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IeGRESAFE 2022

E-PROCEEDING OF

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"Sustaining the Resilient, Beautiful and Safe Cities for a Better Quality of Life"

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COMPARATIVE STUDY ON POTENTIAL DESIGN PARAMETER APPLICATION OF RAINWATER HARVESTING SYSTEM ON MOSQUES

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Abstract

Tropical regions like Malaysia receive year-round rainfall, making it an appealing alternative to use rainwater as a resource. This country gets more than enough rain throughout the year, with an average rainfall around 3,000 mm a year, solely contributed by the hot and humid equatorial weather. In Malaysia, Rainwater Harvesting System (RWHS) has enormous potential for application, particularly in areas where water is heavily used, such as mosques. This study focused on examine and identify similarity and differences in term of application of RWHS for two different type of mosque in Perak. By using the design parameters (DPs) selected for both mosques, it can be identified that the execution for implementing RWHS would contrast for both mosques. The initial findings indicate that there are a different traits implied depending on the type of mosques and site context of the surrounding location, where difference in both mosques would play a huge role in installing the system. Ultimately, RWHS have the potential to provide significant impact on improving water savings for both mosques, with regards to proper calculation and method of installation are carried out thoroughly.

***Keywords**: Design Parameters (DPs), Mosque, Rainwater Harvesting System (RWHS), Water Savings*

INTRODUCTION

Averaging precipitation of 3,000 mm of rainfall annually, Malaysia is considered fortuitous for the endless supply of rainwater that could be harvested for multiple use. According to Lani et al (2018), tropical regions like Malaysia receive year-round rainfall, making it an appealing alternative to use rainwater as a resource. Not only that, as rainwater generally has been confirmed polluting in most regions of the world due to numerous pollutants loads in the atmosphere, but due to the strategic location of Malaysia sandwiched between two seas, local rainwater have been tested and deemed safe for consumption.

Nonetheless, before these rainwaters can be used or consumed, the water needs to be treated first. (Mamum et al, 2014). This is to ensure the cleanliness and the quality of water supplied met the standard of safe consumable resources. According to Shaheed (2017) and WHO guideline (2006), the quality of rainwater gathered may be used as drinking water or used for ablution, especially where the main water supply system is not accessible or during a water crisis.

Previous research conducted on application of RWHS in mosques are not widely discussed, where there is still a lack of study on application and appliances of sustainable elements in religious buildings, though the latter consumes more water daily than any other public building category. Therefore, this study is intended to fill the gap of previous research in finding the potential of application for RWHS in mosques.

In order to investigate further the potential usage of RWHS in mosques, several selected design parameters need to be adopted on mosques to ensure the application would be met optimisely. These design parameters are chosen according to the Malaysia Standard (2014) and Darus (2009) data, where the parameters chosen for this study are i) rainfall data, ii) water demand, and iii) catchment area. Hence, this study aim to do a comparative study on potential DPs of RWHS on two selected mosques in Perak, which is Sultan Idris Shah II Mosque (SISIIM) and Sultan Yusuf Izzudin Shah Mosque (SYISM).

LITERATURE REVIEW

Definition of Rainwater Harvesting System

RWHS is a word used to describe any device that collects rainwater with the intention of turning it into reusable resources. Rainwater harvesting systems (RWHS) utilised to capture, transport, and store rainwater from roof catchment and floor surface into storage tanks for both potable and non-potable applications. In order to impose both application of water usage throughout the building it applied on, a proper rainwater system is needed.

Rainwater from the roof travelled to a collection tank through gutters and downpours. The filtering system receives the rainwater that has been pushed by a pump through a flow section. The storage tanks afterwards held the pure rainwater. The amount of rainfall was distributed to each system using a piping system. To route the fluid, piping systems use pipes of varying diameters joined together by various fittings or elbows, valves to regulate the flow rate, and pumps to pressurise the fluid.

Design Parameters for Rainwater Harvesting System Application

Rainfall Data

The primary input parameter used in the design of RWHS is rainfall data. The estimation of design parameters, particularly storage capacity and catchment area, requires appropriate rainfall analysis. In reality, large portions of the nation are subject to monsoon winds, and they frequently experience floods each year (Chan, 2009). Due to differences in rainfall distribution across years, the frequency distribution of monthly rainfall totals does not match yearly totals at the same likelihood of rainfall occurrence (Njepu, 2018).

This component is the most critical one in design parameters before applying RWHS to any buildings since it will decide if the building is appropriate for employing RWHS or, maybe, whether its location makes it possible for it to be. Even if all the other factors support the application of RWHS, if the rainfall data indicates differently, it will not be possible to maximise the system's efficiency. The purpose of the rainfall data is to analyse the pattern and range of precipitation so that the total amount of captured rainwater may be estimated.

