Connecting urban green infrastructure and environmental justice in South Africa: Integrating social access, ecology, and design

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Abstract

Green Infrastructure (GI) connects across a city's urban fabric and exhibits multiple meanings. It inevitably ties to questions about environmental justice. In South Africa, the historical legacy of colonialism and apartheid has left deep scars and the fragmentation of people and places. The justice issues surrounding urban GI are many, complex and unpredictable. They include insecurity, contested access to urban parks, differing perceptions of equity, contested ownership of urban vegetation, and alienation mediated local community involvement. In this systematic review, we analyze 72 scientific publications connecting urban GI and environmental justice in South Africa to identify current research trends. Using the conceptual frame of environmental justice, we structure our analysis around the commonly-used dimensions of distribution, process, and recognition, with added attention to governance. Our review shows that food security, distributional equity, and physical access to urban green space are dominant, with similarities in the spatial and temporal scales of investigation. Environmental justice studies and political ecology are comparable, and we argue that 1) Research on GI access should follow a more nuanced and rights-based approach, 2) a stronger ecological and climatic/biophysical perspective would be valuable, and 3) integrating landscape designs could uncover more actionable and transformative potential. Common across these three avenues of research is a need to embrace more interdisciplinary, participatory, anticipatory, and dynamic thinking across a broader range of scales.

Keywords: urban green infrastructure, environmental justice, climate change, collaborative learning, transformative change

Résumé

De par ses multiples fonctions et sa signification culturelle, l'infrastructure verte (Green Infrastructure, GI) qui traverse le tissu urbain d'une ville est inévitablement liée aux questions de justice environnementale. En particulier dans des pays comme l'Afrique du Sud, compte tenu de l'héritage historique du colonialisme et de l'apartheid, qui ont laissé de profondes cicatrices et fragmenté les populations et les lieux. Les enjeux de justice liés à l'IV urbaine sont nombreux, complexes et imprévisibles : accès contesté aux espaces verts urbain et perceptions divergentes de l'équité ; végétation urbaine créant un sentiment d'appartenance ; (in)sécurité ou aliénation selon l'implication des communautés locales. Dans cette revue systématique, nous avons analysé 72

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publications scientifiques reliant l'IV urbaine à la justice environnementale en Afrique du Sud afin de déceler les tendances de la recherche actuelle. En utilisant le cadre conceptuel de la justice environnementale, nous structurons notre analyse autour des dimensions couramment utilisées de distribution, de processus et de reconnaissance, en accordant une attention particulière aux aspects de gouvernance. Notre revue montre que la sécurité alimentaire, l'équité de distribution et l'accès physique aux espaces verts urbains dominent la littérature existante, et qu'une grande partie des recherches actuelles ont des échelles spatiales et temporelles similaires d'investigation. En nous appuyant sur la complémentarité des études sur la justice environnementale et de la recherche en écologie politique, nous soutenons que 1) la recherche sur l'infrastructure verte pourrait adopter une approche plus nuancée et fondée sur les droits; 2) davantage d'études intégrant davantage les perspectives écologiques et climatiques/biophysiques plus solides pourraient être utiles ; et 3) l'intégration de l'aménagement paysager pourrait révéler des potentiels plus concrets et transformatifs. Ces trois axes de recherche partagent la nécessité d'adopter une réflexion plus interdisciplinaire, participative, anticipative et dynamique à des échelles plus larges.

Mots clés: infrastructure verte urbaine, justice environnementale, changement climatique, apprentissage collaboratif, changement transformatif

Resumen

La Infraestructura Verde (IG) conecta el tejido urbano de una ciudad e inevitablemente está vinculada a cuestiones de justicia medioambiental. Esto es especialmente cierto en países como Sudáfrica, dado su legado histórico de colonialismo y apartheid, con profundas cicatrices y una fragmentación de personas y lugares. Las cuestiones de justicia en torno a la IG urbana son muchas, complejas e impredecibles. Incluyen el acceso disputado a los parques urbanos, distintas percepciones de la equidad y la propiedad de la vegetación urbana; y diferentes tipos de (in)seguridad y alienación. En esta revisión sistemática analizamos 72 publicaciones científicas que relacionan la GI urbana y la justicia ambiental en Sudáfrica. Utilizando el marco conceptual de la justicia medioambiental, estructuramos nuestro análisis en torno a las dimensiones comúnmente utilizadas de distribución, proceso y reconocimiento, con atención añadida a la gobernanza. Demostramos que la seguridad alimentaria, la equidad distributiva y el acceso físico a los espacios verdes urbanos dominan la bibliografía existente. Estos trabajos comparten líneas de investigación. Los estudios sobre justicia medioambiental y la ecología política son comparables, y nosotros demostramos que 1) hay margen para que la investigación sobre el acceso a la infraestructura verde adopte un enfoque más matizado y basado en los derechos, 2) podría ser valioso realizar más estudios con perspectivas ecológicas y climáticas/biofísicas más sólidas, y 3) la integración de diseños paisajísticos podría descubrir un potencial más procesable y transformador. Estas tres vías de investigación tienen en común la necesidad de adoptar un pensamiento más interdisciplinario, participativo, anticipatorio y dinámico en una gama más amplia de escalas.

Palabras clave: infraestructura verde urbana, justicia medioambiental, cambio climático, aprendizaje colaborativo, cambio transformador

1. Introduction: Connecting urban green infrastructure and environmental justice

The multiple functions of a city's vegetation – from its street trees and gardens to its public parks, agricultural spaces, and natural ridges (Schaffler & Swilling, 2013) – provide benefits. These Green Infrastructure (GI[2]) benefits are multiple and interconnected, ranging from heat island alleviation and flooding resilience to improved mental health, food production, and biodiversity protection (e.g. Wang *et al*., 2019; Hansen & Pauleit, 2014). In other words, all types of GI have beneficial roles to play in light of current and projected climate change, increasing physical and mental health burdens among urban populations, and biodiversity loss. Urban GI benefits are critical to all urban residents (human and non-human), but not all living beings enjoy the same levels, quality, access, influence or recognition when it comes to urban GI, making it an important field to be interrogated through an environmental justice lens (Rutt & Gulsrud, 2016) tightly connected to political ecology research (Ranganathan & Balazs, 2015; Svarstad & Benjaminsen, 2020).

