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Papers

Models and Values of Fees and Incentives for Financing Sustainable Urban Drainage

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Keywords
Systematic review
Drainage tax
Sustainable drainage
Low impact development
Payment for urban environmental services

Abstract
Challenges are observed worldwide in the cost of urban drainage through fees compromising the sustainability of its management. Strategies are needed for greater involvement of users of the drainage system, assuming their responsibility for the cost of this system and collaborating with the system on their properties through the containment and delay of the surface runoff of rainwater to the public network from sustainable technologies. Incentives for these users to implement technologies that minimize the outflow of their properties can be an essential strategy for implementing fees. Therefore, this work aimed to evaluate, through a systematic review (SR), the values and methods of drainage fees and incentives for urban environmental services provided by users of drainage systems. The SR was developed from a search on the Web of Science (WoS) and Scopus platforms, whose data were analyzed using the StArt system. Among the 199 articles studied and published between 2010 and 2021, it was possible to relate fees and incentives practiced. Concerning fee models, the ERU method (Equivalent Residential Unit) was predominant. Regarding the incentive models, the most used was tax reduction.

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INTRODUCTION

The urban rainwater drainage system allows rainwater to be infiltrated, drained, and treated. However, administering this system is still challenging. It has weaknesses, mainly regarding the financing of its management, since many institutions find it difficult to charge and specifically fund this basic environmental sanitation service.

Stormwater fees are necessary to manage the public stormwater system and represent an equitable way for the community to share the cost of public service to reduce the impacts of urbanization. A comprehensive scientific discussion can contribute to the widespread dissemination of the importance of the stormwater fee system and its benefits (Tasca *et al.*, 2019).

Incentives to users of drainage services to implement compensatory technologies that minimize the flow of rainwater from their properties to the public network can be an essential strategy for the implementation of fees and can help to increase the efforts of families to adapt to this payment (Alamy Filho *et al.*, 2016; Fletcher *et al.*, 2015; Gonçalves *et al.*, 2018; Vicente *et al.*, 2023).

Compensatory urban drainage techniques are understood as those that allow infiltration or detention and that increase the evapotranspiration rate. They have the potential to reduce: the amount of stormwater runoff; flow peaks; vulnerability of urban areas to flooding; and contamination of water courses (Alamy Filho *et al.*, 2016; Fletcher *et al.*, 2015; Gonçalves *et al.*, 2018). These devices include wells, channels and infiltration basins; green roofs; floors; and other permeable areas.

The drainage service in Brazil is funded with municipal resources and there are a minority of municipalities that use an urban drainage fee, as are the cases of Santo André, Porto Alegre and Montenegro (SNIS, 2019). The economic sustainability of drainage systems, values and charging models have been discussed by authors who defend the implementation of drainage fees as a way of financing the system (Baptista; Nascimento, 2002; Gomes *et al.*, 2008; Nascimento *et al.*, 2005; Tasca, 2016; Tasca *et al.*, 2018; Tucci, 2002). The focus and location of these researchers' studies are the countries of South Africa, Germany, Australia, Canada, Denmark, Ecuador, the United States, France, England, Poland, Wales, Sweden, Switzerland and Brazil. Even so, these authors report, in studies developed in these locations, difficulties in this collection, leading to more efficient strategies or even specific studies that consider local characteristics when developing the collection model.

Given the above, it is crucial to know: “What are the values and forms of calculation practiced worldwide in charging drainage fees and in payment or incentives for urban environmental services provided by users of the sustainable urban drainage system?”. Considering these issues, this work had the general objective of evaluating values and methods of drainage fees and incentives for urban environmental services provided by users of drainage systems. To this end, a systematic review (SR) was developed based on a search on the Web of Science (WoS) and Scopus platforms, whose data were analyzed using the StArt system, version 2.3.4.2, developed by the Laboratório de Pesquisa em Engenharia of Software (LaPES) from the Universidade Federal de São Carlos (UFSCar).

MATERIAL AND METHODS

In carrying out this review in the search for values and forms of calculation practiced worldwide for drainage rates and incentives for urban environmental services provided by users, the following phases were adopted:

1. Search protocol definition;
2. Access to documents on WoS and Scopus platforms and issuing reports;
3. Import of reports from search platforms into the StArt system;
4. Reading abstracts and sorting documents for complete reading;
5. Extraction of data from documents and records in StArt;
6. Document data analysis.

