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# Comparison of the Scenario of Rainwater Harvesting Potential in Dhaka City and DWASA'S Supplied Water

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## ABSTRACT

Dhaka, Bangladesh's capital is one of the foremost inhabited megacities of the globe. Management and development of sustainable and safe water supply for the city dwellers are completely dependent on ground water and river water availability. The previous years, it has been reflected that Dhaka city experiences water shortage in some areas during the dry season Rainwater harvesting can be an efficient strategy for reducing the present water crisis and minimizing the findings of climate change on water supplies. This study uses rainfall data and the roof surfaces of both residential and business structures to show how rainwater harvesting in Dhaka City could provide a source of potable, clean water. Average rainfall varies from 157 mm to 311 mm in the rainy season. It is found that a maximum of 21% percent of the present water supply can be covered by rainwater harvesting during monsoon.

**Keywords:** Water crisis, Water supply, Scenario of rainwater, DWASA'S, and Rainwater harvesting.

## INTRODUCTION:

Water resources management is now a global concern and the main purpose is to provide clean and affordable water for every living being. For the sustainable socio-economic development of any country, proper utilization of water resources is essential. For food production at the farm and industrial levels, domestic use and industrial production are highly dependent on water availability (Aladenola *et al.,* 2010; FAO, 2008). In most developing countries, rapid population increase and environmental deterioration are limiting people's access to safe potable water to consume. Based on the global population trend, it has been observed that developing countries will contribute more to the human population in the years to come (Brown 2005; UNFPA, 2008). Like many developing countries, Bangladesh cannot satisfy its domestic water needs at the urban level. As Dhaka is one of the most densely populated cities in the world, water demand is increasing gradually. Dhaka Water Supply and Sewerage Authority (DWASA) mostly depends on groundwater for water supply but surface water contributes to some extent.

There are various buildings and steel shades in Dhaka city. The building roof and shades which can be used effectively harnessing of rainwater will reduce pressure on the public water system for supply. Now a day's scarcity of usable water is emerging as a severe crisis. Ascending population and urbanization coupled with climate change will create adverse effects on urban water supply in developing countries (Murad *et al.,* 2007; O'Hara & Georgakakos, 2008; Wheida & Verhoeven, 2007). Bangladesh has a total of 147,570 sq. km. of land area coverage in the globe. The Brahmaputra Basin, the Ganges Basin, and the Meghna Basin are the lowest riparian basins in the nation, and alluvial deposits from these rivers created this low-lying region. And it receives a great amount of rainfall during the monsoon season which prevails almost for five to six months of the year. The enormous benefits associated with rainwater harvesting have been observed and it can also be used as a potable water source if properly collected (Krishna, 2005; Hermann & Schimda, 1999; Fewkes, 1999; Appan, 2000; Handia *et al.,* 2003). In Japan, large-scale rainwater utilization is common in public facilities (Zaizen *et al.,* 1999).

Rainwater harvesting also can be used as a decentralized water supply system for other works. It will reduce storm water runoff, erosion, and pollution in urban environments. In this paper, household rainwater harvesting potential in Dhaka city is estimated which will help in quantifying the potential of roof-based rainwater harvesting and the potable water savings strategies.

## METHODOLOGY:

### Study Area

One of the most massive deltas in the world is Bangladesh (Khatun *et al.,* 2016). Bangladesh's central region is home to the Dhaka Metropolitan Area on latitudes 23°39' to 23°54' North and 90°20' to 90°36' East. The Mean Monthly Temperature in Dhaka varies from 25.1 $^0$C to 33.8 $^0$C (Khatun *et al.,* 2016). The total area in Dhaka Metropolitan is 153192.12 Hectares (RDP Survey, 2013). The lowest minimum temperature was 5.6 $^0$C on (18.1. 1964), the highest maximum temperatures were 42.3 $^0$C on 30.4.1960 and the Highest 24 hours of rainfall in mm was 341 mm on 14.9.2004 (Khatun *et al.,* 2016). Buriganga, Turag, Balu, Shitalakhya, etc. rivers pass through in and around the Dhaka City. These rivers work as the outfalls of the drainage system of the city and keep it flood-free (Tawhid, 2004). It covers around 1528 sq. km area and the population was 17,318,163 in 2015 (Plan, 2015). And as the population is increasing and the need for fresh water is increasing, to meet daily domestic and industrial needs, it is important to develop other water sources. DWASA is basically dependent on groundwater (Both shallow and deep tube wells). They also purify river water to meet up the demand. But it is becoming harder day by day. So, rainwater can complement available water sources in Dhaka and other areas of Bangladesh.