[2] According to Shih and Mabon (2018) the term 'green infrastructure' (GI) can be interpreted as synonymous with 'green space' and 'urban nature', which are terms more often used in sociological literature. We use the term GI, but cover literature applying various related terms (see Table 1)

In South Africa, as in many other places in Sub-Saharan Africa and beyond, large scale environmental changes such as flooding, drought and environmental degradation (Otto *et al*., 2018; Lannas & Turpie, 2009; Musyoki *et al*., 2016) go hand-in-hand with other pressing issues like poverty and personal insecurity (Graham, 2015; Kaoma & Shackleton, 2014). These interrelated trends place high demands on urban GI to deliver multiple benefits, particularly as an important component of compact sustainable cities (Haaland & van den Bosch, 2015). Urban challenges like industrial pollution, encroachment, unhealthy living conditions and social inequalities present a threat to the integrity of urban ecosystems and are highly related to diminishing environmental justice (Leonard, 2013). There are distributional, procedural, recognitional and governance dimensions to environmental justice (see Section 2, Figure 1). The unequal distribution of green spaces that must provide basic recreational and wellbeing benefits to urban residents across income and race has been highlighted (McConnachie & Shackleton 2010; Venter *et al.* 2020). In addition, the selection of plant and wildlife species and the incorporation of locally specific worldviews in the design of these spaces have gained attention (Chelleri, *et al*., 2016; Shackleton & Gwedla, 2021).

On a day-to-day basis, the urban context brings localized risks related to people's safety and access, affecting their ability to interact and gain benefits from nearby nature (Cocks *et al*., 2016). These risks create negative perceptions of GI (du Toit *et al*., 2018), fueled by a lack of access that diminishes the perceived importance of and need for urban green space (Dipeolu *et al*., 2021). From a broader perspective, the bigger environmental and developmental concerns affecting urban residents must include and consider their empowerment and perceptions of equity (Adegun, 2018a). Personal safety, interactions with nature, local empowerment, competing priorities, and equity perceptions are all key aspects of environmental justice, and are all highly relevant in a South African urban context.

The top three disciplinary fields researching GI are environmental science, engineering, and science and technology (Shao *et al*., 2021), which tend to focus on the biophysical features of urban green space. However, several scholars have followed a 'move' towards more explicit consideration of how ecological benefits can reach more vulnerable members of society and redress inequalities (Shih & Mabon, 2018). In other words: while maintaining functional ecological infrastructure is the foundation for sustaining vital urban ecosystem services, analysis of the social system is also needed (Angelstam *et al*., 2017). To aid these analyses, environmental justice as a field closely related to (urban) political ecology can help untangle interconnected economic, political, social and ecological processes, and help direct attention to shifting social relations in ever-changing urban geographical and environmental contexts (Swyngedouw & Heynen, 2003). More "narrow" environmental justice approaches or perspectives can even gain inspiration from complementary political ecology research, and *vice versa* (Ranganathan & Balazs, 2015; Svarstad & Benjaminsen, 2020), as discussed toward the end of this article.

The context-setting in the reviewed literature often dwells on the legacies of apartheid which entrenched lasting negative perceptions of nature at the hands of past discriminatory practices and traumas (Donaldson *et al*, 2016; Wessels *et al*., 2021) and still manifests spatially in urban areas in how it segregates marginalized communities from grey and green infrastructural resources and associated benefits (e.g. Shackleton & Gwedla 2021; Venter *et al* 2020). Meanwhile, several gaps in research are recognized in the literature relating to GI and environmental justice with a focus on South Africa. Cocks *et al*. (2016, p. 824) note that the relationship between urban residents and their surrounding natural environment is largely unexplored, with little attention given to "how residents of the urban margins utilize and relate to their environments, their attachments to these spaces, and the intangible benefits and values associated with them." Leonard (2012) mentions that divergent perceptions of environmental risks by different civil society groupings can receive more attention. Breed *et al*. (2015) point towards a lack in approaches that allow "decision-makers, designers and the public to weigh up the benefits and losses of various land use scenarios", claiming that the role of landscape design practitioners in particular has not received enough attention in research pertaining to urban GI in South Africa. Do these gaps still exist, how "deep" are they, and can they benefit from greater cross-fertilization with political ecology? Are there other relevant trends and gaps needing attention for research in urban GI and justice to move toward?

With no systematic reviews specifically relating environmental justice to GI previously conducted[3] for South Africa or Africa, this review opens the floor to this important focus area connected to central political ecology research areas, such as power inequalities, participation and governance (Svarstad & Benjaminsen, 2020). In this article, we identify emerging patterns in the literature and suggest avenues for future research. We wish to explore which environmental justice dimensions stand out and which receive less attention, and importantly, which avenues of research are relevant to explore further to gain a deeper understanding and thereby improve potentials for developing greener and more just cities. The article is organized as follows: We lay out our conceptual-analytical frame of environmental justice in Section 2, followed by a description of our review approach in Section 3. We outline trends and gaps in justice perspectives for urban GI literature concerning South Africa in Section 4, and round up by proposing avenues for future research in Section 5.