The search protocol definition followed the StArt system's model, which strategy is described below and in full can be seen in the reference Vicente *et al.* (2024).

Question and search criteria

The SR had as its central question: “What are the values and forms of calculation practiced worldwide in the collection of drainage fees and in the payment or incentives for urban environmental services provided by users of the sustainable urban drainage system?”. This question is derived from the definition of the elements presented in Chart 1.

Chart 1 - Description of the search criteria.

Criteria	Description
Popula-tion	Scientific productions that present values and/or forms of calculations practiced in charging drainage fees and/or payment or incentives for urban environmental services provided by users of the sustainable urban drainage system.
Interven-tion	Reading and surveying on amounts and/or ways of calculating drainage rates and/or payment or incentives for urban environmental services provided by users of the sustainable urban drainage system.
Control	Articles with an actual indication of values and/or formulas for drainage fees and/or payment or incentives for urban environmental services provided by users of the sustainable urban drainage system.
Result	- Values currently practiced in the collection of urban drainage fees. - Values currently used for incentives and/or payment for urban environmental services provided by users of the sustainable urban drainage system. - Forms adopted in charging urban drainage fees. - Forms adopted for incentives and/or payment for urban environmental services provided by users of the sustainable urban drainage system.
Applica-tion Context	Evaluation of the use of payment or incentives for urban environmental services provided by users related to adopting urban drainage fees.

Source: The authors (2024).

Database and search terms

The main scientific data search bases selected for this SR were: the Web of Science (WoS) and Scopus. The search process was carried out using keywords called search terms. As shown in Chart 2, articles were prioritized, and the last ten years (2010 - 2021) were adopted as the search period, considering the research date of 03/12 /2021.

Chart 2 - Search terms.

Terms	Synonyms	Terms in Portuguese
Drainage tax	*Stormwater fee*	Taxa de drenagem
Stormwater drainage		Drenagem pluvial
Sustainable drainage		Drenagem sustentável
LID	*Low impact development*	Desenvolvimento de baixo impacto
Payment for urban environmental services	*Payment for environmental services*	Pagamento por serviços ambientais urbanos

Source: The authors (2024).

Based on these terms, the combination of search strings was defined as: “drainage tax” AND “stormwater drainage” AND “sustainable drainage” AND “low impact development” AND “LID” AND “payment for urban environmental services” OR “payment for environmental services.”

The search strings were performed in each database; the results were exported and imported into the auxiliary tool StArt.

The term LID was used instead of compensatory techniques since its definition encompasses their functions and is more widely adopted, as indicated by Vicente *et al.* (2023) and Fletcher *et al.* (2015).

Inclusion, exclusion, quality and data extraction criteria

In the article selection stage, the titles, abstracts and full content were sequentially analyzed, disregarding the documents based on the inclusion, exclusion and quality criteria presented in Charts 3, 4 and 5, respectively.

These quality criteria determined the classification of the articles about the main research question; for this reason, and to guide the prioritization of their complete reading, along with the specific field available in the tool, the documents were classified as very high, high, low and very low.

When reading abstracts and full texts, the selected works were submitted to the data extraction stage. The extracted data were placed in fields created in StArt, as described in Chart 6.

Once the data extraction was complete, they were analyzed, interpreted and documented in this article.

Chart 3 - Inclusion criteria.

Criteria	Inclusion Criteria Description
IC1	Works that present values and/or models for calculating drainage rates and/or compensated values and incentives for the use of devices for sustainable drainage in the urban environment by users will be included.
IC2	Published works available in full in the scientific bases searched will be included.
IC3	Works that present necessary values for implementing sustainable urban drainage management technologies will be included and are related to determining fees and incentives.

Source: The authors (2024).

Chart 4 - Exclusion criteria.

Criteria	Exclusion Criteria Description
EC1	Works that do not present values and/or models for calculating drainage rates and/or compensated values and incentives for the use of devices for sustainable drainage in the urban environment by users will be excluded.
EC2	Works focusing on the rural environment will be excluded.
EC3	Works that do not present an abstract and are not fully available in the scientific databases will be excluded.

