Rainwater Harvesting Potential of North Western Part of Bangladesh

K. ROY[1], S. SHARMIN[2], M. Z. ISLAM[3]

[1]Lecturer, Department of Civil Engineering, RUET, Bangladesh (roykeya0944@gmail.com)
[2] Department of Civil Engineering, RUET, Bangladesh (shaylasharmin.100016@gmail.com)
[3] Department of Civil Engineering, RUET, Bangladesh (zinarul.ruet21@gmail.com)

Abstract

Rainwater harvesting (RWH) is the most traditional and sustainable method, which could be easily used for potable and non-potable, purposes both in residential and commercial buildings. The main emphasis is given on the rainwater harvesting as a source of drinking water. The objective of this research is to study potential of rainwater harvesting system of 6 stations in North-western part of Bangladesh. The rainfall data for 37 years of these stations has been analyzed and a field survey has been conducted to gather sufficient data for making design of a reservoir tank. In performing the study, frequency analysis is performed on annual rainfall data from 6 stations of Bangladesh Meteorological Department (BMD). Mass curve analysis is used to determine required storage volumes for every location. Based on statistical analysis of required storage volumes, design curves are developed for estimation of storage tank volumes covering the need for drinking water of different household sizes.

Keywords: *Rainwater harvesting, Mass curve, storage volume, cost.*

1 Introduction

Bangladesh is located between latitude 20^0 34′ to 26^0 38′ N and longitude 88^0 01′ to 92^0 41′ E and has tropical monsoon with high rainfall from April to September (125 cm to 500 cm). In the north and north-western region of Bangladesh due to heavy extraction of groundwater for irrigation, groundwater depletion continues during summer and was a main constraint for the development of a dependable water supply system. Groundwater depletion, water pollution and wetland degradation are causing serious pressure on water supply system in urban areas (Ahmed, Anwar, & Hossain, 2013). Heavy rainfall is characteristic of Bangladesh causing it to flood every year. With the exception of the relatively dry western region of Rajshahi, where the annual rainfall is about 1,600 mm (63.0 in), most parts of the country receive at least 2,300 mm (90.6 in) of rainfall per year. A rainwater based water supply system requires determination of the capacity of the storage tank and catchment area for rainwater collection in relation to the water requirement, rainwater intensity and distribution. The main objectives of this study are as follows:

- To develop a feasible rainwater harvesting techniques.
- Determination of the required storage volume for different places (Rajshahi, Bogra, Ishurdi, Dinajpur, Rangpur, Syedpur)
- Development of the general required storage volume-demand curve for six stations.
- Development of cost-storage volume relationship to examine suitability of the system.

2 Rainwater Harvesting

Water demand of Bangladesh with high population density cannot be met solely with municipal water supply system especially during the dry season. Among all the alternative sources for water supply, rainwater harvesting has become the most economical solution for the crisis area (Boers and Ben-Asher, 1982). People usually make complaints about the lack of water. During the monsoon lots of water goes waste into the gutters. And this is when rainwater harvesting proves to be the most effective way to conserve the water. We can collect the rain water into the tanks and prevent it from flowing into drains and being wasted. It is practiced on the large scale in the metropolitan cities. In scientific term, rainwater harvesting refers to collection and storage of rainwater and also other activities aimed at harvesting surface and ground water, prevention of losses through evaporation of the limited water endowment of physiographic unit as a watershed (Agarwal and Narain, 1999).

3 Rainwater Catchment Systems

Rainwater catchment systems can be classified according to the type of catchment surface being utilized e.g. roof, ground and rock catchments.

3.1 Roof Catchment System

This is the most common type of catchment used for harvesting rainwater. The system consists of three main components: a roof which acts as a catchment surface, a gutter and downpipe, and a tank.

3.2 Ground Catchment System

This is cheaper than roof catchment and is normally employed where suitable roof surface is available. The main advantage, the availability of large area for water collection. Ground surface is normally not efficient for collecting rainwater unless covered with cement or some other material to reduce its infiltration capacity. This may, however, increase the cost of the system.

3.3 Rock Catchment System

This is generally constructed for communal supplies in areas where unjointed massive rock outcrops provide a suitable catchment surface. The runoff is channeled along stone and cement gutters, constructed on the rock surface, into reservoirs contained by concrete dams. If the dams lie above the settlements, water can be supplied to stand posts through a gravity fed pipe network.

As ground catchment systems and rock catchment systems are beyond the scope of this work, they are not considered further in this thesis. Concentration will be given to the roof catchment system only.

