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## Review

# The unjust distribution of urban green infrastructure is just the tip of the iceberg: A systematic review of place-based studies

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## ABSTRACT

Many cities are turning to greening efforts to increase resilience, but such efforts often favor privileged groups, thereby resulting in injustices. In this systematic review, we analyze 71 place-based studies of green infrastructure (GI) justice in cities worldwide. We draw from environmental justice scholarship, as well as climate and water justice literature to assess the state-of-the-art knowledge of urban GI justice. We examine the way GI is researched to improve our understanding of the types of injustices that exist in GI planning, siting, and implementation, providing rich insights into why injustices exist and pathways to address GI injustice. We find that research on GI justice in cities is growing and expanding its scope in terms of both the types of justice issues analyzed, and the groups of people excluded from the benefits of GI. We find that GI injustice stems from a history of unequal investment and non-participatory decision-making processes, where the unequal distribution of GI is only the “tip of the iceberg”. To address GI injustice around distribution, cities would have to offset a decades-long lack of investment and inclusivity in decision-making processes. Pathways to achieve GI justice point to assessing unbalanced power structures, directing continuous funding to community engagement programs and greening efforts, leveraging existing infrastructure through the multifunctionality of GI, and dedicating funding mechanisms for safety and maintenance. Interdisciplinary and transdisciplinary research is needed to integrate the different dimensions of GI that are tailored to the community on the ground, and to monitor progress toward justice.

## 1. Introduction

From the Million Trees program in New York City that involves residents in tree-planting and tree-adoption initiatives to expand their urban forest (NY Parks and NY Restoration Projects, 2020) to the nation-wide Sponge City program in China that seeks to use greenspace to mitigate the devastating effects of flooding in multiple cities (Li et al., 2017), greening efforts are considered a viable solution to complex social and environmental challenges. Recently, cities around the world signed the C40 Cities Urban Nature Declaration committing to invest in greenspace so that by 2030, 30–40% of the built environment is permeable green cover and at least 70% of the residents, including the most vulnerable, have equitable access to greenspace (Way, 2021). Green infrastructure (GI) is one type of “greening” increasingly promoted in cities as a strategically planned and designed network of

natural and semi-natural areas, integrated with other environmental features and managed to conserve biodiversity and to deliver a wide range of ecosystem services (Benedict and McMahon, 2002).

Today, a wide spectrum of green to gray infrastructure systems can be found in cities (Taguchi et al., 2020). It is typical to find hybrid approaches where green (vegetated spaces), gray (e.g., pipes, roads, canals) and blue (water bodies) infrastructure are combined and designed to work together (Staddon et al., 2018; Zuniga-Teran et al., 2019a). For example, green roofs in buildings can be combined with disconnected downspouts that convey runoff to raingardens along the streets for infiltration. Despite the heightened adoption of GI in cities around the world, researchers highlight multiple challenges associated with the adoption and implementation of GI in cities. These include conflicting regulations, a lack of dedicated and stable funding, responsibility for long-term maintenance, and a need for context-specific design standards

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(Porse, 2013; Zuniga-Teran et al., 2019a, 2019b; Zhao et al., 2019).

Increasingly, injustice associated with GI adoption and practices is seen as a major challenge in many cities. Greening strategies, as part of urban renewal, tend to target middle class and higher income groups, sometimes at the expense of less privileged residents (Haase, 2017). In our earlier review of disciplinary approaches to justice in urban greenspace, we found that it was common for researchers to define justice, or its corollary concepts of inequality and inequity, in terms of the equal distribution of GI benefits among urban residents (Zuniga-Teran and Gerlak, 2019). Yet, in addition to the distributional GI justice issues, injustices occur around landscape and park design that favor the recreational uses of powerful groups (Larson, 2018), exclude minority voices from the decision-making process, and are highlighted by challenges of sustained maintenance (Boone et al., 2009). Therefore, researchers caution that greening efforts may enhance inequities (e.g., gentrification) (Wolch et al., 2014). Mohai et al. (2009) emphasize that to better understand the root causes of environmental injustices, we need to examine place-specific cases.

The purpose of this study is to increase our understanding of justice in urban GI, both in the way it is researched and how it is implemented. We analyze place-based studies that embrace concepts of justice in GI in their design – that is, studies that seek to explore concepts of justice through an examination of GI. “Place” is important to how people experience and understand society and nature (e.g., Agnew, 1989; Jessop et al., 2008), and is key to understanding the practice and politics of water (Ingram, 2011). In addition to the theoretical advantages of understanding GI justice and how it is researched across a diversity of disciplinary and methodological approaches worldwide, we argue that there are real, practical, and planning-related advantages to better analyzing how and why injustices occur in GI design, planning, siting, and implementation.

We turn to the rich climate and water justice scholarship to conceptually frame our analysis of justice in GI. Because GI is related to urban resilience and climate change adaptation, as well as stormwater management and rainwater harvesting, these bodies of scholarship can provide insights into the nature, scope, and extent of justice in GI. Here we draw from the types of justice researchers identify and articulate. This approach provides a lens with which to examine justice in the GI context. This lens in turn helps to call attention to those groups excluded in GI design, siting, and implementation; injustices that emerge from GI projects; the reasons that injustices exist; and pathways to address GI injustice. We conceptualize our findings in terms of an iceberg metaphor, where we see distributional GI injustice as the “tip of the iceberg”. Distribution issues may be more obvious and seen above-water (so to speak), but recognition is the process that illustrates/uncovers other forms of injustice and underlying factors. To address justice issues, we argue that cities ought to take a deeper dive and more closely examine and account for underlying layers of injustices, power structures, rapid urbanization processes, and legacies of disinvestment.

## 2. Conceptual framing: justice in climate and water scholarship

Environmental justice scholarship emerged with an emphasis on the distributional aspect of justice – or the disproportionate location of hazards in close proximity to the neighborhoods of underrepresented minorities. This scholarship dates to the 1980s in the US, with sociologist Robert D. Bullard, who examined the location of solid waste sites among black neighborhoods in Houston, Texas (Bullard, 1983). This study coincided with an activist movement in Warren County, South Carolina, against the dumping of hazardous waste in this predominantly African American county (Holifield et al., 2018). Protests triggered regional and national level studies that supported this finding – minorities were disproportionately affected by the siting of hazardous waste (US General Accountability Office, 1983; Commission for Racial Justice, 1987). Early environmental justice research that focused on equity issues soon transitioned into environmental racism with work by Bullard

himself (Bullard, 1990, 1994) along with other scholars, namely Laura Pulido, who explored the use of pesticides that affected Hispanic workers in California farms (Pulido, 1996), and racially biased urban planning in Los Angeles that negatively affected Chicano communities (Pulido et al., 1996). In most studies, racism has been found as the predictor for the siting of hazardous waste. However, there is also the debate about whether market forces drive poor people to live near these sites, as the surrounding land is usually cheaper; a debate usually referred to as the “chicken and egg” (Mohai et al., 2009).

