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Analysis of the feasibility of the use of rainwater: a case study for standard school infrastructures

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SUMMARY

With the growth in water demand worldwide, cities are experiencing increasing difficulties to guarantee the public supply of drinking water. Therefore, the search for alternatives that replace the available sources needs to be disseminated. An alternative to reduce the demand for drinking water is to use the Rainwater harvesting system. This work analyzes the feasibility of implementing a system for capturing, storing, and distributing rainwater for non-drinking purposes in three standard projects of the National Fund for the Development of Education in three locations in the state of Pernambuco: Recife, Caruaru, and Petrolina. To achieve this objective, local rainfall data, the catchment area used and the demand for non-drinking water in the building were analyzed. Then, sizing calculations of the storage reservoir were performed by different methods. The time for return on investment was considered satisfactory for all types located in Recife and for the 1-room type in Caruaru and Petrolina, considering the benefit from the system in the long term. Therefore, the typologies of 6 and 12 rooms in Caruaru and Petrolina were excluded since they had a return time of more than 24 years. The advantages are not only financial, but also environmental, cultural, and educational.

KEYWORDS: Use of Rainwater. Reservoir sizing. Standard Projects.

1 INTRODUCTION

Water is an essential resource to meet the needs of living beings. According to Marinoski (2007), it is an important element to produce different activities, being fundamental for technological and economic development. However, even though Brazil has one of the largest hydrographic basins in the world, the increase in the world population, climate change, storage, and distribution problems, added to the growing consumption of water resources, have increased water consumption by 1% per year in urban areas, collaborating for a future perspective of water scarcity (UNESCO, 2016).

Despite the problem of water scarcity in Brazil, public actions lack a deeper understanding of sustainability concepts and there are few practical actions as well as the lack of objective parameters to outline concrete plans to reduce socio-environmental impact and increase the efficiency of public buildings. Public authorities, as regulatory institutions, and, mainly, as consumers, must act as an example in the application of sustainable techniques in the construction of public buildings – examples: adopting more eco-efficient measures and aiming at a better relationship with the urban environment as well as with efficiency energy of their buildings. (VIGGIANO, 2010; MAISIRA et al. 2007).

One of the alternatives to reduce the use of drinking water is the use of a rainwater harvesting system for non-potable purposes. In such method, water is collected usually on the building's roof or slab, stored in reservoirs or cisterns, and can be later used in floor and car washing, sanitary flushes, and garden irrigation (TOMAZ, 2005; NUNES; LIMA; SILVA, 2017).

The school becomes a key point of this discussion since it is an institution responsible for the formation of citizens. Through its scope, it can be the vector for the development of sustainable daily practices among students, teachers, employees, and the community in general (SCHERER, 2003; OLIVEIRA, 2013; NUNES, 2015; SOARES, 2016).

In this context, the object of study in this work is school projects provided by the National Fund for the Development of Education - FNDE in three cities in Pernambuco: Recife, Caruaru, and Petrolina. These cities were chosen because they have a higher population index and represent pluviometry indexes of the different regions in the state: Metropolitan Region, Agreste, and São Francisco Region, respectively.

The National Education Development Fund (FNDE) provides municipalities, states, and the Federal District with standard projects for the construction of schools of the Urban and Rural Educational Space model. The program has five different school models, with one, two, four, six, and twelve classrooms (FNDE, 2018).

For municipalities, states, and the Federal District to have access to funds, they must include in their Plan of Articulated Actions (PAR) the need to build this project. PAR is the multidimensional planning of education policy that municipalities, states, and the Federal District must do for a period of four years (FNDE, 2018).

Three school physical infrastructure projects from FNDE were studied. They are part of PAR: technical and financial assistance strategy initiated by the *Todos pela Educação* Plan, instituted by the Decree 6,094, of April 24th, 2007. The selected structures are the educational space projects for 1, 6, and 12 classrooms, which have the capacity to serve up to 60, 360, and 780 students respectively; the first serves rural areas while the rest, rural and urban areas. These structures were chosen because they represent small, medium, and large schools.

Therefore, the technical and economic feasibility of using a rainwater harvesting system in these projects will be analyzed, with the collected water used for non-potable purposes.

The best non-potable demand options identified for the use of rainwater collected were floor washing and garden watering. Although it is possible to use this water for flushing in close coupled toilets, it presents relatively high costs for implementation, given the need for works and adjustments in the hydraulic / hydrosanitary installations in schools.

2 METHODOLOGY

Generally, the accumulation reservoir is the most expensive component of the rainwater collection and use system. Because of that, it requires careful dimensioning so as not to make it unfeasible (MAY, 2004).

2.1 Methods for dimensioning rainwater reservoirs

To estimate the volume of the rainwater reservoir, the following information was collected: school demand for non-potable water; consumption estimates with gardening and floor washing; local rainfall, with historical data from the Pernambuco Water and Climate Agency (APAC); and the building's coverage area.

The NBR 15527 (ABNT, 2007) defines that the dimensioning of the rainwater reservoir capacity can be done with any method, at the discretion of the designer, if the choice is duly justified. Six calculation methods are suggested in the document; they are: Rippl, Simulation, Azevedo Neto, Practical German, Practical English, and Practical Australian.

For the Rippl method, monthly (most common) or daily historical series can be used and consists of determining the volume of the reservoir based on the catchment area as well as the recorded precipitation. It considers that not all precipitated water is stored. It also correlates to the monthly consumption of the building, which can be constant or variable. (AMORIM AND PEREIRA, 2008).

The Simulation method is based on determining the percentage of consumption that will be met, according to a previously defined reservoir size. It is also called the Simulation

Analysis Method of a Reservoir with Supposed Capacity (RUPP; MUNARIM; GHISI, 2011). Azevedo Neto method does not consider the demand for non-potable water, considering only the volume collected and the number of months with drizzle or drought. The Practical German, English, and Australian methods are empirical methods mentioned in NBR 15527 (ABNT, 2007). The equations for each method are shown in figure 1.

Figure 1 - Equations for dimensioning rainwater reservoirs

Rippl Method
Q (t) = C x rainfall (t) x catchment area
V = ΣS (t), only for values S (t)> 0
Where: ΣD (t) < ΣQ (t)
Where:
S (t) is the volume of water in the reservoir at time t;
Q (t) is the volume of rain usable at time t;
D (t) is demand or consumption at time t;
V is the volume of the reservoir;
C is the runoff coefficient.

Azevedo Neto Method
Where:
P is the numerical value of the average annual precipitation, expressed in millimeters (mm);
T is the numerical value of the number of months of drizzle or drought;
A is the numerical value of the projection collection area, expressed in square meters (m^2);
V is the numerical value of the volume of usable water and the volume of water in the reservoir, expressed in liters (L).

Practical German
Where:
V is the numerical value of the annual usable volume of rainwater, expressed in liters (L);
D is the numerical value of the annual demand for non-potable water, expressed in liters (L); A_{dopted} is the numerical value of the reservoir water volume, expressed in liters (L).

Simulation Method
Q (t) = C x rainfall (t) x catchment area
Where: 0 ≤S (t)≤ V
Where:
S (t) is the volume of water in the reservoir at time t;
S (t-1) is the volume of water in the reservoir at time t - 1;
Q (t) is the volume of rain at time t;
D (t) is consumption or demand at time t;
v is the fixed volume of the reservoir;
C is the runoff coefficient.

Practical Australian
Where:
C is the runoff coefficient, generally 0.80;
P is the average monthly precipitation;
it is the interception of water that wets the surfaces and losses by evaporation, generally 2 mm;
A is the collection area;
Q is the monthly volume produced by the rain.
The calculation of the reservoir volume is performed by attempts, until optimized confidence values and reservoir volume are used.

Q (t) is the monthly volume produced by the rain in month t (m^3);
V (t) is the volume of water that is in the tank at the end of month t;
V (t-1) is the volume of water in the tank at the beginning of month t;
D (t) is the monthly demand.
For the first month, the reservoir is considered empty.
When [V (t-1) + Q (t) - D] <0, then the V (t) = 0
The volume of the chosen tank will be T (m^3).
Confidence: Pr = Nr / N
Where:
Pr is the fault;
Nr is the number of months in which the reservoir did not meet demand, that is, when V (t) = 0;
N is the number of months considered, usually 12 months;
Confidence = (1 - Pr); it is recommended that the confidence values are between 90% and 99%.

Practical English
Where:
P = average annual precipitation (mm);

A = is the numerical value of the projection collection area, expressed in square meters (m^2)
V = is the numerical value of the volume of usable water and the volume of water in the cistern, expressed in liters (L).

Source: Elaborated by the authors based on NBR 15527 (ABNT, 2007).

2.2 Analysis of the economic feasibility of implementing the system

2.2.1 Estimate of the implantation cost

To estimate the cost of implementing the rainwater harvesting system in the three school building types, data were collected regarding the type of reservoir to be installed, conditions of rainwater installations in buildings, and the labor required to install the system.

2.2.2 System financial return

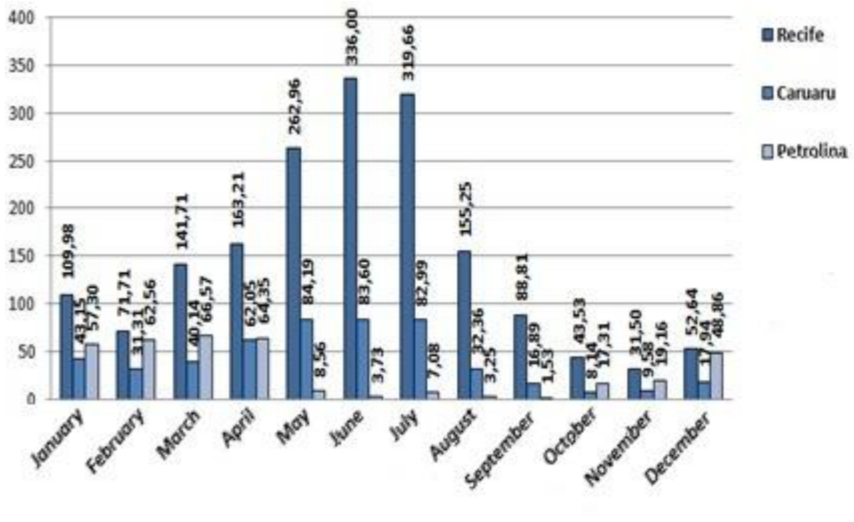
To analyze the feasibility of implementing the system, the average water consumption of the building was calculated. The reduction in the average consumption of drinking water was evaluated with the implementation of the rainwater harvesting system. Based on the fee structure of water supply state company (Companhia Pernambucana de Saneamento – COMPESA), it was possible to analyze the monthly and annual savings.

3. RESULTS AND DISCUSSIONS

3.1. Rainfall data for the cities studied.

This study used a 10-year historical series (2008 to 2017) with monthly rainfall data for the cities of Recife, Caruaru, and Petrolina, obtained through the database of the Pernambuco Water and Climate Agency (APAC). Graph 1 shows the historical average of monthly precipitation calculated for the period considered.

Graph 1. Average monthly rainfall by municipality



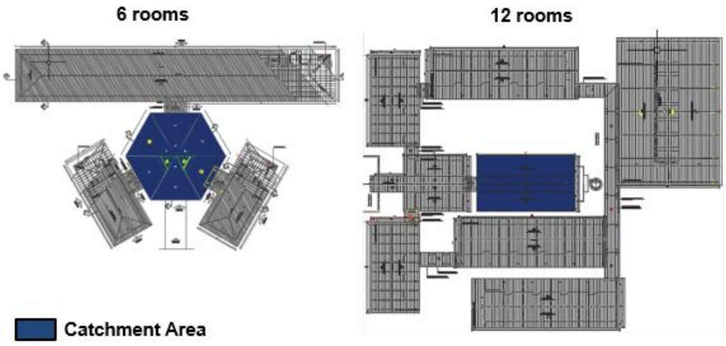
Source: Prepared by the authors based on data from APAC (2018).

3.2. Definition of the catchment area

The calculation of the catchment area was performed by analyzing the blueprint of the school building types studied. Considering the water demand of the school types and the rainfall average for each region, it was concluded that only the full coverage of the school with 1 room would be used, as it is a small catchment area. In schools with 6 and 12 classrooms, the full use of the roof would generate waste due to excessive water leakage.

For the city of Recife, the typologies of 6 and 12 rooms were considered. The catchment area of 221.97 m² was used as the calculation basis for the 6-room project, with the volume collected from the patio roof and. For the project with 12 rooms, we considered an area of 353.96 m² with the coverage of the cafeteria and patio, as shown in figure 2. As it is the capital of the State and has an estimated population of 1,653,461 people in 2020 by IBGE, the school typology with 1 room for the rural area it was not considered for Recife.

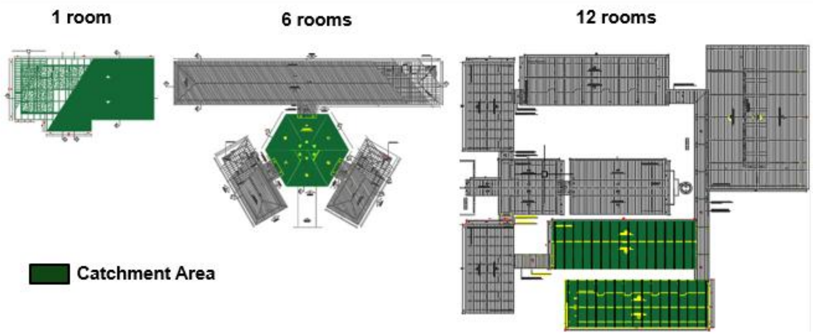
Figure 2 - Catchment area by building type for Recife.



Source: Prepared by the authors from FNDE (2018)

For the cities of Caruaru and Petrolina, as there is a different rainfall regime, the catchment area is 146.15 m², total projection area for the school with 1 classroom; 221.97 m² for the 6-room school, where the patio roof is used; and 950.40 m² for the 12-room projects, using the roof area of blocks E2 and F, as shown in figure 3.

Figure 3 - Catchment area by building type for Caruaru and Petrolina.



Source: Prepared by the authors from FNDE (2018)

3.3. Determination of non-potable water demand

The demands for non-potable purposes considered were washing the floor and watering the garden. Although only the 6-room typology contains a project area of 90.96 m² for the garden, all projects have areas available for setting up school gardens, planting trees and shrubs, among other socio-environmental applications, according to local school management. The parameters and frequency used for calculation purposes, according to Tomaz (2009), were:

• **Garden Irrigation**: For irrigation of Common Garden the rate is 2 L / m² x day. The frequency of garden watering is usually 2 times / week;

• **Patio Cleaning**: The cleaning for common patios is usually of 2 L / m² x day and the frequency is 1 time every 15 days.
The non-potable water demands by school building typology are described in Table 1.

Table 1 - Non-potable water demand.

School Building Typology	Monthly non-potable water demand (m³)
1 classroom	0.69
6 classrooms	4.62
12 classrooms	21.11

Source: Authors.

3.4. Reservoir dimensioning

For the dimensioning of the rainwater reservoir, all the methods described in the NBR 15.527 standard were considered (ABNT, 2007). For this, data from the catchment area, the consumption of drinking water susceptible to substitution by Rainwater, and pluviometry data were used.

3.4.1 Results observed in Recife

Table 2 shows the results of the reservoir sizing methods applied to the municipality of Recife.

Table 2 – Volume (m³) of the reservoir by method and school typology

Methods	**Typology**	
	6 rooms	12 rooms
Rippl	6.00	28.90
Simulation	5.00	25.00
Azevedo Neto	33.13	52.83
Practical German	19.08	30.12
Practical English	19.72	31.45
Practical Australian	6.00	25.00

Source: Authors.

In the application of the Rippl method, for 6 rooms, the occurrence of overflow was observed in all months, generating a result equal to 0 for the accumulated difference. In this context, the value of 6 m³ for this reservoir was fixed, to be considered for later calculations. For the typology of 12 rooms, the maximum volume obtained was 28.90 m³, which would regularize the constant demand to 21.11 m³

For the Simulation method for 6 rooms, the reservoir volume of 5 m³ was arbitrated. The monthly water volume would supply the demand, in addition to generating an overflow in every month. For the 12-room project, the reservoir volume of 25 m³ was arbitrated, which fully met the demand for 21.11 m³, except in December, when there would be a need for an external supply of 2.33 m³.

When using the Azevedo Neto methodology, parameter T equals 2, corresponding to the months of October and November that presented the lowest monthly averages of 43.53mm and 31.50mm, respectively. The reservoir obtained for the 6-room projects had a volume of 33.13 m³, a value approximately 7 times the required demand. For the 12-room project, the volume was 52.83 m³.

In the Practical German method, the annual demand value was used for calculation purposes, with values of 331.28 m³ and 496.38 m³, for the types of 6 and 12 rooms. The volume of the reservoir found was 18.67 m³ and 29.78 m³, respectively. In the direct application of the English method, the volume found was 19.72 m³ and 31.45 m³, for the project of 6 and 12 rooms.

The Practical Australian method was calculated by setting the reservoir value and checking its reliability. The fixed value was 6 m³ and 25 m³, for the projects of 6 and 12 rooms. As a result, the reliability was 92% for both volumes, which meets the recommendation of NBR 15527/07, established the guarantee for this method from 90 to 99%.

3.4.2. Results observed in Caruaru

Table 3 shows the results of the reservoir sizing methods applied to Caruaru.

Table 3 - Volumes (m³) of the reservoir by method and school typology

Methods	Typology		
	1 room	6 rooms	12 rooms
Rippl	0.00	10.70	51.70
Simulation	5.00	12.00	50.00
Azevedo Neto	2.18	3.31	14.21
Practical German	0.50	3.33	15.20
Practical English	0.26	0.39	1.69
Practical Australian	10.00	20.00	20.00

Source: Authors.

In Table 3, apart from the Rippl and Simulation methods, the calculated reservoir values were lower than in the city of Recife. This is due to the rainfall totals in the city of Caruaru being lower than in the city of Recife. Moreover, the rain in the city has a greater temporal irregularity.

The Rippl method considers the monthly average precipitation data, in millimeters, rainwater catchment area, and the demand for non-potable water. The reservoir is dimensioned according to the sum of the water volumes (St) only in the months where they had positive value. Thus, the reservoir for the 1-room construction typology did not prove to be a viable alternative since there were only months with negative values. For the typology of 6 rooms, the total accumulated between the months of September to December was considered. Such months have positive values, which corresponds to 10.7 m³. In the typology of 12 rooms, the accumulated total of February is used as well as the months from August to December, which represents 51.7 m³.

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For the Simulation method, the same parameters as the Rippl method were used. They differ, however, because in the first a reservoir volume is fixed. Thus, after several volumes of reservoirs, a reservoir volume of 5 m³ was reached for the constructive typology of 1 room. With this volume, according to the Simulation Method, the reservoir would supply the school. In addition, it would generate an overflow between the months of March and December of 33.41m³/year, not requiring any external supply with drinking water. For the school with 6 classrooms, a reservoir volume of 12 m³ was determined. This volume would supply the monthly demand and generate an overflow between the months of February and August reaching a total annual value of 28.66 m³. In the typology of 12 rooms, the reservoir volume of 50 m³ was arbitrated, which supplied the non-potable demand, generating an overflow with total annual volume of 116.34 m³. However, despite this high overflow, there was a need for an external supply of 1.55 m³ for the month of December.

As it is an Agreste region, for Caruaru, we consider 8 months with almost no rain or no rain at all to apply the Azevedo Neto method. With the direct application, it reached a value of 1.75 m³ of usable volume and storage in the reservoir for the constructive typology of 1 room. For the school with 6 classrooms, the volume of the reservoir was 2.65 m³; for the school with 12 classrooms, the volume was 11.34 m³.

In the Practical German method with direct application, a storage volume of 0.50 m³ is obtained for the typology of 1 room; 3.33 m³, for the school with 6 classrooms; and 15.20 m³, for the project of 12 classrooms.

With the direct application of the Practical English method, reservoir volumes of 0.26 m³, 0.39 m³, and 1.69 m³ were found for 1 room, 6 rooms and 12 rooms, respectively.
The Practical Australian method is carried out by direct application and by trial. Thus, a 10 m³ reservoir volume with 92% confidence was adopted for the typology of 1 room. The storage volume of 20 m³ with 92% confidence was chosen for both projects of 6 and 12 classrooms.

3.4.3. Results observed in Petrolina

Table 4 shows the results of the reservoir sizing methods applied to the municipality of Petrolina.

Table 4 - Reservoir volumes by method and school typology

Methods	Typology		
	1 room	6 rooms	12 rooms
Rippl	1.76	23.34	110.77
Simulation	10.00	25.00	50.00
Azevedo Neto	1.50	2.50	15.00
Practical German	0.50	3.33	15.20
Practical English	0.18	0.30	1.20
Practical Australian	5.00	*	*

* confidence level not reached

Source: Authors.

In Table 4, except for the Rippl and Simulation methods, the calculated reservoir values were lower than in the city of Recife. As in Caruaru, the cause of these results is the low pluviometry index added to the temporal irregularity of the rain. In situations like these, the ideal is to use methods that over-dimension the reservoir, so that the water collected in the rainy periods can supply the demand in periods of drought.

Applying the Rippl method to 1-room schools in Petrolina, as in Caruaru, it is not feasible to use a rainwater harvesting system, because the difference between the volume of demand and the volume of rain generates negative values for all months. For 6-room schools, the volume of the reservoir corresponds to 23.34 m³; in the typology of 12 rooms, it corresponds to 110.77 m³.

For the Simulation method, the same parameters were used as the Rippl method, setting a value of 25m³ for the 6-room school reservoir and 50m³, for the 12-room school. With this volume, according to the Simulation Method, the 25m³ reservoir would supply the school with 6 rooms, in addition to generating an overflow between the months of February and April in the annual total of 15.14 m³, requiring no external supply of drinking water. For the school with 12 classrooms, the 50 m³ reservoir meets the monthly demand for the months of December to June, requiring a total external supply of 60.77m³ during the months of July to November; it generates an overflow of 59.67m³ between February and March.

For the application of the Azevedo Neto method, eight months with almost no rain or no rain at all were considered since its rainy season is from January to April. With direct application, it reached a value of 1.22 m³ of usable volume and storage in the reservoir for the school with 1 room; for the school with 6 rooms, the volume was 1.87 m³; and for the school with 12 rooms, the calculated volume was 8 m³.

With the direct application of the Practical German method, a storage volume of 0.5 m³ was obtained for the typology of 1 room; 3.33 m³ for the school with 6 classrooms; and 15.20 m³ for the project of 12 classrooms.

With the direct application of the Practical English Method, a reservoir volume of 0.18 m³, 0.3 m³, and 1.2 m³ was found for the typology of 1 room, 6 rooms, and 12 rooms, respectively.

Finally, for the Practical Australian Method, carried out by direct application and by trials, the volume of the 5 m³ reservoir with 92% confidence was calculated, for the typology of 1 room. For the school with 6 and 12 classrooms, several reservoir volumes were tested, but none of them reached confidence levels between 90 and 99%, required by the method for these types of schools. The volume of the reservoir obtained by this method will not be considered.

3.5. Estimated cost

The feasibility study for the implementation of the rainwater harvesting system in the school units was divided into two stages. The first was the budget for carrying out the service according to each school typology and the calculated reservoir. The budget was obtained by consulting the website of the ecological solutions company that provides installation for this type of systems (Ecocasa, 2018). It was based on the budget for the 10 m³ reservoir. The capacities for this budget correspond to the typologies of 6 and 12 rooms: for Recife the capacity was 5,000 and 25,000 liters; Caruaru corresponds to 10,000 and 50,000 liters; and Petrolina, 25,000 and 50,000 liters, respectively. Table 5 shows the costs for the reservoirs.

Table 5 – Cost description implanting the reservoir (Values from May / 2016)

Reservoir Capacity	5000 L		10000 L		25000 L		50000 L	
Item/Average Price	Quant.	Preço Médio	Quant.	Preço Médio	Quant.	Preço Médio	Quant.	Preço Médio
VF1 kit for use of rainwater + refeeding	1,00	R$ 2.800,00	1,00	R$ 2.800,00	1,00	R$ 2.800,00	1,00	R$ 2.800,00
System rainwater cistern	1,00	R$ 5.099,50	1,00	R$ 10.199,00	1,00	R$ 25.497,50	1,00	R$ 50.995,00
Bricklayer + Helper (Daily free)	4,00	R$ 1.400,00	4,00	R$ 1.400,00	6,00	R$ 2.100,00	6,00	R$ 2.100,00
Concrete FCK 18 m³	0,80	R$ 384,00	1,60	R$ 480,00	4,00	R$ 1.920,00	8,00	R$ 3.840,00
Backhoe (R$/h)	1,50	R$ 180,00	3,00	R$ 360,00	7,50	R$ 900,00	15,00	R$ 1.800,00
Pump (1st row up to 1.5 hp) + Engine Room + Electrical materials	1,00	R$ 1.800,00	1,00	R$ 1800,00	1,00	R$ 1.800,00	1,00	R$ 1.800,00
Plumber (R$/h)	3,00	R$ 121,00	6,00	R$ 243,00	15,00	R$ 607,50	30,00	R$ 1.215,00
Electrician (R$/h)	3,00	R$ 121,00	6,00	R$ 243,00	15,00	R$ 607,50	30,00	R$ 1.215,00
Total		**R$ 11.905,50**		**R$ 17.525,00**		**R$ 36.232,50**		**R$ 65.765,00**

Source: Prepared from the budget of Ecocasa (2018)

For the 1-room typology in Caruaru and Petrolina, the use of a fiberglass water tank with a capacity of 2,000 liters was fixed. The cost of implementation was obtained by the Sergipe Works Budget System, with the summary described in table 6 below.

Table 6 - Description of water tank costs

Reference	Material	Workforce	Social Charges	Third Parties	Total
01429/ORSE	R$ 1,060.19	R$ 43.88	R$ 50.15	R$ 3.40	R$ 1,157.62

Source: Elaborated from the budget of Ecocasa (2018)

As a second stage of the feasibility study, the investment Payback calculation was carried out. According to Tomaz (2009), Payback consists of a very simple method for economic analysis of the capital invested and should be only considered in a pre-study to accept or reject a given project. The objective is to measure the time in which the initial investment will be replaced.

To calculate the annual cost for non-potable demand using drinking water supplied by the local concessionaire, the 2018 values of COMPESA were used. The values corresponding to each project are shown in table 7.

Table 7 - Annual cost corresponding to demand

Typology	Monthly Demand	Monthly Cost	Annual Cost
1 room	0.69	R$ 58.72	R$ 704.64
6 rooms	4.62	R$ 58.72	R$ 704.64
12 rooms	21.11	R$ 165.64	R$ 1,987.68

Source: Authors.

The return-on-investment time was presented dividing the value for implementing the system by the annual cost that the demand would meet. The result of the approximate return time expressed in years was presented in table 8.

Table 8 – Return time on investment

Location	Typology	Cost of annual demand	Cost of investment	Return time on investment
Recife	6 rooms	R$ 704.64	R$ 11,905.5	16 years and 9 months
	12 rooms	R$ 1,987.68	R$ 36,232.5	18 years and 2 months
Caruaru	1 room	R$ 704.64	R$ 1,157.62	1 year and 6 months
	6 rooms	R$ 704.64	R$ 17,525.0	24 years and 8 months
	12 rooms	R$ 1,987.68	R$ 65,765.0	34 years
Petrolina	1 room	R$ 704.64	R$ 1,157.62	1 year and 6 months
	6 rooms	R$ 704.64	R$ 36,232.5	51 years and 4 months
	12 rooms	R$ 1,987.68	R$ 65,765.0	34 years

Source: Authors.

4 CONCLUSIONS

The search for water supply alternatives for non-drinking purposes, specifically rainwater harvesting, aims to reduce the consumption of drinking water, especially with nowadays actions to the responsible use of available water resources. Through this work, it was possible to estimate the impact of the implementation of this system in three standard school projects of FNDE in three municipalities in Pernambuco: Recife, Caruaru, and Petrolina.

In Recife, for the typologies of 6 rooms and 12 rooms, the volume of the reservoir with 5 m³ and 25 m³, respectively, would be sufficient to meet the specific water demand – since in the methods that considered the demand, it was found approximated values. For Caruaru, in the types of 1, 6, and 12 rooms, the volume of the reservoir with 2 m³, 10 m³, and 50 m³, respectively, would supply the water demand. For Petrolina, in the types of 1, 6, and 12 rooms, the volume of the reservoir with 2 m³, 25 m³, and 50 m³, respectively, would be sufficient.

The return on investment is considered satisfactory for the two types located in Recife and for the type of 1 room in Caruaru and Petrolina, when considering the benefit from implementing the system in the long term. Therefore, the typologies of 6 and 12 rooms int those cities were excluded; they had a return time of more than 24 years.

The advantages are not limited to the financial impact, but also bring environmental, cultural, and educational benefits. With the reduction in the consumption of drinking water, the school becomes a reference in saving water over the public supply network. In addition, regarding the educational and pedagogical role, it helps to train students who are aware of their role in the conservation and rational use of water.

Furthermore, FNDE standard projects’ more sustainable form of construction available to municipalities would help to publicize the need for water saving. Seeking alternative sources would also indicate committed authorities and public managers to combat the water waste and inappropriate use.

Finally, it is important that this project can be reference for future initiatives on building schools in locations with similar rainfall.

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