4 Methodology

In performing the job, rainfall data is undertaken from Bangladesh Meteorological Department. The maximum amount of rainwater was encountered from a roof top;

$V = fIA$ …………………………. (1)

Where V is the amount of harvestable water, A is the catchment area, I is total amount of rainfall, and f is the runoff coefficient. Surveying was done in a particular area (Terokhadia) of Rajshahi, from where the catchment areas were found as 800 ft^2, 1200 ft^2, 1600 ft^2 and 1900 ft^2. Average household size was found as 6. The system was designed for meeting water requirements of 6 persons living in the entire building. Total area was about 1200 ft^2 per capita water consumption is about 3 lpcd for conservative use.

The method was involved analysis of rainfall data using the mass curve technique. To successful use of this method required a minimum of 10 years of raw data. It was included tabulating the monthly rainfall (mm), monthly supply (liters),monthly amount stored (liters) cumulative supply (liters), monthly demand (liters), monthly amount stored (liters) and total amount stored (liters).

The required tank volume was determined when the table is filled out. The least amount stored during the dry seasons was subtracted from the largest amount stored during wet season. This difference represents the storage volume required for that particular year. The difference between the largest and least amount stored in each year was calculated. The largest difference yields the tank size.

5 Analysis of data

From the analysis of data of rainfall 0f 6 stations for 37 years from 1979 to 2015, it has been found that heavy rainfall in 6 stations concentrates mostly from April to October.

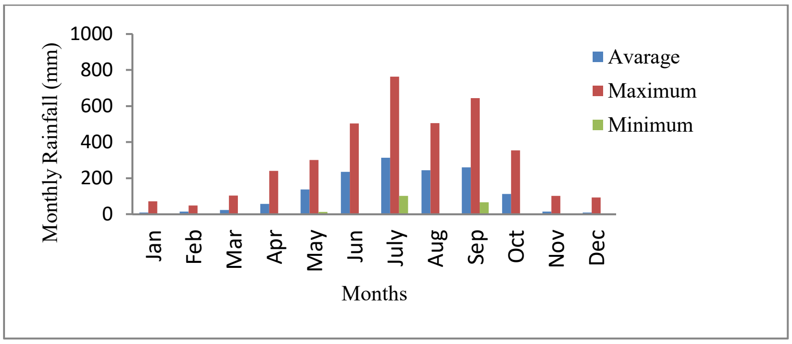

Figure 1. Average monthly rainfall distribution for Rajshahi (1979-2015)

6 Results & Discussions

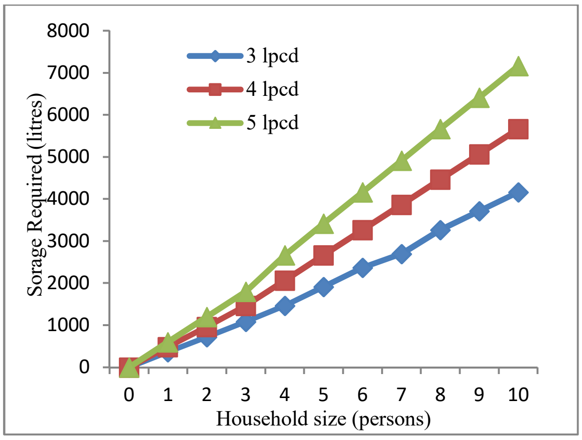

Figure 2. Storage volume and household size relationship for different consumption rates at Rajshahi (f=0.75, A=1200 ft^2)

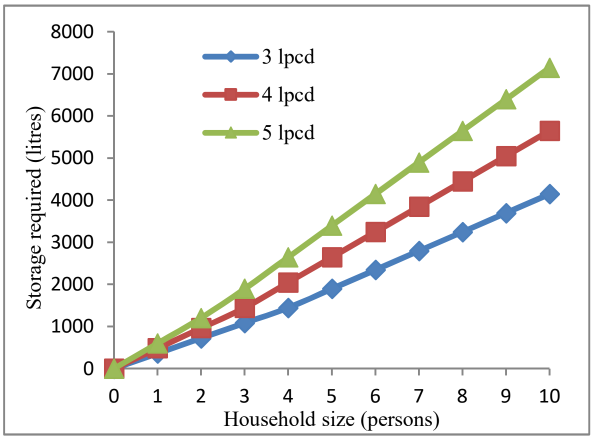

Figure 3. Storage volume and household size relationship for different consumption rates at Rajshahi (f=0.80, A=1200 ft^2)