Scholarly work evolved over the years into studies examining procedural aspects of environmental justice, identifying the need to have inclusive participation in the decision-making process (Walsh and Shrader-Frechette, 2000). Soon afterwards, David Schlosberg developed the tripartite framework for environmental justice adding “recognition” to distribution and procedural justice (Schlosberg, 2004, (Schlosberg, 2007), and eventually capabilities (Schlosberg and Carruthers, 2010). Recognition refers to the devaluation and cultural oppression of minorities, which calls for the acknowledgement of capabilities and a clear definition of rights and responsibilities (Agyeman et al., 2016; Walker, 2012). Environmental justice scholarship became more critical with work by David N. Pellow, who identified gaps in earlier studies and questioned assumptions through interdisciplinary perspectives, while also identifying conceptual differences, multiple levels, and a plurality in ways to understand environmental justice (Mohai et al., 2009; Pellow, 2007, Pellow et al., 2015). Although proximity to hazards remains relevant, the focus of environmental justice scholarship is shifting to encompass the lack of provision of goods and services, including the lack of access to GI (e.g. greenspace and trees) (Walker, 2009, 2012).

Both water and climate justice researchers call attention to distributive and procedural justice in their work. Distributive justice requires something to distribute or share, while procedural justice considers how these objectives are defined and distributed fairly (Forsyth, 2014). Drawing from an environmental justice framework, Schlosberg (2012) argues for an examination of the underlying factors, institutions, and oppressions that determine unequal distribution (Schlosberg and Collins, 2014). In arguing for a capabilities approach to climate justice, Schlosberg (2012: 445) “focuses on the specific range of basic needs and capabilities (including recognition) that human beings require to function”. The capabilities approach addresses needs and vulnerabilities at both the individual and community level. Expanding on this conception, Pellow et al. (2015: 10) conceive the capabilities approach as integral to the very definition of climate justice by advocating for the “freedom of peoples to make choices that maximize their capabilities both now and in the future”.

Building from the climate justice scholarship on procedural and distributive justice and recognition, Wutich et al. (2013) emphasize that procedural justice and recognition are important prerequisites for achieving distributive justice. In their multi-country study of perceptions of water justice in water institutions, Wutich et al. (2013) find that respondents perceive justice in terms of localized concerns and interpersonal injustices. In a similar perspective to Schlosberg’s work on recognition and justice, Zwartveen and Boelens (2014: 147) also draw from the broader environmental justice framework to argue that “it is important to add dimensions of (cultural) recognition and procedural democracy to those of (re)distribution”. Recognition respects and acknowledges different ways of responding to and dealing with water problems.

Issues of power are also important in climate and water justice scholarship. For Klinsky (2018: 105), a critical assessment of power as the “crux of the matter” is necessary in any account of climate injustice. Zwartveen and Boelens (2014: 144) argue that power not only manifests in “explicit laws, rules and hierarchies, but it operates through less visible norms that often present themselves as natural or inevitable”. Zeitoun et al. (2014: 185) warn that, because power and politics often control the spaces in which water processes evolve, procedurally fair processes often lead to asymmetric outcomes. Water justice, therefore, is

in the eye of the beholder – or in the eye of those with power (Swyngedouw and Boelens, 2018).

### 3. Methods and approach

This paper employs a systematic literature review as its analytical method. The systematic review methodology first emerged in the health sciences as a way to codify a large volume of literature using clearly defined criteria (Cox, 2015; Greenhalgh et al., 2005). There is considerable precedent for adapting such a systematic review to analyze literature concerning climate-related adaptations and environmental social science more generally (Berrang-Ford, 2015; Cox, 2015). In these contexts, the systematic review serves as a means to thoroughly, consistently, and clearly assess a defined series of existing literature (Berrang-Ford, 2015).

We used the search engine Web of Science to access studies published between January 2010 and May 2020. Although there are a variety of terms that refer to GI (e.g., greening, beautification, tree-planting), we focus on the stormwater management perspective of this type of urban infrastructure. Therefore, for the initial searches, we used the keywords “green infrastructure” and “justice”, or “green infrastructure” and “equity”. Then, to better capture the diversity of concepts that define GI around the world, we conducted 10 additional searches replacing the term “green infrastructure” with alternative terms. For example, GI is sometimes referred to as low impact development (LID) in the U.S., sustainable urban drainage systems (SuDS) in Europe, and water sensitive urban design (WSUD) in Australia and New Zealand (Taguchi et al., 2020). Therefore, we expanded our search to include: “low impact development”, “water sensitive urban design”, “sustainable urban drainage systems”, “best management practices”, “nature-based solutions”, “ecosystem-based adaptation”, “ecological infrastructure”, “green stormwater infrastructure”, “natural infrastructure”, and “sponge city”. Of these variant searches, only “ecological infrastructures” and “sponge cities” yielded additional unique results.

Taken together, our searches yielded a total of 164 studies, 34 of which were duplicates. We then screened the abstracts of the 130 studies to determine if the studies met our inclusive criteria of: (1) an empirical place-based case study, (2) with a justice/equity component, (3) an urban focus, and (4) that analyzes GI. Selected studies analyze GI and contain a justice or equity component – they either explicitly analyze GI for injustices, or analyze characteristics of GI more generally and then discuss those characteristics’ bearing on issues of justice. Therefore, we included studies with empirical case findings that included a substantial discussion of justice in GI. In applying our criteria, we removed 36 studies from our dataset. During the coding process described below, we identified 23 studies that did not fit our four criteria for inclusion, yielding a total of 71 studies in our final dataset. Appendix A lists all of the reviewed studies.

Members of the team coded several studies to test the coding framework which include types of justice analyzed (distribution, procedural, recognition, rights and responsibilities) and their definitions, excluded population groups, causes for injustices and solutions to injustice, as well as geographic region of the study. Collectively, our team considered and modified (as necessary) the way the questions were articulated, began the coding process, and discussed potential conflicting views, until we reached a common understanding of the coding process. One coder then coded all of the remaining papers in our dataset. A different team member examined the coding by checking 20% of the total articles coded (14 out of 71 studies in our dataset). The studies were selected using a random number generator application based on assigned article numbers. The selected studies were checked for each element of the coding framework described above. Only three areas of conflict were identified across 224 codes in the 14 studies (or 1.3%). The authors resolved the areas of conflict, which were determined to be differences in language rather than in the substance of the coding content. To analyze the data, we used descriptive statistics to inform

frequencies in both counts (n) and percentages. For some questions, we developed contingency tables to identify relationships between different variables.

### 4. Findings

#### 4.1. GI type and geography

We find that researchers study many different types of GI in diverse geographic locations.

The most common type of GI is greenspace (28%, n = 20), which encompasses a variety of spaces for human use, including parks, woodlands, fields, and forests. For example, Donaldson and João (2019: 6) define GI as “(n)atural space (that) includes parks and woodlands, fields, streams and rivers, green space alongside paths and roads, and tree-lined streets”. Small scale GI (20%, n = 14) is another type of GI highlighted, which includes spaces designed for stormwater management but that are too small or otherwise not intended for human recreational use. These include raingardens, decoupling of downpipes, pervious pavement, bioretention cells, green roofs, green walls, and wetlands. For instance, Li et al. (2017) study how wetlands, green roofs, green walls, and raingardens relate to flood vulnerability in Belgium. In addition, researchers call particular attention to parks and greenways (17%, n = 12). Less commonly, researchers focus on urban forests (trees, vegetation and greenbelts) (13%, n = 9) and commons (vacant land, gardens) (6%, n = 4).