Water Demand

The rainwater demand depends on several factors, which includes the number of people using the water; average consumption of water per person; and the range of uses including ablution, bathroom, toilet, drinking and other applications. Each application requires different amount of water, depending on the urgency and frequency of usage. There are several empirical models that may be used to gauge the water demand of a certain building. The first approach would include using the Ordinary Least Squares (OLS) algorithm to block rate tariffs (Pavelescu, 2004). This system would operate under the presumption that all water used by the structure, both potable and non-potable, is recorded in the water bills. Price is the explanatory variable that has received the most emphasis in the majority of the economic research on water demand estimation due to its usefulness in explaining water consumption and the methodological challenges created by block rate tariffs.

Catchment Area

The first surface area where rainfall would be gathered. The catchment region with the largest, hardest, smoothest component is the roof. The size of the catchment surface, the slope of the catchment area, and the material of the catchment utilised will all affect how much rainwater is collected. The area exposed to rain and water runoff are used to calculate the mosque's roof's catchment area (Mzirai & Tumbo, 2010). The approach for the mosque's rooftop catchment area for RWHS is also employed at the home level, which is often used for domestic reasons. A collecting or catchment plan typically consists of a simple structure, such towers or gutters that guide rainfall into the storage container. Roofs are ideal for use as catchment areas because they can easily gather huge amounts of rainfall (Khoury Nolde, 2008).

Implementation of Rainwater Harvesting System at Mosques

Mosque is an important institution for Muslim to unite people physically, social contexts and human spirituality to perform the worship and the center of Muslim life. Many mosques have been recorded to have high water bills, and are currently trying to adapt to a new source of water. Many mosques are attempting to switch to a different source of water since they have been reported to have hefty water bills. Only 13% of Malaysia's mosques and suraus, however, get their water from RWHS, an alternate source. This demonstrates that despite increased knowledge among the mosque management committee, there are still many mosques that have not adopted modern water-saving technologies and the potential to implement RWHS at mosque (Yendo et al., 2015). In term of applying RWHS into mosques, there are two methods of installation; retrofit older mosques and implement the system in the newer constructed mosques during schematic design phase.

METHODOLOGY

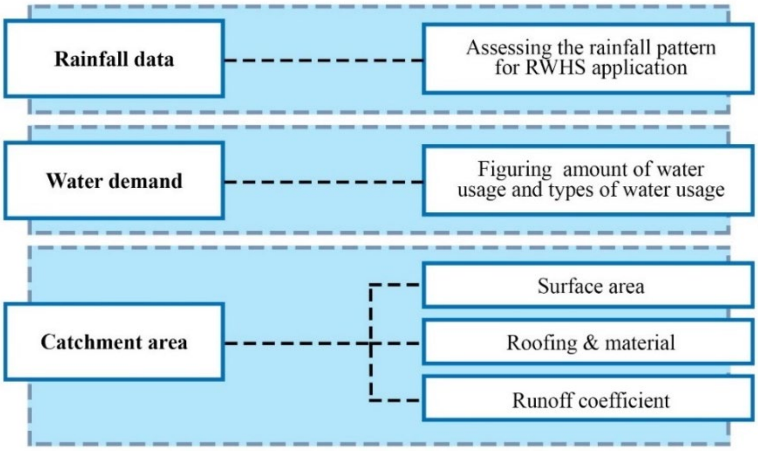
Field Observation for Case Study

The system has been applied on religious institutions like mosques, and a major portion of the cases in which this has happened are identified using the field observation technique. The technique used in this case study is centred on locating possible design parameters for RWHS in mosques and putting forth a workable design for RWHS in mosques based on qualitative data. The case study observation must take into consideration the specific conceptual design and additional design parameters of the applicable RWHS being deployed on site. Making ensuring that the design parameters identified by the SLR match the current RWHS design parameters in Malaysia is crucial. As mentioned earlier, the mosque selected for this study would be SISIIM and SYISM, both located in Perak, with the former in Ipoh and later in Seri Iskandar.

Document Analysis

Document analysis is a method of collecting data in order to assess or analyse various types of documents (Bowen, 2009). Case studies, for example, can be created using document analysis methodologies to generate detailed descriptions of a specific programme, event, or phenomena. (Yin, 1994). The purpose of the document analysis in this study is to acquire extra data needed to complete the data analysis for the study's aim, which is to suggest the correct design of RWHS at two mosques. According to Bowen, the document analysis approach was chosen for this study because it is less time consuming to collect data, it is cost effective because the documents are easier to obtain, and it provides precise information (2009). Other than that, Tangki NAHRIM software was also used to analyse the data and producing the adequate sizing for water tank.

Figure 1
Potential design parameters of RWHS for Site Study Selection.



RESULTS

Both mosques have difference and similarities in term of applying components, in which the discussion would elaborate further regarding the findings.

