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# Effectiveness of Rainwater Harvesting System as Domestic use at Public University in Malaysia: A Review

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**Abstract**: A rainwater harvesting system is a method or technology that collecting and storing rainwater from the rooftop for portable and non-portable use. In 2006, the government announced that it is mandatory to implement the RWH system in large buildings like schools/institutions, factories, or bungalows. Universiti Tun Hussein Onn Malaysia (UTHM), UiTM Malaysia, and Universiti Malaysia Sabah are the institutions that were implementing the RWH system. This study was conducted to review the effectiveness of the rainwater harvesting system in terms of its economic benefits at public universities in Malaysia and highlight the issue when implementing it. Data for this study were collected from secondary data sources. All the data sets were identified through a secondary data source, and it will then be extracted to analyse by using a chart. From the findings, it shows that this system is effective in these three universities in terms of economic benefits where it helps to reduce the cost of water bills. The cost of water bills that can be reduced at Geotechnical Lab UTHM, Kolej Perindu 3 UiTM and, Block K KK Sri Angkasa UMS are as much as RM8690.40/year, RM10460/year and RM2309.71/year respectively. However, this study also has highlighted the issue arises when implementing this system. This system has been seen it is unable to meet the amount of water demand, lack of maintenance which leads the system to get clogged with contaminants and debris at the gutter that may block the water from entering the storage tank and causing the system could not function well. Lack of expertise in this fields also is one of the issues when implementing this system.

**Keywords**: Rainwater Harvesting System, Effectiveness, Water Bills, Public Universities

## 1. Introduction

Water is a fundamental human need that can be provided by surface water, groundwater, or rains. As the world's population expands, so does the demand for water resources, resulting in water scarcity

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challenges. Human activities such as drinking, washing, bathing, and cooking are all directly tied to water usage. We recently had a water scarcity, which has become a severe concern in Malaysia, particularly in the Klang Valley area. This issue might be handled by reducing water consumption and saving water during times of scarcity. One initiative has been established to address the global water shortage, and past research has indicated that adopting a rainwater harvesting system can help alleviate the problem. This system is one of the ideas of water resource sustainability and conservation that aids in resolving water scarcity situations. The rainwater harvesting system for portable and non-portable usage collects rainwater from the roof. [1] described rainwater collection as accessible water collection or storage from the area that use science approaches to gather or storing rainwater. RWHS has two categories: pond harvesting systems and rooftop harvesting systems [2]. They also noted that rooftop harvesting systems have been widely used than pond harvesting systems and that several studies have been conducted on their potential development benefits and applications.

Previous research has found the potential development, the benefits of the rainwater harvesting system, and the technique and treatment system in Malaysia. However, there is a lack of study on how this system could benefit an economy where this system could help reduce the cost of water bills in universities and a lack of study on the issues that may arise when implementing this system. In addition, problems may occur due to the lack of comprehensive guideline on the technique for implementing and maintaining the RWH systems. Thus, this study aimed to review the effectiveness of the RWH system in terms of its economic benefits at public universities in Malaysia and highlight the issue in implementing this system. Universiti Tun Hussein Onn Malaysia (UTHM), Universiti Teknologi Mara (UiTM) and Universiti Malaysia Sabah (UMS) are the universities that will be reviewed in this paper in terms of its economic benefits. These public universities were chosen because they are using the RWH system for domestic use.

## 2. Rainwater harvesting system in Malaysia

In Malaysia, RWH was established by the Ministry of Housing and Local Government in the form of Guidelines for Installing a Rainwater Collection and Utilization System in response to the 1998 drought that affected citizens of Klang and Langat Valley [1], [3]–[5]. According to their research, the purpose of the guideline is to minimise the dependence on the main water supply. The practice of the implementation the RWH system in Malaysia began when the government announced in March 2006 that it would become mandatory [5]. Many studies on the potential development of RWH systems as alternative water resources in Malaysia has been undertaken. National Hydraulic Research Institute of Malaysia (NAHRIM) began with three major pilot projects including a government building, mosque and residential house [1]. Table 1 show some study on the potential development of the RWH system as alternative water resources in Malaysia.