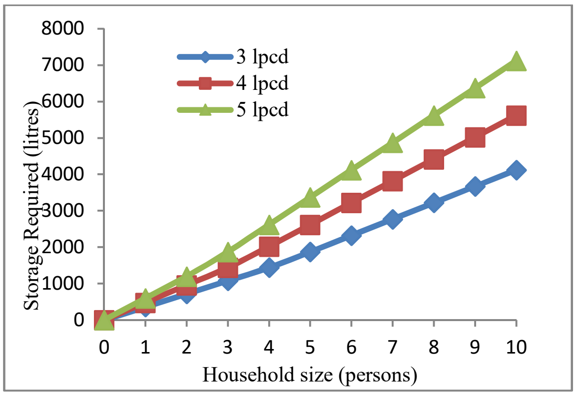

Figure 4. Storage volume and household size relationship for different consumption rates at Rajshahi (f=0.85, A=1200 ft^2)

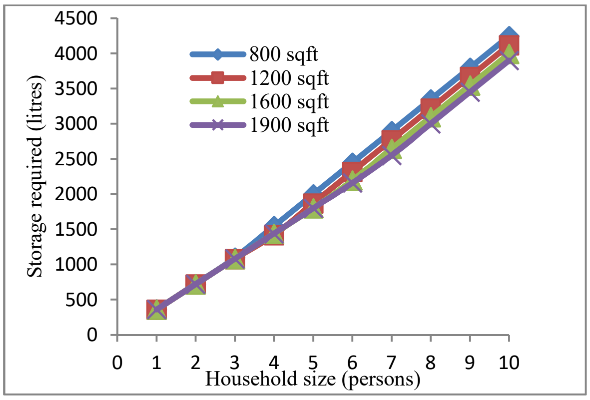

Figure 5. Storage volume and household size relationship for different catchment areas at Rajshahi (f=0.85; q=3 lpcd)

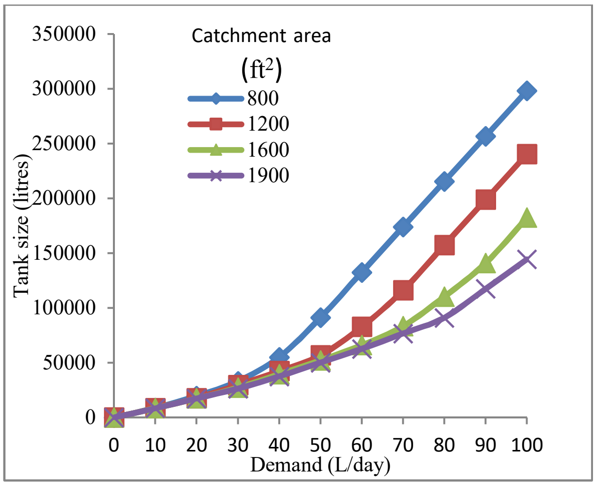

Figure 6. Storage volume-demand relationship for different roof areas for Rajshahi

