

Feasibility Study of Rainwater Harvesting System in Public Premise

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Abstract. Water use is directly impacted by the growth of public buildings, including public halls, schools, government buildings, mosques, and hospitals. Every year, this tends to raise water costs and use, hence water efficiency initiatives must be implemented. Water efficiency is the process of using as little potable water as possible to meet desired needs. Therefore, this article aims to identify the feasibility study on the adaptation of rainwater harvesting system in public premises to decrease the amount of water for consumption used by (1) analyse the potential water savings and associated financial benefits of implementing a rainwater harvesting system, and (2) assess the environmental impact of implementing a rainwater harvesting system. Through the qualitative and quantitative case study analysis of one case study, our results show that the rainwater harvesting system is help to reduce the dependency to current potable water supply between 380m³ to 1025m³ per month based on the demand and cost saving between RM 20,000.00 to RM 22,000.00 per year or RM1,600 to RM 1,900 per month. The increase of the rainwater harvesting use, will reduce demand to the volume of water supply. The findings will be useful when implementing RWHS in public buildings.

1. Introduction

Malaysia, as a rapidly developing nation, faces a growing demand for potable water, especially in public premises such as government buildings, schools, mosques, and hospitals. This increased demand not only puts a strain on existing water resources but also leads to rising water costs for these establishments. Implementing a rainwater harvesting system in public premises could be the solution to reduce the dependency on the current potable water supply. It would not only lead to cost savings but also contribute to the sustainability of the environment.

In addition, every year from October to February, during the heavy rainy season, Malaysia experiences flooding. Malaysian floods are triggered by a number of factors. The fact that there is less open land available in the city is one of the contributing causes. In addition to serving as a source of clean air, open lands also serve as rainwater collecting areas. An inadequate drainage system is another contributing reason [1].

A solution to one of the above-described issues may exist for the other. In a tropical nation like Malaysia, a high rate of precipitation should be able to solve the freshwater shortage problem. However, the state of affairs is quite contradictory. It is not so much an opportunity as it is a disaster. This

contradicting reality may be resolved by new developments in rainwater management and technologies. For instance, widespread adoption of rainwater harvesting technologies could lower runoff water and hence lower the risk of flooding. Additionally, water collected from it can be used for domestic or home purposes. Despite being a tropical nation with abundant rainfall, Malaysia does not make the most use of its rainwater resources. For instance, Sabah experienced heavy rains in 2006. According to information from Malaysian Meteorological Department, Malaysia receives between 2400 and 3000 mm of rain on average annually. The inability to take advantage of the heavy rains turns it into a menace to the metropolis [2]. Therefore, the purpose of this article is to analyze, through cost prediction, the prospective application of rainwater collection in public spaces.

Collecting runoff from a building or other impermeable surface and storing it for future use is known as rainwater harvesting [3]. Rain from a roof is traditionally collected in this way. Rainwater gathers in gutters, which direct it into downspouts and eventually into a storage container. Rainwater collection systems range from basic rain barrel systems to complex systems that collect and store rainwater to meet your whole household's needs. This method has essentially been used for years in a number of nations, including Indonesia, Germany, Singapore, China, India, and Japan. Rainwater collecting technology is being utilized by Singapore, a developed nation with a limited amount of land, to ensure a clean water supply [4]. A 125 m² roof surface in Australia's South West and Great Southern areas can catch up to 51,000 litres of water a year, which can meet some of your household's non-drinking water needs [5]. Rainwater harvesting systems offer a range of benefits, both for your financial and the environment. Here are some of the key advantages:-

