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The impact of implementing Sustainable Urban Drainage Systems (SUDS) in a central neighborhood of a large city in Minas Gerais

Wevelton Ney Machado de Oliveira
Master, UFJF, Brazil.
twmachado@yahoo.com.br
https://orcid.org/0009-0004-0103-9828

Jonathas Batista Gonçalves Silva
Professor, Doctor, UFJF, Brazil.
jonathas.silva@ufjf.br
https://orcid.org/0000-0001-5812-2623

Maria Helena Rodrigues Gomes
Professor, Doctor, UFJF, Brazil.
mariahelena.gomes@ufjf.br
https://orcid.org/0000-0001-6695-2918

Cézar Henrique Barra Rocha
Professor, Doctor, UFJF, Brazil.
cezar.barra@ufjf.br
https://orcid.org/0000-0003-1321-158X

Henrique da Silva Pizzo
Doctor, Cesama, Brazil.
henrique.dipizzo@gmail.com
https://orcid.org/0000-0003-2334-1214

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O impacto da implantação dos Sistemas Urbanos de Drenagens Sustentáveis (SUDS) em um bairro central de uma cidade de grande porte de Minas Gerais

RESUMO
O crescimento urbano e a impermeabilização do solo geram e intensificam os processos do escoamento superficial, o que sobrecarrega os sistemas de drenagem convencionais e contribui para os problemas decorrentes dos eventos pluviométricos. O objetivo do trabalho foi analisar os efeitos da adoção dos Sistemas Urbanos de Drenagens Sustentáveis na bacia hidrográfica do bairro Bom Pastor, na cidade de Juiz de Fora, MG, por meio de um estudo das características morfométricas e pluviométricas da região, visando determinar o escoamento superficial no ponto exutório. Entre os diversos sistemas de drenagens, o telhado verde, o microrreservatório e o pavimento permeável foram selecionados como os mais adequados à realidade local. Fez-se um comparativo do volume do escoamento superficial gerado, consideradas a situação atual e a situação após a implantação dos sistemas de drenagens. Obteve-se uma redução de 21,23% do escoamento superficial que chega ao ponto exutório, por meio da redução do volume de escoamento gerado pela fonte. Busca-se contribuir com as informações geradas na região e estimular a implantação desses sistemas de drenagens, de modo a amenizar os transtornos causados pelo excessivo escoamento superficial local.

PALAVRAS-CHAVE: Drenagem urbana. Alagamentos. Sustentabilidade**.**

The impact of implementing Sustainable Urban Drainage Systems (SUDS) in a central neighborhood of a large city in Minas Gerais

ABSTRACT
Urban growth and soil sealing generate and intensify surface runoff processes, which overloads drainage systems and creates problems arising from rainfall events. The objective of the work was to analyze the effects of adopting sustainable urban drainage systems in the river basin of the Bom Pastor neighborhood in the city of Juiz de Fora, MG, by carrying out a study of the morphometric and rainfall characteristics of the region to determine the flow superficial at the outlet point. They were selected from the various drainage systems; the green roof, the micro-reservoir and the permeable pavement as being the most appropriate to the local reality. A comparison was made of the volume of surface runoff generated considering the current situation and after the implementation of drainage systems. A 21.23% reduction in surface runoff reaching the outlet point was achieved, through the reduction in the volume of runoff generated by the source. The aim is to contribute to the information generated in the region and encourage the implementation of these drainage systems in order to alleviate the problems caused by excessive local surface runoff.

KEYWORDS: Urban drainage. Flooding. Sustainability.

El impacto de la implementación de Sistemas de Drenaje Urbano Sostenible (SUDS) en un barrio central de una gran ciudad de Minas Gerais

RESUMEN
El crecimiento urbano y el sellado del suelo generan e intensifican los procesos de escorrentía superficial, lo que sobrecarga los sistemas de drenaje convencionales y contribuye a los problemas causados por las precipitaciones. El objetivo de este estudio fue analizar los efectos de la adopción de Sistemas Urbanos de Drenaje Sostenible en la cuenca hidrográfica del barrio Bom Pastor, en la ciudad de Juiz de Fora (MG, Brasil), mediante el estudio de las características morfométricas y pluviométricas de la región, con el fin de determinar el escurrimiento superficial en el punto de salida. Entre los diversos sistemas de drenaje, se seleccionaron el tejado verde, el microrreservorio y el pavimento permeable como los más adecuados para la situación local. Se comparó el volumen de escorrentía superficial generado en las dos situaciones (la actual y la tras la implantación de los sistemas de drenaje). Se obtuvo una reducción del 21,23 % en la cantidad de escorrentía superficial que llega al punto de desagüe, ya que se redujo el volumen de escorrentía generado por la fuente. El objetivo es contribuir a la información generada en la región y fomentar la implantación de estos sistemas de drenaje para paliar los problemas causados por el exceso de escorrentía local.

