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# e-Proceeding

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# DESIGN PARAMETERS FOR INSTALLING RAINWATER HARVESTING SYSTEM (RWHS) FOR MOSQUES: A SYSTEMATIC LITERATURE REVIEW ANALYSIS

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## Abstract

The function of Rainwater Harvesting System (RWHS) has been expanded tremendously throughout the years with the latest equipment and current technology. Multiple buildings, such as government buildings and others have been equipped with this system. Previous studies have also proven that collected rainwater can be used for non-potable and potable water. In Malaysia, based on the available rainfall supply, there is a tremendous potential of RWHS usage, especially for buildings that use water the most, such as mosques. Nevertheless, the current RWHS design guidelines and practice in Malaysia regarding implementation in mosques, either existing buildings or newly constructed ones are inadequate. RWHS components are already available in the market, but since all buildings have different water usage and multiple setbacks, a study is needed in order to single out a specific usage of RWHS for mosques. Thus, a systematic literature review (SLR) was carried out to identify the design parameters of RWHS suitable for mosques. A total of 25 articles were abstracted from Scopus, Science Direct, and Google Scholar databases for the SLR. The result shows five design parameters that can be employed to suitably implement RWHS in mosques.

**Keywords:** *rainwater harvesting system (RWHS), design parameters, systematic literature review (SLR), mosque*

## 1.0 INTRODUCTION

The use of water in relation to population development has risen by more than two occasions since the last century. It is expected that water demand will rise by 50% in developing and 18% in advanced nations in 2025. According to Burek et al. (2016), the global population is expected to increase in the range between 8.4 and 9.8 billion people in 2050, and there are 73% of people affected with the water crisis in Asia alone. Malaysia gets an average precipitation of 3000 mm of rainfall which is converted into a peninsular of 566 billion m3, with an estimated 900 billion m3 of water supply runoff dispersed into the river system (Ya'Acob, 2018; Chan, 2004). Malaysia has a current population of 32 million and 75.5% live in metropolitan areas while 24.5% live in rural areas (National Hydraulic Research Institute of Malaysia (NAHRIM), 2017; Ying, 2019). The growing population is anticipated to aggravate the water crisis, because it is estimated that in 2050, Malaysia will have a population of 43 million people and the demand for treated water will grow to 18.2 billion m3 (Shaheed et al., 2017). RWHS can be defined as the collection and storage of rainwater for use rather than to waste it as runoff. The usage of rainwater has been widely introduced by the government as a reliable alternative to reduce and minimize the consequences of water scarcity (Norman et al, 2019).

Rainwater is also an attractive solution to be utilised as raw water sources for clean water (Shaheed & Mohtar, 2015). It was found that implying rainwater as a water resource has many economic, environmental, technological, and social advantages. For example, rainwater provides an alternative water resource for technology and social benefits and reduces the health risks associated with water. Meanwhile, up to 34% of national water use and 10% decrease in peak consumption are met for environmental advantages if all households in the residential region are fitted with RWHS.

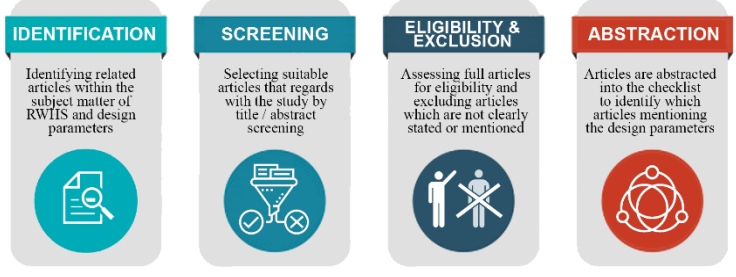
## 2.0 ISSUES

In the past research, the use of rainwater harvesting in mosques was not widely discussed (Gheethi, 2017). Besides, there is still insufficient study of the applications and appliances of sustainable elements in religious buildings especially for mosques and *Surau* in Malaysia. Although 13% of mosques in Malaysia are already equipped with RWHS, comprehensive studies on the application of RWHS of all those mosques have never been carried out extensively (Eusoff, 2016).

