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# *Rainwater Harvesting at Mogadishu University Main Campus: Key Sustainability for Saving Water*

***Eng. Abdirahman Ismail Dhaqane***
**Dean, Faculty of Engineering, Mogadishu University**

**Email**: Dhaqane@mu.edu.so /dhaqanemu@gmail.com

## Abstract

The largest environmental challenge that Somalia faces today is the scarcity of water. Many methods have been suggested to increase the sources of water supply; one alternative source is rainwater harvesting, in the absence of run-off sewer systems in most Somalia rural and urban areas, rainfall harvesting from roads, parking lots, and rooftops can increase water supply for various domestic uses and help struggle the chronic water shortages in the country. This paper presents a feasibility analysis of rainwater harvesting systems for the Mogadishu University Main campus. The results show that a maximum of 15.5 480 m3/y of rainwater can be collected from the roof Faculty of Education buildings provided that all surfaces are used and rain falling on the surfaces is collected. Also, results indicate that in stations like engineering, education, and health science buildings where rainfall water is scarce, and cannot meet up demand per annum, a large catchment roof area is required to improve the collection of water to meet the demand within these buildings. The administration building only meets up the demand per annum. It should be noted that roof rainwater harvesting is only able to provide sufficient water Gardenias and vegetable plots. Finally, this research offers some recommendations to overcome the present challenges as well as to guide future development projects, donor communities, and the Government of Somalia to improve the rainwater and sanitation situation in Mogadishu Main Campus. Therefore, a great potential for exploitation of rainwater harvesting from building roofs is possible at Mogadishu University-Main Campus.

**Keywords***:* Water harvesting; Water supply; Rainwater; Household; Water savings; Mogadishu University Main Campus.

## 1. Introduction

Definition of rainwater harvesting is defined as a method for inducing, collecting, storing, and conserving local surface runoff for agriculture in arid and semi-arid regions (Boers, Th M, and Ben-Asher, 1982). The hydrological cycle of water movement involves the greatest flow of any substance in the biosphere(JACKSON, 2001). Society must move toward the objective of effective and adequate use of water for a sustainable urban future. Rainwater harvesting plays a major role in this mission (Abdulla & Al-Shareef, 2009). In Germany a study performed by (Herrmann & Schmida, 2000) showed that the potential of potable water saving in a house might vary from 30% to 60%, depending on the demand and roof area. (Coombes & Kuczera, 2002) analyzed 27 houses in Newcastle and concluded that rainwater usage would promote potable water saving of 60%.

In Brazil, a study performed by (Ghisi, Montibeller, & Schmidt, 2006) showed the potential water saving by using water harvesting in 62 cities ranges from 34% to 92%, with an average potential for potable saving of69%. Rainwater harvesting is a technology used for collecting and storing rainwater from rooftops, land surfaces, road surfaces, or rock catchments using simple techniques such as pots, tanks, and cistern as well as more complex techniques such as underground check dams (Abdulla & Al-Shareef, 2009). A sustainable source of clean water that is suitable for domestic and landscape uses is collected rainwater. Structural stormwater management involves reducing the volume and contaminants from small storms by capturing and reusing stormwater, such as rainwater harvesting systems, detention and retention systems, green roofs, porous surfaces, and bioswales, increasing infiltration and evaporation, among two main categories of structural and non-structural methods of stormwater management. No management of structural stormwater decreases the amount of runoff, primarily by conserving natural areas (Ranasinghe, 2019)

### 1.2 Importance of Rainwater Harvesting

Campisano, Gnecco, Modica, & Palla, (2013) examined the performance of a domestic RWHS for toilet flushing in 44 Italian cities by using a non-dimensional approach characterized by a demand and storage fraction. Regression curves were developed to describe the relationship between the water-saving efficiency and the modified storage fraction that allowed the RWHS systems to be sized based on the desired water-saving performance level.

