumso is located at latitude 5° 52' 0N and longitude 1° 10' 0W. It has an altitude of 123m above sea level. The total population of the community is about 4,194 (Statistical Services Department, Adansi-North District, 2009). Rainfall data for the study was collected from the near by weather station at AngloGold Ashanti Mines at Obuasi. The average annual rainfall for the study area is 1,449.6 mm; however, the length of the dry season was estimated as 140 days. Flow measurements by the float technique were taken on River Fum so as to determine its flow and also runoff from the area. The first measurement was taken in October 2009 (peak of the rainy season) whilst the second measurement was done in February 2010 (the peak of the dry season).

Results and Discussion

Results of Survey

Household size and Daily water consumption

The number of people in a house was from 3-20. From Table 1, majority of the respondents (55.0%) indicated that the number of people in their households were between 5 and 10, 16.0% mentioned below 5 people (1-4 people), 13.0% indicated 16-20 people whereas the remaining 16.0% mentioned 11-15. Thus, the average number of people in a house was estimated at about 9. Moreover, the average volume of water to be used by an individual was also estimated as one bucket of about 18 litres. Table 1 shows the number of people in a house as well as the assumed daily quantities of water used.

Table 1: Number of people in a Household and their daily water consumption

Number of people in a house	Frequency	Percentage (%)	Daily quantity of water used *(l)*
Below 5 people	16	16.0	> 90
5-10 people	55	55.0	90-180
11-15 people	16	16.0	198-270
16-20 people	13	13.0	288-360
Total	**100**	**100**	

Source: Field survey October 2009

Seasonal water sources and usage in the community

Field observations revealed that there are about 50 open shallow wells, three boreholes (of which, only one is connected to a pump which pumps into a central reservoir which is then distributed to eight standing pipes fairly distributed throughout the community) and a stream for both domestic and commercial purposes. Table 2 shows the available water sources in the community. It was discovered that majority of the respondents (81%) had access to water from boreholes, wells, stream and harvested rain. Only 9% had access to water from boreholes, stream and rainwater whilst 5% each had access to water from boreholes or only open wells. It must therefore be emphasised that rainwater is vital to the community and therefore an appropriate way of harvesting and maintaining it in a cost effective manner is essential to benefit the community.

Table 2: Sources and Access of Water in the Community

Sources of water	Frequency	Percentage (%)
Borehole/well/rainwater/stream	81	81.0
Borehole/rainwater/stream	9	9.0
Only borehole	5	5
Only open well	5	5
Total	**100**	**100**

Source: Field survey October 2009

Table 3 shows the distribution of people in terms of the sources of water preferred during the rainy and dry seasons at Fumso. 65% of the respondents mentioned harvested rainwater whilst 70% indicated that boreholes were the most reliable sources of water for the community and the remaining 30% mentioned open wells as the next alternative. However, most of the open wells are not perennial and are mostly unreliable during the peak of the dry season because of their shallow nature (rarely exceeding depths of 4m). Moreover, the average pumping capacity of 13,900 l/day is not enough to serve the whole community of 4,194 people with an average per capita consumption rate of about 18 l/d resulting in a water deficit of about 70,000 l/day. This threatens their source of water supply during the dry season. This could be met by proper and efficient harvesting of rainwater in the community to better their livelihood.

Table 3: Sources of Water preferred during the seasons at Fumso

Sources of water	Rainy Season		Dry Season	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Harvested rainwater	65	65.0	-	**0.0**
Borehole	24	24.0	70	70.0
Open well	9	9.0	30	30.0
River/stream	2	2.0	-	0.0
Total	**100**	**100**	**100**	**100**

Source: Field survey October 2009

Hydrometry (Seasonal stream flow)

The results of the flow measurement in the stream are shown in Table 4.