Mosques are considered as a building that produces a high amount of potential reclamation of water. These buildings allow the public to use water for ablution, and provide toilets and bathrooms for public usage for free. Mosques also use water for landscaping and kitchen or pantry at the mosque. Therefore, the objective of this study is to fill the gap of previous research in finding the potential application for RWHS through the study of design parameters suited for mosques.

## 3.0 METHODOLOGY

For this study, the method in determining the design parameters would rely on articles mentioning design parameters of RWHS for mosques. The systematic literature review approach is best suited to evaluate these articles. Systematic literature reviews (SLR) are, according to Amos et al. (2018); a method of studying literature review using descriptive techniques for collecting secondary data, assessing studies critically and qualitatively, or a quantitative data synthesis. The results would then suggest a suitable design that would not only be suitable to be implemented in mosques, but would also create new RWHS components for mosque typology. The SLR method consists of four phases as shown in Figure 1.




**Figures 1: Data collection and screening flow phases for SLR**

(Source: Liberati et al., 2009)

## 4.0 RESULTS

### 4.1 Phase 1: Identification

The first phase of PRISMA is to determine sources of literature. For the purpose of this study, three databases were adopted which were Scopus, Science Direct, and Google Scholar. These databases display search results of research published, authors, article sources, research titles, abstracts and many more. In order to find the right articles for this

study, a keyword search was needed. Table 1 below shows the keywords used for the three databases

**Table 1. SLR (PRISMA) keyword search**

| Database | Notes |
|---|---|
| **Scopus** | "rainwater harvesting system", "design parameters", "mosques" "RWHS components" "mosque retrofit" |
| **Science Direct** | "rainwater harvesting system", "design parameter for rainwater harvesting system" "mosques", "RWHS components", "RWHS" |
| **Google Scholar** | "rainwater harvesting system", "mosques", "design parameters for RWSH", |

(Source: Authors' research, 2019)

### 4.2 Phase 2: Screening

The second phase was to identify articles that arose based on the keyword search on each database. This screening method was crucial to find the right articles and abolish any non-related articles that may disrupt the literature review of this study. After a thorough filtration process of full-text assessment, out of 64 articles which were found, only 25 articles were selected for this study by considering several criteria and keywords components.

### 4.3 Phase 3: Eligibility & Exclusion

At the third phase, the selected articles were tabulated according to the main study, which is to find the design parameters. Any articles that were or were not mentioned would then be categorised as either eligible for PRISMA or excluded from this study. The results of eligibility and exclusion of the extracted articles were then summarised and tabulated as shown in Table 2.

**Table 2. Design parameters of RWHS**

| No | Design Parameters / Authors | Year | Catchment area | | Conveyance system | | | Filtering & treatment system | | | Storage tanks | | | Delivery system | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Rooftop | Ground cover | Indirect pump | Direct pump | Gravity fed | First flush | UV filter | Sand filter | Size | Placement | Material | To main water tank | To new water outlet |
| 1 | Norman et al | 2019 | √ | | | | | √ | | | | | | | |
| 2 | Juliana et al | 2017 | √ | √ | √ | | | | | | | √ | | | |
| 3 | Ward et al | 2008 | | | √ | | | | | | √ | √ | √ | | |
| 4 | Sharafaddin et al | 2017 | √ | | | | | √ | √ | √ | √ | | | √ | |
| 5 | Md Lani et al | 2018 | | √ | | | | √ | | √ | √ | √ | √ | | |
| 6 | Obaidullah, R. | 2018 | √ | | | √ | | | | | √ | √ | √ | | |
| 7 | Basinger et al | 2010 | | | √ | | | √ | | | | | | | |
| 8 | J. S. Mun et al | 2011 | √ | | | | | √ | | √ | √ | √ | | | √ |
| 9 | Zakaria et al | 2004 | √ | | √ | √ | | √ | | | √ | | | | |
| 10 | Zankowski et al | 2014 | √ | | | | √ | | | | | | | √ | |
| 11 | Gikas et al | 2012 | | | | √ | | | | | √ | | √ | | √ |
| 12 | Sunar et al | 2018 | | | √ | | | √ | | | √ | √ | √ | √ | |
| 13 | Fayez et al | 2009 | √ | √ | | √ | | √ | | | √ | √ | √ | | |
| 14 | Thamer et al | 2007 | | √ | | | √ | √ | | √ | | √ | | | |
| 15 | Ju et al | 2012 | √ | √ | √ | | √ | √ | | | √ | √ | | | |
| 16 | Sampat et al | 2018 | √ | √ | √ | | | √ | √ | | √ | | √ | | √ |
| 17 | Susilo, G. E. | 2018 | √ | | | | | √ | √ | √ | | | | √ | √ |
| 18 | Kassim et al | 2017 | √ | | | | | √ | | √ | √ | √ | | | |
| 19 | Neto et al | 2012 | √ | | √ | √ | | √ | | √ | √ | | √ | | |
| 20 | Vieira et al | 2013 | | | | | | √ | √ | √ | | | | | √ |
| 21 | Nazahiyah et al | 2008 | √ | | | | | | | √ | | | | √ | |
| 22 | Husna et al | 2015 | | | √ | | | √ | | | | √ | | √ | |

