REVISTA FLORESTA
Engenharia Florestal

ISSN 1982-4688
Edição 56
Universidade Federal do Paraná
Setor de Ciências Agrárias

RAINFALL INTERCEPTION AND REDUCED SURFACE RUNOFF THROUGH STREET TREE PLANTING

Everaldo Marques de Lima Neto[1*], Bianka Luise de Oliveira[2], Ricardo Cordeiro de Lima[3], Maria Neide Moura Martins de Andrade[4]

[1*]Departamento de Ciência Florestal - Universidade Federal Rural de Pernambuco – Recife – PE - Brasil - everaldo.limaneto@ufrpe.br
[2]Departamento de Ciência Florestal - Universidade Federal Rural de Pernambuco – Recife – PE - Brasil - biankalouise@gmail.com
[3]Programa de Pós-Graduação em Ciências Florestais - Universidade Federal Rural de Pernambuco – Recife – PE - Brasil - ricardo.cordeiro@ufrpe.br
[4]Programa de Pós-Graduação em Ciências Florestais - Universidade Federal Rural de Pernambuco – Recife – PE - Brasil - neidemartinsbio@gmail.com

Received for publication: 22/10/2025– Accepted for publication: 07/05/2026

Resumo

Interceptação pluvial e escoamento superficial evitado pela arborização de ruas. As árvores urbanas possuem a capacidade de interceptar a água da chuva por meio de suas folhas, galhos superficiais e troncos, retardando o pico de vazão e reduzindo o escoamento superficial. Diante disso, este estudo teve como objetivo estimar o potencial de regulação hídrica de árvores urbanas no bairro das Graças, em Recife – PE, com o auxílio da plataforma *i-Tree* para quantificar o volume de água interceptado e o escoamento superficial evitado pelas árvores. Foi realizado um inventário florestal urbano, seguindo a planilha de coleta de dados e protocolos da plataforma. Foram consideradas as variáveis: espécie, saúde das copas, classes de diâmetro à altura do peito (DAP), luminosidade, porcentagem de copa ausente, características de uso da terra, altura de copa viva e a área de copa. Foram analisados 137 indivíduos que interceptaram 1.739,8 m³ de águas pluviais e evitaram o escoamento superficial de 355,1 m³ de água. Os valores de interceptação e escoamento superficial evitado demonstraram que estão diretamente relacionados às características das espécies, tamanho da folha, área de copa, ao volume e à saúde da copa e a sua fenologia. Sendo assim, ruas com melhor sanidade de árvores, maior área e volume de copa tendem a apresentar maior capacidade de regulação hídrica. O volume de água retido pelas árvores permite reduzir dos efeitos negativos das chuvas nas vias públicas estudadas, ao reduzir a vazão de escoamento. Os resultados corroboram os serviços ecossistêmicos proporcionados pela arborização urbana. Os produtos gerados pelo programa *i-Tree* podem auxiliar no planejamento das cidades e na gestão das árvores urbanas.
Palavras-chave: Alagamentos. Floresta urbana. Regulação hídrica. Serviços Ecossistêmicos.

Abstract

Urban trees have the ability to intercept rainfall through their leaves, branches, and trunks, delaying peak runoff and reducing surface runoff. In this context, this study aimed to estimate the hydrological regulation potential of urban trees in the Graças neighborhood, Recife, Pernambuco, Brazil, using the i-Tree platform to quantify rainfall interception and avoided surface runoff. An urban forest inventory was conducted following the data collection protocols and guidelines established by the platform. The analyzed variables included species, crown health, diameter at breast height (DBH) classes, light exposure, percentage of crown missing, land-use characteristics, live crown height, and crown area. A total of 137 trees were assessed, which intercepted 1,739.8 m³ of rainfall and avoided 355.1 m³ of surface runoff. The interception and avoided runoff values were directly related to species characteristics, leaf size, crown area, crown volume and health, and phenological patterns. Consequently, streets with healthier trees and greater crown area and volume tend to present higher hydrological regulation capacity. The volume of water retained by urban trees contributes to mitigating the negative effects of rainfall on public roads by reducing runoff flow. The results reinforce the importance of ecosystem services provided by urban trees, and the outputs generated by the i-Tree program can support urban planning and the management of urban forests.
Keywords: Flooding. Urban forest. Hydrological regulation. Ecosystem services.

INTRODUCTION

One of the main challenges in cities is managing rainwater runoff in a largely impervious environment. With the extensive structural development of cities—such as streets, parking lots, and roofs—interconnected networks of impervious surfaces have emerged in the urban landscape, reducing the number and extent of hydrological losses (infiltration, evaporation, and transpiration) compared to non-urban landscapes. As a result, surface runoff begins at precipitation thresholds lower than those observed in natural areas or in areas with greater permeability, causing larger volumes of stormwater to be rapidly channeled through the city via urban drainage and wastewater collection systems (BERLAND *et al.*, 2017).

In this regard, urban trees perform multiple ecological, aesthetic, and social functions that improve the population's quality of life (LIMA NETO *et al.*, 2016). In an ideal scenario, urban planning would strategically incorporate tree planting to maximize the benefits associated with vegetated areas.

In addition to their landscape and social values, urban trees play a fundamental role in intercepting rainwater by temporarily retaining it in their canopies and gradually releasing it into the environment through evaporation, transpiration, and infiltration, thereby directly contributing to the regulation of the hydrological cycle in urban areas (HUANG *et al.*, 2017; YANG *et al.*, 2019).