Table 4: Results of flow measurement in River Fum

Measurements	Distance travelled (m)	Time (s)	
		October 2009	February 2010
1	30	102	300
2	30	101	301
3	30	102	302
Total		**305**	**903**

Source: Field survey; October 2009 and February 2010

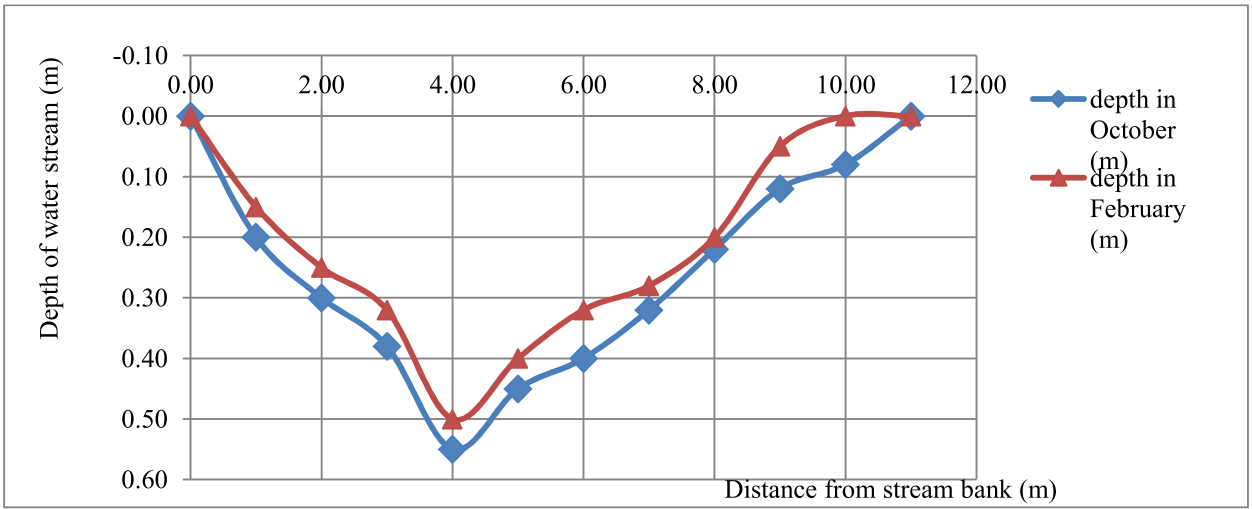


Figure 1: Profile of River Fum at measurement section

Source: Field survey October 2009 and February 2010

The discharges in the stream during October 2009 and February 2010 were estimated to be 0.74 $m^3s^{-1}$and 0.19 m^3s^{-1} respectively. Knowledge of the discharge in the river is relevant since it shows water levels and availability during some periods of the year as well as rainwater that could have been harvested which goes to waste.

Water consumption by individuals and households

Figure 2 shows the quantities or volumes of water used in a day by individuals, 41% of the respondents indicated that they used more than 10 buckets (more than 180 litres) in a day. Also, 40% mentioned that their daily water consumption were between 7 and 10 buckets (126-180 litres), 16% mentioned between 4 and 6 buckets (72-108 litres) whereas the remaining 3% indicated that they used between 1 and 3 buckets (18-54 litres). It is worth noting that, most of the respondents who used more than 180 litres of water in a day were either food vendors or had larger household sizes.