| No | Design Parameters / Authors | Year | Catchment area | | Conveyance system | | | Filtering & treatment system | | | Storage tanks | | | Delivery system | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Rooftop | Ground cover | Indirect pump | Direct pump | Gravity fed | First flush | UV filter | Sand filter | Size | Placement | Material | To main water tank | To new water outlet |
| 23 | Hashim et al | 2013 | √ | | √ | | | √ | | | √ | | | | |
| 24 | Stringer et al | 2005 | √ | | √ | | | √ | | √ | √ | √ | | √ | |
| 25 | Jordan et al | 2008 | √ | | | | | | √ | √ | | | | √ | |
| TOTAL | | | 17 | 6 | 11 | 5 | 3 | 18 | 5 | 11 | 15 | 12 | 8 | 8 | 5 |
| | | | 23 | | 15 | | | 34 | | | 35 | | | 13 | |

(Source: Authors' research, 2019)

Table 2 shows a list of twenty-five articles that mentioned the design parameters of implementing RWHS from which five main components were tabulated. Each parameter was mentioned in the articles listed and every parameter has their individual components that will be discussed in the next phase.

### 4.4 Phase 4: Abstraction

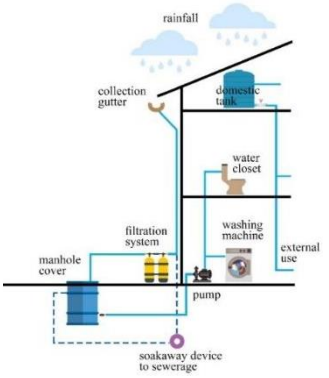
In the final phase, the abstraction of every component was discussed and the design parameter of RWHS was addressed. Each parameter consists of components that may arise on suitability and the major factors needed to ensure that the collected rainwater can be used for the mosque, either for non-potable usage, such as cleaning, flushing and maintaining landscapes; or for potable usage such as drinking or performing ablution.

*Catchment Area*

The first parameter mentioned is the first component that would be used for RWHS, which is the catchment area for rainfall. As the articles suggest, the most suitable option would be the rooftop area, instead of ground catchment, as it is the most available catchment without having to have additional renovation or modification. Regardless of the rooftop being at an angle or a flat surface, it can still be the main component to catch water droplets that would be captured on a higher ground, reducing the usage of extra pump mechanism.

*Conveyance System*

Based on Table 2, the three components for the conveyance system would be indirect pump, direct pump, and gravity fed system. These are the systems specified by NAHRIM as the best ones to be implemented in mosques. Each system has its own merit, although the most mentioned is the indirect pump system. Indirect pump system is a low-cost pump system with a low maintenance cost and great energy efficiency.




**Figures 1: Indirect pump system**

(Source: Author's research, 2019)

For indirect pump systems, the rainwater is initially held in a storage tank and then pumped to a header tank within the building, which is located within the roof area. The advantage of this system is that if the pump fails, the water will still be able to be supplied to the associated fixtures and fittings via the main top-up function. Even in the event of power failure, it is still possible to flush the toilet. Although water pressure is lower than direct pump, which would lead to slow fillings of water closet cisterns, it is still considered the best option as mosques are not meant to be used every hour; it is usually visited only during the five prayer times a day. Its user-friendly feature and low maintenance cost were also the reason this system was often listed in most articles in Table 2.