Source: The authors (2024).

Chart 5 - Quality criteria.

Criteria	Quality Criteria Description
QC1	Was the article written with coherence and textual cohesion?
QC2	Were the methods, techniques and values reported objectively?
QC3	Were the values and calculation models for the urban drainage rate explicitly mentioned?
QC4	Were the values and calculation model for the payment or incentive for the provision of urban environmental services by users explicitly mentioned?
QC5	Were the necessary values for the implementation of technologies for sustainable urban drainage explicitly mentioned?
QC6	If there are practical applications, have they been described in detail?

Source: The authors (2024).

Chart 6 - Extraction criteria fields.

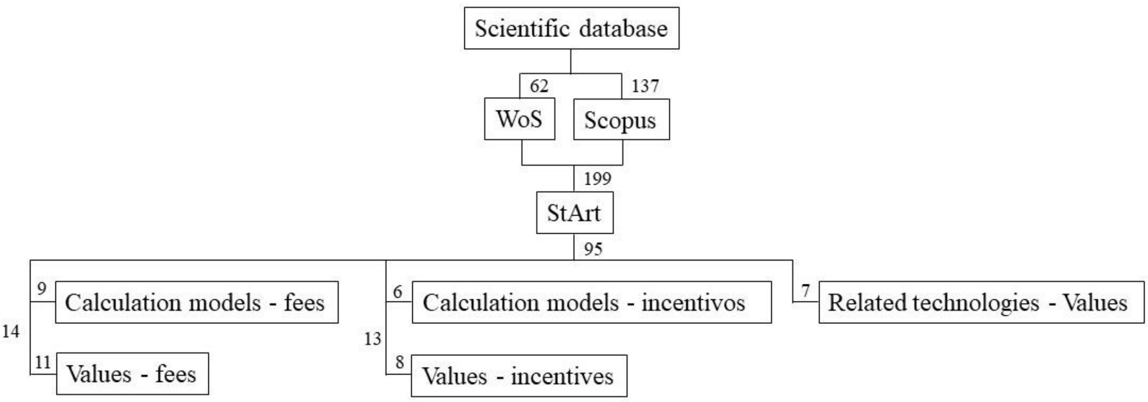
Field	Contents
Drainage rate calculation model and values.	Drainage rate calculation model and values.
Incentive or compensation values and model calculation.	Incentive or compensation values and model calculation.
Values necessary for implementing sustainable drainage technologies per user are related to the fee or incentives.	Values required for the implementation of sustainable drainage technologies per user.
Place where the study was carried out.	City, state and country where the study was developed.

Source: The authors (2024).

RESULTS AND DISCUSSION

The research for this systematic review resulted in a database of 199 papers. Of these, 137 (69%) were on the Scopus base and 62 (31%) were on the WoS base. In a first analysis of titles and abstracts, 104 (52%) works were rejected. Of the remaining 95 (47.73%) works, when data was extracted, a further 42 (21.10%) works were rejected. 14 (7.03%) papers presented information on rates, with 9 (4.52%) presenting data on rate calculation models and 11 (5.53%) providing values. 13 (6.53%) of the works dealt with incentive calculation models, 6 (3.01%) provided incentive calculation models and 8 (4.02%) provided values. 7 (3.52%) works dealt with values related to sustainable drainage technologies. Through Figure 1, it is possible to observe the flowchart of this SR and these quantities. The backup of the analyzes with StArt can be seen in the reference Vicente *et al.* (2024).

Figure 1 – Flowchart of the systematic and quantitative review.



Source: The authors (2024).

Rates, types and values

Chart 7 consolidates the possible types of rates quoted on the surveyed papers. Table 1 presents the values, typology, and locations of the rates found. And the Figure 2 registers the types of fees, where the predominance of charging based on costs (19%) and, in sequence, ERU (16%) and TPA (16%) can be observed. However, suppose the combinations adopted with the ERU are added (ERU + DAC and ERU + EHA). In that case, it can be seen that the ERU was used in 26% of the studies, and it can be inferred that this was the primary method adopted for designing death urban rainwater drainage fees.

