



“It won’t work here”: Lessons for just nature-based stream restoration in the context of urban informality

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ABSTRACT

Nature-Based Solutions (NBS) have been advocated for their potential to contribute to the making of sustainable and just cities. However, a growing body of research shows that NBS cannot inherently provide just outcomes and might instead (re)produce environmental injustices. This research explores NBS for stream/river restoration in ‘informal’ areas, showing how riparian margins have become spaces of conflict. It draws lessons from two linear parks integrated into neighbourhood regeneration strategies in São Paulo. Data were collected from household surveys and focus group discussions to examine local populations’ values towards stream restoration. They provide understandings of residents’ perceptions towards multiple health and safety risks and concerns over contested responsibilities, notably revealing that local preferences for stream burial have been shaped by persisting waste dumping issues. An environmental justice lens helps highlight the limited integration of plural social and cultural values into project plans. This further helps draw lessons on ways to address local conflicts and integrate multiple socio-environmental values into NBS planning, with support from policy tools that allow stronger community engagement. Findings also support the identification of justice pathways for NBS in informal settings. The analysis of material and interpretative human-environment relationships provides evidence of opportunities for NBS to be integrated into everyday uses of local space and pre-existing environmental caring practices. For this, communities need to have stronger influence over decisions affecting them. The research thereby demonstrates that NBS will only become a mechanism for ecological recovery with city-wide benefits if marginalised groups are better included in their planning.

1. Introduction

1.1. Nature-based solutions, infrastructural approaches, and justice

The growing use of the term “Nature-Based Solutions” (NBS) in recent years coincides with the growing vision that ecosystems provide multiple biophysical, socio-cultural and economic benefits. NBS have been defined as actions inspired and supported by nature (European Commission, 2015), as opposed to actions controlling its forces (Welden et al., 2021). By maintaining, enhancing, and/or restoring biodiversity, NBS are seen as solutions to societal challenges including climate

change. Cohen-Shacham et al. (2019) frame NBS as a transversal concept consolidating five ecosystem-based approaches: restoration, issue-specific, protection, management, and infrastructure. Their infrastructure approach in particular, integrates the practice of green infrastructure which it refers to as planned networks of multifunctional green-blue spaces that directly use or mimic ecological processes and provide multiple social, economic and environmental benefits (Mell, 2008; Silva and Wheeler, 2017).

A way NBS have been advocated for is through their potential to strengthen human-nature relationships in cities and foster environmental stewardship (Santiago Fink, 2016; Welden et al., 2021). Yet,

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knowledge gaps have been identified in this area, notably on risks associated to the way complex socio-ecological relationships (or ‘socio-natures’) are (mis)recognised in practice (Kabisch et al., 2016; Cousins, 2021; Tozer et al., 2020). We argue that these relationships are in fact often assumed and/or homogenized. In relation to this, Berbé-Blázquez et al. (2016) demonstrate the need for attention to power relations that influence the production of ecosystem services, and therefore the distribution of their benefits and burdens across social groups. Treating NBS and the infrastructure approaches that fall under its premise as unproblematic sustainability fixes can present the risk of reproducing hegemonic patterns that lead to unjust and unsustainable outcomes for already excluded groups (Finewood et al., 2019; Kotsila et al., 2020; Diep et al., 2022).

As such, we align with scholars arguing that NBS do not intrinsically result in just outcomes since urban greening can introduce new forms of exclusion (Wolch et al., 2014). To explore this, NBS literature has increasingly engaged with environmental and social justice theories (e.g., Shi, 2020; Sekulova et al., 2021; Calderón-Argelich et al., 2021; Cousins, 2021). This literature also shows the needs to expand understandings of NBS in contexts of cities of the Global South, particularly to better consider and integrate communities’ needs and aspirations into NBS planning (Souza and Torres, 2021). To help fill this gap, this paper examines context-specific relationships between society and ecology, more particularly exploring the plurality of values associated to linear parks for river restoration in informal settlements in the city of São Paulo; and this, to draw lessons that can inform the practice of NBS.

1.2. Urban river restoration and implications in ‘informal’ settlements

The location of informal houses on land adjacent to rivers (or floodplains) is common in São Paulo. That is especially due to unfavourable terrain conditions and flood risks to which high and middle-class populations do not want to be exposed (Gonçalves and Nagano, 2018; Silva-Sánchez and Jacobi, 2012). In the meantime, rivers’ poor ecological conditions within these same urban areas mirror gaps in basic service provision and illustrate patterns of socio-environmental exclusion. Since water is in constant movement, local urban river management problems can quickly become issues affecting an entire city and beyond. This concerns both sanitation (e.g., where rivers transport solid and liquid waste across the city), and flood management (e.g., where flood management of tributary streams contribute to peak flows downstream). In principle, NBS should be attractive solutions for their potential to address such issues at low financial costs, while providing social benefits through increased access to green and blue spaces (Ourloglou et al., 2020; Tavakol-Davani et al., 2016). However, NBS for river or stream restoration in informal settlements is complex, precisely because of the barriers added by ‘informality’ and what it implies, for example due to land conflicts and tenure management systems limiting institutional space for infrastructure development (Roy, 2009).

To date, NBS research has widely engaged with urban river or stream conservation, restoration or ‘stream daylighting’, i.e., resurfacing a previously ‘buried’ stream (e.g., Khirfan et al., 2020; McEwen et al., 2020; Somarakis et al., 2019; Xie and Bulkeley, 2020). Yet, few cases explore NBS river/stream interventions in contexts of urban informality. This is also the case for linear parks which aim at ‘greening’ river margins while integrating them in their social environment (Blau et al., 2018; Frantzskaki, 2019). Long-term integration of such type of interventions require the understanding of people’s connections and relationships with rivers but also their senses of self and community (McEwen et al., 2020; Moran, 2010). This also involves understanding multiple ontologies of ecosystem services and associated values, for example to distinguish those that are ‘scientifically-identified’ from those that are ‘directly experienced’, and further question who benefits from them and how (Adegun, 2018; Ernstson, 2013; Juntti et al., 2021; Miller and Montalto, 2019; Tozer et al., 2020; Wild et al., 2017). Pluralistic approaches are particularly important to analyse the scope of

NBS in producing just outcomes. The use of environmental justice as a framework that has been evolving at the crossroads of different disciplines can help expose potential contradictions in the conceptualisation, planning, and implementation of NBS, and also help identify mechanisms through which NBS is instrumental to neighbourhood regeneration where it contributes to creating pathways towards the just governance of cities.

2. Methodology

2.1. Research objectives

The research unpacks complex implications behind planned NBS interventions for stream restoration in the context of urban informality. It examines populations’ diversity of opinions and especially those of groups that are historically marginalised. It seeks to draw lessons from engagement processes with local populations on river restoration interventions and wider development needs and aspirations. It further asks: ‘how can policymakers and planners address justice trade-offs when implementing nature-based solutions in informal settlements?’. Responding to these questions aims at providing insight into experiences of and perceptions towards stream restoration which are explored in parallel to everyday needs and aspirations towards neighbourhood regeneration. This enables to establish contrasts with the way projects are planned and implemented, reflecting on the ways through which diverse demands may have or not been considered by decision-makers.

Evidence from the context of two integrated linear park projects supports theoretical explorations of what we frame as ‘nature-based urban stream restoration’. This exposes the complexity of local urban dynamics, for example between social and ecological systems such as river-community relationships, but also among different groups of the same ‘community’. By doing this, we align with the argument that an epistemological rupture with predominantly expert-led ecosystem services approaches is needed (see for example Juntti et al., 2021). This leads the research to draw lessons for NBS that are not only sought for city-wide river management benefits but can also generate socio-environmentally just outcomes at local level.