*Filtering & Treatment System*

In order to ensure hygiene and suitable usage of rainwater, a filtering and treatment system is needed. Although filter and treatment are a secondary option depending on how the water will be used, either potable or non-potable; most of the articles opted for first flush system. First flush system eliminates and washes accumulated contaminants such as bacteria, mold, and heavy particles from entering the water tank. The first flush diverter, a simple contraption, usually a standpipe, allows this debris-containing water to be diverted from entering the cistern. Sand filter is the secondary stage as it further filters the water particles from microorganism and dirt. At this stage, the water is suitable for non-potable use. A third stage is UV Screening which is intended to kill bacteria and harmful contaminants, and makes the water suitable for potable use. If the mosque intends for exterior use of cleaning, flushing and landscaping, a second tier is the best option. But if the rainwater is needed for ablution and drinking, the third tier filtration is needed to ensure safe water consumption.

*Storage Tanks*

The chosen tank where collected rainwater is stored must first meet the requirement of safety hazard and is free from harmful chemicals. Usually the storage tank is the most expensive component of the rainwater harvesting system that requires careful design and construction. Although all of the factors for storage tanks mentioned above is important, the sizing and placement of tanks are the most important. This is to ensure economical and well-calculated fittings for the mosque. The size and placement of the tank will be calculated based on the catchment area as well as the amount of water fittings of the mosques. In terms of materials, as there are various readily available materials of tanks to choose from, it is mentioned the least in the articles above. In order to ensure adequate and economical flow of usable rainwater, a two-tank method is needed. The first tank is primarily used for collecting rainwater, while the second tank is used to store filtered water, which would then be flowed to the associated outlet. In the event of overflowing rainwater, the first tank would be used to flush out excess water, without having to waste any water in the second tank. In the case for a

mosque, the placement of both tanks may vary according to the size and location available in the perimeter.

(a) Frontage System

(c)Backyard System

**Figures 2: Typical RWHS designs of (a), (b) and (c) has implemented in Malaysia (source: NAHRIM, 2011)**

*Delivery System*

In most of the articles studied above, the delivery system was the least mentioned, as most of the articles highlighted the way and method of the system, and the delivery output is merely relying on the available materials, location of access, and amount of outlet required. The delivery output may vary upon certain types of building usage and the flexibility of mounting new water outlets. In the case of applying it for a mosque, it is advisable to flow the rainwater to the main tank, which would not only reduce the cost of erecting a new water outlet from the system, but is also economical in terms of the construction cost.

## 5.0 CONCLUSION

This systematic literature review acknowledged the design parameters needed to implement RWHS for mosques. This system has been proven effective and sustainable in other buildings. Since mosques utilise water the most for ablution and toilets during the prayer times, it can potentially be implemented, either by injecting this system during designing stage or even post-construction of existing mosques. Having studied the design parameters, the authors' opinion is that there are possibilities in implementing such a system to any other building as well, as long as there is some consideration towards the water demand, methods of implementation, and other factors that would lead to the design parameter of RWHS. It can be concluded that these parameters are most highlighted in the articles mentioned above which further proves the need of RWHS implementation for mosques. Therefore, architects and people in charge of implementing such procedures should focus on these parameters without having excessive study or little exploration.

## REFERENCES

Amos, C. C., Rahman, A., Karim, F., & Gathenya, J. M. (2018). A Scoping Review of Roof Harvested Rainwater Usage in Urban Agriculture: Australia and Kenya in Focus. Journal of Cleaner Production, 202, 174–190.

Bassinger, M., Montalto, F., Lall, U. (2010) A Rainwater Harvesting System Reliability Model-based on Non-Parametric Stochastic Rainfall Generator, Journal of Hydrology 392. 105-118

Burek, P., Langan, S., Cosgrove, W., Fischer, G., Kahil, T., Magnuszewski, P.Wiberg, D. (2016). The Water Futures and Solutions Initiative of IIASA. 23–26.