2. Theory: Environmental justice as a conceptual and analytical framework

Three interrelated dimensions are often applied in research into environmental justice or equity[4], namely i) the distribution of costs, benefits, and harm or risks; ii) the procedures, both formal and socially embedded, through which decisions are made, who is involved and has influence; and iii) recognition of people's varying experiences, contexts, identities, and values, in both decision-making processes as well as distributive outcomes (Walker, 2011; Pascual *et al*., 2010; Pasgaard & Dawson, 2019; Svarstad & Benjaminsen, 2020). While these commonalities or similar dimensions exist across various environmental justice definitions, the concept itself is still "situated and contextual, grounded in the circumstances of time and place" (Walker, 2011, p. 11). McDermott *et al*. (2013) therefore zoom out from these dimensions to ask how they are shaped by the scale and target group of concern, the framing of goals with respect to equity (or justice), and how decisions about the content, target, and aims of equity (or justice) are taken. This theoretical advancement adds valuable perspectives, not only for individual cases on urban GI (in)justice, but also when reviewing existing literature that includes environmental justice aspects in a certain context. A focus on scales and frames applied in research can tell us about the current theoretical and empirical approaches and coverage of studies, but also which areas are currently under-investigated or could contribute to or benefits from political ecology research themes (cf. Ranganathan & Balazs, 2015). For instance, to broaden the focus from the individual or group level of who benefits, who is involved and recognized, it is relevant to complement environmental justice dimensions with a focus on governance (Pasgaard & Dawson, 2019; Sikor *et al*., 2014), including underlying causes and responsibilities, which stand stronger in the political ecology literature (Svarstad & Benjaminsen, 2020). An explicit governance focus could include: the relations and collaboration between different social groups or stakeholders; integration of their different perceptions, forms of knowledge, expertise and notions of justice; and their social learning and adaptive capacity (Cockburn *et al*., 2016, see also Tschakert & Dietrich, 2010). Governance perspectives thereby provide an essential 'middle layer' connecting the core content of justice – represented by its dimensions – with the outer layer shaping decisions about justice (Figure 1).

Taken together, this multispectral view on environmental justice is relevant when investigating urban GI, since urban conditions and their effects on people-nature interactions touch upon all the above-mentioned justice scales and dimensions to some degree. In this review, we are therefore interested in knowing which topics, dimensions, perspectives, sociopolitical scales, and frames are currently covered in the scientific literature on urban GI and environmental justice in South Africa.

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[3] For assessments of literature linking environmental justice and green space *access*, see the synopsis by Jennings *et al*. (2012) and the review by Rigolon *et al*. (2018).

[4] While equity is often treated alongside justice in conservation research and shares similar conceptual dimensions, injustice can be considered a more normative concept than inequity, which is considered more descriptive (Walker, 2011) and a justice analysis often differ from equity assessments by applying wider ethical considerations and broader scales of outcomes and actors (Sikor *et al*., 2014).

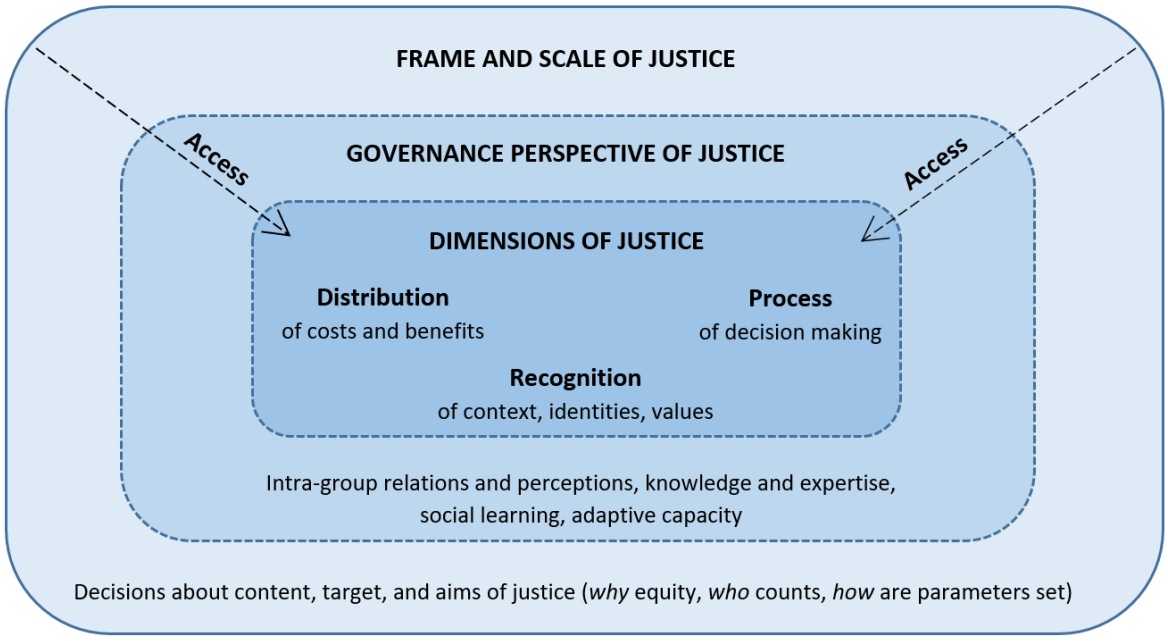

Figure 1: Framework illustrating the conceptual and analytical frame of the article, centering on the commonly used dimensions of justice (distribution, process, and recognition) broadened to include governance perspectives and consideration of scale, as inspired by McDermott *et al*., (2013).

3. Methods: A structured review of literature on urban green infrastructure and justice

The primary method used for building our literature base was an extensive bibliometric search using relevant keywords (Table 1, see also Pasgaard and Strange, 2013). The search for scientific publications was conducted via Web of Science and Scopus. These search platforms connect with comprehensive databases of scientific publication records and were chosen due to their wide global application and analytical tools (Clarivate, 2025), but are also subject to limitations, such as language and document type biases, as well as common geographical and institutional divides in access to journal publishing (Karlsson *et al*., 2007). Search results were exported to EndNote X6 reference manager for storage and screening. The initial search was conducted with the combination of three concept groups, namely 'Justice', 'Urban Green Infrastructure' and 'South Africa' (Table 1). The search words under each concept group were selected based on our own knowledge, experience and stored literature, followed by several pilot searches checking various combinations of words to eliminate irrelevant hits and redundancies.

A total of 214 scientific articles were then retrieved from Web of Science on the 11th of May, 2021. The publication dataset based on the Web of Science search was further populated with additional publications extracted from a similar search in the Scopus database (adding 47 publications). The earliest publications date back to 1998. During a manual screening, irrelevant articles were deselected, for instance those targeting *open space* without a specific GI focus (e.g. Jarvis, 2021; Sinxadi *et al*., 2020) and those concerning the scenic *Garden* Route region (e.g. Smith *et al*., 2015, Barnes & Claassens, 2020), if outside the scope of inquiry. Publications not focusing specifically on South Africa (e.g. Bailey *et al*., 2019) were also excluded. This screening process relied primarily on abstracts, supplemented by reviews of full articles if abstracts were ambiguous (see Poteete & Ostrom, 2008). Out of the screened publications, 72 were manually selected by the first author as key publications based on the following criteria: 1) specific attention to one or more environmental justice perspectives; 2) key focus on urban GI; and 3) primarily addressing South Africa. The selected key publications were read through and qualitatively analyzed by the first author using Nvivo software

for thematic coding (Figure A.1 in the Appendix) following the key concepts of our analytic framework (such as 'Process', 'Perceptions' and 'Governance', see Figure 1) and specific themes added as the review progressed (such as 'Pollution', 'Gender', 'Species', and 'Planning'). Several of the publications were also read by co-authors given their specific expertise in ecology and urban planning, respectively. The de-selected publications still inform the analysis in terms of topics covered and show examples of benefits and risks (Table 2).

