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QUALITATIVE ANALYSIS OF THE SOCIAL SUSTAINABILITY OF URBAN DRAINAGE SYSTEMS IN CHILE

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ANÁLISIS CUALITATIVO DE SOSTENIBILIDAD SOCIAL DE SISTEMAS DE DRENAJE URBANO EN CHILE

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RESUMEN

Avanzar hacia un desarrollo urbano sostenible conduce a aplicar nuevas formas de drenaje, las que entregan múltiples beneficios técnicos y sociales a la comunidad. No obstante, en países como Chile aún existe una gran brecha respecto de metodologías de evaluación de sostenibilidad social de proyectos de drenaje urbano. A través del análisis cualitativo de contenido aplicado a entrevistas a expertos (*n = 11*), este estudio busca (1) identificar métricas para la medición de la sostenibilidad social de sistemas de drenaje urbano; (2) identificar desafíos para la implementación de dichas métricas y (3) proponer modificaciones al método actual de evaluación de sistemas de drenaje para mejorar la inclusión de la sostenibilidad social en el primero. Dentro de los resultados se advirtió que expertos proponen métricas que capturan la sostenibilidad social, pero que, en la práctica, son complicadas de cuantificar. En términos de los desafíos, la fragmentación de responsabilidades de las organizaciones que participan de la gestión de sistemas de drenaje dificulta el uso de nuevas métricas de sostenibilidad social. Por último, se sugiere el desarrollo de una institución que pueda gestionar los sistemas de drenaje urbano de forma global e integral a fin de valorar los beneficios de la sostenibilidad social de sistemas de drenaje urbano. Estos resultados pueden ser utilizados por autoridades y tomadores de decisiones relacionados a sistemas de drenaje urbano para desarrollar nuevas metodologías que tomen en cuenta los beneficios de la sostenibilidad social.

Palabras clave
análisis cualitativo, desarrollo urbano, desarrollo sostenible.

ABSTRACT

Moving towards sustainable urban development leads to applying new forms of drainage, which provide multiple technical and social benefits to the community. However, in countries like Chile, there is still a large gap regarding methodologies to assess the social sustainability of projects in this area. Using a qualitative content analysis applied to experts' interviews (*n = 11*), this study aims at (1) identifying metrics to assess the social sustainability of urban drainage systems; (2) identifying challenges for the implementation of such metrics, and (3) proposing changes to the current system, to assess urban drainage systems that enhance the integration of social sustainability within these systems. The results show that experts proposed metrics that may assess social sustainability, but in practice, these metrics are difficult to quantify. In terms of challenges, the fragmentation of responsibilities from organizations that are involved in managing urban drainage systems may complicate the use of new social sustainability metrics. Ultimately, it is suggested that an institution is created that can manage urban drainage systems using an integrative approach, to account for the benefits of social sustainability of urban drainage systems. These results can be used by authorities and decision-makers who work with urban drainage systems, to move towards methodologies that consider the benefits of social sustainability.

Keywords
Qualitative Analysis, Urban Development, Sustainable Development, Chile.

INTRODUCTION

Urbanization is a historical natural development process and constitutes the largest human impact on natural watersheds since it leads to the loss of their natural ability of infiltration, subsurface storage, and evapotranspiration from the soil; processes that are replaced by an increased generation of direct surface runoff, which significantly affects the dynamics of the water cycle and water quality (Ministry of Public Works [MOP, in Spanish], 2013). In Chile, the urbanized area has increased by 39.5% between 2002 and 2017, a growth that is equivalent to the area of Greater Santiago (National Institute of Statistics [INE, in Spanish], 2019). It is also estimated that by 2050, the country's urban population will be 94.2% (MOP, 2013).

It is because of this that the need arises to generate a change in urban drainage management, integrating sustainability into urban planning as a tool to incorporate drainage systems that provide complementary benefits to traditional ones and, thus, to the communities they serve (Jato-Espino, Toro-Huertas & Güereca, 2022). The concept of sustainability aims at meeting the needs of current generations without jeopardizing the ability of future generations to respond to their needs (Brundtland, 1987; Olawumi & Chan, 2018). In this sense, sustainability has three dimensions that define it: the economic, the environmental, and the social (Sierra, Pellicer & Yepes, 2017; Valdes-Vasquez & Klotz, 2013). To achieve sustainable development, these three dimensions must be comprehensively addressed (Olawumi & Chan, 2018). However, in general, this does not happen, mainly due to the complexity of defining what social sustainability is, which hinders its measurement process (Atanda, 2019). Efforts are therefore required to develop a better understanding of how to capture and measure the concept of social sustainability. Given this context, this study seeks to analyze how social sustainability can be measured in the context of urban drainage systems in Chile. As a starting point, a review of the specialized literature on sustainable urban drainage systems is made, as well as on the concept of social sustainability, and the Chilean context of urban drains.