PALABRAS CLAVE: Drenaje urbano. Inundación. Sostenibilidad.

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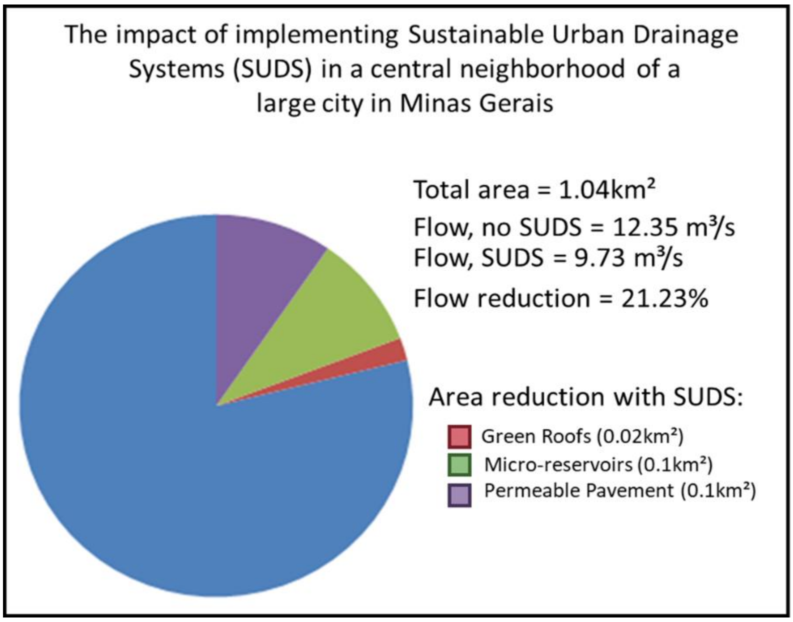
KEY TAKEAWAYS CHART



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1 INTRODUCTION

Ever since human beings began gathering in communities, urban settlement has been causing changes to soils, making them more impermeable, favoring an increase in surface runoff and a decrease in the infiltration of water into the soil. With the expansion of these impervious areas, greater volumes of surface water runoff have caused an increase in urban flooding events, as well as degrading water quality (Vicente; Faria; Formiga, 2023, p.2, *authors' translation*).

Over the last decades, constant urbanization, coupled with demographic, economic, and social development, forced large established urban centers to improve road networks and address the extreme levels of settlement-driven land use. In this context, characteristics such as volumes and quality levels are altered within the water cycle (Schueler; Carvalho, 2024. p.282, *authors' translation*). As a result, previously uncovered, permeable soils have undergone many sealing processes, leading to numerous drainage problems, making flash floods more common, and degrading rainwater quality (Vairinhos, 2017, p.1, *authors' translation*).

Rising river levels, river floods, and flash floods, especially in urban areas, affect city sustainability and cause significant damage to local populations. Reduced soil permeability contributes to a lack of groundwater recharge, which can lead to serious drought problems during periods of severely dry weather. In areas with naturally occurring rising river levels, such as river channel floodplains, lack of land use planning and disorderly settlement, combined with soil sealing, have exacerbated this unsustainable scenario, damaging cities' infrastructure and putting the lives of millions of people at risk, especially those living in river floodplain regions (Marostica; Silveira, 2024, p.2, authors' translation).

The high rates of soil sealing and disorderly—or unplanned—settlement constitute contributing factors to the inefficiency of urban drainage systems. In this sense, it is necessary to seek new techniques to mitigate the consequences of urbanization, so as to increase the infiltration of water into the soil and flow retardation times at the source of surface runoff, thus keeping water in urban drainage basins for longer periods (Pizzo; Galil, 2021, p.34, *authors' translation*).

It is understood that flash flooding is related to the way in which cities developed. It reflects the problems caused by urban environment building processes, marked by the unsustainably high levels of waterproofing, which make current drainage systems inefficient (Corrêa; Teixeira, 2024, p.298, authors' translation). This inefficiency makes it necessary to further investigate materials and techniques that make it possible to build an environment capable of minimizing its own negative impacts.

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2 OBJECTIVES

The goal of the study is to assess the possibility of implementing Sustainable Urban Drainage Systems (SUDS), in order to reduce surface runoff and flash flooding problems caused by overwhelmingly impervious areas in the Bom Pastor neighborhood, in the city of Juiz de Fora, MG.

2.1 Specific objectives

Perform a hydrologic analysis of the catchment basin in the area of study.

Select Sustainable Urban Drainage Systems (SUDS) best suited to local reality and assess scenarios in which these systems are to be used.