The method created Based on Costs encompasses the alternatives adopted by the works that considered the rate and the charging for sewage, water, and public utilities in addition to drainage services. This charging method is an alternative that brings transparency to taxpayers who actually pay for the services provided in the face of urban drainage management, which can get greater acceptability to its users.

Chart 7 - Description of types of fees.

Types of fees	Acronym	Description
Development intensity	DI	The rate is based on the percentage of impermeability of the area related to the lot size. Similar to the Residential Equivalent Factor (REF) method. All categories are charged according to their intensity of development in the area (empty, undeveloped, moderate, high, and very high).
Damage Avoidance Cost	DAC	It is an estimate of the cost of stormwater management that has been externalized to the environment in the form of ecosystem goods and services.
Distributed alternative transportation	DAT	This method considers the management of runoff on municipal roads and calculates the approximate cost based on the average duration of a given user's trip. This component is added to the residential stormwater rate.
Equivalent residential unity	ERU	Financing mechanisms that determine usage based on impermeable area. One ERU is equivalent to the average amount of impermeable space in residential properties. All properties in this category are charged the same.
Equivalent hydraulic area	EHA	Lots are charged according to the combined impact of permeable and impermeable areas on generated runoff. The rate is a combination of these factors and the particular impermeable parcels.
Flat fee	Flat	A flat fee is charged to users of a stormwater transport system.
Hydrological alternative	HA	It is based on property characteristics: soil type, topography, impermeable area, tree canopy, and land use.
Residential equivalent factor	REF	Financing mechanisms that determine use based on the Natural Resources Conservation Service (NRCS) runoff method or rationale method. All properties in this category are charged the same. It differs from an ERU because REF considers other hydrological processes, such as interception storage and runoff from permeable areas.
Tier system	Tier	A system where consumers are categorized into levels based on quantitative factors (impermeable area or water use) or qualitative factors (type of land use or water flow) and charged accordingly. In many cases, a flat fee is charged for various ranges of impermeable areas.
Total property area	TPA	The fee is charged on the total area of the property.
Two-level/dual	Dual	Different rates or methods (usually flat rate or ERU) for residential and commercial properties.
Water usage	WU	The fee is charged according to the volume of drainage of the plot.

Source: Fisher-Jeffes and Armitage (2013), Kea *et al.* (2016) and Tasca *et al.* (2019).

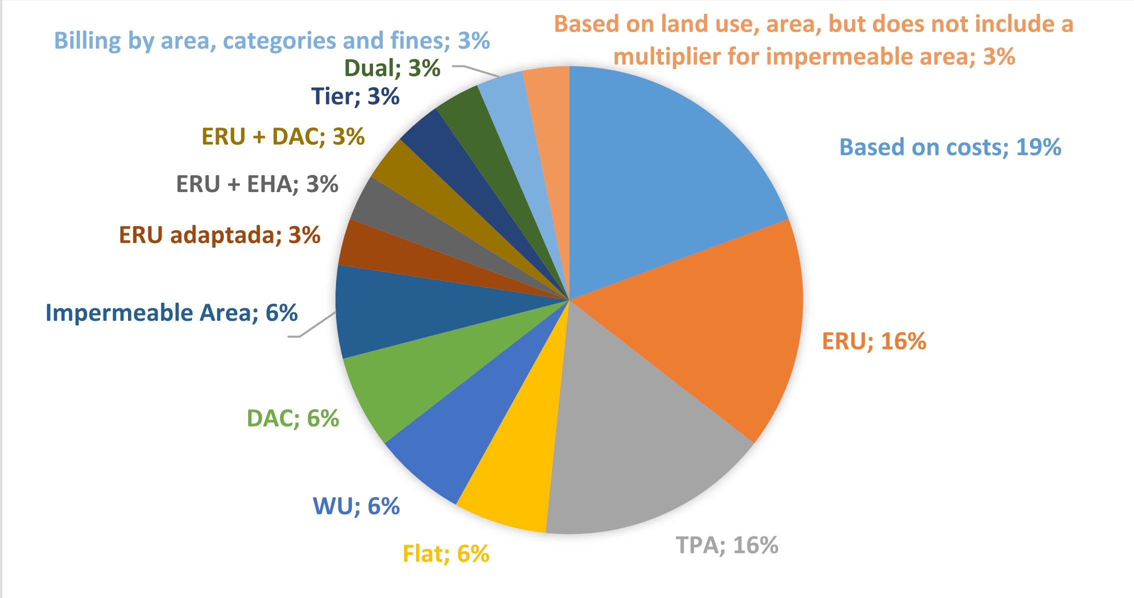
Table 1 - Data on fees.