LITERATURE REVIEW

SUSTAINABLE URBAN DRAINAGE SYSTEMS

Replicating the different components of the existing natural water balance as much as possible, before urbanizing, generates urban drainage solutions that allow not only providing control of the quality and amount of runoff but also providing a more complete service to the community, aimed at improving the quality of life of city dwellers (MOP, 2013). This is the main objective of Sustainable Urban Drainage Systems (SUDS), which seek to manage urban runoff and, at the same time, provide improvements in green areas and environmental quality. According to the official guide in the UK (The SUD Manual), the 4 pillars of design in this framework are (1) Control of the amount of water, management of the flood risk, and maintenance and protection of the water cycle; (2) Management of the runoff quality; (3) Creation and maintenance of better spaces for the people; and (4) Creation and maintenance of better spaces for nature (Woods-Ballard *et al.*, 2007).

The mode in which sustainable drainage systems operate involves managing stormwater as close as possible to its source, reducing runoff, firstly, by infiltration and, when that is not possible, by retention, storing said waters temporarily and then discharging them in a controlled way (Woods-Ballard *et al.*, 2007). Its elements seek to represent the different components of the water cycle, based on the processes of infiltration, evapotranspiration, and water storage. Some examples of these are retention ponds, infiltration trenches, permeable pavements, and green roofs. These can be used individually or grouped into systems, whose configuration will define their effectiveness (Johnson & Geisendorf, 2019).

The technical benefits of these methods aim at reducing the presence of pollutants in surface water bodies, improving the quality of storm runoff, and promoting the recharge of aquifers, in addition to controlling floods (Gogate, Kalbar & Raval, 2017). Economic benefits are also produced by reducing both the costs of treating pollutants in water, as well as energy consumption (Jiang, J. Li, H. Li, Y. Li & Zhang, 2020).

Among the social and environmental benefits are the beautification of landscapes and the generation of habitats for native flora and fauna (Fajardo, Valdelamar & Mouthon, 2019; Jiang *et al.*, 2020). Surveys conducted in the United Kingdom (Jose, Wade & Jefferies, 2015) show that citizens value the biodiversity, health, and aesthetics provided by this infrastructure the most, since access to green areas provides pleasant recreational spaces, where you can walk or play, providing a sense of mental and physical well-being. Due to the aforementioned benefits, SUDS must have a place in city development, as they imply an important advance towards environmental and, above all, social well-being.