**Table 1: Previous research on the potential development of the RWH system in Malaysia**

| Item | Author | Research Title | Result |
|---|---|---|---|
| 1 | [1] | Potential Development of Rainwater Harvesting in Malaysia | • Malaysia has a very high quantity of rainwater sources, which is more than 2000m per annum. So, this has been seen that Malaysia have the potential to implement the rainwater harvesting thus it will help to reduce the environmental effect that will lead to the cause of flooding and health problem due to the overloading to the system.<br>• This method has been viewed as help in to minimise the reliance on treated water supply |

| | | | |
|---|---|---|---|
| 2 | [6] | Rainfall Analysis To Determine The Potential Harvesting Site In Kuantan, Pahang | • The result of the rainfall analysis shows that the maximum annual rainfall is 3682mm. This demonstrates that Kuantan can construct a rainwater collecting system due to the significant rainfall in the Kuantan river basin.<br>• It is shown that Kuantan has the potential to implement a rainwater collecting system due to the significant rainfall in the Kuantan river basin |
| 3 | [7] | Rainwater as a Potential Alternative Source of Water in Tanjong Malim, Perak | • Tanjong Malim was chosen as a good location for the RWH system because it receives the most rainfall in Peninsular Malaysia, with high intensity and frequency of rainfall each year.<br>• This method has benefited users by lowering usage costs, decreasing reliance on treated water supplies, and raising awareness among users about saving water and appreciating natural resources. |
| 4 | [4] | Rainwater Harvesting As An Alternative Water Supply In The Future | • This system will help in overcoming the water problem caused by increased demand for water supplies.<br>• Sandakan's successful implementation has demonstrated that this method should be encouraged since it will also enhance living conditions. |
| 5 | [3] | Utilizing Rainwater For Non-Portable Domestic Uses And Reducing Peak Urban Runoff In Malaysia | • This study found that rainwater systems can meet up to 34% of domestic non-portable household water requirements, with end ability for 5000 litres and 3000litres storage being approximately 65.5 percent and 61.4 percent, respectively.<br>• The peak storm runoff decrease at the catchment outlets is minor (10 percent) with the installation of the rainwater cum detention storage system at all residences, and it has been discovered that it may be reduced even more |
| 6 | [8] | Study On A High Rise Building Incorporated With Rainwater Storage Tank Towards Building Sustainable Urban Environment In Malaysia | • Using the RWH method for high-rise construction is a viable approach toward fulfilling Malaysia's future goals for a sustainable urban environment. |

2.1 Type of rainwater harvesting system

RWH can be categorized as in-field RWH (IRWH), ex-filed (XRWH) and domestic (DRWH) depending on the catchment system used [9]. Malaysia used domestic RWH where the rainwater was collected from the rooftop and kept in the storage tank either underground or aboveground [2], [9]. They posited that RWH might be divided into two effective systems, namely runoff rainwater and rooftop

rainwater. Rooftop harvesting systems are more familiar methods utilised and implemented globally due to their limited scale [2]. According to their findings, rooftop rainwater harvesting is commonly used to meet non-portable and portable water needs.

2.2 Advantages and disadvantages of aboveground and aboveground storage tank

Storage tank which also known as a cistern, stores and distributes rainwater collected from the roof. The storage tank will next be erected either aboveground or underground. An aboveground storage tank has been found that it is easy for maintenance work such as cleaning, easy to detect cracks or leaks occur, and it also does not require a pump in order to extract the rainwater harvesting as it allows gravity indirectly, which reduces cost when compared to an underground storage tank [10]. This sort of storage tank, however, may take up more space than underground storage tank.

Even though an underground storage tank may reduce the space, it requires a pump to extract the water from the rooftop where this will need more money to install the pump [10]. Moreover, it is also difficult to do the maintenance to discover the cracks and leaks, and it may also lead to the damage of the tank caused by the tree roots if the access point is exposed since it is placed underground.

2.3 Rainwater harvesting system benefits

The installation of the RWH system would benefit the environment, economy, and society. The study on the benefits of the rainwater harvesting system is shown in Table 2 below.