In wooded areas, where permeable and semipermeable soils predominate, surface runoff during rainfall events tends to be lower compared to that observed in impervious areas (ALVES; FORMIGA, 2019). Additionally, urban trees have the ability to retain and remove pollutants—including certain heavy metals—present in rainwater, acting as natural filters and contributing to improved water quality in urban environments (LIVESLEY *et al.*, 2016).

Thus, trees act as regulators of the urban water cycle, maintaining water flow and helping to delay peak flood levels, thereby reducing the impacts of flooding (NYTCH *et al.*, 2018). However, different tree species, in their various forms and sizes, are able to intercept varying amounts of stormwater (HOLDER; GIBBES, 2017; YANG *et al.*, 2019). Therefore, further studies are needed to enable the adaptation of the existing urban infrastructure in conjunction with tree planting, so that stormwater is intercepted and surface runoff is reduced (ALVES; FORMIGA, 2019). This need stems primarily from the knowledge gap regarding the distinct contributions of urban tree species to rainwater interception processes, thereby allowing water to be directed both to urban drainage systems and to the groundwater table and the atmosphere.

All rainwater interception and surface runoff managed by individual trees can be calculated using digital platforms, such as the i-Tree Eco software, which allows for the calculation of these and other benefits derived from urban forests (I-TREE, 2019). Alves *et al.* (2018) highlight the importance of computational platforms for analyzing water interception by tree canopies and emphasize the need for a thorough understanding of the influence of trees on urban drainage in such simulations. These statements raise several questions, such as: How much rainwater is intercepted by different tree species in urban areas? Which dendrometric variables influence water regulation?

The city of Recife, Pernambuco, due to its geographic and climatic conditions, is particularly susceptible to extreme daily rainfall events (WANDERLEY *et al.*, 2018). Given this context, this research is justified by the need to understand the role of urban tree cover in mitigating flooding and flash floods. Given the importance of stormwater interception in urban water regulation, this study analyzed the volume of water intercepted and the reduction in surface runoff resulting from street tree cover, with the aim of evaluating the potential of urban trees as providers of this ecosystem service. In addition, the study sought to identify and correlate the tree-related variables that most influence these processes, using the Graças neighborhood in Recife as the study area.

MATERIALS AND METHODS

Characterization of the study area

The study was conducted in the Graças neighborhood, which is located in the city of Recife, the capital of Pernambuco, between the coordinates 8° 04' 03'' S and 34° 55' 00'' W (Figure 1). The city covers an area of 218.84 km², divided into 94 neighborhoods and 6 (six) Political-Administrative Regions (RPAs), at an elevation of 4 m above sea level, with an estimated population of over 1.6 million (IBGE, 2022). The neighborhood of Graças is located in RPA 3, in the North Zone. It has a total area of 144 ha, a population of 20,538 with a population density of 143.08 inhabitants per ha, and comprises 7,015 households, with approximately 2.9 residents per household and an average monthly nominal income of R$ 9,484.01 per household. This neighborhood was selected because it is among the most forested in the city (IBGE, 2022), which made it possible to achieve the objectives of this study.

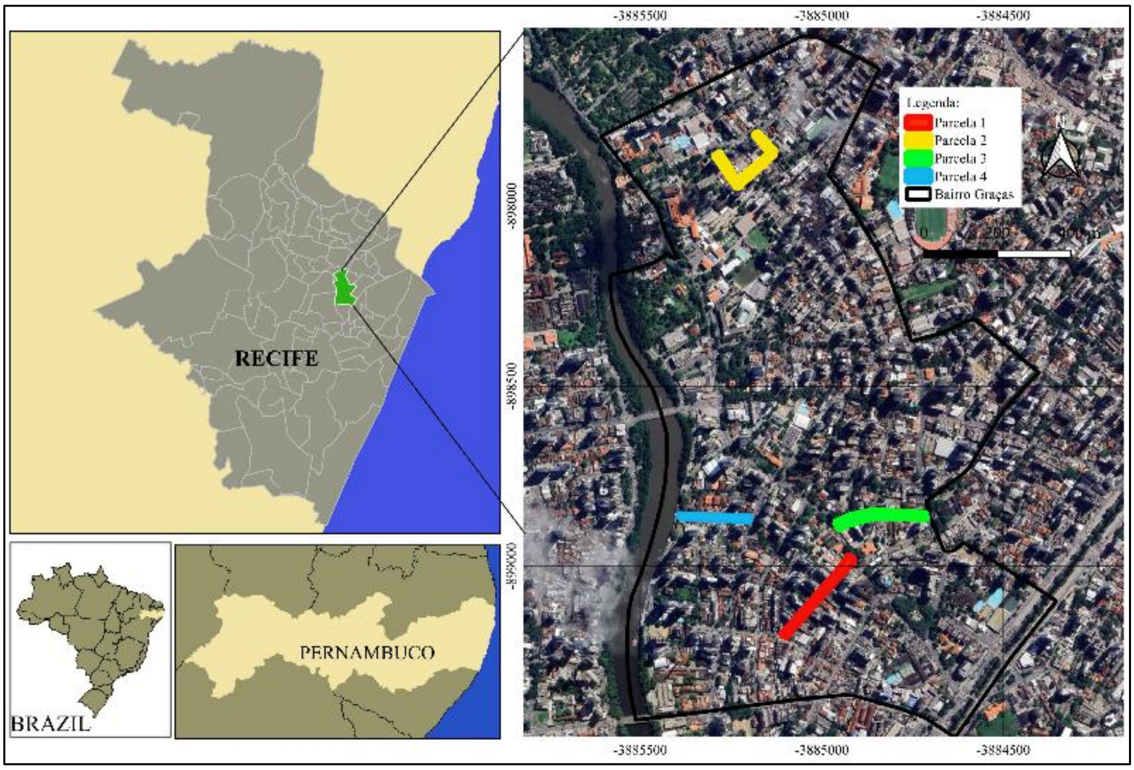

Figure 1. Study area location map.
Figura 1. Mapa de localização da área de estudo.

