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Planning for the Local Impacts of Climate Change: Nobody Left Behind?

Editor
Mark Seasons

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Editorial

The Equity Dimension of Climate Change: Perspectives From the Global North and South

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Abstract
The articles in this thematic issue represent a variety of perspectives on the challenges for equity that are attributable to climate change. Contributions explore an emerging and important issue for communities in the Global North and Global South: the implications for urban social equity associated with the impacts caused by climate change. While much is known about the technical, policy, and financial tools and strategies that can be applied to mitigate or adapt to climate change in communities, we are only now thinking about who is affected by climate change, and how. Is it too little, too late? Or better now than never? The articles in this thematic issue demonstrate that the local impacts of climate change are experienced differently by socio-economic groups in communities. This is especially the case for the disadvantaged and marginalized—i.e., the poor, the very young, the aged, the disabled, and women. Ideally, climate action planning interventions should enhance quality of life, health and well-being, and sustainability, rather than exacerbate existing problems experienced by the disadvantaged. This is the challenge for planners and anyone working to adapt to climate change in our communities.

Keywords
climate change; disadvantaged communities; environmental justice; equity; vulnerability

Issue
This editorial is part of the issue “Planning for the Local Impacts of Climate Change: Nobody Left Behind?” edited by Mark Seasons (University of Waterloo, Canada).

1. Introduction

This thematic issue explores an emerging and important issue: the implications for urban social equity associated with the impacts caused by climate change. Much is known about the technical, policy, and financial tools and strategies that can be applied to mitigate or adapt to climate change in communities. We also know that the local impacts of climate change are experienced differently by socio-economic groups in communities. This is especially the case for the disadvantaged and marginalized—i.e., the poor, the very young, the aged, the disabled, and women. Ideally, climate action planning interventions should enhance quality of life, health and well-being, and sustainability rather than exacerbate existing problems experienced by the disadvantaged.

It is now time to consider what all this means for the people with whom, and for whom, we plan our communities, and plan for climate change. In this issue, we ask what this all means from an equity and social justice perspective. Who benefits and who loses from the impacts of climate change? Whose lives are made worse off? Who should participate in climate action planning? How do we identify areas of vulnerability? What is the state of theory and practice?

Of course, there is no single, representative experience in the Global South, nor in the Global North for that matter. Context is always the key consideration, whether planning in the Global North or Global South. This selection of articles offers important insights into the challenges faced by communities in both global regions, and the effort to address, and manage, inequity caused or made worse by climate change.

2. Overview of the Thematic Issue

In the lead-off article, Swanson (2021) poses really interesting and relevant questions in her contribution: Are

we considering and integrating equity when planning for climate change? And if so, how? The reality is that while a growing number of cities are preparing for climate change by developing adaptation plans, little is known about how these plans and their implementation affect the vulnerability of groups experiencing various forms of underlying social inequity. Accordingly, this article provides some much-needed theoretical context for our consideration of the state of practice and synthesizes the extant research that explores the justice and equity issues inherent in climate change adaptation. Swanson's analysis suggests that climate change adaptation planning favours certain privileged groups while simultaneously denying representation and resources to marginalized communities; this finding is clearly worrisome. The article begins to unpack the relationship between social inequity, vulnerability, and adaptation planning, providing the necessary background for future research that examines whether, and to what extent, urban adaptation plans acknowledge and prioritize social vulnerability.

With that conceptual context in place, we then move to a discussion of the varied experiences with the integration of social equity in climate change planning from settings in the Global North and Global South. This challenge is addressed here through two sub-themes: the first explores how decisions are made when planning for climate change, and the role(s) of communities in that process; and second, the various decision-making strategies and tools that could be used to address the impacts of climate change with regard for considerations (i.e., the imperatives) of social equity objectives.

As Cash (2021) explains in her article, people who live in informal settlements in the Global South are especially vulnerable to extreme weather events and their consequences, such as flooding, landslides, and fire that are regular occurrences. Communities located in coastal areas face severe challenges from seasonal and typhoon-induced flooding; this is especially concerning because these places lack the resources and capacity to plan for and manage these impacts. Cash's research shows that unstable and inequitable land rights practices exacerbate community vulnerability because residents already live in really precarious states. A case study is offered in this article to illustrate the nature of a common challenge, and to examine solution possibilities that could be applied elsewhere. The article focuses on the efforts to secure tenure and upgrade their community by the residents of Sitio Libis, located in Canumay East, City of Valenzuela, Philippines. Cash's research demonstrates that enabling conditions created by government and/or NGOs are required for transformational outcomes; however, local resources, skills, and knowledge are not sufficient by themselves. Cash's findings highlight the potential contribution of "smart partnerships" among state-civil society-private sector actors in support of small-scale (i.e., community-based) climate action.

We see the importance of context—and of the perspectives of our communities' young people—in Zimba et al. (2021). The authors note that, globally, meaningful youth participation in planning processes aimed at dealing with climate change impacts has been advocated for sustainability purposes through, among others, the UN Framework Convention on Climate Change. The city of Mzuzu, Malawi, serves as a case study that illustrates broader trends and patterns in climate adaptation planning processes. The authors explain that local community members have been involved in planning processes at the community level. However, they note that an equitable representation of the community's different age and cultural groups has not been considered; the city's youth, in particular, have been marginalized because they have been excluded from these decision-making processes. This article assesses the factors affecting youth involvement in the planning process, leading to a set of recommendations for a youth-oriented engagement strategy.

We know that cities have a dual role with regard to climate change: they produce the majority of greenhouse gases, and the adverse impacts of climate change are most pronounced in cities. This reality is addressed in Wendnagel-Beck et al.'s (2021) article. They argue that cities evolve over time, and therefore our approach to planning for climate change impacts must be adaptive and responsive to a changing community context and reality. This calls for a research and planning process that monitors and evaluates changes in the community's economic structure, physical form, and functional and social characteristics. That approach, in turn, requires the collection and analysis of data and information that is meaningful and informative. In this regard, the authors note that multi-dimensional approaches are needed to capture urban changes in city form and function; this includes mobility patterns, land use, land cover, economic activities, socio-demographic characteristics, or human behavior—factors that should be considered individually and cumulatively. They examine how urban structure types are used in local adaptation strategies, to develop recommendations, and to set concrete targets for climate adaptation with special regard for human vulnerability to adverse impacts. To do this, the authors focus on the German cities of Karlsruhe and Berlin as exemplars of this planning approach. The comparative analysis provides new insights into whether and how climate adaptation plans consider physical and social structures. Based on the analysis, Wendnagel-Beck et al. offer recommendations about how to address and integrate both aspects in an adaptation-focused planning process.

The impacts of climate change are most pronounced in delicately balanced, and therefore vulnerable, ecosystems. This is certainly the situation in Canada's North, in the community of Nunavik, Québec. In Paquet et al. (2021), we see vulnerability though an arctic climate and cultural (i.e., Inuit) lens. Communities in Canada's North are characterized by precarity of a special kind.

Nunavik's residents have experienced significant social and environmental disruptions due to climate change. They are heavily reliant on imported (and very expensive) fuel sources for power generation, specifically carbon-based fuel sources. As the authors note, over time, Nunavik's residents have taken control of these petroleum-based resources and their distribution, transforming this energy source into a major regional economic asset. Recently, there has been a transition towards renewable energy technologies (RETs) in Nunavik. Interestingly, Nunavik residents are concerned about the adverse impacts on the ecosystem caused by "clean energy" sources such as hydro-electric dams and wind turbines; diesel fuel is perceived as the better choice, with fewer immediate impacts. At first glance, this seems a sensible and comfortable transition for the community. However, continued reliance on unsustainable energy sources would exacerbate the local impacts of climate change. This article raises interesting and perplexing questions: What does equity mean in this context? Would it be fair to undermine or eliminate this important economic asset? Who would make that decision—the indigenous residents or white people? The article presents two main results: (1) the level of substantive equity depends mainly on the type of RET and on idiosyncrasies between communities, and (2) local governance and procedural equity need to be asserted so that RETs can become true catalysts for equity.

Effective and meaningful citizen engagement is a common challenge for planners and decision-makers in many communities, whether in the Global North or Global South. This subject is addressed by Wolff et al. (2021). As they explain, concerns regarding the impacts of climate change on marginalized communities in the Global South have led to calls for communities to be more active agents in the process of planning for climate change. So, how could community residents contribute in a meaningful, empowering way to the shared struggle to manage the impacts of climate change? How might appropriate technologies be used by non-experts in this struggle? Using the Revitalising Informal Settlements and their Environment (RISE) project as a case study, the article explores the use of citizen-photography methods that map flood levels and thereby contribute to project-level flood risk reduction planning processes. The research indicates that the engagement model and the technology used were key to the success of the flood-monitoring project; community residents made a real, tangible contribution. The different experiences with the practice of monitoring floods in two case study countries—Fiji and Indonesia—provide insights into the many benefits of more inclusive risk management practices.

On a related matter, the nature of the relationship between urban morphology and community vulnerability deserves attention. How does urban structure and organization of land and services affect community capacity to adapt to climate change? How might we determine the spatial and equity implications of different adaptive capacities? These important questions are addressed in the article by Barbosa and Suárez Pradilla (2021). As the authors explain, socio-spatial equity represents a challenge for Latin American cities. There is increasing awareness of the role that spatial planning plays in the effort to identify and manage inequitable access to resources and capacity, generally, a situation that has been made more complicated because of climate change. The case study focuses on the northern limits of the city of Bogotá. Their research proposes an approach that analyzes spatial syntax and (social) intensity of activities and infrastructure. The findings can be used by analysts to characterize the urban structure itself and identify areas of vulnerability. They conclude that the degree of vulnerability is higher, and adaptive capacity is reduced, in outlying communities compared with central areas of the city.

3. Conclusion

These articles reflect varied experiences in different parts of the Global North and Global South. While each setting is unique, it is possible to find common themes in these articles. Technical expertise and solutions are necessary, but often not sufficient factors when dealing with the local impacts of climate change. In every case discussed here, we see the value of inclusive, meaningful consultation in adaptation planning and management.

Indeed, the contributions in this thematic issue indicate that the process of planning and decision-making is often just as important, perhaps more so, than the actions taken. We also see the need to recognize agency in communities, and the important contributions that people in vulnerable communities can make in the shared struggle caused by climate change. Finally, we are reminded of the need—indeed, the obligation—to ensure that opportunities are offered for disadvantaged communities to articulate their values, needs, and wants, and to make a commitment to address the impacts of climate change in an equitable manner—so that nobody is left behind.

Conflict of Interests

The author declares no conflict of interests.

References

Barbosa, V., & Suárez Pradilla, M. M. (2021). Identifying the social urban spatial structure of vulnerability: Towards climate change equity in Bogotá. *Urban Planning*, *6*(4), 365–379.

Cash, C. (2021). Creating the conditions for climate resilience: A community-based approach in Canumay East, Philippines. *Urban Planning*, *6*(4), 298–308.

Paquet, A., Cloutier, G., & Blais, M. (2021). Renewable energy as a catalyst for equity? Integrating Inuit inter-

ests with Nunavik energy planning. *Urban Planning*, *6*(4), 338–350.

Swanson, K. (2021). Equity in urban climate change adaptation planning: A review of research. *Urban Planning*, *6*(4), 287–297.

Wendnagel-Beck, A., Ravan, M., Iqbal, N., Birkmann, J., Somarakis, G., Hertwig, D., Chrysoulakis, N., & Grimmond, S. (2021). Characterizing physical and social compositions of cities to inform climate adaptation: Case studies in Germany. *Urban Planning*, *6*(4), 321–337.

Wolff, E., French, M., Ilhamsyah, N., Sawailau, M. J., & Ramírez-Lovering, D. (2021). Collaborating with communities: Citizen science flood monitoring in urban informal settlements. *Urban Planning*, *6*(4), 351–364.

Zimba, J. M., Simbeye, B., & Chilunga Chirwa, S. (2021). Towards intergenerational equity: Analysis of youth engagement strategies in climate action planning in Mzuzu, Malawi. *Urban Planning*, *6*(4), 309–320.

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Review

Equity in Urban Climate Change Adaptation Planning: A Review of Research

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Abstract
A growing number of cities are preparing for climate change by developing adaptation plans, but little is known about how these plans and their implementation affect the vulnerability of groups experiencing various forms of underlying social inequity. This review synthesizes research exploring the justice and equity issues inherent in climate change adaptation planning to lay the foundation for critical assessment of climate action plans from an equity perspective. The findings presented illuminate the ways in which inequity in adaptation planning favours certain privileged groups while simultaneously denying representation and resources to marginalized communities. The review reveals the specific ways inequity is experienced by disadvantaged groups in the context of climate change and begins to unpack the relationship between social inequity, vulnerability, and adaptation planning. This information provides the necessary background for future research that examines whether, and to what extent, urban adaptation plans prioritize social vulnerability relative to economic and environmental imperatives.

Keywords
adaptive capacity; climate change adaptation; equity; justice; vulnerability

Issue
This review is part of the issue "Planning for the Local Impacts of Climate Change: Nobody Left Behind?" edited by Mark Seasons (University of Waterloo, Canada).

1. Introduction

As the impacts of climate change are increasingly being experienced in communities around the world, discussions about climate change adaptation have become the norm in many urban policy settings. A growing number of cities are preparing for the impacts of climate change by developing adaptation plans, but little is known about how these plans and their implementation affect the vulnerability of groups experiencing various forms of underlying social inequity (Anguelovski et al., 2016). As the pace of climate change accelerates, the perceived urgency for the adoption of climate action plans means cities may further relegate social equity considerations relative to environmental and economic imperatives. As cities plan for climate change adaptation, their interventions should reduce the vulnerability of disadvantaged groups by ensuring inclusive planning processes and equitable outcomes. Overlooking social equity concerns in adaptation planning leads to interventions that can reinforce existing trends of socioeconomic vulnerability and create new sources of inequity. Equity and justice are essential components of achieving adequate, fair, and enduring climate action (Klinsky et al., 2017). Accordingly, there is a critical need to examine whether, and to what extent, adaptation planning processes and outcomes are inclusive, equitable, and just.

Adaptation has been variably defined within the climate change context, although responding to vulnerability has emerged as a common theme in the climate justice literature (Hanna et al., 2014; Smit & Wandel, 2006). Vulnerability refers to the extent to which people and places are susceptible to the adverse effects of climate change and is a function of both exposure and sensitivity to risk (Kelly & Adger, 2000; Paavola & Adger, 2006). Vulnerability has both social and physical dimensions: Social vulnerability describes susceptibility based on social, economic, and political factors, while

physical vulnerability concerns the exposure of people and places to climatic events. Vulnerability is thus a multidimensional concept with connections to population growth, resource depletion, poverty, environmental management, equity, and (in)adequate public policies (Cardona et al., 2012). Vulnerability to specific or multiple environmental stresses ranges in scale from the household or community level to the level of the global population, although practical interventions that reduce vulnerability are most commonly found at the local scale (Smit & Wandel, 2006). It is closely associated with the concept of adaptive capacity, defined as the ability of an affected system, region, or community to cope with the impacts and risks of climate change (Smit et al., 2001). Climate change adaptation planning—the process through which communities assess their climate vulnerabilities and respond to the risks and opportunities posed by a changing climate (Canadian Institute of Planners, 2011)—is a means of enhancing the adaptive capacity of a community via projects and programs that enable the community's built, natural, and human systems to accommodate climate changes with minimal disruptions. The quality of climate change adaptation planning at the urban level is thus directly related to residents' adaptive capacity.

This review synthesizes research exploring the ways inequities are experienced by disadvantaged groups in the context of climate change. The review provides foundational information regarding climate change impacts in urban areas and the interconnections between underlying forms of social inequity, vulnerability to climate change, and adaptive capacity. This information offers context for research contributions focused on the implications of climate change for urban social equity. Specifically, the reviewed findings provide a baseline for critical assessment of the equity and inclusiveness of urban climate change adaptation planning and inform research that examines whether, and to what extent, adaptation plans prioritize social vulnerability. The relationship between social stratification and exposure to climate risks is well-understood, but the relationship between social inequities and adaptation policy responses is much less clear (van den Berg & Keenan, 2019). Meaningful inclusion of marginalized groups remains on the periphery of adaptation planning, partly due to weak recognition of disadvantaged groups (Anguelovski et al., 2016). This lack of recognition extends to the identities of these groups (i.e., knowing who the disadvantaged populations are), and their needs and priorities. This issue is tied to the need to develop a more robust understanding of vulnerability, including who is most vulnerable to climate change and in what specific ways.

Studies of vulnerability and disadvantage related to climate change must acknowledge the difference between the effects of *climate change*, and the effects of *policies that address climate change*. Both have uneven social impacts, but climate change and climate policy do not necessarily affect the same social groups in the same ways. Assessing the effects of climate change adaptation planning means identifying who gains and who loses from adaptation policy decisions. Previous assessments of this nature have revealed that adaptation actions often reinforce existing inequities and do little to alleviate underlying vulnerabilities (Adger et al., 2005). The unanticipated consequences of climate action planning include urban segregation, spatial inequity, widespread displacement of vulnerable communities, and undesirable land use planning and development interventions. These outcomes are well-documented (Anguelovski et al., 2016; Long & Rice, 2019; Sovacool et al., 2015) and it is against this backdrop that the need to improve our understanding of who is truly vulnerable has become clear. This review begins to address these issues by focusing on the relationship between inequity and vulnerability to climate-related stresses and carving out a specific area of equity-focused study within the field of climate change adaptation planning more broadly. The sections that follow describe the effects of climate change on disadvantaged groups and explore forms of inequity in the climate change planning process to provide a comprehensive overview of the equity implications of climate change and the policies and plans designed to help communities adapt to its effects.

2. Approach

The objective of this review is to provide a foundation for research that examines climate change planning from an equity perspective. The research findings synthesized in the following sections were gathered during a review of climate justice literature published in English between 2000 and 2020. The review draws on peer-reviewed publications selected from the University of Waterloo library catalogue based on an advanced search of publication titles, keywords, and abstracts using variations of the terms adaptive capacity, urban climate change adaptation, equity, equality, justice, and vulnerability. Studies focused on climate change adaptation planning approaches and outcomes in early adopter cities from the Global North and South were selected to ensure representation of diverse development and geographical contexts and corresponding sources of vulnerability. This approach establishes the relationship between pre-existing social inequity, vulnerability, and climate change adaptation across a range of social and geographic contexts. Literature focused on distributive, procedural, and recognition justice frameworks was also reviewed to explore the justice implications of adaptation interventions. Discussion of the common characteristics used to assess the quality of plans from an equity perspective was informed by a review of plan quality research to draw conclusions about the current state of adaptation planning in the context of equity. The findings presented are part of a broader effort to better

understand the relationship between social inequity, vulnerability, and adaptation policy responses.

3. The Relationship Between Climate Change and Social Inequity

Devising effective adaptation interventions requires a robust understanding of the interconnections between climate change, social inequity, vulnerability, and adaptive capacity. This means climate change adaptation planning must first and foremost consider the relationship between climate change and social inequity, specifically the ways individuals and communities are differently exposed to climate change impacts depending on factors such as income, education, race, ethnicity, gender, age, and (dis)ability. Studies of vulnerability in the context of climate change have repeatedly found that disadvantaged groups experiencing initial social inequity are disproportionately affected by climate change, resulting in greater subsequent inequity (Islam & Winkel, 2017; Thomas et al., 2018). Social inequity is multidimensional and variably refers to inequities based on demographic characteristics, inequities regarding assets and income, and inequities regarding political power and access to public resources. In the context of climate change, inequity is part of the discussion of climate justice, which is situated within the broader environmental justice movement. Climate justice discourse overlaps with, and expands, more traditional environmental justice concerns by focusing on vulnerabilities and community resilience (Schlosberg, 2013). Barnett (2006) identifies five key assumptions of the climate justice agenda which are unpacked in the remainder of this review: 1) the responsibility for climate change is not equally distributed; 2) climate change will not affect all people equally with some people and groups more vulnerable; 3) this vulnerability is determined by political-economic processes that benefit some people more than others; 4) climate change will compound under-development; and 5) climate change policies may themselves create unfair outcomes by exacerbating, maintaining, or ignoring inequities. These central claims of the climate justice debate, especially those related to the distribution of vulnerability and impacts, are inextricably intertwined.

Much of the existing research on climate justice has focused primarily on the debate over differences between countries in terms of their responsibility for causing climate change and their consequent responsibility for carrying out mitigation and adaptation activities (Islam & Winkel, 2017). It is well-understood that the countries that have contributed least to climate change will be the ones most impacted by its effects (Bathiany et al., 2018), leading to demands for redistribution efforts by those least affected and most responsible (Steele et al., 2012). In addition to addressing between-country inequities, the climate justice debate requires us to consider the relationship between climate change and within-country inequity. The following sections explore this relationship by highlighting the main channels through which the inequity-aggravating effects of climate change materialize at the urban level and describing some of the resulting local inequities that exist between areas occupied by elite versus poor urban populations.