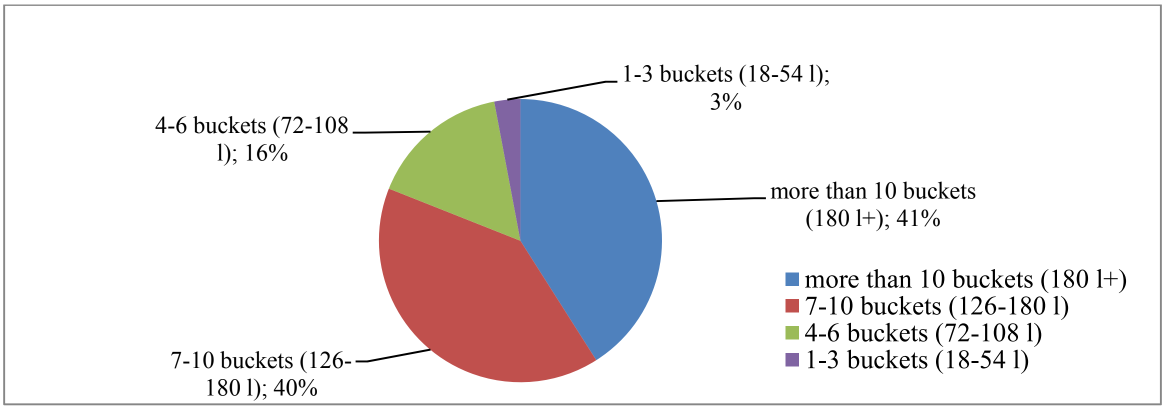


Figure 2: Quantities of daily water used
Source: Field survey October 2009

It was also discovered that majority of children (58%) used 1-3 buckets (18-54 litres) whilst only 5% of the children used 7-10 buckets (126-180 litres). The trend, however, was different for the adults. It was realised that majority (37%) of the adults used as much as 4-6 buckets (72-108 litres) of water per day whiles only 18% used more than 10 buckets per day (more than 180 litres). Also, 21% of the adults used 1-3 buckets (18-54 litres) whilst the remaining 18% used more than 10 buckets (more than 180 litres). It can be deduced that most children in the community used less water (18-54 litres) as compared to the adults. This is shown in Table 5.

Table 5: Quantities of water used in a day by the various groups of people

Quantity of water used per day (litres)	Children		Adults	
	Frequency	Percentage	Frequency	Percentage
1-3 buckets (18-54 litres)	58	58.0	21	21.0
4-6 buckets (72-108 litres)	22	22.0	37	37.0
7-10 buckets (126-180 litres)	5	5.0	24	24.0
More than 10 buckets (more than 180 litres)	15	15.0	18	18.0
Total	**100**	**100**	**100**	**100**

Source: Field survey October 2009

This data suggests that an average of 9 buckets (162 litres) of water is used by a household indicating an average of 1 bucket (18 litres) for an individual. Therefore, the minimum quantity of water to be used in designing the rainwater harvesting system will contain a minimum of 9 buckets a day per household.

The studies also showed that the main containers commonly used in fetching water were buckets (18 litres capacity). This was due to its light weight, accessibility and availability in the community. This information is vital and therefore needed in the design of a model for collecting water, transporting and saving clean rainwater for the community. With regards to the number of buckets fetched per day, it was noted that majority of the respondents (30%) indicated that they fetched more than 12 buckets (> 216 litres) in a day. 26% each mentioned between 4-6 buckets (72-108 litres) and 10-12 buckets (180-216 litres), 13% fetched 7-9 buckets (126-162 litres) whilst 5% fetched only 1-3 buckets (18-54 litres). This data suggests that there are differences among the households in the community when it comes to fetching water. However, it must be noted that the quantity fetched in a day is not necessarily the quantity used in a day. However, when this information is compared to the usage of water, it was discovered that, the demand for water in the community (84,000 litres/day) really exceeds its supply (13,900.00 litres/day) in terms of the quantity fetched daily. This emphasizes the need to depend on available means of fetching and sustaining rainwater for the community apart from the normal borehole source of water.

Furthermore, 80% of the respondents indicated that, they experienced water shortages whilst the remaining 20% had never encountered water shortages. This also confirms that water shortage is a major challenge in the community. The data collected revealed that majority of the respondents harvest water during rainstorms. However, 73% indicated that they harvested water regularly or anytime it rained. It must be emphasized that majority of the respondents who harvested rainwater regularly are far (about 400-1000m) from the available water sources in the community and needed to supplement their high daily water requirement as a result of large household sizes. The remaining 27% do harvest rainwater seldomly. The reason being that they have sunk open wells in their homes and others were very close to the water sources in the community. It must be emphasized that the longevity and quality of harvested rainwater for the community in an economical and cost effective way is vital. This also brings to mind the significance of determining appropriate measures to harvest rainwater in the most hygienic and economical way to benefit the community. Reasons given by respondents why people harvested water during rain storms were accessibility, quality (clean, pure and tastier), free and cheaper source of water, among others. In summary, rainwater is preferred by the community due to its easier accessibility, quality (clean, pure, healthier and tastier), cost and quality as discussed in the work of Krishna (2003 and 2005) and Lundgren and Åkerberg (2006). This attests to the fact that a means of harvesting and maintaining this source of water would benefit the community tremendously.

Average Roof Catchment area

Knowledge of the roof catchment area is very useful in estimating the discharge and water consumption rate during the design and modelling process. The total estimated roof catchment areas of the sampled houses were estimated at 30,043.80 m^2 with the average roof catchment area being 300.45m^2. Table 6 shows the distribution of the catchment sizes in the community.