### Analytical Methods

Runoff collection from rainfall can be split into two different processes: roof and land-based. The main objective of this research is to give importance to roof-based rainwater collection from both residential and industrial areas of Dhaka. How much rainwater is collected depends on the area of the roof, depth of rainfall and storage, and runoff coefficient of the materials of the roof (Aladenola *et al.,* 2010). Five years' daily rainfall data has been collected from BMD, Dhaka to determine rainfall patterns, average, monthly, and annual rainfall, and months that are wet and dry each year.

A five-year monthly average rainfall data of 2009-2013 were plotted against their respective months in order to show the pattern of distribution of rainfall. The coefficient of variation of the monthly rainfall has been calculated for annual variability. The variational coefficient of the monthly rainfall is calculated using Eq.1 (Aladenola *et al.,* 2010):

$$CV = Sv/Va \quad \ldots\ldots \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Here,
CV = The variational coefficient of the monthly rainfall
Sv = the standard deviation of the monthly rainfall (in mm) Va= mean of the monthly rainfall (in mm) The volume of rainwater that can be harvested is calculated using Eq. 2 (Aladenola *et al.,* 2010):

$$VR=(R*HRA*RC)/1000$$

Here,
VR Volume of rainwater harvested (in cubic meters) R monthly average rainfall depth (in mm) Rc Runoff coefficient (no unit) The roof area has been collected from Rajuk (Plan, 2015). The runoff coefficient has been taken from the Runoff coefficient fact sheet of the California Water Board (Board, 2011).

## RESULTS AND DISCUSSION:

**Fig. 1** illustrates Dhaka rainfall pattern. In 2009, the rainfall depth was 676 mm in July; in 2010, 340 mm in August and in 2011, 490 mm in July, in 2012, 282 mm in July, in 2013, 378 mm in April and the lowest 0 mm in the dry period (December to February).

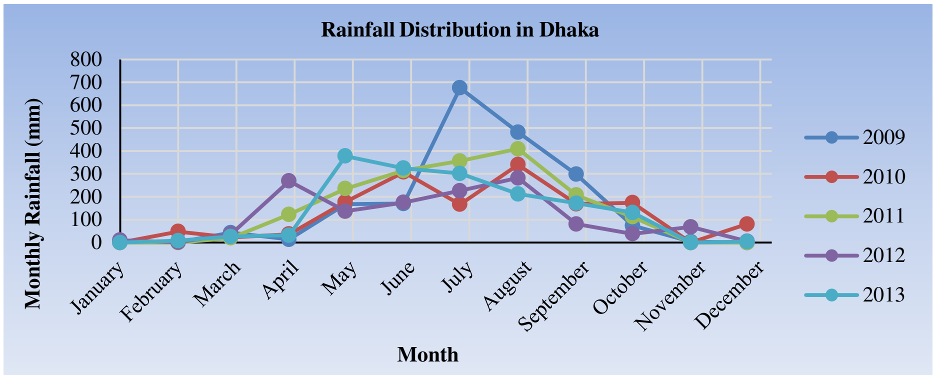


**Fig. 1:** Rainfall Distribution in Dhaka from 2009 to 2013.

**Table 1:** No. of months in the years (total monthly rainfall).

| No. of months in the years (total monthly rainfall) | | | | | |
|---|---|---|---|---|---|
| | 2009 | 2010 | 2011 | 2012 | 2013 |
| no rain 0 | 1 | 2 | 4 | 0 | 2 |
| Light rain 1-10 | 3 | 0 | 0 | 3 | 2 |
| Moderate rain 11-22 | 1 | 1 | 1 | 0 | 0 |
| Moderate heavy 23-43 | 1 | 1 | 0 | 2 | 2 |
| Heavy rain 44-88 | 1 | 1 | 1 | 2 | 0 |
| Very heavy rain > 89 | 0 | 0 | 0 | 0 | 0 |
| Very heavy rain 100-199 | 2 | 4 | 2 | 2 | 2 |
| Very heavy rain 200-299 | 1 | 0 | 2 | 3 | 1 |
| Very heavy rain > 300 | 2 | 2 | 3 | 0 | 3 |