3.1. Defining Disadvantage

In this review, disadvantaged populations are understood as those for whom underlying social inequity—and corresponding reduced adaptive capacity—causes disproportionate suffering from the adverse effects of climate change. The differential impacts of climate change on various populations are well-understood given considerable evidence suggesting that socially and economically disadvantaged people suffer disproportionately from climate impacts (Adger et al., 2005; Intergovernmental Panel on Climate Change, 2014; Jerneck & Olsson, 2008; Steele et al., 2012; United Nations Human Settlements Program, 2011). Differentiation in demographic variables such as age, gender, (dis)ability, ethnicity, education, and health are often cited as being related to both vulnerability and the ability to cope with risk (Islam & Winkel, 2017; Smit et al., 2001). Those who are unable to cope with injuries and illnesses caused by the impacts of climate change—especially children and the elderly—are also at considerable risk of being adversely affected (Davoudi et al., 2009). Previous incidents have demonstrated this reality: Most of the lives claimed by the European heat wave (2003) and Superstorm Sandy (2012) were among the poor and isolated elderly (Davoudi et al., 2009; Kunz et al., 2013), while the aftermath of Hurricane Katrina (2005) reminds us that climate events first and foremost affect economically disadvantaged populations and communities of colour (Byrnes, 2014; Schrock et al., 2015). Similar patterns of vulnerability have been documented in the Global South among women and people living in poverty (Islam & Winkel, 2017).

3.2. Climate Change and Local Inequities

There are three main channels through which the inequity-aggravating effects of climate change materialize: 1) increased exposure of disadvantaged groups to the adverse effects of climate change; 2) increased susceptibility to the damage caused by climate change among these groups; and 3) decreased ability for disadvantaged groups to cope and recover from the damage suffered. These conditions can compound individual characteristics (such as gender, age, and (dis)ability) as well as underlying forms of social marginalization (such as ethnic and racial exclusion) to create considerable vulnerability among already disadvantaged groups (Shi et al., 2016). Conversely, the inequity-aggravating effects of climate change favour more socially advantaged populations who are better prepared to respond to increased

stress from climate risks. Just as the ability to lessen one's ecological footprint is determined by education, income, and access to green infrastructure, the ability to live a climate-resilient lifestyle also depends on socioeconomic variables that determine one's ability to move to a safer area, ensure their assets, and gain access to amenities, services, and social protection (Davoudi et al., 2009; Hallegatte et al., 2018; Long & Rice, 2019). In Rio de Janeiro, Brazil, for example, poverty coupled with the lack of secure land tenure for a notable portion of the city's population make poor neighbourhoods especially vulnerable to climate change impacts that are expected to increase in severity. While these highly vulnerable sub-populations occupy low-income informal settlement areas near waterways where they are at considerable risk, relatively less vulnerable upper-class residents live in high-rise apartment buildings located in areas less susceptible to inundation (Blake et al., 2011).

In this context, the urban population can be divided into categories of the urban elite, who have the political influence and financial stability to insulate themselves from climate change, and the urban poor, who find themselves lacking the capacity to reduce the direct and indirect impacts of climate change (Davoudi et al., 2009; Long & Rice, 2019). This division of the urban population has visible implications for planning: There are notable differences between the areas occupied by the climate-resilient elite and those that are home to the climate vulnerable poor (as the Rio de Janeiro case demonstrates). Lower-income groups with reduced access to city services and amenities tend to be more susceptible to natural environmental threats and climate risks, and recent studies have demonstrated that poorer urban neighbourhoods experience slower response times and less adequate emergency services during environmental disasters (Anguelovski et al., 2016; Graif, 2016; Wamsler et al., 2013). On the other hand, the climate-resilient lifestyle of the urban elite carries the security of living in insulated areas that are less susceptible to climate risks (Long & Rice, 2019). Findings from Hallegatte and Rozenberg (2017) confirm that lower-income groups may be seriously affected by climate change even when impacts on the rest of the population are limited. In the context of limited financial resources and increased stress from climate change, socioeconomic status becomes an important determinant of vulnerability and access to services.

4. Understanding Disadvantage and Injustice

The justice and inclusivity of adaptation interventions largely depends on how planning actors define and measure vulnerability and disadvantage in a certain context. As such, gaps and shortcomings in our understanding of who is truly vulnerable to climate change can lead to adaptation plans and interventions that aggravate rather than reduce inequity (van den Berg & Keenan, 2019). Scholars have developed various categories and typologies for identifying disadvantaged populations in the context of climate change, many of which relate to how certain groups experience injustice in the process and outcomes of adaptation planning.

4.1. Acts of Commission and Omission

Anguelovski et al. (2016) categorize urban adaptation injustices as either acts of *commission* or acts of *omission*. Injustices of commission refer to adaptation interventions—such as infrastructure investments, land use regulations, or the establishment of newly protected areas—that disproportionately affect or displace poor and marginalized residents. Informal settlements in Global South cities often experience injustices of commission as governments faced with climate change engage in adaptation efforts involving resettlement programs. Informal settlements in Manila, Philippines, for example, were blamed for clogging drainage networks during devastating flooding events in 2009 and 2012, prompting the relocation of thousands of informal households away from waterway embankments as part of an effort to upgrade the city's flood management infrastructure (Anguelovski et al., 2016). Acts of commission share features of the concept of entrenchment, which Sovacool et al. (2015) define as the process by which adaptation projects aggravate political, socioeconomic, or cultural inequities, contributing to the subsequent disempowerment of disadvantaged groups. Displacement of informal settlements in the name of adaptation represents a process of entrenchment that exacerbates existing inequities and reinforces the unequal distribution of power (Shi et al., 2016). Relocated communities in Manila continue to be exposed to environmental threats in resettlement sites, where they have fewer livelihood resources to cope with impacts (Anguelovski et al., 2016). While these poorer, often minority communities are relocated to higher risk areas through processes of entrenchment and acts of commission, wealthier, formal communities remain in place.

On the other hand, injustices of omission occur when the protection of wealthier communities or assets is prioritized over the protection of poorer or marginalized ones (Anguelovski et al., 2016). In New Orleans, for instance, power imbalances and social inequity between wealthier, whiter neighbourhoods, and lower-income communities of colour have limited local efforts to upgrade urban infrastructure in ways that would better protect minority residents from climate risks (Anguelovski et al., 2016). Acts of omission often occur when adaptation is framed as a private responsibility rather than a public good or when planning processes exclude impacted communities. Such plans usually result in the protection of elite groups and economically valuable areas at the expense of low-income or minority neighbourhoods. Acts of omission resemble practices of exclusion, which occur when adaptation projects limit access to resources for some groups or marginalize

certain populations in the decision-making process (Sovacool et al., 2015).

It should be noted that acts of commission and omission often occur as part of broader efforts to mainstream adaptation in national development planning. The links between development and adaptation—specifically the relationship between poverty and adaptive capacity—have resulted in efforts to address the two in an integrated way (Ayers et al., 2014; Sherman et al., 2016). A full discussion of mainstreaming adaptation in development is beyond the scope of this review, but it is worth noting that vulnerable populations are disproportionately exposed to the negative consequences of poorly planned adaptation strategies that do not take inequities related to income, education, race, ethnicity, gender, age, and (dis)ability into consideration (Byskov et al., 2019). Further, retrofitting adaptation into existing development agendas—either by rebranding existing development activities as adaptation or co-opting new adaptation programs to support existing development agendas—risks maladaptation that inadvertently reinforces, redistributes, or creates new sources of vulnerability at the urban scale (Eriksen et al., 2021). Accordingly, there is concern about whether and how adaptation may be introducing new forms of vulnerability for some people and places, and about the equity dimensions of these potential redistributive effects (Atteridge & Remling, 2017).

4.2. Distributive, Procedural, and Recognition Justice

Recognizing that disadvantaged populations suffer from injustices of commission and omission in the context of climate change, the justice of climate action planning is traditionally understood as a trilogy of procedural, distributive, and recognition justices. These dimensions of justice have been variably defined in the climate justice literature, highlighting the deeply contested and context-dependent nature of ideas of fairness and justice (Shi et al., 2016). Although these terms continue to be negotiated in the context of conflicting views and interests, distributive justice is generally understood to concern the allocation of benefits and burdens among multiple stakeholders, while procedural justice is concerned with fair, transparent, and inclusive decision-making (Grasso, 2007; Paavola & Adger, 2006). Procedurally just planning enables meaningful and representative participation during the plan development and implementation process: This dimension of justice complements distributive justice by focusing on process rather than outcome, taking into account the power and participation disadvantages of marginalized groups. Although these complementary forms of justice are closely related, they are not necessarily automatically addressed together. Recognition justice emerges in the context of policy framing and analysis and considers how particular populations are made visible or invisible in policy development contexts. This dimension of justice is concerned with determining who is considered a relevant stakeholder, and which needs are included in climate-related decision-making frameworks (Klinsky & Mavrogianni, 2020). Klinsky and Mavrogianni (2020) suggest that a multivalent approach to justice that includes distributive, procedural, and recognition justice concerns may be a useful way to integrate lines of analysis within the climate justice discourse. A multivalent framework also supports a transition from *observations* of inequities to *analysis* of why these occurred and how they could be addressed by decision-making processes (Klinsky & Mavrogianni, 2020). Although a multivalent approach to justice has been used in climate-related contexts—such as the analysis of climate change mitigation policy (Klinsky, 2015)—much climate change adaptation planning has been predominately focused on achieving distributive justice (Bulkeley et al., 2013).

One of the key challenges in the application of procedural and recognition justice is ambiguity surrounding the concept of vulnerability (van den Berg & Keenan, 2019). Our understanding of what it means to be vulnerable partly depends on the emphasis placed on various dimensions of risk and vulnerability. Variables such as exposure, sensitivity to risk, and capacity to cope determine the extent to which populations are adversely affected by climate risks (Garschagen & Romero-Lankao, 2015), and as such, these variables inform our definition of what it means to be vulnerable. Our limited understanding of vulnerability is evidenced by vulnerability assessments that often do not adequately capture the social and political processes and relations that marginalize specific groups and determine how vulnerability is distributed across an urban population (Eriksen et al., 2021). Our understanding of vulnerability directly influences our definition of disadvantage in the context of climate change, which has important implications for determining who should be targeted by vulnerability-reducing interventions. Adaptation planning processes can privilege or undermine participation of certain groups by redefining what it means to be vulnerable and who is included in such definitions (Anguelovski et al., 2016), highlighting the need for variability and dynamism in the framing of vulnerability to ensure a full range of affected groups are represented. As climate change continues to shift the dynamics and distribution of inequity and risk, we need to adopt a flexible understanding of who is likely the most vulnerable and focus more attention on the potential for adaptation to inadvertently redistribute vulnerability (Atteridge & Remling, 2017).

5. Social Inequity as a Determinant of Adaptive Capacity

The previous sections of this review have established that there is a direct connection between underlying social inequity and the likelihood of being adversely affected by climate change impacts. The social, economic, and political inequities that shape local vulnerabilities also influence adaptive capacity: The ability to adapt

is thus enabled and constrained by the broader conditions influencing the vulnerability of a specific population. Eakin et al. (2014) understand adaptive capacity as being composed of two dimensions: generic and specific capacities. Generic capacities are associated with basic human development needs (e.g., health, education, economic security), while specific capacities are those necessary for managing and reducing specific climate threats. The interaction between generic and specific capacities has implications for levels of current vulnerability and the ability to adapt to future change: Populations with high generic and high specific capacities are most likely to achieve transformative adaptation outcomes that reduce overall vulnerability. While these two dimensions of adaptive capacity must be addressed explicitly and simultaneously to achieve adaptation goals, the degree of concerted attention each dimension requires depends on social and geographic context (Eakin et al., 2014). Previous research investigating the generic and specific determinants of adaptive capacity have repeatedly found economic resources to be a key driver of the ability to cope with climate risks (Brooks et al., 2005; Sayers et al., 2018; Smit et al., 2001). On the global scale, it is widely accepted that wealthier nations are better prepared to bear the costs of adaptation than poorer nations given the relationship between poverty and vulnerability. It has also been established that disadvantaged groups *within* nations are especially vulnerable to climate change because they are often more exposed to climate threats and have limited access to vulnerability-reducing resources and emergency services (Long & Rice, 2019, Smit et al., 2001).

Enhanced adaptive capacity is a practical means of coping with changes and uncertainties in climate and is a necessary condition for reducing vulnerability at the urban level. However, the socioeconomic characteristics of urban populations compound the justice and equity issues inherent in local climate change planning processes to create barriers to enhanced adaptive capacity. Inequities exist between cities in terms of their capacity and resources to plan for and respond to climate change, and between residents in terms of their ability to participate in planning processes (Chu & Michael, 2019; Shi et al., 2016). While the latter can often be attributed to inequities in economic, social, and political power, the former is primarily influenced by time and resource constraints (Byskov et al., 2019). Studies in Canada have found that larger urban areas are more apt to be engaged in some form of adaptation planning because they benefit from greater access to resources and planning capacities (Hanna et al., 2014). Within cities, the uneven distribution of adaptive capacity creates areas of higher exposure to climate impacts on one hand, and areas of relative protection from these impacts on the other (Shi et al., 2016). Unless these disparities between and within cities are addressed, adaptation efforts may reinforce patterns of urban inequity. Accordingly, there is a need to critically assess the equity and inclusiveness of climate change adaptation planning both in terms of process and outcomes (Meerow & Mitchell, 2017). The following section provides the necessary background for such an assessment by mapping the general landscape of climate change adaptation planning in the context of equity.

6. The Current State of Climate Change Adaptation Planning in the Context of Equity

The research findings reviewed in the previous sections have revealed that socioeconomic conditions determine vulnerability, which subsequently influences adaptive capacity. Findings also indicate that for adaptation efforts to be effective and socially accepted, they must strive to advance distributive, procedural, and recognition justice goals. These findings have important implications for effective climate change adaptation planning, yet the degree to which equity considerations are integrated into climate action plans remains under-researched. Despite growing efforts to mainstream climate change adaptation at the local level, it remains unclear whether adaptation efforts are helping to resolve inequities (Anguelovski et al., 2016), and "very little research has examined the actual distributive outcomes of ongoing and proposed adaptation interventions on the ground" (Shi et al., 2016, p. 132). There is also ongoing debate among scholars about the degree to which reactive versus anticipatory adaptation actions exacerbate or reduce vulnerabilities, although the details of that debate are beyond the scope of this review.

6.1. Procedural Justice in Climate Change Adaptation Planning

In cases where issues of equity and justice are considered, studies predominately focus on distributive justice, or the outcomes of adaptation processes. Consequently, procedural justice, or fairness in the process of planning climate change adaptation efforts, is often overlooked (van den Berg & Keenan, 2019). Building equity into adaptation efforts hinges on the capacity of actors from marginalized communities to engage and actively participate in local adaptation planning efforts (Schrock et al., 2015). Thus, enhancing the procedural justice of adaptation planning practice calls for broader and more meaningful participation of marginalized groups. Recognizing this reality—and given the fact that procedural justice receives less attention from planners than distributive justice concerns—the remainder of this section focuses on procedural justice and equity in planning processes.

Planners generally agree on the importance of broad participation in policy responses to climate change, and calls for public participation in the development of adaptive responses are prominent in major policy documents on climate change that guide urban adaptation (notably the United Nations Framework Convention on Climate Change and the Third Assessment Report of the Intergovernmental Panel on Climate Change). The merits

of community engagement in planning processes are also widely recognized, including increased quality and legitimacy of decisions (Paavola & Adger, 2006; van den Berg & Keenan, 2019) and generating buy-in from community members which aids in plan implementation (Guyadeen et al., 2019). Byskov et al. (2019) further argue that there are moral and knowledge-based reasons for including civil society actors in adaptation planning processes: Vulnerable communities possess valuable knowledge about local conditions that informs effective adaptation, and these populations have a right to influence the development of adaptation plans that affect them. Although cities often reference inclusion in their adaptation planning documents (Chu & Cannon, 2021), this consideration appears surface-level given several studies that have concluded there is room to improve procedural equity in actual decision-making processes. For example, a recent survey of municipal climate change plans in 63 of the most populous communities across Canada found that only 40% of plans identified public participation as part of the plan creation process, and only 35% discussed the purpose of broader participation at all (Guyadeen et al., 2019). These findings are consistent with previous plan quality studies that have found limited evidence of stakeholder engagement or public participation during plan development (Baker et al., 2012; Fu et al., 2017). These studies reveal that despite the importance scholars and practitioners ascribe to public participation, cities often overlook this element of the climate change planning process.

One reason for this oversight may be the tension between the urgent need for adaptation and the resource- and time-demanding processes required by justice ideals (Byskov et al., 2019). Procedural injustice may also be attributed to the apparent trade-off between broadly inclusive planning processes and long-term program stability. A comparison of inclusive approaches to urban climate change adaptation planning by Chu et al. (2016) revealed that in Quito, Ecuador, broad-based participatory planning approaches that engage citizens and affected communities have led to equally broad adaptation plans that lack specificity in how adaptation interventions are to be implemented, financed, and politically sustained. In contrast, adaptation planning approaches in Surat, India, which feature procedural justice considerations less prominently and instead emphasize strategic partnerships between key government, private, and civil society actors, have supported the implementation of durable adaptation projects but denied voice to vulnerable groups (Chu et al., 2016). While the latter approach appears more likely to ensure long-term program stability, this approach also confines decision-making responsibilities to a few elite community leaders and restricts the representation of marginalized groups in future programs and plans. These findings highlight an apparent trade-off between procedural justice considerations that ensure equity and justice outcomes in the short-term, and long-term viability of adaptation agendas. This is a trade-off that climate change adaptation planning is yet to fully eliminate.

6.2. Plan Quality in the Context of Equity

Plan quality measures the extent of the presence or absence of key components within a plan and has become an established framework for assessing the strengths and deficiencies of plans. Plan quality literature highlights eight commonly referenced characteristics that researchers have used to assess various types of plans across different scales. These characteristics focus on both the content and procedural aspects of plans and reflect consensus among researchers regarding the baseline characteristics that comprise high quality plans (Guyadeen et al., 2019). These characteristics include: 1) fact base; 2) goals; 3) policies; 4) implementation; 5) monitoring and evaluation; 6) inter-organizational coordination; 7) participation; and 8) plan organization and presentation. The participation characteristic is especially relevant for advancing equity in climate change plans because it focuses on how various groups are engaged and represented during the plan creation process. As such, the remainder of this section focuses on the participation characteristic.

Participatory planning processes serve to give voice to local concerns regarding the adverse impacts of climate change and help identify demographics that are particularly vulnerable to these impacts. Amplifying the voices of the most vulnerable during participatory decision-making processes grounds adaptation interventions in a sound understanding of vulnerability and increases the likelihood that the priorities and needs of vulnerable populations will be incorporated into policy (Byskov et al., 2019; Forsyth, 2018). Local patterns of vulnerability are dynamic: The relative importance of indicators such as age, race, ethnicity, and gender changes over time (Kashem et al., 2016; Thomas et al., 2018). Therefore, to maximize the procedural fairness of adaptation planning for the benefit of vulnerable populations, van den Berg and Keenan (2019) argue two things must be done. First, we must develop our capacity to frame and measure vulnerability in dynamic terms, and second, we must acknowledge, engage, and provide representation to vulnerable populations. Intentional inclusion and representation of marginalized groups are key elements of Sandercock's (2009) conception of the right to the city; that is, the right to presence, to occupy public space, and to participate as an equal in public affairs. The argument for prioritizing these aspects of the participation process is self-evident: To have meaningful participatory engagement, planners need to know who to engage with (hence the emphasis placed on improving our understanding of vulnerability). Moreover, an intervention that is successful for one individual may not be considered successful by another, highlighting the need for recognition and representation of vulnerable populations' range of interests, needs, and priorities during

the planning process. Conversely, lack of meaningful public engagement and recognition of marginalized communities' development visions exacerbates procedural and recognition justice concerns and increases distrust in local plans.

Beyond participatory planning processes, efforts to adapt should promote more transformative solutions that deliberately address underlying drivers of vulnerability and forms of socio-spatial inequity (Pelling et al., 2015). Yet, cities in the Global North and South appear to overlook social equity considerations relative to environmental and economic imperatives (Schrock et al., 2015). Indeed, growing evidence suggests policy priorities are being oriented toward an "increasing focus on strategically important environmental resources and assets and the weakening of the commitment to comprehensive approaches and concerns with social justice and equity" (Hodson & Marvin, 2017, p. 13). This trend may be a result of the perceived urgency for the adoption of climate action plans or the prioritization of neoliberal economic interests at the expense of social concerns (Trencher, 2019). In any case, overlooking social equity has the harmful effect of exacerbating existing urban inequities and providing new avenues for injustice (Intergovernmental Panel on Climate Change, 2014; Webber, 2016). Specifically, lack of attention to equity concerns leads to the absence of key participants who advocate for the interests of disadvantaged groups during the planning process. In turn, adaptive capacity in the most vulnerable communities remains inadequate. Pursuing transformative adaptation actions that are rooted in justice and equity considerations requires cities to more closely critique the plans and policies that have historically contributed to unequal access to resources. Planners must also pay more explicit attention to the distributive, procedural, and recognition justice implications of adaptation planning to avoid aggravating the vulnerability of disadvantaged groups.