Che-Ani. A. I., Shaari, N., Sairi, A., Zain, M. F. M., & Tahir, M. M. (2009). Rainwater Harvesting as an alternative water supply in the future. European Journal of Scientific Research, 34(1), 132-140.

Eusoff, Y. A., Jusan, M. M., Denny, M., & Ghani, N. A. (2016). The application of green technology principles in resource conservation of mosques in Johor and Terengganu. Man in India, 96(12), 5323–5336.

Fayez A. A., Al-Shareef, A. W. (2009) Roof Rainwater Harvesting Systems for Household Water Supply in Jordan. Published by Elsevier B. V. 195-207 (Desalination 243)

Gikas, G. D., Tsihrintzis, V. A. (2012). Assessment of Water Quality of First-Flush Roof Runoff and Harvested Rainwater, Journal of Hydrology. 466-467

Hashim, H., Hudzori, A., Yusop, A., Ho, W. S. (2013). Simulation based Programming for Optimising of Large Scale Rainwater Harvesting System: Malaysia Case Study. Resource, Conservation and Recycling Journal 80. 1-9

Husna, A. Z., Antaryama, I. G. N., Nastiti, S. (2015) Optimising Rainwater Harvesting System for Hotel Design at Humid Tropical Climate. International Journal of Education and Research Vol. 3, No. 6 335-344

J.S. Mun & M.Y. Han (2012). Design and Operational Parameters of a Rooftop Rainwater Harvesting System: Definition, Sensitivity and Verification. Journal of Environmental Management 93(1):147-53.

Jordan, F. L., Seaman, R., Riley, J. J., Yoklic, M. R. (2008) Effective Removal of Microbial Contamination from Harvested Rainwater using a Simple Point of use Filteration and UV-Disinfection Device. Urban Water Journal Vol. 5, No. 3, Environmental Research Laboratory, Soil, Water and Environmental Science Department, College of Agricultural and Life Science, University of Arizona, Tucson, AZ. 209-218

Ju Young Lee, Gippeum Bak & Mooyoung Han (2012). Quality of Roof-Harvested Rainwater – Comparison of Different Roofing Materials. Pages 422-429

Juliana, I. C., Kusuma, M. S. B., Cahyono, M., Kardhana, H., Widjaja, M. (2017). Rainwater Harvesting System Implementation for Domestic Water Use: The Environment and Financial Benefits.

Kassim, A. H. M., Sulaiman, S. M., Mohamed, R. M. S. R., Gheethi, A. A. S. (2017). Rainwater Harvesting Study at Masjid Jamek Riyahdus Solihin, Pintas Puding, Batu Pahat Johor Malaysia. 3rd International Conference on Science, Engineering & Engineering (SEE) USQ, Brisbane, Australia. 13-16

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gotzsche, P. C., Ioannidis, J. P. A., et al (2009). The PRISMA Statement for Reporting Systematic Literature Reviews and Meta-analyses of Studies that Evaluate Health Care Interventions: Explanation and Elaboration. Journal of Clinical Epidemiology 62 (2009) el – e34.

Md Lani, N. H., Yusop, Z., & Syafiuddin, A. (2018a). A Review of Rainwater Harvesting in Malaysia: 1–21.

National Hydraulic Research Institute of Malaysia (NAHRIM), (2011). Nahrim Technical Guide No. 2: the Design Guide. 3–12.

Nazahiyah, S. R., Ali, Z. MD, Musa, S. (2008) Treatment of Rainwater Quality using Sand Filter. International Conference on Environment (ICENV) 1-8

Neto, R. F. M., Calijuri, M. L., Carvalho, I. D. C., Santiago, A. D. F. (2012) Rainwater Treatment in Airports using Slow Sand Filtration Followed by Chlorination: Efficiency and Costs. Resources, Conservation and Recycling Journal 65. 124-129

Norman, M., Shafri, H. Z. M., Mansor, S. B., & Yusuf, B. (2019). Review of remote sensing and geospatial technologies in estimating rooftop rainwater harvesting (RRWH) quality. International Soil and Water Conservation Research. 1-9

Sampat, D., Mishra, K., Sisodia, M., & Choudhary, A. (2018). Retrofitting of an Existing Structure: An Experimental Study Demonstrating Use of Building Information Modelling and Rating Systems for Sustainable Development. 2015(December 2015).