To analyze geographic location, we follow Gerlak et al. (2018)’s classification.<sup>1</sup> We find that most studies analyze cases in the U.S. & Canada and Europe, representing 72% of the studies (41% and 31% respectively). We find an absence of studies in Sub-Saharan Africa outside South Africa (3%). For Oceania, all studies refer to Australia (6%). We find a few studies in Latin America (3%), Middle East/North Africa region (3%), and South Asia (7%). For East Asia (4%), most studies examine a city in China. For example, in their study of GI in Shanghai, China, Xiao et al. (2019) explore disparities in park access; Chen and Hu (2015) examine the provision of public greenspace in 285 Chinese cities; and Zhu et al. (2019) apply a GI equity index in the Haizhu District of Guangzhou, China. In addition, we found a couple of comparative studies (3%) that focused on cities in multiple geographic regions.

We also examine geographic location in terms of the Global North and the Global South.<sup>2</sup> In examining how GI is researched, we find that, in some cases, type of GI is related to geographic location. For example, all types of GI are included in studies in the Global North. However, studies in the Global South focus on the human-use of GI (parks), trees in general, or in urbanization-related studies (e.g., greenbelts in Latin American studies). Vacant land as a form of GI is studied solely in North American shrinking cities, while commons or farmland as forms of GI are studied in South Asia, as they relate to livelihoods of marginalized groups (people living in slums).

#### 4.2. Defining and operationalizing GI justice

We find that researchers embrace a variety of types of justice in their studies. Most studies examine distributional and procedural justice (46% and 33%, respectively) (Table 1). For example, Christman et al. (2018) examine distributional justice in Philadelphia, PA, providing a framework that allows for the more equal distribution of GI in low-income, dense neighborhoods. Mason et al. (2019: 335) explore

<sup>1</sup> We moved Mexico to the South America category and renamed the category “Latin America”.

<sup>2</sup> The Global North includes the US and Canada, Europe and Australia, while the Global South encompasses the rest of the world, including Latin America, the MENA region, Sub Saharan Africa, South Asia and East Asia.

**Table 1**  
Type of GI Justice addressed in the studies.

Types of GI justice	Definition	Percent of studies
Distributional justice	Access or proximity to GI	46
Procedural justice	Inclusivity in decision-making processes	33
Recognition	Emphasis on a neglected group	13
Interactional justice	Recognition of different uses, practices, preferences and needs	13
Rights and responsibilities	Delineation of whose rights or responsibilities are being ignored	8
Mobility justice	Ability to use GI (source of resources or livelihood) and move up the social ladder	1

procedural justice issues by examining knowledge of GI in low-middle income communities in Knoxville, TN, and ways to increase that knowledge and interest stating that "storing rainwater in innovative ways requires engagement with a diversity of stakeholders, leading to new challenges for municipalities interested in working with individuals to achieve societal benefits".

It is not uncommon for researchers to examine several types of justice. For example, [Newell et al. \(2013\)](#) explore both how green alleys are distributed in seven U.S. cities and also how people are engaged in the GI planning and maintenance process in Los Angeles, CA. In their study of GI in multiple European cities, [O'Brien et al. \(2017\)](#) seek to discover who is excluded from accessing GI, as a matter of distributional justice, and also how people need to be involved in the GI process, as a matter of procedural justice. They argue that "there is a recognition that social and economic disadvantage and exclusion have ethnic and age-related dimensions" ([O'Brien et al., 2017: 168](#)).

In addition to the four types of justice commonly referenced in climate and water justice scholarship, we find some studies (12.67%, n = 9) refer to *interactional justice*, or "the recognition of different uses, practices, preferences and needs in green infrastructure planning" ([Anguelovski et al., 2019: 149](#)). This research emphasizes "aspects of maintenance and public safety" ([Mansor et al., 2017; 2771](#)), uses ([Keith et al., 2018; Larondelle and Haase, 2017; Sikorska et al., 2019](#)), or "where vulnerable people... feel welcome and safe" ([Carmichael et al., 2019; Kabisch and Haase, 2014; O'Brien et al., 2017; Rigolon and Németh, 2018: 72](#)). In addition, one case (1.40%) refers to *mobility justice*, which occurs when access to GI as a source of resources and livelihoods allows marginalized people to ascend the social ladder ([Sultana et al., 2020](#)).

Overall, we see a trend toward an increase in the way GI justice is operationalized in the scholarship across time ([Fig. 1](#)). While we did not find place-based studies on urban GI justice published in 2010 or 2011,

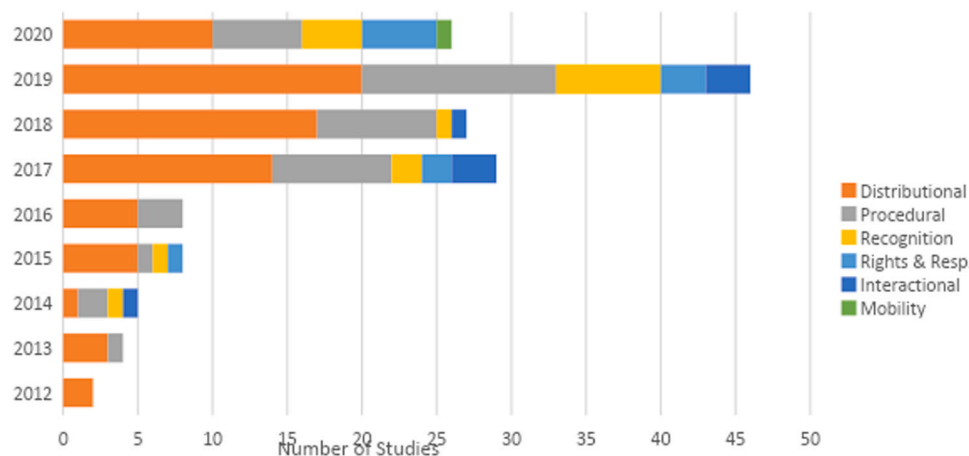
earlier studies in our sample (2012) show mostly distributional metrics, with incipient procedural metrics. By the middle of this past decade, all types of justice are measured or mentioned in some of the studies. The most recent studies (after 2017) are more likely to acknowledge the four types of justice, as well as *interactional* and *mobility* justice. These findings suggest a growing multi-faceted approach to justice around GI and also reflect the emergence of GI as an area of study.

### 4.3. Why injustices exist and why they matter

The way GI is researched informs our understanding of how it is planned, sited, and implemented. Researchers describe a number of reasons why injustices exist around GI. First, socio-economic factors play a key role in GI injustice (37%, n = 26). These factors include intentional urban planning (zoning, land use, housing), lack of equitable investment across the city, and immigration and rapid urbanization processes that fail to provide the necessary urban infrastructure. Minority and low-income groups have disproportionately less access to greenspace and GI. In part, this phenomenon can be explained by historic practices associated with land use, zoning, and housing patterns. Poorer communities generally attract less public investment and face greater challenges associated with legacy pollution. In their study of urban forestry governance in Melbourne, [Gulsrud et al. \(2018: 42\)](#) note that "historic cycles of poverty and disinvestment brought about by redlining and other policies related to race and class are often manifested in public resources such as parks and other community infrastructure". Similarly, in his study of stormwater systems in Los Angeles, [Porse \(2018\)](#) speculates that more vulnerable areas by regional rivers in the city were seen as undesirable and thus inhabited by traditionally disadvantaged demographics, who have then been relatively ignored in infrastructure development compared to other areas.