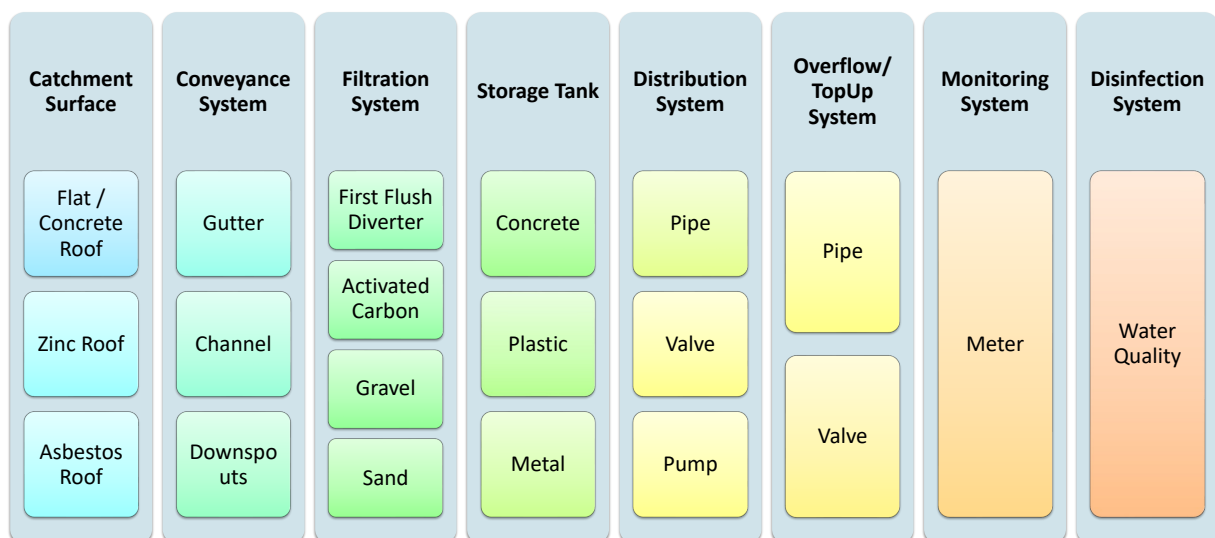
1) Financial Benefits:

- **Reduced Water Bills:** By collecting rainwater for uses like toilet flushing, laundry, and irrigation, you can significantly decrease your reliance on municipal water, leading to lower water bills.

2) Environmental Benefits:

- **Water Conservation:** Rainwater harvesting helps conserve freshwater resources, which are becoming increasingly scarce in many regions.
- **Reduced Stormwater Runoff:** By capturing rainwater, reduce the amount of storm runoff that can overwhelm drainage systems.
- **Reduced Erosion:** Decreased runoff helps prevent soil erosion around your property.

There are 8 basic components in rainwater harvesting system as below:-



1.1. Catchment Surface

In a rainwater harvesting system, the roof or other area designated for collecting rainwater is effectively the catchment surface. It serves as the rainfall's initial point of contact before it is directed into storage. The most common kind of catchment surface is a roof. Sheds, garages, and other buildings' roofs can be great places to store rainwater. Although the type of roof material is not very significant, it is advisable to stay away from materials that can leach toxins, such as lead or copper flashing.

1.2. Conveyance System

The plumbing network that directs the collected rainwater from the catchment surface—such as your roof—to the storage tank is known as the conveyance system in rainwater harvesting. In short, it serves as a pipeline connecting the storage container and the scooping surface (catchment). Among the elements are:

- Gutter - The lengthy, trough-shaped channels that are normally put in place around the borders of your roof. As raindrops slide from the roof, they collect them.
- Downspouts - The vertical pipes that transport the rainfall gathered in the gutters to the ground.
- Additional pipe - The extra pipe your system needs to link the downspouts to the storage tank may come from its design. This can entail running the pipes outside of your building or underneath.

1.3. Filtration System

In rainwater harvesting, the filtering system is essential to maintaining the water's purity. The amount of filtering required will vary depending on whether rainwater is going to be used for drinking, laundry, or gardening. The many filtration stages used in rainwater harvesting systems are listed below:

- Pre-Filter (First Flush System) - This initial stage targets larger debris like leaves, twigs, and insects. It prevents them from entering the storage tank where they could clog pipes, decompose, and compromise water quality.
- Primary Filter (In-Line Filter) - This mid-stage filtration tackles finer particles like sand, silt, and organic matter. It helps protect pumps and other components within the system from getting clogged.
- Secondary Filter (Optional - Depending on Use) - This final stage of filtration is used for applications where high-water quality is critical, such as drinking water or indoor uses.

1.4. Storage Tank

The filtered rainwater is kept in a storage tank. It can be constructed from steel, concrete, fiberglass, or polypropylene. It is preferable to use non-reactive materials for storage tanks, and they must be cleaned gradually to get rid of debris and stop developing algae. Both above and below ground can be used for storage tanks.