7. Conclusions

This review has drawn on climate justice literature to establish the direct connection between social inequity and climate change impacts, and to clarify the ways equity and justice issues materialize in adaptation planning. Exploring various conceptions of disadvantage and vulnerability enhances our understanding of who is truly vulnerable in the context of climate change—knowledge we need to plan adaptation interventions that reduce rather than aggravate inequity. Findings from studies of climate change adaptation planning approaches in cities in the Global North and South reveal that adaptation planning affects urban equity and justice regardless of development, political, and ecological context. Moreover, inequitable climate change adaptation interventions appear to exacerbate, redistribute, and create new forms of socio-spatial inequities across diverse urban contexts.

Research has revealed that the vulnerability of a given population depends on a complex set of drivers and interacting conditions that can also influence adaptive capacity. Improving our understanding of the constraints and opportunities for enhancing adaptive capacity is necessary to promote more transformative adaptation solutions that deliberately address underlying drivers of vulnerability. Economic and environmental benefits and costs are important criteria for assessing the quality of adaptation plans, but these considerations are not sufficient to determine the overall effectiveness of adaptation measures. Equity considerations are a necessary component of adaptation planning, but more research examining whether, and to what extent, urban adaptation plans prioritize social vulnerability is needed.

The research findings discussed throughout this review illuminate the ways in which adaptation planning favours certain privileged groups while simultaneously denying resources and voice to marginalized communities experiencing various forms of social inequity. These findings inform the identification of disadvantaged groups for whom underlying social inequity causes disproportionate suffering from the adverse effects of climate change. Directions for future research include investigation into whether climate change adaptation planning at various scales adequately considers the needs and priorities of disadvantaged populations, both in terms of process and outcomes. Further exploration of the debate about the degree to which reactive versus anticipatory adaptation actions exacerbate or reduce vulnerabilities would also be useful, as would further study of the relationship between socioeconomic variables and the ability to live a climate resilient lifestyle at the household level. Finally, future research should address the challenges and trade-offs of featuring justice and equity considerations prominently in urban adaptation planning while also ensuring long-term program stability.

Greater effort to understand the complexities of vulnerability is needed given the scope of the climate challenge and the various ways in which climate change negatively impacts community development, quality of life, and sustainability (Meerow & Woodruff, 2020). As the number of cities engaging in climate change adaptation planning continues to grow, the quality of adaptation plans in terms of equity considerations should be more closely assessed. Researchers must consider whether adaptation efforts are effectively prioritizing the needs of marginalized and vulnerable populations, or whether they "merely re-package business-as-usual [planning] approaches" (Anguelovski et al., 2016, p. 332) that have historically excluded marginalized voices and made disadvantaged groups more vulnerable. This review begins to lay the groundwork for research that responds to these concerns by providing context for critical assessment of adaptation plans from an equity perspective.

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Conflict of Interests

The author declares no conflict of interests.

References

Adger, W., Arnell, N., & Tompkins, E. (2005). Successful adaptation to climate change across scales. *Global Environmental Change*, *15*, 77–86.

Anguelovski, I., Shi, L., Chi, E., Gallagher, D., Goh, K., Lamb, Z., Reeves, K., & Teicher, H. (2016). Equity impacts of urban land use planning for climate adaptation: Critical perspectives from the Global North and South. *Journal of Planning Education and Research*, *36*(3), 333–348.

Atteridge, A., & Remling, E. (2017). Is adaptation reducing vulnerability or redistributing it? *Wiley Interdisciplinary Reviews: Climate Change*, *9*(1), Article e500. https://doi.org/10.1002/wcc.500

Ayers, J., Huq, S., Wright, H., Faisal, A. M., & Hussain, S. T. (2014). Mainstreaming climate change adaptation into development in Bangladesh. *Climate and Development*, *6*(4), 293–305.

Baker, I., Peterson, A., Brown, G., & McAlpine, C. (2012). Local government response to the impacts of climate change: An evaluation of local climate adaptation plans. *Landscape and Urban Planning*, *107*(2), 127–136.

Barnett, J. (2006). Climate change, insecurity, and injustice. In W. Adger, J. Paavola, S. Huq, & M. Mace (Eds.), *Fairness to adaptation to climate change* (pp. 115–130). MIT Press.

Bathiany, S., Dakos, V., Scheffer, M., & Lenton, T. (2018). Climate models predict increasing temperature variability in poor countries. *Science Advances*, *4*(5), Article eaar5809.

Blake, R., Grimm, A., Ichinose, T., Horton, R., Gaffi, S., Jiong, S., Bader, D., & Cecil, L. (2011). Urban climate: Processes, trends, and projections. In C. Rosenzweig, W. D. Solecki, S. A. Hammer, & S. Mehrotra (Eds.), *Climate change and cities: First assessment report of the urban climate change research network* (pp. 43–81). Cambridge University Press.

Brooks, N., Adger, W., & Kelly, M. (2005). The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. *Global Environmental Change*, *15*(2), 151–163.

Bulkeley, H., Carmin, J., Castan Broto, V., Edwards, G. A. S., & Fuller, S. (2013). Climate justice and global cities: Mapping the emerging discourses. *Global Environmental Change*, *23*(5), 31–40.

Byrnes, W. M. (2014). Climate justice, Hurricane Katrina, and African American environmentalism. *Journal of African American Studies*, *18*(3), 305–314.

Byskov, M. F., Hyams, K., Satyal, P., Anguelovski, I., Benjamin, L., Blackburn, S., Borie, M., Caney, S., Chu, E., Edwards, G., Fourie, K., Fraser, A., Heyward, C., Jeans, H., McQuistan, C., Paavola, J., Page, E., Pelling, M., Priest, S., & Swiderska, K. (2019). An agenda for ethics and justice in adaptation to climate change. *Climate and Development*, *13*, 1–9. https://doi.org/10.1080/17565529.2019.1700774

Canadian Institute of Planners. (2011). *Climate change adaptation planning: A handbook for small Canadian communities*. https://www.cip-icu.ca/Files/Resources/RURAL-HANDBOOK-FINAL-COPY

Cardona, O.-D., van Aalst, M. K., Birkmann, J., Fordham, M., McGregor, G., Perez, R. S., Pulwarty, R. S., Schipper, E. L. F., & Sinh, B. T. (2012). Determinants of risk: Exposure and vulnerability. In C. B. Field, V. Barros, T. M. Stocker., D. Qin, D. J. Dokken, K. L. Ebi, M. D. Mastrandrea, K. J. Mach, G.-K. Plattner, S. K. Allen, M. Tignor, & P. M. Midgley (Eds.), *Managing the risks of extreme events and disasters to advance climate change adaptation* (pp. 65–108). Cambridge University Press.

Chu, E., Anguelovski, I., & Carmin, J. (2016). Inclusive approaches to urban climate adaptation planning and implementation in the Global South. *Climate Policy*, *16*(3), 372–392.

Chu, E., & Cannon, C. (2021). Equity, inclusion, and justice as criteria for decision-making on climate adaptation in cities. *Current Opinion in Environmental Sustainability*, *51*, 85–94.

Chu, E., & Michael, K. (2019). Recognition in urban climate justice: Marginality and exclusion of migrants in Indian cities. *Environment & Urbanization*, *31*(1), 139–156.

Davoudi, S., Crawford, J., & Mehmood, A. (2009). *Planning for climate change: Strategies for mitigation and adaptation for spatial planners*. Earthscan.

Eakin, H., Lemos, M., & Nelson, D. (2014). Differentiating capacities as a means to sustainable climate change adaptation. *Global Environmental Change*, *27*, 1–8.

Eriksen, S., Schipper, E. L. F., Scoville-Simonds, M., Vincent, K., Adam, H. N., Brooks, N., Harding, B., Khatri, D., Lenaerts, L., Liverman, D., Mills-Novoa, M., Mosberg, M., Movik, S., Muok, B., Nigtingale, A., Ojha, H., Sygna, L., Taylor, M., Vogel, C., & West, J. J. (2021). Adaptation interventions and their effect on vulnerability in developing countries: Help, hindrance, or irrelevance? *World Development*, *141*, Article 105383.

Forsyth, T. (2018). Is resilience to climate change socially inclusive? Investigating theories of change processes in Myanmar. *World Development*, *111*, 13–26.

Fu, X., Gomaa, M., Deng, Y., & Peng, Z. (2017). Adaptation planning for sea level rise: A study of US coastal cities. *Journal of Environmental Planning and Management*, *60*(2), 249–265.

Garschagen, M., & Romero-Lankao, P. (2015). Exploring

the relationships between urbanization trends and climate change vulnerability. *Climatic Change*, *133*, 37–52.

Graif, C. (2016). (Un)natural disaster: Vulnerability, long-distance displacement, and the extended geography of neighbourhood distress and attainment after Katrina. *Population and Environment*, *37*, 288–318.

Grasso, M. (2007). A normative ethical framework in climate change. *Climatic Change*, *81*, 223–246.

Guyadeen, D., Thistlethwaite, J., & Henstra, D. (2019). Evaluating the quality of municipal climate change plans in Canada. *Climate Change*, *152*(1), 121–243.

Hallegatte, S., Fay, M., & Barbier, E. B. (2018). Poverty and climate change: Introduction. *Environment and Development Economics*, *23*(3), 217–233.

Hallegatte, S., & Rozenberg, J. (2017). Climate change through a poverty lens. *Nature Climate Change*, *7*(4), 250–256.

Hanna, K., Seasons, M., Dale, A., Filion, P., & Ling, C. (2014). Planning for climate change: The state of current practice in Canada. *Plan Canada*, *54*(2), 28–36.

Hodson, M., & Marvin, S. (2017). Intensifying or transforming sustainable cities? Fragmented logics of urban environmentalism. *Local Environment*, *22*(Suppl. 1), 8–22.

Intergovernmental Panel on Climate Change. (2014). *AR5 Climate change 2014: Impacts, adaptation and vulnerability*. https://www.ipcc.ch/report/ar5/wg2

Islam, S., & Winkel, J. (2017). *Climate change and social inequality* (Working Paper No. 152). Department of Economic & Social Affairs. https://www.un.org/esa/desa/papers/2017/wp152_2017.pdf

Jerneck, A., & Olsson, L. (2008). Adaptation and the poor: Development, resilience and transition. *Climate Policy*, *8*, 170–182.

Kashem, S. B., Wilson, B., & Van Zandt, S. (2016). Planning for climate adaptation: Evaluating the changing patterns of social vulnerability and adaptation challenges in three coastal cities. *Journal of Planning Education and Research*, *36*(3), 304–318.

Kelly, P., & Adger, W. (2000). Theory and practice in assessing vulnerability to climate change and facilitating adaptation. *Climate Change*, *47*, 325–352.

Klinsky, S. (2015). Justice and boundary setting in greenhouse gas cap and trade policy: A case study of the Western Climate Initiative. *Annals of the Association of American Geographers*, *105*(1), 105–122.

Klinsky, S., & Mavrogianni, A. (2020). Climate justice and the built environment. *Buildings and Cities*, *1*(1), 412–428.

Klinsky, S., Roberts, T., Huq, S., Okereke, C., Newell, P., Dauvergne, P., O'Brien, K., Schroeder, H., Tschakert, P., Clapp, J., Keck, M., Biermann, F., Liverman, D., Gupta, J., Rahman, A., Messner, D., Pellow, D., & Bauer, S. (2017). Why equity is fundamental in climate change policy research. *Global Environmental Change*, *44*, 170–173.

Kunz, M. B., Mühr, T., Kunz-Plapp, J. E., Daniell, J. E., Khazai, B., Wenzel, F., Vannieuwenhuyse, M., Comes, T., Elmer, F., Schröter, K., Fohringer, J., Münzberg, T., Lucas, C., & Zschau, J. (2013). Investigation of Superstorm Sandy 2012 in a multi-disciplinary approach. *Natural Hazards and Earth System Sciences*, *13*, 2579–2598.

Long, J., & Rice, J. (2019). From sustainable urbanism to climate urbanism. *Urban Studies*, *56*(5), 992–1008.

Meerow, S., & Mitchell, C. (2017). Weathering the storm: The politics of urban climate change adaptation planning. *Environment and Planning A*, *49*(11), 2619–2627.

Meerow, S., & Woodruff, S. (2020). Seven principles of strong climate change planning. *Journal of the American Planning Association*, *86*(1), 39–46.

Paavola, J., & Adger, W. (2006). Fair adaptation to climate change. *Ecological Economics*, *56*(4), 594–609.

Pelling, M., O'Brien, K., & Matyas, D. (2015). Adaptation and transformation. *Climate Change*, *133*(1), 113–127.

Sandercock, L. (2009). When strangers become neighbours: Managing cities of difference. *Planning Theory & Practice*, *1*(1), 13–30.

Sayers, P., Penning-Rowsell, E. C., & Horritt, M. (2018). Flood vulnerability, risk, and social disadvantage: Current and future patterns in the UK. *Regional Environmental Change*, *18*(2), 339–352.

Schlosberg, D. (2013). Theorising environmental justice: The expanding sphere of a discourse. *Environmental Politics*, *22*(1), 37–55.

Schrock, G., Bassett, E., & Green, J. (2015). Pursuing equity and justice in a changing climate: Assessing equity in local climate and sustainability plans in US cities. *Journal of Planning Education and Research*, *35*(3), 282–295.

Sherman, M., Berrang-Ford, L., Lwasa, S., Ford, J., Namanya, D. B., Llanos-Cuentas, A., Maillet, M., Harper, S., & IHACC Research Team. (2016). Drawing the line between adaptation and development: A systematic literature review of planned adaptation in developing countries. *Wiley Interdisciplinary Reviews: Climate Change*, *7*(5), 707–726. https://doi.org/10.1002/wcc.416

Shi, L., Chu, E., Anguelovski, I., Aylett, A., Debats, J., Goh, K., Schenk, T., Seto, K. C., Dodman, D., Roberts, D., Roberts, J. T., & VanDeveer, S. D. (2016). Roadmap towards justice in urban climate adaptation research. *Nature Climate Change*, *6*(2), 131–137.

Smit, B., Pilifosova, O., Burton, I., Challenger, B., Huq, S., Klein, R. J. T., Adger, N., Downing, T., Harvey, E., Kane, S., Skinner, M., Smith, J., & Wandel, J. (2001). Adaptation to climate change in the context of sustainable development and equity. In J. J. McCarthy, O. F. Canziani, N. A. Leary, D. J. Dokken, & K. S. White (Eds.), *Climate change 2001: Impacts, adaptation, and vulnerability* (pp. 877–912). Cambridge University Press.

Smit, B., & Wandel, J. (2006). Adaptation, adaptive capac-

ity and vulnerability. *Global Environmental Change*, *16*, 282–292.

Sovacool, B., Linné, B., & Goodsite, M. (2015). The political economy of climate adaptation. *Nature Climate Change*, *5*(7), 616–618.

Steele, W., Maccallum, D., Byrne, J., & Houston, D. (2012). Planning the climate-just city. *International Planning Studies*, *17*(1), 67–83.

Thomas, K., Hardy, R. D., Lazrus, H., Mendez, M., Orlove, B., Rivera-Collazo, I., Roberts, J. T., Rockman, M., Warner, B. P., & Winthrop, R. (2018). Explaining differential vulnerability to climate change: A social science review. *Wiley Interdisciplinary Reviews: Climate Change*, *10*(2), Article e565. https://doi.org/10.1002/wcc.565

Trencher, G. (2019). Towards the smart city 2.0: Empirical evidence of using smartness as a tool for tackling social challenges. *Technological Forecasting and Social Change*, *142*, 117–128.

United Nations Human Settlements Program. (2011). *Cities and climate change: Global report on human settlements 2011*. Earthscan.

van den Berg, H., & Keenan, J. (2019). Dynamic vulnerability in the pursuit of just adaptation processes: A Boston case study. *Environmental Science & Policy*, *94*, 90–100.

Wamsler, C., Brink, E., & Rivera, C. (2013). Planning for climate change in urban areas: From theory to practice. *Journal of Cleaner Production*, *50*, 68–81.

Webber, S. (2016). Climate change adaptation as a growing development priority: Towards critical adaptation scholarship. *Geography Compass*, *10*(10), 401–413.

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Article

Creating the Conditions for Climate Resilience: A Community-Based Approach in Canumay East, Philippines

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Abstract
People who reside in informal settlements in the Global South are most vulnerable to extreme weather events and their consequences, such as flooding, landslides, and fires. Those located in coastal areas face severe challenges from seasonal and typhoon-induced flooding. Research shows that uncertain land rights exacerbate community vulnerability because residents are under constant threat of eviction by private sector actors or the state. Individual and community upgrading is rarely possible in such a situation. This article focuses on the efforts to secure tenure and upgrade their community by the residents of Sitio Libis, located in Canumay East, City of Valenzuela, Philippines. The study demonstrates that while community-based approaches require skills and capacities of community members, enabling conditions created by government and/or NGOs are required for transformational outcomes. While the people of Sitio Libis did not conceptualize their efforts in terms of climate change adaptation, their success suggests the possibility for smart partnerships among state-civil society/private sector actors to emerge in support of small-scale climate action.

Keywords
climate change; climate justice; community-based adaptation; informal settlements; just city; Manila; re-blocking; social equity

Issue
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1. Participatory Development and the Right to the City

The belief that citizen-led, community-based approaches will result in positive developmental outcomes is persistent across disciplines and issue areas (Dale et al., 2020; Lang et al., 2020; Mathie & Cunningham, 2008; Westoby et al., 2020). Participatory theories and methods emerged in the 1960s in response to failed and/or contested projects undertaken worldwide in the post-World War II era of international development (Arnstein, 1969; Chambers, 1983). Most of the focus across the Global South was on rural development, giving rise to methods such as the participatory rural appraisal and farmer-to-farmer learning (Gonsalves et al., 2005). In the 1980s and 90s, this perspective shifted to include urban areas as neoliberal globalization restructured the capitalist world economy contributing to the emergence of mega-cities across the Global South (Brenner & Theodore, 2002; Sassen, 1991, 2002; Tadiar, 2013). One consequence of this global transformation was the rise of slums and what Ravallion et al. (2007) describe as the “urbanization of poverty.” Thus, participatory urban appraisal emerged as a technique for addressing community-based problems particularly in slums and informal settlements.

Nonetheless, what is to be done, by and for whom, particularly in relation to urban poverty, remains a highly contested topic (Holland & Blackburn, 1998). “Bottom-up’’ approaches stand in stark contrast to the persistence, even dominance in many countries, of “top-down’’ approaches to land use planning. Planning practice originated in top-down decision-making approaches that may be attributed to planners such as Robert Moses and Ebenezer Howard. Prior to

the 1970s, planning decisions were made by a group of experts who believed that they knew what was best for a community and imposed their plans accordingly. Remarkably, the mainstream of urban design continues to draw on ideas such as the concentric zone model—now almost 100 years old—and assess cities around the world in terms of Western ideas of "best practice" (Park et al., 1925; for the critique see, e.g., Appadurai, 2002; Roy, 2009; Simone, 2005, 2008, 2010).

In line with broader developmental trends, multiple planning professionals promoted more participatory models. For example, John Friedmann introduced transactive planning while Paul and Linda Davidoff's advocacy planning emerged at this time. One of the most well-known tools for assessing community engagement within a planning project is Arnstein's (1969) ladder of citizen participation. Arnstein's ladder had eight steps, moving from no citizen control to effective empowerment: (1) manipulation and (2) therapy, which together constitute "non-participation"; (3) informing, (4) consultation, and (5) placation, which together constitute various degrees of tokenism; (6) partnership, (7) delegation, and (8) citizen control, which mark varying degrees of citizen power. Numerous derivations of this model have emerged over time (Cornwell, 2008; Pretty, 1995; White, 1996). Pretty (1995, p. 1252), for example argues that "self-mobilization," as the highest rung on the ladder, means that:

> People participate by taking initiatives independently of external institutions to change systems. They develop contacts with external institutions for resources and technical advice they need, but retain control over how resources are used. Self-mobilization can spread if government and NGOs provide an enabling framework of support. Such self-initiated mobilization may or may not challenge existing distributions of wealth and power.

Community-based adaptation (CBA) approaches, which emerged largely from climate change and development practice, would be situated at the "citizen control" end of the ladder. In CBA, community members drive the entire planning process—from conception to implementation to evaluation. Community members may draw on the expertise of others but the desire to do so comes from them—not from an outside entity or person. "Community-based adaptation to climate change is a community-led process, based on communities' priorities, needs, knowledge, and capacities, which should empower people to plan for, and cope with, the impacts of climate change" (Reid et al., 2009, p. 13). Rather than an outsider pointing out the deficits within a community, members themselves identify actions that they wish to take to improve their community and to increase its security in light of climate threats and hazards. Ultimately, CBA approaches acknowledge the expertise that exists within a community and begin at the local level to build on these strengths. However, it must be noted that CBA approaches are not without their critiques. For example, Titz et al. (2018) have argued that, if one is not careful, the notion of community may be romanticized, with existing power imbalances ignored. Dodman and Mitlin (2013, p. 650) have argued that CBA "accepts rather than questions the underlying political economic processes that have contributed to the growing climate crisis and adaptation deficit." Of course, these criticisms are not new and reflect challenges of scale—temporal as well as spatial—and perspective—both practical and ideological (Chambers, 1983; Fainstein, 2009; Marcuse, 2009).