Table 6: Catchment size distribution in the community

Catchment area (m^2)	Frequency	Percentage (%)
Below 100	1	1.0
100-200	28	28.0
201-300	31	31.0
301-400	13	13.0
401-500	11	11.0
Above 500	16	16.0
Total	***100***	***100.0***

Source: Field survey October 2009

Installation and cost of installing rainwater harvesting systems

32% of the respondents had installed a simple domestic water harvesting system (consisting of strip of aluminium roofing sheets, half pipes, plastic drum, polytank, and so on) for harvesting water whereas the remaining 68% had not installed any rainwater harvesting system but rather used direct roof catchment without gutters. However, typical rain gutters found in the community consisted of a strip of aluminium roofing sheet (as shown in Figure 3) as in the case of many rural communities in Ghana which is not based on any hydrological considerations. It could be deduced that majority of the practitioners of rain water harvesting do not have rain gutters to facilitate collection of sufficient rainwater during the rainy season, therefore a more effective means of collecting and storing rainwater is needed. Also, majority of the respondents (68%) had no rain gutters. The studies also revealed that, despite the usage and benefits of rainwater, the cost of financing this water source was perceived to be very high by the community members. Information on the approximate cost of installing a rainwater harvesting system revealed that out of the 32% who had installed rain gutters, 25% of the respondents spent below GH ¢50.00, 6% spent between GH ¢50.00 - 150.00 (consisting of strips of aluminium roofing sheets as gutters, plastic drum) whilst only 1% spent above GH ¢200.00 (consisting of complete fabricated aluminium gutters, screens, faucet and a polytank). However, the cost of the proposed fully installed rainwater harvesting system is estimated at GH ¢ 389.00.

Figure 3: A Typical Rain Gutter at Fumso
Source: Field survey October 2009

Uses of rainwater for household chores

Majority (98%) of the respondents mentioned that rainwater was used for all household chores (washing, cooking, cleaning) including drinking whilst only one percent (1%) used harvested water for drinking and washing.

Type and capacity of storage facilities

Regarding the type and capacities of storage facilities used in the community (Figure 4), 72% of the respondents indicated that they used barrels (180 litres) and other household equipment of varying capacities (10-30 litres) to harvest rainwater, 23% used buckets (18 litres), 4% mentioned plastic containers of various sizes (10-70 litres) and the remaining 1% used a 2,000 litre polytank. It must therefore be noted that the capacities of the storage facilities in the community are not large enough to store the required volumes of water and almost all the respondents indicated that their storage facilities got full during the storms and the extra water went waste. Also, 84% indicated that the harvested rainwater can serve the households for 1 to 2 days. 15% said that the harvested rainwater could serve the household for 3 to 4 days and 1% mentioned that the water could serve them up to 7 days. This suggested that the harvested water remains for an average of 2 days after which shortages are likely to occur in situations where the rains are not consistent.

a. Cast metal pot (about 30 litres)

b. Plastic drum (about 180 litres)

Figure 4: Examples of storage facilities at Fumso

Source: Field survey October 2009

Storage volume required

Based on the calculations made, a storage tank with a capacity of about 20,000 litres would be needed by the average household with a size of 9 people to harvest enough water to cater for the dry periods of the year. Table 7shows the recommended approximate storage capacities for the various household sizes in the community.

Table 7: Storage capacities of various household sizes in the community

Household size	Approximate storage capacity required (*l*)
5 people	10,000
5-10 people	10,000-21,000
11-15 people	24,000-32,000
16-20 people	34,000-43,000

Source: Field survey October 2009

Views on qualities of stored Harvested Rainwater

The respondents gave different views about the quality and danger of harvested water stored after about 4 days or more as the water becomes slippery to touch, dirty and tasteless. These reasons contribute to the fact that harvested rainwater does not last for long as a source of potable water if not treated and maintained well. It can be deduced from the above that harvested water is not treated and handled well in the community and hence must be treated. Application of chlorine can help improve on the quality of stored harvested water. Observations from the field also indicated that education and provision of filters to community members will go a long way to improve rainwater harvesting system in the community. Another is covering the stored water to prevent breeding of mosquitoes and entry of dirt and not allowing light into the stored water to encourage algal growth. These issues when well addressed will help more people to easily accept and implement the technology. It must, however, be noted that no matter the model to be designed, an effective monitoring system must be included and frequent education is needed. This will help the community to enjoy good drinking harvested rainwater and also help curb any water crisis during the dry season.

