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Spatial variability of reasonable government rebates for rainwater tank installations: A case study for Sydney

Monzur A. Imteaz*, Muhammad Moniruzzaman

Department of Civil and Construction Engineering, Swinburne University of Technology, Melbourne, VIC, 3122, Australia

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ABSTRACT

This paper presents the spatial variability of reasonable government rebates for rainwater tanks installations with a case study for the largest Australian city, Sydney. Five different rain-gauge stations are selected around different regions covering Sydney metropolitan area. An earlier developed daily water balance model (eTank) is used considering five average years' rainfall data as an input for each region. It is shown that significant variations among the regions are expected in regards to rainwater savings; even with the same tank size, same roof connection and same rainwater demand, south-east region saves more water than that of west and north regions. Also, region having lowest annual rainfall is not necessarily having lowest rainwater savings potential. Also, in regards to water savings efficiency, region having highest annual rainfall may not render highest water savings efficiency. Providing a double-sized tank or double sized roof is likely to increase the savings only up to 1.29 times. It is found that the payback periods of total rainwater tank related costs widely vary depending on region, tank, roof and demand scenario; a variation from 20 to 90 years without government rebate is expected. However, with reasonable government rebates these payback periods can be brought down to 8 years. To optimise government's spending a variable rebate scheme can be introduced based on the current findings.

1. Introduction

1.1. Background

Among many nations including some arid countries water has been considered as very cheap commodity, as such many of them has been using it lavishly without considering long-term effect of such lavish use and energy (and other resources) requirements to produce water. As for example, per capita water uses in USA, New Zealand and Canada are 4337, 3263 and 2808 L/day respectively (Statista, 2013), even in an arid region like UAE per capita water consumption is 550 L/day (Khaleej Times, 2016). However, with ever-increasing growth of population and consequently water demands, laden with adverse impacts of climate change, nations and countries started to shift their traditional concept/approach of water production and uses. As such emerging ideas are developing to tackle the situation in a sustainable, holistic and prudent way. One such emerging approach is 'water-food-energy Nexus', which considers and analyses balancing needs of these systems in a holistic manner considering potential conflicting sectoral imperatives and overall gain/loss towards energy, water or food security (Smajgl et al., 2016). There were some initiatives towards such adaptive flexible and reflective approaches using linkages among different systems (water, food and energy) by China's National Water Policy, Europe's Water Framework Directive and Australia's National Water Initiative and the Murray-Darling Basin (Allan et al., 2013). Regionally, different countries adopting different water conserving and recycling measures to follow such initiatives. In New South Wales (Australia), government has introduced a sustainability measure and benchmarking through implementing Building Sustainability Index (BASIX), which requires all new houses in New South Wales (NSW) to save at least 40% potable water by adopting various water savings techniques including installation of rainwater tanks. Despite several campaigns and incentives, in general a positive willingness towards the widespread installations of rainwater tanks is often missing, mainly due to lack of convincing information/understanding of effectiveness of any proposed on-site stormwater harvesting system from end-users' side (Imteaz et al., 2011). Further confusions and uncertainties arise among the end-users due to inter-annual variations of water-savings due to climatic conditions, which is often very significant for Australian cities (Imteaz et al., 2013a).

1.2. Studies involving cost analysis

Most of the studies on rainwater tank dealt with the potential water

* Corresponding author.
E-mail address: mimteaz@swin.edu.au (M.A. Imteaz).

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savings, however from end-users' point of view 'cost effectiveness' is the prime concern, which not only depends on potential water savings, but also on water price, tank installation and maintenance costs. For remote areas without having any centralized water supply system, residents are bound to use rainwater to augment their water demands. However, for the city residents where centralized water supply exist, installation and maintenance of rainwater tanks may not always turn out to be cost-effective; i.e. for cities having moderate to high rainfalls, where water cost is comparatively higher than the installation and maintenance costs of rainwater tank, implementation of rainwater tank will be cost-effective considering a design life of several years. Whereas, if the water price is comparatively lower, as it is the case for many cities, implementation of rainwater tank may not turn out to be cost-effective even considering a longer design life (i.e. 25 years). Tam et al. (2010) studied cost effectiveness of installing rainwater tank as compared to the use of other water sources (i.e. water from dams, desalination, purchase irrigation water, groundwater, and non-potable water recycling) for seven Australian cities. In order to do so, various costs were computed including installation and maintenance costs, and compared with unit costs from other sources. The average costs of using rainwater tank and monetary savings in compared to other sources were then calculated for combinations of outdoor plus indoor or sole outdoor uses only. It was found that between the two studied uses, sole outdoor use turned out to be more beneficial compared to 'outdoor plus indoor' use. They have reported that with the sole outdoor use, annual costs savings (compared to other water sources) depending on roof and tank sizes are $83–$240 for Gold Coast, $65–$181 for Sydney and $0–$36 for Brisbane. However, surprisingly for other studied cities (Melbourne, Adelaide, Perth and Canberra) for any reasonable combination of roof and tank sizes, annual cost savings are negative. Khastagir and Jayasuriya (2011) have presented cost analysis through calculating payback periods of rainwater tanks situated in Melbourne, Australia. They found that the cost of accessories alone contributed almost half of the cost of rainwater harvesting system if it is connected with toilet, laundry and irrigation. It was found that payback periods ranged from 14 to 40 years depending upon tank size, discount rate, inflation rate and rainfall characteristics of different areas across Melbourne. A 14 years' payback period can be achieved with a 5 kL tank size for area having annual rainfall about 1000 mm. Whereas, the payback period can be as high as 40 years with a tank of 1 kL in an area having low annual rainfall (454 mm). Ghisi and Schondermark (2013) studied investment feasibility of rainwater harvesting system for five towns in Brazil. Through using average historical year rainfall data, they have calculated discounted payback periods for all the five regions. It was found that payback periods less than 10 years are achievable with a smaller roof connection (90 m^2); even a lowest payback period of 2 years can be achieved for a tank size of 3–4 m^3. However, the payback periods can be more than 10 years, for bigger roof connections (150–300 m^2) with larger tank sizes but lower demand. Matos et al. (2015) calculated payback period of highly effective rainwater harvesting system for a large commercial building located in Portugal. Three different scenarios with the variations in tank size, rainfall and demand were tested for the same building, and then annual water savings and financial benefits were computed. It was found that with a discount/interest rate of 10% depending on tank size and connected roof area, payback periods of 2–6 years can be achieved; with a lower discount/interest rate payback periods will be further reduced. However, for a single residential rainwater tank, where space for the bigger tank is an issue, in most cases the payback period turns out to be very high.