Shaari, N., Irfan, A., Ani, C., Nasir, N., Fauzi, M., Zain, M., & Fui, G. S. (2008). Rainwater Harvesting: Potential for Quality Living. (Icbedc), 599–611.

Sharafaddin, A. A. S., Taher, T. M., Noaman, A. A. (2017) Manual for Rooftop Rainwater Harvesting Systems in the Republic of Yemen. 113 pg

Stringer, A., Vogel, J., Lay, J., Nash, K. (2005) Design of Rainwater Harvesting Systems in Oklahoma. Oklahoma Cooperative Extension Service, Division of Agricultural Sciences and Natural Resources, Oklahoma State University.

Sunar, N. M., Kosat, A. T., Harun, H., Hamid, N. H. A., Khalid, A., Zaidi, E., Azhar, A. T. S. (2018). Development of Smart Kit Rainwater Harvesting System for Potable Water Purpose. International Journal of Engineering & Technology, 7 (4.30) 338-341

Susilo, G. E. (2018). Rainwater Harvesting as Alternative Source for Wudhu Water in Indonesia. Civil and Environmental Science Journal Vol. 1, No. 02, pp 62-69

Thamer, A.M; Megat-Johari, M.M; Noor, A.H.G (2007). Study on Potential Uses of Rainwater havesting in Urban Areas. Paper presented at Rainwater Utilization Colloquium on 19 & 20 April 2007 at NAHRIM Mini Auditorium.

Vieira, A. S., Weeber, M., Ghisi, E. (2013) Self-Cleaning Filtration: A Novel Concept for Rainwater Harvesting Systems, Resources, Conservation and Recycling Journal 78. 67-73

Ward, S., Memon, F. A., Butler, D. (2008). Rainwater Harvesting: Model-based Design Evaluation. 11th International Conference on Urban Drainage, Scotland. 1- 11

Ya'Acob, M. E., Ideris, M. M., Latiff, N. A., & Iskandar, A. N. (2018). Conceptual design of an integrated PV catchment storage system for rainwater harvesting. IOP Conference Series: Earth and Environmental Science, 146(1).

Zakaria, N.A., Ab. Ghani, A., R. Abdullah, R., Sidek, L.M., Kassim, A. H. & Ainan, A. (2004). A New Urban Stormwater Management Manual for Malaysia (Manual Saliran Mesra Alam-MSMA). Advances in Hydro-Science and -Engineering, Volume VI, 1–10.

Zankowski, J., Sun, Y., Nassar, A., Mehta, K. (2014) Gutter Design and Business Development for Domestic Rainwater Harvesting Systems: A Case Study., International Journal for Service Learning in Engineering Vol. 9, No. 1, pp 64-78, Spring 2014

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**PERMOHONAN KELULUSAN MEMUAT NAIK PENERBITAN UiTM CAWANGAN PERAK MELALUI REPOSITORI INSTITUSI UiTM (IR)**

Perkara di atas adalah dirujuk.

2. Adalah dimaklumkan bahawa pihak kami ingin memohon kelulusan tuan untuk mengimbas (*digitize*) dan memuat naik semua jenis penerbitan di bawah UiTM Cawangan Perak melalui Repositori Institusi UiTM, PTAR.

3. Tujuan permohonan ini adalah bagi membolehkan akses yang lebih meluas oleh pengguna perpustakaan terhadap semua maklumat yang terkandung di dalam penerbitan melalui laman Web PTAR UiTM Cawangan Perak.

Kelulusan daripada pihak tuan dalam perkara ini amat dihargai.

Sekian, terima kasih.

**"BERKHIDMAT UNTUK NEGARA"**

Saya yang menjalankan amanah,

**SITI BASRIYAH SHAIK BAHARUDIN**
Timbalan Ketua Pustakawan

*nar*

Setuju.

27.1.2023

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