Determining the size of a gutter required for harvesting rain

Ideally, guttering should be cheap to produce, efficient in capturing run-off water, easy to align and install, resistant to damage and must be easier to be cleaned if not completely self-cleaning. Gutters define the upper limit of rainfall intensity that can be conveyed to the storage as they are limited by friction and the water level will rise with flow-rate until the gutter overtops. This overtopping height is critical. If it is made too low by employing a very small gutter volume, significant losses may occur, yet if the gutter is made very large in an attempt to catch and convey every drop of water, the cost may become very high and untenable (Martinson, 2007). Therefore, the optimum size of a gutter required for harvesting rain must be determined.

Assumptions made

The following assumptions were made:

1. The slope of the gutter is constant
2. The slope for houses in the community lies in the range of 0.26 (15°) and 0.5 (30°) but 0.33 (19°) was used for the calculations based on the dimensions of the average house at Fumso
3. The average intensity of rain in the study area is 127.7 mm/h
4. The effects of wind were neglected at high rainfall intensities and
5. For rain gutters made from any material, the Manning's roughness co-efficient is in the range of 0.01 and 0.15.
6. Flow in the gutter is constant and at steady state and
7. The gutter is long enough so that the flow in it approaches the Manning solution.

Calculations

Water Conveyance

It was assumed that all water falling on the roof enters the gutter so the cost of water per litre captured could be minimised. Ideally, tropical gutters should be sized to match a rainfall intensity of about 2 mm/min of rainfall (Still and Thomas, 2002).

Then, from the Rational formula, Q = CIA,

Where,

C is the catchment coefficient = 0.9

A is the surface area of catchment (m^2)

I is the average rainfall intensity (mm/h)

Considering I= 127.7 mm/h (from rainfall data) and A = 560 m^2 (maximum area in plan from survey)

$$\Rightarrow Q = 0.9 \times \frac{127 \times 10^{-3}}{3600} ms^{-1} \times 560\ m^2$$

$Q = 1.78\times10^{-2}\ m^3s^{-1}$

Assuming this volume of water is conveyed by the root into the gutter, and

$\mathbf{Q=}\boldsymbol{AV}$

$$\rightarrow \mathbf{Q} = \boldsymbol{A}\frac{\mathbf{1}}{\boldsymbol{n}}\boldsymbol{R}^{2/3}\boldsymbol{S}^{1/2} \quad \text{.............................} (1)$$

Where: Q is the flow in the gutter (m^3/s),

A is the cross-sectional area (m^2),

v is the velocity of flow in gutter (m/s),

n is the Manning roughness coefficient (usually between 0.01 and 0.15 for gutters according to Martinson (2007),

R is the Hydraulic radius (m), thus R= A /P,

P is wetted perimeter (m),

S is the Slope of the gutter.

Then

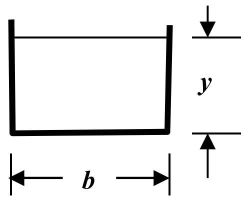
$$\mathbf{Q} = \boldsymbol{A}\frac{\mathbf{1}}{\boldsymbol{n}}\left(\frac{\boldsymbol{A}}{\boldsymbol{P}}\right)^{2/3}\boldsymbol{S}^{1/2} \quad \text{..............................} (2)$$

$$\rightarrow Q = \frac{1}{n}\frac{A^{5/3}}{P^{2/3}}\ \boldsymbol{S}^{1/2}$$

$$Qn = \frac{A^{5/3}}{P^{2/3}}\boldsymbol{S}^{1/2}$$

$$\frac{Qn}{\sqrt{S}} = \frac{A^{5/3}}{P^{2/3}} \quad \text{..............................} (3)$$

For a square gutter with depth, y and width, b



Then A = by and P = b+ 2y

$\rightarrow$ b = $\frac{A}{y}$

Then P = $\frac{A}{y}$ + 2y .... (4)

Maximizing discharge in gutter implies minimising perimeter of gutter

$\rightarrow \frac{dp}{dy} = 0$

From P= $\frac{A}{y}$ + 2y .... (4)

$\rightarrow \frac{dp}{dy} = -Ay^{-2} + 2 = 0$

$Ay^{-2} = 2$

$\rightarrow A= 2y^2$

Also, P = 4y

From $\frac{Qn}{\sqrt{S}} = \frac{A^{5/3}}{P^{2/3}}$ .... (3)