Ghisi & Schondermark, (2013)An RWHS investment feasibility study for the residential sector for five cities in the state of Santa Catarina, Southern Brazil, was presented. They observed that the ideal tank capacity would be conservative for high rainwater demands and in such cases an investment feasibility analysis should be carried out in order to obtain a more appropriate tank capacity. Supplying adequate water to meet social needs and ensuring equity in access to water, particularly in urbanized regions is a subject of concern. Among the various alternative technologies to increase freshwater resources, rainwater harvesting is one of the decentralized and environmentally sound solutions(UNEP, 2002). Numerous advantages and benefits of rainwater harvesting have been described by previous researchers (Jackson, 2001); This is enough to see rainwater harvesting as a countermeasure to the management of water supplies and flood control during the climate change crisis. Despite having some obvious advantages over other outlets, because of its limited capacity or water quality issues, rainwater use has not been widely acknowledged. It is very important to quantitatively assess its effectiveness on multiple variables, such as flood control and water availability, to encourage rainwater harvesting effectively. (Kim & Furumai, 2012). DRWH has recently become an important activity in water resource management worldwide, especially for urban and suburban areas affected by limited freshwater availability. Rainwater harvesting systems can also mitigate the impact of sewer storm water flows, as these systems are usually fitted with storage tanks to absorb and store amounts of rainfall (Campisano et al., 2013).

For many domestic uses, such as toilet flushing and garden watering, rainwater may replace potable water (Campisano et al., 2013), Literature research has shown that the housing demand for toilet flushing can achieve up to 30%of the household consumptions, thus suggesting significant water-saving benefits from the implementation of DRWH systems (Mukhopadhyay & Akber, 2001).

The rainwater harvesting system has been seen as a sound alternative water source technique for increasing water supply capacities(Hatibu & Mahoo, 1999). Urban development and rising demand for water put stress on current water supplies. Attention is now focusing on alternatives such as rainwater catchment systems as supplementary water sources with multi-purpose functions. Roofs constitute a significant proportion of the large impermeable areas protected by towns, thereby providing a significant opportunity to gather rainwater(Villarreal & Dixon, 2005).

Although rainwater harvesting has been historically used in areas where water supply was limited by climate or infrastructure issues, more recently such a practice has been undertaken also in humid and well-developed regions to mitigate the environmental impact on freshwater sources and also to reduce stormwater runoff volumes manage urban flood risk and decrease urban waterlogging problems (Mitchell, Deletic, Fletcher, Hatt, & Mccarthy, 2007).

An integrated urban stormwater harvesting system should provide five core functions: (a) collection, (b) treatment, (c) storage, (d) flood and environmental flow protection, and (e) distribution to end-users (Mitchell et al., 2007).

Rainwater Harvesting (RWH) can be used in this scenario as one of the best climate adaptation methods for water conservation (Julius & Prabhavathy, 2013). Rainwater harvesting is a simple low-cost process that collects, stores, and reuses rainwater, requiring minimal specific knowledge and expertise (Ranasinghe, 2019)

### 1.3 Research Objectives

The present study emphasizes the value of roof rainwater harvesting systems at Mogadishu University-Main Campus for domestic water supply. The objectives of this paper are to:

1. Evaluate the potential for water savings by using rainwater in different sector of the campus buildings
2. To investigate quantitatively the effectiveness of rainwater harvesting in supplying water for selected usages (toilet flushing, air conditioning, garden irrigation, and cleaning) indifferent building types
3. To recommend future utilization rainwater harvesting for domestic water supply.

### 1.4 Significant of Research

The RWHS is used to conserve mains water in urban areas, where the supply of mains water is present. As water is becoming scarce, it is important to achieve self-sufficiency to fulfil the water needs of the day. Problems are when all of the water becomes surface runoff when the rain falls. Surface runoff from the source of rainwater harvesting must be decreased. The Greater attraction of a rainwater harvesting system at Mogadishu University's main campus is the low cost of rainwater harvesting and utilization. Rainwater harvesting is used for collecting and storing rainwater from rooftops at Mogadishu University-Main Campus. The potential rainwater harvesting volume is estimated based on the total roof area, the average annual rainfall, and the runoff coefficient.