Schlosberg (2007) framework of environmental justice through distribution, recognition and participation here supports the analysis of justice trade-offs and opportunities that have emerged from the two stream restoration projects. The distributive justice perspective helps analyse the (mal)distribution of environmental risks and burdens for local populations which result from project interventions. Justice as recognition supports the deconstruction of narratives around local problems, including the way they are framed by different actors, and who is responsible for their occurrence. Participatory justice analyses power relations and helps question the limits of local populations’ influence on decisions and reflect on participatory mechanisms in place. Capabilities – sometimes considered the fourth dimension of Schlosberg’s environmental justice framework (Svarstad and Benjaminsen, 2020) – is approached here as an integrated component that encompasses the three other dimensions but is not operationalized.

The study also seeks to contribute to the scholarship that has applied environmental theories to Brazil, ranging from the context of agricultural modernization and grassroots struggles, up to urban green infrastructure, ecosystem services, and NBS more recently (e.g., Wolford, 2008; Acsegrad, 2009; Porto, 2012; Pinho, 2016; Torres et al., 2020; Juntti et al., 2021). In this study, we focus on the environmental justice analysis of specific processes and outcomes from river restoration projects in the context of *favelas*. We pay particular attention to residents’ experiences and perceptions towards NBS functions (i.e., practical tasks fulfilled by ecosystems services), and most importantly what they mean in relation to the values they hold (i.e., worth of such tasks).

2.2. Linear parks in São Paulo: the cases of Sapé and Água Podre

Contrasting with decades of grey infrastructure in water management symbolised by canalized rivers and large-scale detention ponds (*piscinões*), Brazilian governmental institutions started engaging with river and stream renaturalisation principles in the 2000s (Moroz-Caccia Gouveia, 2016). Linear parks and greenways were part of the city's master plans in 2002 and 2004, with primary objectives to manage floods, restore streams and improve urban mobility (Gonçalves and Nagano, 2018; Travassos, 2010). The municipality of São Paulo currently uses the following definition of linear parks:

“A linear park is a continuous system of green areas along valley floors, which have for objectives to preserve and restore the natural environment and natural water drainage and retention [functions], in addition to configuring public space for leisure and mobility. Linear parks are located along watercourses and road systems—they are therefore linear elements of the urban landscape. Their benefits can be classified into four categories: hydrological, environmental, landscape and social” (Municipality of São Paulo, 2021)

It is worth noting that in the first municipal programme in which linear parks appeared, they were defined as “urban interventions that aim to re-establish citizens' awareness of the natural environment in which they live by progressively expanding green areas” (Municipality of São Paulo, 2002, p. Article 106). In the particular context of low-income areas, linear parks appear to have therefore presented opportunities beyond those of water management, to transform human-nature relationships but also to increase municipal control over land (Parra, 2017; Soares, 2014). Linear park river management strategies were later integrated together with the concept of green infrastructure and NBS which have gained increased attention over the past few years (SABESP, 2020; Municipality of São Paulo, 2020, 2021).

Over 11% of São Paulo's population lives in informal settlements referred to as *favelas* (IBGE, 2018), where river or stream management can be particularly complex due to interrelated service provision needs such as sanitation. The Água Podre and Sapé neighbourhoods¹ in which are located *favelas* have precisely been facing these issues. The linear park projects that were first developed for river restoration purposes in these two areas later evolved as wider neighbourhood regeneration projects, i.e., with slum/favela upgrading components (Fig. 1). Both projects have eventually been designed with comparable objectives. They have included the infrastructural reinforcement of stream banks, in-situ relocation of population living on stream margins, connection of ‘informal’ sanitation systems to the municipal network, and creation of walking and/or cycling pathways. As such, the linear park projects have had multiple purposes: achieve stream restoration, provide services to informal areas, regenerate the wider neighbourhoods in which they are located, but also improve integration of these urban areas into the wider city fabric.

Located within the Jaguaré basin in the West Zone of the city, Água Podre and Sapé are both socio-economically diverse urban areas. Both projects are relevant for this study due to their implementation within Special Zones of Social Interest (ZEIS) where *favelas* are located. As shown on Fig. 1, both neighbourhoods are closely located along two tributaries of the same river basin. Yet, the two areas largely differ in terms of socio-spatial characteristics. Sapé is a more densely populated neighbourhood than Água Podre. In 2019, an estimated 2600 families were living in Sapé along the stream, compared to approximately 1400

families in Água Podre. This difference is partly explained by Sapé's informal settlement being more densely populated and spatially dominating the neighbourhood's landscape, whereas Água Podre is characterised by a juxtaposition of different urban typologies. These include several small informal settlements or “*favelinhas*” of just a few households across the neighbourhood which also comprises of middle-class households.

In Água Podre (whose name translates as ‘rotten water’ in English), the project was launched in 2006 and the depollution of the stream officially started in 2011. At the time of writing of this study, the project is still far from completion. At least 45 families have been displaced but the 222 planned housing units are yet to be constructed. New informal houses were built along the stream. Uncertainty remains on whether the construction of the linear park will ever be completed but a group of residents continues to apply pressure on governmental authorities to demand its full implementation.

At the time fieldwork was conducted in 2019, a large part of the Sapé project had been completed, including the stream canalisation, and the construction of sewers connections. Yet, the incompleteness of ecological objectives regarding the renaturalisation of the riparian areas means the project has not met municipal linear park design standards for the permanent preservation of protected areas Pizarro and Lino (2012), (personal communication, April 22, 2020). This led to the ‘downgrading’ of the project to the appellation of ‘green corridor’. Yet, the appellation ‘linear park’ is commonly used by local governmental authorities as well as Sapé inhabitants to refer to the project. In addition, one of the four planned condominiums was not constructed, leaving several hundred displaced families waiting for in-situ relocation.

2.3. Exploring nature-based stream restoration through a mixed-method approach

This research follows a mixed methods approach which combines quantitative and qualitative data collection and analysis. This approach allows the exploration of the complexities of case studies, for example to analyse the overlay of multiple social and ecological systems that constitute them. It uses several types of data collected from complementary sources through the application of multiple methods (Denscombe, 2008). Household surveys and Focus Group Discussions (FGDs) were conducted in Sapé and Água Podre neighbourhoods over a period of four months in 2019. The tools for household surveys and FGDs were co-developed and applied by a team of researchers from different disciplines encompassing geography, engineering, architecture, and anthropology. All methods were conducted in Portuguese.

Surveys were designed around five key themes: flood risks and resettlements, current river and sanitation conditions, experience and aspirations towards stream restoration, use of local green areas, and participation in decision-making for local urban development. The selection of households followed a multistage cluster sampling. For each neighbourhood, only clusters of households located along the stream were selected. Due to lack of updated and/or detailed public data (the last census was conducted in 2010), the number of inhabitants living in each cluster had to be estimated. For this, calculations considered different housing typologies: apartments in condominiums, shacks, and semi-detached houses. Each cluster of households was divided into segments following Alves et al.'s (2011) sampling method. Divisions into segments of each neighbourhood are represented in Fig. 2. Segments were then selected using a randomisation approach in Excel. Surveys were conducted in one household per segment. In total, 128 household surveys were conducted (N = 69 in Água Podre and N = 59 in Sapé). Data were quantitatively analysed using SPSS Statistics and qualitatively analysed using the data analysis software Nvivo.