1.5. Distribution System

The distribution system in rainwater harvesting is the network that delivers the stored rainwater to its designated points of use. Think of it as the plumbing that carries the water from your storage tank to the tap, hose bib, or irrigation system. The complexity of the distribution system depends on how you intend to use the harvested water.

1.6. Overflow or Top-up System

In a rainwater harvesting system, the overflow or top-up system plays a critical role in preventing damage and ensuring optimal water management. The overflow system typically involves a designated

overflow pipe located at the top of the storage tank. This pipe channels excess rainwater away from the tank to a safe drainage area. A top-up system can be useful in areas with limited rainfall or during extended dry periods. It ensures a consistent supply of rainwater for your designated uses. It involves a mechanism to refill the rainwater tank with another source of water, typically municipal water supply.

1.7. Monitoring System

A monitoring system in rainwater harvesting optional to the system, but it can be a valuable tool for optimizing water usage and ensuring the system's health. By monitoring water levels and rainfall, can optimize the water usage and avoid overusing the stored rainwater. Monitoring also can help identify potential problems like contamination early on, allowing for timely maintenance. Data on flow rates can help identify leaks or areas of high-water consumption, this could allow to identify areas for improvement in the distribution system.

1.8. Disinfection System

If you intend to use the collected water for purposes other than irrigating your plants, disinfection is an optional system when it comes to rainwater harvesting. Rainwater can include bacteria, viruses, and other microbes despite being naturally deficient in minerals and chlorine. By removing these biological pollutants, disinfection contributes to the water's safety for use in a variety of applications.

2. Methodology

2.1. Evaluation technique

The potential of rainwater harvesting is quantitatively assessed using a numerical method. The research identifies the monthly record of usage of water in public premise, as well as the water bill from the municipal distributor. Table 1 show the water usage. The average daily water usage for every person in the public premise is derived based on the number of staff and water usage. The formula to calculate the average of water usage is shown by the formula below.

$$Q = \frac{\text{Number of water usage (m}^3\text{)}}{\text{number of staff in the public premise (nos)}}$$

Table 1 shows the data of water usage from the case study area for the month of January to September 2022. Study area which has number of occupants of 160 pax are working every day from Monday to Friday, 7:30am to 6:00pm. The average water usage for the study area are 2238.22m³ per month or equal to 8.29m³ per day and 14.55m³ per month per pax.

Month	Water Usage (m ³)	Average Usage (m ³ /month/pax)
January	1879	11.74
February	2140	13.38
Mac	2174	13.59
April	2209	18.81
May	2414	15.09
June	2308	14.43
July	2229	13.93
August	2392	14.94
September	2399	15.00

2.2 Study Area

The public premise is located at Seri Kembangan, Selangor which with the area of 76,000m² as show in map below: -

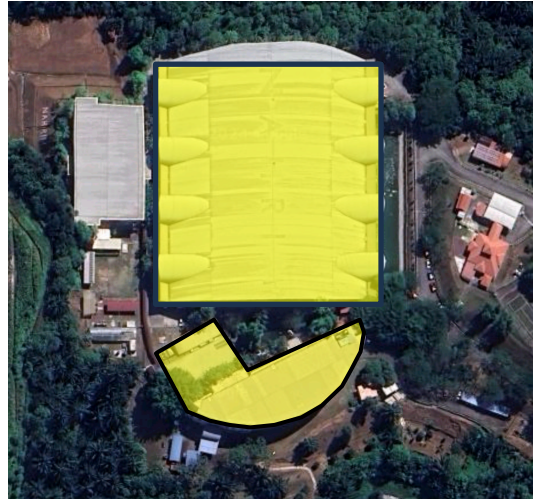


Figure 1. Study area

This public premise is famous with the laboratory and research on development of water resources which is need the huge amount of water to be use daily. Thus, the alternative to reduce the demand and cost of management due to high bill of water, the rainwater harvesting system has been install to reduce the demand of fresh water from the local water distributor.