## 2. Materials and Methodology

It was necessary to obtain rainfall data, potable water supply, student number, and dwellings in each building to achieve the objectives set out above. The study covers faculties Engineering, Education and Computer science, and Health Sciences buildings as well as and Administration building. The total roof area in each building was calculated based on the average area of different dwellings and their number. Based on the total roof area, the average annual rainfall, and the runoff coefficient, the possible rainwater harvesting volume is estimated. Then the potential saving percentage is calculated by dividing the potential volume of harvested rainfall by the annual domestic demand. Data on population and number of dwellings was needed to calculate the number of people per dwelling in each building on the campus. The amount of water that can be harvested was calculated according to the equation: Water supply = Rainfall (mm/year) x area of the catchment (nr) x runoff coefficient (n)

### 2.1 Calculation of Potential of Collectable Rainwater

The capacity of collectible rainwater in a region depends on the amount of rainfall, the distribution of rainfall in different seasons, the quantity of water, the area of rainwater collection, and the coefficient of surface runoff. Rainfall is not spread uniformly over various seasons and is typically concentrated in monsoon climate zones in certain months (rainy season). Due to the amount of rainfall in some rainfall events is not enough to form runoff in some months, the seasonal loss coefficient (the ratio of rainfall in the rainy season to annual rainfall) should be taken into account in the calculation of the potential of collectible rainwater.

### 2.3 Designing Rainwater System

For the design of a rainwater harvesting system, rainfall data is needed for a period of at least 10 years. The more accurate and precise the data is, the better the design would be for the area. Due to socio-economic conditions and different uses of domestic water, water consumption and demand for domestic purposes are also expected to vary across these regions. People may use as little as a few litres per day. A 20 lpd (gallons or capita per day) is the commonly accepted minimum (WHO, 2004). (Jo, 2003) suggested that water demand can be computed from the following expression: Water Demand = 20 x n x 365 litres / year, with n = number of people in the household.

### 2.4 Coefficient of Use

The coefficient of use represents the percentage of rainwater that can be captured and used in the building. A coefficient of use of 80 % was applied in all of the campus buildings because of concrete roof. Thus, losses of 20 % of the rainwater that is discarded for roof cleaning and evaporation.

## 2.5 Water harvesting potential of a site

The supply of rainwater depends on annual rainfall, the surface of the roof and the runoff coefficient. Table 1 gives types of catchments material and their runoff coefficient.

**Table 1: Types of catchments materials and runoff coefficients (Adapted from (Adrain, 1989)**

| Type of catchments | Materials | Runoff coefficients (n) |
|---|---|---|
| Roof catchments | Tiles | 0.8-0.90 |
| | Corrugated metal Sheets | 0.7-0.90 |
| Grand surface coverings | Concrete | 0.6-0.80 |
| | Brick pavement | 0 .5-0.60 |
| Untreated ground catchments | Soils on slope less than 10 percent | 0. 0 -0.30 |
| | Rocky natural catchments | 0. 2-0.50 |
| | Green area | 0.05-0.1 |

Based on the above factors, the water harvesting potential of an area could be estimated using Equation 1: Water supply = Rainfall (mm/year) x area of catchment (nr) x runoff coefficient (n)

Rainwater collected from the top of the roof/catchment area collectively considered the volume of storm water controlled in the area, assisted by local mitigation of flash floods.

**Table: 2 Building Parameters**

| Building Name | Width (m) | Length (m) | Area (m2) |
|---|---|---|---|
| Faculty of Engineering | 22 | 46 | 1,012 |
| Faculty Health Science | 29 | 40 | 1,160 |
| Faculty Education | 30 | 50 | 1500 |
| Administration apartments | 38 | 38 | 1,444 |

# 3.0 Result and Discussion

This chapter presents the research results and analysis of the first two research objectives and discussion for all parts

## 3.1 Water Demand Calculations

***Engineering Building***

There is an average of 250students in the compound, and then water demand for engineering building will be:

Water demand = 20 x n x 365 litres/year, n = number of students in the building;

Water demand = 20 x 250 x 365 = 1,825,000 litres/year for the engineering building which is about 152,083litres/month. This implies that for a given dry period of six months, the required minimum storage capacity will be 912,499 liters (228,124 gallons). This is however a rough estimate of 1 gall = 4litres.

For a concrete roof of 572 m2and a runoff coefficient of 0.8.

Water supply = 400*572*0.8 = 183,040 litres/years (45,760 gallons/year).