The socio-demographic data of the household sample are summarised in Table 1. The median age of respondents was 52.5 (56.0 in Água Podre and 50.0 in Sapé). While the total number of female respondents (59%) exceeded that of male respondents (41%), the sample profile

¹ We recognise the plural meanings of the word ‘neighbourhoods’ which needs disambiguation considering the complex territorial and administrative organisation of São Paulo. ‘Neighbourhood’ is here used as a translation of the Portuguese word ‘*bairro*’. Since the territorial limits of the Sapé and Água Podre *bairros* are contested in practice, we chose to use the sub-basin as territorial divisions. In both cases they are composed of both formal and informal areas.

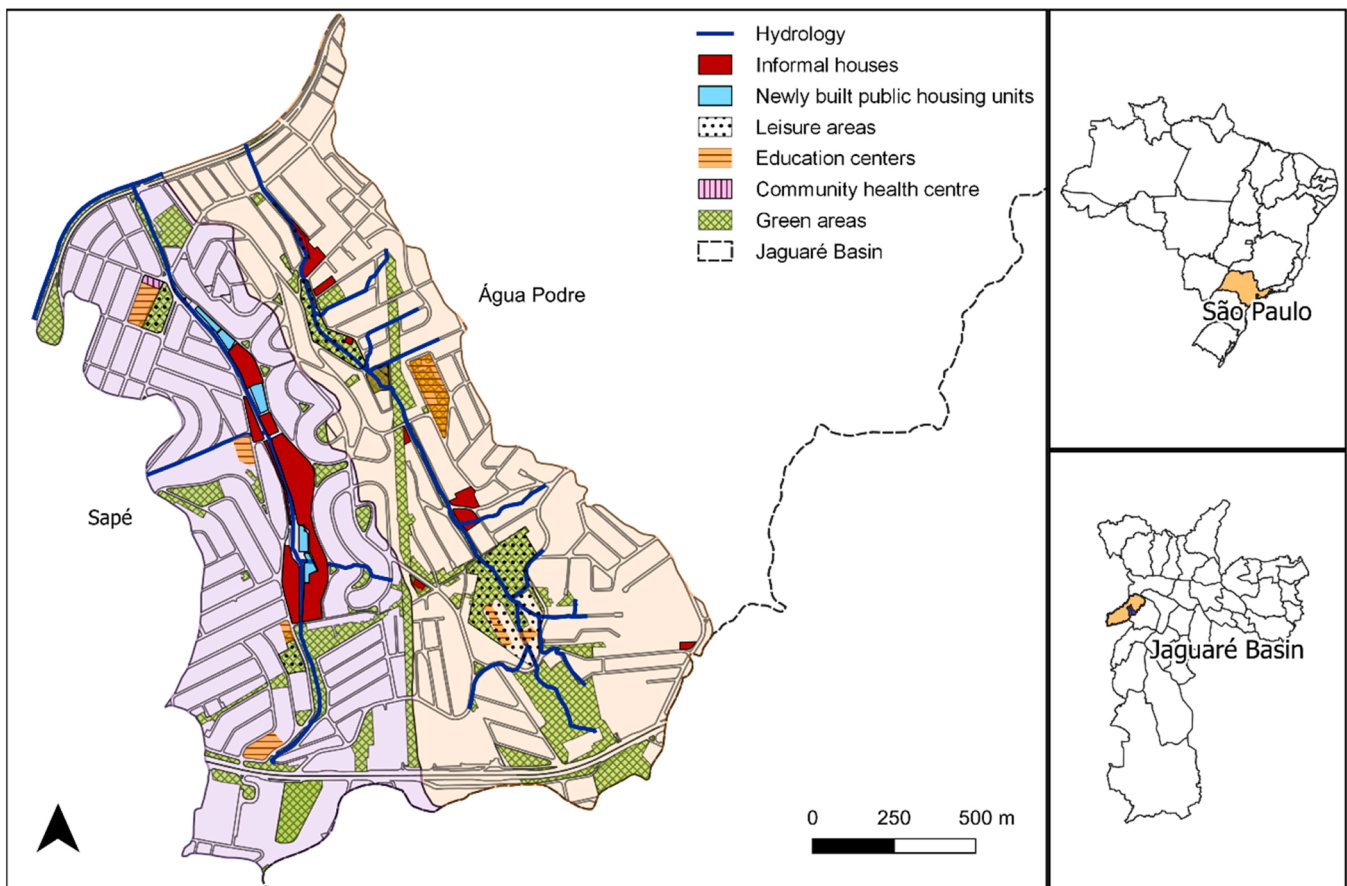


Fig. 1. Left: Sapé and Água Podre within the Jaguaré basin with administrative boundaries in purple and orange respectively; Bottom right: Jaguaré basin in the city of São Paulo; Top right: the city in the state of São Paulo. (For interpretation of the references to colour in this figure, the reader is referred to the web version of this article).

aligns with that of other surveys conducted in São Paulo with a low margin error (see for example [RNSP and IBOPE, 2020](#)). Income estimates of respondents were derived from household expenses (rent and household bills, food, transport, phone and internet, health expenses, and school fees). According to these estimates, 84.5% of the Sapé population and 76.1% of the Água Podre population would dispose of less than the equivalent of one minimum wage per month² ([Federal Government of Brazil, 2019](#)).

Focus Group Discussions allowed the validation of household survey results and the further exploration of specific themes. Two FGDs were conducted in each of the case study areas. Between 9 and 11 people participated in each FGD. The first part of discussions covered the following thematic areas: river restoration, waste disposal issues, inter-community relationships, and community participation in planning. During the second part, participants were presented a series of images showing stream restoration models. Different scenarios were articulated to discuss different design elements including open or buried stream, conserved riparian areas, infrastructure and space for mobility and leisure, and safety railings along the streams. This helped identify and explore factors considered important for participants. Participants were asked to vote for their preferred model at the end. Each FGD lasted between two and a half and three hours, led by at least one facilitator and two note takers. Notes were thereafter quantitatively analyzed in Nvivo.

² In 2019, Brazil's minimum wage per capita per month was of R\$998, equivalent to about US\$248 (exchange rate of 4.0242 as per <https://www.xe.com/currencycharts/?From=USD&To=BRL>).

3. Results: local experiences and perceptions towards nature-based stream restoration

3.1. Local benefits and burdens from the linear park projects

Respondents to surveys and focus group discussions reported that while multiple benefits were provided to local residents as a result of the linear park projects,³ not all were sustained over time, and several other expected project components were not provided at all. Many of the benefits reported as having been provided could be associated to regulating services such as flood regulation and erosion control, and cultural ecosystem services such as the development of recreational areas. This was particularly the case in Sapé where project implementation went to further stages than in Água Podre. Flood issues that used to occur in Sapé appeared to have been addressed, as respondents described that river floods have not occurred since the stream was canalized. This is considered to be a particularly important point considering the casualties caused by past flood events. Interviewees from Água Podre did not report major flood issues to address.

The stream depollution interventions conducted as part of the projects appeared to have significantly improved river ecosystems' health. However, respondents largely reported that gains were only maintained over the short-term. Reports on stream conditions showed how water

³ Note that the terms 'nature-based solutions' and 'green infrastructure' were generally avoided during interactions with residents to minimise communication barriers. However, the term 'linear park' was used since it has become part of people's everyday language as a result of the projects developed in their area.