With an "As" climate type, according to the Köppen-Geiger Climate Classification (MEDEIROS *et al.*, 2018), Recife is characterized by a humid tropical climate with a dry season in the summer and rainfall in the winter. According to INMET (2025), the city's average annual temperature is 25.9 °C, with average minimum and maximum temperatures around 20 °C and 30 °C, respectively. Annual accumulated precipitation is approximately 2,263.4 mm, with the highest rainfall rates concentrated between April and August.

Data Collection

Data on the number of trees in the studied neighborhood were obtained from the Quantitative Census Inventory Report conducted in 2015, made available through the internal technical archives of the Recife Municipal Department of the Environment, classified as an unpublished institutional document. Thus, the streets were classified according to the number of trees per kilometer of tree-lined sidewalk. Consequently, a random sampling process was carried out, with the streets to be inventoried selected by lottery, using a 95% probability of sampling sufficiency and a maximum error of 10% (Araújo *et al.*, 2019). In total, four plots were selected by lottery for the inventory (Figure 1): Rua da Amizade (Plot 1), Rua Xavier Marques (Plot 2), Rua Confederação do Equador (Plot 3), and Rua Aníbal Falcão (Plot 4).

After the streets were selected, dendrometric measurements of the sample units began, using a *Haglof* ECII clinometer, a *Garmin eTrex* 10 GPS, a 20-meter measuring tape, a Silva 515 Ranger compass, and a standard measuring tape. Measurements were taken on both sides of the street, and azimuths were also recorded to guide future measurements.

To collect the data, the specifications of the *i-Tree Eco* program were followed; therefore, a template spreadsheet provided by the platform was used, in which the following data were collected for each sampled tree: botanical species, diameter at breast height (DBH), total tree height, total height of the living crown (measured from the insertion of the first living branch of the crown to the tree's apex), stem height (distance from the ground to the base of the crown), and crown length in the north-south and east-west directions, for subsequent determination of the crown's projected area.

Crown light exposure was assessed based on the number of sides of the tree directly exposed to sunlight: north, south, east, west, and the top of the crown. A side was considered "exposed" when at least 25% of its area received direct sunlight during the day. The score ranged from 0 to 5, depending on the number of sides receiving direct sunlight.

The percentage of missing canopy was estimated visually, according to the *i-Tree Eco* classes, representing the canopy volume not occupied by branches and leaves due to pruning, mortality, or damage. The classes used were: 0%, 1–25%, 26–50%, 51–75%, and 76–100%. Land use in the vicinity of each tree was classified as: commercial, institutional, multifamily (such as buildings and condominiums), parks and plazas, residential (houses), and vacant land, according to the typology observed at the sampling site.

In addition to dendrometric and structural variables, the geographic coordinates of all sampled trees were recorded. These data, along with the other information collected in the field, were organized into a comprehensive inventory and entered into the *i-Tree Eco* software, as this method allows for the individualized analysis of the ecosystem services provided by each tree, including rainfall interception and reduced surface runoff.

Data processing

Data analysis was conducted using the *i-Tree* platform, whose tools are primarily designed to quantify benefits and assess the ecosystem services provided by urban trees. Initially, data regarding the city of Recife and its annual precipitation were entered into the platform using the *i-Tree Database* tool (I-TREE, 2019), including: Continent, Country, State, City, Zone, Currency, Geographic Coordinates, Elevation, Climate, Temperatures, Vegetation, and Heavy Rainfall. Data on precipitation times and amounts were provided by the National Institute of Meteorology (INMET) in 2016. Climate information had to be adjusted to align with characteristics more similar to those of U.S. states and converted to Fahrenheit (°F).

To submit the species to the i-Tree Eco platform, the fields required by the program's measurement protocol were filled out, including: genus, specific epithet, family, order, class, common name, growth form, leaf density, and leaf type. Additionally, the optional fields—growth rate, longevity, height at maturity, and native continent—were also filled in to improve species parameterization and the accuracy of ecosystem service estimates.

The data were stored in *the i-Tree Database* (Location, Precipitation, and Species) and then incorporated into the updated version of the software (*i-Tree* Eco version 6.1.30) along with the tree inventory information, which was processed in *Microsoft Excel* and subsequently imported into *i-Tree Eco*, thereby allowing all data to be processed together.

In addition, Pearson's correlation was used, at a 1% significance level, to analyze the data on rainfall interception and prevented surface runoff in relation to the values of the variables DBH, live crown height, stem height, crown length, crown loss (%), and light availability, thereby determining the dendrometric variables that most influence water regulation.

RESULTS

The forest inventory was found to be satisfactory when considering the sampling error related to conditions in the Graças neighborhood. The floristic composition of the area included, among the 137 individuals, 30 species distributed across 29 genera and 22 botanical families. Plot 1 had the highest canopy area among the four streets evaluated, despite having the fewest number of species. The other public streets had lower values, notably Plot 4, which had the lowest canopy area but the second-highest number of species (Table 1).