3 METHODS

3.1 Description of the area of study

The study encompasses a specific area that includes part of the Bom Pastor neighborhood, as well as surrounding neighborhoods, which may constitute catchment areas for rainfall volumes and surface runoff. According to the City of Juiz de Fora (2023), the neighborhood is located in the city's central region. In order to consider the aforementioned potential catchment areas, parts of the Alto dos Passos, Boa Vista, Graminha, Parque Guaruá, Olavo Costa, and Vila Ozanan neighborhoods were taken into account.

The hydrologic analysis included morphometric characteristics, so as to pinpoint determining factors behind the region's surface runoff dynamics. Figure 1 shows the area of study's catchment area.

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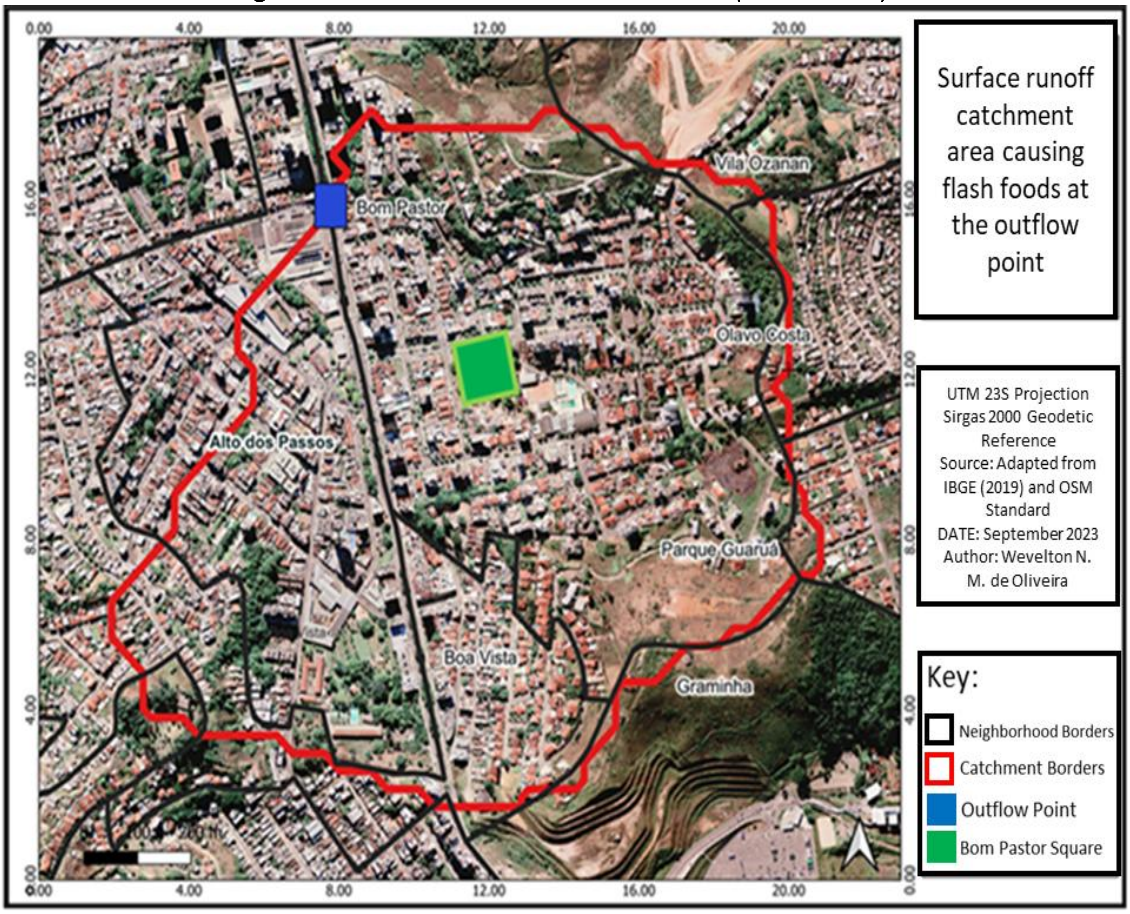
Figure 1 - Surface runoff catchment areas (Bom Pastor)



Source: The authors (2023).

3.1.1 Catchment area size and perimeter

The catchment basin was defined by using the digital surface model (DSM) provided by Brazil's geomorphometric database, known as Topodata, at a 30-meter scale. The DSM was then subject to a consistency analysis, in which cells with spurious depressions were excluded. After generating the contour lines map, said map indicated an elevation range of 105 m, with the lowest location sitting at 704 m, at the outflow point, and the highest sitting at 809 m. These steps were necessary to delineate the catchment basin. Area and perimeter calculations were performed using "CalcArea" tools from the QGIS software.