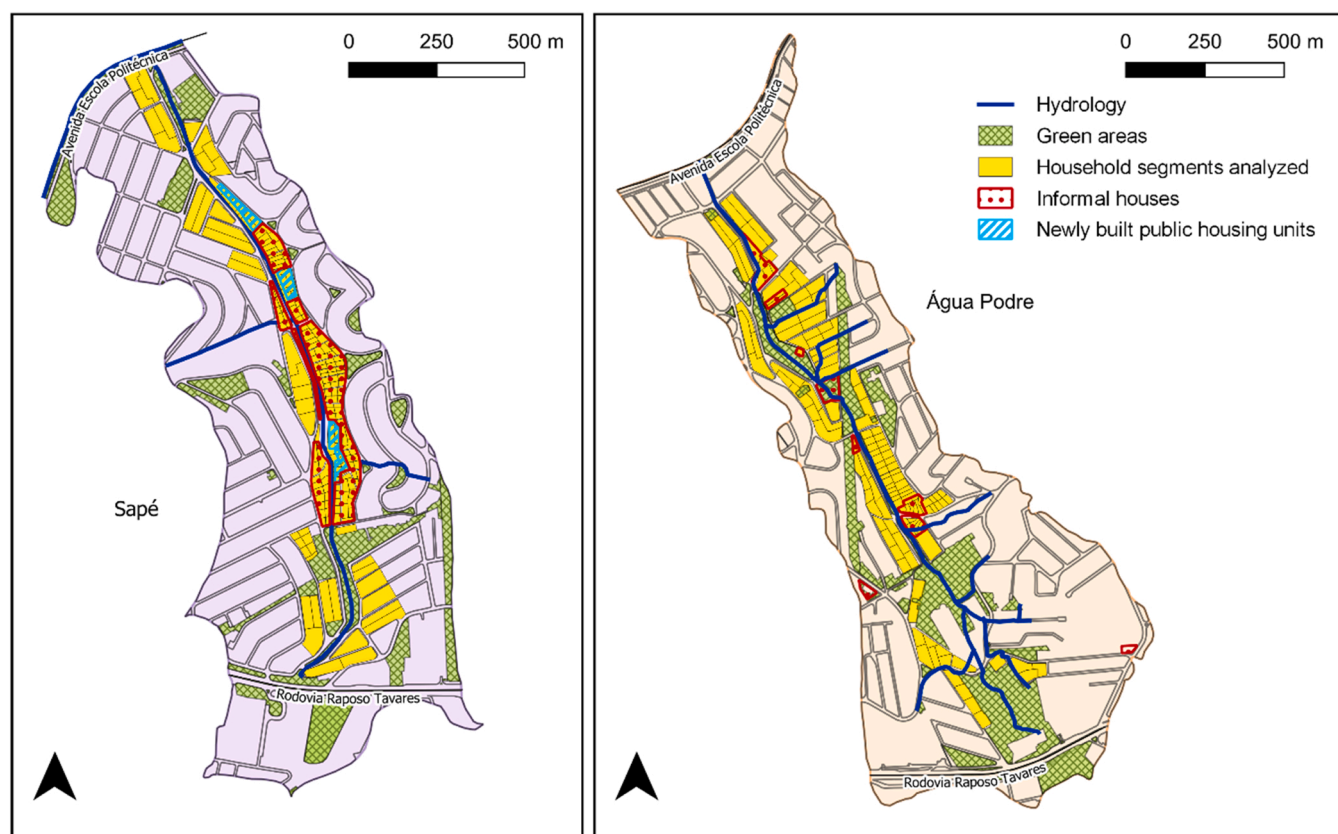


Fig. 2. Divisions of Sapé and Água Podre neighbourhoods into segments for the design of household survey samples.

Table 1

Summary of the socio-demographic data of the sample (*MS = Minimum Salary, i.e., R\$ 998 per month per capita in 2019).

Variable	Class	Sapé		Água Podre	
		% within neighb.	Total (N)	% within neighb.	Total (N)
Age range	18–29	20.30%	12	15.90%	11
	30–39	13.60%	8	13.00%	9
	40–49	15.30%	9	7.20%	5
	50–59	25.40%	15	23.20%	16
	60–69	15.30%	9	21.70%	15
	> 70	10.20%	6	15.90%	11
	No info.	0.00%	0	2.90%	2
Gender	Female	64.40%	38	53.60%	37
	Male	35.60%	21	46.40%	32
Ethnic group	White	28.80%	17	40.60%	28
	Black	15.30%	9	21.70%	15
	Mixed	55.90%	33	31.90%	22
	Asian	0.00%	0	0.00%	0
	No info.	0.00%	0	5.80%	4
Income/m/c	< 0.5 MS*	54.20%	32	34.80%	24
	0.5–1 MS*	27.10%	16	39.10%	27
	1–2 MS*	11.90%	7	20.30%	14
	2–5 MS*	3.40%	2	2.90%	2
	5–10 MS*	0.00%	0	0.00%	0
	No info.	3.40%	2	2.90%	2
	Land	35.60%	21	69.60%	48
	+ home ownership				
	Only home	25.40%	15	11.60%	8
	Rents home	13.60%	8	11.60%	8
	Neither	1.70%	1	4.30%	3
	Other	23.70%	14	2.90%	2

quality degraded again in Sapé despite the construction of infrastructure collecting wastewater that used to be disposed of directly into the stream by local residents. In Água Podre where only small sanitation interventions had been conducted at the time of fieldwork, the local population has remained exposed to the poor health conditions of local river ecosystems. As a result, descriptions of both streams by survey respondents were predominantly negative. Persisting issues with household solid waste disposal into the streams were further mentioned as of major concern, for example in relation to pest proliferation and associated diseases. Around a third of respondents mentioned having seen bikes, sofas, and construction debris in the streams. Smell was also used as a descriptive factor for over a fourth of all respondents using terms like “stinky” and “bad/strong/terrible smell” to characterise their stream.

While a part of Sapé respondents who benefited from the housing interventions reported being satisfied with the outcomes, other explained how they introduced further inequalities as many families could not benefit from the relocation scheme. Due to planned housing units not having been built, new shacks were constructed on the same land from which families had been evicted by the government. Residents reported land trafficking has been affecting ongoing ecological conservation efforts. Many also associated the expansion of informal settlements in their neighbourhood to the recurrence of wastewater disposal issues. Among interviewees who had resettled in new housing units, several explained having encountered issues. This has included the loss of space for commercial activities and difficulties to pay for utility bills which were not previously accounting for. In Água Podre, access to housing has also been conflictual since the eviction of families is one of the only parts of the project having been completed, but without adequate compensation being offered to them. Several residents who participated in the study blamed the population involved in the expansion of informal settlements. They argued this has delayed the linear park project, an argument that coincides with that of the

government (personal communication, August 23, 2019).

Besides, a range of socio-environmental benefits and burdens were introduced by additional interventions made along the streams' margins planned for the provision of amenities. The restoration of stream banks participated in improving the aesthetics of the neighbourhoods. In Sapé, a cycling lane and recreational areas with sports equipment were also built along the stream as part of the project. Due to project incompleteness, a group of residents built their own recreational park along the stream in Água Podre. However, interviewees reported that these spaces have also been affected by pollution and 'informal occupation'. Criminal activities in these spaces such as drug dealing were also reported as of major concern by respondents.