This seemingly universal tension between top-down versus bottom-up planning is exacerbated by the nature of the post-colonial state across most of the Global South (Hansen & Stepputat, 2001). The colonial state was a highly centralized means for often violent social control and economic extraction. This hierarchical structure persisted into the post-colonial period and manifested most clearly in centralized national development plans, policies, and programs. Far from including citizens as participants in the planning process, these affairs were, and in many cases continue to be, negotiated between central state authority and external actors such as the World Bank, the International Monetary Fund, the European Union, and various inter-governmental organizations as well as multinational corporations. The Philippines under the 21-year dictatorial rule of Ferdinand Marcos (1965–1986) typifies this situation. During his tenure as president, Marcos waged a war against the urban poor, turning to heavy-handed tactics of slum clearance and forced eviction sometimes masqueraded behind concepts such as "city beautification" and *balik probinsya* ("back to the countryside"). Dominant narratives of "congestion," "overcrowding," and "disease" were used to justify demolition of informal settlements and citizens' displacement to rural areas (UN-Habitat, 2018).

This raises questions of what is a city and who is it for? At about the time Arnstein was devising her ladder of participation, Lefebvre (1968a, 1968b) was articulating his idea of "the right to the city." While Lefebvre's initial conception of the right to the city was philosophical and idealistic, it has taken on more pragmatic characteristics in subsequent decades. Harvey (1985) used it in support of his argument against neoliberal "accumulation by dispossession," with gentrification being one clear urban manifestation of this concept. Similar leftist critiques of neoliberal globalization and its impact on people, places, and things can be seen in the work of Mitchell (2003), Simone (2005), and Marcuse (2009). Specifically in relation to cities, Castells (1983) and Smith (1979, 1984) highlighted the importance of urban social movements, recognizing that urban development is unavoidably (and possibly necessarily) a conflictual process. Slater (2009) highlights how "the right to the city" has in fact become a rallying cry for marginalized community-based organizations. Brown (2013) contrasts the philosophical (e.g., Lefebvre) and practical (e.g.,

Slater)—both of which emerge out of Marxist, socialist, and feminist perspectives of equity and inclusion—with the liberal, human rights-oriented approach taken by inter-governmental organizations such as UN-Habitat and UNESCO. The liberal perspective is often criticized by the Left as re-centralizing urban planning, moving back down Arnstein's ladder toward, at best, consultation. Nevertheless, and as will be demonstrated in the case study below, the idea of a "right to the city" creates common ground for highly differentiated actors: from local community-based organizations to global social movements; from municipal, state, and federal government organizations to national banks, international financial institutions, and cooperative associations. These are strange bedfellows, but they coalesce around common purpose—i.e., slum-upgrading—through the discourse of stakeholder participation in support of a right to the city. As shown below, the outcomes in support of CBA in Sitio Libis align with Pretty's observation regarding self-mobilization as well as Fainstein's notion of "just cities," which Ninglekhu and Rankin (2017, p. 264) describe as marking a choice of "pragmatics of the socially just capitalist city over the unattainable utopia of the socialist city.''

2. Methodology

The initial intent of the project upon which this study is based was to engage in a peer-to-peer learning experience which would bring together individuals from the Homeless People's Federation of the Philippines Inc. (HPFPI) and people from Slum Dwellers International (SDI) in Sierra Leone to share experiences. The intent was for people in Sierra Leone to learn how those in the Philippines had success in purchasing the land in which they lived, engaged in re-blocking, and implemented climate adaptation measures. Step one was to involve the Sierra Leone group to travel to the Philippines to meet with leaders from HPFP and to visit the communities. However, the individuals from Sierra Leone were not granted visas and the project had to be altered. The initial question was to address scalability of the Philippines model. This study draws on the research conducted for the original study but combines it with a critical analysis of secondary sources to reflect on the potential for citizen-based action to form a foundation for meaningful climate change adaptations.

Participatory action research was utilised in this study wherein community members assisted with the collection of data. Specifically, participants led discussions with community members, used video and photographs to collect data, and led community tours, allowing for questions and answers to develop with community members. One of the benefits of participatory action research is that "participants have special access to how social and educational life and work are conducted in local sites by virtue of being insiders" (Kemmis et al., 2013, p. 5).

SDI facilitated the community entry point as they have had an existing partnership with the HPFPI for many years. The HPFPI created the link between the researchers and the head of the Sitio Libis, who accompanied and participated in all elements of the research with the external researchers.

In addition to the data collected in collaboration with community members, there were four focus groups with experts such as a lawyer, government officials, youth, and community members. A snowballing technique was used whereby one interview or conversation led to another. This often occurred during the transect walks and informal conversations that occurred throughout the research. Grey material was reviewed and was often gathered throughout the snowballing process. All interviews, videos, photographs, grey literature review, and review of official documentation (website searches of policies, plans, and existing peer-reviewed papers) were triangulated.

3. Study Area

3.1. Background and Context

The Republic of the Philippines consists of 7,641 small islands in Southeast Asia and covers a landmass of 300,000 square kilometers (Government of the Philippines, 2021b). The Global Climate Risk Index (Eckstein et al., 2021, p. 13) ranks the country as fourth most vulnerable in the world over the first two decades of the 21st century (behind Puerto Rico, Myanmar, Haiti, and ahead of Mozambique, The Bahamas, and Bangladesh). Over this time period, the Philippines recorded 317 extreme events, considerably more than Nepal (191) and Bangladesh (185) in second and third place respectively. The *World Risk Report* (Bündnis Entwicklung Hilft, 2018) placed the Philippines third, behind Vanuatu and Tonga.

In Metro Manila, the level of risk is even higher than that of the country as a whole. Unchecked and largely unplanned growth over several decades has heightened vulnerability by supplanting the natural environment (thereby eliminating nature-based solutions) with a built environment that exacerbates the negative impacts of extreme events at every turn. Valenzuela City is a good example of this as over decades the low-lying delta area was first drained and turned into farmland, then populated by both light and heavy industry which inevitably attracted migrants in search of economic opportunity leading to the expansion of both formal and informal housing.

Valenzuela City constitutes one part of an area designated as KAMANAVA, i.e., the geographical extent of four cities at the northern tip of Metro Manila: Caloocan, Malabon, Navatos, and Valenzuela. This entire area is an estuarine environment, generally below five metres above sea level (masl), a considerable amount of which is below the high tide line. According to Porio (2014, p. 85):

> The KAMANAVA flood basin is particularly susceptible throughout the year to the effects of sea-level rise and tidal storms. During the last few years, the residents have reported changes in the climate patterns marked by increases in sea levels during tidal/storm surges, as reflected in the water marks left in their house posts.

There are three rivers that pass in and around Valenzuela City: Tullahan, Pole, Meycauayan.

Climate change is increasing the intensity of typhoons (IPCC, 2014) and sea level rise will especially impact the Philippines, causing coastal erosion and land loss, inundation and sea flooding, upstream movement of the saline/freshwater front, and seawater intrusion into freshwater lenses (IPCC, 2020). Studies show that millions of people will be displaced from South Asian coastal zones, assuming a one-meter rise in sea levels. According to the Government of the Philippines (2021a), climate change also creates threats to biodiversity and food security, and endangers vulnerable groups such as women, children, indigenous people, and the poor.

3.2. Sitio Libis, Canumay East, City of Valenzuela

In the 1960s, the Philippines experienced mass migration of rural citizens into urban areas. However, urban areas did not have the infrastructure, housing, or capacity to adequately contain the influx of people. In 1970, 31.8% of the population lived in urban areas, rising to 37.5% in 1980 (Republic of the Philippines, 1991). As of 2015, the urban population sat at 51.2% (Philippines Statistics Authority, n.d.). Over the same period, the total population of the Philippines increased from 35 million to more than 110 million, with Metro Manila's population growing from 3.97 million to 14.16 million, of which an estimated 3 million live in informal settlements. According to the World Bank (2021), in 2018, 43% of the population of the Philippines lived in slums.

The urban poor have few choices for improving their situation. In the words of urban specialist Mike Davis:

> With land inflation raging even on the distant urban edge, the only choices seemingly left to the poorest Manilenos are either to risk death in the flood-prone metropolis by squatting in the beds of esteros or along the precarious banks of rivers, or to occupy the interstices of wealthier barangays where violent eviction is an imminent threat. (La Viña, 2017).

Without secure land, housing, and properly serviced communities, the poor survive in a never ending, unbreakable poverty cycle:

> Hundreds of thousands of urban poor households in the Philippines live on land that does not belong to them and they suffer the constant threat of being displaced. In addition, many live in informal settlements on dangerous sites—for instance on dump sites, along railroad tracks, under bridges and on riverbanks, shorelines, low-lying areas and critical slopes. (Teodoro & Rayos Co, 2009, p. 415)

Sitio Libis sits within Canumay East (population 50,000), a barangay of the City of Valenzuela (population 569,000). Sitio Libis is comprised of an estimated 342 families, the first of whom arrived in the area in the 1970s. In 2010, the community came together to form the United Libis Homeowners Association (ULHOA). Theresa Carampatana serves as Association President. Average floor space per family in the informal settlement is 28 square meters. The entire settlement is 15,688 square meters, was built on land owned by the Philippines Veterans Bank, and is bordered entirely by industrial enterprise.

The relative success of the people of Sitio Libis in securing land tenure, and thus the right to improved livelihoods, cannot be understood outside of the particular governance setting. As the challenges of slum dwelling increased over the last fifty years, so too has the changing political landscape created opportunities for positive change. As shown below, dramatic legal, institutional, and organizational changes created an enabling environment perhaps unique to the Philippines.

3.3. Changing Forms of National Governance

During President Ferdinand Marcos' era (1965–1986), squatting was illegal and those who lived in informal settlements were considered as criminals. Presidential Decree 772 imposed a penalty of imprisonment for six months to one year for those guilty of squatting—those who "unlawfully encroach on public and private land without the express consent of the landowner" (UN-Habitat, 2018, p. 50).

In 1986, the newly elected President Corazon C. Aquino aimed to reverse oppressive practices enforced during the 20 years of rule by President Ferdinand Marcos and set out to implement principles of human rights and social justice. Among other things, Aquino created the Presidential Commission on Urban Poor (PCUP) with the aim to include the urban poor in policy and program development. The PCUP ensures that issues pertaining to the urban poor have a direct link (and therefore importance) to the President.

Importantly, there is a strong emphasis on urban land reform and housing in the Constitution. For example, Article XIII, Section 9, states:

> The State shall, by law, and for the common good, undertake, in cooperation with the public sector, a continuing program of urban land reform and housing which will make available at affordable cost decent housing and basic services to underprivileged and homeless citizens in urban centers and resettlement areas. (Republic of the Philippines, 1987)

The Constitution implements the principles of housing social justice in various acts, including the Urban Development and Housing Act of 1992 and the Comprehensive and Integrated Shelter Finance Act of 1994. The Urban Development and Housing Act mandates that affordable housing and services be made available to homeless urban citizens and for this process to be participatory in nature. Section 10 states:

> Urban or rural poor dwellers shall not be evicted nor their dwellings demolished, except in accordance with law and in a just and humane manner. No resettlement of urban or rural dwellers shall be undertaken without adequate consultation with them and the communities where they are to be relocated. (Republic of the Philippines, 1987)

The Comprehensive and Integrated Shelter Finance Act is the basis for a "comprehensive and integrated shelter and urban development financing program by increasing and regularizing the yearly appropriation of the major components of the national shelter program" (Republic of the Philippines, 1994). The implementation of this act is the responsibility of a number of programs. One of these is the Community Mortgage Program (CMP):

> [The CMP is] a mortgage financing program of the Social Housing Finance Corporation… which assists legally organized associations of underprivileged and homeless citizens to purchase and develop a track or land under the concept of community ownership. The primary objective of the program is to assist residents of blighted areas to own the lots they occupy, or where they choose to relocate to and eventually improve their neighbourhood and homes to the extent of their affordability. (Republic of the Philippines Bureau of Internal Revenue, 2021)

The CMP is administered by the Social Housing Finance Corporation and consists of three stages: land purchase, site development, and house construction (Social Housing Finance Corporation, 2021). The CMP has resulted in "noticing that the sequence of planning-servicing-building-occupation (which contributes to making land scarce and expensive) has been replaced by incremental improvement of housing quality and infrastructure—mostly done by the main occupants" (UN-Habitat, 2018, p. 52). Regarding service delivery, the Local Government Code of 1991 was created to delineate the responsibility of delivering basic services to local governments: "It aimed to enhance provision of services in the grass roots level as well as improve the efficiency in resource allocation. Further, it sought to widen the decision-making space by encouraging the participation of stakeholders, especially in the local level" (Republic of the Philippines, 1991, p. 1).

3.4. Local and Global Actors and Influences

A variety of global actors, forces, and factors shape the Philippines policy environment. For example, UN-Habitat, UNESCO, and the Global Land Tool Network serve as nodes for knowledge mobilization. Through the Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs), the UN System provides the conceptual framework for collective action, in particular by creating avenues for state, civil society, and private sector actors to pursue common interests. The MDGs and SDGs, moreover, provide an entry point for global and local civil society actors to press governments to hold to commitments they have made under various UN covenants and agreements. There are multiple civil society actors who represent and work closely with informal settlement dwellers and the urban poor to secure tenure. Pertinent to this study is SDI, which is an organisation consisting of a network of "community-based organisations of the urban poor in 32 countries and hundreds of cities and towns across Africa, Asia and Latin America" (SDI, 2021). The organisations that make up the SDI network all work at the local level and rely on a peer-to-peer learning model with an overall goal to secure safe, suitable housing through inclusive processes.

At the national level, the two most important NGOs are the (HPFPI) and the Technical Assistance Movement for People and Environment Inc. (TAMPEI). Each of these entities operate as umbrella organizations, representing the interests of thousands of CBOs, while also providing human, technical, and financial resource support and capacity building. The HPFPI:

> Brings together low-income community organizations from cities across the Philippines all engaged in finding solutions to problems they face with secure land, housing, income, infrastructure, health, welfare and access to affordable credit….The common denominator throughout the Philippines Homeless People's Federation is *savings*. The money which people save together creates a revolving community fund from which members can take loans for their small enterprises, for emergencies and day-to-day needs and for improving their houses. Members also save for land and housing in special housing savings accounts and many take part in community-based health care schemes. (HPFPI, 2001, p. 73)

While the post-Marcos and post-Cold War era has witnessed the emergence of an enabling environment for improving the lives of the poor and marginalized in the Philippines, one should be under no illusions regarding the complexity and scale of the challenge. For example, according to UN-Habitat (2018, p. 54):

> Some obstacles remain for effective access of NGOs and civil organizations to the Local Development Councils. Many local governments have been slow to

comply with UDHA provisions, especially regarding urban poor affairs offices. Even when NGOs and civil organizations are represented at local government level, their influence ability is very limited.

4. Case Study: Secure Land Tenure as Basis for Climate Security?

People who live informally, often referred to as "squatters" or "slum dwellers," experience dual vulnerabilities: one is to eviction and the other is to natural hazards, which are increased by climate change. These vulnerabilities are mutually reinforcing, with residents unable to coordinate actions and make investments upon land that does not belong to them. Efforts undertaken within the Philippines and elsewhere in the world by organizations such as SDI, HPFPI, and TAMPEI show that this precarious existence can be mitigated by land ownership. As shown below, land ownership presents opportunities for accessing human, financial, and technical resources otherwise not available to squatters.

For several decades, people in Sitio Libis lived informally on the privately-owned land, meaning they had no legal entitlement to living there and were constantly threatened with eviction. In 2010, the landowner, a bank, told the community that they had one year to purchase the land for 30 million Philippine pesos (approximately 64,000 USD) or else they would be evicted from the land. Motivated by the concern of being evicted, a group from the community contacted local government authorities for assistance. Members of the community sought help from their local congressman and local government authority; however, since they were an informal area, they did not qualify for any of the government programs designed to help the poor. The group searched for organisations who are helping the poor on the internet and sent letters to ten organisations asking for help. One of these organisations was the HPFPI, which was the only organisation that responded to the letters sent by residents of Sitio Libis. Theresa Carampatana was one of the leading women who initiated this process and is currently the president of the HPFPI. She stated during the interview process:

> We went to the local government authority, but they didn't have the funds to finance [this] and the government money could not be spent on privately owned lands. So nobody was really helping us….We asked our congressman if he [could] shed out from his budget a little amount [to] help us buy the land and he said no, he [could] not spend any government money on us. And so we were left, you know, we didn't have any help, so we searched on the internet. We googled "organisations who are helping the poor" and then there were lists—a lot of organisations who are helping the poor—so we wrote letters to those organisations. We called them and said: "Hello, we are informal settlers in Valenzuela, we need help, how can you help us?" There were ten organisations who we called but only Homeless [HPFPI] came back to us and said: "We can talk."

The group searched the internet to learn about the work that HPFPI was engaged in. They found a video that told the story of another informal community in the region, Payatas, which used community savings to purchase and then upgrade the land they were living on. This video can be found on the HPFPI YouTube webpage. Theresa Carampatana, key informant, commented:

> We already saw the video of the people in Payatas who are doing savings and that Father Roberto was helping and then the international community recognized them and then there were a lot of projects they did using their savings and so we thought, you know, maybe this group can help us also. If they can help the poor people in Payatas, why can't they help us?

Representatives from HPFPI taught the group about how other informal communities used community savings to purchase and then upgrade their own neighbourhoods. Initially the people within Sitio Libis were hesitant to embark on community savings because they feared that the HPFPI would steal their money. Trust was slow to develop; however, they eventually realized that this was their only strategy for purchasing the land. So, the people of Sitio Libis formed the ULHOA and began a community savings program. The initiative was launched with a ceremony whereby community members dropped five peso coins into a coin bank that was shaped like a house. They saved a million pesos after a year:

> In the start we saved 50 pesos per month but then we went to the community and said: "If we only save 50 pesos it will take us 13 years before we can pay the down payment of 2.5 million." We asked them: "How do you want to go about this? What do you want to do? Do you want to spend the next 13 years saving 50 pesos if you can save 500 or 1000 pesos so the saving terms will become shorter, and that we can pay the bank right away… because the bank cannot wait….They gave us a year to pay. (Theresa Carampatana, key informant interview)

After the community saved 1.5 million pesos it returned to the HPFPI for help. Only after demonstrating their own capacity to save money was the community then able to apply to HPFPI for funding. Their proposal was successful; they were awarded another 1.5 million pesos:

> They [HPFPI] asked us to prepare a loan proposal and then it was discussed in the community….The community agreed we take a loan….We submitted the proposal to Homeless… and then they gave us a 1.5 million loan because we are doing savings… and so the combined—our savings and the loan—we paid

> the bank the 10% down payment that started it all. (Theresa Carampatana, key informant interview)

The community then had the 10% down payment that the bank required for a mortgage to purchase the land. It was also able to negotiate for a loan through the CMP:

> For 25 years we were saying we would buy the land….We were saying we would save, but we don't have money. They won't listen to us unless we pay a 10% down payment for the land. (Theresa Carampatana, key informant interview)

After making the down payment the bank and the community signed a Memorandum of Understanding (MOU), which was a requirement to obtain financing through the National CMP. It took two years for their application to the CMP program to be processed:

> Actually [it takes] one year but our land was very complicated. We have a transmission line—a danger zone—across the land that we wanted to buy. So it was a very complicated situation. We had to divide the land, separate the danger zone outside the CMP area. So we could take a loan from the government for the area that is not in the danger zone. So it took us longer—a longer process. (Theresa Carampatana, key informant interview)

The community obtained funding through the CMP. The landowner (the bank) was paid in full (22.5 million pesos) by the government through the CMP. The original title was changed to the ULHOA. The community originally agreed to pay back the loan over 25 years (although they have decided to increase the payments so that the loan could be paid back sooner, also paying less interest on the loan):

> Our members are 50/60 years old so they don't want to pay the loans until they are 75, so we said if they want to repay in a much lower and a lesser interest rate you should pay at least double of the minimum payment, because some of our members are paying 350–450 pesos per month but they can actually pay 500 or 600 pesos, so it would be lesser years paying back. (Theresa Carampatana, key informant interview)

The process involved many community meetings and considerable negotiation between community members. It was only after the community obtained secure tenure that they could systematically and collectively address the common hazards and vulnerabilities that threatened their safety and security. Prior to land ownership, community members simply coped with the flooding by waiting for the water to decrease. The floods often stayed for up to an hour before they would decrease again. Homeowners moved items to the second floor (if they had one) or piled items close to the ceiling of their dwellings. Homeowners had to stand on chairs or try to get as high as they could until water decreased. When there were fires community members had to collectively put fires out and people were severely injured or died. Once infrastructure was put into place (for example, proper drainage and pipes for excess water) the hazards associated with living on the land were lessened.