**Table 2: Benefits of RWH system**

| Categories | Findings | Location | Reference |
|---|---|---|---|
| Environment | Meet up to 34% of household water consumption and a 10% decrease in peak discharges as it may be reduced further if the system is installed in a residentials | Malaysia | [3] |
| | If the RWH is used in the urban catchment, 35 percent of the flooded area can be decreased. | Italy | [11] |
| | Rainwater harvesting aids in reducing reliance on treated water supplies. | Jordan | [10] |
| Economy | Water savings of an average of 29 percent and 18 percent were achieved for facilities in Slovakia and Poland, respectively. | Eastern Europe | [12] |
| | The rainwater harvesting system will be cost-effective and potentially save up to 21.6 percent of residential water consumption. | China | [13] |
| | Water bill savings of around RM10460 per year | Malaysia | [14] |
| Social | Installing this RWH system and functioning as a demonstration project may educate communities about the significance of water conservation. | Canada | [15] |
| | The use of the RWH system in public buildings will set a good | Brazil | [16] |

| | |
|---|---|
| example for the community by educating people about water conservation while also contributing to the social dimension of sustainability. | |

## 3. Methodology

### 3.1 Study Area

This paper will review the rainwater harvesting system at Universiti Tun Hussein Onn Malaysia (UTHM), UiTM Malaysia, and Universiti Malaysia Sabah (UMS) on its effectiveness in terms of its economic benefits. The rainwater harvesting system at UTHM was installed on the flat roof of Geotechnical's Lab at the Faculty of Civil Engineering and Built Environment [17]. Figure 1 shows the water runoff from the catchment area 1 and area 2 at Geotechnical's Lab UTHM. According to [17], this area were chosen because of the direction of the water that falls into the storage tank. The rainwater harvesting system at UiTM Malaysia was installed at Kolej Perindu 3, the male residential college [14]. While for the rainwater harvesting system at Universiti Malaysia Sabah (UMS) were intalled at two residential colleges: Kolej Kediaman Kampung E and Kolej Kediaman Sri Angkasa [18]. But, in this study, for UMS it only takes the data for Kolej Kediaman Sri Angkasa, Block K.

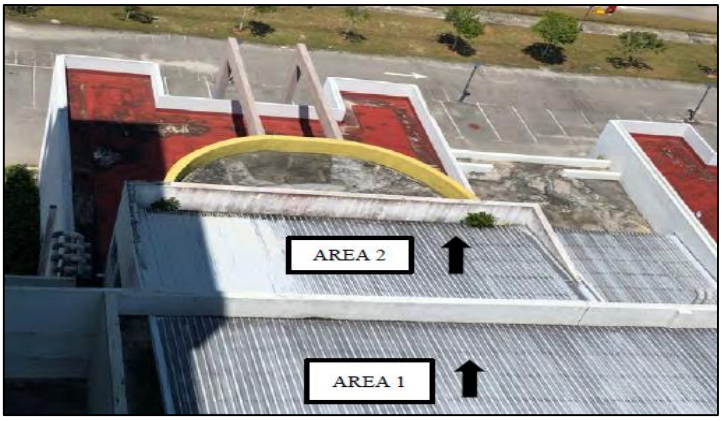


**Figure 1: The catchment area at Geotechnical Lab, UTHM [17]**

### 3.2 Research Method

This review paper used a quantitative approach for data collection and data analysis. As for data collection, this review paper used secondary data, which involves using existing data from other sources. For this study, secondary data set were identified from the different secondary data sources. After several data have been identified, it is vital to know the variables from the existing data sources complies with the research question. Several parameters have been identified and extracted from the existing data, and all the data are reliable and valid. The parameter identified and extracted are the value of catchment area, size of tank, water demand, average annual rainwater yield estimation, and water bills.

## 4. Finding and Discussion

### 4.1 Catchment area

The catchment area is the first thing that needs to be collected to know the size of the storage tank. Figure 2 shows the lowest value of the catchment area from the three universities are UTHM which is 410.15m$^2$, and the highest is UiTM, with 3000m$^2$. This is because the catchment area calculated at UTHM is not for the whole building, but it only takes at the area of the Geotechnical Lab where the RWH system was installed. While for UiTM, the catchment area is calculated for the whole building of

the Kolej Perindu 3. [7] stated that the extra widespread the roof size, the more rainwater could be harvested. This statement is also supported by [15], where they stated that if the result catchment area is genuinely enormous, a more prominent number of end-use applications could consider more water-saving.