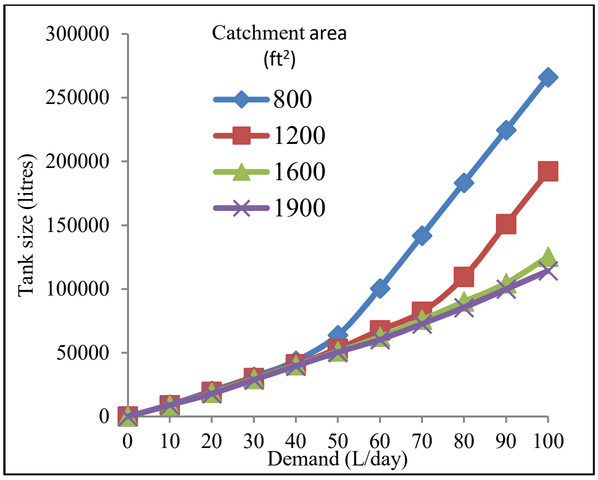

Figure 7. Storage volume-demand relationship for different roof areas for Bogra

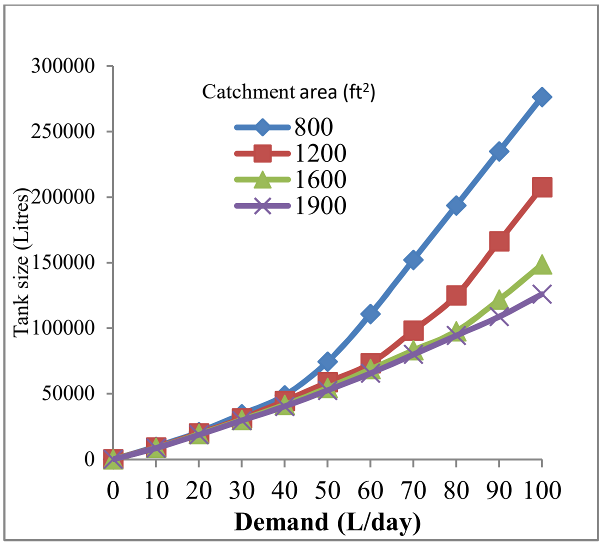

Figure 8. Storage volume-demand relationship for different roof areas for Ishurdi

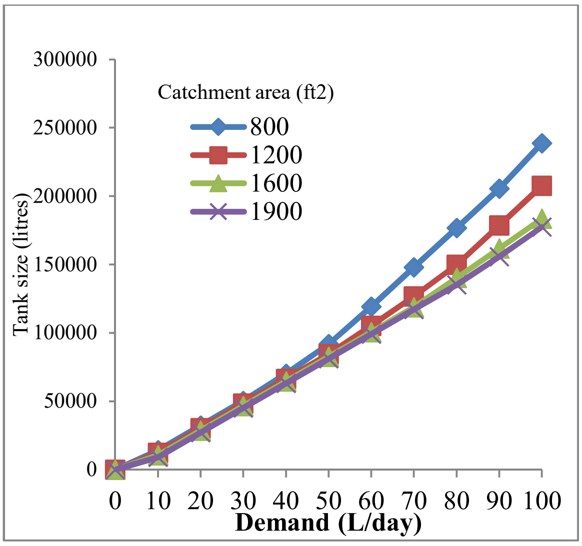

Figure 9. Storage volume-demand relationship for different roof areas for Rangpur

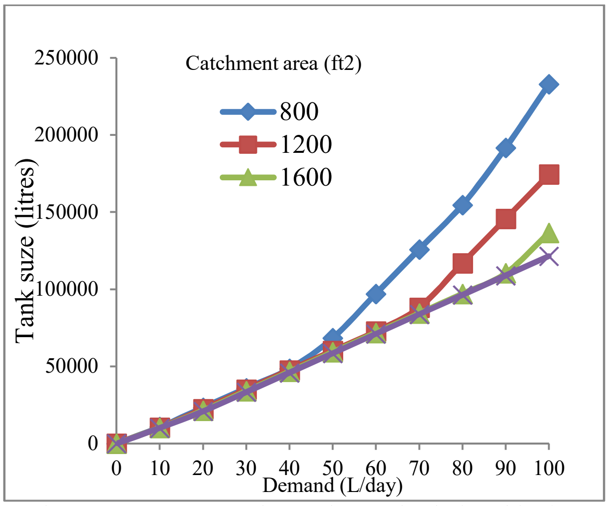

Figure 10. Storage volume-demand relationship for different roof areas for Dinajpur

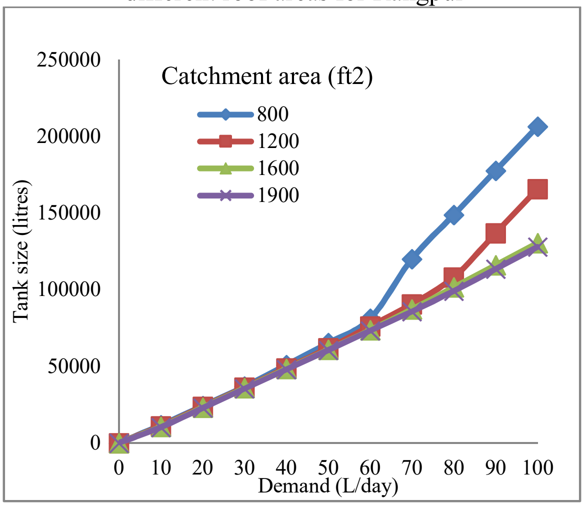

Figure 11. Storage volume-demand relationship for different roof areas for Syedpur