Some researchers also report more modern socio-economic problems associated with GI and urbanizations. For example, [Goldenberg et al. \(2018\)](#) find inequities in poorer, more diverse, and denser neighborhoods in Stockholm, Sweden, as a result of rapid urbanization and insufficient current efforts to address this challenge. They term this "ethnic segregation" around access to blue-green infrastructure ([Goldenberg et al., 2018: 3614](#)). Cities from Bradford, UK ([Ferguson et al., 2018](#)), to Tehran, Iran ([Bahrini et al., 2017](#)), face immigration patterns that have led to sprawl, the creation of new slums, increased urban density, and a general lack of open public greenspaces.

Flawed urban planning also explains the presence of GI injustice (32%, n = 23). Researchers note a lack of planning, poor planning, inexperience with GI planning, and opportunistic GI planning. Increased housing density and urban densification practices, along with urban consolidation and commodity housing, are seen as causes of GI inequity



**Fig. 1.** Type of justice studied in GI cases over time.



and justice. In Sydney, Australia, [Lin et al. \(2015: 957\)](#) find that "urban consolidation, higher density housing and larger houses on smaller blocks all influence the amount of space available for tree cover in residential areas and this disproportionately affects communities with high socio-economic disadvantage". Privatization of public space is also identified as a cause for injustice ([Chen and Hu, 2015](#); [Shokry et al., 2020](#)). [Xiao et al. \(2019: 88\)](#) highlight the rise of newly developed commodity housing in Shanghai in the form of a gated community, which tends to provide a higher quality of internal community green space, or "club" green space. This privatized green space substitutes public green space and can thus be associated with new inequities. Other researchers raise concerns about gentrification ([Rigolon and Németh, 2018](#); [Sanchez and Reames, 2019](#)). In their study of tree planting in Canadian cities, [Duinker et al. \(2015: 7387\)](#) argue that, even when city planning incorporates tree planting and park development in lower-income areas (disadvantaged, underprivileged) to rectify social injustice, it also increases the desirability of these areas and thus contributes to the gentrification and displacement of the original residents.

A failure in governance accounts for a large proportion of GI injustice (31%, n = 22). Inadequate engagement with local communities in decision-making is seen as a key element of the failure in governance that produces GI inequity and injustice. In the Walnut Creek neighborhood of Raleigh, NC, policymakers have historically overlooked African American residents and frequently excluded them from environmental decision-making processes. "They may not engage in GI initiatives due to perceptions about the distribution of costs and benefits, distrust of local government, prioritization of other household needs, and transience of residence in the affected neighborhood" ([García-Cuerva et al., 2018: 649](#)). A failure in governance also includes the presence of weak or unclear policies, and inadequate communication and coordination. Poorly developed and aging infrastructure also produces GI inequity. A lack of public funding and investment further perpetuates imbalances associated with GI. [Finewood et al. \(2019: 918\)](#) find that infrastructure development in Pittsburgh, PA, has more often than not failed to include disadvantaged communities in decision-making. They do not find that GI has reversed this trend, even as it holds the potential to do so.

#### 4.4. Who is excluded from GI?

In our examination of research studies on GI justice, we find that income is the most prominent socio-economic variable, followed by race and ethnicity, among other characteristics. In their study in Philadelphia, PA, [Mandarano and Meenar \(2017\)](#) conduct spatial and statistical analysis to examine distributional GI justice. They find that low-income communities have less GI access. Similarly, [Hamstead et al. \(2018\)](#) use geolocated social media data to explore park visitation in New York City.

They conclude that parks located in high-minority neighborhoods are lower quality and less accessible, and they do not accommodate as many visitors as parks in low-minority neighborhoods.

We see an increase in the number of groups of people excluded from GI by year of publication. Our sample shows that the original groups studied at the beginning of the decade included low-income and racial minorities. Over time, however, we find that researchers have broadened the groups of people identified in their research studies as excluded from GI (Table 2). For example, [Davis et al. \(2012\)](#) examine the distribution of GI in Chicago, IL, as it relates to socioeconomic gradients such as income and race. More recently, [Zhu et al. \(2019\)](#) call attention to not only the poor, but also the elderly, less educated, renters, and people living in flood-prone areas of Guangzhou, China – all of whom are excluded from GI benefits. Researchers also increasingly include non-human species as a group that lacks consideration in decision-making processes related to GI (e.g., [Jayakaran et al., 2020](#); [Kowarik, 2019](#); [Meerow, 2019](#)).

Interestingly, we notice differences between geographic regions and the groups of people excluded from GI. While low-income people are identified as negatively affected in all of the geographic regions, racial minorities were mentioned in studies located in the Global North. In contrast, studies from the Global South allude to immigrants (rural to urban) with the exception of MENA and East Asia (China). Females are studied in one European study ([Li et al., 2020](#)), and elderly populations are mentioned in studies located in Europe (e.g., [Kabisch and Haase, 2014](#); [O'Brien et al., 2017](#)) and East Asia ([Zhu et al., 2019](#)). Studies that examine GI issues in youth and children populations are located in Europe ([Assmuth et al., 2017](#); [Raymond et al., 2016](#)) and Oceania ([Byrne et al., 2016](#)). Education is a demographic variable identified in GI justice cases in US & Canada (e.g., [McClintock et al., 2016](#)), Europe (e.g., [Bănică et al., 2020](#); [Larondelle and Haase, 2017](#)) and East Asia ([Zhu et al., 2019](#)). Non-human species are recognized in studies located in US & Canada ([Finewood et al., 2019](#); [Meerow, 2019](#)) and Europe ([Sikorska et al., 2019](#)).

Europe is the most diverse geographic region, examining the highest number of groups affected by GI justice issues (16 out of 18 groups, or 89%), followed by the U.S. and Canada (12 out of 18 groups, or 67%) (Fig. 2). Europe is the *only geographic location* with studies that examine women and the unemployed (e.g., [Li et al., 2020](#)), disabled, and artists (e.g., [Assmuth et al., 2017](#)). Single-parent households are identified only in a study in the U.S. and Canada (e.g., [Christman et al., 2018](#)). A study in Latin America is the only one recognizing the lack of car or cellphone as a variable for GI justice issues ([Cruz-Sandoval et al., 2020](#)). Taken together, these findings around excluded population groups reflect a shift, or expansion, by some researchers in their research design and approach that helps reveal a fuller picture of the kinds of people and

**Table 2**  
Number of studies according to excluded population group and year of publication.

	Excluded group	2012	2013	2014	2015	2016	2017	2018	2019	2020
Demographics	Poor	1	1	1	3	4	9	13	10	4
	Racial and ethnic minorities	1			1	3	1	8	4	2
	Females								1	1
	Youth/children					2	1			1
	Elderly			1			2		1	1
	Single parent households								1	
Living in...	High density area		1	1			1	4	2	1
	Far from GI		1				2	1	6	
	Flood-prone areas							1	1	2
	Rental unit					1		2	3	1
Occupation-related	Artists						1			
	Unemployed or retired									2
	Less educated					1	1	1	1	1
	Disabled						1			
	Immigrants			1		1	3	1	2	8
Other	Non-human								4	3
	No car/no phone									1
	Not engaged								4	2