Concept groups	**Search words**
JUSTICE	justice OR equit* OR ownership OR empower* OR participat* OR representati* OR access* OR "local communit*" OR inclusi* OR household
URBAN GREEN INFRASTRUCTURE	"Green Space*" OR greenspace* OR "Green Infrastructure*" OR "Ecological Infrastructure*" OR "Environmental Infrastructure*" OR "open space*" OR "urban ecosystem service*" OR "urban nature" OR "city nature" OR garden* OR "urban park*" OR "urban greening" OR "urban forest*", "urban woodland*", "urban wetland*", brownfield* OR "urban forag*"
SOUTH AFRICA	South Africa*

Table 1: List of concepts groups and search words with proper use of asterisks marked with *, i.e. "South Africa" or "South African"). At least one word from each of the three concept groups must occur (Boolean operators AND and OR). Book chapters, as document type, were included in the systematic review. To refine the search in WoS, the word "access" in combination with "article", e.g. "open *access article*", was removed using the Boolean operator NOT.

4. Analysis: Trends and gaps in scientific literature covering justice perspectives in urban GI in South Africa

In line with our conceptual framework (Figure 1), our analysis departs from the three commonly used justice dimensions, namely: *distribution* of costs, benefits, and risks; *procedures*, both formally and socially embedded; and, *recognition* of people's varying experiences, contexts, identities, and values. These three dimensions are situated within a context of governance, and limited by the frame and scale of justice. We apply this framework to first explore the dimensions of GI justice, leading up to an examination of justice-governance perspectives, and the target and scale of the justice issues found in the reviewed publications.

Distribution, procedure, and recognition

For interrogating the distributional justice of urban GI in South Africa according to the reviewed literature, we initially look at what urban GI benefits are at stake and what risks or costs are represented in the literature (Table 2). How are their distributions reported? This was achieved by extracting and categorizing the text coded in Nvivo.

	Category	Benefits	Risks or costs	Examples of literature
Environmental	Vegetation	Medicinal and indigenous species Trees and non-timber products Aesthetic values Cultural identity values	Crime and fear Insecurity Pollution	(Shackleton and Gwedla, 2021) (Garekae and Shackleton, 2020) (Goodness, 2018) (Graham, 2015)
	Biodiversity	Protection of native biodiversity Local revenue from indigenous plants Ecological restoration and resilience	Invasive alien species Restoration time-lags Human-wildlife conflicts	(Chamberlain *et al*., 2019) (Goodness, 2018) (Mosina *et al*., 2014) (Ulian *et al*., 2017)
	Water	Irrigation water Flooding control Resilience to floods	Excess garden irrigation Water pollution Flooding	(Meyer and Jacobs, 2019) (du Plessis *et al*., 2020) (Jiusto and Kenney, 2016) (Shackleton *et al*., 2018)
	Temperature	Heat control Shade and cooling effect		(Jagarnath *et al*., 2020) (Shackleton *et al*., 2014)
Socioeconomic	Income and expenses	Tourism Sale of cultivated/wild products Energy source like wood Female-headed income (gardens)	Maintenance costs Garden crop theft Damage by animals	(Kanosvamhira and Tevera, 2020) (Kaoma and Shackleton, 2015) (Shackleton *et al*., 2015) (Shisanya and Hendriks, 2011) (van Averbeke, 2007)
	Employment	Green collar jobs like gardening Green entrepreneurship	Discontinuity in funding Lack of skills and expertise Lack of access to markets	(King and Shackleton, 2020) (Lucke *et al*., 2019) (Ulian *et al*., 2017)
	Health	Food and medicine Recreation Physical health Mental health	Allergies Toxic species or materials Personal safety	(D'Haese *et al*., 2013) (Laurie *et al*., 2017) (Mosina and Maroyi, 2016) (Shackleton *et al*., 2015) (Bisaga *et al*., 2019)
	Education	Indigenous Knowledge legitimacy Inclusion of schools in activities	Lack of expertise Staff turnover	(Mudaly, 2018) (Laurie *et al*., 2017) (Ulian *et al*., 2017)
Cultural/political	Ownership	Sense of belonging Sense of independence Responsibility and care	Exclusion/alienation Sense of not belonging Illegal land use Unsecure tenure rights	(Shackleton and Njwaxu, 2021) (Colding *et al*., 2013) (Lucke *et al*., 2019) (Thornton, 2009)
	Culture	Place for rituals Aesthetic values Changing gender norms	Violation of sacred places Perceived untidiness Power struggles	(Shackleton and Njwaxu, 2021) (Shackleton *et al*., 2015) (Trefry *et al*., 2014)
	Social networks	Bonding and bridging Avoiding crime Female independence Change agents	Exclusion of certain groups Favoritism and elite capture Lack of access to markets	(Kanosvamhira and Tevera, 2020) (Lucke *et al*., 2019) (Shackleton *et al*., 2014) (Trefry *et al*., 2014)
	Identity	Sense of place, identify and self Heritage and historical values Shared sense of cultural identity	Loss of lifestyles Gender discrimination	(Shackleton *et al*., 2014) (Trefry *et al*., 2014)
	Knowledge	Creating and sharing knowledge Learning opportunities	Loss of traditional knowledge Generational shifts	(Lucke *et al*., 2019) (Mudaly, 2018)

Table 2: Overview of benefits and costs or risk related to urban GI covered in the literature reviewed, with examples of sources. The list is not exhaustive of topics or literature, and many categories naturally overlap, e.g. vegetation and biodiversity, or culture and identity.