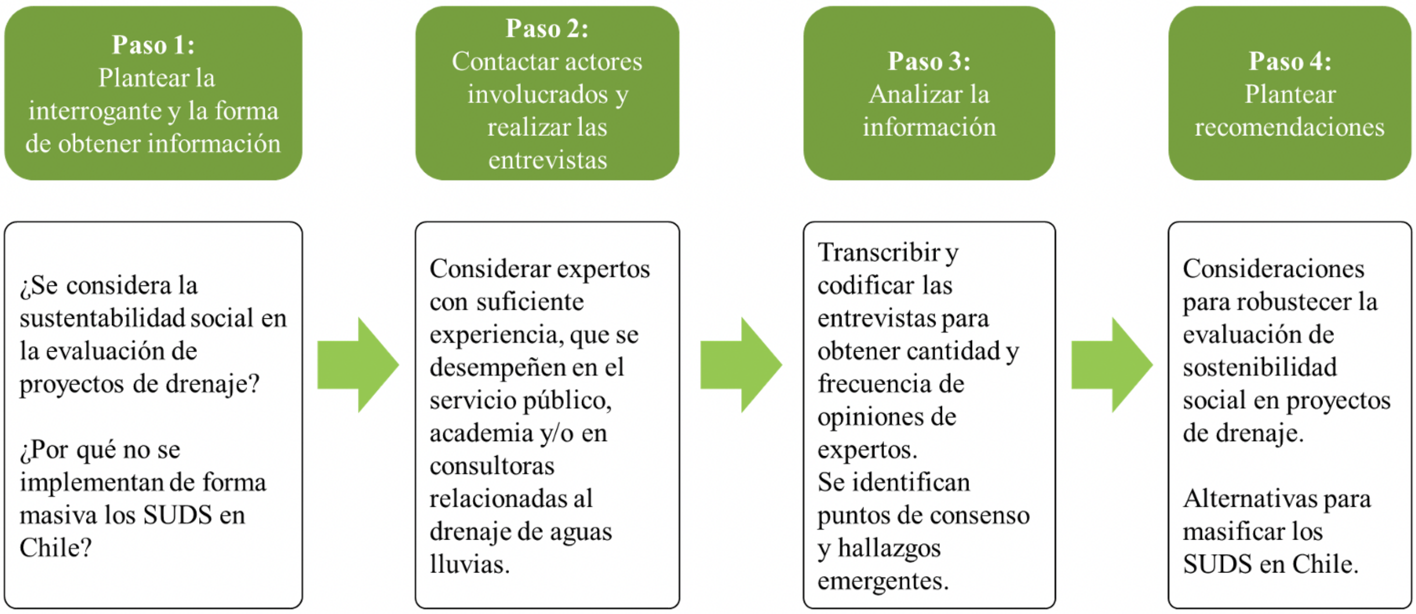

Figure 1. Summary of research steps followed in this study. Source: Preparation by the authors.

SOCIAL SUSTAINABILITY

Social sustainability is a concept that underlies multiple areas of knowledge and that assumes social development as the path to achieving greater equality, safety, and social responsibility, placing special emphasis on city development (Eizenberg and Jabareen, 2017). To achieve social sustainability, specific actions and policies must be contemplated that protect people, regardless of their origin, culture, or beliefs, to generate a greater community and a sense of belonging for the citizens (Vallance, Perkins & Dixon, 2011).

Social sustainability is evaluated through multicriteria evaluation methods since it seeks to represent the multidimensionality of reality through a diversity of perspectives, which determine its state of development (Jiménez *et al.*, 2019; Sierra, Yepes & Pellicer, 2018). Social criteria are the result of the grouping of indicators or principles that value a social aspect. However, their definition is not fully specified, since there are no pre-established social criteria that are valid for all contexts. The basic criteria of social sustainability are usually: equality, economy, local development, mobility and accessibility, health, poverty reduction, and environmental security. They have integrated new concepts, such as happiness, quality of life, the sense of belonging, and well-being (Chini, Canning, Schreiber, Peschel & Stillwell, 2017; Shen, Ochoa, Shah & Zhang, 2011) which, in turn, are more difficult to measure due to their intrinsic subjectivity (Atanda, 2019; Lami & Mecca, 2021). The assessment should analyze the entire life cycle of the structure, considering future needs; otherwise, the scope of social sustainability will be limited (Sierra *et al.*, 2018). However, some studies have focused on the social sustainability of specific stages of the life cycle of urban drainage systems, such as maintenance (Gogate *et al.*, 2019) and its more sustainable alternatives.

Another fundamental aspect for the development of metrics capable of measuring social sustainability is the participation of the different stakeholders (Axelsson *et al.*, 2013; Sierra *et al.*, 2018), people or organizations that may affect or be affected by the development of a project (Chinyio & Olomolaiye, 2009). The stakeholders to be considered in infrastructure projects may include local communities, NGOs, political representatives, infrastructure agencies, and experts in the infrastructure systems under study (Araya, Faust & Kaminsky, 2020; Chinyio & Olomolaiye, 2009; Valdes-Vasquez & Klotz, 2013). Therefore, it is key to understand how each of the stakeholders associated with infrastructure projects understands social sustainability. In the context of urban drainage systems, the specialized literature has rarely included the role of the different stakeholders. Indeed, in the bibliographic review evaluated by Ferrans, Torres, Temprano, and Sánchez, (2022), it was identified that the vast majority of studies in this area did not include the role of stakeholders (86% of the analyzed texts), and of the 14% that did, most considered the role of experts in urban drainage systems or authorities. Obviously, this emphasizes the role of experts in the development of a better understanding of the sustainable development of urban drainage systems.

Having suitable metrics is essential for a better evaluation of social sustainability, as it allows specifying and expanding the range of benefits, supporting them with objective data, and reducing the bias that user surveys could have (Jarvie, Arthur & Beevers, 2017). This is why