3.1.2 Catchment basin terrain

This step consisted in determining terrain hypsometry and average slope, using the available DSM from Topodata.

To determine hypsometry, a part of this DSM was cut out along the limits of the catchment area. This included verifying band stats of its respective minimum and maximum values.

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The Topodata-sourced DSM was also used for analyzing terrain declivity, which involved the use of the “Slope” tool from the QGIS software. Values were assigned according to the percentage-based slope classification outlined by Embrapa (1979), so as to generate a color pattern for the cutout area.

3.1.3 Rainfall metrics

The intensity-duration-frequency (IDF) curves were determined based on data sourced from the Plúvio 2.1 program, specifically for the city of Juiz de Fora. The data were thus applied to the IDF generation formula on Microsoft Excel. Return periods of 5 and 10 years were chosen for use in the relevant equations, observing guidelines set in the City of Juiz de Fora Drainage Manual (2011). Various time periods were chosen, ranging from 5 minutes to 24 hours.

3.1.4 Time of concentration

The City of Juiz de Fora Drainage Manual (2011) suggests two different equation types, depending on the characteristics (surface flow or channel flow) of the location for which the calculations are performed. In the case of this study, the decision was to use the suggested equation for surface flow, as shown in Equation 1, as this is the most appropriate choice for the premises. The n parameter (Manning roughness coefficient) was set at 0.011, which is the benchmark value for smooth concrete, asphalt, gravel, or bare soil surfaces. The P24 parameter was set at the rainfall intensity value corresponding to a return period of 5 years (micro drainage projects, residential areas, worst-case scenario) in a time period of 24 hours.

$$Tc = \frac{5{,}474 \times (n \times L)^{0{,}8}}{P_{24}^{\ 0{,}5} \times S^{0{,}4}} \qquad \text{(Equation 1)}$$

Where:
Tc = time of concentration (min);
n = Manning roughness coefficient (sourced from the benchmark table);
L = flow length (m);
P24 = 24-hour duration rainfall (mm);
S = slope (m/m).

3.2 SUDS selection

The criterion for selecting SUDS options was ease of implementation. Since such systems would be implemented by locals in existing buildings, said criterion accounts for low structural interference. With local realities in mind, the choice was made for systems which allow for control right at the source, in order to reduce and slow down surface runoff.

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3.2.1 Green roof

Part of rainfall volumes would be absorbed by plants and stored in the green roof's reservoir, slowing down surface runoff.

3.2.2 Micro-reservoir

The micro-reservoir would store rainfall volumes from conventional roofs and other ground-level areas, absorbing volumes beyond the green roof's intake capacity, and consequently working in tandem with it.

3.2.3 Permeable pavement

Permeable pavement would be implemented in parking spaces and other areas designed for pedestrian and vehicle movement, which are prone to taking in rainfall volumes, whether directly or indirectly.

3.3 Catchment area flow calculation according to the present scenario (no SUDS)

Flow calculation relied on a modified version of the Rational Method, as shown in Equation 2. The runoff coefficient (C) was set at 0.75, which is the worst-case scenario benchmark for residential areas. The catchment area was considered to be entirely made of impervious zones.

$$Q = 0{,}278 \times C \times I \times A \times \varphi \qquad \text{(Equation 2)}$$

Where:
Q = flow (m^3/s);
C = runoff coefficient (dimensionless);
I = rainfall intensity (mm/h);
A = area (km^2);
ϕ = flow retardation coefficient (dimensionless).

According to parameter tables, flow retardation coefficient calculation is performed with a N=6 parameter for slopes greater than 1%, as shown in Equation 3.

$$\varphi = \frac{1}{\sqrt[N]{100A}} \qquad \text{(Equation 3)}$$

Where:

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ϕ = flow retardation coefficient (dimensionless);
N = slope-dependent coefficient (dimensionless);
A = area (km²).

Regarding rainfall intensity calculation, rainfall duration time should correspond to the time of concentration, which is set at 13.2 minutes. Return period (TR) was set at 5 years (residential areas, worst-case scenario). As far as other input values are concerned, regional data sourced from Plúvio 2.1 were used as is. The considered area (A) was equal to 1.044 km².

3.4 Sustainable Urban Drainage Systems (SUDS) sizing

The SUDS options considered were applied to a hypothetical 1,000 m² land plot. In accordance with the City of Juiz de Fora Drainage Manual (2011), the pre-development flow—which determines the plot's maximum outflow—and the required storage volume were calculated, as shown in Equation 4 and Equation 5, respectively.

$$Qpd = 0{,}0266 \times A \qquad \text{(Equation 4)}$$

Where:
Qpd = pre-development flow (m³/s);
A = plot or neighborhood area (ha).

$$V = 523 \times AI \qquad \text{(Equation 5)}$$

Where:
V = required storage volume (m³);
AI = total impervious area over which rainfall flows to drainage systems (ha).