$\rightarrow \frac{Qn}{\sqrt{S}} = \frac{(2y^2)^{5/3}}{(4y)^{2/3}}$

$\rightarrow \frac{Qn}{\sqrt{S}} = 2^{\left(\frac{5}{3}\right)-\left(\frac{4}{3}\right)} \times y^{\left(\frac{10}{3}\right)-\left(\frac{2}{3}\right)}$

$(\frac{Qn}{\sqrt{S}}) = 2^{\frac{1}{3}} \times y^{\frac{8}{3}}$

$\rightarrow y^{8/3} = (\frac{Qn}{2^{1/3} \times S^{1/2}})$

$\therefore y = (\frac{Qn}{2^{1/3} \times S^{1/2}})^{3/8}$

For n= 0.01; Q = 1.78×10^{-2} m^3s^{-1} and S = 0.33

$\rightarrow y = (\frac{1.78\times10^{-2} \times 0.01}{2^{1/3} \times 0.33^{1/2}})^{3/8}$

$y = (\frac{1.68\times10^{-4}}{2^{1/3} \times 0.33^{1/2}})^{3/8}$

$y = (\frac{1.78\times10^{-4}}{0.7238})^{3/8}$

$\therefore$ y= 0.04431 m (44.31 mm)

For a square gutter, the depth (y) equals the width (b)

Hence, b = 44.31 mm

$\rightarrow$ A = *by* = 44.31mm × 44.31mm

$\therefore$ A = 1963.376 mm^2 (0.00196 m^2)

For n= 0.15, Q = 1.78×10^{-2} m^3s^{-1} and S = 0.33

$\rightarrow y = (\frac{1.78\times10^{-2} \times 0.15}{2^{1/3} \times 0.33^{1/2}})^{3/8}$

$y = (\frac{2.67 \times10^{-3}}{2^{1/3} \times 0.33^{1/2}})^{3/8}$

$y = (\frac{2.67 \times10^{-3}}{0.7238})^{3/8}$

$\therefore$ y = 0.122344 m (122.34 mm)

Since for a square gutter, the depth (y) equals the width (b)

b = 122.34 mm

$\rightarrow$ A = *by* = 122.34 mm × 122.3 mm

$\therefore$ A = 14967.075 mm^2 (1.5×10^{-2} m^2)

Deductions

The following deductions can be made from the results of the calculations:

1. The depth of a rain gutter required for conveying rainwater at an intensity of 127.7 mm/h and a slope of

19° is within the range 44.31 mm and 122.34 mm.

2. The depth of gutter increases with increase in the roughness co-efficient and

Implementation of the project

This piece of research can be implemented directly by individuals who can afford the designed system, communities with financial support from financial institutions and credit unions and the government, philanthropist and non-governmental organisations with community members providing free labour. The project must be implemented such that the average community member can understand and appreciate its impact.

Maintenance and Repairs

Tanks must be well covered to avoid the entry of mosquitoes and other animals. This comprises screening all vents (openings). Additionally, tanks should be well cleaned at the beginning of every rainy season.