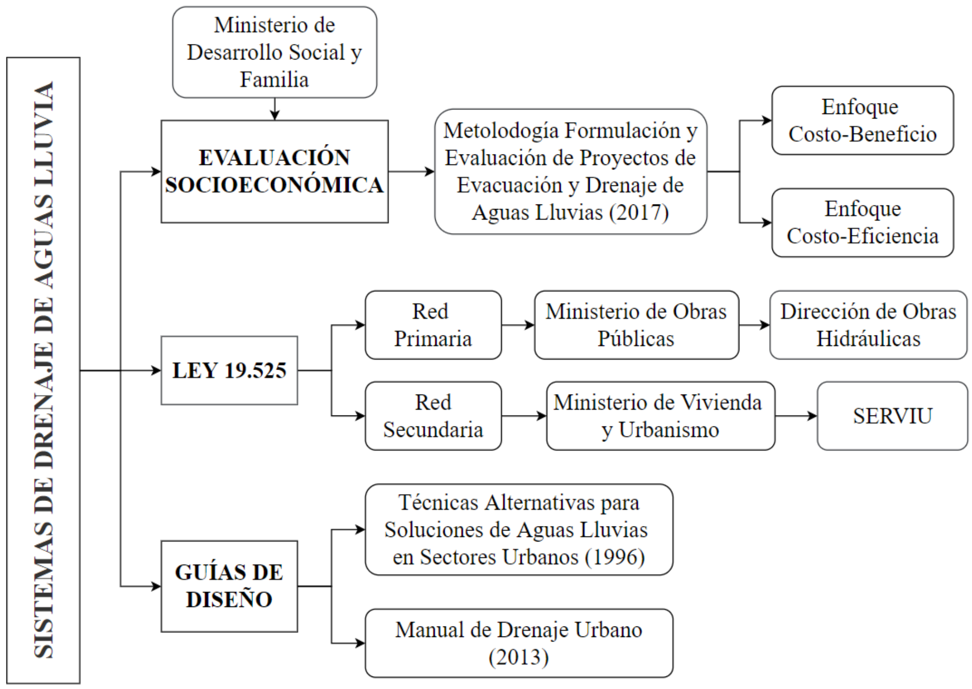

Figure 2. National context of urban drainage. Source: Preparation by the authors.

it is necessary to make studies in diverse contexts, such as the Chilean one, to contribute to the evaluation of social sustainability. Figure 1 shows a summary of the steps followed to make this study.

CHILEAN CONTEXT OF URBAN DRAINAGE

In 1997, the Chilean law regulating Rainwater Evacuation and Drainage Systems was passed. This emphasizes the reduction of flood damage in cities through the construction and operation of rainwater drainage infrastructure, which is independent of the wastewater network (Law No. 19.525, 1997).

It also divides the rainwater network into primary and secondary networks. The first is defined in the master plans and corresponds to natural channels and large diameter pipes, built and operated by the Public Works Ministry (MOP, in Spanish) through the Directorate of Hydraulic Works (DOH, in Spanish). On the other hand, the rest of the network is considered secondary, and its construction and operation depend on the Housing and Urbanization Service (SERVIU, in Spanish) (Law N° 19.525, 1997).

The Ministry of Social Development and Family (MIDESO, in Spanish) makes the technical-economic evaluation using the evaluation methodology of public urban drainage projects (MIDESO, 2017). The evaluation approach is the cost-benefit approach for investment projects greater than 30,000 UF[1;] otherwise, the cost-efficiency approach is the one used. The social benefits are evaluated, such as resource release and benefits for reduced flood damage, valued through the avoided damage and hedonic prices methodology. The relationship between the institutions responsible for urban drainage is illustrated in Figure 2.

The evaluated benefits make it difficult to finance projects that contemplate social benefits unrelated to the damages avoided by flooding, generally provided by sustainable drainage, such as aquifer recharge, water purification, and aesthetic and recreational aspects that contribute to the well-being of the population, which, on the other hand, are difficult to value.

For all the above, this study intends to address the limitations of the existing methodology for evaluating the social benefits of rainwater drainage projects, analyzing the current state-of-the-art, and exploring the level of awareness of experts and stakeholders. Based on the Chilean case study, it is expected to determine the main shortcomings of the current methodology, as well as the improvements that could be considered to strengthen it.

1 UF: Unidad de Fomento or Unit of Foment is an inflation-indexed unit of account, calculated and published by the Central Bank of Chile (BCCh)

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	Field	Job title or position	Years of experience
1	Academia	Head of Academic Department	18
2	Academia	Professor	25
3	Academia	Researcher	1
4	Public institution	Social Assessment Analyst	16
5	Public institution	Head of Social Assessment Department	10
6	Public institution	National Infrastructure Manager	25
7	Public institution	National Infrastructure Manager	15
8	Public institution	Head of Technical Division	26
9	Public institution	Head of Technical Unit	15
10	Public institution	Head of Community Interaction Unit	17
11	Engineering/Consulting	Consulting engineer	1.5

Table 1. Characterization of the expert panel. Source: Preparation by the authors.

METHODOLOGY

DATA COLLECTION THROUGH INTERVIEWS

Given the importance of taking into account the different stakeholders in the development of sustainable urban drainage systems, in this study, it was decided to focus on one stakeholder in particular: experts in urban drainage infrastructure systems.