3.4.1 Green roof model calculations

For the sake of example, an arbitrated 200 m² area was set for building an extensive green roof. For the 0.20 m reservoir, expanded clay was the filling material of choice, owing to its low weight and its void ratio (40%). The resulting setup consists in a reservoir with a 16 m³ retention capacity.

3.4.2 Micro-reservoir model calculations

Considering the plot's 1,000 m² of catchment area, a 30 m² micro-reservoir was defined. Height sizing was performed according to Equation 6.

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$$H = \frac{V}{A} \quad \text{(Equation 6)}$$

Where:
H = reservoir height (m);
V = required storage volume (m³);
A = available area for reservoir construction (m²).

3.4.3 Permeable pavement model calculations

The area to be drained (A) was set at 1,000 m², and the draining area (Ab) was set at 200 m². The resulting drainage ratio (R = A / Ab) equals 5. For the infiltration coefficient, according to data found in the City of Juiz de Fora Drainage Manual (2011), the choice was the cutoff point for most infiltration systems (equal to 0.001), with a factor of safety of 3.0, which corresponds to minor inconveniences. Therefore, the actual infiltration coefficient (q) was set at 0.0003.

Calculations were performed assuming that the filling material has an effective porosity of 40%, which classifies as uniform grain-size gravel. Regarding rainfall intensity, the IDF curve was calculated for three different duration periods (15 minutes, 30 minutes, 60 minutes), with a return period (TR) of 10 years.

The aforementioned parameters were then applied to Equation 7, which yields maximum height. The goal was to find the highest value.

$$h_{máx} = \left(\frac{t}{\emptyset}\right) \times (R \times I - q) \quad \text{(Equation 7)}$$

Where:
hmáx = maximum pavement height (m);
t = time (h) (tested with the three periods used in the IDF curve);
Ø = filling material effective porosity (dimensionless);
R = drainage ratio (dimensionless);
I = rainfall intensity (mm/h);
q = infiltration coefficient (dimensionless).

3.5 Comparison of pre- and post-SUDS implementation scenarios in the catchment area

Calculating the impact of implementing all three types of SUDS included: 100 green roofs retaining surface runoff from a 20,000 m² area, 100 micro-reservoirs retaining runoff from a 100,000 m² area, and 100 patches of permeable pavement retaining runoff from a 100,000 m² area. This amounts to a total reduction of 220,000 m² (0.22 km²) in the surface runoff catchment areas. For the sake of comparison, the next step was to calculate “before and after” scenarios.

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4 RESULTS

Defining the catchment basin involves analyzing characteristics such as area, perimeter, geometry, terrain, and declivity, which constitute vital information to properly knowing hydrologic dynamics.

4.1 Catchment basin area and perimeter

Chart 1 shows the catchment area's dimensions.

Chart 1 — Dimensions of the catchment area draining to the outflow point

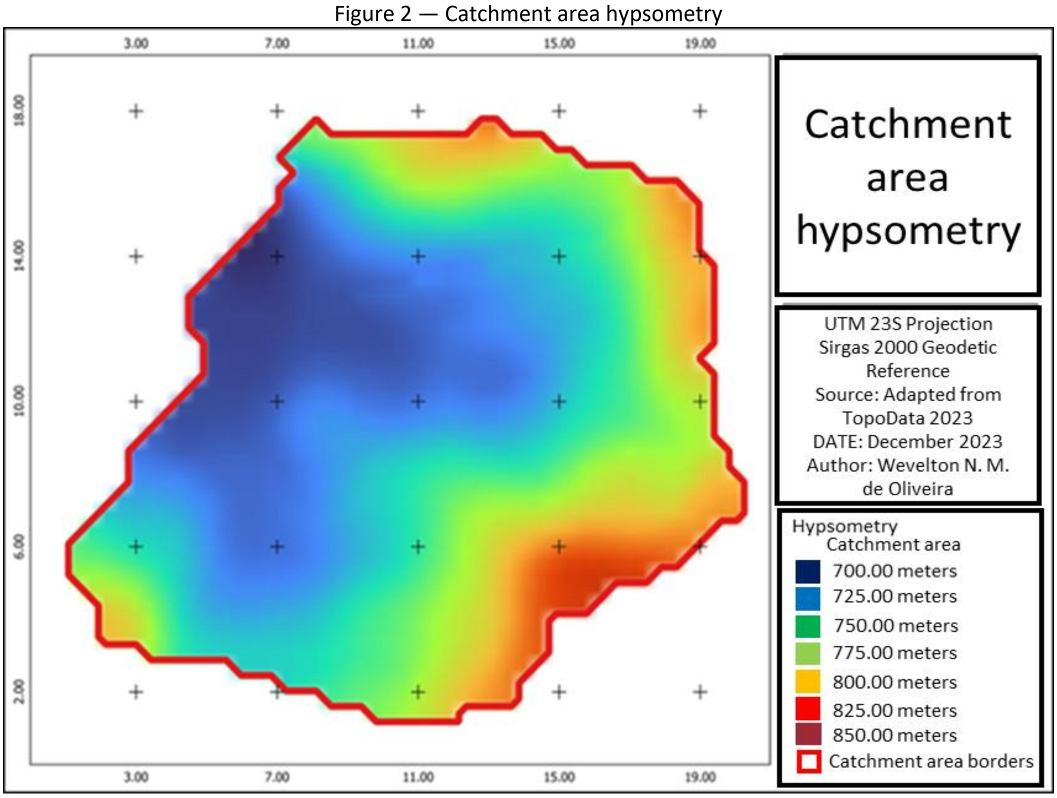
Dimensions of the catchment area draining to the outflow point			
Catchment Area	**m² (square meters)**	**km² (square kilometers)**	**ha (hectares)**
Permeable area	12,169.76	0.012	1.217
Impermeable area	1,031,398.85	1.03	103.14
Total catchment area	1,043,568.61	1.044	104.36
Total perimeter (meters)	4,160.38		