4.1. Building Back Better: Climate Vulnerability and Adaptation

Typical of informal settlements everywhere, Sitio Libis has long existed without access to municipal services. In a monsoonal environment, the absence of proper drainage compounds problems of a lack of sanitation services and the porosity of makeshift housing:

> After thirty minutes of intense rain, the community would be flooded up to the knees or waist and we would have to put all of our valuables close to the ceiling. (Theresa Carampatana, key informant interview)

The electricity for the community also consists of an array of wires that would spark when the extreme rains arrived:

> The wires would heat up, there would be shortages, sparks would occur, and fires would start. (Key informant 2)

The streets within the informal settlement were also very narrow, which meant that emergency vehicles such as ambulances and fire trucks could not get into the community to put out fires and to help victims of the storm. Only after the community purchased the land could it request financial and technical expertise from the government to assist with adaptation measures.

> Before owning the land, the government did not respond to our requests for help to prevent and cope with these issues. As informal settlers we didn't have rights to right of way, drainage, outflow. However, after we owned the land we were able to obtain help from the government to improve the conditions in the settlement. (Key informant 3)

The ULHOA held community meetings to decide how to manage the extreme flooding that occurred in their area. The decision was made to obtain help through TAMPEI, which is the technical arm of the HPFPI. TAMPEI consists of young architect, engineering, and planning professionals who assist with community-led projects to improve housing, upgrade communities, map settlements, and embark on various planning initiatives (TAMPEI, 2019).

The community worked with TAMPEI to develop an integrated management plan that included improving drainage, solid waste management, widening of the main thoroughfare and home upgrading, including

improved electrical connections (TAMPEI, 2019, p. 28). Known as "re-blocking," the process reformats and restructures the spatial layout of a settlement to optimize drainage, increase width of streets so that emergency vehicles can pass, and optimize the configuration of a slum (Brelsford et al., 2019).

The re-blocking process would require the "slashing" of houses to make rooms for widening the roads. This was a negotiated process, managed by the community and minimizing relocation and disruption. It was a slow process to start as regulations require access roads to be six metres in width. Widening the roads would significantly reduce the housing space of many residents. Eventually the city government agreed to reduce the road width requirement to four metres on condition that fire hydrants be installed at strategic locations along the route. Amending the law took four years and it was another three years before the re-blocking process began (TAMPEI, 2019).

With support from the HPFPI and TAMPEI, UHLOA was able to obtain 15 million pesos from the National Government to assist with the re-blocking process. This assisted with the relocation of those who lost their homes due to the widening of the street (Libis donated land and the government paid for the building of the new homes):

> Without the trust accumulated during planning and in savings groups it would have been hard to convince people to remove part of their home for road widening or for making space for other [community] members. (Theresa Carampatana, key informant interview)

When speaking with homeowners who lost a section of their homes, we were told that they understood that it was important in order to widen the road so that emergency services can access the settlement and so proper drainage and electricity can be installed. Community members collaborated so that everyone would be able to have a home. In one case, a homeowner allowed for part of their own home to be knocked down to build a structure for another very low-income member. Ultimately, drainage to remove flooding and the wiring to prevent fires were both improved as part of the re-blocking process. Progress on re-blocking has been slow. By 2019, 27 houses had been re-blocked along the main road (TAMPEI, 2019). According to one community member, "the dialogue between the City and the community demonstrated that negotiations on land housing rights can be done in a peaceful manner, where both parties are on a win-win solution" (as cited in TAMPEI, 2019, p. 33).

5. Discussion

The belief that citizen-led, community-based approaches to community development will result in positive, sustainable development continues to dominate community planning literature (Dale et al., 2020; Hidalgo et al., 2021; Lang et al., 2020; Westoby et al., 2020). There is a very long history of support for this type of participatory method of development—starting in the 1960s with individuals such as Jacobs (1992) and Arnstein (1969) who argued that communities benefit when they have control over outcomes. This is in stark contrast to the top-down models imposed by planners such as Robert Moses and Ebenezer Howard, who believed that one master plan created by an expert could create what they knew was best for the public. The birth of community-based action in the Global South first occurred in rural areas; however, throughout the 1980s and 90s, as urban areas began to grow in population, the community-based approach shifted to address the challenges created by the growth of slums. Slum-upgrading is not the sole focus of participatory urban development. Ideas such as climate resilience and the green economy also are anchored in community-based approaches (Hidalgo et al., 2021). Put differently, the need to address climate change has created space for local communities to build resilience at a variety of geographical scales. There is recognition that responses to issues such as the heat island effect, flooding, and drought can be community-scale through projects such as softening pavements, creating urban parks, and tree planting. Thus, there is space for central planning and community-based planning to integrate. Planners can work with community members to address locally relevant issues, including developing scenario plans for coping with future unknowns that climate changes bring.

Despite positive efforts, there continues to be tension between top-down versus bottom-up, citizen-led approaches. In response to this, various concepts have been developed to try to bridge the gap between expert-led top down and citizen-led bottom up, with "the right to the city" being a dominant approach. The right to the city is interpreted in different ways: as a philosophical ideal (Lefebvre, 1968a), as a rallying cry (Slater, 2009), and as an instrumental and functional approach (UN-Habitat, 2018). Fainstein's "just city" concept turns on a search for a pragmatic outcome within the "socially just capitalist city."

The case study shows that citizens have skills that they can utilize to initiate transformational change within their communities. In the Sitio Libis case, the process of obtaining secure land tenure and upgrading occurred because people within the community first had the ability to conduct research on the internet to learn about the resources available to them. Community members learned about the programs available, conducted community savings, wrote funding proposals, and adjusted to challenges that emerged (such as understanding land use plans around danger zones and negotiating mortgage requirements). Community leaders also established a network through the HPFPI and others who could support their work and provide consultation on navigating the administrative components of purchasing the land

and improving their settlement. Evidently there are internal strengths and assets that community members hold that outsiders may neglect to acknowledge because people who live in informal settlements are often viewed derogatorily, as "slum dwellers" (with the negative connotations that come with that term).

The case study shows clearly that community-based approaches can result in positive change; however, this case demonstrates that these actions do not occur alone. Low-income communities require support for major change to occur. In this case, positive community change occurred with the help of NGOs, government actors, and the private sector. A broader lesson, then, is that governments must have supportive laws, policies, plans, and principles in place to support the urban poor. Indeed, the Philippines exemplifies this type of enabling governmental environment. Efforts to improve conditions for the urban poor have been in place since Aquino gained presidential power in 1986 and set in motion the significant reforms described above. This revolutionary change tipped the balance in populist fashion toward the poor with the PCUP exemplifying this shift in government thinking and practice.

Regarding equitable climate change planning, this case shows that the language of climate change has not been used to foster citizen engagement; but in the future it could be a building block for a public-private-community partnership. Importantly, this case demonstrated that successful CBA resulted from state-civil society private sector cooperation and collaboration. This aligns with Fanstein's "just city" perspective, that the people of Sitio Libis worked within the existing system (however unfair it may be at a macro scale) and not against it (in pursuit of some imagined utopia) for specific, short- and medium-term, community-scale gains.

Clearly, the actions taken by the community of Sitio Libis were self-mobilising (Pretty, 1995). Faced with a series of natural (flood, fire) and social (the threat of eviction) challenges, they initiated the process by taking action independent of external agencies to create change. At the same time, in order to purchase their land and conduct re-blocking, citizens utilised the support systems and programs government and civil society organizations made available to them.

6. Conclusion

As stated in the methodology, this project intended to bring informal settlement dwellers from Sierra Leone to the Philippines to learn how they could utilise community savings to secure tenure and improve their communities. Clearly, international (i.e., SDI), national (i.e., HPFPI), and local (ULHOA) groups perceive the case study as a success story worthy of emulation. Certainly, there are replicable elements not unique to this small community. Indeed, the community savings approach is well established in international development practice, as is the practice of re-blocking. There are also general lessons to learn, as stated by the people of Sitio Libis themselves:

> In the end, as the residents of ULHOA put it, they see massive mobilization, organizational unity, effective communication, transparent and fair leadership as critical elements needed to win against the challenges they are currently facing. Furthermore, they highlight the urgent need to educate their fellow members, and other poor groups in general, about legitimate approaches to land and housing rights. (TAMPEI, 2019, p. 34)

As shown here, participatory approaches are necessary and valuable and positive outcomes are possible when the state plays an enabling role. Given the magnitude of the challenges being created by climate change, it seems doubtful that CBA can be scaled up enough to build resilient cities. Despite this pessimistic conclusion, the struggle for the right to the city will no doubt continue, neighborhood by neighborhood.

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Conflict of Interests

The author declares no conflict of interests.

References

Appadurai, A. (2002). Deep democracy: Urban governmentality and the horizon of politics. *Political Culture*, *14*(1), 21–47.

Arnstein, S. (1969). A ladder of participation. *Journal of the Institute of Planners*, *35*(4), 216–224.

Brelsford, C., Martin, T., & Bettencourt, L. (2019). Optimal reblocking as a practical tool for neighbourhood development. *Environment and Planning B: Urban Analytics and City Science*, *46*(2), 303–321.

Brenner, N., & Theodore, N. (2002). Cities and geographies of actually existing neoliberalism. *Antipode*, *34*(3), 349–379.

Brown, A. (2013). The right to the city: Road to Rio 2010. *International Journal of Urban and Regional Research*, *37*(3), 957–971.

Bündnis Entwicklung Hilft. (2018). *World risk report 2018*. BEH and Ruhr University Bochum—Institute for International Law of Peace and Armed Conflict.

Castells, M. (1983). *The city and the grassroots: A cross-cultural theory of urban social movements.* University

of California Press.
Chambers, R. (1983). *Rural development: Putting the last first*. Wiley.
Cornwell, A. (2008). Unpacking "participation": Models, meanings and practices. *Community Development Journal*, *43*(4), 269–283.
Dale, A., Vella, K., Ryan, S., Broderick, K., Hill, R., & Brewer, T. (2020). Governing community-based natural resource management in Australia: International implications. *Land*, *9*(7).
Dodman, D., & Mitlin, D. (2013). Challenges for community-based adaptation: Discovering the potential for transformation. *Journal of International Development*, *25*, 640–659.
Eckstein, D., Künzel, V., & Schäfer, L. (2021). *Global climate risk index 2021*. Germanwatch.
Fainstein, D. (2009). Planning and the just city. In P. Marcuse, J. Connolly, J. Novy, I. Olivo, C. Potter, & J. Steil (Eds.), *Searching for the just city: Debates in urban theory and practice* (pp. 19–39). Routledge.
Gonsalves, J., Becker, T., Braun, A., Campilan, D., De Chavez, H., Fajber, E., Kapiriri, M., Rivaca-Caminade, J., & Vernooy, R. (Eds.). (2005). *Participatory research and development for sustainable agriculture and natural resource management: A sourcebook. Volume 1: Understanding participatory research and development*. CIP-UPWARDS, IDRC.
Government of the Philippines. (2021a). *Climate change impacts*. National Integrated Climate Change Database and Information Exchange System. https://niccdies.climate.gov.ph/climate-change-impacts
Government of the Philippines. (2021b). *Home*. https://www.gov.ph/es.html
Hansen, B. T., & Stepputat, F. (2001). Introduction: States of imagination. In B. T. Hansen & F. Stepputat (Eds.), *States of imagination: Ethnograhic explorations of the postcolonial state* (pp. 1–38). Duke University Press.
Harvey, D. (1985). *The urbanization of capital*. The Johns Hopkins University Press.
Hidalgo, D. M., Nunn, P. D., Beazley, H., Sovinasalevu, J. S., & Veitayaki, J. (2021). Climate change adaptation planning in remote contexts: Insights from community-based natural resource management and rural development initiatives in the Pacific Islands. *Climate and Development.* Advance online publication. https://doi.org/10.1080/17565529.2020.1867046
Holland, J., & Blackburn, J. (1998). *Whose voice? Participatory research and policy change*. Intermediate Publications.
Homeless People's Federation. (2001). Meet the Philippines Homeless People's Federation. *Environment and Development*, *13*(2), 72–84.
IPCC. (2014). *Asia*. https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap24_FINAL.pdf
IPCC. (2020). *The regional impacts of climate change: An assessment of vulnerability.* https://www.ipcc.ch/report/the-regional-impacts-of-climate-change-an-assessment-of-vulnerability
Jacobs, J. (1992). *The death and life of great American cities*. Penguin Random House.
Kemmis, S., McTaggart, R., & Nixon, R. (2013). *The action research planner: Doing critical participatory action research.* Springer.
La Viña, T. (2017, March 28). Duterte and the urban poor. Manilastandard. https://manilastandard.net/opinion/columns/eagle-eyes-by-tony-la-vina/232897/duterteand-the-urbanpoor.html
Lang, R., Chatterton, P., & Mullins, D. (2020). Grassroots innovations in community-led housing in England: The role and evolution of intermediaries. *International Journal of Urban Sustainable Development*, *2*(1), 52–72.
Lefebvre, H. (1968a). *Everyday life in the modern world*. Transaction.
Lefebvre, H. (1968b). *Le droit à la ville* [The right to the city] (2nd ed.). Anthropos.
Marcuse, P. (2009). From critical urban theory to the right to the city. *City*, *13*(2/3), 185–197.
Mathie, A., & Cunningham, G. (Eds.). (2008). *From clients to citizens: Communities changing the course of their own development*. Intermediate Technology Publications.
Mitchell, D. (2003). *The right to the city: Social justice and the fight for public space*. Guildford Press.
Ninglekhu, S., & Rankin, K. (2017). The urban poor: The urban majority and everyday life. In A. L. Bain & L. Peake (Eds.), *Urbanization in a global context* (pp. 245–259). Oxford University Press Canada.
Park, R. E., Burgess, E. W., & McKenzie, R. D. (1925). *The city*. University of Chicago Press.
Philippines Statistics Authority. (n.d.). *Home*. https://psa.gov.ph/grdp
Porio, E. (2014). Climate change vulnerability and adaptation in Metro Manila. *Asian Journal of Social Science*, *42*, 75–102.
Pretty, J. N. (1995). Participatory learning for sustainable agriculture. *World Development*, *23*(8), 1247–1263.
Ravallion, M., Chen, S., & Sangraula, P. (2007). New evidence on the urbanization of global poverty. *Population and Development Review*, *33*(4), 667–701.
Reid, H., Alam, M., Berger, R., Cannon, T., Huq, S., & Milligan, A. (2009). *Community-based adaptation to climate change: An overview*. IIED. https://pubs.iied.org/sites/default/files/pdfs/migrate/G02608.pdf
Republic of the Philippines Bureau of Internal Revenue. (2021). *Community Mortgage Program (CMP)*. https://bit.ly/3ogvSU0
Republic of the Philippines. (1987). *The Constitution of the Republic of the Philippines*. https://www.officialgazette.gov.ph/constitutions/1987-constitution
Republic of the Philippines. (1991). *Local government code*. http://legacy.senate.gov.ph/lisdata/82027399!pdf
Republic of the Philippines. (1994). *Comprehensive and*

integrated shelter financing act of 1994 (Republic Act No. 7835). https://bit.ly/3kQgETz
Roy, A. (2009). The 21st-century metropolis: New geographies of theory. *Regional Studies*, *43*(6), 819–830.
Sassen, S. (1991). *The global city: New York, London, Tokyo*. Princeton University Press.
Sassen, S. (2002). *Global networks, linked cities*. Routledge.
SDI. (2021). *Who is SDI?* https://sdinet.org/who-is-sdi/about-us
Simone, A. M. (2005). The right to the city. *Interventions*, *7*(3), 321–325.
Simone, A. M. (2008). The politics of the possible: Making urban life in Phnom Penh. *Singapore Journal of Tropical Geography*, *29*(2), 186–204.
Simone, A. M. (2010). *City life from Jakarta to Dakar: Movements at the crossroads*. Routledge.
Slater, T. (2009). Missing Marcuse: On gentrification and displacement. *City*, *12*(2/3), 293–311.
Smith, N. (1979). Toward a theory of gentrification: A back to the city movement by capital, not people. *Journal of the American Planning Association*, *45*(4), 538–548.
Smith, N. (1984). *Uneven development*. Blackwell.
Social Housing Finance Corporation. (2021). *Social housing finance corporation*. https://www.shfcph.com/Mandate.html
Tadiar, N. (2013). Lifetimes of disposability in global neoliberalism. *Social Text*, *31*(2), 19–48.
Technical Assistance Movement for People and Environment, Inc. (2019). *iSiyudad: Selected narratives of HPFPI communities in asserting their right to the city*. TAMPEI.
Teodoro, J. I. E., & Rayos Co, J. C. (2009). Community-driven land tenure strategies: The experiences of the Homeless People's Federation of the Philippines. *Environment and Urbanization*, *21*(2), 415–441.
Titz, A., Cannon, T., & Kruger, F. (2018). Uncovering "community": Challenging an elusive concept in development and disaster related work. *Societies*, *8*(3). https://doi.org/10.3390/soc8030071
UN-Habitat. (2018). *Alternative solutions to forced evictions and slum demolitions: Case studies from Africa, Asia, North and South America*. UN Human Settlements Programme.
Westoby, R., McNamara, K. E., Kumar, R., & Nunn, P. D. (2020). From community-based to locally led adaptation: Evidence from Vanuatu. *Ambio*, *49*, 1466–1473.
White, S. (1996). Depoliticising development: The uses and abuses of participation. *Development in Practice*, *6*(1), 6–15.
World Bank. (2021). *Philippines economic update, December 2020: Building a resilient recovery*. https://openknowledge.worldbank.org/handle/10986/34899

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Article

Towards Intergenerational Equity: Analysis of Youth Engagement Strategies in Climate Action Planning in Mzuzu, Malawi

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Abstract
Globally, meaningful youth participation in planning processes aimed at dealing with climate change impacts has been advocated for sustainability purposes. Article 6 of the United Nations Framework Convention on Climate Change requires parties to ensure there is public participation in addressing climate change, its effects, and the development of responses. In the city of Mzuzu, Malawi, local community members have been involved in planning processes at different planning levels but more intensively at the community level. Despite this approach receiving much attention, minimal consideration has been put on which societal groups are to be engaged directly, with youths being excluded to a large extent, even though about 49% of the population in Malawi is aged between 10 and 34 years. This article, therefore, seeks to foreground how current stakeholder engagement strategies in climate change planning marginalise the youth. To do this, this article critically reviews current stakeholder engagement strategies and assesses the extent to which youth are involved in the planning processes in Mzuzu City. It further assesses the factors affecting youth involvement in the planning process and subsequently recommends how stakeholder engagement strategies can be designed and implemented to ensure effective youth engagement in climate change planning processes in the city.

Keywords
climate change; Malawi; planning; stakeholder engagement; youth

Issue
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1. Introduction

Article 6 of the United Nations Framework Convention on Climate Change requires parties to ensure there is public participation in addressing climate change, its effects, and the development of responses (United Nations, 1992). Youths form a basic bedrock of society and that calls for their involvement in all initiatives affecting society, from the planning stage to the implementation stage (Oladeji et al., 2017). The involvement of the youth in the planning process often contributes to the speedy and successful implementation of activities (Udensi et al., 2013).

Studies have revealed that several factors affect youth inclusion in planning processes. For countries that have adopted a decentralised system of government to enhance community participation in governance systems such as Malawi, decentralisation to local governance structures is still contributing to a lower level of participation than expected in terms of changing regulatory, administrative, and financial public decision-making (Helmsing, 2002). Further, there is a lack of assistance from the government at the grassroots level and inadequate recognition of youths as a formidable labour force in the community (Akinboye et al., 2007).

Besides the dynamics in the relationship among youths, adults, and institutions (Camino, 2000; Tarifa et al., 2009), socioeconomic factors, inadequate awareness, nonchalant attitude, and selfishness also affect participation (Kaseya & Kihonge, 2016; Udensi et al., 2013). Youth participation is viewed as a process of allowing young people to contribute to any developmental activity meaningfully and actively within their community (Checkoway & Gutiérrez, 2006). Although youth in Malawi—those aged between 10 and 34—constitute about 48.7% of the population (National Statistical Office, 2019), their involvement in planning processes including those related to climate change management is minimal.