Table 1. Number of tree species sampled in the streets in neighborhood of Graças in Recife - PE.
Tabela 1. Quantidade de espécies arbóreas amostradas nas ruas do bairro Graças em Recife - PE.

Plot	No. of Individuals	No. of Species	Canopy Area (ha)
Plot 1	41	5	1.10
Plot 2	38	19	0.75
Plot 3	23	7	0.40
Plot 4	35	14	0.17
Total	**137**	**-**	**2.42**

The mean values for diameter, height, length, and percentage of missing canopy, as well as the light provided by these trees, varied considerably among the streets studied. This is likely due to the different morphological characteristics of the species comprising them (Table 2), such as the average height of the living canopy on each street, which ranges from 5 to 14 m and is directly proportional to the average canopy length. Regarding missing canopy, it was found that plots with higher percentages of areas not covered by branches and leaves exhibited lower rainwater retention capacity, which may compromise interception and reduce the trees' efficiency in reducing avoided surface runoff.

REVISTA FLORESTA
Engenharia Florestal
ISSN 1982-4688
Edição 56
Universidade Federal do Paraná
Setor de Ciências Agrárias

Table 2. Mean values of the variables observed on the studied streets in the Graças neighborhood, Recife, PE.
Tabela 2. Valores médios das variáveis observadas nas ruas estudadas do Bairro das Graças em Recife - PE.

Plot	DBH	Live Crown Height (m)	Trunk Height (m)	Crown Length (m)	Missing Crown (%)	Light Exposure
Plot 1	1.58	14.25	2.93	9.91	45.22	4.22
Plot 2	1.89	11.43	3.57	7.84	35.03	4.13
Plot 3	1.16	12.50	4.48	8.35	36.08	3.91
Plot 4	1.11	5.41	2.21	3.91	27.46	4.06

Regarding land use, it was observed that the studied samples consisted of multifamily housing (buildings and condominiums) and commercial properties. This indicates a high level of imperviousness in the surveyed areas due to the volume of buildings. No types of green spaces (squares and parks) were found in the vicinity of the analyzed sites.

Rainwater Interception and Prevented Surface Runoff

It was observed that the 24,175.5 m² of tree canopy area across the 137 sites studied intercepted a total volume of 1,739.85 m³ of rainwater, with Rua da Amizade (Plot 1) recording the highest intercepted volume. In general, Table 3 shows that the volume intercepted decreases for each street as the canopy area decreases. It is possible that, for streets with similar canopy areas, the difference in the intercepted volume may also be explained by variations in their vegetation composition, such as species and morphology.

Table 3. Interception and flow avoided in the studied streets in neighborhood of Graças in Recife - PE.
Tabela 3. Interceptação e escoamento evitado nas ruas estudadas do Bairro das Graças em Recife - PE.

Plot	Crown Area (ha)	Interception (m³ year⁻¹)	Avoided Runoff (m³ year⁻¹)
Plot 1	1.10	790.97	161.42
Plot 2	0.75	540.79	110.36
Plot 3	0.40	287.51	58.67
Plot 4	0.17	120.58	24.61
Total	2.42	1,739.85	355.06

Table 3 shows that the individuals studied prevented a total volume of 355.06 m³ of stormwater runoff. The results regarding the runoff volume on each street varied significantly, following the same pattern observed for the tree canopy area. This demonstrates that on public roads, the impact of these trees on the capacity to reduce surface runoff is greater. By way of comparison, it can be observed that the volume of runoff prevented in Plot 1 was approximately seven times greater than that recorded in Plot 4, a ratio similar to the difference between the canopy areas of these plots.

Total rainfall in 2016 amounted to 2,074.60 mm, and the rate of water intercepted by the trees is shown in Figure 2. The bars represent rainfall, in millimeters (mm), for each month of 2016, with values ranging from 38.7 to 337.6 mm in November and June, respectively. The line represents the rainfall interception rates in cubic meters (m³) provided by all trees combined in the same year. The volume of water intercepted, in turn, reached its minimum value in November at 32.45 m³ and its maximum value in June at 283.06 m³.