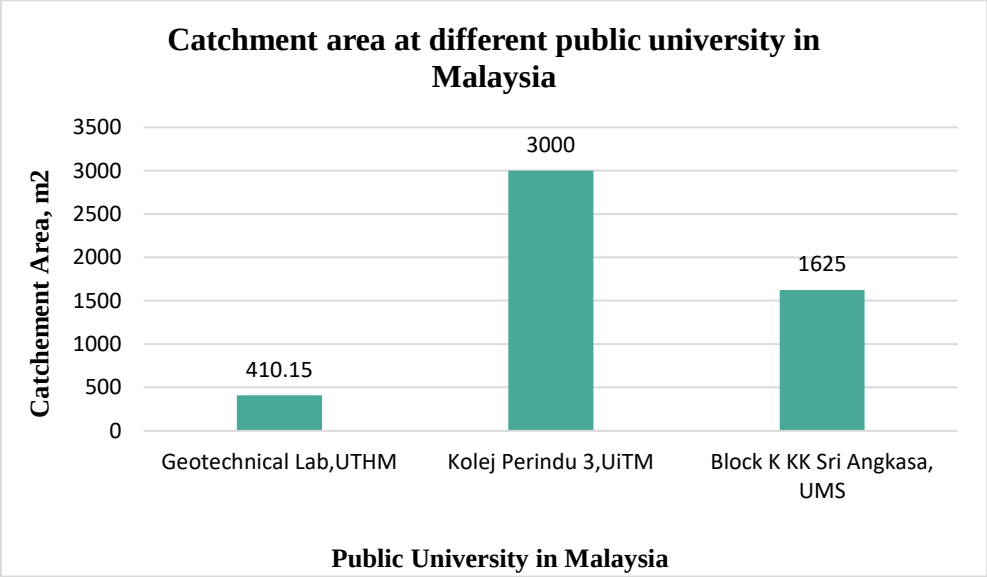


**Figure 2: Value of catchment area**

4.2 Tank Size

In order to collect rainwater, a water tank must be able to harvest rainwater effectively [7]. So, in order to design the water tank. Based on Figure 3 below, we can see that at Geotechnical Lab, UTHM has the enormous tank size, which is 45.6 $m^3$. The particular reason for the circumstances is that, the bigger tank size is needed to cater the average maximum volume of water runoff at Geotechnical Lab, UTHM, which is 3173 liters per day and could save a significant amount of harvested rainwater. This statement also has been supported by [22], where they discovered that bigger tanks would be more effective for optimizing water savings and that these tanks might yield considerable water savings. Conversely, Block K KK Sri Angkasa, UMS has the smallest size of tank, which is 16.3$m^3$, while the size of tank for Kolej Perindu 3, UiTM is 30$m^3$ with 90% reliability.