3.2. Plurality of needs and aspirations associated to stream restoration

Surveys demonstrated the importance attributed by residents to local streams' ecological health. This was demonstrated by results of a closed-ended question about development priorities in each neighbourhood (Fig. 3). 'River's health' was largely indicated as the priority for action in

Água Podre (44.9% of respondents), followed by 'water and wastewater' (31.9%). 35.1% of Sapé respondents chose 'solid waste collection', either as the unique top priority, or as one of the priorities along two, three or four of the other options. 26.3% of Sapé interviewees indicated 'river's health' as the top and unique priority, thereby showing that many residents consider that pre-existing or re-emerging stream issues are yet to be addressed and should be a priority, and this despite the linear park infrastructure along the banks having been implemented recently. Across both neighbourhoods, 'floods' was the least selected option thereby confirming that flood risks have been mitigated. Several respondents commented on the interconnectedness of these different issues.

Further exploration of residents' views on preferred forms of river restoration revealed an important plurality of opinions. Some residents expressed satisfaction with regards to linear park designs. Yet, a majority indicated the need for a full transformation, notably that stream burial would be preferable. That concerned 52.2% of Água Podre respondents (Fig. 4), and 32.2% of Sapé respondents (Fig. 5). 34.8% in Água Podre and 54.2% in Sapé discussed river management

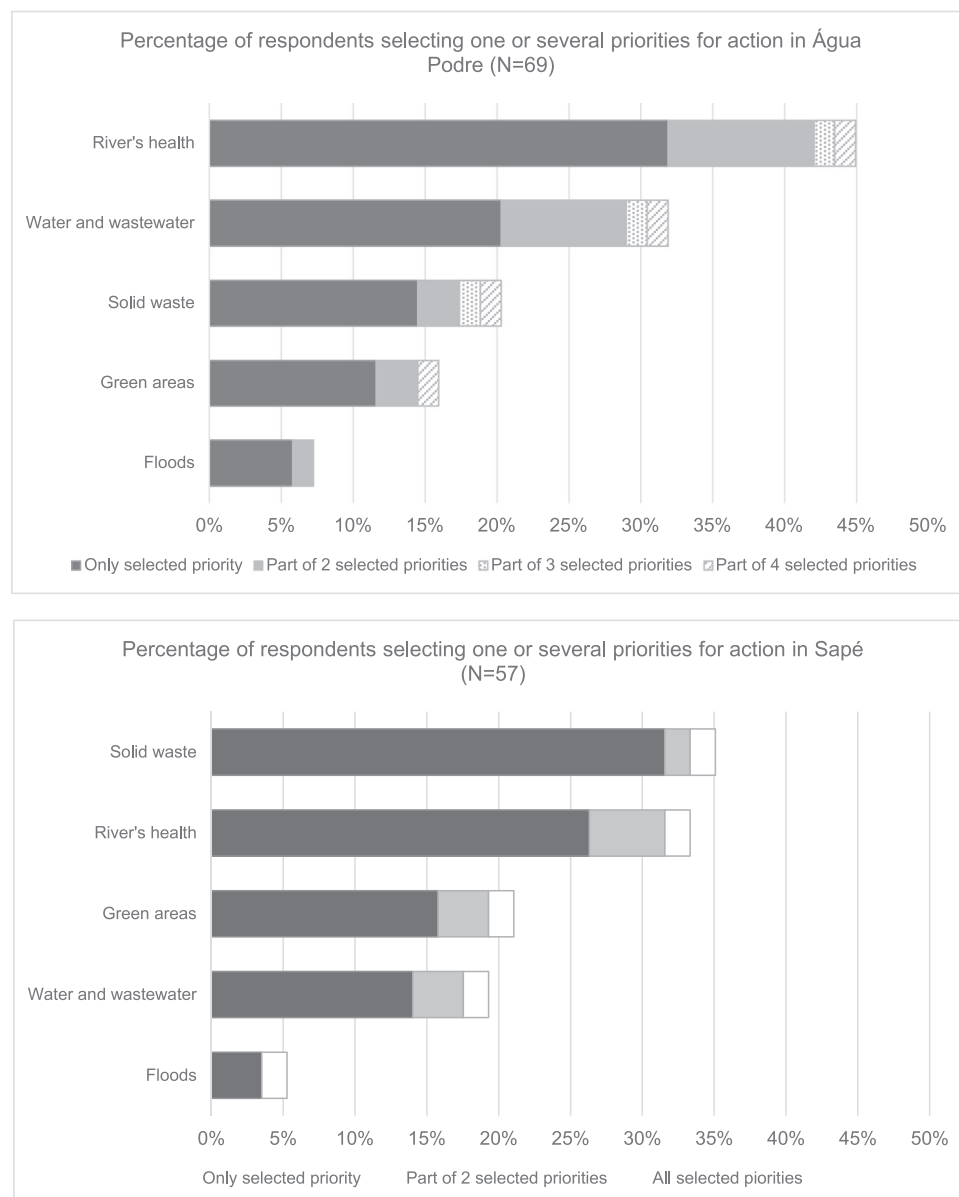


Fig. 3. Selected local development priorities by respondents for their neighbourhood. Several respondents chose not to select only one option, but indicated two, three, or four priorities for action.

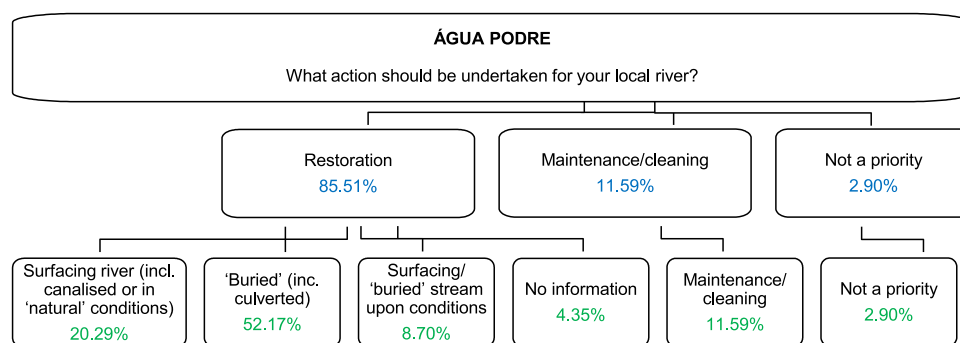


Fig. 4. Break down of the type of river intervention preferred in Água Podre. N = 69.

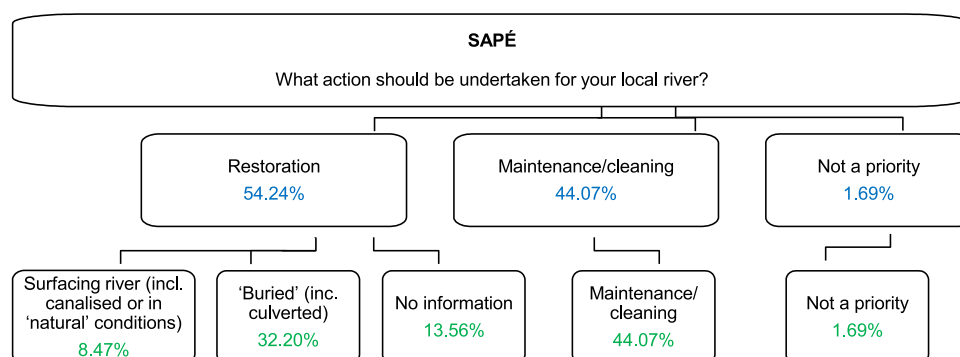


Fig. 5. Break down of the type of river intervention preferred in Sapé. N = 59.⁴¹

interventions that were identified as indicative of a preference for their local stream to remain 'open'.