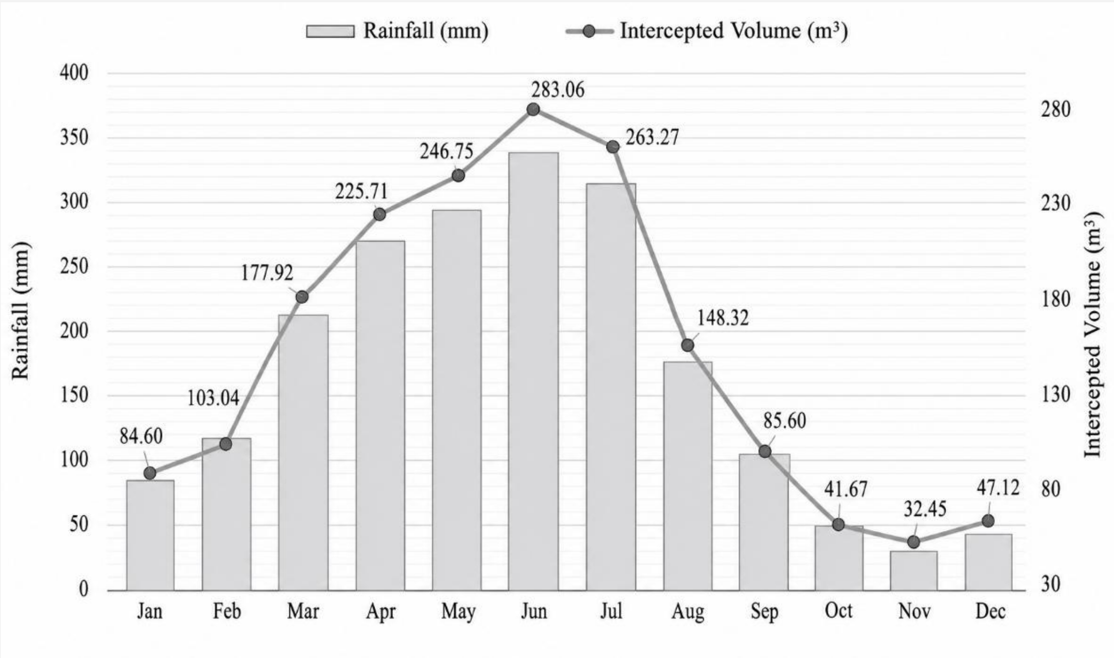

Figure 2. Relationship between the average monthly distribution of rainfall (mm) and the volume of water intercepted (m³) by tree streets in neighborhood of Graças, Recife-PE.
Figura 2. Relação entre a distribuição média mensal das chuvas (mm) e o volume de água interceptado (m³) pela arborização de ruas do Bairro das Graças, Recife-PE.

Figure 3 shows the variations in the volume of surface runoff prevented by the individuals studied, with the solid line representing the variation over the months. As with the interception data, the data on prevented surface runoff show that the lowest volume was recorded in November (6.62 m³) and the highest volume in June (57.78 m³). The maximum volume coincides with the period of peak rainfall in the city of Recife, which extends from May through August, with October being the driest month and having the lowest rainfall intensity.

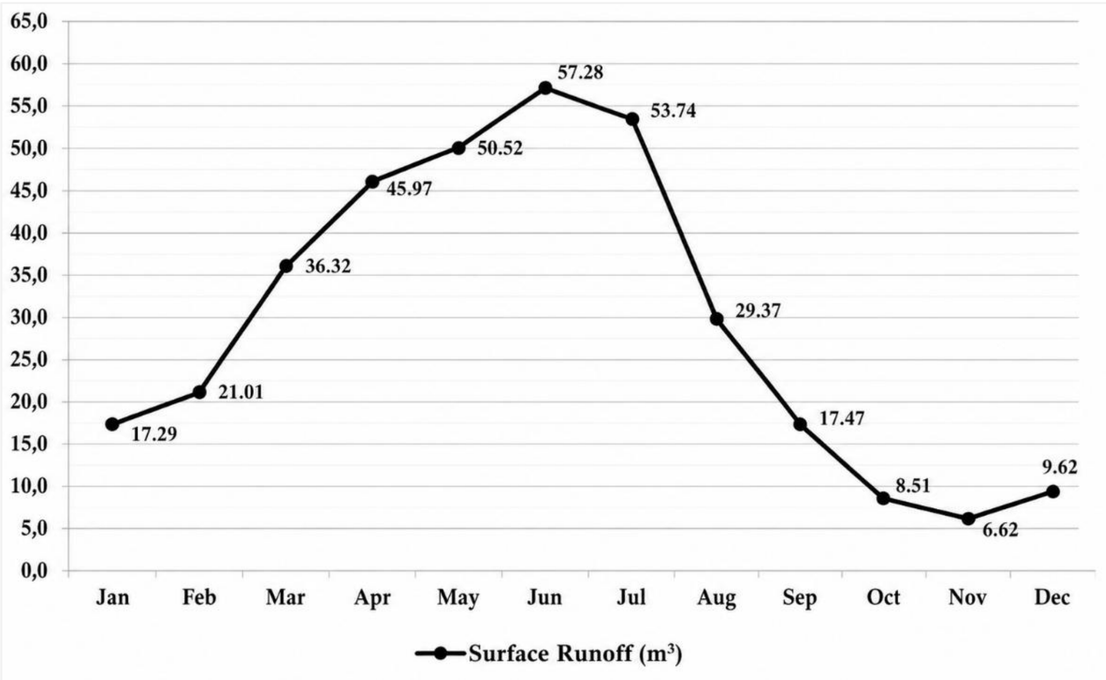

Figure 3. Monthly average of avoided surface runoff (m³) by tree streets in neighborhood f Graças, Recife-PE.
Figura 3. Média mensal do escoamento superficial evitado (m³) pela arborização de ruas do Bairro das Graças, Recife-PE.

Regarding dendrometric variables, Pearson's correlation coefficient showed similar values between the volume of intercepted rainfall and the volume of avoided surface runoff (Table 4). This is likely due to a direct correlation between these volumes, since both are interdependent and influence one another.

Table 4. Pearson's correlation between dendrometric variables and volumes of intercepted water and avoided runoff. **indicates significance at $p < 0.01$.
Tabela 4. Correlação de Pearson entre as variáveis dendrométricas e os volumes de água interceptada e escoamento superficial evitado. ** A correlação é significativa no nível 1%.