The United Nations Joint Framework Initiative on Children, Youth and Climate Change (2013) recognises youths as having an increasingly strong social and environmental awareness, and the energy and knowledge to lead societies towards a low carbon and climate-resilient future. The United Nations *World Youth Report* (United Nations, 2020) indicates that youths, despite being mere beneficiaries of the 2030 Sustainable Development Agenda, are architects when it comes to its development and implementation. This is empowering youths to take a pivotal role in development. However, not all youths have the capacity to take a leading role in development. Active youth participation remains a key issue and is often side-stepped in research due to logistical and ethical concerns (Schelbe et al., 2015; Wattar et al., 2012). In addition, given that by the year 2030 the proportion of youth in developing countries will increase by 62% (Population Division of the United Nations Department of Economic and Social Affairs, 2019), systematic inclusion of this growing population in the planning process has the potential to lead to the sustainability of the initiatives implemented. Further, the involvement of youth in making decisions regarding climate action is a step towards addressing intergenerational justice by ensuring that people who are most likely going to feel the effects of the current decisions being made are actively involved in the decision-making process. Despite this significant potential, youth inclusion in climate action planning processes is limited. This article, therefore, foregrounds the current gaps in stakeholder engagement strategies and barriers to youth participation in such processes. It recognises how most studies in Malawi target community members as a homogenous entity with minimal consideration on individual societal groups. Furthermore, studies on youth participation in Malawi mostly concern health policy, party politics, economics, and agriculture (Chinsinga & Chasukwa, 2012; Gondwe et al., 2020; Wigle et al., 2020). Except for the involvement of youth in climate change learning to enhance climate literacy in Malawi (Ministry of Forestry and Natural Resources, Environmental Affairs Department, 2021), little is known about how young people are involved in climate change planning processes. This study, thus, reviews current stakeholder engagement strategies and assess the extent to which youth are involved in the planning processes in Mzuzu City. It further assesses the factors affecting youth involvement in the planning process and proposes how stakeholder engagement strategies can be designed and implemented to ensure effective youth engagement in climate change planning processes in the city. To achieve a youth-inclusive climate action planning process, this article provides a framework as a step-by-step guide. This framework can potentially be used in countries with similar engagement strategies and decentralised systems of governance.

This study is guided by various theoretical understandings of participation in planning processes. Participatory theory is a broad and complex concept. There has been improvement and adjustment in participatory methodologies, with the 1980s seeing the advancement of bottom-up approaches in contrast to top-down approaches with emphasis on the inclusion of local indigenous knowledge in planning processes (Claridge, 2004). Several theories in participation have informed this study. Firstly, the civic voluntarism model (CVM) views resources, engagement, psychological engagement, issues engagement, and recruitment through networks as prerequisites for effective participation (Barkan, 2004; Burns et al., 2001). Although developed in relation to political participation, this model is relevant in other planning processes. Using this model, people participate if they have access to *resources* such as time, money, and civic skills. This understanding of participation is arguably linked to studies that associate socio-economic status and educational background with levels of meaningful participation in planning processes (Angba et al., 2009; Corner et al., 2015; Mohamud et al., 2018). Even though others might possess these resources, the level of participation might be not as expected (Rubenson, 2000). Resources alone might not be enough to guarantee participation.

Psychological engagement means people should be self-interested and motivated to take part in the processes (Barkan, 2004). In this case, for youth to participate in local planning processes, they need to have the attitude and "inner drive" to participate. This is closely associated with *issues engagement*, another component of the CVM that concerns the relevance or significance of the processes to the participants (Barkan, 2004). For youth to participate in local climate action planning, they need to be convinced of how such processes will benefit them. Yet, psychological and issues engagement would only be possible if the individuals are well-informed of climate change impacts and the existence and relevance for local planning processes. Finally, *recruitment* through personal networks plays a role in participation. Youths with connections to various relevant institutions are more likely to participate in planning processes. We, therefore, argue that the way current stakeholder engagement strategies are employed in Mzuzu City restricts the recruitment of youth in local climate action planning processes. Further, other factors such as culture, attitudes, and awareness, which border

on psychological and issues engagement lead to minimal participation of the youth.

Being included in planning processes alone does not entail meaningful participation. As Arnstein (1969) noted, the extent of participation varies from the minimal levels of non-participation (manipulation and therapy) through tokenism (information, consultation, and placation) to citizen control (partnership, delegation, and citizen control). This model is akin to Pretty's model of 1995 (Pretty, 1995; Tosun, 2004). Each level in the participation ladder corresponds to the decision-making power present at that level, with increased decision-making power at higher levels of participation. Based on Arnstein's work, several authors have developed further models to better theorise citizen participation. These models include a new ladder to citizen participation (Connor, 1988), the split ladder of participation (Hurlbert & Gupta, 2015) and an "extended" Arnstein's ladder (Kotus & Sowada, 2017), among others. Despite sharing a common critique on Arnstein's ladder as being too simplistic to explain the participation process, this article draws from the consensus among this scholarship to argue that meaningful participation is congruent to the extent of participation, with lower levels proving insignificant for local climate action planning processes.

Considering the foregoing, this article draws from the general incentives model of participation (Adhikari et al., 2014) to develop a framework for designing and implementing a youth-inclusive stakeholder engagement process. Different studies have looked at various incentives as a factor affecting a community's participation in activities (Hobbs & White, 2012; Wehn & Almomani, 2019). It proposes how to design and implement stakeholder engagement processes that disinhibit and encourage youth participation in local climate action planning processes. For this study, stakeholder engagement processes are all activities/approaches used to involve different stakeholders in the planning of local climate action.

2. Methodology

2.1. Description of the Study Area

Mzuzu City (Figure 1), located in Mzimba District, is the third-largest urban centre in Malawi, after Lilongwe and Blantyre, respectively. The city has a fast-growing population with an intercensal annual growth rate of 5.4%, the highest among cities in Malawi (National Statistical Office, 2019).

Mzuzu City has been experiencing an increase in disasters such as floods, landslides, and strong winds since the early 2000s (Kita, 2017). The city recorded the worst flood disaster in its history in 2016, whereby more than 1,900 people were displaced. Out of the 15

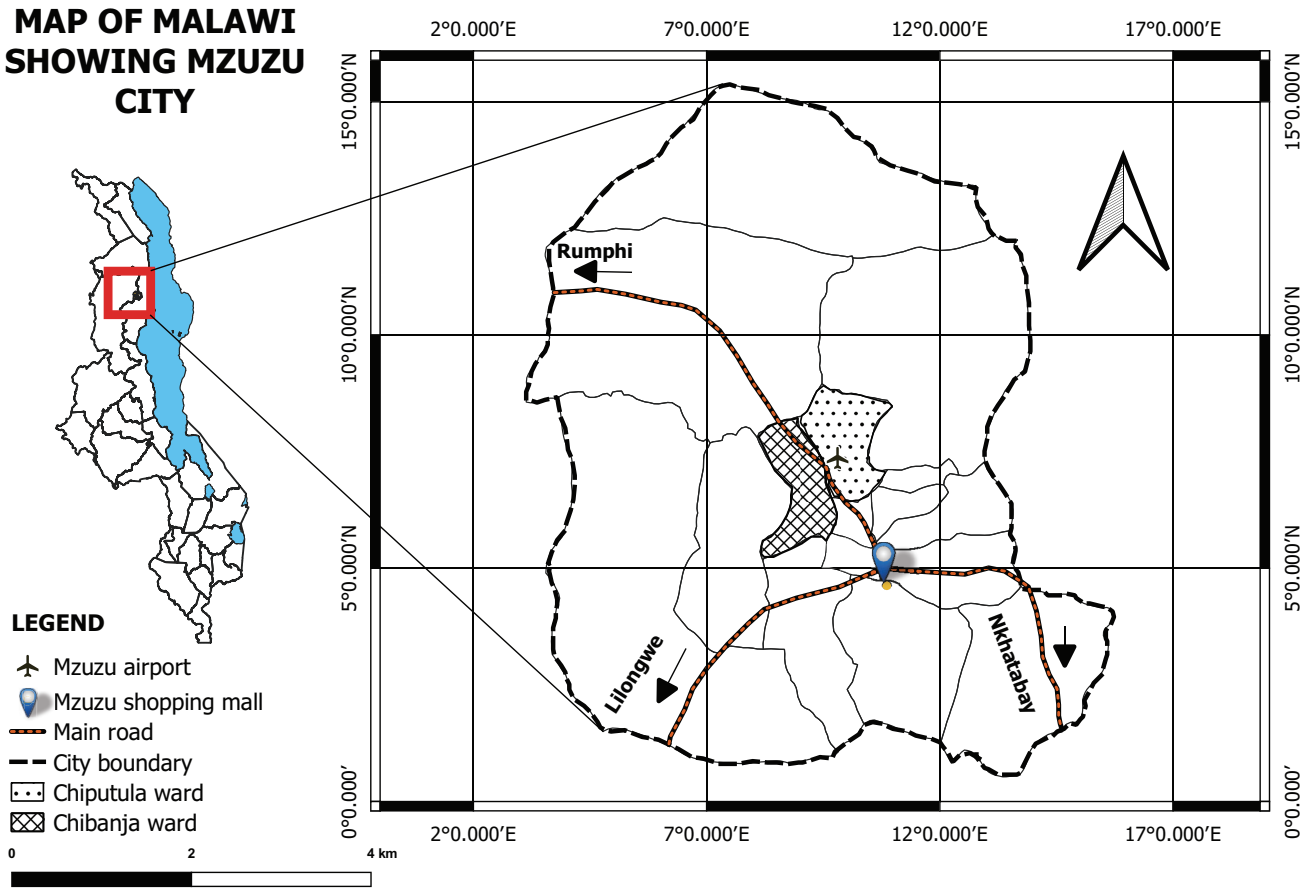

Figure 1. Map of the study area.

wards in Mzuzu City, five wards are highly vulnerable to climate-related disasters (Malawi Red Cross Society, 2019). The empirics of this study, however, are from two of the five wards, Chibanja and Chiputula, chosen because of the high frequency of floods and their associated severe impacts.

2.2. Data Collection and Analysis

To achieve the research aims, the study employed qualitative data approaches as they are ideal to answer why and how a social phenomenon occurs and the underlying causes of the phenomenon (Kaae & Traulsen, 2015). This was done through focus group discussions and in-depth key informant interviews conducted between August 2020 and January 2021. All participants in the focus group discussions gave verbal consent to participate in the research. Except for two key informants, four participants provided verbal consent to the interview. Focus group discussions were used because of their robustness in the in-depth exploration into the shared and unshared opinions, knowledge, perceptions, and concerns of individuals regarding a particular topic (Seal et al., 1998; Waste Programs Sub-Workgroup for Community Engagement, 2017). In each ward, two focus group discussions were conducted, one with youths and the other with Ward Civil Protection Committee (WCPC) members. Each group was comprised of 12 members. For the youth group, the study targeted those aged between 18 and 35 who had been residents in the study area for at least five years. Such participants were perceived to be knowledgeable of the area and climate governance practices therein. Snowballing sampling technique was used to identify youth participants whereby community leaders, as well as the youths, were asked to identify those youths who are active in community projects. As for the WCPC, the only requirement was being a member.

Further, in-depth key informant interviews with four key NGO officials and two government officials undertaking climate change interventions in Mzuzu City were also conducted. Informed by the aims of the study, a checklist was designed and used to guide all interviews. The interview guide for the youth and WCPC focus group discussion aimed at capturing community participation and youth engagement. Questions that sought to understand how and when the community is involved were used for the former theme, and questions that sought to source information on how the youth are engaged and how they participate in climate action planning and implementation activities were used for the latter theme. The interview guide for the key informant interview aimed at capturing current stakeholder engagement strategies, community participation, and youth engagement in climate action planning processes, with questions that targeted the approaches used by the respective organisation in engaging communities and further questions that sought to capture the level of dedication to climate action by the communities.

All interviews were recorded using a voice recorder. The recordings were translated from Chitumbuka and Chichewa languages and transcribed verbatim into English. Following Taylor-Powell and Renner (2003), the data was coded/categorised and coherent themes were identified which revealed patterns and connections within and between categories. It was based on these themes that interpretation of the data was made.

3. Results and Discussion

3.1. Current Stakeholder Engagement Strategies

The principal resource for responding to climate change impacts is public support, the people's knowledge, and expertise (Conde et al., 2004; Moser & Pike, 2015). Different institutions take slightly different approaches when engaging stakeholders. All participants reported consultations as the major form of engagement whereby the stakeholders were mostly just given information about the intended interventions for them to relay to their respective community members. Based on Arnstein (1969), this is still at the tokenistic level, which is insignificant for meaningful participation. However, further analysis of the data revealed the following three engagement strategies employed in Mzuzu City.

3.1.1. The Use of Established Local Government Structures

Most stakeholder engagement strategies target local governance structures at the sub-city level (Figure 2). In the decentralised governance structure, the Ward Development Committee is the key committee at the community level which leads the identification and implementation of development activities in the ward. Since the most common climate change-related impacts experienced in Mzuzu are floods, the local disaster risk management structure, i.e., civil protection committees, are often engaged. These committees are aligned with development structures at the neighbourhood, ward, and city level. The WCPC is a vital structure actively and widely engaged by institutions implementing climate change interventions. Stakeholders prefer the use of pre-existing community structures for engagement purposes since the use of local resources ensures that communication and activities are well-targeted and reflect community interests and capacity (Wiseman et al., 2010), which are important prerequisites for implementation success.

Noting the impracticality of always engaging all community members, the WCPC is mainly engaged as a representative of the community, a role that also involves making decisions on behalf of the communities. In this regard, some institutions only engage WCPC members in their planning processes and take their views as those of the community. In other cases, the decision-making role extends to the identification of participants for engagement activities. As one NGO official put it: "For the times

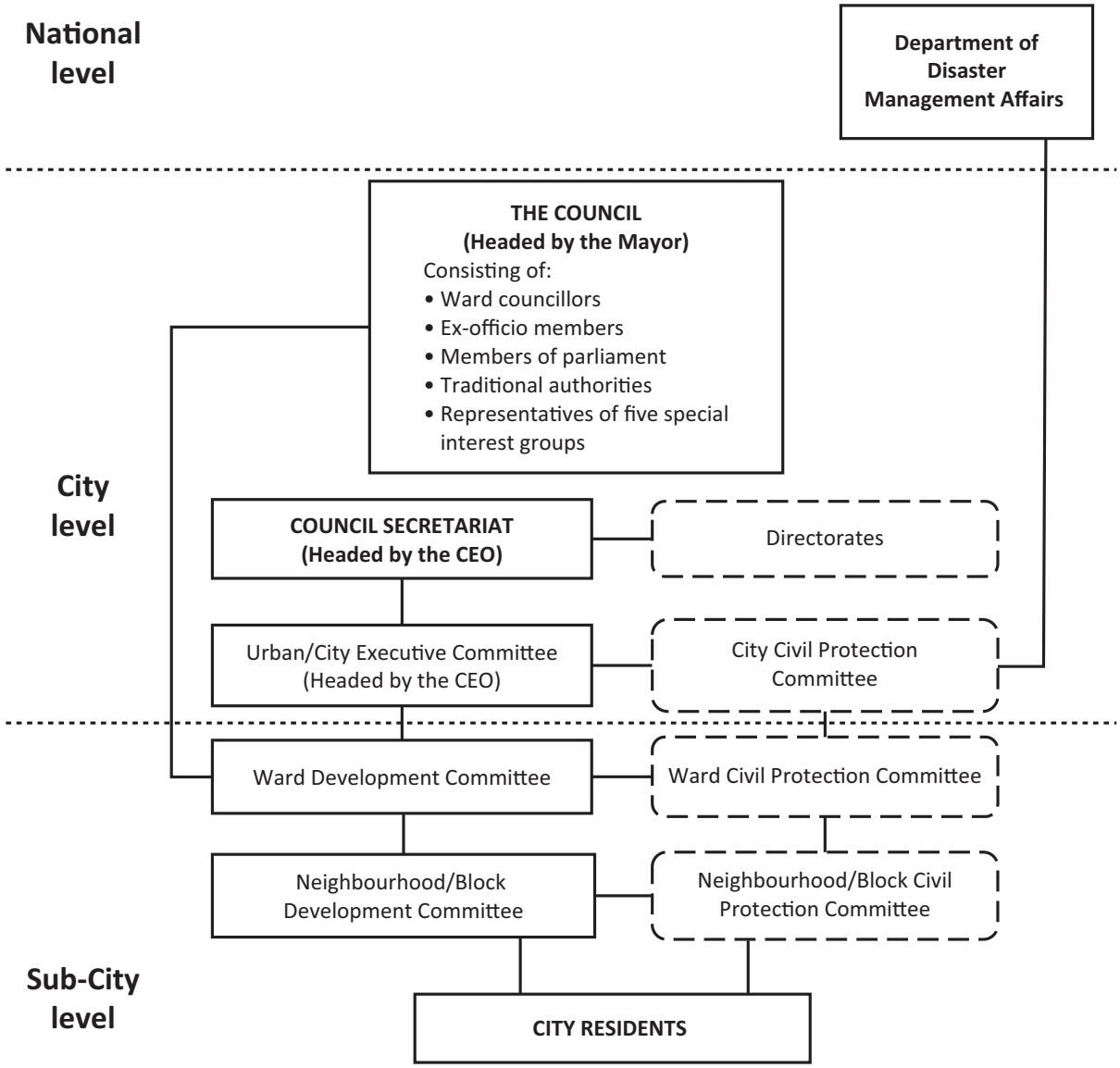

Figure 2. Local government structure. Source: Author's work, adapted from Ministry of Local Government and Rural Development (2013).

that we use the local structure, we often go through the WCPC. They are the ones who identify the participants as per the groups we need whether youths or women, or anyone.''

This use of the community structures as representatives of the people, along with the assumed power they have, leaves the engagement strategy prone to elite capture. This is problematic, as elite capture inhibits citizen engagement in local governance processes (Waheduzzaman et al., 2018). During the study, most youths reported issues of favouritism where only those known to the WCPC members and community leaders are involved in engagement processes.

3.1.2. Direct Engagement With Youth Groups/Clubs

Approaches to stakeholder engagement vary and are heavily dependent on the issue being tackled. For interventions that specifically target youths, some implementing organisations approach the youths directly through youth clubs. Responses from youth and NGO officials alike revealed that when there is direct engagement, the youths are motivated and they dedicate themselves fully to the process, which ensures project success and sustainability. However, this approach benefits only those who are in clubs or have formulated youth groups. As one NGO official elaborated:

> We target youths where they meet simply because when you target them individually it will be difficult to say we are working with these youths. Working with youth who are already organised in structures makes it easier to plan, implement, and monitor the impact of initiatives than with separate individuals from their homes.

As most of the climate action-planning processes are undertaken under existing projects, the findings show that the implementers are focused on the success of the project within the project implementation period, which makes it difficult for them to mobilise the youths in the communities. The youth groups, therefore, simplify the task of implementation and monitoring of planning processes. One major flaw with this arrangement is that only the very same youths are engaged over time. Those that are not in youth clubs, for various reasons, are kept out of the planning and implementation processes.

3.1.3. Use of Individual Community Leaders

Community leaders such as chiefs, block leaders, and ward councillors, are often engaged as key stakeholders in the community. Participants reported that these community leaders are usually involved as key informants during consultations and serve as information channels to the community members on planning and implementation processes. This strategy has proven to work to some extent as partnerships with local and well-respected people can usefully strengthen community engagement activities and outcomes (Wiseman et al., 2010). Most respondents observed that the inclusion of community leaders, as information channels, encourages local ownership and support because the leader's words or views are widely accepted and respected by the community.

With the perception that community leaders have vast knowledge of their community, sometimes they are tasked with stakeholder identification for the planning process. This strategy is problematic. Most youth participants reported that this approach enables leaders to prioritise their close friends, party supporters, and relations in the selection of participants regardless of their abilities to contribute effectively to the discussions. This, therefore, leads to the exclusion of people who would effectively contribute to the initiative's success. Projects that followed this procedure mostly got negative feedback during evaluation. One participant reported a project that was given negative appraisal from community members which affected its further implementation. This practice defeats the purpose of meaningful stakeholder participation which aims to allow stakeholders to plan and influence programs in the planning process.

3.2. Factors Affecting Youth Engagement in Local Climate Action Planning Processes

3.2.1. Inadequate Awareness of Climate Action Planning Processes

Most of the youths within the study areas have limited information regarding the existing planning processes for climate action. During the youth focus group discussions in both wards, the youth reported that they are aware that climate action planning activities happen in their communities. However, they do not know when they are scheduled to take place and how they could get involved. An NGO official concurred:

> The problem we have about youths is that our youth lack exposure and information which affects productivity to participate in developmental activities….I will give you an example of social incubators where we have few youths attending because they don't know that they can join social incubators. That's the problem.

This problem is not only exacerbated by the lack of coordination between local governance structures and youth clubs, but also the lack of formalisation of the youth clubs as part of the existing local governance structures. According to Fedessa et al. (2018), a lack of information results in a low level of awareness when it comes to developmental activities in the community. Youth are eager to participate in planning processes if there is proper sensitisation in the communities on what is happening, what role they will take, and how it will benefit them.

3.2.2. Cultural Aspects

Adults in Mzuzu City often take the leading role in planning processes and constitute the majority of participants in the community. Akin to most African societies, youths, when invited to a village meeting or any planning process, find it hard to express themselves and debate on important issues with elders within the group, as one youth participant explained:

> Culturally, it is impossible to have an exchange of words or debate with elders… this is seen as a lack of respect….When the youth express themselves, their views are often not taken on board. As such, they fail to make significant contributions even though they are insightful.