**Table 2:** Standard Deviation of Mean Monthly Rainfall of different years.

| Year | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|
| Mean | 160.92 | 126.92 | 148 | 110.75 | 132.5 |
| Standard deviation | 219.92 | 115.18 | 147.84 | 104.14 | 142.22 |

**Table 1** shows the five-year rainfall pattern from 2009 to 2013. In all years Dhaka receives moderate to very heavy rain at least 2/3 months each year. But there are also months there is no rain and light rain. So, the rainfall pattern is erratic and varies seasonally. In **Table 2** the standard deviation of mean monthly rainfall varies from 104.1381 to 219.92497. The high values of variability in rainfall distribution in a certain year show high seasonal variations of rainfall in Dhaka. And this high seasonal variation is expected due to the climate change (Bagchi *et al*., 2020; Aladenola *et al.,* 2010).

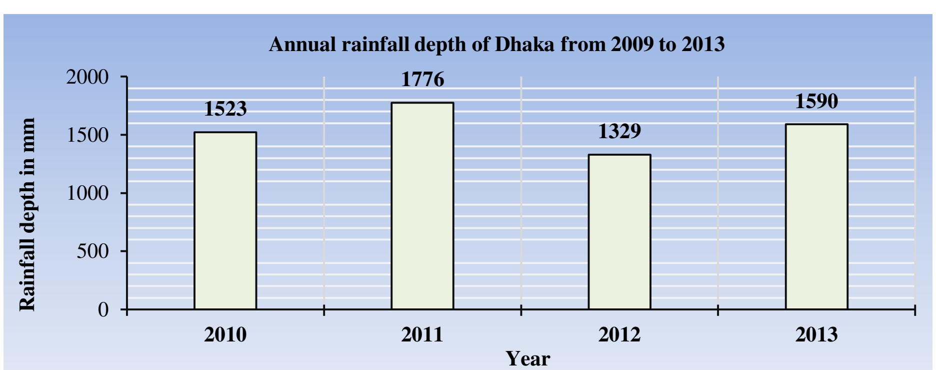


**Fig. 2:** Annual rainfall depth of Dhaka from 2009 to 2013.

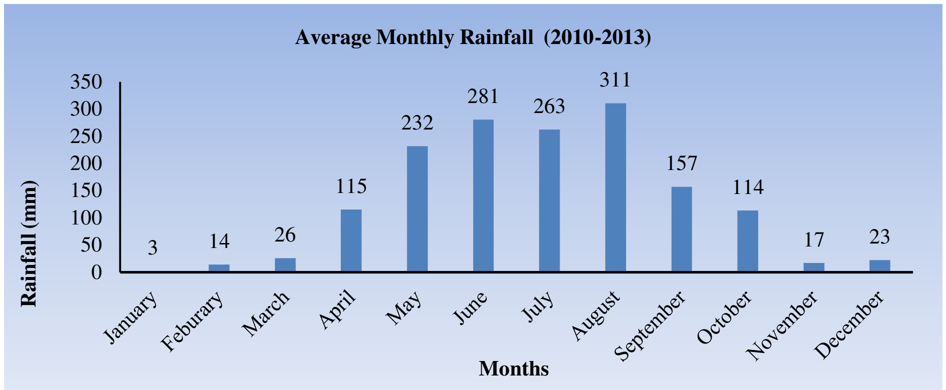


**Fig. 3:** Average Monthly Rainfall (2010-2013).

**Fig. 2** shows the yearly rainfall depth variability. The highest depth annually of 1776 mm has observed in 2011and the lowest annual rainfall was 1329 mm in 2012. The mean annual rainfall was 1554.5 mm. **Fig. 4** compares the water supply provided by DWASA and rainwater that can be harvested in that month calculated in **Table 3** and the percentage water supply of DWASA which can be achieved by rainwater harvesting. The figure shows as in the rainy season, there is the greatest amount of rainfall, so the maximum percentage of water can be harvested in the rainy season.