Distribution is often discussed in the literature in terms of equity and access (Paganini & Lemke, 2020; Willemse, 2013, 2015; Shackleton *et al*., 2014), and distributive justice is even set as an explicit frame in some of the articles (e.g. Venter *et al*., 2020). Adegun (2018b, p. 331, emphasis added) for instance, describes environmental justice in relation to GI as "the *fair distribution* and *equitable consumption* of green space as an environmental good." In a similar fashion, accessibility is often addressed in the publications with a sole focus on physical or spatial access (Das & Honiball, 2016, 2019; Willemse, 201; Venter *et al*., 2020). Some

publications, however, consider social aspects and physical access in combination (Donaldson *et al*., 2016; Lategan & Cilliers, 2016; Bahta *et al*., 2018). Such social aspects can include *visual* access, e.g. modified through types of fencing (Lategan & Cilliers, 2016) or artificial lighting (Willemse, 2013), the availability of land types supporting particular activities (Kanosvamhira & Tevera, 2020), or access to *markets* or to *knowledge,* regarding for instance the extraction or processing of GI resources, including through extension services (Paganini & Lemke, 2020; Tesfamariam *et al*., 2018), weather forecasts (Bharwani *et al*., 2005), or childhood experience (Garekae & Shackleton, 2020). While these publications provide perspectives that go beyond spatial and physical components of access, there is still room for more research explicitly addressing what shapes people's access to urban GI and related benefits. For instance, how can we explain and justify *non*-park use among groupings in society and what are the socio-spatial and systemic relations pertaining to park use (cf. Donaldson *et al*., 2016)? It is equally important to explore whether those who do use urban GI can actually translate their physical access into desired benefits (e.g. by applying tools to extract or process GI resources, or through trade). Such structures and mechanisms of access, when defined as the 'ability to benefit from something' (cf. Ribot and Peluso, 2003), remains to be interrogated in the South African context. This gap is also noticed by Colding *et al*. (2013) in their study on urban common property systems, management, and socioecological learning with a suggestion to further study *how* self-organized community gardens occur and *how* they benefit users. This request takes us into our second dimension of GI justice.

Procedural justice aspects in the publications center mainly around community management and inclusion. This focus comes across clearly in studies on community-based or participatory management (Chelleri *et al*., 2016; Cilliers & Cornelius, 2018; Adegun, 2018a) in for instance urban agriculture (Bisaga *et al*., 2019) or for conservation and income from indigenous plants (Ulian *et al*., 2017). Wesselow and Mashele (2019) go deeper into social networks and trust in order to emphasize the role of leadership and incentives for creating community resilience in gardening projects, and Tesfamariam *et al*. (2018) and Bisaga (2019) conclude that household participation in the food garden programs are shaped by institutional factors such as access to markets and irrigation facilities, government support, membership associations, and access to extension services and credit. These aspects can be compounded by power dynamics and the ability to decentralize leadership and self-organize (Wesselow & Mashele, 2019), which speaks to community self-agency and power dynamics (Trefry *et al*. 2014). Several studies show how lack of maintenance negatively affects GI use (McKay & Tantoh, 2021; Willemse, 2013; Shackleton & Blair, 2013), but also how local communities are often willing to contribute resources to their maintenance and should therefore be invited and involved (Shackleton & Blair, 2013), keeping an eye on gender roles (Bisaga *et al*., 2019), potential conflicts and social exclusions (Adegun, 2018a).

Although called for by some scholars (Angelstam *et al*., 2017; Colding *et al*., 2013), deeper issues of rights studied by political ecologists, such as tenure security, property regimes, and user rights, are only explicitly addressed in a few of the reviewed publications, including Thornton (2009) on land rights and community-based agriculture in a peri-urban context, and Shackleton and Shackleton (2016) on land tenure and invasive species control. More often such rights are not part of the study or are addressed peripherally (e.g. Bahta *et al*., 2018). For instance, Connor and Mtwana (2018) briefly discuss fencing of urban GI as a way to claim ownership or to control access of people and/or animals, van Averbeke (2007) notes how land (re)claims can constrain urban agriculture, and Davids *et al*. (2016) spatially map the distribution of urban ecosystem services relative to categories of ownership. The overall limited focus on rights in the literature connecting GI and justice is peculiar, since rights are strongly connected to legal ownership – and access to – urban GI, since access is essentially right-based, whether being legal or illegal (i.e. not socially sanctioned by state and society) (cf. Ribot & Peluso, 2003). The reviewed publications expose several reasons for advancing rights-based research in GI justice studies, one being that substantial portions of urban ecosystem services hotspots lie outside of formally regulated and managed conservation areas (see Davids *et al*., 2016). Other reasons are that incentives and responsibilities to manage GI are related to property ownership (Shackleton & Shackleton, 2016), that property typologies differ in their greenness (Shackleton *et al*., 2014), and that rights-based approaches can help uncover how people can use common, unmanaged land and define their own boundaries of ownership (Thornton, 2009). A deeper analysis of laws, regulations, enforcement, and perceptions of rights would be interesting as part of (procedural) urban GI justice perspectives.

Several of the reviewed publications center on informal urban settlements (Adegun, 2017, 2018a, 2018b; Bisaga *et al*., 2019; van Averbeke, 2007; Lategan and Cilliers, 2016) and address procedural justice – including rights and property aspects – related to the disadvantages, value-attachment and basic needs of people living in such settlements. The GI relevance is equally clear, as when Kaoma and Shackleton (2015) note that the contribution of non-timber forest products from urban trees was the highest (33%) amongst the poorest, informal migrant sectors (see also Shackleton *et al*. [2014] on low-cost housing and urban greening). Or as noted by McKay and Tantoh (2021) concerning local discontent with littering, dumping and environmental degradation in informal settlements. While these important issues strongly connect to procedural justice, they are also rooted in our third dimension of justice: Recognition.