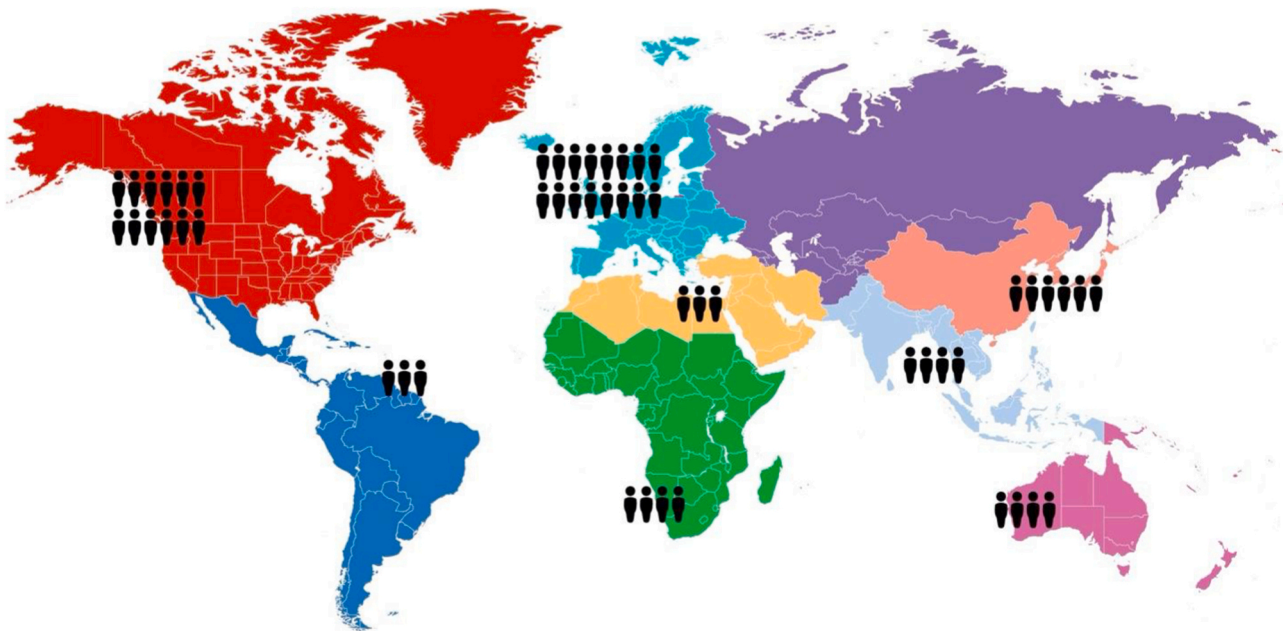


Fig. 2. Number of excluded population groups from GI according to geographic region.

entities excluded from receiving GI benefits.

According to the research studies, areas deprived of vegetation vary within cities. As expected, many cases ( $n = 20$ ) mention poor minority neighborhoods as the ones experiencing justice issues around GI. However, many studies ( $n = 18$ ) find justice issues everywhere in the city. For example, Keith (2018: 56) studies accessibility and transportation, stating that "(w)hen (urban green space) UGS is not integrated into community infrastructure and transportation networks, access can be a major constraint to regular use – particularly for individuals living in close proximity to trails where neighborhood walkability is limited". In addition, high-density areas are related to justice issues in some studies ( $n = 4$ ) and to downtown areas in others ( $n = 5$ ). In a few cases ( $n = 3$ ), injustices are localized along linear elements related to ageing infrastructure including cap parks on freeways (Houston and Zuñiga, 2019), railways (Rigolon and Németh, 2018), and the former Berlin Wall (Kowarik, 2019). For some studies ( $n = 6$ ), justice issues are linked to vulnerability to flooding (García-Cuerva et al., 2018; Li et al., 2020), combined sewer overflow (Heckert and Rosan, 2016), or downstream location (La Rosa and Pappalardo, 2020; William et al., 2017). A few studies ( $n = 4$ ) refer to periurban areas as the ones experiencing justice issues (e.g., Bănică et al., 2020; Cruz-Sandoval et al., 2020), and only a few cases ( $n = 4$ ) identify proximity to an amenity (forest or waterfront) (e.g., Assmuth et al., 2017; Larondelle and Haase, 2017) or polluted waterfront (potential amenity) (Draus et al., 2019) as the reason for injustice.

We find some association between location of injustices within the city and geographic location, with differences between the Global North and Global South. Studies that show justice issues in poor minority neighborhoods and downtown areas tend to be located in the Global North, such as the US and Canada (e.g., Mandarano and Meenar, 2017; Shokry et al., 2020) and Europe (e.g., Baró et al., 2019; Li et al., 2020; Rall et al., 2019). Similarly, the studies that find justice issues along aging infrastructure or amenities, or vulnerable areas to flooding, are located in the Global North (e.g., Kowarik, 2019; Rigolon and Németh, 2018). In contrast, all of the studies that focus on marginalized communities are located in the Global South (Adegun, 2017; Anguelovski et al., 2019; Singh, 2018). We find geographic diversity in studies focusing on periurban areas of the city [e.g., in Europe (Bănică et al., 2020), Latin America (Cruz-Sandoval et al., 2020), MENA (Bahrini et al., 2017), and areas with higher density – including South Asia (Arshad and

Routray, 2018), US and Canada (Baker et al., 2019), and Oceania (Byrne et al., 2016)].

#### 4.5. Addressing injustice

The research studies analyzed here point to a diverse set of solutions to address GI injustice (Fig. 3). The most common proposed solutions relate to policies and governance (53%,  $n = 38$ ). These include considering innovative and integrative policies (10%,  $n = 7$ ), enhancing collaborative approaches (7%,  $n = 5$ ), developing decision support systems (6%,  $n = 4$ ), calling for a systematic mainstreaming of GI in governance practices (9%,  $n = 6$ ), clearly defining rights and responsibilities (7%,  $n = 5$ ), or pointing to partnerships between local organizations, academics, and different levels of government as a key ingredient to address equity issues (16%,  $n = 11$ ).

Many cases (44%,  $n = 31$ ) identify community engagement as a strategy to include the diverse voices, needs, desires, and concerns of the community. In this way, community engagement can address procedural and interactional injustices. Not surprisingly, funding is identified as a key solution to GI justice issues in many research studies (28%,  $n = 20$ ). It is seen as critical for GI implementation, the development of engagement programs that provide financial support to low-income families (tax breaks, rent assistance, etc.), and capacity building for local residents (financial, physical and technical assistance).

Urban design strategies are indicated as a potential solution to GI justice issues in several of the research studies (28%,  $n = 20$ ). These strategies include transportation systems (active travel, public transit, and street connectivity) that connect GI to the surrounding community (11%,  $n = 8$ ). These also include the development of a network of GI at the city scale (9%,  $n = 6$ ), the adoption of the watershed scale as the appropriate one for GI design (3%,  $n = 2$ ), the transformation of neglected areas into GI (6%,  $n = 4$ ), and the expansion of public GI (street trees) (11%,  $n = 8$ ).