Country	Year	Value (USD)	Margin (USD)	Value m² (USD)	Value m³ (USD)	Fee method	Reference
South Africa	2013	-	22.20-81.39*	-	-	ERU+DAC	Fisher-Jeffes and Armitage (2013)
	2010	113.40	-	-	-	DAC	Tasca *et al.* (2018)
Germany	2020	0.76*	-	-	-	-	Boguniewicz-Zablocka and Capodaglio (2020)
	2014	-	-	1.51	-	TPA	Tasca *et al.* (2018)
Australia	2017	56.64	-	-	-	Flat	Tasca *et al.* (2018)
Brazil	2019	82.80	-	0.28	-	ERU	Tasca *et al.* (2019)
	2002, 2008, 2016	42.72	-	-	-	ERU+EHA	Tasca *et al.* (2018)
	2005	-	-	-	-	The average cost of impermeable area	Nascimento *et al.* (2005)
Canada	2021	-	540 - 761 278 - 600 195 - 228	1.43 25.15 2.35	-	-	Adebe *et al.* (2021)
	2015	109.56	-	-	-	Tier	Tasca *et al.* (2018)
Ecuador	2016	-	3 – 1,440	-	-	WU	Tasca *et al.* (2018)
United States	2020	-	-	0.09 – 1.54	-	-	Malinowski *et al.* (2020)
	2018	19.1	-	-	-	Area, billing categories and fines for improper disposal	Tasca *et al.* (2018)
	2017	-	0 - 1,818.08	-	-	ERU adapted	Fedorchak *et al.* (2017)
	2016	61.68	-	-	-	ERU	Tasca *et al.* (2018)
	2013	50.88	-	-	-	TPA	Grigg (2013)
		53.64	-	-	-	TPA	
		77.52	-	-	-	Flat	
		678.24	-	-	-	Cost of sewage collection	
		-	-	-	-	Waterproof area	
		-	-	-	-	A small fee to cover part of the cost of stormwater management	
		-	-	-	-	ERU	
		-	-	-	-	Dual: Residential - TPA / Commercial - waterproof area	
		-	-	-	-	Fee schedule based on land use and area	
		-	-	-	-	Along with the utility bill	
		-	-	-	-	Cost of collecting and treating the drainage or sewage collection system	
	2007	963	-	-	-	DAC	Cutter (2007)
France	2013	-	-	1.04*	-	TPA	Carron and Guénégou (2013)
	2011, 2012	1,613.52	-	-	-	ERU	Tasca *et al.* (2018)
Poland	2020	-	-	0.07; 1.70; 0.24*	0.18	Cost of sewage collection / WU or in the impermeable area	Boguniewicz-Zablocka and Capodaglio (2020)
		-	-	-	0.19; 0.62*	-	Godyn *et al.* (2020)
	2014	6,96	-	-	-	ERU	Tasca *et al.* (2018)

* Values in euros (USD1.04) converted to dollars on 06/29/2022.

Source: The authors (2024).

Figure 2 - Fee collection methods used.



Source: The authors (2024).

This method imposes a significant challenge: for the managing bodies to have absolute accurate control over their management and, above all, the costs involved and their transparency. Evidence of this can be seen in the Urban Stormwater Drainage and Management Diagnosis of the Sistema Nacional de Informações sobre Saneamento (SNIS), an information system for the Brazilian sanitation sector, which only 65.6% of Brazilian municipalities provided information in 2019 to compose this document of great importance for the management or rainwater drainage in Brazil (SNIS, 2019).

Fisher-Jeffes and Armitage (2013) argue that, ideally, the stormwater management fee should be calculated based on the stormwater runoff load each property is potentially placing on the environment, and the consequent cost to the local authority to avoid damage. It is essential to demonstrate this burden to landowners and show the potential benefits of good stormwater management to highlight that the stormwater fee is not an unfair additional burden.

To charge for drainage services based on flow, it is necessary to install measuring devices on each property. This can be a complicating factor, as in the case of Brazilian municipalities, where for services related to sanitary sewage, there is a more usual charging mechanism, such measurement is not even made. Charging is based on the volume consumed of drinking water per property, whether it is metered or based on a fixed rate.

It was identified that ERU and TPA are widely used methodologies, given their modulation simplicity. The TPA is even rudimentary compared to the ERU, as the first considers the property's total area. In contrast, the second determines the use based on the impermeable site and stipulates categories for its charge. This is evidence that, to overcome the challenges faced with the implementation of charging rates for rainwater drainage services, simple methods must be used until one can be mastered, as its usage and its acceptability to the paying community.

According to Tasca *et al.* (2019), ERU is a viable and fast method for designing service fee structures. In addition to being simple and relatively easy to apply, it requires few resources for its development and can be easily adapted according to the peculiarities of each city. Changes in the type of cost considered, billing classes, and fee discounts, for example, can be applied at any time. It is the primary method used in the United States. In a study carried out by the same authors in the small town of Santo Amaro da Imperatriz, located in southern Brazil, the ERU was adopted and proved to be a viable and fast technique for funding rainwater services. Its simplicity allows its application in several locations.

Fisher-Jeffes and Armitage (2013) present the ERU or REF combined with a discount scheme as the fairest and most appropriate option for the case of South Africa. The REF method alone was not used by any of the works studied in this review.

Separately from the ERU, the results of the charging method based on Impermeable Areas are presented since these data refer to works in which the ERU was not referenced, and such categories were not specified. The technique was adopted in 6% of the pieces.

According to Table 2, the highest value of annual fees was USD 1,818.08 and the lowest value was USD 0.00 (fee exemption). When fees were charged per m^2, values between USD 0.07 and USD 25.15 per m^2 were identified. In cubic meters, values ranged from USD 0.18 to USD 0.62 per m^3. An average annual rate of USD 366.56 was reached; for charges in m^2, the average was USD 3.22 m^2 and for costs in m^3, the average was USD 0.33 m^3. The highest (USD 1,818.08) and lowest (USD 0.00) annual rate was found in the United States. Regarding rates per m^2 (USD 0.07 m^2) and per m^3 (USD 0.18 m^3) were registered in Poland, and the highest rates per m^2 (USD 25.15 m^2) were found in Canada and per m^3 (USD 0.62 m^3) in Poland.

Table 2 - Minimum, maximum, and average rates found.

	Country	**Year**	**Annual rate (USD)**	**Country**	**Year**	**Rate per m^2 (USD)**	**Country**	**Year**	**Rate per m^3 (USD)**
Minimum	United States	2020	0	Poland	2020	0.07	Poland	2020	0.18
Maximum	United States	2017	1,818.08	Canada	2021	25.15	Poland	2020	0.62
Mean	-	-	366.56	-	-	3.22	-	-	0.33

Source: The authors (2024).

This work did not detail whether these values were associated with the types of residential, commercial, or industrial areas since the objective was to raise the values practiced in general. This may explain the wide range of values found since higher rates are expected for commercial, industrial and/or high-impact areas on drainage systems.

About the fee models and in addition to Chart 7, it is essential to note that they should be defined by the incremental cost of providing the service and not by the average price, as suggested by Grigg (2013). Fees can only cover indirect stormwater costs: operation and maintenance. For legal reasons, investment costs cannot be included in the price (Tasca *et al.*, 2018).

It is common for local governments to face a variety of options for organizing their stormwater services, and no model fits their reality. The choice of model will depend on the values of the community, the situation of its concessionaires, and public works services. A narrow range of drainage and water quality services may be easier to finance with user fees than a complete program that includes floodplain management (Grigg, 2013). Therefore, these results must be seen as an analysis of the possibilities of values and models of drainage rate, which must be related to the specificities of the locality for its implantation.

In practice, stormwater rates are not high enough to motivate single-family families to reduce their runoff. In addition, the lack of integration between stakeholders can be a barrier to funding stormwater (Tasca *et al.*, 2018). More than charging fees, even if accompanied by incentives, it is vital to consider a program attended by actions that enable integration between agencies and the community, social communication, and environmental education.

Incentives, types, amounts, and their relationship with fees

Table 3 presents the compiled data on the incentives, their values, typology, and locations, which will be discussed in sequence.

Table 3 - Data on incentives.

Country	Year	Incentive method	Incentive for runoff reduction (%)	Incentive (%)	Incentive (USD)	Incentive in m² (USD)	Incentive in m³ (USD)	Others	Reference
United States	2020	Tax reduction	-	18 a 100	-	0.09 – 1.26	-	-	Malinowski *et al.* (2020)
	2018	-	-	-	13.12	-	-	-	Tasca *et al.* (2018)
	2013	Others	-	-	-	-	-	Property valuation from 4.83% to 14.64%	Chang *et al.* (2018)
Australia	2017	Tax reduction Law obligation	-	-	38.92	-	-	-	Tasca *et al.* (2018)
France	2013	Tax reduction Law obligation	-	10 a 90	-	-	-	-	Carron and Guénégou (2013)
Poland	2020	Tax reduction Law obligation	10, 30 ou mais	-	-	0.09; 0.17; 0.22*	-	-	Boguniewicz-Zablocka and Capodaglio (2020)
		Tax reduction Law obligation Financing	10 a 30	-	1,631.90* 7,199.04*	-	0.03; 0.07; 0.10; 0.17*	-	Godyn *et al.* (2020)

* Values in euros (US$1.04) converted to dollars on 06/29/2022.

Source: The authors (2024).

Incentives applied to the application of fees were mentioned in 43% of the studies. The practice of these is associated with retention, infiltration, and low-impact structures. Both Boguniewicz-Zablocka and Capodaglio (2020) and Godyn *et al.* (2020) presented the incentives related to the percentage of runoff retention. While Godyn *et al.* (2020) mention a margin of 10% to 30%, Boguniewicz-Zablocka and Capodaglio (2020) mention a margin of 10%, 30%, or more of retention.

Regarding the incentives applied, it was observed that they ranged from 10% to 100%. In terms of values, they varied between USD 13.12 and USD 7,199.04; when associated with m², the values varied between USD 0.09 m² and USD 1.26 m² and when associated with m³, they ranged between USD 0.03 m³ and USD 0.17 m³. Studies related to these incentives were conducted in Australia, the United States, Poland, and France.

Malinowski *et al.* (2020) classified it into six categories of policy incentives for using green structures: tax reduction, financing, construction license, sustainability certification, law obligations and agile administrative process. They noted that of all the incentive policies studied, financial subsidies and law obligations are the most commonly used ways to promote green infrastructure worldwide.

Among these incentive policy categories listed by Malinowski *et al.* (2020), the present study identified that 83% of the cited incentives indicated tax reduction, and 67% of the works cited compliance with the legislation where the stimuli were practiced. A smaller amount (17%) was observed for financing the implementation of structures that retain rainwater. A new category can be added to this list by these authors, which is the appreciation of the price of properties that have or are in regions with low-impact structures, as was observed in 17% of the studies studied.

The works that presented values and/or models of incentives related these to values and/or models of fees, which indicates a promising trend in implementing fees associated with incentives. Chang *et al.* (2018) state that charging a drainage fee associated with incentives is an effective measure to encourage public participation in implementing low-impact development technologies (LID) on their own property. Fisher-Jeffes and Armitage (2013) state that without subsidies associated with fees, there will be a limited improvement in stormwater management for some sectors of society and a failure to address the stormwater problem in its entirety.

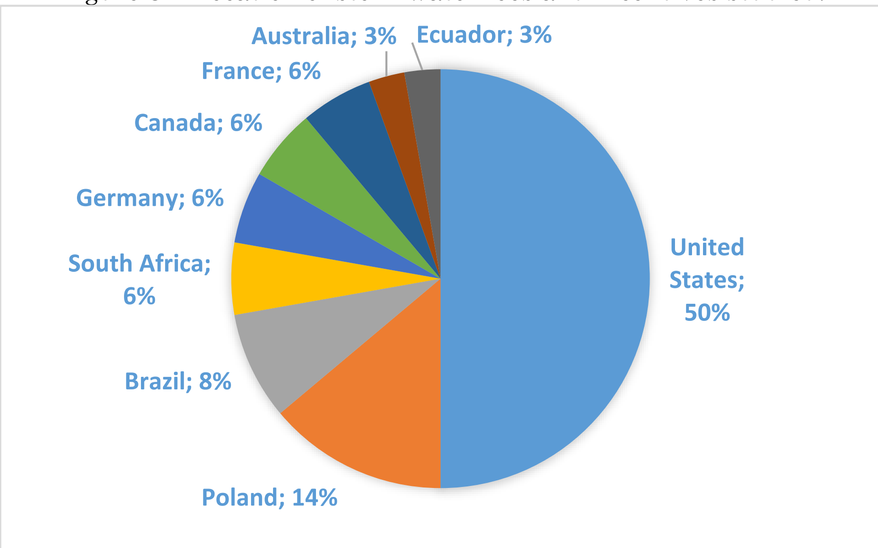
With this, it is understood as an educational and motivational measure of the application of incentives associated with drainage rates, as they have the potential to motivate users of drainage systems to collaborate with more sustainable environments from the use of compensatory technologies, minimize the overload of public drainage structures; minimize environmental pollution by optimizing public stormwater treatment systems; and also provide financial resources from fees that enable more sustainable urban drainage management.

Locations and technologies associated with fees and incentives

The locations where the rates of rainwater and incentives were studied are presented in Figure 3. The United States was the object of 50% of the works portraying that this country has extensive experience in using rainwater rates.

Some works discussed compensatory technologies, their implantation, operation, and maintenance values, which may indicate a tendency to associate these with the implantation of drainage fees and incentives. The technologies addressed were: green roofs, rainwater harvesting and storage (RWH), rain gardens, permeable parking lots, permeable pavement, bio-ditch, infiltration ditch, green filter strips, detention tanks, and retention tanks. However, considering the search terms adopted in this SR, it is believed that due focus was not given to a satisfactory survey of the implantation, operation, and maintenance values for these devices, which should be the object of a specific work.

Figure 3 – Location of stormwater fees and incentives studied.



Source: The authors (2024).

FINAL CONSIDERATIONS

This systematic review allowed identifying values and forms of calculation practiced worldwide in collecting drainage fees and the payment or incentives for urban environmental services provided by users of the urban drainage system from 2010 to 2021, considering research carried out on 03/12/2021.

Regarding the rainwater drainage fee models, the predominance of charging by the ERU method was observed because, as it is easy to apply, it highlights the need for simpler calculation models until, once implemented, they are improved for the local realities where they are applied.

Concerning incentive models, the most used is tax reduction, characterized by the need to provide financial returns to the user of rainwater drainage services through the adoption of compensatory techniques in a faster and more tangible way.

Considering that 43% of the presented data promotes fees and incentives, it is concluded that the implementation of charging fees for drainage services associated with incentives for the adoption of compensatory techniques is a promising path. In addition to encouraging users to provide urban rainwater drainage services through the adoption of compensatory and sustainable techniques based on economic gain, there is an educational measure in which the community assumes its responsibility on its area to promote more attractive characteristics.

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Sustainable urban environment similar to what existed before its development.

The United States had the most significant number of papers analyzed, proving to be the leading location in carrying out research and taking on rainwater drainage fees and incentives for the adoption of compensatory techniques in relation to other locations, such as Poland, Brazil, South Africa, Germany, Canada, France, Australia, and Ecuador.

This work identified an opportunity for complementary studies: a survey of fees associated with incentives by categories such as residential, commercial, or industrial; identification of the relationship between the use of compensatory technologies related to costs and incentives.

Finally, it should be noted that, even though the work highlights trends in values and methods of fees and incentives, each location has its particularities that must be studied individually to validate appropriate values and methods.

SUPPLEMENTARY MATERIALS AND DATA AVAILABILITY STATEMENT

Data supporting the results of this study on the StArt system are openly available on a page https://zenodo.org/records/10630561. It was agreed with the journal.

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AUTHOR CONTRIBUTION

Ana Paula Camargo de Vicente collected, analyzed the data and wrote the text. Karla Maria Silva de Faria and Klebber Teodomiro Martins Formiga provided guidance, analyzed the data and revised the text. All authors read and agreed to this paper's submitted version.