These results were further explored during FGDs when participants discussed different scenarios of stream restoration (Fig. 6). In all four FGDs, a majority of participants voted for models showing open streams. In Água Podre, preferences were noted for the model illustrating a similar design to that of Sapé linear park (#1) and the model illustrating nature-based stream restoration with conserved riparian zones (#5). Participants to the two FGDs in Sapé expressed preference for the model showing a nature-based restoration with guard rails (#6). However, many noted that despite their wish to conserve stream banks, stream burial would be a more realistic option to protect water resources from harmful pollution behaviours which they associate to the 'bad' *favela* residents or *favelados*:

"It would be great, but if there were proper maintenance. I would be willing to help maintain the place. It would be ideal, but it won't work here. The [*favela*] population won't preserve it." (Sapé, M, 30–49)⁵

Residents' views on vegetated riverbanks were explored in both the surveys and focus group discussions, for example with the question: "do you think vegetation on the river margins has an impact on flood mitigation, and on improving water quality?". While a majority responded "Yes" to both types of impacts across the two neighbourhoods, results indicated a statistical difference between Sapé and Água Podre responses. Sapé residents were found to be particularly more likely to report a connection between vegetation and water quality. This was particularly the case among low-income groups.

69.1% of all interviewees responded being willing to make space for raingardens outside their house. Such space is usually used for car parking. Among those indicating they would welcome the change,

several commented it would nevertheless depend on design and location details. Individuals opposed to the development of raingardens in their area often justified their response with the 'lack of free space' and the 'non-necessity of such interventions'. While some respondents generally demonstrated interest in expanding any form of green space in their area, they also indicated that a focus on their *quality* should prevail over their *quantity*. Concerns were expressed over pollution issues and maintenance responsibilities, which residents consider problematic given the lack of action by the government. Several respondents reported the way organised criminal groups currently occupy public spaces could prevent the peaceful use of new green space by residents. In particular, one person commented: "I think there should be none [i.e., green space]. Squares here are cruel".

3.3. Participation in decision-making

Several of the interviewees explained having been informed or involved during the planning phase of both projects. For example, participation occurred through management councils (*conselhos gestores*) to collectively agree on project design and household resettlements, and of which several community representatives were part. However, despite these communication channels in place, some respondents explained being unclear about the project and its development. Several also explained having expressed interest in being actively involved in decision-making and approached the authorities to get more information. Across Água Podre and Sapé, the interviewed population reported wanting to be involved in workshops (or *mutirões*) that could be organised in the neighbourhoods (49.2%) or consulted for future project developments (34.4%). 9.4% reported they just wanted to be kept informed, and only 7% were not interested in being contacted.

Regarding Água Podre linear park project in particular, survey respondents complained about poor community engagement despite the consultation organised by the municipality in 2007. Most people interviewed explained not being aware of the project status, and several

⁵ (Location, gender, age range)



Fig. 6. Examples of digital simulations of river transformation scenarios discussed during Água Podre FGDs. Top: current (pre-intervention) situation; 1) surfacing stream with gabions and railing (as implemented in Sapé); 2) culverted stream with walkway; 3) culverted stream with cycling lane; 4) culverted stream with exercise equipment; 5) renaturalized river margins; 6) renaturalized river margins with railing.

respondents explained they had never heard about it. FGDs in Água Podre demonstrated that those actively looking for information and those who contacted municipal institutions in charge have had difficulties accessing information. Regarding Sapé, one participant explained consultation processes took place at the beginning of the project, but that the municipality did not take decisions based on their results:

“Two engineers working on the linear park came and asked what we wanted. People chose the model with the ‘closed’ stream. But the municipality did not want to ‘close down’ the stream and communicated to the engineers it will have to remain open. The municipality justified [this decision] with financial costs.” (Sapé, F, 70 +).

A majority of interviewees expressed being interested if community gardening initiatives were to be organised (Table 2). To the question “would you participate in *hortas* (gardens) projects”, 21.1% of the respondents across the two case study areas specified their participation would depend on conditions such as time and location, coordination,

Table 2
Residents’ willingness to participate to community gardening (*‘hortas’*).

	“Yes” 77 (60.2%)	“No” 24 (18.8%)	“It depends” 27 (21.1%)
Neighbourhood (N = 128)			
Sapé	40 (31.3%)	10 (7.8%)	9 (7.0%)
Água Podre	37 (28.9%)	14 (10.9%)	18 (14.1%)
Gender (N = 128)			
Female	50 (39.1%)	13 (10.2%)	12 (9.4%)
Male	27 (21.1%)	11 (8.6%)	15 (11.7%)
Age (N = 126)			
18–29	14 (11.1%)	4 (3.2%)	5 (4.0%)
30–39	9 (7.1%)	2 (1.6%)	6 (4.8%)
40–49	10 (7.9%)	3 (2.4%)	1 (0.8%)
50–59	20 (15.9%)	6 (4.8%)	5 (4.0%)
60–69	14 (11.1%)	4 (3.2%)	6 (4.8%)
70 +	8 (6.3%)	5 (4.0%)	4 (3.2%)
Income/c/m (N = 125)			
< 0.5 SM	35 (28.0%)	10 (8.0%)	12 (9.6%)
0.5–1 SM	25 (20.5)	11 (8.8%)	7 (5.6%)
1–2 SM	13 (10.4%)	3 (2.4%)	5 (4.0%)
2–5 SM	3 (2.4%)	0 (0.0%)	1 (0.8%)

⁴ Participants explained considering “canalisation” and “stream burial” as forms of stream restoration. Where the terms were used interchangeably, further specifications were asked. From this, ‘canalisation’ – where streams remain uncovered – has been differentiated from ‘stream burial’ – where streams are paved over.

and measures taken to limit vandalism. Many added that the municipality should provide financial support. During FGDs, respondents described the way they take care of green areas on their own, including

in spaces along the stream margins. Diverse motivations behind the cultivation of community gardens were shared during FGDs. Besides ‘love for nature’, some individuals explained wanting to raise awareness among the population, for example on ways to take care of the environment and to discourage pollution behaviours:

“Obviously this is because we want a nicer neighbourhood, but it is also because we want to inhibit the disposal of solid waste. Everyone knows that planting reduces solid waste disposal” (Água Podre, M, 30–49).

Some of them also explained *hortas* were currently cultivated in specific spaces to prevent the further expansion of informal housing.

4. Analysing justice trade-offs and opportunities for stream restoration

4.1. Justice as distribution, recognition, and participation

4.1.1. Distribution

The distributive dimension of environmental justice raises the questions of ‘*what is to be distributed?*’ and ‘*to whom?*’. In the context of the two case studies, this requires understanding what ecosystem services have been prioritized by the governmental authorities in charge, and what benefits were actually provided as a result of project implementation. Here we have paid particular attention to environmental conservation efforts in parallel to changes in access to space and essential public services by historically marginalised populations. This is important since efforts of cross-sectoral collaboration for both the Sapé and Água Podre linear park projects not only opened opportunities to improve river ecosystems’ health, but also to reduce inequalities of access to drainage and sanitation services, and to land and housing rights.

The linear park projects were designed to support the long-term depollution of urban rivers with impacts at city and basin levels, while generating benefits to local populations in parallel. Residents’ testimonies confirmed that a range of ecosystem services were provided, and particularly regulating services (e.g., stormwater and pollution regulation) and cultural services (e.g., newly created recreational areas). Yet, these appear to have been limited over time. Very importantly, different parts of the populations were not served equally, particularly when considering the execution of housing plans. They resulted in the displacement of families that have not received adequate compensation, even years after the projects were initiated and now remain in a latent state.