Recognitional aspects, such as social identity and values related to urban GI, is the justice dimension with the least *targeted* coverage when looking across the reviewed publications, meaning that it is more often peripherally than centrally addressed. It is also the most abstract and intangible dimension to pin down. Recognitional justice in the reviewed literature ranges from spiritual values (Shackleton *et al*., 2015) and shared identity and heritage (Cocks *et al*., 2016) to the sometimes overlapping and undefined notions of sense of place, sense of community, or sense of belonging in relation to urban GI (Radebe & Irurah, 2016; Denoon-Stevens & Ramaila, 2018). Sense of ownership (or the lack hereof), which is an aspect related to procedural justice and rights, stands out in several studies as a key catalyst (or barrier) for people to take responsibility for gardening, livestock, or maintenance related to urban GI (Angelstam *et al*., 2017; Connor & Mtwana, 2018, Lucke *et al*., 2019; Shackleton & Shackleton, 2016; Wesselow & Mashele, 2019). Gender perspectives, sometimes in connection with sense of ownership (e.g. Bahta *et al*., 2019), are central in work by Connor & Mtwana (2018), Trefry, Parkins, & Cundill (2014), and Nemutamvuni *et al*. (2020), which are all on food security. While other studies shed some light on safety-of-access concerns (Cocks *et al*., 2016), cultural relations (van Averbeke, 2007), representation in decision-making (McKay & Tantoh, 2021) – thus cutting across the three justice dimensions – the missing gender perspectives are also recognized as a study limitation by some scholars (Paganini & Lemke, 2020).

Connecting the three justice dimensions, the study by Trefry *et al*. (2014) weaves together several key elements of recognitional justice, such as power, gender, identity and institutions, to explore how cultural change is linked to food security. Culture as an organizing concept with enhancing and various constraining practices, they say, does not receive suffient attention in the published research. Their study exemplifies the important linkages between distributional (food security), procedural (power, instituions) and recognitional (identity, culture) justice which are all connected to urban GI in South Africa. We now turn from these core dimensions to the governance layer (Figure 1).

Governance perspectives

In terms of justice in urban GI governance, we examine whether and how various perspectives are covered in the reviewed publications, such as:

- inclusion of and collaboration between different social groups,
- integration of different forms of knowledge, perceptions, expertise, and notions of justice, and
- social learning and adaptive capacity.

In their work on community resilience in local urban gardening networks, Wesselow and Mashele (2019) manage to cover all aspects we were searching for related to justice in urban GI governance, i.e. social inclusion, collaboration, learning, adaptive capacity and knowledge integration (see Section 2). They do so by tying their study of leadership structures to lessons on shared values and ownership among a diverse mix of gardening group members, and to the creation of community resilience in the shape of building trust, collective learning, and redundancy in leadership functions to ensure continuity in case of changes. They specifically note how a no-money approach fostered group cohesion, encouraged voluntary commitment, and limited conflicts while also lowering power imbalances and dependency on food purchases.

Attention to governance illuminates the differences – and sometimes tensions – between different people's perceptions of urban GI, its benefits and risks, and the priorities of government, local authorities or conservation practitioners. Studies discussing competing priorities and trade-offs, especially between State authorities and local people, exemplify how these tensions are covered in the literature. For instance, Cocks *et al*. (2016) elaborate how essential delivery of basic services like housing or sanitation often happens at the expense of environmental protection, while other scholars weigh nature conservation agendas against the physical security of local communities (Graham 2015). Other studies balance provisional and recreational upgrading desired by city authorities against residents' urgent need to first stop an ongoing degradation of their urban GI (McKay & Tantoh, 2021), or contrast the need for provisioning ecosystem services against colonial notions of recreation and aesthetics (Shackleton & Njwaxu, 2021; Shackleton & Gwedla, 2020). Nemutamvuni, McKay, & Tantoh (2020, p. 2) express how "[g]overnments are also often caught in a difficult position in terms of balancing economic growth with conservation of biodiversity", for instance when private property developers view urban GI as 'vacant' spaces to be utilized. A priority balance, also in terms of physical access to and quality of urban GI, is something that government officials and urban planners need to find (Willemse, 2013).

Several studies respond to these challenges by showing the value of transdisciplinary and collaborative – often experimental – co-production of knowledge and learning across stakeholders (e.g. Jiusto & Kenney, 2016; Angelstam *et al*., 2017). We explore the potentials of these approaches in Section 5. Other studies explicitly reflect upon knowledge and expertise when discussing urban GI and justice in South Africa. Attention is often tied to discussions about (problematic) North-South relations and Western mindsets (Leonard, 2012; Mudaly, 2018; Paganini & Lemke, 2020), which is a highly relevant governance aspect in an African and broader Global South city context, and perhaps particularly in South African due to the history of Apartheid and its legacies (Shackleton & Gwedla, 2021, Venter *et al*., 2020). Several scholars investigating urban GI benefits and access contextualize their studies with an explicit focus on these Apartheid legacies (e.g. Leonard, 2013; Shackleton & Gwedla, 2021; Donaldson *et al*., 2016; Thornton, 2009; Willemse, 2013; Lategan & Cilliers, 2016) tying closely to spatial urban planning perspectives and their inevitable justice and governance implications. Venter *et al*. (2020 p. 1) even coin the term "Green Apartheid" to unfold how "[u]rban green infrastructure remains unequally distributed across income and race geographies in South Africa." Their problem framing and findings are symptomatic of the dominant distributive notion of justice across the publications mentioned above. This leads us to our last analytic layer, namely the frame and scales of justice (Figure 1).

Scales and frames

Following McDermott *et al*. (2013), we round up our review by zooming out from the core dimensions and governance perspectives of the publications to pay attention to the temporal and social scales of justice, and the framing of equity goals and parameters as presented in the reviewed literature. As mentioned above, spatial distribution of GI and land use priorities are often framed as the main problems, and urban planning during the Apartheid period often sets the historical context and baseline in the reviewed literature (Venter *et al*., 2020). Few studies go deeper into root causes or further back in time (Shackleton & Gwedla, 2021). Many studies are locally focused (one city or province), and few take a regional or cross-regional perspective, with some exceptions, most notably Paganini and Lemke (2020), Venter *et al*. (2020), and Donaldson *et al*. (2016). The shortage of spatially comparative cases was noticed by Radebe and Irurah (2016), who argue for the need to understand why urban recreational parks similar in size, design and amenities differ across neighborhoods in terms of place attachment and use.