**Table 3:** The percentage water supply of DWASA which can be achieved by rainwater harvesting.

| Month | Average of total monthly rainfall from 2010 to 2013 (mm) | Runoff from total area (m^3) | Runoff from the total area (*10^7) liter | Average of total water production in 2010-2013 (1*10^7) Liter |
|---|---|---|---|---|
| January | 2.5 | 108000 | 10.8 | 5882 |
| February | 14.25 | 615600 | 61.56 | 5422 |
| March | 26.25 | 1134000 | 113.4 | 5870 |
| April | 115.25 | 4978800 | 497.88 | 5879 |
| May | 231.75 | 10011600 | 1001.16 | 6137 |
| June | 280.5 | 12117600 | 1211.76 | 6049 |
| July | 262.75 | 11350800 | 1135.08 | 6303 |
| August | 310.75 | 13424400 | 1342.44 | 6354 |
| September | 157.25 | 6793200 | 679.32 | 6070 |
| October | 113.75 | 4914000 | 491.4 | 6256 |
| November | 17 | 734400 | 73.44 | 6074 |
| December | 22.5 | 972000 | 97.2 | 6205 |
| Total | 1554.5 | 67154400 | 6715.44 | 72501.4975 |

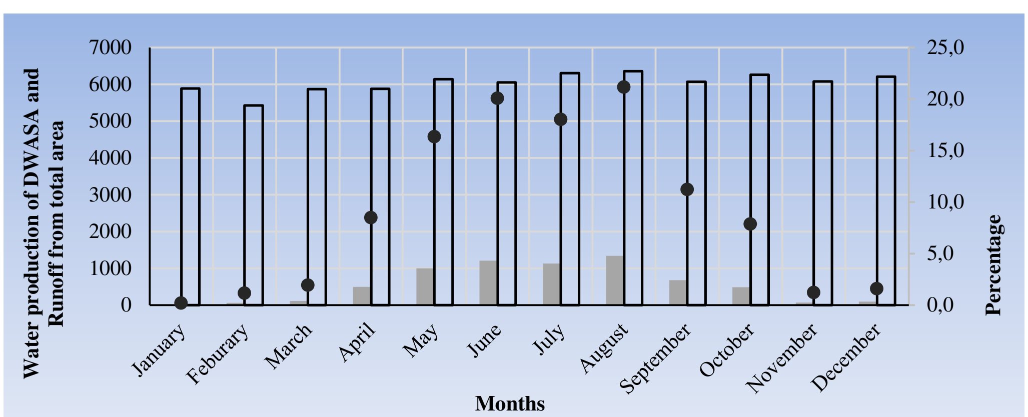


**Fig. 4:** Comparison of DWASA water supply and amount of harvested rainwater.

In order to lessen the vulnerability of the water supply in metropolitan settings, roof water collection can be useful as it will be more accessible and sensitive than centralized water reservoirs (Aladenola *et al.,* 2010).

Maximum rainwater volume that can be harvested is 1342.44*10^7 liters in August and Minimum harvested water is calculated 10.8*10^7 liters January of that particular year. So, it is evident that a large amount of water can be harvested though it will vary in seasons. If the water can be reserved then it will lessen the amount of groundwater extraction and need for water purification of surface water. Though the storage capacity depends on the available space and affordability.

## CONCLUSION:

To compare the quantity of water supplied by the DWASA and harvested rainwater in Dhaka, 5-year rainfall data of Dhaka City was collected from BMD. The monthly average rainfall data has been plotted against month to observe rainfall distribution pattern and annual rainfall has been plotted against years to observe the variation of annual rainfall. The objective of the paper was to calculate approximately to which extent the harvested rainwater can cover the amount of water supplied by DWASA. And in this study, the water is not considered potable water. Using rainwater in lieu of DWASA-supplied water will be helpful to save potable water and reduce water wastage. If an adequate amount of rainwater can be stored to use in the dry season it will reduce water shortage during pre-monsoon and post-monsoon seasons. And as one of the most crowded cities is Dhaka and the maximum buildings are not built maintaining the proper rules many of the buildings have no provision for rainwater harvesting, so it would not be easy to create additional rainwater storage for the existing buildings.

But if the recently developed buildings keep the provision of rainwater harvesting and if it's possible to identify which previously built buildings can create new storage for rainwater harvesting, it will sufficiently help the city dwellers, DWASA and it will reduce groundwater extraction to a much extent.

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## CONFLICTS OF INTEREST:

The authors say they have no conflicts of interest.

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