Surface function	DBH	Height - Living crown	Height - Stem	Length of the crown	Crown missing (%)	Light
Rainfall Interception	.754** .000	.783** .000	.464** .000	.913** .000	.130 .131	.233** .006
Avoided Runoff	.754** .000	.783** .000	.463** .000	.913** .000	.131 .127	.233** .006

Dendrometric variables related to the crown showed a high correlation with interception and reduced surface runoff. It was also observed that dendrometric variables related to the stem, such as DBH (0.754) and stem height (0.463), were significant for the volumes of water intercepted and reduced surface runoff. This behavior may be related to the fact that these stem variables receive part of the rainwater runoff from the branches, which, depending on rainfall intensity, buffers the flow of rainwater reaching the surface.

Variations in interception capacity and runoff in each plot occurred due to the different ages and sizes of the trees and the morphological characteristics of the species comprising them.

DISCUSSION

Rainwater Interception

Based on the results presented, it is noted, as expected, that variations in canopy area are directly related to the water interception capacity of tree canopies; therefore, streets with larger canopy areas tend to store more water. However, with regard to diversity, a high number of species does not always result in high rainwater storage. Due to the inherent morphological characteristics of each species, such as canopy shape and size, significant differences in interception capacity may occur between species (HOLDER; GIBBES, 2017; YANG *et al.*, 2019). Leaf size is cited in the literature as a relevant characteristic for rainwater interception. Studies such as that by Yang *et al.* (2019) indicate that species with smaller leaves tend to be more efficient at intercepting rain compared to those with larger leaves. Although this variable was not directly measured in the present study, this pattern helps explain the differences observed among species in terms of interception capacity, which are primarily associated with canopy morphology and structure.

Another factor that also affects interception is related to the duration and intensity of rainfall events. Interception is more efficient during shorter and less intense events compared to heavy, prolonged storms (XIAO *et al.*, 1998; ALVES *et al.*, 2018). This is because rainfall events of shorter duration and lower intensity are generally insufficient to completely saturate the canopies of trees with greater relative water-storage capacity, which is associated with structural attributes such as larger canopy area and volume, higher leaf density, and more complex canopy architecture (HUANG *et al.*, 2017).

By intercepting rainwater, the tree canopy reduces both the intensity and the volume of water that directly hits the ground, allowing some of this water to evaporate or slowly run off the branches and trunks (down-trunk runoff), delaying its arrival at the ground (Wang *et al.*, 2008; Livesley *et al.*, 2014). This mechanism helps alleviate pressure on urban drainage systems, reducing the occurrence of ponding, flooding, and erosion. Furthermore, this interception is particularly important during intense and rapid rainfall events—which are common in urban centers—as it acts as a natural regulator of water runoff (Armson *et al.*, 2013). Thus, the presence and proper management of urban trees—especially species with dense, well-developed canopies—play a strategic role in mitigating the impacts of rainfall in urbanized areas, promoting greater resilience to extreme events and contributing to the environmental sustainability of cities.

Furthermore, particularly during short and less intense rainfall events, there is greater transport of pollutants by water (XIAO *et al.*, 1998). Thus, trees act efficiently as filters by retaining rainwater. Although pollutant removal was not directly assessed in this study, this mechanism helps to understand the additional benefits associated with rainwater interception facilitated by urban tree cover. Hilde and Paterson (2014) found that this rainwater interception was the second-largest ecosystem service provided by urban trees in the city of

Hutto, Texas. To reach this conclusion, the authors used the *i-Tree Streets* program—also part of the *i-Tree* platform—which quantifies the annual benefits of each tree studied in monetary terms. Using this same program, along with quadratic regression models, Berland and Hopton (2014) observed that 2,997 trees intercepted a total of 20,079.9 m³ of stormwater in Cincinnati, Ohio.

Xiao and McPherson (2002) used the model proposed by Xiao *et al.* (1998) in their studies and found that 29,229 public trees in the city of Santa Monica, California, had the potential to intercept 193,168 m³ of stormwater in one year. Given that the *i-Tree Streets* program is based on the model proposed by Xiao *et al.* (1998), it is important to note that there are differences in the generation of results between it and the *i-Tree Eco* program, the main one being the individual-level result for annual surface runoff avoided (HIRABAYASHI, 2013). According to the same author, only *i-Tree Eco* has the capability to isolate data, which makes the results more consistent with reality.

Avoided surface runoff

The trees studied proved to be effective in retaining and dissipating stormwater in the Bairro das Graças neighborhood. Despite the impacts of urbanization, which leads to an increase in impervious areas, the presence of trees resulted in a considerable reduction in the neighborhood's surface runoff during weather events in the study period, indicating that there were delays in the occurrence of peak flows, thereby reducing their magnitude. According to Alves and Formiga (2019), the reduction in surface runoff can be further enhanced by increasing permeable or semi-permeable areas, since, under these conditions, runoff tends to be reduced through the influence of trees, which intercept rainfall, delay runoff, and promote water infiltration into the soil.

In this regard, the selection of species to be planted in roadside tree planting programs becomes a decisive factor regarding the potential of individual trees to prevent surface runoff. Evergreen trees tend to be more efficient than deciduous or semi-deciduous trees, as the interception and retention of rainwater depend on the presence or absence of leaves in the canopy (ZABRET; SRAJ, 2019). Therefore, when selecting species for afforestation projects, those with high deciduousness should be avoided so that their ability to interfere with and reduce runoff beneath their canopies is not compromised. Plot 1 illustrates this point well, as a small number of species was sufficient to ensure the largest canopy area and the highest rate of prevented surface runoff in the study area. In contrast, Plot 4, although it had nearly three times as many species, recorded the lowest values for canopy area and runoff prevention, indicating that plant diversity, on its own, does not imply greater water regulation capacity, which depends primarily on the size, area, and structure of the tree canopies.