Proposed rainwater harvesting system for the community

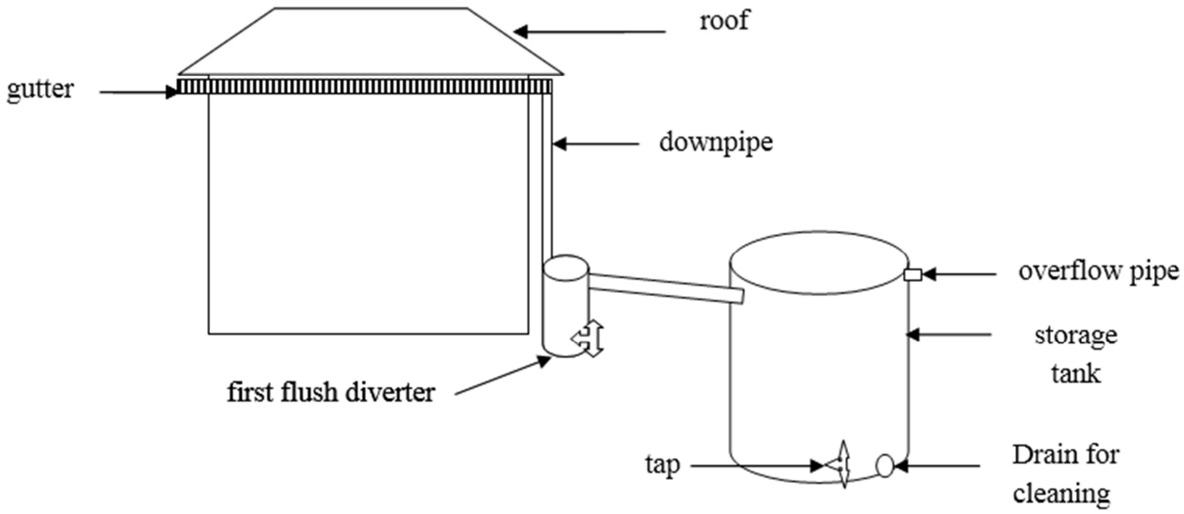


Figure 5: Sketch of the proposed rainwater harvesting system

The materials needed for the design include:

i. screens (mosquito-proof net)
ii. faucet and other guttering and piping materials
iii. PVC pipes (10 cm diameter)
iv. polytank and
v. aluminium roofing sheet

However, for a rural setting, a simple corrugated aluminium roofing sheet could be used as the gutter to replace the pre-fabricated aluminium gutters for affordability and accessibility. Also, PVC pipes could be used as downpipes and would be fastened at every 60-70 cm of its length by wires or nailing.

