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COMMUNITY RAINWATER HARVESTING FINANCIAL PAYBACK ANALYSES - CASE STUDY IN MALAYSIA

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Abstract. Malaysian water demand is increasing at an alarming rate reaching 27 to 38% higher than the World Health Organisation recommended consumption limit of 165 liters per capita per day. Therefore, the Malaysian water shortage crisis is quite possible in future due to this water demand uptrend. The average annual rainfall of Malaysia is 2,400 mm but large portion of this fresh water resource becomes runoff and lost through our catchments. Urban flash flood is also becoming more frequent due to fast pace of urban development and anthropogenic induced runoff. Malaysia has experienced drought and flooding in different areas and therefore, it is crucial to study the feasibility of alternate water resources in Malaysia to manage and maintain the sustainability of urban township. This study reviewed a past rain water harvesting system (RWHS) case and conducted the financial payback analyses on its proposed system. If there were 177 rain days per year with at least 52 mm of rainfall event depth, the payback period of the proposed RWHS would be 5.8 years when the discount rate (i%) = 2% and 8.2 years if i% = 10%. The payback period became longer when the annual rain days dropped below 106 and 89 rain days per year. If the proposed RWHS only serve the community under this study, it will take 12 days to consume 800 m^3 stored water, while any rainfall of consecutive days will not be harvested as the underground storage tank is in full capacity. The proposed RWHS must be filled up at least 38 times per year in order to break even with the proposed annual maintenance cost but will never be able to achieve any payback from its initial investment. Rain water harvesting and full utilisation is the only way to achieve high water cost savings and shorter payback period, and maximise urban excess runoff reduction.

1. Introduction

The increasing world population is causing the steep rise in water demand globally, while water security of our future is becoming less promising [1 2 3]. Malaysian water demand increased from 10.4 billion m^3/year in 1998 to 12.1 billion m^3/year in 2010. By 2050, the projected demand will reach 17.7 billion m^3/year [4]. On average, Malaysian water consumption ranges from 209 to 228 liters per capita per day (lcd) [5] which is about 27-38% higher than the recommended consumption limit of 165 lcd [6] set by the World Health Organisation (WHO). Therefore, the Malaysian water shortage crisis is quite possible in future due to this water demand uptrend. The average annual rainfall of Malaysia is 2,400 mm [7] but large portion of this fresh water resource becomes runoff and lost through our catchments. Urban flash flood is also becoming more frequent due to fast pace of urban development and anthropogenic induced runoff. Malaysians have experienced drought and flooding in different areas and therefore, it is crucial to study the feasibility of alternate water resources in Malaysia to manage and maintain the sustainability of urban township.

Rain water harvesting system (RWHS) is one of the alternatives to collect and utilize natural fresh water from Mother Nature, while the implementation of large scale RWHS is able to reduce the occurrence of urban flash flood up to 10% as reported by South Korean research [8] and improve the water quality of water bodies [9]. However, the general concern of adopting RWHS is the initial high upfront cost with the payback uncertainty due to the unforeseen future rainfall amount and pattern. It is also not appealing to consider RWHS as Malaysian water tariff is quite low compared to our neighbor countries. RWHS is only economical when it serves as a mechanism in water supply and flood control at the same time [10]. When implemented through proper planning, large scale RWHS or network functions like water storage infrastructure serving the water demand of urban communities.

2. Study Site and Methodology

This study reviewed past RWHS study conducted by NAHRIM on part of the community within Taman Wangsa Melawati (as shown with dashed line in Figure 1) in the Selangor state of Malaysia. 242 double storey terrace units, 10 shops, 1 mosque, and 1 kindergarten are in this community with total catchment area of 15,540 m^2. Daily water demand from the past study estimated 240 liters for each terrace unit, 375 liters for each shop, 1,100 liters for the mosque, and 2,450 liters for the kindergarten. Total daily water demand of this community was estimated to be 65.4 m^3.