To compute that of Education building, the average of 700 students in the compound. Water demand for the building will thus be:

Water demand = 20 x 700 x 365= 5,110,000 litres/year which is about 851,666 litres/month the required minimum storage capacity will be 5,109,999 litres (1,277,499 gallons/year).

Water supply = 400*1500*0.8 = 480,000 litres/years (120,000 gallons/year).

To compute that Health science building, the average students is 700 the water demand for the building will thus be:

Water demand = 20 x 700 x 365 = 5,110,000 litres/year which is about 851,666 litres/month the required minimum storage capacity will be 5,109,999 litres (1,277,499 gallons/year).

Water supply = 400*1,160*0.8 = 371,200 litres/years (92,800 gallons/year).

The administration building, assume that there is an average of 50 people in the building, then water demand for administration building will be:

Water demand = 20 x 50 x 365 = 365,000 litres/year which is about 30,416litres/month the required minimum storage capacity will be 182,499 litres (45,624 gallons/year).

Water supply = 400*1,444*0.8 = 462,080 litres/years (92,800 gallons/year).

**Table: 3 Estimated Values for Average Water Demand Required, Minimum Storage Runoff Coefficient and Water Harvesting Potentials**

| Building | Roof Area (m2) | Average rainfall (mm) | Runoff coefficient of concrete | Water demand per average of Students in building | Water demand for ahousehold litres/month | Required minimum storage capacity | Water harvesting potential of each litres/gallon station (rainwater supply) litres/annum |
|---|---|---|---|---|---|---|---|
| Engineering campus | 1,012 | 400 | 0.8 | 1,825,000 | 152,083 | 912,499 | 183,040 |
| Education campus | 1500 | 400 | 0.8 | 5,110,000 | 851,666 | 5,109,999 | 480,000 |
| Health science campus | 1,160 | 400 | 0.8 | 5,110,000 | 851,666 | 5,109,999 | 371,200 |
| Administration building | 1,444 | 400 | 0.8 | 5,109,999 | 30,416 | 182,499 | 462,080 |

Table 3 presents estimated values of water harvesting potentials for the four building stations at the Mogadishu University. From Table 3, it could be seen clearly that for a roof area of engineering 572 m2 and an average rainfall of 400 mm, a person can gladly store 183,040 liters, which is above the maximum storage requirement of 912,499 liters for a six-month duration of dry months in the engineering building. Also, in the case of education building, it will be observed that a person can gladly store 480,000 liters/year which is above the minimum storage requirement for a household of 5,109,999 liters for six dry months.

Results also indicate that stations like engineering, education, and health science where rainfall water is scarce, and cannot meet up demand per annum, large catchment roof areas are required to improve the collection of water to meet the demand within these buildings. Administration building a person can gladly store 462,080 liters, which is below the maximum storage requirement of 182,499 for six dry months. Therefore, the administration building only meets up the demand per annum. It should be noted that roof rainwater harvesting is only able to provide sufficient water for a small vegetable plot. Such rainwater collection is strongly recommended for practice in Mogadishu University-Main Campus.

## 4. Conclusion and recommendation

Great potential for exploitation of rainwater harvesting from building roofs is possible at Mogadishu University-Main Campus. Results show that a maximum of 15.5 480 m3/year of rainwater can be collected from the roof faculty of Education buildings provided that all surfaces are used and all rain falling on the surfaces is collected. There is a need to improve understanding of the social impact, potential, and performance of partial rainwater harvesting as practiced by educational institutional campuses in the city, assessing its cost and benefits, and improving the domestic roof rainwater harvesting technology itself. The results of this study provide useful information for the further development of the rainwater harvesting program in Mogadishu.

**Based on the findings of the elaborations, the following recommendation emerges:**

1. To improve understanding of the social effects, capacity, and efficiency of partial rainwater harvesting as practiced in small houses by families, evaluate its costs and benefits and enhance the technology of domestic roof rainwater harvesting itself.
2. Rainwater harvesting cannot only provide a source of water to increase water supplies but also can involve the public in water management.
3. Policymakers should consider new domestic rainwater harvesting policies and improve and implement existing legislation and policies in Somalia on domestic or site-specific rainwater harvesting systems.
4. State or municipal codes need to address public health concerns by specifying water quality

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