Youth occasionally interact with adults and when involved with adults, it is within a prescribed limit because they are bound by culture (Mohamud et al., 2018). Such intergenerational factors limiting youth participation in Malawi have also been observed in other sectors (Mchakulu, 2007). In Mchakulu's study, the youth would either moderate their responses to stay within the expected cultural norms or completely avoid differing from the elder's opinion altogether. Such sociocultural contexts ought to be understood when designing planning processes in the community (Camino, 2005; Ungar, 2013).

3.2.3. Scheduling of Engagement Activities

The day of the week or the time at which climate action planning processes occur affect youth participation. Planning processes targeting weekdays are a challenge to most youths. This is the time most of the youth are in schools or at work. Youths from this study

expressed how time affects their participation:

> People from the city council and other organisations used to just come during the week, so we told them that when putting your own programs, you have to consider the people you are meeting. The fact that this is a community does not mean we have nothing to do. There are people, especially the youths, who go to school, some run small scale businesses, and others go for piece work to earn a living.

Most youths easily participate meaningfully and actively when the planned time is in line with their availability in general. The preferred day for the youth which increases the chances of participation is Saturday. As one of the participants of the youth focus group discussion put it:

> We have had some activities conducted on Saturdays, early in the morning, before anyone goes to church or other activities. They announce a day or more before the day of the activity. So, it's a matter of waking up early and doing your part (participate in the activity/deliberations) then proceed to your personal activities.

These findings are consistent with those of a study by Kaseya and Kihonge (2016) in Kenya, in which they found that the day of the week the forum is scheduled affected people's participation in development activities. In their study, over 80% of participants preferred participation activities to be conducted during weekends rather than weekdays. Therefore, the scheduling of stakeholder engagement events on weekdays is a significant factor affecting youth participation.

3.2.4. Youth's Attitudes and Characters

The study found that incentives "obsession" and lack of unity among youths are some of the factors affecting youth participation. Most youths opt to participate only in activities that bring money. Although a study by Collins et al. (2008) found that incentives can motivate teens to be interested in out-of-school activities, incentives have shown to be Janus-faced. A key informant in this study narrated how incentives have negatively affected youth participation:

> Youths got used to receiving money, so when no money is attached to a project, they don't show up….They say when good things come, we don't involve them but we invite them when there are voluntary activities….That thinking is what causes more youth not to show up during climate action planning processes.

Furthermore, lack of commitment by most of the youth has resulted in them being side-lined during planning processes. Most officials from NGOs mentioned the lack of commitment from youth as one big challenge. They indicated that when involved, most youths do not even contribute as much as expected, with one official reporting a young person responding to an invitation to participate as "something for the elderly, not youth." This attitude, however, is evidence of *subject political culture* prevalent in Malawi, which is "characterised by elements of indifference and/or passivity among citizens inspired by the recognition that they have a very limited capacity to influence the content and strategic aspects of public policy" (Chingaipe & Msukwa, 2012, p. 30). This culture is often linked to politics of paternalism from the one-party system and the top-down approaches that continue to be used in the multiparty dispensation.

3.3. Towards a Youth-Inclusive Stakeholder Engagement Strategy in Local Climate Action Planning Process

Stakeholder theory requires that leaders understand and incorporate the interests of stakeholders in their operations. In this study and the framework presented in this section, stakeholder engagement is understood as "any process that involves stakeholders in some form of collaborative effort directed towards a decision, which might involve future planning and/or behaviour change" (Gardner et al., 2009, p. 11). Often, inclusive governance practices involve "information-seeking practices" (Brown, 2002, p. 373). Drawing from the experiences and findings of this study, however, this article strongly opines that effective youth engagement requires purposive and deliberate strategies in the design and implementation of stakeholder engagement strategies. This section outlines a framework to guide the organisation and implementation of climate action planning processes to ensure that they are youth inclusive. Figure 3 presents the process of a youth-inclusive local climate action planning process. The framework is presented to correspond to the climate action planning processes implemented in the area. It is envisaged that if the youth inclusion practices are integrated in the action planning process, implementation will not only be less cumbersome but also cost-effective.

For stakeholder-engagement strategies to be youth-inclusive and enhance effective youth participation, serious attention should be given to both the design/organisation and implementation of the strategies. The processes in the organisation/design stage should be successfully done before the implementation of the engagement activities. The first step is the organisation or designing stage. This step focuses on the preparation or groundwork that should be done before undertaking the particular stakeholder engagement activities. A youth-inclusive process ought to firstly strengthen the engagement capacities of the youth, by training them in not only the subject matter but also active citizenship. On the one hand, training or increased awareness on the subject matter is fundamental as it is only when participants as individuals and collectives are equipped with

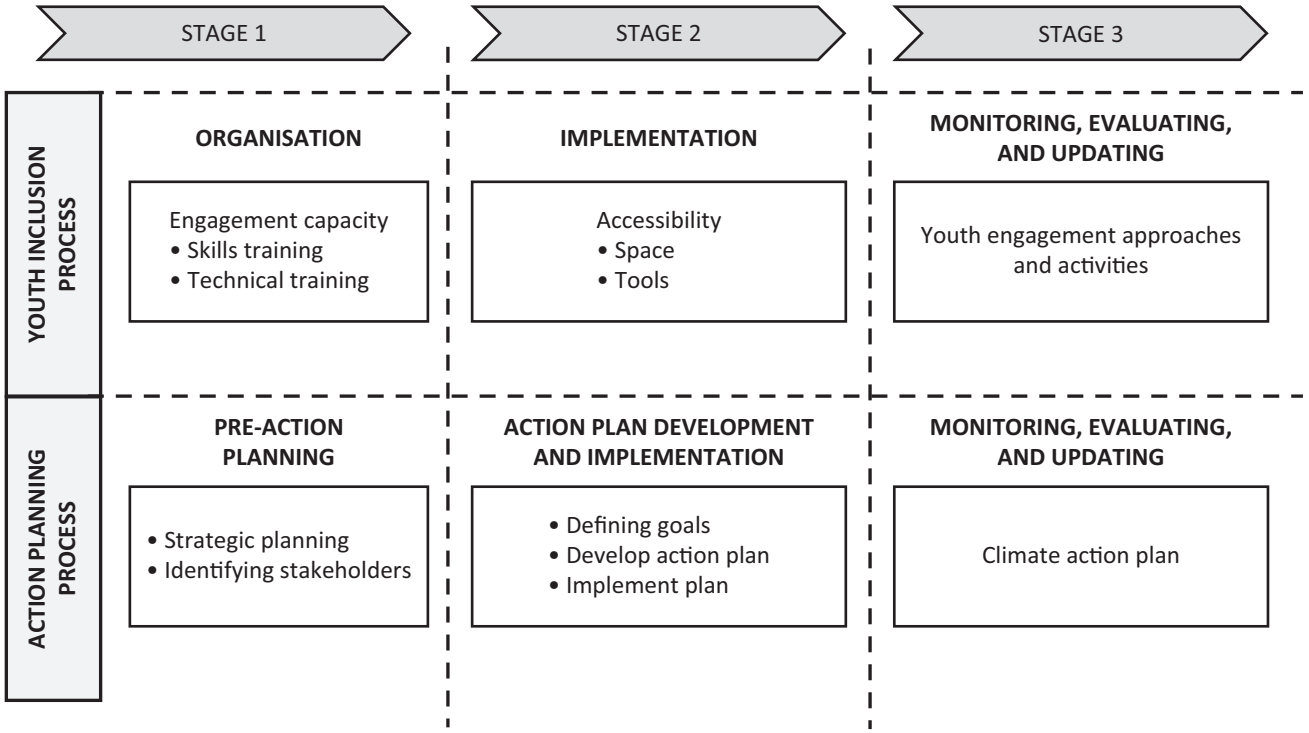

Figure 3. Framework for designing and implementing youth-inclusive stakeholder engagement strategies.

skills and knowledge that they can actively participate in planning processes (Cuthill & Fien, 2005). Technical training should not only focus on equipping youth with basic concepts used in the climate change discipline but it should also address the current relevant debates in the governance of climate change at the global and local level. On the other hand, strengthening engagement capacity also involves skills training. This may include training in active citizenship as it is critical to equip the youth with relevant negotiation skills to successfully engage in deliberative processes. Besides active citizenship, youths, through the re-energised youth clubs, can be given training in technical and entrepreneurial skills and capital to help them be economically independent. Rather than nurturing the attitude of providing financial incentives to "boost the morale of the respondents and also encourage attendance" (Kaseya & Kihonge, 2016, p. 486), economically and psychologically empowered youths, arguably, will readily engage in local climate action planning processes.

In line with the CVM and the general incentives model of participation, it is only upon the enhancement of youth engagement capacities that the implementation of engagement activities can be done. Such a comprehensive approach to training will go beyond knowledge exchange and lead to changes in attitudes and behaviour. In the case of Mzuzu City, this can easily be done through reinvigorating youth clubs which are now almost inactive. A vibrant network of youth clubs across the city will ensure that they are represented at all levels in the local planning processes, including at the city council level. Ultimately, increasing engagement capacities should increase the levels of engagement and the quality of participation beyond tokenistic levels, which are themselves not beneficial to the process or the participants (Kirby & Bryson, 2002).

The second stage is the implementation stage. As with engagement activities in other settings, climate action planning processes can take various forms. These range from information-seeking activities such as surveys, to more deliberative activities, such as policy-drafting sessions. For an engagement activity to be youth-inclusive, accessibility should be prioritised. Firstly, this can be achieved through the provision of dedicated engagement spaces for the youth. Practically, and considering the cultural barriers mentioned earlier, this entails leading agencies in the local planning processes creating spaces for youth to participate in climate action planning rather than having the youth as part of a bigger group representing the communities. These could be youth-only focus group discussions and planning workshops with participants identified in or through the existing youth clubs. Besides creating youth-targeted spaces, accessibility also focuses on the tools and formats of the engagement activities being implemented. This could include the use of language youth can easily understand and relate to and other creative approaches such as music, drama, and sporting activities. Studies in other sectors such as health have shown that the use of sporting events increases the chances of effective engagement with the youth in Malawi (Michaels-Igbokwe et al., 2015). Hence, extending such an approach to climate action planning processes would make stakeholder engagement strategies

and climate action planning processes appealing and accessible to the youth.

The final stage involves monitoring, evaluating, and updating the approaches. Akin to various complex processes, youth-inclusion approaches and activities need to be monitored and evaluated to assess the levels of achievement of the set goals. During the implementation processes, lessons must be learnt. It is based on the experiences and lessons learnt that the approaches and activities should be updated to make them more effective in ensuring youth inclusion in climate action planning. This stage should be synchronised with the monitoring and evaluation of the climate action plan developed and implemented for more comprehensive and cost-effective results.

In light of the evidence, therefore, a youth-inclusive process in local climate action planning ought to address the design and implementation of the engagement activities, including underlying constraints. As such, the engagement capacities of the youth should be strengthened, including through technical and skills training. Further, following co-designing of youth-targeted engagement activities, youth-friendly spaces and tools should be used during the implementation of the engagement activities. This should be accompanied by monitoring, evaluation, and constant updating of the approaches and activities based on the lessons learnt.

4. Conclusions

The study sought to foreground how current stakeholder engagement strategies in climate action planning marginalise the youth. The findings have revealed significant gaps and barriers in the current stakeholder engagement activities which contribute to the marginalisation of the youth in local climate action planning processes. The use of established local governance structures which are often captured by politicians has meant only youths who are politically connected are involved in planning activities. Additionally, the hunt for monetary incentives, at times, prompts those in authority in the communities not to involve many people, including the youth, even if their participation is required. The article further assessed the factors affecting youth involvement in the planning process which include lack of awareness, cultural aspects, scheduling limitations and youth's attitudes. Considering the foregoing, a framework is, hereby, proposed for designing and implementing stakeholder engagement strategies to ensure effective youth engagement in climate action-planning processes in the city. Such a framework, though developed based on experiences from Mzuzu City, may be applicable in cities sharing similar contextual situations. These include cities in developing countries with similar cultural challenges to youth participation and following decentralised systems of governance. The application of the framework in such areas will require minimal adjustments. For cities with different contexts, practitioners should consider socio-cultural factors such as youth-adult relationships and how the society perceives the youth in action planning processes. Further, the governance context should also be considered. This is particularly important because significant adjustments may need to be made when applying the framework in a study area that follows a centralised system of governance as the current framework was designed based on lessons from a decentralised system of governance.

The empirics in this study are limited to two wards in Mzuzu City and the local disaster risk management structures. Cognisant of the fact that climate change is a cross-cutting issue, it would be helpful to understand how other structures responsible for critical sectors such as urban planning, health, water, and sanitation engage youth in their planning processes. Further research employing an intersectionality approach would also help to understand how multiple factors in youth's lives, such as class, gender, education, religion, or tribe, concurrently affect their ability to participate in local planning processes. Moreover, and for Malawi's case in particular, there is a need to formalise the youth clubs and their links to local structures such as the WCPCs so that youths are kept informed and participate in all planning processes. These youth clubs should further have a network that could represent the youth at the city council level. Such deliberate and strategic arrangements will give the youth more avenues to participate and influence climate action planning processes.

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Conflict of Interests

The authors declare no conflict of interests.

References

Adhikari, S., Kingi, T., & Ganesh, S. (2014). Incentives for community participation in the governance and management of common property resources: The case of community forest management in Nepal. *Forest Policy and Economics*, *44*, 1–9. https://doi.org/10.1016/j.forpol.2014.04.003

Akinboye, O., Ayanwuyi, F., Kuponniyi, F., & Oyetoro, J. (2007). Factors affecting youth participation in community development in Remo North Government Area of Ogun State. *The Social Sciences*, *2*(3), 307–311.

Angba, A. O., Adesope, O. M., & Aboh, C. L. (2009). Effect of socioeconomic characteristics of rural youths on their attitude towards participation in community development projects. *International NGO Journal*, *4*(8), 348–351.

Arnstein, S. R. (1969). A ladder of citizen participation. *Journal of the American Planning Association*, *35*(4), 216–224. https://doi.org/10.1080/01944366908977225

Barkan, S. E. (2004). Explaining public support for the environmental movement: A civic voluntarism model. *Social Science Quarterly*, *85*(4), 913–937. https://doi.org/10.1111/j.0038-4941.2004.00251.x

Brown, W. A. (2002). Inclusive governance practices in non-profit organizations and implications for practice. *Non-Profit Management and Leadership*, *12*(4), 369–385.

Burns, N., Schlozman, K. L., & Verba, S. (2001). *The private roots of public action: Gender, equality, and political participation*. Harvard University Press.

Camino, L. (2000). Youth-adult partnerships: Entering new territory in community work and research. *Applied Developmental Science*, *4*, 11–20. https://doi.org/10.1207/S1532480XADS04Suppl_2

Camino, L. (2005). Pitfalls and promising practices of youth-adult partnerships: An evaluator's reflections. *Journal of Community Psychology*, *33*(1), 75–85. https://doi.org/10.1002/jcop.20043

Checkoway, B. N., & Gutiérrez, L. M. (2006). Youth participation and community change. *Journal of Community Practice*, *14*(1/2), 1–9. https://doi.org/10.1300/J125v14n01_01

Chingaipe, H., & Msukwa, C. (2012). *Whose voice? Citizen participation and influence in public policy processes in Malawi*. Malawi Economic Justice Network.

Chinsinga, B., & Chasukwa, M. (2012). Youth, agriculture and land grabs in Malawi. *IDS Bulletin*, *43*(6), 67–77. https://doi.org/10.1111/j.1759-5436.2012.00380.x

Claridge, T. (2004). *Designing social capital sensitive participation methodologies*. Social Capital Research. https://www.socialcapitalresearch.com/wp-content/uploads/2013/01/Social-Capital-and-Participation-Theories.pdf

Collins, A., Bronte-Tinkew, J., & Burkhauser, M. (2008). *Using incentives to increase participation in out-of-school time programs*. Child Trends. https://www.childtrends.org/wp-content/uploads/2013/05/child_trends-2008_06_18_pi_ostincentives.pdf

Conde, C., Lonsdale, K., Nyong, A., & Aguilar, Y. (2004). Engaging stakeholders in the adaptation process. In B. Lim & E. Spanger-Siegfried (Eds.), *Adaptation policy frameworks for climate change: Developing strategies, policies and measures* (pp. 47–66). Cambridge University Press.

Connor, D. M. (1988). A new ladder of citizen participation. *National Civic Review*, *77*(3), 249–257. https://doi.org/10.1002/ncr.4100770309

Corner, A., Roberts, O., Chiari, S., Völler, S., Mayrhuber, E. S., Mandl, S., & Monson, K. (2015). How do young people engage with climate change? The role of knowledge, values, message framing, and trusted communicators. *Wiley Interdisciplinary Reviews: Climate Change*, *6*(5), 523–534. https://doi.org/10.1002/wcc.353

Cuthill, M., & Fien, J. (2005). Capacity building: Facilitating citizen participation in local governance. *Australian Journal of Public Administration*, *64*(4), 63–80. https://doi.org/10.1111/j.1467-8500.2005.00465a.x

Fedessa, B., Haile, F., & Mansingh, P. J. (2018). Determinants of youth participation in the community development process in Ambo District, Oromia Region, Ethiopia. *IMPACT: International Journal of Research in Applied, Natural and Social Sciences*, *6*(7), 1–12. http://oaji.net/pdf.html?n=2017/491-1533806775.pdf

Gardner, J., Dowd, A.-M., Mason, C., & Ashworth, P. (2009). *A framework for stakeholder engagement on climate adaptation* (CSIRO Climate Adaptation Flagship Working Paper No. 3). CSIRO. https://research.csiro.au/climate/wp-content/uploads/sites/54/2016/03/3_CAF_WorkingPaper03_pdf-Standard.pdf

Gondwe, S., Kasiya, S., Maulidi, F., & Munthali, G. T. (2020). *Assessment of youth employment initiatives in Malawi: Implementation realities and policy perspective* (FARA Research Report Volume 5 No. 6). Forum for Agricultural Research in Africa. https://research4agrinnovation.org/wp-content/uploads/2021/03/assessment-of-youth-employment-initiatives-in-malawi-implementation-realities-and-policy-download.pdf

Helmsing, A. H. J. (2002). Decentralisation, enablement, and local governance in low-income countries. *Environment and Planning C: Government and Policy*, *20*(3), 317–340. https://doi.org/10.1068/c0040

Hobbs, S. J., & White, P. C. L. (2012). Motivations and barriers in relation to community participation in biodiversity recording. *Journal for Nature Conservation*, *20*, 364–373. https://doi.org/10.1016/j.jnc.2012.08.002

Hurlbert, M., & Gupta, J. (2015). The split ladder of participation: A diagnostic, strategic, and evaluation tool to assess when participation is necessary. *Environmental Science and Policy*, *50*, 100–113. https://doi.org/10.1016/j.envsci.2015.01.011

Kaae, S., & Traulsen, J. M. (2015). Qualitative methods in pharmacy practice research. In Z.-U.-D. Babar (Ed.), *Pharmacy practice research methods* (pp. 49–68). Springer. https://doi.org/10.1007/978-3-319-14672-0_4

Kaseya, C. N., & Kihonge, E. (2016). Factors affecting the effectiveness of public participation in county governance in Kenya: A case of Nairobi County. *International Journal of Scientific and Research Publications*, *6*(2), 476–487. http://strategicjournals.com/index.php/journal/article/viewFile/381/410

Kirby, P., & Bryson, S. (2002). *Measuring the magic? Eval-*

uating and researching young people's participation in public decision making. Carnegie Young People Initiative.

Kita, S. M. (2017). Urban vulnerability, disaster risk reduction and resettlement in Mzuzu City, Malawi. *International Journal of Disaster Risk Reduction*, *22*, 158–166. https://doi.org/10.1016/j.ijdrr.2017.03.010

Kotus, J., & Sowada, T. (2017). Behavioural model of collaborative urban management: Extending the concept of Arnstein's ladder. *Cities*, *65*, 78–86. https://doi.org/10.1016/j.cities.2017.02.009

Malawi Red Cross Society. (2019). *Vulnerability and capacity assessment report: Strengthening resilience to disasters in urban and rural Malawi (STRIM) project, Mzuzu City*.