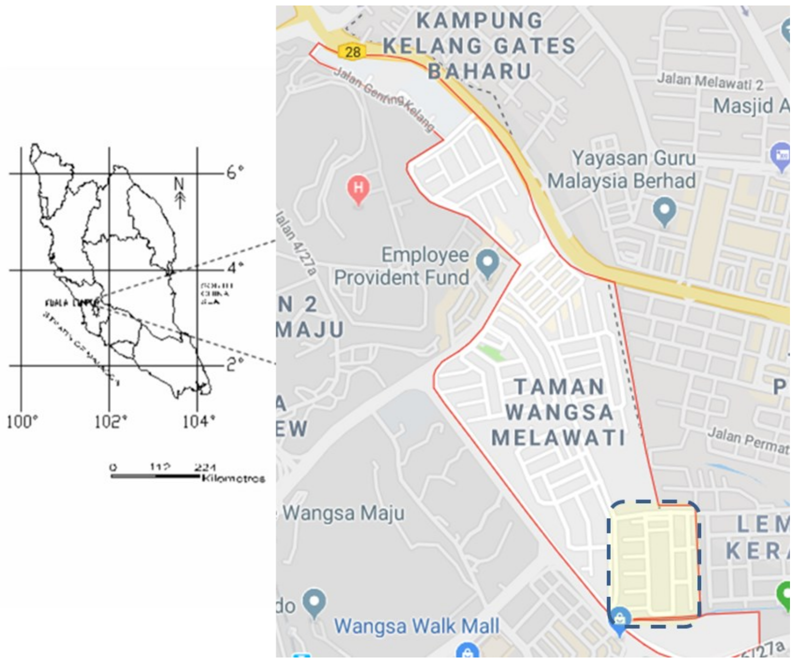

Figure 1. Location of RWHS study within Taman Wangsa Melawati

This community was chosen for RWHS study as it has a public garden in the middle for a potential installation of a 800 m^3 underground storage tank with cost estimation as shown in Table 1. The layout of the proposed RWHS is shown in Figure 2.

Table 1. Overall Cost Estimation of the RWHS

No.	Items	Estimated Cost (RM)
1	Plumbing and Piping	770,750
2	Pumps and Fittings	50,000
3	Underground Storage Tank	208,000
4	Elevated Distribution Tank	176,000
	Overall Cost:	**1,204,750**
	Projected Annual Maintenance (5% of overall cost):	60,237.50

According to one of the studies, Selangor state water tariff for domestic use is RM 2/m^3 and RM 2.28/m^3 for non-domestic accounts, while on average, there were 177 rain days/year in Kuala Lumpur area between 1953 and 2008 [5]. Therefore, this study adopted the past rain days/year statistics to assume that there will also be at least 177 rain days/year in this community in future. From the total catchment area of this community, rainfall event depth must be greater than 52 mm in order to be able to harvest 800 m^3 of rainwater to fill up the proposed underground storage tank, which will be sufficient to cater to the consumption of this community for 12 days. In the event that the proposed underground storage tank cannot be filled up, the anticipated water savings from this RWHS will be less promising with longer payback period.

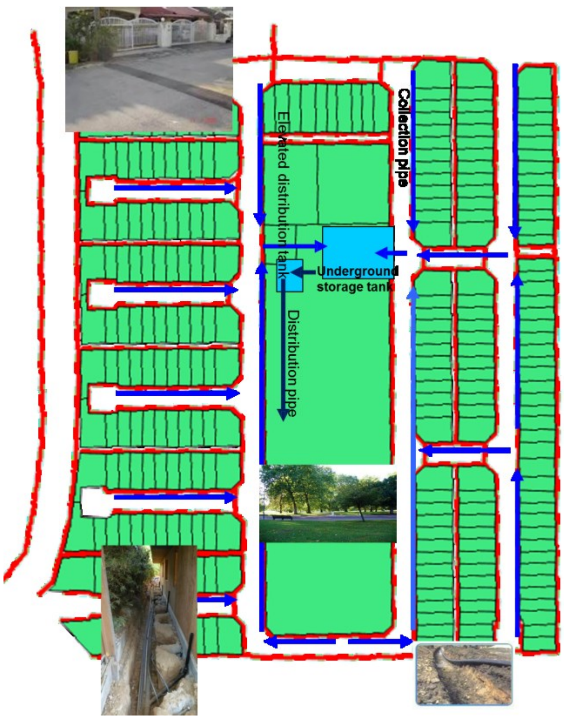

Figure 2. Proposed RWHS within Taman Wangsa Melawati

This study used the minimum water tariff cost of RM 2/m^3 to quantify the projected water saving cost in future with rainfall event of 52 mm or more under three different scenarios. Nearby communities will tap into this storage tank and consume 800 m^3 stored water within 2 days. **Scenario one:** There will be 177 rain days/year with 177 rainfall events of 52 mm rainfall depths or more in future. **Scenario two:** There will be 106 rain days/year (to represent the 40% below average condition) with 106 rainfall events of 52 mm rainfall event depths or more in future and **Scenario three:** There will only be 89 rain days/year with 89 rainfall events of 52 mm rainfall event depth or more in future to represent the 50% below average raining days/year scenario for this community. Compound interest rate financial analyses was conducted under multiple discount rates (i% from 2% to 10%) in order to calculate the payback period (years) for this RWHS proposal under aforementioned three different scenarios from rain water harvesting only.