Source: The authors (data calculated with QGIS CalcArea, 2023).

4.2 Hypsometry and average terrain slope

On the hypsometric map, shown in Figure 2, the blue-colored region represents areas at lower elevations, between 700 and 750 meters, where the outflow point is located.

Figure 2 — Catchment area hypsometry



Source: The authors (2023).

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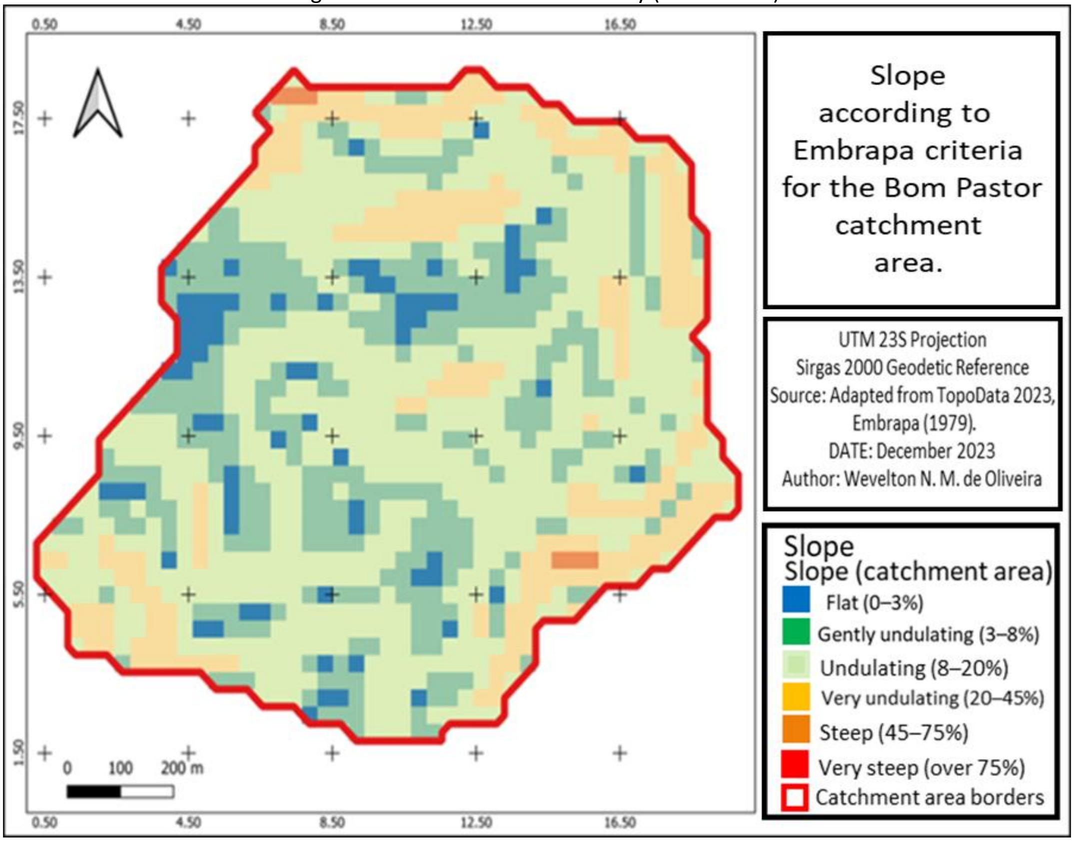
Figure 3 shows terrain slope levels. It highlights the ease with which flash floods may occur at the outflow point, since its surroundings are mostly made of flat or gently undulating areas.