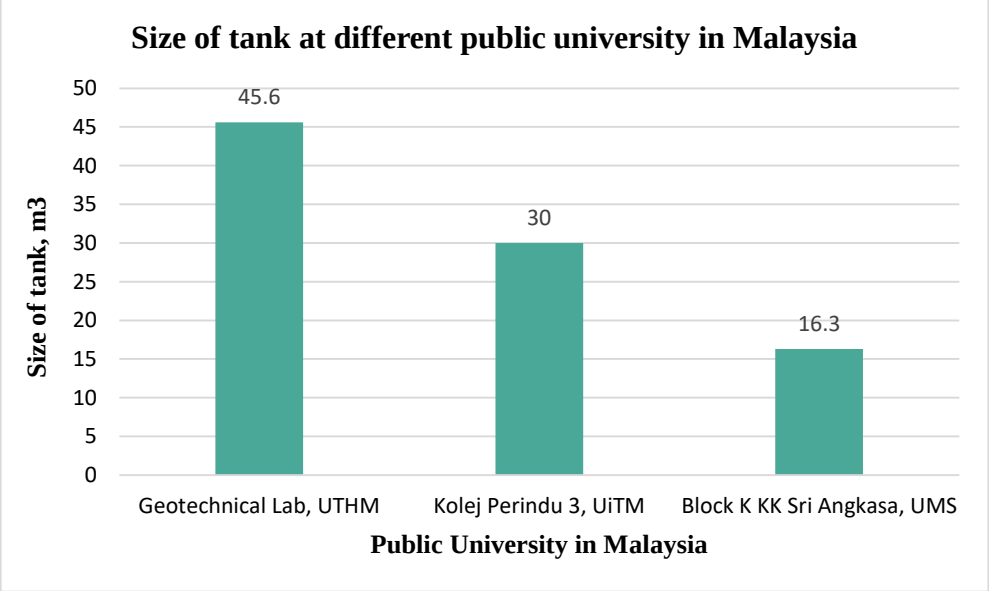


**Figure 3: Size of tank**

4.3 Water demand

Daily water demand is required to estimate how many liters of water the consumers have consumed. In this section, we need to consider several factors: the number of consumers using the same water source, the average consumption per person, and the range of uses for instance, bathroom, toilet flushing, laundry, etc.. [18]. From the graph in Figure 4, it can be seen that Block K KK Sri Angkasa, UMS has the highest value of water demand, which is 946660 liter/day, as the consumers at Block K KK Sri Angkasa, UMS use the water for toilet flushing, general cleaning and laundry as compared to UiTM where the consumer uses the water for toilet flushing. Thus, the value of water demand at Kolej Perindu 3, UiTM is the lowest, 17820 liter/day. Besides Block K KK Sri Angkasa, UMS also has many consumers, which is 896. This factor also has affected the highest value of water demand. On the other hand, the value of water demand at Geotechnical Lab, UTHM is 109224 liter/day, and the consumers use the water for toilet flushing, water taps and sink pipes.

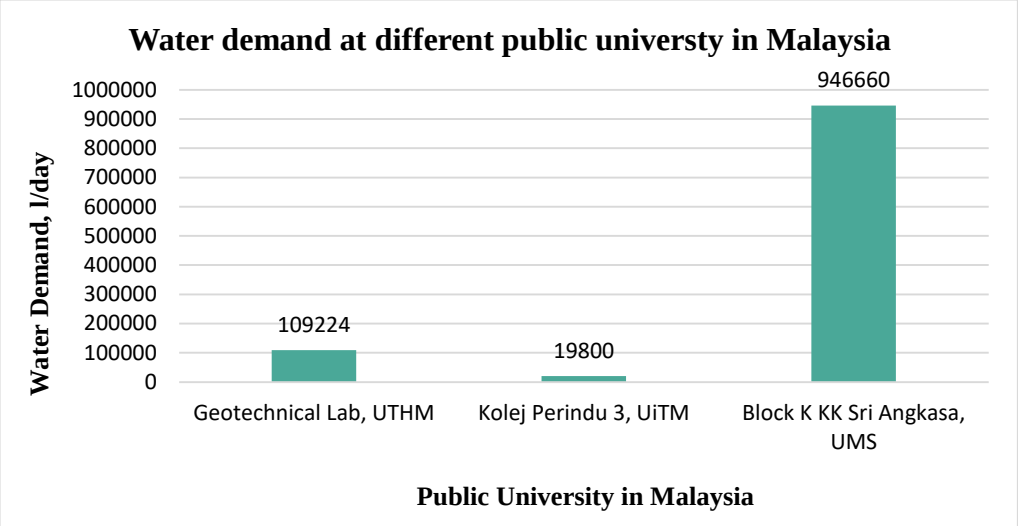


**Figure 4: Value of water demand**

4.4 Water Saving

Value of water saving is needed to know the amount of harvested rainwater that could cater to the water demand. The quantity of harvested rainwater depends on the tank size, where a larger tank can store more water [23]. Their study found that by using a tank size of $30m^3$ could save water as much as $1075m^3$ compared to a smaller size of tank. The volume of harvested rainwater in the tank will be sufficient to meet the water demand if the tank is appropriately sized [15]. The value of AARY for Geotechnical Lab, UTHM is $115m^3$ as the selected town is Kluang, $107m^3$ for Kolej Perindu 3, UiTM where the nearest town is Klang, and Block K KK Sri Angkasa, UMS, the AARY for Kota Kinabalu was used, which is $109m^3$. From the graph, as shown in Figure 5 below, the value of water saving for Geotechnical Lab, UTHM is $5244m^3$/year, while for Kolej Perindu 3, UiTM and Block K KK Sri Angkasa, UMS are $6500m^3$/year and $1776.7m^3$/year, respectively. Kolej Perindu 3, UiTM has the highest volume of harvested rainwater with a $30m^3$ size tank.