3. Result and Discussion

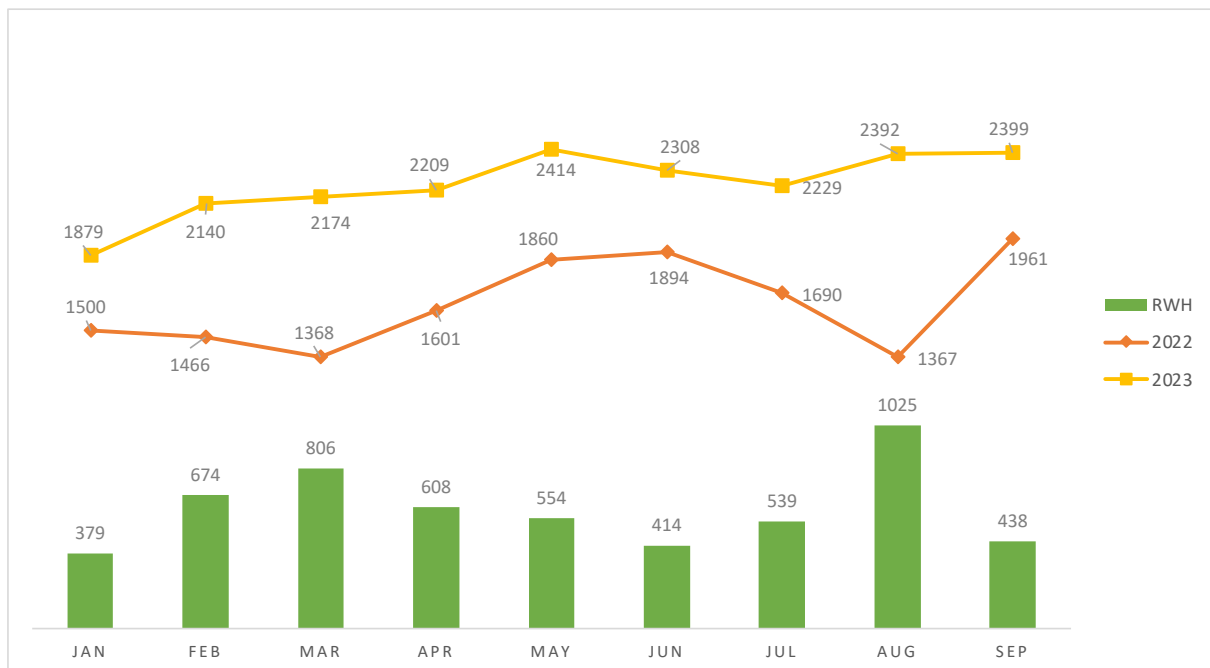
Table 2 show the saving of water usage after the implementation of Rainwater Harvesting system for toilet flushing and gardening at the public premise that has been choose as study area. It shows the average of water demand saving of 600m³ per month which could elaborate to 7200m³ per year.

Table 2. Water Usage Data before and after Rainwater Harvesting System installation

Month/Year	2022	2023	Saving
Jan	1879	1500	379
Feb	2140	1466	674
Mar	2174	1368	806
Apr	2209	1601	608
May	2414	1860	554
Jun	2308	1894	414
Jul	2229	1690	539
Aug	2392	1367	1025
Sep	2399	1961	438

Figure 2 shows that the data of water usage (m^3) for 2023 versus 2022 including the rainwater harvesting data (m^3). From figure it shows the values of water usage without rainwater harvesting system on 2022 was higher compare to 2023 after the implementation of rainwater harvesting system for the toilet flushing and gardening. The saving of water usage after implementation of rainwater harvesting are between 380m^3 to maximum of 1025m^3 based on demand usage of the month. This also have given cost saving to the premise between RM 20,000.00 to RM 22,000.00 per year or RM1,600 to RM 1,900 per month.

Figure 2. Data of Water Usage for 2022, 2023 and rainwater harvesting



4. Conclusion

In order to meet home demands and lessen reliance on the current water supply, rainwater collection systems are being used. The analysis of rainwater collecting systems in this study suggests that they have the ability to lower water supply demand and save up to RM1900.00 per month. However, more research on the storage capacity and location is required in order to realize that full potential. Rainwater harvesting helps to at least two of the three sustainable components of sustainability. It benefits the public premise economics and environment. It helps the environment by reducing runoff water and providing alternative water for domestic use. Because they have a backup water source, buildings equipped with rainwater harvesting system can also save money on water. Therefore, it proof that the rainwater harvesting system could be install as the one of initiative to reduce the demand of current fresh water from the water distributor and also sustain the water usage for the future. Save water, save money and save environment.

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