

Research Article

Rainwater Harvesting: A Sustainable Solution to Water Scarcity

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Abstract: The global water crisis is a pressing challenge, characterized by water scarcity, unequal access to clean water, and environmental degradation. In the face of this crisis, rainwater harvesting emerges as a sustainable and practical solution. This method involves collecting and storing rainwater, making it a valuable source for various applications. Rainwater harvesting mitigates water scarcity by providing a local and reliable water source. It conserves precious freshwater resources, reduces the energy-intensive treatment of centralized water supplies, and enhances water quality. This paper discusses the outcome prototype of the rainwater harvesting model in residential home and the significance of rainwater harvesting as a key strategy to address the water crisis, offering a sustainable and resilient approach to ensure access to clean water for all.

Keywords: water crisis; rainwater harvesting; water scarcity; environmental degradation; sustainable water source



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1. INTRODUCTION

The global water crisis is an increasingly urgent challenge affecting regions worldwide, with diverse consequences for both people and the environment. Water scarcity, unequal access to clean water, and environmental degradation are some of the primary issues associated with this crisis. Water scarcity is a growing concern in many parts of the world, driven by factors such as population growth, urbanization, and climate change (Berry et al., 2014). In Malaysia, a nation known for its lush landscapes and abundant rainfall, the water crisis is a pertinent concern as well. The country faces a growing demand for freshwater due to population growth, industrialization, and agricultural needs, coupled with changing precipitation patterns attributed to climate change. To address these challenges, Malaysia has been implementing various water management strategies, including rainwater harvesting (Hafizi Md Lani et al., 2018). While Malaysia has made progress in water resource management, the

global water crisis underscores the need for ongoing efforts and global cooperation to ensure sustainable access to clean water for all.

To address this challenge, innovative and sustainable solutions are imperative. One such solution that has gained significant attention and recognition is rainwater harvesting, a green technology with the potential to alleviate water stress, conserve resources, and reduce environmental impact. It is obvious that this issue is becoming a critical issue that will give a big impact to our country at certain state. The main factor of the rising water crisis is population growth, urbanisation, and the pollution. Therefore, some studies have been carried out to overcome the water crisis in Malaysia in terms of physical, social, and economic aspects. To overcome the water crisis, the use of rainwater had been widely used as an alternative.

The intention of this study is to investigate the feasibility and potential of rainwater harvesting systems in residential settings, with the ultimate goal of developing a functional prototype tailored to the needs of typical home environments. As the world grapples with water scarcity and the need for sustainable water management solutions, rainwater harvesting has emerged as a promising approach (Islam, 2019). By harnessing rainwater as an additional water source for non-potable household use, such as irrigation, toilet flushing, and laundry, this technology aims to alleviate pressure on centralized water supply systems and reduce water-related costs for homeowners. The development of a residential home model prototype represents a practical and scalable solution that can be adapted to various settings, promoting both sustainable water practices and environmental stewardship.

2. METHOD & MATERIAL

In the development of a prototype house with a rainwater harvesting system, several key methods and components are employed to ensure the effective collection, storage, and distribution of rainwater. First, the roof of the house is equipped with a specialized gutter and downspout system designed to channel rainwater into a collection point, typically a rooftop water tank acting as a reservoir. This tank serves as the primary storage unit for the harvested rainwater.

Water pumping system is an important thing to supply through the engine with much needed water to ensure reliable and effective operation. The water pumps are needed in between the water reservoir and filter because to generate the flow or movement of water. The water pumps that are used are diaphragm submersible water pump DC 3V-5V. Refer to (M. D. Lee et al., 2019) the power required by average power pump is 150 W for a house system. The type of water pump used in home is pressure booster pumps. The automated pumping system includes a pressure tank to maintain consistent water pressure across all openings linked to the piping system, making it an excellent choice for usage in residential structures. (Vguard, n.d.).

Figure 3 represents the flow chart of flow rainwater from water reservoir to the tanks in the house. A network of pipes and tubes is strategically laid out to facilitate the flow of treated rainwater to designated areas within the house, including toilets, the kitchen, the laundry room, and the master bedroom's bathroom. Additionally, an overflow system is incorporated to direct excess rainwater to the garden, preventing water wastage while contributing to sustainable landscaping. This comprehensive approach to rainwater harvesting in the prototype house serves as a practical model for achieving water self-sufficiency and promoting sustainable water practices in residential settings.



Figure 1. Front view of prototype.