The fact the projects were only partially implemented does not only mean that desired outcomes could not be fully achieved, but also indicate that further inequalities were introduced. The case of Sapé particularly illustrates the way new issues can emerge from river restoration interventions that are not sustained over time. A range of environmental risks were reported by study participants as having re-emerged post-project implementation (e.g., pest), while creating responsibilities of maintenance of newly created green spaces. Residents expressed concerns over further burdens being introduced if river restoration were to occur through a renaturalisation of river ecosystems, perceiving those risks will outweigh any possible gains. Therefore, an environmental justice perspective here shows that the overall limited social and ecological performance of the projects emerge from the challenge of articulating multiple NBS functions across temporal and spatial scales.

4.1.2. Recognition

Justice as recognition here helps deconstruct dominating normative narratives articulated by powerholders through discursive mechanisms that present the decisions made by the authorities in relation to the linear park projects as ‘rational’. Yet, testimonies from residents of the two neighbourhoods collected from surveys and focus group discussions showed a clear contrast but also a plurality of values related to what the

projects ought to address and how they could have materialized differently from what the authorities decided. While some of the values brought forward by residents have aligned with governmental plans, others have also fundamentally conflicted with them (e.g., stream burial). Values articulated by decision-makers must be better linked to the diversity of local needs and aspirations, and therefore to a wider range of benefits sought by residents.

Multiple risk factors influencing local populations’ perceptions towards river restoration could be identified. When focusing on testimonies from individuals who advocate against nature-based stream restoration, these factors range from pollution to maintenance issues mentioned above, health risks, amenity aspects, flood events, use of space, criminality, and wider intercommunity frictions, as well as grievance towards authorities. Some of these factors have fuelled residents’ emotional detachment from rivers, which have translated into preferences for stream burial. Furthermore, fieldwork in Sapé and Água Podre has shown that many residents have developed formed of environmental stewardship which indicate the need to challenge discourses around communities’ lack of interest in or awareness of questions of environmental conservation.

The plurality of such values reflects residents’ different everyday experiences and perceptions. For example, discussions showed that stream burial was associated to modernization, a perception shaped by a long history of city-wide river canalisation and stream burial in São Paulo. Reducing the debate to open/closed stream restoration design, and subsequently drawing lessons on people’s care for the environment, therefore omits nuances in residents’ own value assignment of the streams which considers other factors. It overlooks opportunities to map out interrelated socio-cultural issues, for example with the way nature-based stream restoration is seen as a risk due to mistrust in the authorities responsible for maintenance services. All of these have revealed complex river-community relationships that go much beyond care for nature and demonstrate the need to address neglected patterns of risks in low-income areas in the city.

4.1.3. Participation

The analysis of engagement processes led by the authorities in charge with the populations of both neighbourhoods indicate that residents were given the opportunity to express the concerns described above but had limited influence over the final decisions. This restricted influence over decision-making is recognised as a missed opportunity for neighbourhood regeneration planning strategies to benefit from residents’ own problematisation of stream restoration, beyond matters related to the linear parks’ design. In the case of Sapé, the management council (*conselho gestor*) appears to have been used as a mechanism to inform the population about governmental decisions, as opposed to having initiated a process of collaboration. Results indicate that the most marginalised voices of the local populations were not always represented and were therefore lost during negotiations. Considering important contrasts between communities’ range of indicated needs and interests and actual outcomes, these are in fact indicative of high-level tensions within decision-making processes. This raises complexities around the integration of preferences towards stream burial into existing stream restoration strategies when policies and regulations restrict space for the adaptation of projects.

Água Podre case study illustrates fragmented and interrupted dialogue between decision-makers and the local population. The fact a group of residents has self-organised to demand implementation of the project since 2007 particularly counters decision-makers’ common argument that local populations do not show interest in participating to decision-making. On the contrary, it appeared that the group has been holding authorities accountable for authorities’ own plan. However, it must be noted that this group does not necessarily represent the entire diversity of opinions of the population of Água Podre and does not appear to include individuals from the lowest-income groups. Therefore, like in Sapé, the fact the group of residents has been in direct dialogue

with the government has not guaranteed the representation of the voices of the most marginalized groups. In contrast, their capacity to express what they value – as a group and as individuals – has been inhibited. This includes values in terms of well-being and ‘functionings’ (i.e., the things an individual might value doing or being), and therefore indirectly capabilities (Svarstad and Benjaminsen, 2020), which have been overlooked in project design.

4.2. Value articulation and power relations

The exploration of power relations in the articulation of values for the projects enables to deepen the environmental justice analysis of results. Power analyses shed light on some of the root causes of the identified environmental injustices (Langemeyer and Connolly, 2020), and particularly in the way complex river-community relationships have been flattened in discourses and have thereby silenced a range of local needs. Values of river-community rapprochement articulated by institutions in charge to justify project-related decisions contrast with the way many residents narrate the way local risks emerge or multiply, notably around wastewater and solid waste disposal, maintenance, and land occupation. We identify that these concerns shape people's own valuation of their local stream as a burden more than as an asset, and that this impedes the development of forms of care. As theorised by the sociology and anthropology literature on attachment to ‘urban nature’, stream burial would be considered by people as a way to allow physical and emotional distancing from such concerns (see for example Ryan, 2005; Botea and Rojon, 2015; Cefai, 2010; Bourget, 2019).

Justice concerns emerge from the way normative discourses on river-community relationships reproduce multiple assumptions. They include assumptions around ‘sense of place’ as an inherent outcome of infrastructural interventions and associated expectations towards communities as environmental stewards. At the same time, the process of perpetuating these values might silence populations' own concerns and sometimes traumas (e.g., in relation to flood events), as well as their own needs and aspirations. Particularly relevant to the case of São Paulo, we argue that this type of discursive construction also silences the way residents are subject to socio-cultural influences resulting in expressed preferences for stream burial. Analysing the city's history of engineered interventions shows how the same institutions currently promoting urban greening are often the same as those that have advocating for stream burial as a necessary path to development (Diep et al., 2022). It is important to further differentiate residents' valuation of streams from that of wider ‘urban nature’ which tend to be simplified in discourses towards ‘communities’ or ‘favelados’. The identification of existing initiatives in the two studied neighbourhoods, for example to cultivate *hortas*, demonstrate the way residents have taken care of their local environment.

Justice theories also help identify further concerns that emerge from intercommunity conflicts over local issues. Surveys and focus group discussions highlight the way community members tend to blame other community members - the *favelados* - for these issues. As such, instead of river margins fulfilling a ‘territorialising function’ supporting community cohesion and a positive place identity (DeLanda, 2016; Juntti et al., 2021), they have become ecological spaces for dispute. A culture of denunciation has emerged, where individuals have reported ‘criminal behaviours’, including waste dumping practices, to legal authorities. This culture is encouraged by the municipal government which publicly calls for denunciation. This is analysed as a strategy to divide communities, create internal frictions and consequently remove attention on government's liability. We also identify how some residents express having accepted the government's lack of continued engagement – for example materialised through lack of maintenance – and against which they feel powerless. This reinforces how problems often go beyond design dilemmas or population's lack of interest into ecological questions, but also revolve around lack of dialogue and accountability (Parikh et al., 2020). Finally, attention to value articulation also reveals

the way ‘non-human’ systems have received little benefits from the project. Although the ecological performance of the projects is not explored in detail here, the fact gains in river ecosystems preservation could not be sustain indicate the reproduction of human-centred worldview in the delivery of NBS (Pineda-Pinto et al., 2021; Toxopeus et al., 2020).