The experts were contacted via email and the interviews were mostly conducted remotely, lasting between 30 and 45 minutes. The interviews were recorded and then transcribed, with the interviewee's permission to do so. The selection criteria of interviewees were that in their work, they were linked either with urban drainage, social evaluation of projects, or sustainable urban infrastructure development, through academic, consulting, or institutional organizations. The last three are very important, as they provide knowledge from the operational perspective of the system. In this way, a total of 11 successfully completed interviews were obtained.

The sampling method of semi-structured interviews was chosen because it allows for a dynamic and flexible interaction between the interviewer and the interviewee.

The interviews sought to answer the following 3 questions:

1. What metrics could be used to assess sustainability, in general, and the social sustainability of sustainable urban drainage systems?
2. What barriers are there in the implementation of such metrics?
3. What modifications would you make to current measurement systems?

The expert panel was classified according to their field and years of experience, which on average was 15.4 years (Table 1).

QUALITATIVE ANALYSIS OF INTERVIEWS

The interviews were transcribed and analyzed qualitatively using the Weft QDA program. The answers were coded according to their most recurrent topics, using the live coding method (Saldaña, 2013). The coding was developed until reaching the saturation point, where new interviews only provided marginal information regarding the topic under study. This situation is in line with what the literature suggests, namely that this saturation point is reached at around 12 interviews (Galvin, 2015). To determine the frequency, explicit ideas were considered through content analysis (Namey, Guest, Thairu & Johnson, 2008). Finally, the codes were grouped according to the data-driven approach (Namey *et al.*, 2008), that is, around the relationship observed between them, evidenced in the answers of the interviewees. Each code used appears in Table 2 and considers five categories: environmental benefit, social benefit, social equality, difficulties, and aspects to be improved. It is important to underline that the five categories observed in Table 2 emerged from the analysis of the interviewees' responses. Similarly, it should be noted that, although one of the

		Criterion	Definition	Response example
EVALUATION METRICS	ENVIRONMENTAL BENEFITS	Water quality	Quality of rainwater drained into water bodies.	"...water purification to avoid the contamination of water bodies due to the entry of pollution..."
		Amount of water	Rainwater that generates storm runoff.	"...contributing to holding back the accumulated water and not generating a greater peak ..."
		Heat island effect	Temperature increase suffered by urban centers.	"...reducing the heat island effect, as it improves the ventilation of the city..."
		Aquifer recharge	Infiltrate water into the groundwater.	"...the infiltration of rainwater generates a benefit in the water resource; in a dry period, the value of stored water is quite important..."
		Reuse of water resources	Avoid using other water sources by using rainwater.	"...increasing the water retention of the soil, as it can be used to reduce the use of other water sources for irrigation..."
	SOCIAL BENEFITS	Amenity, aesthetics, and community benefits	Better integration of infrastructure in communities.	"...quality of life, aesthetic elements, recreational, and even spiritual ones, which mean living more harmoniously with the water in the city..."
		Public information, education, and awareness-raising	Educating the community about the role of urban drainage	"...now, it is seen that society is demanding this since they are more aware..."
	SOCIAL EQUALITY	Access to green areas	Standardizing access to green areas.	"...there is a large shortfall of green areas, not distributed homogeneously both at the country and the regional level and between regions..."
		Access to water	Standardizing the access to water.	"...if there is no water, there will be no food, it's that simple. There can be places that do not have access or that have a deficit regarding some of these issues..."
BARRIERS OR DIFFICULTIES FOR IMPLEMENTATION	Availability of resources	Availability of information	Databases for decision making.	"...availability and richness of data that is available to guide methodologies in that direction (sustainability).."
		Availability of resources	Resources to manage the infrastructure.	"...it is difficult due to the availability of information, calibration, and measurements. It is complicated to have the resources to obtain those data..."
		Fragmentation of responsibilities	Unclear division of responsibilities between agencies; these do not follow the same goal.	"...a recognition of the entire water cycle is required, that the drop that falls over there gets here..."
		Evaluation methodologies	Limited range of benefits assessed.	"...methodology for integrated projects and that capture other benefits that are just from rainwater and the flood damage avoided..."
		The rainwater paradigm	Way of conceiving solutions to rainwater drainage.	"...to change the paradigm of water that falls on the city, not to remove it quickly, but to integrate it into the urban water cycle..."
		Professional preparation	Insufficient training for professionals	"...there is a lack of interest or knowledge, there is always a bit of inertia, the same thing is done because everyone does the same thing..."

	Criterion	Definition	Response example
MODIFICATIONS OR ASPECTS TO BE IMPROVED	Global water entity	An integrated organization that plans infrastructure for rainwater.	"...rainwater does not have a primary or secondary network. It would be ideal to have an entity dedicated to comprehensive planning..."
	Secondary standards	Standards whose objective is to maintain and protect water quality.	"...the more secondary standards there are, the more we are going to worry not just about industries, but also about cities..."
	Planning on a household scale	Design of houses with sustainable drainage.	"...that runoff could be avoided if every time we urbanize, we take care to locally control the runoff that occurs..."
	Comprehensive valuation of benefits	Expand the range of benefits evaluated.	"...for the principles (of sustainability) applied to be transferred, it is important to have methodologies that consider them..."

Table 2. Code Dictionary. Source: Preparation by the authors.

categories included in Table 2 (i.e., environmental benefits) does not belong to the concept of social sustainability, it was incorporated anyway because it was integrated into the first question asked to the interviewees (see the previous section). It should be emphasized that even though this category is presented here (Table 2), as it emerged from the interviews, the focus of this study was always on social sustainability.

LIMITATIONS

Within the limitations of this study, it is contemplated, first of all, that the results may present a bias due to the number and origin of the interviewees, as well as because of the analysis method, which varies from one researcher to another (Hernández, Fernández & Batipsta, 2014). This analysis focuses on the opinion of experts in urban drainage systems and does not include other stakeholders who are also involved in the development of these systems. However, the wealth of information obtained through interviews provides results that help reflect and guide future research motivated by the answers of experts in the area. In addition, experience gives rise to the comparison of these opinions with those of other stakeholders related to urban drainage systems that future studies could carry out. Another limitation of this research lies in the size of the sample, which consists of a total of 11 respondents, which could be considered small. However, studies that have analyzed the opinion of experts to develop infrastructure systems have used comparable samples (e.g., n=7 [El Hattab, Theodoropoulos, Rong & Mijic, 2020]; n=6 [Hacker, Kaminsky, Faust, & Rauch, 2020]; n=12 [Uribe, Faust, & Charnitski, 2019]; n=15 [Araya & Vasquez, 2022]).

RESULTS AND DISCUSSION

This section discusses the results that provide answers to the three questions posed in the methodology: (1) What metrics could be used to evaluate the social sustainability of urban drainage systems?, (2) What barriers does the implementation of the identified metrics face? and (3) What modifications are proposed to the existing system?

The summary of the qualitative analysis results regarding the metrics that could be used to measure social sustainability in urban drainage systems is shown in Table 3. It presents the five categories that emerged in the information qualitative analysis process, with their respective subcategories.

The times each subcategory is mentioned in the interview answers (i.e., frequency) is indicated, as well as the number of interviewees that refer to this subcategory in their answers, which is shown in parentheses. These results reflect how aware the interviewees are of the possible metrics to evaluate social sustainability in urban drainage systems. For clarity purposes, the frequency of each subcategory is also shown in a percentage, which is expressed for each category, and the total of each category is expressed regarding the grand total. Again, the values in parentheses refer to the total number of interviewees; thus, 100% indicates that all interviewees mentioned the subcategory.

Category	Subcategory	Frequency of responses (Interviewees)		Percentage value	
ENVIRONMENTAL BENEFIT	Water quality	7	(4)	23%	(36%)
	Amount of water	5	(5)	17%	(45%)
	Heat island effect	3	(3)	10%	(27%)
	Aquifer recharge	10	(8)	33%	(73%)
	Reuse of water resources	5	(4)	17%	(36%)
	Total	30	(11)	22%	(100%)
SOCIAL BENEFIT	Amenity, aesthetics, and community benefits	12	(7)	67%	(64%)
	Public information, education, and awareness-raising	6	(4)	33%	(36%)
	Total	18	(7)	13%	(64%)
SOCIAL EQUITY	Access to green areas	5	(4)	71%	(36%)
	Access to water	2	(2)	29%	(18%)
	Total	7	(5)	5%	(45%)
OBSTACLES	Availability of information	9	(6)	17%	(55%)
	Availability of resources	8	(6)	15%	(55%)
	Fragmentation of responsibilities	13	(5)	24%	(45%)
	Evaluation methodologies	14	(6)	26%	(55%)
	The rainwater paradigm	6	(3)	11%	(27%)
	Professional preparation	4	(3)	7%	(27%)
	Total	54	(11)	40%	(100%)
MODIFICATIONS	Global water entity	6	(4)	24%	(27%)
	Secondary standards	3	(1)	12%	(9%)
	Planning on a household scale	8	(5)	32%	(45%)
	Comprehensive valuation of benefits	8	(6)	32%	(55%)
	Total	25	(8)	19%	(73%)

Table 3. Frequency of responses on emerging categories. Source: Preparation by the authors.

BENEFICIOS SOCIALES EVALUADOS EN METODOLOGÍA MIDESO

- Menor daño en propiedades residenciales
- Recuperación en terrenos baldíos anegadizos
- Menor daño en propiedades comerciales e industriales
- Menor daño en establecimientos públicos
- Menor daño en vehículos
- Menor deterioro de la infraestructura vial
- Disminución de los costos generalizados de viaje
- Menores gastos de emergencia y limpieza de vías y sumideros
- Menor ausentismo laboral
- Menor ausentismo escolar
- Liberación de recursos públicos de salud
- Liberación de recursos públicos en ONEMI
- Beneficios no valorados

BENEFICIOS SOCIALES IDENTIFICADOS

- Calidad de agua
- Cantidad de agua
- Efecto isla de calor
- Recarga acuifero
- Reutilización recurso hídrico
- Amenidad, estética, y beneficios comunitarios
- Información publica, educación y sensibilización
- Acceso a áreas verdes
- Acceso al agua

Figure 3. Comparison between the social benefits currently considered and those obtained from the interviews conducted. Source: Preparation by the authors.

EVALUATION METRICS

On asking the interviewees about the benefits of sustainable drainage, 100% mentioned the environmental aspect, while 64% referred to the social aspect. This indicates that, within the expert group, there is less awareness of social benefits compared to environmental ones (Table 3). Similar results were obtained in Ferrans *et al*. (2022), where this lower awareness of social benefits is explained by the lack of research aimed at analyzing the social benefits of urban sustainable drainage systems.

On the other hand, the main environmental benefit mentioned by 73% of the interviewees is the contribution of aquifer recharge, which is understood as a benefit in possible water shortage scenarios. As for the social benefit, 64% highlight the aesthetic contribution of green areas in urban areas, defined as: "aesthetic and recreational elements, even spiritual ones, which mean coexisting more harmoniously with water within the city". These benefits are in line with two points of the SUDS design philosophy set out in its manual (Woods-Ballard *et al*., 2007), which are: protecting the water cycle and creating better spaces for people.

Regarding social sustainability, experts underline the role of social equality in terms of access to green areas and water. For example, one of the interviewees pointed out that: "There is a very large deficit of green areas in general in Chile, and these are also not homogeneously distributed throughout the country, both regionally and between regions." When analyzing figures of green areas per inhabitant indicators (i.e., m^2/inhab.) published in the cadaster of green areas of the INE (2018), the following values are noted: Arica (3.75), La Serena (11.01), Valparaíso (1.25), Talca (7.15), Valdivia (11.18). Within the Metropolitan Region, there are great differences between communes, for example, San Miguel (1.97) and Vitacura (18.67). The standard set by the National Urban Development Council is 10 (m^2/inhab.) and, according to their figures, only 15% of the communes meet this standard and 51% of the communes are below 5 m^2/inhab. (INE, 2018). It should not be forgotten that both equality in access to green areas, and the state of these, are fundamental for the community to make use of them and be benefited from them, to promote mental health and community life (Anthun *et al*., 2019).

The amenity, aesthetics, and community benefits suggest that drainage solutions not only have a socio-cultural component, but that also offer advantages often overlooked by institutions that are not associated with their hydraulic function, such as increasing the status and added value of neighborhoods. This is an aspect also evidenced by Ashley *et al*. (2018) in the United Kingdom, where people surveyed mentioned being willing to pay more for a home close to a green area generated for sustainable drainage.

Finally, given that the Chilean context is being analyzed, in Figure 3 it is possible to appreciate, on the left, the benefits that until today are contemplated in the social evaluation of rainwater drainage projects and, on the right, those identified through interviews. The comparison shows a gap between the current benefits and those discussed by experts. It can be seen that the list of existing benefits in the MIDESO methodology focuses on elements that are currently quantifiable, while the benefits obtained in this study may be difficult to quantify like, for example, amenity. However, it is considered relevant to highlight that the benefits identified in this work are not seen as benefits that should replace those in the current methodology, but as benefits that should be added to the existing ones. In this way, the importance of social sustainability in the development of sustainable urban drainage systems could be strengthened.

OBSTACLES

Regarding the difficulties detected by experts to apply social sustainability metrics, 45% of the interviewees highlighted the fragmentation of responsibilities between institutions, as indicated by one of them: "MOP (DOH) only has competence in the primary network, so it does not have the faculty to act at the local level. It would be ideal to start storing rainwater in houses, or on sidewalks before they reach the streets". This obstacle had already been identified in previous studies carried out in Chile (Patagua, Fundación Legado Chile and Pontificia Universidad Católica de Chile, 2021).

At a national level, an equivalent situation occurs, since there are basins located in more than one region, which implies that a coordination process is required between the DOHs of the regions involved, and also between the SERVIUs, which arises only from the goodwill of those in charge, but is usually lost when the department heads change, since "there is no organic system to do this coordination". Finally, the divided responsibilities hinder the delivery of solutions or the proposal of public spaces for comprehensive use or purpose, with the understanding that a public project can respond to multiple needs and not only to the role the agency that presents it has, as expressed by one interviewee: "there is a body concerned with a specific issue, this makes the work of the public sector difficult in general, the integrated view does not exist, it is spread in destination organisms." Something similar happens in Europe, where the different levels of action have been investigated, be it national, regional or local, and where policies and measures can be applied with the purpose of guaranteeing the path towards sustainable drainage (Gimenez, Breuste & Hof, 2020), which would be more efficient if implemented by a single body.

In the same vein, 55% mention specific evaluation methodologies, demonstrating that these hinder the realization of multisectoral projects. The methodology understands that an urban drainage project can only solve flooding problems, which are widely addressed by traditional systems, but leaves aside the benefit that a nature-based solution could provide in the social and environmental field. In this regard, one interviewee commented that "there is a lack of assessment methodologies that consider these aspects and that may not have been internalized. It is really important to approve projects and those numbers have to consider dimensions other than the economic one, like that associated with the environmental". The lack of methodologies is not a particular trait of the Chilean reality, but rather is found in several international diagnoses (e.g., Ashley *et al.*, 2018; Jimenez et al., 2019).

On the other hand, the current methodology does not consider the multiple needs that a project could cover, classifying it only in one function. Thus, for example, in the creation of a floodable park (i.e., Victor Jara Floodable Park in Santiago de Chile), the hydraulic dimension involved had to be evaluated using a rainwater and landscape methodology, through the cost-efficiency approach, as there is no methodology for this type of works, namely, the project was divided into two and was not evaluated comprehensively. Finally, the evaluation process is difficult because social sustainability metrics are difficult to monetize: "it is difficult to evaluate benefits, it is a global challenge. In the parks' aspect, it is possible to recognize those benefits, but it is very difficult to quantify them, putting them into numbers".

MODIFICATIONS

As a way to link and contextualize the results of this section, the modifications proposed by the interviewees are paired with the obstacles that these could impact (see Figure 3).

Household-scale planning and comprehensive benefit evaluation were the modifications most frequently referred to by the interviewees (Table 3). Household-scale planning proposes to develop techniques together with the communities, to avoid excessive runoff into primary networks. These initiatives have been applied in other countries: for example, in one Argentine locality, a specific flood problem was solved through sustainable drainage at the neighborhood scale (Villalba, Curto, Malegni & Linfante, 2019). This aims at projecting works with a lower cost and impact on the environment, with a consequent paradigm shift for professionals, who could consider the development of local rainwater management projects instead of carrying out works to deal with large design storms.

This work tries to promote an integrated valuation of benefits, which, among other aspects, proposes the creation of comprehensive assessment methods, which not only quantify the damages avoided by flooding but also the countless social benefits of SUDS, which might influence the projects that are to receive greater funding due to a greater quantification of their benefits.

The eventual creation of a global entity to manage sustainable urban drainage systems would mainly help to reduce the fragmentation of responsibilities in the management of rainwater systems. With this, monitoring conditions could be improved, more information would be available for decision-making, there would be a more efficient use of resources and, therefore, the availability of funds for other projects would increase.

CONCLUSION

In the study presented here, interviews were conducted with experts linked to the development of sustainable urban drainage systems in Chile. From their responses, we obtained (1) a group of metrics to measure the social sustainability of urban drainage systems; (2) information on the obstacles to the implementation of these metrics; and (3) suggestions for modifications to the current system for the sustainability assessment of urban drainage systems.

The main benefits identified by the experts were the contribution to aquifer recharge through the infiltration of rainwater, and the beautification of spaces with green areas. These benefits also have a direct impact on social equality, one of the aspects of social sustainability, since they directly relate to universal access to water and green areas. Regarding the obstacles to new metrics for evaluating the social sustainability of urban drainage systems, the fragmentation of the responsibilities of the institutions associated with the management of urban drainage systems stands out, along with the limited capacity of the current methodology to assess comprehensive urban drainage alternatives. In terms of the experts' suggestions to modify the current context, it is suggested to consider a comprehensive valorization of the benefits of urban drainage systems, an entity that addresses water resource management in a global and integrated way, as well as expanding the planning of water reuse at a household scale.

Finally, to strengthen the evaluation methodologies, it is recommended that subsequent studies look closer at the comprehensive valorization of social and environmental benefits, and focus on nurturing such methods with more complete and extensive databases.

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