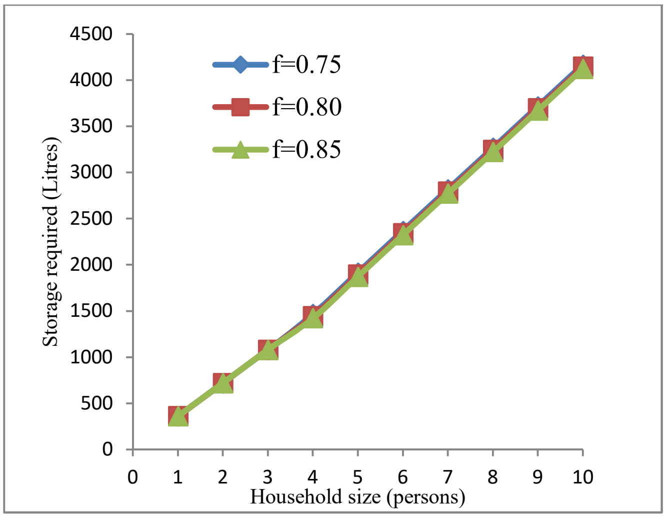

Figure 12. Effect of runoff coefficients (roofs) on storage volume for Rajshahi (q=3 lpcd, A=1200 ft^2)

As rainwater harvesting is a new approach for Bangladesh, there is not much data available regarding the material and construction cost for storage tanks. Moreover costs vary for different types of storage tanks. An attempt has been made to establish a relationship between cost and storage volume from the table 1.

Table 1. Cost estimation of rainwater collection system

			Unit price($)	Total price($)
Structural Material	Gutters	11 m	0.31	3.41
	Pipe (4 inch φ)	16 feet	1.7	27.2
	Cup (Holler type)	1 piece	2.5	2.5
	T socket	1	0.63	0.63
	Tap	1	0.82	0.82
	Lock	1	0.19	0.19
	Great ball (2 inch)	1	5.63	5.63
	L joint	2	0.5	1
	Brick(9.5”×4.5”×2.75”)	1262	0.06	75.72
	Labor	1	15	15
	Annual maintenance		5	5
	Total			137.1

*1 US$ = 78.4 Tk.

After all the calculations, a total amount of $138 would be necessary for building and operating whole system. The table presents the list, unit price and total price of all materials that would be required. Unit price is only applicable in Bangladesh. Unit price for this proposed system may vary in other countries all over the world.

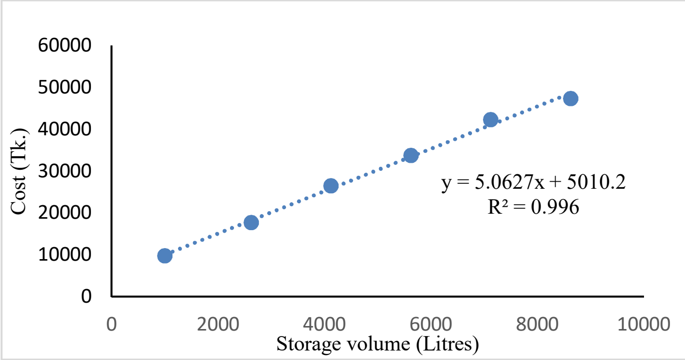

Figure 13. Cost-storage volume relationship for Bangladesh.

Conclusions

The success of the rainwater harvesting system depends on the interest, enthusiasm and active support of the users. With the application of appropriate water quality standards, treatment methods, and cross-connection safeguards, rainwater harvesting can be effectively used in conjunction with public water systems (Rahman, Afreen, 2011).

- The heavy rainfall only concentrates from April/May to October when an adequate quantity of rainwater is available.
- In designing a rainwater harvesting system, the monthly rainfall has more significance than the average yearly rainfall.
- It is observed that the required storage volumes calculated by the mass curve analysis for different runoff coefficients do not show significant differences.
- From mass curve analysis, required storage volume found 2321 litres for household size 6 persons, 1200 sqft. Catchment area and 3 lpcd consumption rate.
- Moreover, a low cost rain water harvesting system is proposed. The cost of the system is $138 for 2321 litres capacity tank and it is assumed to be affordable in the region.

References

Agarwal and Narain (1999). Rainwater harvesting as an alternative water supply in future. Published in Euro Journal. Page-133,www.eurojournals.com/ejsr.htm.

Ahmed, M., Anwar, R., & Hossain, M. A. L. I. (2013). Opportunities and limitations in practicing rainwater harvesting systems in Bangladesh, 2(4), 67–74.

Bangladesh Meteorological Department, Different Climatological Data for the period 1979 to 2015 at 6 stations of Bangladesh, Dhaka.

Boers, Th.M. and Ben-Asher, J. (1982). A review on rainwater harvesting and Agricultural water management. Global Publication Ltd., 145-158.

Rahman, Afreen, H. (2011). Potential of Rainwater harvesting in Dhaka city, (March).