4.3. Lessons for nature-based river restoration in São Paulo

Currently emerging NBS policies for river restoration in São Paulo and wider Brazil need to ensure they do not introduce new forms of environmental injustices. That is particularly relevant considering the city's history of river management having historically produced and patterns of socio-environmental exclusion. We argue that sustainable and just nature-based river restoration cannot be achieved without differentiated urban policy and planning approaches enabling the inclusion of ‘informal’ areas where many river management challenges persist. By exposing underlying environmental governance issues that go beyond infrastructural designs, NBS represents an opportunity to tackle structural barriers to the socio-spatial integration of marginalised groups in the city's fabric. Inequalities in access to public services must be addressed in parallel to allow the development of senses of place that can further favour human-nature relationships. We recommend that NBS river restoration policies in São Paulo develop focus on existing local practices of environmental care and everyday uses of space.

The case studies illustrate how flood risks, wastewater and solid waste, tenure for land and housing as well as amenity space management are intertwined challenges to river management in peripheral areas and need to be synergistically addressed. They are currently formal planning policies in São Paulo that guide city-level, basin-level and area-based strategies for integration of various social and environmental objectives without creating conflicts of development objectives. These have enabled the development of linear park projects like those of Sapé and Água Podre and resulting cross-sectoral collaboration that distinguish them from traditional projects. However, important challenges remain around institutional collaboration in practice. Populations' perceived lack of reliability of governmental authorities in charge is a persistent issue and is not only due to project incompleteness and delays, but also to unaccountability in public service provision.

As evidenced by testimonies, the involvement of a large number of stakeholders does not guarantee the distribution of decision-making power. Fragmented governance processes could have in fact affected public engagement, resulting in the ‘invisibilization’ of local needs. It is nevertheless residents' everyday uses of, and interactions with river margins that play the most significant role in the way riverscapes transform into places. Therefore, policy structures need to focus further on mechanisms that understand and build on people's own incentives for appropriation and care of such space. For this, NBS policy and planning can build on Brazil's rich tradition of participatory approaches. That means that current science-based assessments that inform river interventions must better consider different experiences, values, and perceptions since they influence people's engagement with nature. In parallel, the mapping of local needs in collaboration with residents need to answer key questions during planning procedures such as ‘who bears responsibility for maintenance’ and ‘how to ensure accountability is held?’. This aligns with Torres et al. (2021) who argue that flexible and adaptable multi-stakeholder decision-making processes will expand social learning and therefore expand institutional capacity in undertaking just initiatives.

We further identify that committees like management councils need to become platforms of influence for local populations to participate in the collective development (or ‘co-creation’) of projects. They can give visibility and formal support to existing environmental initiatives for the planned integration of NBS, such as community-led gardening and river cleaning actions. Participatory budgeting can be explored further as a mean to support such initiatives, while creating further incentives for

appropriation of the ecological space occupied by local populations. Opportunities for collaborative management of communal spaces should be explored for the creation of networks of blue and green spaces considering local interests, like for community gardens in the areas studied in this research. This can open prospects for activating stewardship and collective mobilisation. As opposed to nurturing a culture of denunciation, it can strengthen social cohesion within neighbourhoods, and particularly between groups of 'formal' and 'informal' settlements. We argue that such production of senses of collective belonging and political agency benefitting historically marginalised groups will contribute to the socio-environmental integration of peripheral areas in the city.

5. Conclusions

Challenges in river restoration embody complex environmental justice questions related either to the presence of infrastructure or its absence. The holistic principles on which NBS have been developed can create opportunities for social inclusion in context of informality, provided they embrace the dynamics of neighbourhoods where socio-spatial exclusion interlinks with environmental degradation. São Paulo has increasingly institutionalised urban greening strategies for neighbourhood development. However, there is need to identify and understand how their application might result in more than less injustices, notably because of a reliance on technical interventions combined with a lack of attention to society-ecology relationships. Every neighbourhood has its own history of intercommunity interactions and human-nature connections, and rivers and streams particularly portray the complexity of these relationships which are detrimental to the socio-ecological integration of solutions. We argue for more recognition of the multiplicity of values associated by people to river restoration and their wider environment. That way NBS can be mechanisms for both ecosystem conservation and the making of just cities that meet its population's interests including those of marginalised groups.

This study explored the context of two linear park projects for stream restoration planned as part of Água Podre and Sapé neighbourhood regeneration strategies in Western São Paulo. The analysis of residents' personal and collective experiences and perceptions that condition the way top-down interventions affect them locally helps question the assumption that 'green' solutions intrinsically lead to just outcomes for marginalised groups. This analysis particularly helps highlight narratives that contrast with the rational basis of rapprochement between people and nature used by experts on linear parks. We also unpack local complexities to challenge discourses used by governments, planners and other groups in power portraying communities as homogeneous groups. This limits the recognition of their own values and capabilities, and overlooks the diversity of needs and aspirations requiring attention for socio-ecological integration in projects.

More specifically, findings show how residents associate streams to multiple types of risks including floods, health risks, criminality, and maintenance responsibilities. We identify the considerations of such risks affecting residents' everyday lives as largely explaining why a majority described the need to 'bury' streams. For some people, this was argued as a manner to protect the river from pollution. Another influencing driver was identified in the widespread association of river burial with socio-economic development. Therefore, a range of socio-cultural factors has appeared to play a role in people's attachment/detachment relationship with streams. We call for better understanding of interactions between people and streams and ways through which these are intrinsically connected with wider issues of urban exclusion manifested in struggles related to land access and basic service provision. For São Paulo in particular, further efforts of collaboration between different sectors will be crucial.

The environmental justice analysis helps challenge the assumptions that linear parks and other infrastructure NBS approaches inherently lead to a rapprochement of people with nature. This type of biases often

acts as inhibitor of local knowledge mobilisation in planning phases, which NBS policies will need to address. Reflections are needed on the mechanisms in place for better integration of communities' values in nature-based urbanism through alternative forms of participatory approaches. For stream restoration, we suggest that committees and other public engagement platforms should be used by planners to collaborate with residents, for example to collectively map out and problematise neighbourhood-wide everyday interactions between people, streams, and the environment. Planning phases need to be used for the identification of ways through which NBS can be integrated into local dynamics of environmental stewardship. Finally, we call for further environmental justice analyses that support reflections on how and under which conditions NBS can achieve better inclusivity of informal settlements in cities.

Ethical approval

All ethical approvals and informed consents were obtained to conduct this study (UCL reference: 13941/001; CONEP reference: 3.434.274).

CRedit authorship contribution statement

Loan Diep: Conceptualisation, Data curation, Formal analysis, Methodology, Visualisation, Writing – original draft, Writing – review & editing. **Barbara Pozzan dos Santos Duarte:** Data curation, Formal analysis, Visualisation, Writing – review & editing. **Anaís Figueiredo Bourget:** Data curation, Writing – review & editing. **Priti Parikh:** Methodology, Supervision, Validation, Writing – review & editing. **José Rodolfo Scarati Martins:** Supervision, Validation. **David Dodman:** Methodology, Supervision, Validation, Writing – review & editing.

Declaration of Competing Interest

The authors declare no conflict of interest.

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