1.3. Research gaps

A vast majority of studies on rainwater harvesting presented a single outcome(s) for a particular city, even though many of those studies considered multiple cities (i.e. Ghisi et al., 2007) a single value of expected water-saving was presented for each city, which is not realistic, especially for large cities. In fact, with the ever-increasing trend of population and migration of people to the city areas, most of the cities around the world getting larger and larger. Khastagir and Jayasuriya (2010) showed significant differences in the optimum tank size requirements within the city of Melbourne to meet a same demand with the same supply reliability. Again significant variations of potential water savings and reliabilities were reported for different Australian cities; Melbourne (Imteaz et al., 2013a) and Adelaide (Imteaz et al., 2015). However, Sydney being the largest city of Australia, such in-depth analysis on spatial variation was not conducted. Also, it is unknown how such spatial variations can affect economic considerations within different regions of such a large city like Sydney.

As mentioned earlier, due to uncertainties in economic gains, many residents are not acting on implementing rainwater tanks within their properties even though there are numerous campaigns by the government. To overcome this reluctance many governments offering incentives in the form of "rebate" to the residents who install rainwater tank, i.e. residents who install rainwater tanks get some of their expenses refunded. With global financial crisis, many countries/governments struggling to continue such rebate for a longer period. As for example, the NSW Home Saver Rebates Program spent A$170 million under the Climate Change Fund. One in eight NSW households received a rebate for climate-friendly appliances, materials including rainwater tanks. The program commenced on 1 July 2007 and ended on 30 June 2011 (NSW OEH, 2017). Often, among the authorities a question arises as "what should be the optimum rebate amount?". This paper presents evaluation of optimum rainwater tank rebates, which would be attractive to the residents, while not exerting a financial burden for the government. Also, as potential water savings are expected to vary within a large city, this paper summarises reasonable variations of such government rebate with a case study for Sydney metropolitan area. To evaluate spatial variations in financial scale, being the largest city of Australia, Sydney was selected.

2. Methodology, study area & data

2.1. Methodology

To be able to calculate payback period for a certain harvesting system for a certain locality, as a first step it is necessary to calculate potential annual rainwater harvesting amount for a particular scenario. Expected annual water savings were calculated for five different regions of Sydney using an earlier developed daily water balance model, eTank. Imteaz et al. (2017) have provided details on eTank methodology, application and comparison with contemporary tools. To date, among all the available tools on rainwater tank analysis, publications related to eTank and its development & application is the highest. Hydrologic calculations and logical sequences in eTank are schematically described in Fig. 1. eTank eventually calculates annual stormwater use, annual overflow amount and annual townwater use. As a particular year might have an unusual rainfall pattern (i.e., sporadic bursts and/or longer dry periods) compared to usual pattern of occurrences, this study used five years of daily rainfall data to represent an average year. Imteaz et al. (2013b) presented the advantage and accuracy of using 5 years' data to represent a particular climate (dry, average and wet). Annual water savings for each of the selected five years were calculated using the eTank tool for different combinations of tank sizes (5 kL and 10 kL), daily demands (300 L and 500 L) and roof areas (100 m^2, 200 m^2 and 300 m^2) for five regions within Sydney metropolitan area. From the cumulative water savings for five years, average annual water savings for each of the selected regions were calculated. Annual water savings were converted to annual monetary savings through multiplying the water savings amounts with the unit water cost charged by the local water authority (Sydney Water). Future water savings amounts were scaled down using net present value (NPV) as calculated by the following equation: