Potential for Saving Drinking Water Through the Use of Rainwater in Social Housing in Viçosa-Brazil

Ahorro potencial de agua potable mediante el uso de aguas pluviales en viviendas de interés social de Viçosa-Brasil

Potencial de economia de água potável por meio do uso de águas pluviais em habitações de interesse social em Viçosa-Brasil

Juan Esteban Sánchez-Galvis[1], **María José Sánchez-Galvis**[2], **Iván Andrés Sánchez-Ortiz**[3*]

Abstract 🔊

[Objective] The main objective of this research was to evaluate the potential for saving drinking water by using rainwater as a source of supply for non-potable purposes in two neighborhoods with social housing in the municipality of Viçosa, Minas Gerais, Brazil. **[Methodology]** The consumption statistics for each month of 2020 were used for each of the homes comprising the Benjamin José Cardoso and Sol Nascente Housing Complexes, and the fraction of drinking water that is destined in homes for non-potable purposes was estimated. The information corresponding to the monthly rainfall records of the last 50 years was analyzed and the monthly volume of rainwater that could be harvested in each house was calculated. **[Results]** The average monthly volume of rainwater that could be captured through the roof area of each dwelling is 3.39 m³. During the rainy months of the year, it would be feasible to save a higher percentage of water than that allocated for non-potable purposes. Sizing a rainwater reservoir that exceeds the monthly needs for non-potable purposes would allow the surplus of collected water to supply the liquid during the dry season. **[Conclusions]** Since the average percentage of savings in drinking water for both neighborhoods exceeded 53%, the saving of the monthly consumption can contribute to the reduction of payments for the drinking water service and the consumption of the liquid in the municipality, particularly during drought months.

Keywords: potable water savings; rainwater usage; roof catchment; water availability.

*   Corresponding author

Juan Esteban Sánchez-Galvis, ✉ juanessangal@gmail.com. 🆔 https://orcid.org/0000-0003-0905-1296
María José Sánchez-Galvis, ✉ mariajosesg22@gmail.com. 🆔 https://orcid.org/0000-0002-9204-8196
Iván Andrés Sánchez-Ortiz, ✉ iaso@udenar.edu.co. 🆔 https://orcid.org/0000-0001-7579-5969

1   Departamento de Engenharia Química, Universidade Federal de Viçosa, Viçosa, Minas Gerais, Brasil.
2   Departamento de Medicina, Universidad Cooperativa de Colombia, Pasto, Nariño, Colombia - Departamento de Serviço Social, Universidade Federal de Viçosa, Viçosa, Minas Gerais, Brasil.
3   Departamento de Recursos Hidrobiológicos, Universidad de Nariño, Pasto, Nariño, Colombia.

Resumen 🔊

[Objetivo] El principal objetivo de esta investigación fue evaluar el potencial de ahorro de agua potable, mediante el empleo de la pluvial como una fuente de abastecimiento para usos no potables, en dos barrios con viviendas de interés social del municipio de Viçosa (Minas Gerais, Brasil). **[Metodología]** Se utilizaron las estadísticas de consumo correspondientes a cada mes del 2020, para cada una de las casas que conforman los complejos habitacionales Benjamin José Cardoso y Sol Nascente, así como se estimó la fracción de agua potable destinada en los hogares para usos no potables. Se analizó la información correspondiente a los registros de lluvias mensuales de los últimos 50 años y se calculó el volumen mensual de agua de lluvia que podría colectarse en cada casa. **[Resultados]** El volumen promedio mensual de agua pluvial que podría captarse en el área de tejado de cada hogar es 3,39 m³. Durante los meses lluviosos del año, podría almacenarse un porcentaje de agua mayor al destinado para usos no potables; el dimensionamiento de un reservorio de agua de lluvia que supere las necesidades por mes del líquido para dichos propósitos podría viabilizar un excedente de agua colectada que garantice el recurso a lo largo de la temporada seca. **[Conclusiones]** Ya que el porcentaje promedio de ahorro de agua potable para ambos barrios supera el 53 %, el ahorro de consumo mensual puede contribuir a la reducción en el pago del servicio del agua potable y el consumo del líquido del municipio, principalmente en los meses de sequía.

Palabras clave: ahorro de agua potable; uso de agua de lluvia; captación de agua en techos; disponibilidad de agua.

Resumo 🔊

[**Objetivo**] O principal objetivo desta pesquisa foi avaliar o potencial de economia de água potável por meio do uso da água pluvial como fonte de abastecimento para usos não potáveis em dois bairros com habitações de interesse social no município de Viçosa (Minas Gerais-Brasil). **[Metodologia]** Foram utilizadas estatísticas de consumo de cada mês do ano de 2020 para cada uma das casas que compõem os conjuntos habitacionais Benjamin José Cardoso e Sol Nascente, e foi estimada a fração de água potável utilizada nas residências para usos não potáveis. Foram analisados os registros mensais de precipitação dos últimos 50 anos e calculado o volume mensal de águas pluviais que poderia ser coletado de cada residência. **[Resultados]** O volume médio mensal de águas pluviais que poderia ser coletado da área do telhado de cada residência é de 3,39 m³. Durante os meses chuvosos do ano, poderia ser armazenada uma porcentagem maior de água do que aquela destinada a usos não potáveis; o dimensionamento de um reservatório de águas pluviais que ultrapassem as necessidades mensais do líquido para esses fins poderia viabilizar um excedente de água coletada para garantir o líquido durante a estação seca. **[Conclusões]** Como a porcentagem média de economia de água potável para ambos os bairros é superior a 53%, a economia no consumo mensal pode contribuir para a redução do pagamento do serviço de água potável do município e do consumo do líquido, principalmente nos meses de seca.

Palavras-chave: economia de água potável; uso de águas pluviais; coleta de água do telhado; disponibilidade de água

Juan Esteban Sánchez-Galvis • María José Sánchez-Galvis • Iván Andrés Sánchez-Ortiz

Introduction

Water is a renewable resource, but it depends on the dynamics of the hydrological cycle. While its total volume does not change, there are many variables that affect its availability for human activities, highlighting the limitations of using this resource (Soriano *et al*., 2016). Water security is the ability of a population to safeguard sustainable access to adequate amounts of water of acceptable quality to maintain livelihoods, human well-being, and socio-economic development to ensure protection against waterborne and water-related pollution disasters and preserve ecosystems in a climate of peace and political stability (United Nations, 2013).

The tremendous increase in water demand, accompanied by population expansion, rapid urbanization, and economic booms, has intensified the issue of water scarcity and is now jeopardizing food security, regional stability, and sustainable development in numerous areas (Li *et al*., 2019). The pressures of regional water use and supply will intensify with rapid socio-economic development. Meanwhile, the inefficient utilization and irrational allocation of water resources can generate a series of adverse effects on regional water security and sustainable socio-economic development (Liu *et al*., 2019). Clearly, the growth in water demand compared to supply constraints is leading to an untenable situation that needs not only water conservation, but also significant efforts in water redistribution (Blignaut & Heerden, 2009).

Ensuring water security for communities has been a global concern (Ghisi *et al*., 2006). In the case of Brazil, water availability has gradually declined in recent years. By the end of the twentieth century, the country reported a water potential of 5610 km^3/year for a population of 157,070,163 inhabitants, which represented a water availability of 35,732 m^3/inhabitant (Rebouças *et al*., 1999). Von Sperling (2006), using data from the World Resources Institute, reported a per capita water availability of 47,125 m^3/inhabitant/year. The National Water Agency of Brazil (Agência Nacional de Águas, 2005) estimated a water availability of 33,376 m^3/inhabitant, based on the information related to surface waters with an average flow of 179,433 m^3/s and a population of approximately 170 million inhabitants. More recent information from the World Bank indicated a water availability of about 31,000 m^3/inhabitants/year in Brazil for the year 2014, considering a population of 200 million inhabitants (World Bank, 2014). It is clear that population growth increasingly compromises water availability in Brazil. Additionally, changes in the hydrological cycle due to human influences, such as deforestation, changes in land use, and the effects of climate change, impact water availability (United Nations, 2013).

According to Chenoweth (2008), a range of estimates of per capita water requirements have been developed, ranging from 20 L/inhabitant/day through to 4,654 L/inhabitant/day (7.3 to 1,699 m^3/inhabitant/year). However, when considering the components of a minimum water requirement estimate for human health, economic and social development, the author suggests that a country requires a minimum of 135 L/ inhabitant/day (49.3 m^3/inhabitant/year).

Figure 1 presents the demographic and water availability values in the Southeast region of Brazil, including the states of Minas Gerais, São Paulo, Espiritu Santo, and Rio de Janeiro, between 1900 and 2060. Although the projected water availability
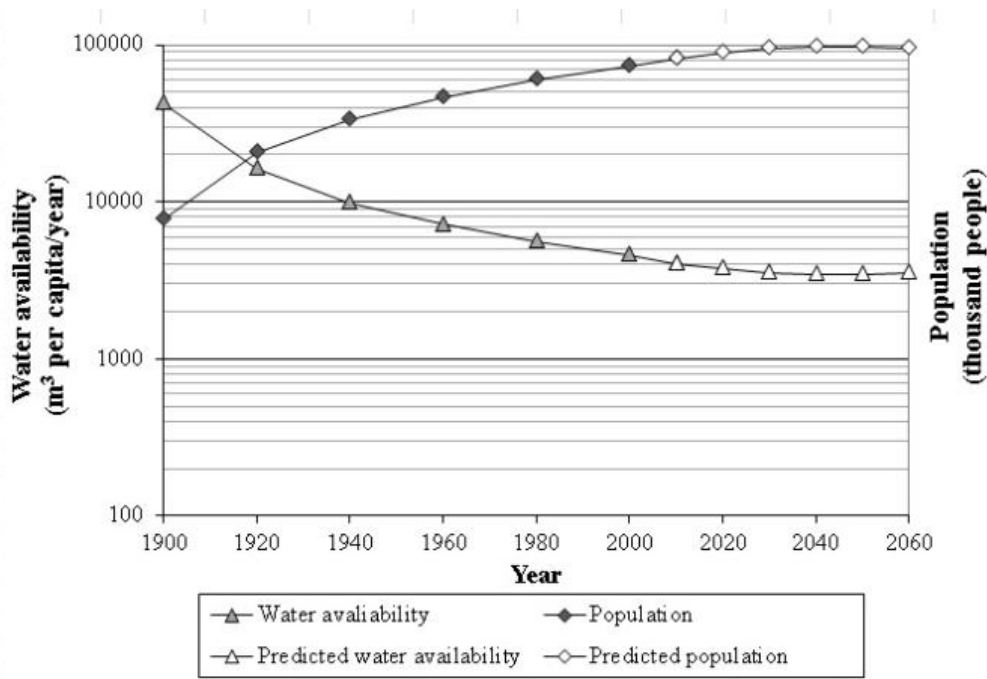
Figure 1. *Population and water availability in the Southeast region of Brazil.*
Adapted from IBGE (2020), IBGE (2021) and Ghisi (2006).

for 2060, i.e., 3541 m³/inhabitant/year, is not below the 2500 m³/inhabitant/year threshold established by UNESCO (WWAP, 2012) as a reference for water vulnerability, the graph depicts a decrease in availability in the states of the region. This decrease is primarily attributed to population growth, as registered and projected by the Brazilian Institute of Geography and Statistics.

In 2015, representatives of Brazilian government agencies declared that the southeastern region of the country faced the most severe water crisis since 1930 (Folha de São Paulo, 2015). The impacts of the water crisis have historically accumulated in the state of Minas Gerais. In 2014, the drought drastically affected the water supply in several municipalities in the southwestern region of the state, specifically in the area known as Zona da Mata Mineira (Zona da Mata–MG, 2014). In 2015 in the municipality of Viçosa, as a consequence of

this crisis, the mayor's office of the city issued a decree declaring a state of emergency, which imposed restrictions on water usage, rationing of the drinking water service and various contingency plans (Zona da Mata–MG, 2015). Although the droughts in the following years were not equally drastic, the situation of the municipality raised concerns among its population and representatives at the Municipal Council (Câmara Municipal de Viçosa, Estado de Minas Gerais, 2019). In the state of Minas Gerais the increase in water demand, associated with environmental and climatic issues, generated conflicts over water use in some cases. Evidence of this can be found in the 2020 Mineiro Institute of Water Management's declaration of 67 conflict areas (Oliveira *et al*., 2020).

The motivations for seeking solutions and alternatives to reduce water stress are undoubtedly important because, despite being renewable, quality water resources are

scarce (Moura *et al.*, 2020). One alternative increasing the urban demand for drinking water is the use for both potable and non-potable purposes. In that sense, Goodwin *et al.* (2018) stated that the reuse of wastewater for non-potable purposes is less controversial than its reuse for drinking water. They also affirmed that the acceptability of reuse is associated with the degree of contact or exposure to water. For instance, high-exposure water usage, like in swimming pools, is likely to be less acceptable than the use in toilet flushing. In the absence of reuse alternatives to reduce the use of drinking water, the two main alternatives in water management can be grouped as follows: (i) improving efficiency in water use; and (ii) exploring alternative sources of water (Silva *et al.*, 2015). Rainwater harvesting is one of the most promising alternative sources of water, as it can be easily collected and used for non-potable purposes without significant treatment.

Rainwater is an alternative water supply for domestic use in urban environments. Such use can constitute an anticipated response to the high demand on a water network resulting from urban growth. Additionally, it can help mitigate the effects of climate change in both developed and developing countries (Morales-Pinzón *et al.*, 2015). Over the past few decades, rainwater harvesting systems development have been globally developed to address water scarcity. Since most domestic demand can be satisfied with low-quality water, rainwater can substitute higher-quality drinking water for both outdoor and indoor uses (Villar-Navascués *et al.*, 2020). Rooftop rainwater harvesting involves collecting and storing water from rooftops. This practice can provide water supply in almost any place, either as a sole source or by reducing stress on other sources

through water savings (Ojwang *et al.*, 2017). Domestic rooftop rainwater harvesting systems, in particular, can support improved water resource allocation, providing relevant water-saving benefits at the household level (Campisano & Lupia, 2017).

According to Tomaz (2003), in Brazil, the consumption of water intended for non-potable residential uses, such as toilet flushing, laundries and washing machines, can constitute 40% of the total water consumed, which is comparable to the 38% reported by Silva *et al.* (2015) in a study conducted in single-family homes in Portugal. Alternative sources can replace this fraction of water to conserve drinking water and generate cost savings for consumers.

Determining the feasibility (potentiality) of implementing rainwater harvesting technology in a specific region requires a quantitative study. Within this context, this research aimed to evaluate the potential for saving drinking water through the use of rainwater as a source of supply for non-potable purposes in urban homes in two social housing neighborhoods in the municipality of Viçosa, Minas Gerais, Brazil. The study serves as a reference to analyze the potential for reducing drinking water consumption through the collection and use of rainwater for non-potable purposes in communities with single-family homes under similar conditions.

Methodology

• Place of research, housing characteristics

The municipality of Viçosa, Minas Gerais, Brazil, is located in the mesoregion known as Mata Mineira Zone, in the Rio Doce watershed (Maria *et al.*, 2014). The main watercourses in the area include the Turvo Sujo River and its sub-tributary,

the São Bartolomeu stream, which cross the urban area and constitutes one of the main sources of water for the city's population..

Since 1970 mainly, the urban growth relocated buildings that had previously occupied the bottom of the city's valleys not only to the hills in the downtown area but also to those in the outskirts of the city. (Coelho, 2020).

As a result of the rapid urban growth of the city, the municipality of Viçosa defined locations to build housing for low-income families. In that sense, through investments, the Federal Government executed the programs called *Minha Casa Minha Vida*, aimed at families with incomes ranging between 0 and 3 minimum wages. These homes were built in lots near the Nova Viçosa neighborhood (Silva, 2014).

According to Barbosa & Caixeiro (2016), between 2011 and 2012 three housing complexes were constructed: the Benjamin José Cardoso complex, also known as "Coelhas 1", which was constructed in September 2011 and has single-family houses built on lots of 10 m x 13 m; the Floresta housing complex, which is a vertical condominium, consisting of 80 housing units distributed among five four-story buildings with four apartments per floor; and the César Santana Filho or Sol Nascente complex, also known as "Coelhas 2," located 500 m from the Benjamin José Cardoso complex, with single-family houses built on lots of 10 m x 15 m. Since this study focused on independent single-family housing units, it was conducted in the housing complexes Benjamin Jose Cardoso and Sol Nascente. The two housing complexes and other houses built with the *Minha Casa Minha Vida* program used a standard typology suggested by the Caixa Econômica Federal Brasilera (Borges, 2013). Each unit has two rooms,

a living room, a kitchen, and a bathroom, with a total area of 40.34 m²; the houses have ceramic tile supported in metal structure as covering material.

According to Alves (2009), the distribution of people per bedroom in the urban region of Nova Viçosa, where Coelhas 1 and Coelhas 2 complexes are located, is as follows: 67.10% with 1 or 2 people, 24.83% with 3 people, 4.72% with 4 people, and 3.35% with 5 or more people. Based on the above and considering that the houses have two rooms, the average number of occupants per household is 5 people.

- Consumption of drinking water in homes

The monthly consumption statistics for the year 2020, as reported by the Serviço Autônomo de Água e Esgoto-SAAE (Directorate of Engineering and Maintenance of the Autonomous Water and Wastewater Service) of Viçosa were used for every household in the Benjamin Jose Cardoso (Coelhas 1) and Sol Nascente (Coelhas 2) Housing Complexes. In the analysis of the data, household consumption values exceeding 30 m³ per month were excluded because they indicated possible pipe breakage or issues in hydraulic or sanitary devices like toilets.

To estimate the proportion of drinking water used for non-potable purposes in homes, this study adopted the 40% reported by Tomaz (2013) and Neves-Filho *et al*. (2019).

- Rainfall data

The analysis of monthly rainfall for the city of Viçosa used historical information available in the Meteorological Data Bank (BDMEP) offered by the National Institute of Meteorology (INMET), belonging to the Ministry of Agriculture, Livestock and Supply of

the Brazilian government. Specifically, the rainfall data for Viçosa was obtained from the Viçosa (A510) station, located at 20.76° South Latitude and 42.86° West Longitude, which operates at an altitude of 712.20 meters above sea level. The analyzed data corresponded to the historical series of monthly rainfall spanning from January 1, 1970 to December 31, 2020. The data series are available at https://tempo.inmet.gov.br/page

With the information corresponding to the 50 years of monthly rainfall records, the values of the average monthly multi-sheet rainfall, the minimum and maximum values and the average of the typical rainfall deviations for each month of the year were determined.

- Calculation of the volume of rain to be captured

To determine the monthly amount of precipitation that could be captured, the expression proposed by Ghisi & Oliveira (2007) was used, with adaptations as described in Equation 1:

$$MVRH = \frac{MR * TRA * Rc}{1000} \qquad [1]$$

Where:

MVRH: Monthly volume of rainwater that could be harvested in each house (m³/month/house)

MR: Monthly average rainfall (mm/day = L/m² per day)

TRA: Total roof area of each house (m²)

Rc: Runoff coefficient (non-dimensional)

1000: Conversion factor, from L to m³

The following are some of the values used in the literature for the runoff coefficient in tile roofs made of ceramic material:

0.75 (Kumar, 2004), 0.80 (Ghisi et al., 2006; Silva et al., 2015; Ghisi & Oliveira, 2007), and 0.87 (Silveira et al., 2016). Additionally, in several studies conducted on rainwater collection and use for single-family homes (Neves-Filho et al., 2019), public schools (Andrade-Lima et al., 2017), and vertical buildings (Santos-Martins et al., 2021), runoff coefficient in the order of 0.8 has been used. In this study, a conservative value of Rc = 0.80 was chosen to account for the discarding of an initial volume of the "first flush" runoff that eliminates high concentrations of pollutants from the first millimeters of rain that flows across the roof surface, carrying these pollutants.

- Potential for substitution of drinking water used for non-potable purposes by rainwater

The potential to substitute drinking water monthly destined for non-potable uses by rainwater was calculated employing the Equation 2:

$$PSDWNPA = 100 * \frac{MVRH}{DWMCNPU} \qquad [2]$$

Where:

PSDWNPA: Potential substitution of drinking water used for non-potable applications (%)

MVRV: Monthly volume of rainwater harvested in each house (m³/month per house)

DWMCNPU: Drinking water monthly consumption for non-potable uses (m³/month per house)

- Potential for saving drinking water

The potential to save drinking water monthly was calculated based on the Equation 3:

$$PWS = 100 * \frac{MVRH}{DWMAC} \qquad [3]$$

Where:

PWS: Potential water saving (%)

MVRV: Monthly volume of rainwater harvested in each house (m³/month per house)

DWMCA: Drinking water monthly average consumption (m³/month per house)

Analysis and Results

• Consumption of drinking water in homes

The drinking water consumption values for 2020 provided by the SAAE of Viçosa corresponded to 268 family units for both social housing complexes.

Figure 2 presents the monthly variation of drinking water consumption corresponding to the 137 dwellings of the Coelhas 1 Housing Complex.

There was a high variability in consumption values in homes, with the highest average consumption and standard deviation in the month of August (8.02 ± 6.39 m³/month); on the other hand, the month of October registered the lowest average consumption (5.51 ± 4.32 m³/month).

Figure 3 reports the monthly variation of drinking water consumption corresponding to the 131 dwellings of the Coelhas 2 Housing Complex.
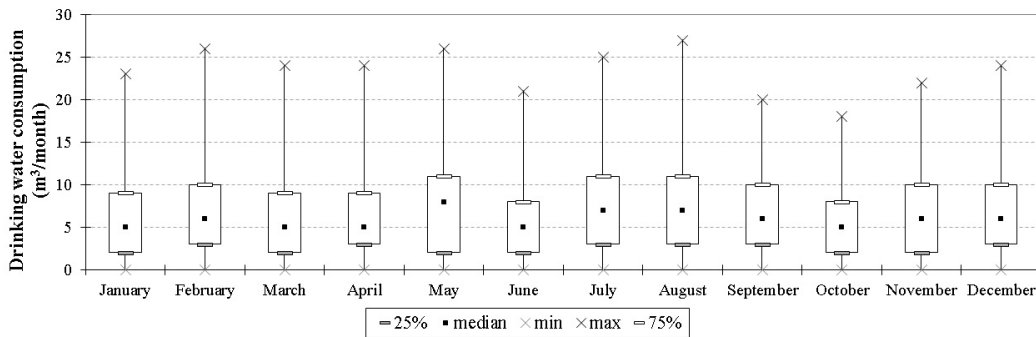

Figure 2. *Monthly variations of drinking water consumption in the Benjamin José Cardoso Housing Complex.*
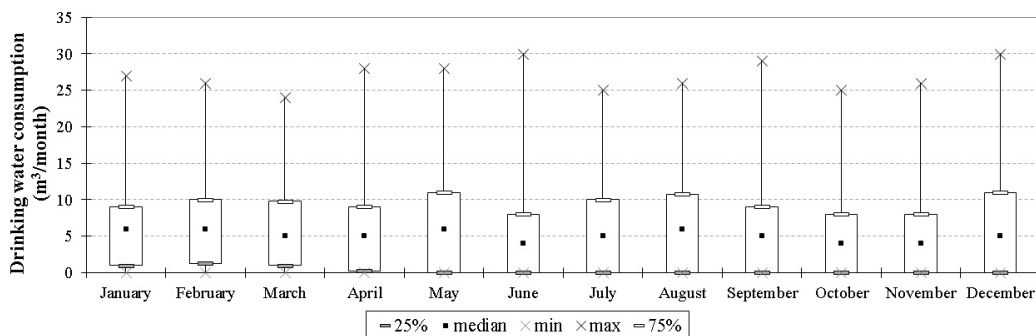Note: *data derived from research.*

Figure 3. *Monthly variations of drinking water consumption in the Sol Nascente Housing Complex.*
Note: *data derived from research.*

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Similar to the consumption values recorded in the Coelhas 1 Complex homes, a high variability was observed in the different households, with the highest average consumption occurring in May (6.98 ± 6.40 m³/month). Conversely, the lowest average consumption was registered in October (4.87 ± 5.38 m³/month).

Considering that approximately 40% of the monthly drinking water consumption of in homes is intended for non-potable purposes, Table 1 lists the estimated volumes of such consumption for the two housing complexes.

The average volumes of drinking water used for non-potable purposes were 2.64 m³/month for the Benjamin Jose Cardoso Housing Complex and 2.49 m³/month for the Sol Nascente Housing Complex.

• Rainfall over the city of Viçosa

Based on the rainfall data provided by INMET through the BDMEP, Table 2 presents the minimum, maximum, and standard deviation of multi-year monthly values calculated for the rains recorded between 1970 and 2020, with the exception of the period between 1984 and 1990 since such information is not available.

The months ewith no recorded rainfall were as follows: June 2003; July 1980, 1981, 1996, 2010, 2011, and 2016; August 1991, 1995, 1999, and 2007; and September 1994 and 2004. On the other hand, the maximum monthly rainfall within the studied period occurred in the months of November 2014 and December 2008.

Figure 4 illustrates the average rainfall, with its respecting numerical values, and the standard deviations calculated for the city of Viçosa in the study period.

The graph clearly shows the three most critical months of each year, when droughts have occurred, severely impacting the state of Minas Gerais, particularly the municipalities of the Mata Mineira area, including the municipality under study.

Table 1.

Monthly volume of drinking for non-potable purposes (m³/month)

Month / Housing complex	January	February	March	April	May	June
Coelhas 1	2.43	2.62	2.47	2.55	3.01	2.17
Coelhas 2	2.54	2.69	2.50	2.56	2.87	2.09
Month / Housing complex	July	August	September	October	November	December
Coelhas 1	3.09	3.21	2.79	2.20	2.58	2.54
Coelhas 2	2.56	2.78	2.43	2.04	2.13	2.66

Note: data derived from research

Table 2.

Multi-year monthly rainfall data on the city of Viçosa

Month/Value	January	February	March	April	May	June
Minimum	30.4	15.7	3.8	1.8	2.0	0.0
Maximum	496.8	416.8	353.2	138.2	146.8	58.8
Standard deviation	123.2	91.8	83.5	34.0	30.6	16.3
Month/Value	July	August	September	October	November	December
Minimum	0.0	0.0	0.0	25.9	62.2	2.6
Maximum	94.4	85.4	147.4	263.9	605.7	605.7
Standard deviation	19.9	19.2	38.0	58.1	103.2	98.8

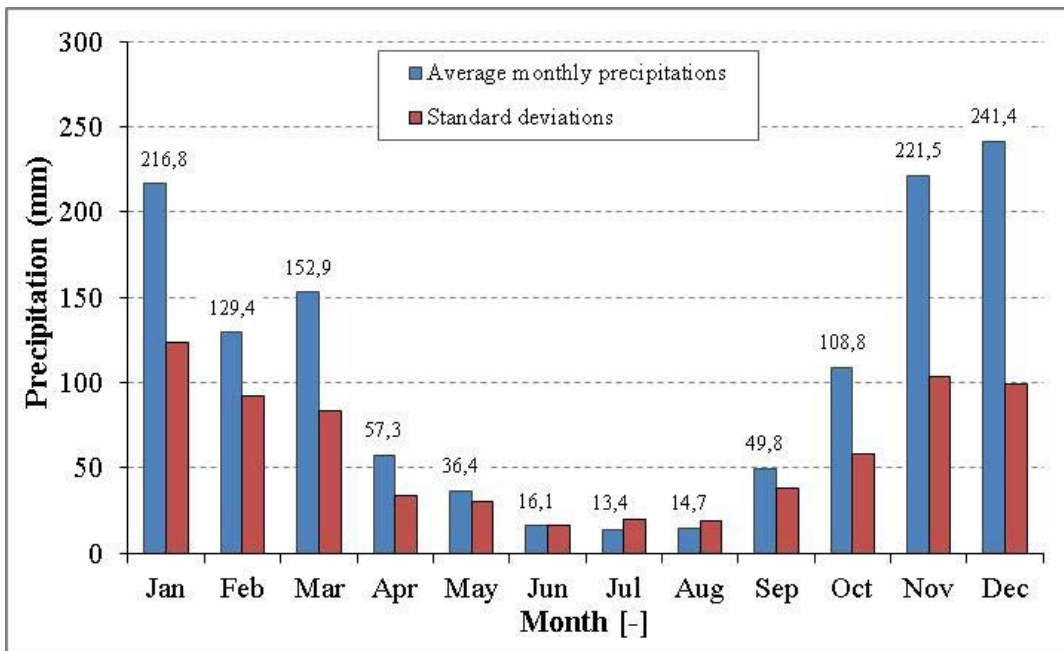*Note: data derived from research*

Figure 4. *Average values and standard deviation of multi-year monthly rainfall for Viçosa MG.*
Note: data derived from research.

Table 3.
Monthly volume of rainwater that can be captured per household

Month	January	February	March	April	May	June
Harvested volume (m³)	7.00	4.18	4.94	1.85	1.18	0.52
Month	July	August	September	October	November	December
Harvested volume (m³)	0.43	0.47	1.61	3.52	7.15	7.80

Note: *data derived from research*

- Monthly volume of rain likely to be captured

Considering the horizontal projection of the roof area available for rainwater harvesting (40.34 m²), the volumes to be captured calculated with Equation 1 from the multi-year monthly average rainfall are presented in Table 3.

The average monthly volume of rainwater that could be captured through the roof area of each dwelling is 3.39 m³.

- Potential for substitution of drinking water used for non-potable purposes by rainwater

The percentages of monthly consumption of drinking water that could be replaced by rainwater, by virtue of its use for non-potable purposes, are presented below in Table 4.

The results presented in Table 4 show that during the middle of the year, between October and March, it is feasible to replace – with ease – the use of drinking water for various purposes such as laundry rooms, toilet flushing and washing machines, and garden irrigation with rainwater. Storage of rainwater must hold rainwater collected during rainy or wet periods to use during dry periods when there is water scarcity from

Table 4.

Percentage of monthly consumption of drinking water for non-potable purposes that can be replaced by rainwater

Month / Housing complex	January	February	March	April	May	June
Coelhas 1	288.6	159.6	199.7	72.5	39.0	23.9
Coelhas 2	275.4	155.6	197.9	72.4	40.9	24.9
Month / Housing complex	July	August	September	October	November	December
Coelhas 1	14.1	14.8	57.6	159.5	276.9	307.3
Coelhas 2	16.9	17.0	66.2	172.4	336.5	292.6

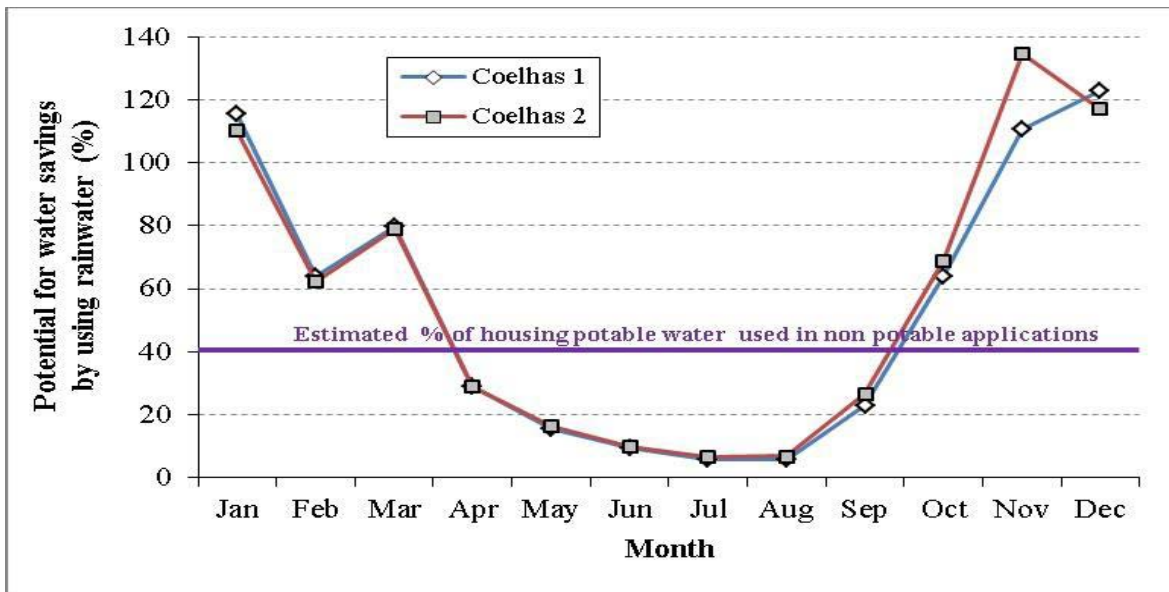*Note: data derived from research*

Figure 5. *Monthly percentage of potential savings of drinking water for the Coelhas 1 and 2 housing complexes*.
Note: data derived from research.

the usual available sources (Azizul, 2017). According to Avis & Avis (2019), harvested rainwater storage is used to carry over any net surplus or compensate for water deficits. Therefore, the sizing of a rainwater reservoir that exceeds the monthly liquid needs for these purposes would enable the surplus water collected to supply the shortfall between April and September. In some cases, the daily demand for non-potable water could be met by utilizing either the harvested rainwater from the storage tank or a backup water supply, or a combination of both if necessary (McCarton *et al.*, 2021).

• Potential for saving drinking water

Figure 5 illustrates the calculated percentages of the potential for monthly savings of domestic drinking water for the two housing complexes.

It is evident that during the first three and last months of the year it would be feasible to save a higher percentage of water than that destined for non-potable purposes, with an overall average value of 53.8% for Coelhas 1, ranging between 5.6 and 122.9%; and an average of 55.6% for Coelhas 2, ranging between 6.8 and 134.6%.

Our values exceed the range of 17.0 to 25.3% reported by Macena *et al*. (2020) for single-family houses and multi-family buildings in Campina Grande, Paraíba, a region with a semiarid climate in Northeast Brazil. They also exceeded the average values of 44.9% reported by Gonçalves *et al*. (2011) for single-family homes in Irati, Paraná, in the southern region of Brazil. They were similar to the 57% reported by Marcelino & Cauduro (2021) for a single-family house in Içara, Santa Catarina, in the southern region of Brazil. In comparison to results obtained in other similar investigations conducted for the Brazilian Southeast region, the average values calculated in this study exceeded the range of 35.5 and 33.6% reported by Ghisi & Oliveira (2007) for two types of single-family homes in the city of Palhoça, state of Santa Catarina. Additionally, the values exceeded the average of 39.4% reported by Sánchez *et al*. (2009) for the residential sector of Piracicaba, São José dos Campos, Sorocaba, and Ribeirão Preto, which are intermediate cities in the state of São Paulo. However, this value was lower than the overall average of 69% reported by Ghisi *et al*. (2006) for 62 cities in the state of Santa Catarina, because the average catchment area for this research was 81.84 m², which represents slightly more than double the area available in the homes in this study.

Since the average percentage of general drinking water savings for both neighborhoods exceeded 53% to meet water needs for toilet flushing, irrigation of gardens, laundry rooms, and washing machines, achieving a 40% saving in monthly consumption can significantly contribute to reducing the payment for the drinking water service. The reduction in monthly payments for the 268 homes of Coelhas 1 and 2 housing complexes is not the only benefit. The 6.60 m³ average monthly consumption of the 137 homes of the Benjamin Jose Cardoso Housing Complex and the 6.22 m³ of the 131 homes of the Sol Nascente Housing Complex, respectively, represent a significant reduction in the monthly consumption of drinking water in Viçosa by 1,719 m³, which is particularly beneficial for this municipality, especially during drought months. If government programs were implemented to promote potable water savings through rainwater harvesting and usage, this could lead to significant potable water savings and preservation of water resources in the city of Viçosa.

It is recommended to conduct specific studies to determine the costs of implementing rainwater harvesting systems for non-potable purposes and the period of return on investment for the investigated construction type. Likewise, it is advisable to evaluate alternatives for government support at the federal, state, or municipal level that favor their execution in housing settlements of social interest. Studies in the Brazilian context have documented several periods of return on investments associated with rainwater collection and use for non-potable purposes; the following are examples of these periods: 12.6 years for single-family residences of medium socioeconomic stratum in Palmas-Tocantins (Batista, 2019), between 1 and 9 years for homes in different cities and regions of Brazil (Leite *et al*., 2022), over 14 years for small constructions in Marau-Rio Grande do Sul (Katagiri *et al*., 2019), and 6.07 years for application in public schools in Recife-Pernambuco (Andrade-Lima *et al*., 2017).

Conclusions

The potential for saving drinking water through the harvesting and use of rainwater in the housing complexes of social interest Benjamin Jose Cardoso and Sol Nascente de Viçosa was demonstrated.

The average monthly savings in drinking water were 53.8% at the Coelhas 1 housing complex and 55.6% for the Coelhas 2 housing complex, depending on the monthly average rainfall values.

These values indicate that the volume of rainwater collected can cover more than 40% of non-potable consumption water such as garden irrigation, toilet flushing, car washes, and floor cleaning.

The implemented methodology for this study is useful for estimating potential savings in water supply consumption in communities with various types of urban and rural conditions, especially in regions facing increasingly critical water stress.

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Conflict of Interest

The authors declare no competing interests.

Author's Contribution Statement

All the authors declare that the final version of this paper was read and approved.

The total contribution percentage for the conceptualization, preparation, and correction of this paper was as follows: J.E.S.G. 20 %, M.J.S.G. 20 % and I.A.S.O. 60 %.

Data Availability Statement

The data supporting the results of this study will be made available by the corresponding author, [I.A.S.O.], upon reasonable request.

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