Verification of the economic feasibility of rainwater harvesting systems in regions with long periods of drought

Vérification de la faisabilité économique des systèmes de collecte des eaux de pluie dans les régions en sécheresse de longue durée

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RÉSUMÉ

Les systèmes de collecte des eaux de pluie et d'égouts peuvent être d'une grande utilité contre les pénuries d'eau. Dans ce sens, cependant, lors du dimensionnement des réservoirs de ces systèmes pour des régions avec de longues périodes sans précipitations, il est observé que des volumes importants sont générés, ce qui rendrait difficile leur implantation et leur viabilité. Ces travaux ont donc pour but de vérifier la faisabilité de systèmes de collecte des eaux de pluie à des fins non potables, conçus uniquement pour les périodes de pluie, afin de réduire la consommation d'eau potable pendant cette période afin de générer davantage de stockage pour les périodes sèches. La période de récupération, le retour sur investissement (ROI) et une simulation de la valeur de l'investissement du système dans un fonds d'investissement ont été utilisés. En conséquence, nous avons obtenu des systèmes avec des valeurs de retour sur investissement dans la période considérée comme réalisable et des valeurs faibles de retour sur investissement. Cela montre que l'utilisation des systèmes pluviométriques a un rendement, mais ils ont besoin d'un incitatif gouvernemental pour que leur utilisation soit envisagée à grande échelle.

ABSTRACT

Rainwater harvesting and sewage systems can be of great value against water shortages. In this sense, however, when dimensioning reservoirs of these systems for regions with long periods without rainfall, it is observed that large volumes are generated, which would make their implantation and viability difficult. Thus, this work has the purpose of verifying the feasibility of rainwater harvesting systems for non potable purposes that are designed only for the rainy periods, in order to reduce the consumption of drinking water in this period to generate more storage for the dry periods. Payback, Return on Investment (ROI) and a simulation of the value of the system's investment in an investment fund were used. As results, we obtained systems with Payback values within the period considered as feasible, and low values of ROI. This demonstrated that the use of rainfall systems has a return, but they need a governmental incentive to have their use considered on a large scale.

KEYWORDS

Compensatory techniques, Economic viability, Rainwater harvesting system, Urban drainage, Urban water

1 INTRODUCTION

The use of individual-scale rainfall systems is a possibility in the fight against water scarcity, given its simple implementation and maintenance. With the use of rainwater for non-potable purposes, it is possible to reduce the pressure on water resources, especially treated water provided by local concessionaires. It also generates benefits in urban drainage, but to a lesser extent (FARRENY, GABARREL, RIADERVALL; 2011).

However, because it is an investment made by the population, its implementation will only be considered advantageous if the economic benefits and the return on invested capital are confirmed, regardless of the environmental advantages that may occur.

Thus, the identification of the volume of the reservoirs required for storing rainwater, when considered as regions with very long periods of drought can lead to volumes that are impractical from a technical and economic point of view. It is necessary to identify a solution that can overcome this obstacle.

Thus, it was chosen in this work to study regions with long periods of drought through an approach that considers only the rainy months for dimensioning of the volumes to be reserved, verifying the existence of economic viability of the rainwater harvesting system for non- drinking water. For that, the systems designed for the rainy months of the city of Goiania, a Brazilian capital located in the center-west of the country, will be approached. Possessing this information, will be analysed through Payback, Return on Investment (ROI) and also through consideration of the investment of the value of implantation in an investment fund the economic viability of the system.

1.1 Non-potable rainfall systems apllied in the city of Goiania

Rainwater harvesting systems can be understood as measures to control the precipitation effluents at the source, since it retains part of the volume drained in reservoirs. In addition, this type of system also has financial appeal, allowing the reduction of utilities' water consumption.

According to Fewkes (2012), all rainfall systems used in residences are composed of at least one retention surface, conductors and one or more reservoirs.

For the purposes of designing rainwater harvesting systems, it is necessary to determine the catchment area and the size of the rainwater reservoir, and the other components of the system suit them (BAPTISTA, NASCIMENTO, BARRAUD; 2011). As residences are generally used in the areas of roofs for collecting rainwater, it remains to define the size of the reservoirs that will store precipitous rainfall. In this work, the volumes to be reserved were previously calculated using the Rippl methods and the modified Rippl method, where the following volumes were obtained for buildings with areas of 50 m², 120 m², 200 m² and 300 m² for the months of greatest rainfall (October to March), according to Table 1. It was also possible to calculate the percentage of service for non-potable demand calculated.

Table 1 – Reservation volumes in accordance with the methodologies used

Edification	Method	Reservoir Volume (m³)	Monthly rainwater demand met (m³)*	% attended in relation to the estimated
50 m²	Rippl	5,66	5,10	99%
	Rippl Modified	3,48	5,01	97%
120 m²	Rippl	1,08	4,82	94%
	Rippl Modified	1,55	4,96	96%
200 m²	Rippl	0,50	4,93	84%
	Rippl Modified	1,56	5,67	96%
300 m²	Rippl	0,50	5,02	85%
	Rippl Modified	1,38	5,83	99%

* The monthly demand for rainwater in this item corresponds only to the months of higher rainfall (October to March).

Source: the authors.

2 METHODS

In order to verify the economic feasibility of rainwater harvesting systems, Payback, ROI and the investment simulation of the value used to construct the system (GARRISON, NOREEN, BREWER; 2013) were used.