3. Results and Discussion

The RWHS harvested a total of 141,600 m^3/year of rain water under the first scenario through 177 rain days. Water tariff cost of RM 2/m^3 produced RM 283,200/year savings for the community (Refer to Table 2 for the overview of annual savings of the RWHS under three different scenarios). After the discount of the RM 60,237.50 annual maintenance cost for the RWHS, the net annual cash flow is RM 222,962.50. The payback period of the RM 1.2 million RWHS investment under different discount rates showed 5.8 years when i% = 2% and 8.2 years if i% = 10%. However, the payback period of the proposed RWHS became longer under the other two scenarios when there were less rain days/year with at least 52 mm rainfall event depths. Scenario two showed that the RWHS would take 12.6 years to breakeven if i% = 2% and 55.5 years if i% = 9%, while the payback period under scenario three showed that the RWHS would take 17.5 years to breakeven if i% = 2% and 36.3 years to breakeven even if i% is only 6%.

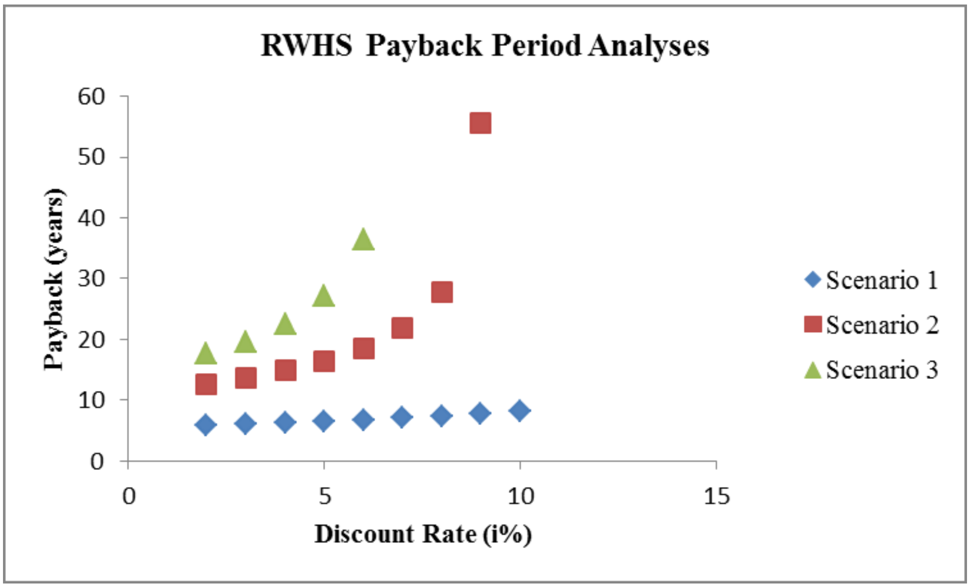

Figure 3. Payback period of the proposed RWHS within Taman Wangsa Melawati

Table 2. Overview of the RWHS under 3 scenarios

Scenario	Rain days/year*	Harvested volume (m^3)	Annual Savings (RM)
1	177	141,600	283,200
2	106	84,800	169,600
3	89	71,200	142,400

*Minimum rainfall depth is 52 mm

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4. Conclusions

The community under this study is densely populated as many other urban areas in Malaysia. If there were 177 rain days with at least 52 mm of rainfall event depth, the payback period of the proposed RWHS would be very promising provided that the discount rate of the initial RM 1.2 million investments can be secured below 10%. There will be no payback for scenario 2 if the discount rate is more than 9% and no payback for scenario 3 if the discount rate is more than 6%.

The payback period also became longer when the annual rain days dropped below average. However, it is noteworthy to mention that although the total catchment area of this community under this study was only 15,540 m^2 the RWHS was able to harvest nearly 71,000 to 85,000 m3 of rain water annually under the scenarios two and three to serve the water demand of the community and its nearby communities under this study.

If the proposed RWHS only serve the community under this study, it will take 12 days to consume 800 m3 stored water while any rainfall of consecutive days will not be harvested as the underground storage tank is in full capacity. The proposed RWHS must be filled up at least 38 times per year in order to break even with the proposed annual maintenance cost but will never be able to achieve any payback from its RM 1.2 million investment. Rain water harvesting and full utilisation is the only way to achieve high water cost savings and shorter payback period, and maximise urban excess runoff reduction.

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