Integrating User Preferences Using Multi-criteria Decision Analysis To Evaluate Rainwater Harvesting Alternatives: A Case For Teresa, Rizal

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ABSTRACT

A large percent of the globe's population is experiencing a water shortage and alternative water sources would soon be a necessity. Rainwater harvesting (RWH) is an alternative that can be utilized as it is relatively abundant and easy to collect. However, in the Philippines, only about six percent of the annual rainfall is captured. This paper used multi-criteria decision analysis to assess the preferences of 329 rural residents in Teresa, Rizal to evaluate possible RWH alternatives. Reliability, cost, adoption factors, and benefits were the main criteria used in the analysis. Scores were evaluated and transformed using yield after spillage to determine rainfall reliability. Alternatives were weighted and ranked considering different scenarios. It was found that the general respondents found all criteria important. A 1000L plastic tank with a 20L first flush is likely to be adopted followed by a 3000L ferrocement tank with a 200L first flush. Those with higher incomes considered cost and benefits with higher importance, thus a 5,000L ferrocement tank is most preferred. In preparing for future scenarios a larger storage tank is recommended to accommodate the increase in rainfall variability.

METHODOLOGY

Five main data points were gathered; these include historic rainfall, water demand estimate, system costs, system configuration, and survey weights.. The weights for each of these factors were to be determined from the preferences that were generated from the main survey. For the data processing, yield after spillage algorithm has that been improved by Fewkes et. al. (2000) was used. This incorporates the rational method to obtain the rainfall volume and assumes a yield or the amount that the system can supply for use. Further simulations mainly ran on Microsoft Excel and Google Sheets, with custom functions implemented on a VBA-enabled sheet. Multi-criteria decision analysis (MCDA) is used in this study dut to its various applications for environmental studies (Kiker et.al, 2005). This is used as a decision support tool that will effectively analyze multiple streams of dissimilar info and reduce them into a singular basis for evaluation. The study is conducted to set the preferences and attitudes of the residents and incorporate these into the evaluation of rainwater harvesting systems. With the preferences incorporated in the RWH system design, we can then expect a higher rate of adoption in the case RWH alternatives will be deployed.

CONCLUSIONS

Residents of the area wish their rainwater to be used for toilet flushing, watering plants and cleaning. However they find these systems to be potential breeding grounds for mosquitoes and find water quality to be unclean. The study finds that the alternative most preferred for the general resident would be the P10 alternative (Plastic tank with 1000L size), providing a balance of reliability, cost, ease of use and benefits. For those with higher income the F50 alternative is suggested, as this deem fit for their preferences.

INTRODUCTION

About 71% of the global population experiences moderate to severe water scarcity for at least one month in a year (Mekonnen et.al, 2016). The Philippines Statistics Authority noted that the country's population reached 100 million in 2015 with a growth rate of 1.72 from 2010 to 2015. With an ever-growing population, water demand in the Philippines is expected to rise. The water demand in Metro Manila is expected to rise to 800 million liters per day by 2025 (Shah, 2017). Few studies have been done for rainwater harvesting potential in Southeast Asia that looks at its practices and people's attitudes (Ozdemir et.al, 2011). Most in the rural area use groundwater as source, but is depleted which brings land surface subsidence, seawater intrusion, sea-level rise, streamflow depletion, loss of springs, and ecological damages (Famiglietti, 2014).

RESULTS AND DISCUSSIONS

Residents mainly wanted the collected rainwater for toilet flushing, watering plants and cleaning. With these preferences, alternative P10 had the highest utility (0.617), followed by alternative F30 (0.614). Alternative P10 is made of multiple plastic tanks with a total of 1000 liters. P10 has a relatively low size compared to F30's 3,000 liters and F50's 5,000 liters. However low storages have the benefit of being able to minimize water quality degradation by minimizing the detention period (Palla, 2011). P10 has scores ranging from 0.44 to 0.72, compared to F30's range of 0.25 to 0.86. F30 has the second-highest value, with high scores on reliability and benefits and low scores in the criteria cost and adoptability. When we consider the total utility (Figure 1) F30 scored the second highest (0.614) followed by F50 (0.608).