Looking at GI quality more closely, many studies (30%,  $n = 21$ ) suggest improving the quality of GI. This includes a diverse set of strategies, including identifying the need to ensure long-term maintenance of GI (23%,  $n = 16$ ), enhancing the quantity and quality of amenities in parks located in low-income areas (6%,  $n = 4$ ), or addressing safety issues (1%,  $n = 1$ ). In addition to quality concerns, researchers point to the need for planning efforts (23%,  $n = 16$ ) to identify GI priority areas

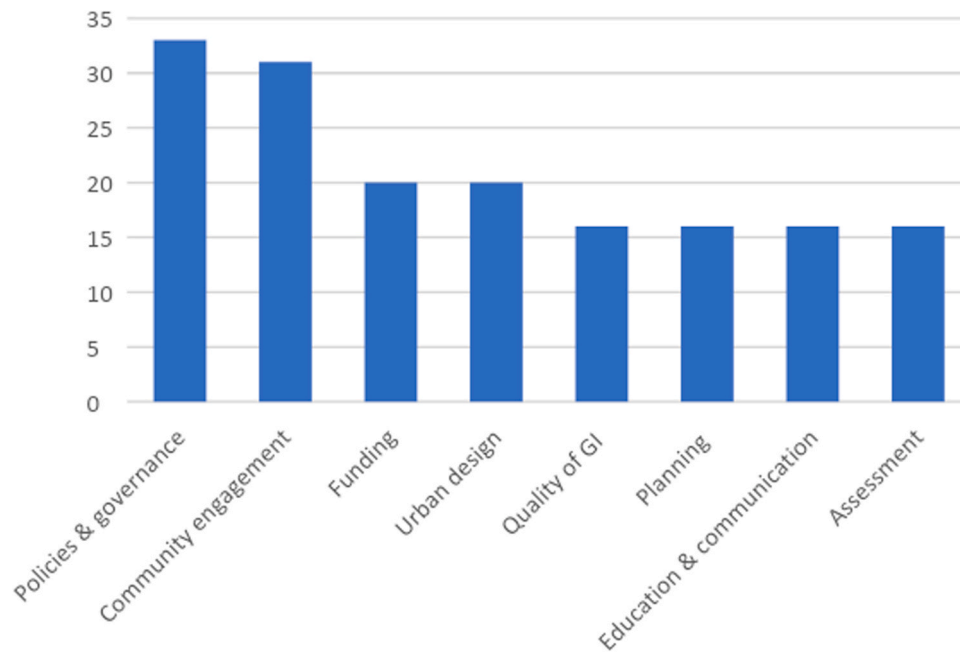


Fig. 3. Proposed solutions to GI justice issues.

using indexes, suitability models, and strategic planning. Education and communication efforts to raise awareness of the benefits of GI are mentioned in several studies (18%,  $n = 13$ ). Finally, many studies (23%,  $n = 16$ ) suggest assessment of the benefits of GI as solutions to GI justice issues. These efforts include evaluation programs to assess the effectiveness of GI and ecosystem services from GI, according to the needs of the community or by using interdisciplinary approaches that integrate socio-cultural and scientific knowledge. We notice an increase in proposed solutions over time as the understanding of GI justice issues broadens. Researchers are identifying multiple solutions in more recent years, which is likely tied to the multi-dimensional ways they are increasingly viewing types of justice in their work.

## 5. Understanding urban GI injustice: its causes, evolution, and solution pathways

In this systematic review, we analyze 71 studies published between 2010 and 2020 to understand justice in GI planning, siting, and implementation as well as how GI justice is studied. Overall, we find a growth of GI as an area of study as well as a broadening understanding of GI injustice in the literature that reflects the multidimensionality of GI. By examining justice in place-based cases, we are able to see how the evident distributional GI justice issues are just the “tip of the iceberg”, revealing unfair underlying processes and historic legacies of disinvestment. In light of this, we reflect on the diverse array of proposed solutions that, in general, lead to pathways to democratize GI in urban planning and urbanization.

### 5.1. Broadening understandings of GI injustice

Overall, we find an evolution of GI justice literature that has broadened the scope of types of justice, as well as affected groups. Our results show a shift over the last decade – earlier research examined distributional injustices in cities, while more recent studies focus on procedural justice issues and draw attention to recognition as a way to expand our understanding of the politics and interests behind GI planning, design, siting, implementation, and maintenance. In addition, we see that more recent studies increasingly mention interactional justice issues and introduce the concept of mobility justice. This longitudinal analysis provides evidence that the pluralistic environmental justice

framework is being used more broadly by researchers over time.

In terms of affected groups, early studies identify poor minority groups as the sole demographic excluded from the benefits of GI. In contrast, more recent publications identify additional groups, some of which may still be related to economic status (immigrants, less educated, unemployed, lack of car or cellphone, single parent), and others of which are not necessarily related to low-income status (elderly, youth, females, renters, disabled). In addition, there are groups that have not been studied at all, including Indigenous communities (e.g., Pacific Islanders in the US, Adivasi in India), ethnic minorities (e.g., Uighurs in China, Caribbeans in the UK, Hispanics in the US and Canada), and migrant workers (e.g., seasonal farm workers in the US), among others. Additionally, in recent studies, interest in the rights to GI of non-human species, biodiversity, or nature in general, has emerged in studies in the Global North. This suggests that context matters – in terms of the prevailing understanding of social and environmental awareness and shifting political views – and that we need more diverse ways to examine justice.

However, we see notable differences in the research studies across the globe – especially between those examining the Global North and those examining the Global South - in how GI injustices occur. Studies in the Global North tend to explore the recreational benefits of GI, or where people play. In contrast, studies in the Global South do not locate GI as a recreational amenity. These tend to view GI as a source of livelihood, or where people work and find resources (Derksen et al., 2017; Sultana et al., 2020), as a hazard-mitigation opportunity where people live (e.g., Li et al., 2017), or as a way to stop the accelerated and uncontrolled urban sprawl in megacities (e.g., Anguelovski et al., 2019), and as the privatization of the public realm (e.g., Xiao et al., 2019). Ascribing the issue to a lack of city planning and resources, and struggles with urban poverty and marginalization (Fernández and Wu, 2018; Fernández-Álvarez, 2017; Lindley et al., 2018), studies find that GI justice issues in the Global South are more pronounced. The difference in the number of studies between the Global North and the Global South may be attributed to the degree of development – namely, wealthy countries may have more resources to build parks and other GI amenities in cities. Climate justice issues between the Global North and the Global South have been identified before, in terms of which countries cause and which countries suffer the consequences of burning fossil fuels (Mohai et al., 2009). Presence of GI in turn opens more possibilities for inequalities

(heat, flooding, type of amenities, quality of GI, maintenance, groups involved in decision-making processes, etc.), upon which studies can focus. This aligns with Lara-Valencia and Garcia-Perez (2015), who find that parks in Hermosillo, Mexico, are scarce and too small for meaningful recreational uses.