Table 1
Comparative data of Case Study of implementing RWHS at SISIIM and SYISM

Components	Sultan Idris Shah II Mosque (SISIIM)	Sultan Yusuf Izzudin Shah Mosque (SYISM)
Image		
Location	Ipoh, Perak	Seri Iskandar, Perak
Maximum capacity	2,500 pax	3,000 pax
Rainfall Data	2806.34 mm	1995.7 mm
Water Demand	18,000 litres (18 m^3) daily	13,000 litres (13 m^3) daily
Catchment Area	545 m^2	1764 m^2
Storage tank	60, 000 litres or 60 m^3	80, 000 litres or 80 m^3

Based on all the design parameters selected for both mosques, it can be calculated for the total efficiency of the RWHS applied. The calculation for efficiency would take consideration based on the total amount of daily water demand, as well as the efficiency of the size of water tank chosen, in which the overall amount of water sufficiently able to be harvest would be as follows:

Table 2
Comparative data of the system's efficiency at SISIIM and SYISM

Efficiency component	Sultan Idris Shah II Mosque (SISIIM)	Sultan Yusuf Izzudin Shah Mosque (SYISM)
Water demand estimate *(using Block Rate Tariff Method)*	18,000 litres (18 m^3) daily	13,000 litres (13 m^3) daily
Storage tank expected capacity	60, 000 litres or 60 m^3	80, 000 litres or 80 m^3
Storage tank efficiency (ability to sustain enough water over time)	Only 8.5% of the time, the tank will be at 50% capacity or more	51.1% of the time, the tank will be at 50% capacity or more
Water demand expected	9,383.9 litres (9.4 m^3) daily	12,930.66 litres (12.9 m^3) daily
Water demand percentage	52.13% of the total water demand estimation	99.46% of total water demand estimation
Target GBI efficiency	30%	30%
Water-saving efficiency (Based on Tangki NAHRIM 2.0 results)	15.64%	29.84%
Total cost saving	RM 96.58 monthly	RM 130.68 monthly

As the table shown above, the data suggests that SISIIM would fall in term of efficiency, as it manages to grasp roughly 16% efficiency, as opposed to SYISM, which scores almost as close as targeted highest point in GBI rating tools with almost full mark of 30% efficiency. Based on the estimation of water demand for both mosque, SISIIM would only manage to meet half of the demand, while SYISM would able to fully meet the requirement. This would result in greater amount of money save in term of monthly water bills, without having to discuss the total cost of implementing RWHS for both mosques. Based on the average monthly water bills, although SISIIM have lower bill than SYISM, the later have a higher amount of cost saving, which subsequently directly proportional to the water-saving efficiency.

The bar set for 30% could also be increased for both mosques if certain design parameters and components were to improvised and proper thought and consideration are put into during the final stage, such as the catchment area and storage tank, as this would largely effect in term of placement of storage tank, cost of overall system implementation and availability of catchment area.

DISCUSSION

In order to discuss the design parameters selected for implementing RWHS for both mosques, each design parameters will be extracted individually to assess the outcome. Each component within the design parameters would vary for both mosques, as according to the scenario and location of both sites.

Rainfall Data

Perak have been blessed with high rain precipitation throughout the state as both mosques manage to achieve the appropriate level of 2000mm rainfall. These would allow the system to run to sufficiently without any mishap and likely to prevent damage due to droughtiness and lack of water in the storage tank. Therefore, this design parameters should be the first data to collect and study to ensure a proper RWHS could be implemented.

Water Demand

Both mosque are classified as state and district mosque, which is known to be in a vast amount of community. This ensures that the water demand of the location are adequate and sufficient enough to implement the system while able to save cost in term of water bill. Having smaller community or congregation members would result in small amount of water demand, thus having insignificant use of the system. But this does not justify that the system merely applicable for large mosques. The system proves to be efficient in any form of building that have high percentage of water usage, regardless of the state of the building. Therefore, it is imperative to acknowledge the water demand to ensure adequate of treated rainwater supply for the public use.

Catchment Area

This design parameters is within its own category as this parameter may have notably large variables, as this reflect the total design package of the mosque. In this research, the study aims to use available rooftop area as a base for catchment area, without having the construct additional structure or major renovations required. This is to ensure that the design parameters are reliable and can be applied to any mosque structure regardless of the rooftop design schemes. But the consequences faced by SISIIM mosques is that there are not enough rooftop catchment area that could hold enough rainwater to be collected and met the water demand. In this scenario, there are many possibilities to solve the issues, but most of them would require large sum of money to implement. As costing of the system is in the limitation of this research, the variety of solutions that could be implement to ensure sufficient catchment area would be having floor level runoff as a catchment area.

CONCLUSION

From the findings of this research, it can be concluded that RWHS has the potential to have a significant impact on improving the performance of global water supply system when applying all of the design parameters highlighted. All factor-related and components mentioned in regard with the design parameters aspects must be considered to avoid system loss and damage, in which involve both field observation and calculative measurements. By ensuring all components met the requirement, a proper RWHS can perform up to the standard in the long period run effortlessly. This research has proven that in order to implement RWHS for water savings, it is viable at the category of state mosques and district mosques, where all the design parameters can be met. This method can be replicated for other mosques which have capacity and capability to adopt the system, as mentioned in the Quran,

"And those (whom Allah is pleased with) who, when they spend their wealth, are not extravagant and are not niggardly; and (on the contrary) their expenditure is rightly moderate between the two means (wasteful and stingy)." (Al-Furqan, verse 67)

This proves that there are possibilities in having savings in daily use of the mosques, and where there are possibility to ensure the savings, it can be done as long as it does not disrupt or any inconvenience happen throughout the process.

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