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Solution to drinking water supply for rural community based on rainwater harvesting

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ABSTRACT

Rainwater harvesting (RWH) systems can be used to produce drinking water in rural communities where there are limited/no clean drinking water supplies. Previous research has focused on the application of RWH systems for individual urban households. This study aims to develop a community-scale RWH system for rural drinking water production with three main research objectives: (1) developing a water balance model to assess the feasibility of the RWH system; (2) developing a simple water filter to treat roof harvested rainwater and investigating the levels of health risk associated with untreated and treated rainwater, and; (3) evaluating the environmental sustainability of the proposed RWH system components via life cycle assessment.

Multiple scenarios were considered for the daily-time-step based modelling of the RWH system including:

- 200–1000 consumers
- 25–1600 kL rainwater storage
- Three levels of potable water usage
- Local rainfall patterns
- Economic parameters of Australia and Vietnam.

Reliability analyses showed a strong correlation between water demand and water supply with a system reliability of 90–95%, which allows both Australian and Vietnamese systems to achieve a similar capacity of annual drinking water production and economic value. However, in comparable scenarios, the cost of the Vietnamese systems are higher than the cost of the Australian systems due to the greater rainwater storage requirements to sustain the higher rainfall in rainy season and the longer period of dry season throughout the year in Vietnam, which reduce the benefit-cost ratio and increase the payback time. Additionally, subsidised mains water prices are low, whilst bottled water prices are comparatively high as the standardised unit price of the produced drinking water. This model suggests that the RWH system can be feasibly implemented at the minimum water price of 1.0 AU¢/L with a payback period between 6–20 years.

As community-scale RWH systems are too large to implement in real-world test-studies, a pilot-scale RWH system with an innovative low-cost filtration unit was built to investigate the quality of roof harvested rainwater. Physical, chemical and microbiological characteristics of water samples were examined over 12 months for 26 sampling events. Results show that the harvested rainwater quality was significantly improved by using a first flush device, but it did not meet Australian Drinking Water Guidelines. Hence, further treatment was recommended with the novel filtration unit that has a lifespan of about 6 months.

Finally, the RWH system was considered as having a low environmental impact in the life cycle assessment owing to the sustainability of its system factors/parameters.

Additionally, group discussions amongst public health experts, water resource management authorities, environmental engineers and rural rainwater consumers has provided much evidence to support the implementation of the filtration unit and other common RWH techniques. The findings of this study can serve rural communities with an affordable and sustainable RWH system to meet the clean water needs as recommended by the United Nations Sustainable Development Goals program.