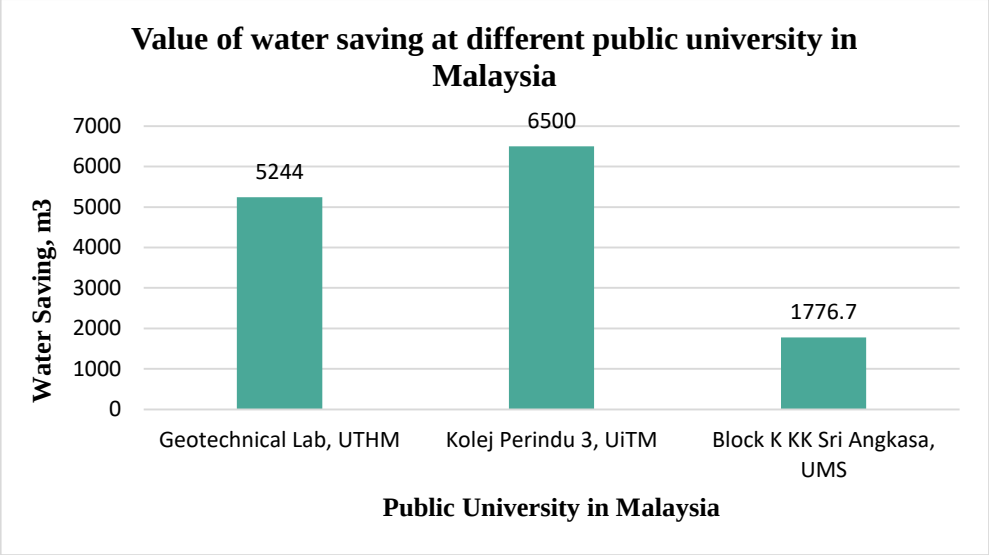


**Figure 5: Value of water saving**

4.5 Water bills

RWH system helps to reduce water bills [4], [7]. Water bills can be calculated by the volume of harvested rainwater multiplied by the latest water tariff [18]. Water tariff is based on the water authorities. As for UTHM, the water tariff is from Ranhill SAJ, for UiTM is from Air Selangor, while UMS is from Sabah State Water Department. RWH system was supposed to be more cost-effective with a higher water tariff [24]. Malaysia water tariffs are relatively affordable as compared to neighbouring nations [25].

Figure 6 shows the cost of the water bill that could be saved by implementing the RWH system. The cost of water bills that can be saved at Geotechnical Lab, UTHM, Kolej Perindu 3, UiTM and Block K KK Sri Angkasa, UMS are as much as RM8690.40/year, RM10460/year and RM2309.71/year, respectively. However, Kolej Perindu 3, UiTM has the enormous amount of water bills that can be reduced. This is because the RWH system at Kolej Perindu 3, UiTM could save the harvested rainwater as much as 6500 $m^3$/year where it is also the most significant value among the other two universities in this study.

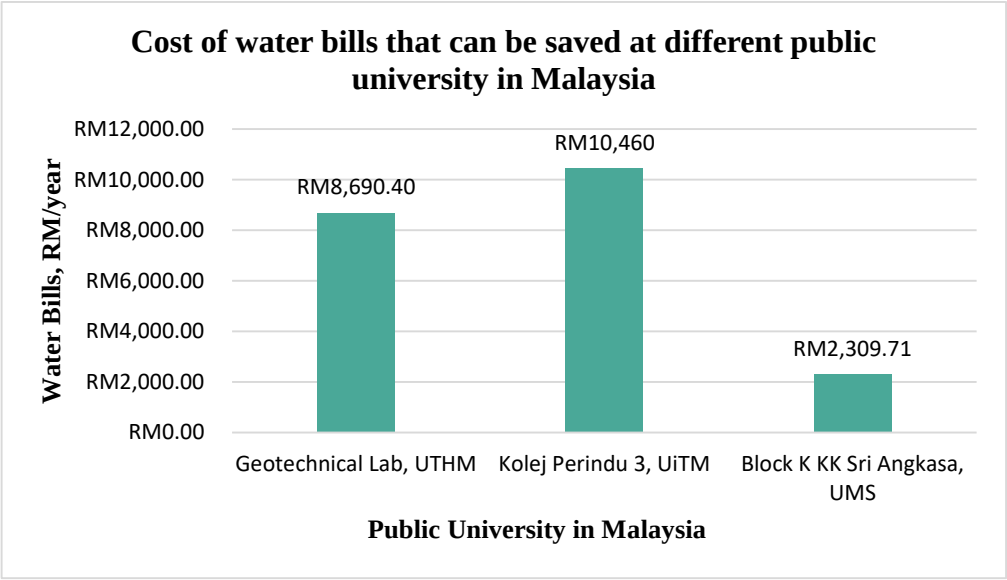


**Figure 6: Cost saving for the water bills**

This can be seen that the RWH system is effective in terms of economic, where it helps to reduce the cost of the water bills. This statement also has been supported by [26], where the RWH system implemented at Fairfield University helps to save 0.05% in water usage per year and save water bills as much as $51.14 per year.