Factors such as price and durability, and maintenance were found to be significantly correlated to income at the 0.01 and 0.05 level accordingly. Those with higher income, value price more than those in the lower-income category as this could be because price increase brings about value and durability of which they can afford. Those with lower income need water such that they are willing to buy water, given any price, thus resulting to less price importance. Cheaper alternatives must then be further explore. For those with high income the best alternative for them becomes the F50 as this alternative has the highest benefits of all. Thus for those with higher income, larger storage is recommended. When considering a future scenario that involved an adjustment in rainfall (PAGASA, 2018) and demand (Kearton, 2005), this resulted in a shift in preferred criteria to a larger storage tank with F50 now being the highest scoring alternative. Thus larger storage is needed to be able to meet larger demand. Zhang (2009) and to be more resilient to the effects of climate change.

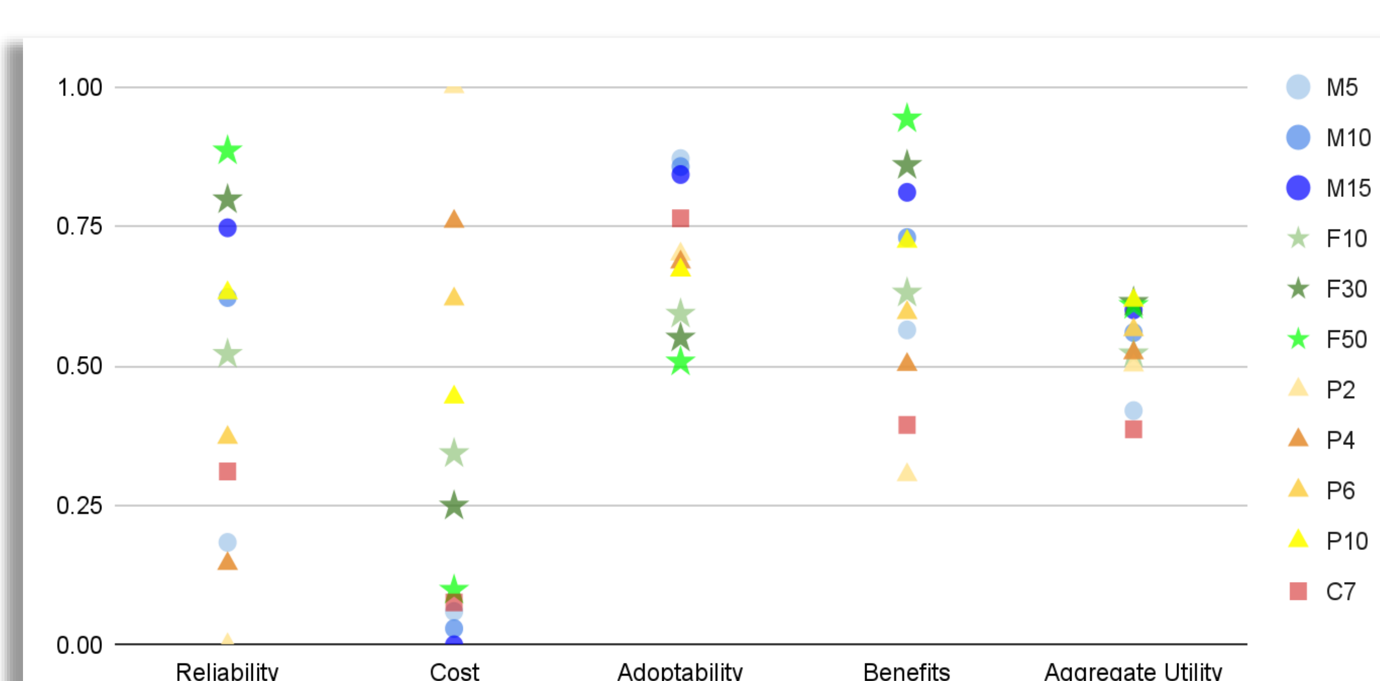

Figure 1: Aggregate Utility result and individual scores of each alternative