Although street tree planting is not the primary solution to flooding, given that urban centers have canalization, culvert, and drainage systems, the results confirm that trees contribute to the interception of rainwater. Furthermore, they reduce surface runoff, helping to alleviate the burden on urban drainage systems by preventing surface runoff. During a 57-hour rainfall event, public trees in Santa Monica, California, USA, prevented 12,159 m³ of water from running off (XIAO; MCPHERSON, 2002). On the other hand, Xiao *et al.* (1998) report that as storm intensity increases, the effectiveness of trees in controlling surface runoff decreases. This occurs because the vegetation becomes saturated during these major rainfall events; thus, according to the authors, trees cannot be considered a major aid in flood control.

In complete inventories entered into the *i-Tree Eco* program, the model assumes that the area is fully vegetated, that is, with permeable soil (HIRABAYASHI, 2013). As noted by Alves and Formiga (2019), in areas with natural ground cover or permeable pavements, virtually the entire volume of precipitation infiltrates, resulting in no significant surface runoff. This means that the resulting value for avoided surface runoff in this study is, in fact, the difference between the volume of rainfall and the volume of water that infiltrated.

However, due to the impervious surfaces of the streets analyzed, it is evident that not all of this water infiltrated, resulting in an unaccounted-for volume of surface runoff. It is therefore suggested that future studies conducted with the *i-Tree Eco* program in urban areas use a sample-based inventory to avoid this issue.

Regarding the correlation between rainfall interception and surface runoff with dendrometric variables, it is observed that the tree canopy (tree cover) contains the greatest number of variables that influence the delay in water accumulation on the soil surface, through gradual drainage via trunk runoff and leaf drip, indicating their effectiveness in reducing flooding. These attributes are important because in cities—as a result of soil sealing—increased peak flow and earlier peak onset, along with increased surface runoff volume, are the primary effects of urbanization that cause floods and waterlogging (SILVA; SANTOS, 2018; XIAO; MCPHERSON, 2002).

It is recommended that future studies adopt methodological approaches that allow for the analysis of the interception capacity of urban trees as a function of the intensity and duration of each rainfall event. This analysis is especially relevant for extreme precipitation events, characterized by high rainfall volumes and intensities, which are directly associated with the occurrence of waterlogging, flash floods, and flooding in Brazilian cities.

CONCLUSIONS

- The presence of 137 trees enabled a reduction in surface runoff of 355.1 m³/year of rainwater by intercepting a volume of 1,739.8 m³/year. The values for runoff and rainwater interception varied in proportion to canopy area, highlighting the importance of tree cover in maintaining the hydrological cycle.
- The volume of water retained by the trees helped mitigate the negative effects of rainfall on the public roads studied by reducing runoff flow.
- Dendrometric variables influenced water regulation, with the exception of the percentage of missing canopy, determined by the volume of the canopy not occupied by branches and leaves.
- The platform used is a tool for understanding the water regulation ecosystem service provided by urban trees, and is of great value for managing urban tree planting. We suggest including rain gauges and daily data on precipitation amount and intensity at the study site so that the results generated by the *i-Tree Eco* program are even more accurate and allow for analyses of the maximum interception capacity of individual trees.

ACKNOWLEDGEMENTS

This study was supported by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and by the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq).

REFERENCES

ALVES, P. L.; FORMIGA, K. T. M. Efeitos da arborização urbana na redução do escoamento pluvial superficial e no atraso do pico de vazão. **Ciência Florestal**, Santa Maria, v. 29, n. 1, p. 193–207, 2019. DOI: https://doi.org/10.5902/1980509825820

ALVES, P. L.; FORMIGA, K. T. M.; TRALDI, M. A. B. Interferências de espécies arbóreas na interceptação das águas pluviais urbanas. **Revista Brasileira de Ciências Ambientais (Online)**, Rio de Janeiro, n. 47, p. 89–100, 2018. DOI: https://doi.org/10.5327/z2176-947820180214

ARAÚJO, Y. R. V.; MOREIRA, Z. C. G. ; BORGES, L. A. C. ; SOUZA, A. N. ; COELHO JUNIOR, L. M. . Avaliação da arborização viária da cidade de João Pessoa, Paraíba, Brasil. **Scientia Forestalis**, Piracicaba, v. 47, n.121, p. 71-82, 2019. DOI: https://dx.doi.org/10.18671/scifor.v47n121.07

ARMSON, D.; STRINGER, P.; ENNOS, A. R. The effect of street trees and amenity grass on urban surface water runoff in Manchester, UK. **Urban Forestry & Urban Greening**, v. 12, n. 3, p. 282–286, 2013. DOI: https://doi.org/10.1016/j.ufug.2013.04.001

BERLAND, A.; HOPTON, M. E. Comparing street tree assemblages and associated stormwater benefits among communities in metropolitan Cincinnati, Ohio, USA. **Urban Forestry and Urban Greening**, Munich, v. 13, n. 4, p. 734–741, 2014. DOI: https://doi.org/10.1016/j.ufug.2014.06.004