### 4.6 Discussion

This study shows that the volume of harvested rainwater could not cater for the water demand for all the universities. This is due to the larger population and the average consumption per person using the different water sources. Nevertheless, the RWH system in those three universities has shown its effectiveness in terms of economic benefits, where it helps to save the cost for the water bills. As for Geotechnical Lab, UTHM, the cost for the water bills that could be saved is as much as RM8690.40/year as the value of harvested rainwater is 5244$m^3$, and the catchment area is 410.15$m^2$. At Kolej Perindu 3, UiTM, the cost of water bills that can be saved is RM10460/year. While, at Block K KK Sri Angkasa, UMS, the cost of water bills that can be saved is as much as RM2309.7/year with the value of harvested rainwater is 1776.7$m^3$, and the catchment area is 1625$m^2$. UMS has the lowest cost savings for water bills because the data taken for this study was only at Block K KK Sri Angkasa. Therefore, these universities have been proved that by implementing this system, it would give benefits in terms of economics where the RWH system helps to reduce the cost of the water bills and also helps to reduce the dependency on treated water supply.

Based on the literature review, it has been found that there is a problem arise with this system. [27] found that 91.7% of their respondent faced a problem when implementing this system. The major problem is that the system could not cater for the water demand. Another problem is in terms of its performance. This is due to the lack of maintenance of the system that affects the effectiveness of the system RWH system may be ineffective if other technical parameters, as such first flush volume are being neglected [28]. Moreover, [29] stated that inadequate maintenance of rainwater tanks could result in health hazards for individual users and the general public due to the spread of water-borne illness and possibly costly high impact. This system's major causes are lack of maintenance because of budget constrained and lack of expertise in this field [30].

[17] found that the existing rainwater harvesting system located underground near to the student's parking and aboveground at South Tower's rooftop at Faculty of Civil Engineering and Build Environment (FKAAB), UTHM were not functioning due to the internal problem of the pumps. It also happens at Municipal Court and Food Court, Seberang Perai where the RWH system is not functioning due to the pump problem and low water pressure [30]. Another reason why the RWH system at FKAAB, UTHM were not functioning was that the underground storage tank is not suitable for UTHM as the soil is acidic. This problem has affected the quality of rainwater where the water from the underground storage tank turns to reddish-brown water and is not saved from being used. The particular reason for the circumstance is lack of maintenance. This has been supported by [31] through a discussion where the deterioration in water quality was caused by system contamination due to lack of maintenance. This problem has also been found by[21] at Tun Dr Ismail College, UTHM where the harvested rainwater contains high Fe concentrations that lead to the brownification effect that will harm the residents. However, this system helps to reduce monthly water bills of the college up to a minimum of RM840 and reduces the dependency on the treated water supply.

## 5. Conclusion

Based on the study, the RWH system has been seen as effective in terms of economic benefits where it helps reduce the cost of the universities' water bills. Indirectly, this system also helps in reducing the uses of the treated water supply at these universities. However, based on the review, this system could not cater to the value of the universities' water demand, which means it's still need support from the treated water supply. Furthermore, some of the system could not function well due to the lack of maintenance and lack of expertise in this field. Based on this study, there are some recommendations to be proposed for further research. The recommendations are expected to help other researchers and practitioners give more attention and improve the effectiveness of the RWH system on its performance

as this study only focuses on its effectiveness in terms of economic benefits. The recommendations are as follow:

i. The storage tank's design size must be reliable to cater to the value of water demand. The reliability analysis can be carried out by using Tangki NAHRIM.
ii. A study on the maintenance organization in the university should be conducted to identify the maintenance work schedule for this system.
iii. Maintenance organization in the university should have a regular schedule in doing maintenance works for this system to maintain this system's life span.

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