The temporal scale and societal target in many of the reviewed studies is often limited to present income groups (e.g. Willemse, 2013) with less attention to different types of wellbeing assets (with the exception of Cocks *et al* 2016), different generational groups, or changes in assets and group compositions over time. This dominantly static approach in the studies rests on tangible factors, like distance to urban parks and income, and reflects a focus on distribution as the equity or justice goal, as noted earlier. The choice of distributive justice parameters is explicitly shared in a few studies (Venter *et al*., 2020), while others argue in favor of investigations *explaining* the distribution of environmental risks and benefits (Leonard, 2012). This tendency could be an attempt to measure the lack of change in the spatial effects of Apartheid that deliberately distanced marginalized

people from resources. Nevertheless, existing literature on urban GI and justice leaves room for research with broader, deeper, and more dynamic spatial, temporal, and social frames of justice.

5. Perspectives: Potential avenues of justice research

The publications connecting urban GI and justice in South Africa above show a wide coverage of important topics, a large pool of existing data, a deep knowledge about people and places, and an eagerness to ask critical questions and move research agenda forward. The deep dives into local situations in particular (e.g. Trefry *et al*. 2014; Wesselow & Mashele, 2019) provide strong local evidence on how the connection between urban GI and distributional justice play out in reality, an aspect which is central to political ecology research (Svarstad & Benjaminsen, 2020). On the other hand, while our review shows a focus on physical access (to GI) and participatory GI management, we find that less attention is given to the sociopolitical mechanisms shaping people's access and inclusion. This gap leaves room for deeper right-based analyses, gender perspectives, and transnational learning that go beyond proximate dimensions of access into deeper processual aspects, with greater cross-fertilization between political ecology and urban GI specialists (Ranganathan & Balazs, 2015). Governance aspects of urban GI justice center on competing land use priorities among stakeholders, and while there are discussions of GI knowledge and expertise, less is said about the capacity of various people and places to adapt to the ever-changing ecological and sociopolitical urban GI landscape.

Leaning on the analysis of trends and gaps above, we emphasize three promising interlinked avenues of research which we believe can advance our understanding of urban GI justice in South Africa. The first concerns the typical selection of topics, scales and groups of justice illustrated above. The current focus on current spatial distribution of GI benefits is indeed relevant and therefore perhaps expected, but nonetheless constraining (see also Zuniga-Teran *et al*., 2021). We live in a time with unforeseen and sometimes rapid and extreme changes in urban GI conditions and uses, caused by external factors such as global pandemics and climatic changes, as well as internal system changes and social developments. This is not only true for (South) Africa. Also European and US urban GI justice scholarship should seek a more explicit justice framing and a deeper understanding of "the political dynamics of the urban environment [which] is increasingly important in an age in which expanding urban populations, increasingly complex urban networks and a more rapidly fluctuating climate test the boundaries of urban-ecological systems" (Rutt & Gulsrud, 2016, p. 126).

Globally, a broader, deeper and more dynamic bottom-up approach to urban GI justice would be valuable, navigating "with foresight rather than hindsight, […] the complex dynamics in multi-scalar contexts" (Adegun 2018, p. 793), "untangling the real problems" around marginalization, systemic change, and agency (Paginini & Lemke 2020, p. 1016), applying activits-led and participatory action approaches (Martinez-Alier *et al.,* 2014; Pietta & Tonomi, 2021)

There is room for studies to go beyond local snapshots of present-day distributive inequalities towards addressing human and system capacities, a point also made by Svarstad and Benjaminsen (2020) arguing that environmental justice research can benefit from deeper investigations of power and (how to change) underlying causes of injustice. As Zuniga-Teran *et al*. (2021, p. 235) argue in their global review on place-based urban GI justice studies, "there are real, practical, and planning-related advantages to better analyzing how and why injustices occur in GI design, planning, siting, and implementation." Such analyses could be done through rights-based and recognitional approaches exploring the local (co-)management processes needed to adapt to upcoming known and unknown challenges, local needs, and to build local and regional adaptation capacity – both social and ecological. This is in line with Cilliers *et al*. (2014) who recognize the importance of prediction and scenario building in urban planning as part of a transdisciplinary approach connecting with urban ecology and environmental management. They note how environmental governance should contribute more to transdisciplinary urban GI planning approaches – and indeed to critical transnational learning (Ranganathan & Balazs, 2015, 266) – by asking "who makes decisions in relation to which mandate and how does the decision making process work?" Such questions are particularly important to ask when studying the complex spectra of formal-informal, public-private, and managed-unmanaged spaces of urban GI (Breed *et al*., 2023). More dynamic, adaptive mindsets would also embrace an observation by Sardeshpande and Shackleton (2020), who cite urban land managers stressing the uncertainties in the flows and yields of ecosystem services and the

abstract nature beyond their control. We echo these calls for more anticipatory, inclusive, and dynamic research scales and approaches, which more explicitly incorporate uncertainties and capacities to adapt to both climate and ecological changes as well as to projected social developments (Ziervogel *et al*., 2017; Tschakert & Dietrich, 2010; Colding *et al*., 2013). A transformative change in policy and practice with inclusion of a broad range of stakeholder perspectives is needed to achieve truly multifunctional benefits from GI that address strategic objectives of cities (Titz and Chiotha, 2019). Urban Political Ecology studies can lead the way with participatory action research studies on changing socio-natural relationships, citizen-expert interactions, and place-making (power) dynamics transforming and re-transforming the urban landscape (Pietta & Tonomi, 2021).