Figure 2. Side view of prototype

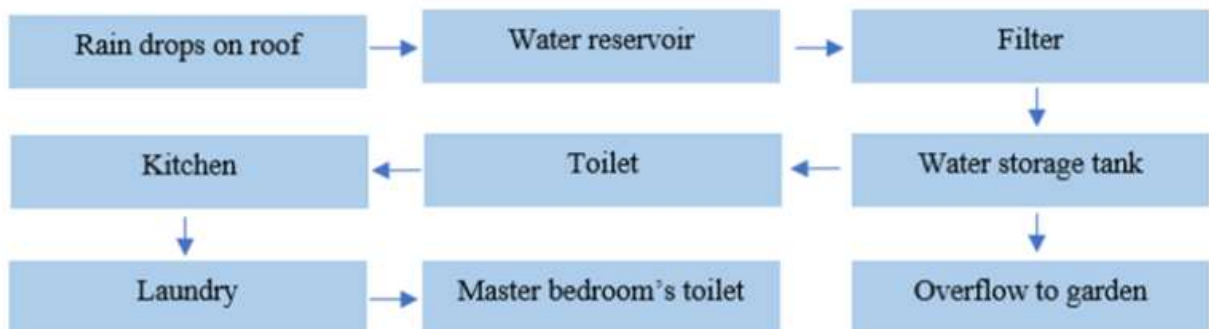


Figure 3. Flow chart of the system

3. RESULTS AND DISCUSSION

Table 1 shows the results of the simulation of the prototype of rainwater harvesting system. The time taken to fill up 150 gallon (567.8 L) of a house water tank, min (x) is equal to 2934.8 min (48.9 hours). Based on the data, the estimation on how much water can be collected from the roof in one year can be calculated. For example, $100 \text{ m}^2 \times 3000 \text{ mm} = 3 \times 10^5$ litres of water. Then, estimate 20% must be deducted because not all water will get in the water reservoir or tank due to some will spill over the gutters and some will evaporate. Therefore, in one year, estimation of water can be received from rainwater harvesting system is 2.4×10^5 litres of water. Hence, this design for innovation of rainwater harvesting using water pump system for a house is possible to be apply for a house water system as alternative water supply to supplement piped water (Lani et al., 2018). So that the users can maintain and control the amount of water themselves directly will help to reduce the water bills.

Table 1. Results of time taken during the simulation.

Water tank	Volume of water (mL)	Time taken to fill up the tank (min)			
		1	2	3	Average
Toilet	237	1.62	1.60	1.59	1.60
Kitchen	237	1.15	1.10	1.12	1.12
Laundry	237	1.10	1.08	1.13	1.10
Master bedroom's toilet	237	1.05	1.12	1.09	1.08
Total	948	4.92	4.90	4.93	4.91

Malaysia is particularly suitable for the implementation of rainwater harvesting systems in residential houses owing to its favourable climatic conditions and water resource management needs. With an equatorial climate characterized by consistent rainfall throughout the year, Malaysia enjoys an abundance of precipitation. This offers ample opportunities to capture rainwater, even during the monsoon season, which can be effectively stored for later use. In regions with intermittent water supply or fluctuating rainfall patterns, rainwater harvesting serves as a reliable supplementary water source, reducing the dependency on centralized water supplies. Moreover, Malaysia's growing population and urbanization have placed increased pressure on existing water resources, making the adoption of sustainable water management practices, such as rainwater harvesting, a pertinent solution to address water scarcity and enhance residential water self-sufficiency in the country (Muhammad et al., 2020). Malaysia can be categorized as one of the countries that has a high domestic water consumption, which ranges from 209 to 228 litres per capita per day (Lani et al., 2018a). For instance, if a house had five people which using about 1000L a day, this would be a demand of 3.65×10^5 litres of water per year. Although, the water collected from rainwater harvesting system is not quite enough to meet the demands of the house and therefore there is still a potential to save about 66% of water consumption per year. In several countries, including Australia, the United States, and Iran, the implementation of rainwater harvesting system can result in high percentage reliability for residential buildings above 95% (Lani et al., 2018a).

4. CONCLUSION

In conclusion, the integration of a rainwater harvesting system using a multi-pump setup in residential houses represents a significant leap towards a more sustainable and water-resilient future. This innovative approach not only addresses immediate water supply challenges but also aligns with key themes of saving energy, reducing costs, promoting greener technology, and preparing for a more sustainable tomorrow. The multi-pump system's ability to optimize water distribution and pressure management within the house has clear energy-saving benefits. By eliminating the need for excessive energy consumption in traditional water supply methods, this technology significantly reduces the carbon footprint of households while simultaneously cutting down on utility bills. Moreover, the cost-effectiveness of rainwater harvesting with multi-pump systems is a compelling feature. The initial investment in such a system is rapidly offset by the considerable savings in water expenses. This makes

it an economically attractive choice for homeowners while also lightening the load on municipal water infrastructure, which, in the long run, can lead to cost savings for communities.

As a green technology, this rainwater harvesting approach aligns with the growing global emphasis on environmental sustainability. By reducing reliance on conventional water sources, it minimizes the strain on ecosystems, and decreases the carbon emissions associated with water treatment and distribution. The incorporation of such systems into homes contributes to an eco-friendlier lifestyle and sets an example for the broader adoption of sustainable practices. Looking to the future, rainwater harvesting systems with multi-pump capabilities promise to play a pivotal role in addressing water security and sustainability. As the world grapples with changing climate patterns, increasing water demands, and the imperative to adopt greener technologies, these systems offer a practical and scalable solution. They empower individuals and communities to take control of their water supply, reduce their environmental impact, and prepare for a more water-resilient future.

In essence, the use of multi-pump rainwater harvesting systems in residential homes is not just a solution for the present but a significant step towards a more sustainable, energy-efficient, cost-effective, and environmentally responsible future. This paper and project highlight the immense potential of such systems and lays the foundation for further research and implementation, creating a pathway to a greener and more water-secure world.

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