Figure 3 — Catchment area declivity (Bom Pastor)



Source: The authors (2023).

4.3 Form factor, compactness coefficient, and circularity ratio

Form factor (Kf), which ranges from 0.75 to 1.00 for regions prone to flash floods, was found to be 0.88 in this case. It is worth stressing that the area in question is classified as round, slightly elongated.

Compactness coefficient (KC), which ranges from 1.00 to 1.25 for round basins remarkably prone to significant events of rising river levels and flash floods, was found to be 1.14 in this case.

The circularity ratio (IC), when equal to 1.00, represents a perfect circle, which is the basin shape most prone to river flooding events. In this case, the IC was found to be 0.76. Therefore, this region is 76% similar to a perfect circle. Its characteristics make it prone to flash floods.

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4.4 Time of concentration

Time of concentration refers to the time it takes for all of the basin to be actively draining to the outflow point. Due to the basin's impermeability and shape, the time of concentration was found to be 13.2 minutes.

4.5 Drainage system projections

In order to understand the impact of SUDS implementation, it is necessary to calculate the catchment area's current flow. Next, it is necessary to calculate the areas of the land plots covered by these SUDS. Considering that its surface runoff flow will be retained, these specific areas are not included in the calculations. Then, as a result of the new catchment area, the new flow is calculated. This makes it possible to compare both scenarios.

4.5.1 No-SUDS scenario

Rainwater collection systems were not considered in this step of the process. All rainfall was assumed to turn into surface runoff. The modified Rational Method equation yields a flow retardation coefficient (ϕ) of 0.46. With the parameter values in hand, the outflow point flow (Q) was calculated as 12.36 m^3/s. This result is shown in Chart 2.

Chart 2 — Local data in the no-SUDS scenario

Local data in the no-SUDS scenario		
Area	1.04356861	km^2
Flow	12.36	m^3/s

Source: The authors (2024).

4.5.2 SUDS retention capacity calculation

The impact of the implementation was first analyzed separately—and then simultaneously—in different buildings, considering 100 units of each SUDS implemented.

The result of green roof calculations, with an absorption area of 200 m^2, was a pre-development flow (Qpd) of 0.000523 m^3/s and a storage volume (V) of 10.46 m^3. The result of micro-reservoir and permeable pavement calculations, with an absorption area of 1,000 m^2, was a pre-development flow (Qpd) of 0.0026 m^3/s and a storage volume (V) of 52.30 m^3.

4.5.2.1 Green roof

The chosen dimension, 200 m^2, corresponds to a total of 16 m^3 in retained waterfall. Assuming the implementation of 100 units, the result is a reduction of 0.02 km^2 in the catchment area contributing to surface runoff buildup. This result is shown in Chart 3.

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Chart 3 — Results of implementing 100 green roofs

Total area, no SUDS	1.04	km²
Total flow, no SUDS	12.35	m³/s
Area reduction from 100 green roofs	0.02	km²
New, reduced area	1.02	km²
New flow (reduced area)	12.09	m³/s
Reduction	2.10	%

Source: The authors (2024).

4.5.2.2 Micro-reservoir

Rainfall storage was calculated considering the 1,000 m² land plot area. Assuming the implementation of 100 such systems across the neighborhood, the result is a 0.1 km² reduction in the catchment area. This result is shown in Chart 4.

Chart 4 — Results of implementing 100 micro-reservoirs

Total area, no SUDS	1.04	km²
Total flow, no SUDS	12.35	m³/s
Area reduction from 100 micro-reservoirs	0.1	km²
New, reduced area	0.94	km²
New flow	11.15	m³/s
Reduction	9.75	%

Source: The authors (2024).

4.5.2.3 Permeable pavement

Assuming a drained area of 1,000 m², the implementation of 100 units across the neighborhood, also led to a 0.1 km² reduction in catchment area, as shown in Chart 5.

Chart 5 — Results of implementing 100 permeable pavement systems

Total area, no SUDS	1.04	km²
Total flow, no SUDS	12.35	m³/s
Area reduction from 100 permeable pavement units	0.1	km²
New, reduced area	0.94	km²
New flow	11.15	m³/s
Reduction	9.75	%

Source: The authors (2024).