We also find that studies in the Global North have identified many more affected groups than those in the Global South. In addition, we see a time lag difference in research conducted in the Global North vs. the Global South. Research in the Global North is transitioning in focus from distributional justice studies to procedural justice studies; research in the Global South is just starting to examine distributional justice issues and its relation to livelihoods for marginalized groups and their potential social mobility (Sultana et al., 2020). Previous research has also identified a time lag difference between global regions: cities in the Global South are still striving to implement grey infrastructure systems prior to transitioning to GI (in that order), while cities in the Global North have grey infrastructure in place (albeit aging in some cases) and are focusing on greening efforts (Parr et al., 2016).

### 5.2. Unveiling the nature of GI injustice

We argue that GI distribution justice issues are just the “tip of the iceberg” of underlying processes in decision-making. These processes tend to exclude less powerful groups (procedural injustice), fail to acknowledge the needs and uses of vulnerable populations (interactional injustice), and unclearly define to whose rights and

responsibilities these injustices pertain. Hughes (2013) describes this type of mechanism for injustice as *thick injustice* – GI injustice is not a result of an institutional practice or event, but rather, a result of a history of decisions and a record of investments over time that have benefited some groups over others. Mohai et al. (2009) recognize that housing discrimination in the US has impeded minorities from moving away from undesirable areas in the city (e.g., areas deprived of vegetation), while affluent whites have had the option and the financial capacity of relocating to greener and more expensive areas. This aligns with water justice literature, which states that water infrastructure projects, like GI, are the result of not only technological and engineering solutions, but also power dynamics that engender inequities (Swyngedouw and Boelens, 2018). Likewise, climate justice literature sees injustices as a consequence of historic processes where the more powerful societal groups have received investment, labor, energy, and institutional support (Klinsky, 2018; Pellow et al., 2015).

All of these types of GI injustice are combined with historic legacies of redlining and disinvestment in minority neighborhoods, unbalanced power structures, weak or unclear policies, and urbanization processes related to densification and unplanned urban sprawl. These phenomena, along with the privatization of the public space and gentrification, result in distributional injustice – the lack of access to quality GI for low-income, disadvantaged, or underrepresented residents (Fig. 4). In this conceptualization of GI injustice, we see procedural justice as the crucial piece (at the center of the iceberg) to addressing the other types of justice – distributional, interactional, mobility, and the definition of

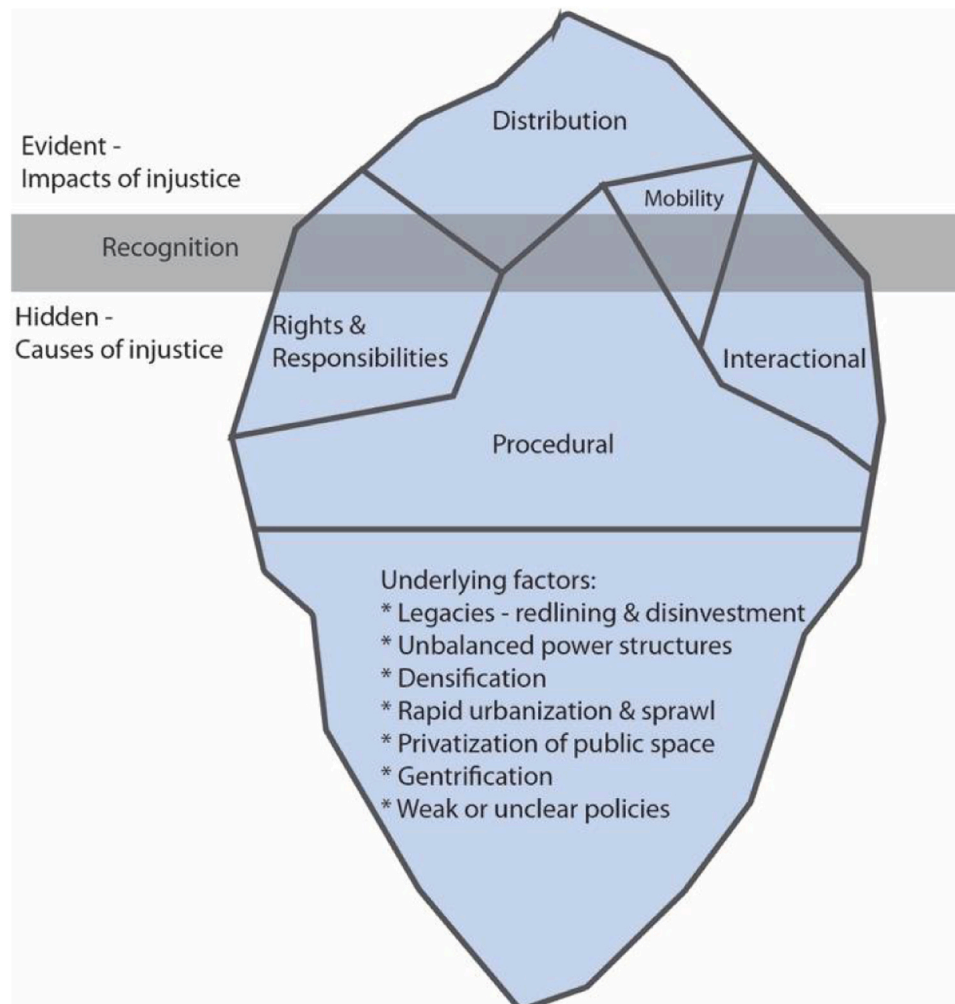


Fig. 4. Conceptualization of urban GI justice as an iceberg.



rights and responsibilities for justice. We see recognition, which is part of the tripartite framework for environmental justice (Schlosberg, 2004), and adopted in climate justice literature (Bulkeley et al., 2014), as the process that reveals hidden causes of injustice. We support this conceptualization of recognition as the “iceberg waterline” that determines the division between the evident and hidden aspects of justice, which is supported by the increasing number of affected groups identified in the literature and the different types of justices studied. Our analysis suggests that some aspects of each type of justice are becoming evident in more recent studies (recognized), while other aspects are still to be discovered.

In addition to the underlying factors that remain “hidden”, we see that there are still trade-offs of greening projects that need to be considered in terms of social and environmental justice. The studies analyzed here primarily consider only instances of exclusion from the benefits of GI. However, there may be other social injustices that have concerning and tangible negative effects on GI implementation elsewhere. For example, in water-scarce regions, a neighborhood’s requiring more water for newly planted trees could reduce water availability in another neighborhood. Similarly, the cost of GI improvements in one part of a city may result in budget deficits in poorer parts.

### 5.3. Pathways to address GI injustice in cities

Greening of the public realm – through the planting of street trees, rain gardens, permeable pavement (including alleys and vacant lots), among others – is the most practical solution to GI distributional injustice. Residents can access greenspace and enjoy its benefits directly from their homes in a network of green streets. Such greening has been advocated by landscape architects for over a century (Boston’s Emerald Necklace is an iconic example of a connected network of greenspaces) (Strohbach et al., 2013); and by researchers studying urban forests and the ecosystem services that trees provide (Escobedo et al., 2015; Nesbitt and Meitner, 2016; Schwarz et al., 2015). Protecting existing trees through different policies (economic instruments such as tax incentives, penalty fees) in public and private land is an efficient way to ensure the provision of ecosystem services at the city level. Some countries have acknowledged the rights of non-human species, including trees, in cities (Steele et al., 2015). Researchers also look at urban design and transportation systems as a way to provide better access to GI. This aligns with Zuniga-Teran et al., (2019b) who find that walkability levels in neighborhoods may influence the mode of transportation used to reach GI and the frequency of use; and also with Ngom et al. (2016), who find that transportation networks, including biking and walking pathways, may influence access to greenspace and levels of physical activity and health.