2.1 Definition of parameters and values of rainwater harvesting systems

Initially, it was necessary to define how the system was conceived. In a simplified way, two possibilities were used: the use of lower reservoir in concrete (buried) or in polyethylene (supported), the other items being standardized (upper reservoir in polyethylene, centrifugal pumping system and PVC pipes). In order to determine the values of the system, it was carried out the survey of quantities of the necessary inputs. With the list, the works cost composition sheets provided by the National System of Prices and Indices for Civil Construction (SINAPI) of the state of Goias were used. Of all building costs, 30% of Budget Difference Income (BDI) were inserted. Water and sewage tariffs, preventive and corrective maintenance were also considered, in order to include all the components of the system.

We also considered the values converted to dollars, in order to make it easier to understand the values considered. At the date of the survey, the conversion between real currencies and commercial US dollars was at R $ 3.9026 / US $.

2.2 Definition of Payback, ROI and Investment Simulation

To define Payback we used Equation 1.

$$Payback = \frac{Fci}{R} \tag{1}$$

were payback is the time of return of investment, in years, Fci is the investment, in dollars and R is the revenue generated, in years. Paybacks above 20 years was considered impracticable.

Already for ROI identification, Equation 2 was used.

$$ROI = \frac{(T.R) - Fci}{Fci} \tag{2}$$

were ROI is the return on investment, in %, T is the time considered for evaluation, in years, R is the revenue generated, in years and Fci is the investment, in dollars. The time for evaluation of ROI in this paper was 20 years.

As another factor of economic feasibility can be considered the budgeted amount for the implantation of equipment or investment converted as capital into an investment fund. Considering equal contributions during the study period, Equation 3 can be used.

$$M = C\left[\frac{(1+i)^n - 1}{i}\right] \tag{3}$$

were M is the amount withdrawn at the end of the period, in dollars, C is the capital invested per year, in dollars, i is the interested rate per year, in % and n is the period considered for the study, in years.

In this paper, was considered the capital invested as the cost of the rainwater harvesting system in each situation. The interested rate per year was conceived as 10%, a common rate for low-risk investments (GARRISON, NOREEN, BREWER; 2013). The period considered for the study was 20 years, in line with the other economic parameters of the study.

3 RESULTS AND DISCUSSION

With the parameters defined previously, the results obtained was located in the Table 2.

Table 2 – Results of deployment costs, income and expenses and economic indicators of rainwater harvesting systems

Edification (m²)	Reservoir Volume (m³)	Deployment Costs		Income and Expenses		Economic Indicators Concrete Res.		Economic Indicators Polyethylene Res.		Value-added Investment	
		Concrete Reservoir (US$)	Polyethylene Reservoir (US$)	Economy of water per year (US$)	Operation Manutention per year (US$)	*Payback (years)*	ROI	*Payback (years)*	ROI	Interest Rate (per year)	ROI (annual contribution)
50	3,48	1.189,32	1.056,05	76,59	23,58	22,44	-10,86%	19,92	0,39%	10%	186%
	5,66	1.524,84	1.432,82	77,79	34,26	35,03	-42,91%	22,93	-12,78%	10%	186%
120	1,08	914,08	793,67	73,85	20,38	17,09	17,00%	14,84	34,74%	10%	186%
	1,55	986,41	931,83	75,92	21,44	18,11	10,45%	17,11	16,92%	10%	186%
200	0,50	875,69	819,79	75,46	20,26	15,86	26,07%	14,85	34,67%	10%	186%
	1,56	1.038,83	1.038,83	85,81	23,60	16,70	19,77%	17,27	15,81%	10%	186%
300	0,50	1.010,16	872,79	76,74	20,47	15,56	28,51%	14,57	37,28%	10%	186%
	1,38	1.202,29	1.045,93	85,57	25,19	19,92	0,42%	17,33	15,44%	10%	186%

Source: the autors.

Some informations can be obtained from the Table 2:

- The concrete reservoirs have cost higher than those of polyethylene in the same volumes, however, they are more durable and have a better architectonic aspect;
- for small catchment areas and high demands, the systems did not present a financial return;
- an increase in viability is observed with the increase of catchment area, especially in the smallest reservoirs identified;
- the smallest reservation volumes are those with more attractive Payback;
- all simulated reservoirs have ROI below investment funds at rates of 10% per annum. This means that in this way the deployment of these systems on a large scale would depend on government incentives;
- the increase in the size of the reservoirs does not represents financial gains.

4 CONCLUSIONS

The use of non-potable rainfall systems could be more natural for populations in cities with long periods of drought. However, the perception of the inhabitants of the cities with these rainfall characteristics is that this system would not bring financial benefits.

In this sense, the study carried out generated results that justify the use of the rainfall system for some situations, obtaining financial and environmental benefits. Moreover, the use of this system on a reasonable scale would bring benefits in terms of damping heavy rains, reducing the demand on public storm drainage systems.

It is also possible to verify the feasibility of simpler systems, with the withdrawal of the lower reservoir and the centrifugal pump, which could make the system even more attractive and simple.

LIST OF REFERENCES

Baptista, M. B., Nascimento, N. O. and Barraud, S. (2011). *Compensatory techniques in urban drainage*. ABRH.

Farreny, R., Gabarrell X. and Rieradevall J (2011). Cost-efficiency of rainwater harvesting strategies in dense Mediterranean neighbourhoods. *Resources, Conservation and Recycling,* 686-694.

Fewkes, A. (2012). A review of rainwater harvesting in the UK. *Structural Survey*, *30*(2), 174-194.

Garrison, R. H., Noreen, E. W., and Brewer, P. C. (2013). *Management accounting*. AMGH.