4.5.3 Simultaneous implementation of all SUDS in the catchment area (in different buildings)

By summing all the areas whose rainfall volumes were excluded from runoff buildup, there is a total 0.02 km² (= 100 * 200 m² = 20,000 m²) from green roofs, as well as 0.1 km² (= 100 * 1,000 m² = 100,000 m²) from micro-reservoirs, and another 0.1 km² (= 100 * 1,000 m² = 100,000 m²) from permeable pavement. The total reduction in catchment area is thus 220,000 m² (= 0.22 km²), leading to a new flow of 9.73 m³/s. The consequence of this scenario is a 21.23% drop in surface runoff buildup. It is worth noting that this value is given under the assumption that all rainfall over the catchment area is turned into surface runoff.

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In order to draw comparisons, experiments were sought involving mixed use of different kinds of SUDS. According to a study by Vairinhos (2017), conducted in the city of Coimbra, Portugal, in the Zona das Flores neighborhood, 51.4% of 217.9 hectares were made of impervious areas with flash flood problems. The positive impact of using different kinds of SUDS was a reduction in surface runoff and, as a result, less flash flooding. The best results in the study are remarkable: the use of reservoirs and permeable pavement accounted for a 28.9% drop in flow volumes.

The study conducted by Fröhlich e Cauduro (2019), in the city of Sombrio, in southern Santa Catarina, provides another example of mixed use of SUDS. The area of study in this case is 142.74 km². With the implementation of Sustainable Urban Drainage Systems (SUDS), including infiltration wells, infiltration trenches, and permeable pavement, there was a 31.51% drop in the rainfall flow taken in by Conventional Urban Drainage Systems (CUDS). As a consequence, there was a drop in the occurrence of flash flooding events in the region.

The percentage drop in intake flows achieved with SUDS implementation, as shown in this work, was found to be highly coherent with results from other experiments, conducted by several authors, in terms of order of magnitude. This attests to the fact that implementing such systems in the Bom Pastor neighborhood is a completely viable endeavor, reducing the occurrence of flash flood problems observed in the region.

5 CONCLUSIONS

Given the analyzed region's morphometric and pluviometric characteristics, it is, in fact, subject to flash flood events at the outflow point. This finding is confirmed by calculating form factor, compactness coefficient, and circularity ratio, which reiterate the traits of a drainage basin prone to flash floods.

Three kinds of SUDS—green roofs, micro-reservoirs, and permeable pavement—were selected as surface runoff mitigation measures, which was achieved by reducing the catchment area.

The initial flow was found to be 12.35 m³/s, a product of the initial catchment area of 1.04 km², assuming no public rainfall drainage systems present. SUDS implementation reduced the initial catchment area by 0.22 km², resulting in a final catchment area of 0.82 km² and a final flow of 9.73 m³/s. A comparison of initial and final scenarios shows a remarkable 21.23% drop in total flow drained to the outflow point.

All aforementioned data lead to the conclusion that flash flood problems may be reduced by changing construction methods within land plots. Implementing different kinds of SUDS makes it possible to mitigate this problem directly at its source, avoiding the need for large-scale public construction projects.

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STATEMENTS

AUTHOR CONTRIBUTION STATEMENT

When describing each author's contribution to the paper, please use the following criteria:

• **Study Conception and Design** State the persons behind the central ideas of the study, and the persons who helped set the goals, materials, and methods. (Wevelton and Jonathas).
• **Data Curation:** State the persons who organized and verified the data in order to ensure quality. (Wevelton, Jonathas, Cézar, Maria Helena, and Henrique).
• **Formal Analysis:** State the persons who performed data analysis using specific methods. (Wevelton, Jonathas, Henrique, Cézar, and Maria Helena).
• **Grant Obtainment:** State the persons who obtained grant money to conduct the study. (Not applicable).
• **Investigation:** State the persons who conducted data collection or practical experiments. (Wevelton and Jonathas).
• **Methods:** State the persons who developed and adjusted materials and methods used in the study. (Wevelton and Jonathas).
• **Writing - First Draft** State the persons who wrote the paper's first draft. (Wevelton).
• **Writing - Review**: State the persons who reviewed the text, improving its clarity and coherence. (Jonathas, Maria Helena, Cézar, and Henrique).
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• **Oversight:** State the persons who supervised the work and ensured the overall quality of the study. (Jonathas)

CONFLICTS OF INTEREST STATEMENT

We the authors, **Wevelton Ney Machado de Oliveira, Jonathas Batista Gonçalves Silva, Maria Helena Rodrigues Gomes, Cézar Henrique Barra Rocha, and Henrique da Silva Pizzo**, hereby state, regarding the paper entitled "[**The impact of implementing Sustainable Urban Drainage Systems (SUDS) in a central neighborhood of a large city in Minas Gerais**]":

1. **Financial Interests**: This work does not involve any financial interests that could influence its results or interpretations.
2. **Professional Relationships:** This work does not involve any professional relationships that could affect its analysis, interpretations, or the display of results.
3. **Personal Conflicts:** This work does not involve any personal conflicts of interest related to its contents.