BERLAND, A.; SHIFLETT, S. A.; SHUSTER, W. D.; GARMESTANI, A. S.; GODDARD, H. C.; HERRMANN, D. L.; HOPTON, M. E. The role of trees in urban stormwater management. **Landscape and Urban Planning**, Amsterdam, v. 162, p. 167–177, 2017. DOI: https://doi.org/10.1016/j.landurbplan.2017.02.017

HILDE, T.; PATERSON, R. Integrating ecosystem services analysis into scenario planning practice: Accounting for street tree benefits with i-Tree valuation in Central Texas. **Journal of Environmental Management**, Belgium, v. 146, p. 524–534, 2014. DOI: https://doi.org/10.1016/j.jenvman.2014.05.039

HIRABAYASHI, S. i-Tree Streets/Design/Eco Rainfall Interception Model Comparisons. (2013) Disponível em: <http://www.itreetools.org/eco/resources/iTree_Streets_Design_ bEco_Rainfall _Interc eption_Mo del_Comparisons.pdf>. Acesso em: 04 dez. 2022.

IBGE. Instituto Brasileiro de Geografia e Estatística. **Recife (PE): Cidades e Estados (2022)**. Disponível em: https://www.ibge.gov.br/cidades-e-estados/pe/recife.html. Acesso em: 06 jan. 2026.

INMET. **Normais Climatológicas do Brasil 1991-2020**. Disponível em: <https://clima.inmet.gov.br/GraficosClimatologicos/PE/82900>. Acesso em: 21 dez. 2025.

I-TREE. i-Tree Eco: Application Overview. Disponível em: <https://www.itreetools.org/tools/i-tree-eco/i-tree-eco-overview>. Acesso em: 14 dez. 2022.

LIMA NETO, E. M; BIONDI, D.; LEAL, L.; DA SILVA, F. L. R.; PINHEIRO, F. A. P. Análise da composição florística de Boa Vista-RR: subsídio para a gestão da arborização de ruas. **Revista da Sociedade Brasileira de Arborização Urbana**, Piracicaba, v. 11, n. 1, p. 58-72, 2016. DOI: https://doi.org/10.5380/revsbau.v11i1.63390

LIVESLEY, S. J.; MCPHERSON, G. M.; CALFAPIETRA, C. The urban forest and ecosystem services: Impacts on urban water, heat, and pollution cycles at the tree, street, and city scale. **Journal of Environmental Quality**, Madisson, v. 45, n. 1, p. 119–124, 2016. DOI: https://doi.org/10.2134/jeq2015.11.0567

MEDEIROS, R. M.; HOLANDA, R. M.; VIANA, M. A.; SILVA, V. P. Climate Classification in Köppen Model for the State of Pernambuco - Brazil. **Revista de Geografia (Recife)**, Recife, v. 35, n. 3, p. 219–234, 2018. DOI: 10.51359/2238-6211.2018.229388

NYTCH, C. J.; MELÉNDEZ-ACKERMAN, E. J.; PÉREZ, M.E; ORTIZ-ZAYAS, J. R. Rainfall interception by six urban trees in San Juan, Puerto Rico. **Urban Ecosystems,** Tenesse, v. 22, p. 103–115, 2019. DOI: https://doi.org/10.1007/s11252-018-0768-4

RECIFE. Prefeitura do Recife: **Caracterização do Território**. Disponível em: <http://www2.recife.pe.gov.br/pagina/caracterizacao-do-territorio>. Acesso em: 22 nov. 2019.

SILVA, S. T.; SANTOS, R. F. M. A interceptação das águas pluviais através da arborização urbana. **INOVAE - Journal of Engineering, Architecture and Technology Innovation,** São Paulo, v. 6, p. 191-206, 2018.

WANDERLEY, L. S.; NÓBREGA, R. S.; MOREIRA, A. B.; ANJOS, R. S.; ALMEIDA, C. P. As chuvas na cidade do Recife: uma climatologia de extremos. **Revista Brasileira de Climatologia**, Curitiba, v. 22, p. 149-164, 2018. **DOI:** https://doi.org/10.5380/abclima.v22i0.56034

WANG, J., ENDRENY, T. A., & NOWAK, D. J. (2008). Mechanistic simulation of tree effects in an urban water balance model. **Journal of the American Water Resources Association,** 44(1), 75–85. https://doi.org/10.1111/j.1752-1688.2007.00139.x

XIAO, Q.; MCPHERSON, E. G. Rainfall interception by Santa Monica's municipal urban forest**. Urban Ecosystems**, Tenesse, v. 6, p. 291–302, 2002. DOI: https://doi.org/10.1023/B:UECO.0000004828.05143.67

XIAO, Q.; MCPHERSON, E. G.; SIMPSON, J. R.; USTIN, S. L. Rainfall interception by Sacramento's urban forest. **Journal of Arboriculture**, London, v. 24, n. 4, p. 235–243, 1998. DOI: https://doi.org/10.48044/jauf.1998.028

YANG, B.; LEE, D. K.; HEO, H. K.; BIGING, G. The efects of tree characteristics on rainfall interception in urban áreas**. Landscape and Ecological Engineering**, Tokyo, v. 15, p. 289–296, 2019. DOI: https://doi.org/10.1007/s11355-019-00383-w

ZABRET, K.; SRAJ, M. Rainfall Interception by Urban Trees and Their Impact on Potential **Surface Runoff. Clean – Soil, Air, Water**, Weinheim, v. 47, n. 8, p. 1-8, 2019. DOI: https://doi.org/10.1002/clen.201800327