The second avenue – in line with the need for a more dynamic mindset – is strengthening the interface with the ecological or broader natural science component of GI justice research, which is too often "left out" (as also mentioned by Anderson *et al*., 2014). This was a complaint also made about political ecology studies broadly speaking (Walker, 2005), many of which have environmental justice at their core. Inspired by the reviewed literature and related recent publications, examples of relevant ecological focus areas for urban GI justice studies in South Africa could include:

1. *biodiversity*, its distribution and conditions, its multifunctional benefits, and the various perceptions affecting people's use of and relational values to urban GI (for inspiration, see Graham, 2015; Cocks *et al*., 2016; Sardeshpande & Shackleton, 2020; Shackleton & Shackleton, 2016; Gwedla & Shackleton, 2017), and the moral and ethical obligation to protect and preserve other living beings (Dickman *et al*., 2015)
2. *livestock grazing,* its ecological effects in terms habitat diversification (Filazzola *et al*., 2020), its impact on biodiversity (Koch *et al*., 2019; Wessels *et al*., 2021), its sociocultural meanings and benefits (Thondhlana *et al*., 2022) across GI users, planners and managers, and the GI management implications (so far mostly discussed as negative in terms of urban GI and crop damage, see Shackleton & Njwaxu [2021], Venter *et al*. [2020])
3. *climate change* impacts and risks, including extreme events like flooding (Musyoki *et al*., 2016), droughts (Windfield, 2024) and heat waves, affecting species compositions, garden irrigation, drinking water, etc., which in turn affect people (differently) across time, space, wealth gradients, age, gender, ethnicity, etc.
4. *nature management* approaches, such as strict protection by fencing, tree planting (Gwedla *et al*., 2022), regulation of wild plant harvesting and other traditional practices in urban protected areas (Wessels *et al*. 2021), management through urban foraging (Sardeshpande & Shackleton, 2020), and rewilding, illustrating different types of management with dramatically different rights, repercussions and perceptions across GI users (and managers).

These areas of potential focus are not mutually exclusive, nor are the above topics not covered to some extent in the reviewed literature. However, some areas like nature management typologies or the role of animals (domestic or wild) feeding or living in urban GI, deserve more attention from a justice perspective, especially in the light of the dynamic context and contested conditions in relation to for instance climate change and land rights.

The third avenue embraces the latter two and points towards more collaborative, action-minded and applied research. One could even call it a "socially inclusive communicative approach" (Breed *et al*., 2015) leaning on inter- and transdisciplinary to integrate GI dimensions and perspectives (Zuniga-Teran *et al*., 2021). This avenue could be aided by inclusion of concrete scenario-building and design proposals for greener urban planning (Breed *et al*., 2015; 2023) integrating power and justice perspectives in real-life situations connecting and contributing to environmental justice research and political ecology studies alike.

Within the literature connecting urban GI and justice anchored in urban planning, several studies call for design interventions (Cilliers & Cornelius, 2018, Sardeshpande & Shackleton, 2020), but remarkably few integrate an architectural (urban) landscape design component, even when topics like nature perceptions, access,

maintenance (especially pollution and security), and ownership are central. As mentioned by Garekae and Shackleton (2020) on the benefits and barriers of urban foraging, there is need for designing multi-functional urban spaces promoting various activities, such as foraging of wild species, by specific identification and reservation of "spaces endowed with appropriate species, within easy access, as a core component of more holistic green infrastructure planning" (p. 9). Breed (2022) notes a strong tendency by local designers – also evident in some GI and justice-related publications (e.g. Shackleton *et al* 2017; Garekae & Shackleton (2020) – to emphasize nature's functional utility values, trading off qualitative concerns, such as the therapeutic, aesthetic, enjoyment and spiritual value of landscape (see Cocks *et al*. 2016). These tendencies compromise value pluralism. Instead, designers could formulate design activities and experiences that build on local nature relationships that were historically neglected, keeping in mind "maintenance" components balancing the duality of novelty (change) and normality (embeddedness), should the designs become reality through experimentation (Broto & Bulkeley, 2013).

While many of the planning and design visions proposed in publications we reviewed do not give detailed concrete design proposals or interventions, they call for a stronger focus on how landscape design could inject a more innovative, dynamic, forward-looking, practical, and aesthetic voice into the current scholarly literature, especially by integrating visual representations and concrete physical proposals into existing debates. Design studies could use visual representations to propose GI design alternatives (not limited to): access pathways, alternative lighting and other hard infrastructure; facilities such as playgrounds, medicinal / food gardens and waste handling; boundary demarcation including fencing typologies; accommodation of ecological dynamics such as livestock grazing, constructed wetlands for stormwater water filtering and re-use; and, recreational areas combined with areas for production and trade. In their reflexive study on university collaboration with eThekwini Municipality, Breed and Merhtens (2022) have shown how co-development of and exposure to real-life projects not only stimulate design students' transformative learning and build their professional capacities to transform a future city, but also provide stimulation for alternative and innovative design solutions for the municipality. Similar co-development potentials are explored by Jiusto and Hersh (2009) on student involvement in a transdisciplinary "slum" re-development project, and Mudaly (2018) on the value of Indigenous Knowlegde in teacher education curricula. In a sense, such collaborative, action-minded studies have the potential to build crossroads between the three proposed avenues by also incorporating ecology and stronger transformative dynamics.

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Appendix

Figure A.1: Nvivo qualitative coding. Overview and frequency of themes in the reviewed literature.

Recurring themes categorized/coded. Themes were identified deductively following the theoretical framework (examples in blue circles), and inductively as they occurred in the review process (examples in green circles)

Number of reviewed publications with elements of the specific theme (code)

Number of text extracts on the specific theme in total
Note that one text extract can be coded under several themes

Codes

Name	Files	References
ACCESS	27	78
APARTHEID	5	5
BLUE GRIP	15	33
DISSERVICES	6	17
Crime - security	14	26
Pollution	3	4
DISTRIBUTION	2	3
Benefits	28	66
Costs	7	10
Equity	7	12
Gender	5	11
EDUCATION	3	4
GOVERNANCE	14	23
Maintenance	10	15
Priorities	8	16
INFORMAL SETTLEMENTS	8	11
INTRO	6	8
Gap	6	12
Justification	9	12
JUSTICE	4	9
Justice framing, scope and target	5	7
KNOWLEDGE	9	13
Collaborative learning	2	7
Co-production	3	6
Education	6	7
METHODS	3	4
NORTH-SOUTH	13	32
PERCEPTIONS	19	38
PLANNING AND DESIGN	4	8
PROCESS	3	3
Conflict	1	1
Decision	3	6
Participation	22	41
Politics	2	4
RECOGNITION	8	13
Identity	9	21
Ownership	17	35
Values	6	7
SPECIES, NATIVE etc	13	34
SURVEY QUESTIONS	11	39
WAY FORWARD	19	42
Planning	14	27