A model to improve rural water supply using rainwater as a supplement

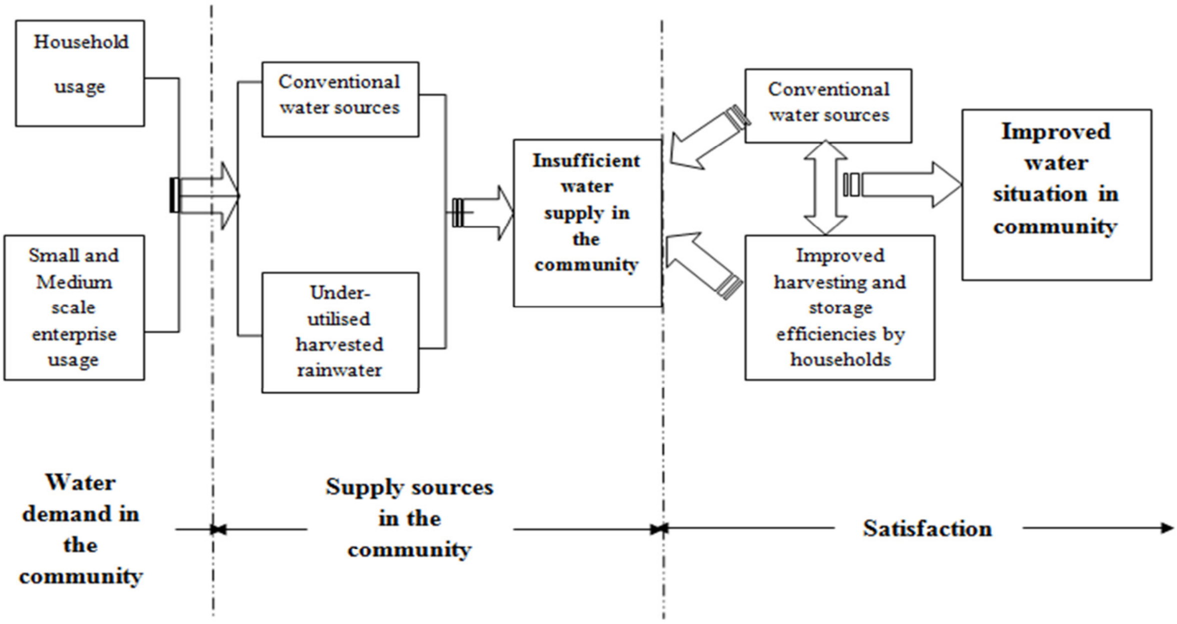


Figure 6: Model to improve rural water supply using rainwater as a supplement

Conclusions and Recommendations

The study revealed that the number of people in a house at Fumso could be as low as 3 whilst the largest number of people in a house was also identified as 20 with the average number of people in a house being 9. The sources of water used in the community were boreholes, a stream, harvested rainwater and open wells. However, harvested rainwater is preferred by 65% of the respondents during the rainy (wet) season whereas borehole is the most preferred source of water in the dry season since the stream and open wells in the community dry up. The average volume of water used by an average household size of 9 is 9 buckets (162 litres) per day. Adults in the community used an average of 6 buckets (108 litres) whereas children used an average of 4 buckets (72 litres) in a day. Furthermore, during the peak of the dry season (November to February) about 80% of the people experienced water shortages. All the respondents harvest rainwater during storms with various reasons including its easy accessibility, nature (clean, pure, healthier and tastier), cost and quality. About 68% of the respondents practise roof catchment without gutters i.e. members of the house just place containers of various capacities under the roof to harvest rainwater whenever it rained. Also, out of the 32% who have installed rain gutters, only 1% had installed a complete rain gutter around the whole house for harvesting rainwater anytime it rained with the remaining 31% installing a strip of small roofing sheet as rain gutter to harvest water. As a result of this situation coupled with low capacities of storage facilities, the people only harvest few litres of water during storms leaving the rest to go waste. 98% of the respondents used the harvested rain water for all household chores including cooking, bathing and washing.

The cost of installing a rainwater harvesting system was also identified as a major challenge. The cost of installing a strip of small roofing sheet as rain gutter for harvesting water was found to be GH ¢50.00. This was, however, borne by the individual landlords with no subsidies or assistance whatsoever. Nevertheless, 29% of respondents (landlords) maintained their own rain gutters with the remaining 3% hiring labour for that task.

Storage facilities identified in the community included polytank (2,000 litres), barrels (180 litres), plastic containers and other household equipment of various capacities. Almost every house used one or more of the above listed storage facilities or any available facility to store rainwater. It must, however, be noted that the capacities of the storage facilities in the community are nothing to write home about. On the average, 241.58 litres of water are harvested during storms and about 40,000 litres of water goes as runoff unharnessed from the estimated catchment areas in the community. Notwithstanding this fact, the harvested water could only serve the households for a maximum of five days depending on the per capita consumption. This also suggests that the harvested water remains for an average of 2 days after which shortages are likely to occur in situations where the rains are not consistent.

The main purification method employed by people in the community was the use of either a mosquito proof net or a clean cloth. About 78% of the respondents do not employ any form of purification method when using the harvested rainwater. They, however, indicated that once the first rain sets in and the roof is cleaned, there is no need to purify the harvested water since naturally rainwater is a clean and pure source of water. In order to improve domestic rainwater harvesting at Fumso, there must be provision of filters and other accessories and also intensifying education on domestic rainwater harvesting since there was little or no form of education concerning this topic in the community. Domestic rainwater harvesting system was recommended by almost all the respondents giving diverse reasons as: solving the water shortage situation in the community; easy access to source of water; clean, pure and tastier source of water; free and cheaper source of water; lathers easily when used for laundry purposes and lastly, prevention of settlement erosion and waste. In summary, rainwater is preferred by the community due to its easy accessibility, nature (clean, pure, healthier and tastier), cost and quality. This attests to the fact that a means of harvesting and maintaining this source of water would benefit the community tremendously.

The study also revealed that the average monthly rainfall for the study area and its environs is about 120.80 mm with the drier months being November, December, January and February. Notwithstanding the fact that there are more rainy days than drier days and the people also harvest rain during storms, the harvesting efficiency is very low (less than 1%) in the community. Furthermore, the discharges in the stream during October 2009 and February 2010 were estimated to be 0.74 $m^3s^{-1}$and 0.19 m^3s^{-1} respectively. This indicates that there is much more water in the river around October for use by the community whereas during the peak of the dry season few quantities of water of less quality can be obtained from the river since it dries becoming ditches and ponds. The average roof catchment areas of the various structures measured were also estimated to be 305.25 m^2 and gutter depth of ***44.31 mm*** may be required to harvest rainfall at intensities around 127.7 mm/h given a roof slope of about 19°.

The abundance of rainfall in the study area makes it very attractive to practice domestic rainwater harvesting in conjunction with the other water sources available in the community. Frequent monitoring, education and capacity building are also very essential for the community to enjoy good drinking harvested rainwater. Finally, it is recommended to stakeholders that

1. Feasibility studies on communal rainwater harvesting systems be carried out
2. Rainwater harvesting in peri-urban areas of Ghana must be considered
3. Research should be conducted into cheaper designs for first-flush diverters and storage tanks to contain cost.

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