However, greening intended to address distributional injustice is not a straightforward solution. Our analysis suggests that, ironically, injustices can be enhanced through greening efforts. Therefore, to avoid enhanced inequities, cities across the world should invest in a more equitable GI planning approach. In studies of shrinking cities in the Global North (e.g., Detroit, USA, see Safransky, 2014) and slums in cities within the Global South (e.g., Medellin, Colombia, see Anguelovski et al., 2019), research shows that accumulation through green dispossession harms the more vulnerable populations while benefiting the more powerful. With “sustainability” and “green city” goals as the narrative for greening initiatives, the urban poor are displaced from their homes, their livelihoods, and their social capital to make room for green interventions enjoyed by the affluent or powerful (Anguelovski et al., 2019). This aligns with climate justice research that shows that adaptation and mitigation programs may enhance inequities among the more disenfranchised or less powerful (Marino and Ribot, 2012; Schlosberg, 2012).

In advocating for GI equity and justice, researchers highlight interactions through a multidimensionality lens. For example, in his study of GI in a Johannesburg, South Africa, informal settlement, Adegun

(2017) explores a range of social, environmental, and economic dimensions to highlight how GI can support human well-being and the supply of ecosystem services, space for sporting activities and community meetings, vegetable gardens to generate income, and pollution mitigation. Similarly, in their investigation of GI in Swedish, Australian, and German cities, Kiss et al. (2020) draw attention to protections against climate change, improvements to the urban environment, and public health inequalities. In this way, they highlight effective and inclusive governance as the path to these diverse GI benefits.

The multidimensionality aspect of GI justice issues is linked to the multifunctionality of GI, which has been seen as a way to address justice issues (Zuniga-Teran and Gerlak, 2019). Parr et al. (2016), for example, argue that GI must be designed for multiple functions – recreation, wildlife habitat, stormwater management, rainwater harvesting, beautification, air purification, etc., thus giving opportunity for multiple dimensions and perspectives, according to the needs and wants of the community. Some cities have been looking at school grounds as opportunities to offer parks to the surrounding communities that otherwise would be deprived of this type of amenity (Olin, 2021). Studies reviewed here also point to the interactional aspects of GI justice, in terms of the quality of GI, where maintenance and types of amenities can substantially affect GI safety and human use, which has also been established in earlier studies (Kimpton, 2017). These findings also align well with the One Water approach of the U.S. Water Alliance, a national NGO that gathers business leaders, public officials, community leaders and environmental organizations to holistically manage all sources of water, from drinking water to stormwater to wastewater (U.S. Water Alliance, 2021).

Researchers propose a range of solutions to GI injustice that mostly involve a ‘democratization of GI’ in urban planning, which aligns well with our understanding of procedural justice. Most saliently, community engagement may increase the variety of voices in decision-making processes – a finding that has been established in previous studies (Gerlak and Zuniga-Teran, 2020; Heckert and Rosan, 2016). In some cases, it may also be necessary to convey the benefits of GI with unengaged, less politically powerful communities through educational campaigns to increase their understanding that greening efforts may be in their best interest. Because disadvantaged communities are less likely to participate in engagement processes (they often lack the leisure time or incentive to participate) (Gerlak and Zuniga-Teran, 2020), resources are needed to create incentives for participation. Researchers offer a list of tools to support just GI planning (suitability models, indexes, strategic planning, etc.), but funding is often identified as the solution to most justice issues – for community engagement, capacity building, communication and education, rent assistance to prevent gentrification processes, and more. This finding is echoed by Zhao et al. (2019), who identify continuous funding as the main challenge for advancing stormwater management programs; and with Wolch et al. (2014), who advocate for greening efforts that are “green enough” but not so transformational that greening does not trigger gentrification.

Although community engagement seems to be at the center of GI justice issues, here we argue that cities must examine and address the underlying factors, oppressions, and institutions that determine these injustices in the first place (Schlosberg, 2012). In this way, while approaches to distributional injustice may yield the best headlines, it is really the bottom of the metaphorical iceberg that must be addressed. This means assessing power structures and imbalances to identify the reasons behind injustices and the people who are disproportionately affected or neglected (Hughes, 2013). Urban planning initiatives must place the principles of justice at the core of greening interventions (Anguelovski et al., 2020) as well as other urbanization processes (e.g., densification, urban expansion, and privatization). Oscilowicz et al. (2021) state that to address gentrification, displacement, and lack of inclusivity in the process, planners and policymakers need to find the right mix of equitable and participatory green development tools and anti-displacement policies. Willingness and ability to participate will

remain limited unless there are real incentives (time off from work, stipends, rewards, prestige, etc.) to individuals to participate. Greening projects should consider the needs and livelihoods of the less-privileged groups (Anguelovski et al., 2020; Sultana et al., 2020; Woroniecki et al., 2019). Resources should be directed to historically marginalized areas of cities to fund participatory planning processes, support co-design of recreational uses and amenities, implement anti-gentrification initiatives, leverage existing infrastructure, and fund collaborative greening implementation and sustained maintenance. These efforts are likely to empower historically disempowered communities and generate employment opportunities that can be intentionally directed to include vulnerable communities. Only then can real progress in addressing GI injustices be made.

## 6. Conclusions

This study offers an overview of the state of the literature at the intersection of environmental justice and GI. This systematic review improves our understanding of how GI justice is studied, why GI injustices occur in cities, and identifies pathways that can help address these issues. We uncover a broadening of scope in research around GI justice. More specifically, we reveal that distributional injustice is just the ‘tip of the iceberg’ and that low-income minority groups are not the only negatively affected groups. We examine other types of injustices and unveil the underlying factors that cause GI injustice – from unbalanced power structures, to decades of lack of investment in certain areas of the city, to rapid or unplanned urbanization processes.

Overall, this study further develops the pluralist framework of environmental justice. We provide longitudinal evidence of expanding attention to that plurality, and we illustrate a conceptual way to understand the relationships of injustice across that plurality, as well as a range of solutions to multiple injustices. To address the underlying causes of GI injustice and help cities prepare for global environmental change, we highlight how greening efforts must consider and assess their own unbalanced power structures, intentionally democratize decision-making processes, and leverage the multifunctionality and multidimensionality aspects of GI in existing infrastructure and investments. While community engagement offers a simple way to have inclusivity in the decision-making process and expand the notions of justice, we also identify an array of potential interventions (greening the streets, urban design strategies, transportation, planning, anti-displacement policies) that can address GI injustices simultaneously. Interdisciplinary and transdisciplinary research is needed to place justice at the core of greening initiatives – from urban planning and stormwater management to climate adaptation, landscape design, transportation, park management and other GI-related dimensions.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.envsci.2021.10.001](https://doi.org/10.1016/j.envsci.2021.10.001).

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## Further reading

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