Mchakulu, J. E. J. (2007). Youth participation in radio listening clubs in Malawi. *Journal of Southern African Studies*, *33*(2), 251–265. https://doi.org/10.1080/03057070701292574

Michaels-Igbokwe, C., Lagarde, M., Cairns, J., & Terris-Prestholt, F. (2015). Designing a package of sexual and reproductive health and HIV outreach services to meet the heterogeneous preferences of young people in Malawi: Results from a discrete choice experiment. *Health Economics Review*, *5*(1), 15–17. https://doi.org/10.1186/s13561-015-0046-6

Ministry of Forestry and Natural Resources, Environmental Affairs Department. (2021). *Malawi's strategy on climate change learning*. Government of Malawi. https://www.uncclearn.org/wp-content/uploads/2021/02/Updated-Malawis-Strategy-on-Climate-Change-Learning-2021.pdf

Ministry of Local Government and Rural Development. (2013). *Guidebook on the local government system in Malawi*. Government of Malawi. https://www.resakss.org/sites/default/files/Malawi MLGRD 2013 Guidebook on the Local Government System in Malawi.pdf

Mohamud, A. J., Muturi, P. W., & Samantar, M. S. (2018). Factors influencing youth participation in community development initiatives of Garowe District. *International Journal of Social Science and Economic Research*, *3*(3), 1107–1145.

Moser, S. C., & Pike, C. (2015). Community engagement on adaptation: Meeting a growing capacity need. *Urban Climate*, *14*, 111–115. https://doi.org/10.1016/j.uclim.2015.06.006

National Statistical Office. (2019). *Malawi population and housing census report—2018*. Government of Malawi. http://www.nsomalawi.mw/images/stories/data_on_line/demography/census_2018/2018 Malawi Population and Housing Census Main Report.pdf

Oladeji, J. O., Olaore, O. M., & Fapojuwo, O. E. (2017). Participation of rural youths in community development process in Osun State, Nigeria. *Nigerian Journal of Rural Sociology*, *17*(2), 51–57.

Population Division of the United Nations Department of Economic and Social Affairs. (2019). *World population prospect 2019: Ten Key findings*. United Nations. https://population.un.org/wpp/Publications/Files/WPP2019_10KeyFindings.pdf

Pretty, J. N. (1995). Participatory learning for sustainable agriculture. *World Development*, *23*(8), 1–7. https://doi.org/10.1016/0305-750X(95)00046-F

Rubenson, D. (2000, April 14-19). *Participation and politics: Social capital, civic voluntarism, and institutional context* [Paper presentation]. ECPR Joint Sessions of Workshops, Copenhagen, Denmark.

Schelbe, L., Chanmugam, A., Moses, T., Saltzburg, S., Williams, L. R., & Letendre, J. (2015). Youth participation in qualitative research: Challenges and possibilities. *Qualitative Social Work*, *14*(4), 504–521. https://doi.org/10.1177/1473325014556792

Seal, D. W., Bogart, L. M., & Ehrhardt, A. A. (1998). Small group dynamics: The utility of focus group discussions as a research method. *Group Dynamics: Theory, Research, and Practice*, *2*(4), 253–266. https://doi.org/10.1037//1089-2699.2.4.253

Tarifa, T., Machtmes, K., Fox, J. E., & Johnson, E. (2009). Factors affecting youth voice in decision-making processes within youth development programs. *Journal of Youth Development*, *4*(4), 85–99. https://doi.org/10.5195/jyd.2009.244

Taylor-Powell, E., & Renner, M. (2003). *Analyzing qualitative data*. University of Wisconsin-Extension. https://cdn.shopify.com/s/files/1/0145/8808/4272/files/G3658-12.pdf

Tosun, C. (2004). Expected nature of community participation in tourism development. *Tourism Management*, *27*, 493–504. https://doi.org/10.1016/j.tourman.2004.12.004

Udensi, L., Daasi, G. L., Emah, D., & Zukbee, S. (2013). Youth participation in community development (CD) programmes in Cross River State: Implications for sustainable youth development in Nigeria. *IOSR Journal of Humanities and Social Science*, *13*(5), 61–67. https://doi.org/10.9790/0837-1356167

Ungar, M. (2013). The impact of youth-adult relationships on resilience. *International Journal of Child, Youth and Family Studies*, *4*(3), 328–336. https://doi.org/10.18357/ijcyfs43201312431

United Nations. (1992). *United Nations framework convention on climate change*. https://unfccc.int/resource/docs/convkp/conveng.pdf

United Nations. (2020). *World youth report: Youth social entrepreneurship and the 2030 agenda*. https://www.un.org/development/desa/youth/wp-content/uploads/sites/21/2020/07/2020-World-Youth-Report-FULL-FINAL.pdf

United Nations Joint Framework Initiative on Children, Youth and Climate Change. (2013). *Youth and climate change: A generational challenge*. United Nations. https://www.un.org/esa/socdev/documents/youth/fact-sheets/youth-climatechange.pdf

Waheduzzaman, W., As-Saber, S., & Hamid, M. B. (2018). Elite capture of local participatory governance. *Policy and Politics*, *46*(4), 645–662. https://doi.org/10.1332/030557318X15296526896531

Waste Programs Sub-Workgroup for Community Engagement. (2017). *Community engagement strategy: Issues to consider when planning and designing community engagement approaches for tribal integrated waste management programs*. Tribal Infrastructure Task Force. https://www.epa.gov/sites/default/files/2017-03/documents/tribalswcommunityengagementstrategy508.pdf

Wattar, L., Fanous, S., & Berliner, P. (2012). Challenges of youth participation in participatory action research—Methodological considerations of the Paamiut Youth Voice research project. *International Journal of Action Research*, *8*(2), 185–212. https://doi.org/10.1688/1861-9916_IJAR_2012_02_Wattar

Wehn, U., & Almomani, A. (2019). Incentives and barriers for participation in community-based environmental monitoring and information systems: A critical analysis and integration of the literature. *Environmental Science and Policy*, *101*, 341–357. https://doi.org/10.1016/j.envsci.2019.09.002

Wigle, J., Paul, S., Birn, A. E., Gladstone, B., & Braitstein, P. (2020). Youth participation in sexual and reproductive health: Policy, practice, and progress in Malawi. *International Journal of Public Health*, *65*(4), 379–389. https://doi.org/10.1007/s00038-020-01357-8

Wiseman, J., Williamson, L., & Fritze, J. (2010). Community engagement and climate change: Learning from recent Australian experience. *International Journal of Climate Change Strategies and Management*, *2*(2), 134–147. https://doi.org/10.1108/17568691011040399

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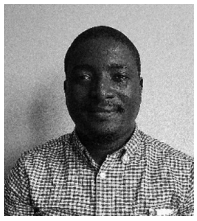

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Article

Characterizing Physical and Social Compositions of Cities to Inform Climate Adaptation: Case Studies in Germany

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Abstract
Cities are key to climate change mitigation and adaptation in an increasingly urbanized world. As climate, socio-economic, and physical compositions of cities are constantly changing, these need to be considered in their urban climate adaptation. To identify these changes, urban systems can be characterized by physical, functional, and social indicators. Multi-dimensional approaches are needed to capture changes of city form and function, including patterns of mobility, land use, land cover, economic activities, and human behaviour. In this article, we examine how urban structure types provide one way to differentiate cities in general and to what extent socio-economic criteria have been considered regarding the characterization of urban typologies. In addition, we analyse how urban structure types are used in local adaptation strategies and plans to derive recommendations and concrete targets for climate adaptation. To do this, we examine indicators, background data used, and cartographic information developed for and within such urban adaptation plans, focusing in particular on the German cities of Karlsruhe and Berlin. The comparative analysis provides new insights into how present adaptation plans consider physical and social structures, including issues of human vulnerability within cities. Based on the analysis we make recommendations on how to improve the consideration of both physical and socio-economic aspects of a city to support pathways for adaptation.

Keywords
city typologies; climate adaptation; Germany; physical structures; socio-economic structures; urban indicators; vulnerability assessment

Issue
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1. Introduction

In the context of climate change, cities play a dual role: They accelerate climate change through increased greenhouse gas emissions and are places particularly affected by climate change (e.g., heat stress and flash floods; Rößler et al., 2014). To ensure a high quality of living for urban residents in a changing climate, adaptation measures have to be implemented at different spatial scales (Rößler et al., 2014). Urban planning can contribute to climate change mitigation through, for example, compact settlement forms, infrastructure that supports sustainable mobility and lifestyles, or resilience measures (e.g., nature-based solutions; Somarakis et al., 2019; Wende

et al., 2010). Adaptation to the effects of climate change is an important challenge for spatial and urban planning. Future planning approaches must assess and consider a range of impacts on environment, society, and economy. Adverse societal impacts of climate change are significantly impacted by exposure and vulnerability of different population groups or settlement types and infrastructures (see Intergovernmental Panel on Climate Change [IPCC], 2012). Temperature rise, the apparent shift of the distribution of precipitation from summer to winter, and the increase in frequency of extreme events (e.g., heavy rain and heat waves) are expected to intensify further, based on current projections (IPCC, 2018). Socio-economic development and physical changes of cities and regions modify exposure and vulnerability patterns (Birkmann et al., 2013). To assess vulnerability of urban residents to different impacts of climate change, multiple physical and socio-economic indicators that are also relevant for planning strategies need to be considered (Kappes et al., 2012; Li et al., 2016).

Cities are often subdivided into spatial units with similar physical conditions (e.g., building types, transport access, types of open space, and functionality). In some cases, socio-economic structures also are considered, such as residents' ages, income, and access to services. Because of their specific characteristics, each urban structure type may be affected differently by climate change and weather events (Beermann et al., 2013). Building typologies can influence exposure and vulnerability to different weather and climate related events, such as heat stress (IPCC, 2014). For example, in single-family houses with large gardens, air conditioning, and vegetation that provides shade, people may be less exposed to heat compared to multi-family homes in densely populated inner-city areas without these cooling potentials. Consequently, considering current and future characteristics of physical and social structures in cities, including different urban typologies within cities and their dynamics, is important for adaptation planning. Present adaptation strategies in cities in Germany consider different urban structure typologies for their formulation of adaptation needs and adaptation goals.

In this article, we investigate existing climate change adaptation plans for urban development and planning in two German cities—Berlin and Karlsruhe. These case study cities are used to examine (a) how different urban areas are characterized for adaptation in urban planning, and (b) how typologies within these strategies and plans differentiate physical and socio-economic structures that are relevant to identifying adaptation needs and climate resilient development.

2. Conceptual Framework

2.1. Climate Vulnerability and Adaptation

It is widely acknowledged, in addition to mitigation strategies, that adaptation strategies are essential to proactively manage future risks and to reduce or even prevent adverse consequences of climate change for societies and cities (Birkmann, 2013; IPCC, 2012, 2014; Mertz et al., 2009). There is emerging consensus that next to hazard or climate information, the differential vulnerability of people and infrastructure exposure needs to be assessed to develop a more comprehensive information basis for adaptation (Birkmann, 2013; Ford et al., 2018; IPCC, 2014). The strong interest from different disciplines on concepts of vulnerability and the multi-dimensional nature of vulnerability (e.g., physical, social, and economic) has led to different definitions, approaches, and methods across disciplines. Taking into account the existing variety of approaches to assess vulnerability (e.g., Bogardi & Birkmann, 2004; Carreño et al., 2007; Füssel & Klein, 2006; IPCC, 2012; Turner et al., 2003; Wisner et al., 2004), we build on this literature and use the definition of vulnerability developed within the context of recent IPCC (2012, 2014, 2018) reports by researchers from both climate change research and disaster risk reduction.

In this context, *vulnerability* is defined as "the propensity or predisposition to be adversely affected" (IPCC, 2018, p. 560). Climate vulnerability may incorporate components including sensitivity or susceptibility to harm, but also response capacities, such as the lack of capacity to cope and adapt (Birkmann, 2013; IPCC, 2012). Considered this way, vulnerability does not solely focus on the fragility or susceptibility of a community, population group, or infrastructure, but also considers capacities to deal with and to adapt to shocks and hazards. Other approaches examine the vulnerability of ecosystems or capture and assess the vulnerability of coupled social-ecological systems (Bennett et al., 2016; Burton et al., 2002; Ford et al., 2018; O'Brien et al., 2007).

Therefore, the operationalization of vulnerability is a challenge, since it needs to measure and reflect social structures and societal development processes as well as material outcomes within systems that appear highly complex and are characterized by interdependencies that are difficult to capture (Adger, 2006). However, assessing vulnerability is an essential element to understand risks and to highlight the importance of social factors and societal structures in the construction of risk and the identification of adaptation options (Birkmann, 2013). Information about climatic hazards and physical structures within cities needs to be complemented with information about human vulnerability and respective socio-economic drivers of vulnerability to support urban adaptation planning. Hence, the analysis of urban typologies used within present adaptation strategies is an important research task to better understand what type of factors are, or are not, currently considered.

The term "urban structure types," *Stadtstrukturtypen* in German, was established in the 1990s to categorize different urban settlements. Since then, this concept has been used in planning and monitoring of cities and settlements (Novack & Stilla, 2014). Mapping urban

structure types allows differentiation of the urban system into distinct areas that include various configurations of built, open spaces, green spaces, and infrastructure (Heiden et al., 2012). To ensure these typologies can effectively inform future climate adaptation policies, an integrated approach that incorporates the physical and socio-economic characteristics of a city is needed. In this article, we examine whether and how such socio-economic aspects and profiles are linked to settlement types/structures used in present approaches. In addition, we explore how these typologies could be strengthened to also include aspects of human vulnerability.

To aid development of a more integrated approach encompassing multiple dimensions of urban development, indicator-based methods provide a useful tool as they reduce complexity and allow a systematic operationalization and monitoring of the various aspects through time (Chrysoulakis et al., 2021). Indicators in ecology and environmental planning are used to depict and evaluate environmental conditions or changes (Heink & Kowarik, 2010). To assess climate vulnerability and adaptive capacities, different sets of indicators have been developed (e.g., Birkmann, 2013; Chrysoulakis et al., 2014; He et al., 2019; Parsons et al., 2016; Wolf & McGregor, 2013). However, it is important to note that indicator-based approaches regarding vulnerability also have limitations and are criticized because of uncertainties and data limitations (see, e.g., Turner et al., 2003). In many studies, aspects of economic vulnerability are represented with "conventional" economic indicators; at the same time, social vulnerability also often encompasses intangible factors that are difficult to quantify and validate (Sorg et al., 2018). There are numerous other indicator systems that are used in closely cognate urban disciplines and applications (e.g., consideration of green infrastructure cost and benefits in cities for various environmental services; Grimmond & Souch, 1994; McPherson et al., 1997). However, in this article we focus particularly on the indicators used within existing urban adaptation concepts in two cities. Furthermore, we highlight the importance of other indicators that could provide further information about societal vulnerability at the household or settlement structure scale, such as household composition, age, education, income, and employment.

2.2. Typologies of Urban Structure

In general, typologies are both analytical and descriptive tools for developing and refining ideas, creating categorical classification, and sorting various case studies (Collier et al., 2012). In urban planning and architecture, recent examples include typologies that aim to provide historical narratives, reflect the urbanization process, categorize development trends, classify economic activities, and examine a wide range of environmental issues (Fragkias & Seto, 2009; Kloosterman & Lambregts, 2007; Li et al., 2020; Nijman, 2007; Zhou et al., 2017). One key-use is to identify parameters that allow variability across a city to be assessed. In climate change research, urban typologies can be broadly categorized into those that consider physical and socio-economic aspects (Solecki et al., 2015). Typologies of urban structure have also been used globally in an attempt to categorize cities in the context of climate adaptation (Hrabovszky-Horváth et al., 2013; Salas & Yepes, 2018; Storch & Schmidt, 2008).

There are several ways through which planners, sociologists, geographers, economists, and environmentalists have attempted to define the physical and social structure of cities (including the economic, political, cultural, and institutional characteristics of the society). According to Wilson (2010, p. 201), "social structure refers to the way social positions, social roles, and networks of social relationships are arranged in our institutions, such as the economy, polity, education, and the organization of the households." There is increasing evidence that socio-economic urban structure is a central-driving consideration in global environmental research and climate change studies (Banzhaf & Hofer, 2008; Crenshaw & Jenkins, 1996).

Physical urban structure mostly corresponds to spatial configuration of various structural elements of the built environment (Roca Cladera et al., 2009). Implicitly, physical/spatial structure includes "the characteristics of urban form and structure, as well as spatial configurations of structural elements, which can influence ecological functioning and human well-being in cities" (Larondelle et al., 2014, p. 427).

Overall, urban structure types are an important method and entry point for the analysis of intra-urban variations, both in terms of physical as well as social structures and dynamics. Urban structure types can be categorized with a variety of indicators which are used to quantify and measure different societal structures and specific dynamics. Table 1 provides an overview of indicators used to assess physical, socio-physical, and socio-economic structures and typologies in cities. These indicators range from capturing urban form, to featuring spatial configurations of different societal groups, integrating physical infrastructure to social infrastructure, and combining building typologies together with the household characteristics within an urban area.

3. Methodology

For this study we have undertaken an extensive literature review, assessing publications from multiple disciplines including urban planning, environmental planning, and social science, and examining physical and socio-economic indicators used to define and characterize "urban structure types" in adaptation research and applied in urban adaptation concepts. Both case study cities, Berlin and Karlsruhe, have published urban adaptation plans that use urban structure typologies. For these case studies, adaptation plans, project articles/reports,

Table 1. Examples of indicators used to characterize social and physical structures of cities.

Indicator	Component	Example references
(a) Physical		
Land use/ land cover	Functional building use	Nguyen et al. (2014); Xu et al. (2019)
	Green spaces/open/public spaces	
	Road transport infrastructure	
Building typology	Morphology (e.g., footprint, height, building density, arrangement)	Hrabovszky-Horváth et al. (2013); Kappes et al. (2012); Lowry and Lowry (2014)
Density	Population density (pop./km^2)	Galster et al. (2001); Kappes et al. (2012); Torrens and Marina (2000)
	Average household size (people/housing unit)	Kappes et al. (2012); Song and Knaap (2004)
(b) Physical-socio-economic		
Centrality	Mean distance to social infrastructure (m)	Galster et al. (2001); Song and Knaap (2004); Theobald (2001)
Accessibility	Street connectivity (ratio streets to intersections)	Song and Knaap (2004); Weston (2002)
	Median perimeter of residential blocks (m)	Song and Knaap (2004); Weston (2002)
Neighborhood mix	Land use contiguity (Juxtapose Interspersion Index)	Torrens and Marina (2000)
	Land use richness (Patch Richness)	Frenkel and Ashkenazi (2008)
	Land use diversity (Simpsons Diversity Index)	Frenkel and Ashkenazi (2008); Weston (2002)
(c) Socio-economic		
Social	Age distribution	Cutter et al. (2003); Hahn et al. (2009); Scheuer et al. (2011); Song and Knaap (2004); Sorg et al. (2018)
	Gender ratio	Mustafa (2003); Yoon (2012)
	Illiterate population (%)	Eakin and Bojórquez-Tapia (2008); Hahn et al. (2009); Handayani et al. (2017)
	Disabled Population (%)	Hahn et al. (2009); Panthi et al. (2016); Sorg et al. (2018)
	Ethnicity / migration background	Cutter et al. (2003); Fekete (2009); Sorg et al. (2018); Yoon (2012)
Economic	Number of (un)employed	Cutter et al. (2003); Hahn et al. (2009); Yoon (2012)
	Household income	Cutter et al. (2003); Jamshed et al. (2020); Shah et al. (2018)
	Social capital and livelihood	Eakin and Bojórquez-Tapia (2008); Jamshed et al. (2020); Qaisrani et al. (2018)
	Economic performance (sales, industry, etc.)	Cutter et al. (2003)
	House ownership	Burton (2010); Fatemi et al. (2017); Lee (2014)
Infrastructure and utilities	Access to social facilities (hospitals, retirement home, kindergarten)	Mustafa (2003); Panthi et al. (2016); Qaisrani et al. (2018); Shrivastava (2003); Zhao and Chen (2015)
	Access to amenities (water supply, gas, electricity)	Islam et al. (2013); Qaisrani et al. (2018); Zhao and Chen (2015)
	Dilapidated buildings	Fekete (2009); Xu et al. (2019)
	Hospital beds per capita	Leichenko et al. (2015)
Technology	Access to internet	Fatemi et al. (2017); Yoon (2012)

Note: Indicator categories adapted from Lowry and Lowry (2014) and Malakar and Mishra (2016).

and cartographic information are analysed (e.g., environmental atlas in Berlin; Senate Department for Urban Development and the Environment, 2016a). To verify core findings, expert interviews, for example with representatives of the Senate Department for Urban Development and Housing of the City of Berlin, were conducted. The analysis provides new insights on how these urban typologies consider physical and social aspects and also reveals gaps that should be addressed in the future. The following research questions were used to investigate the urban adaptation strategies in Berlin and Karlsruhe:

- How are "urban structure types" defined?
- Which indicators are used to differentiate urban structure types?
- To what extent have socio-economic and demographic indicators been integrated into this characterization?
- How do the different "urban structure typologies" inform adaptation strategies and measures?

4. Case Studies: Berlin and Karlsruhe

Large and medium-sized cities in Germany play a key role in climate adaptation. German cities are often characterized by a polycentric structure that provides important economic, social, and cultural functions for the residents and surrounding areas. However, these structures may be vulnerable to climate change due to: (a) concentration of vulnerable groups, (b) climate change combining both urban (e.g., urban heat island) and regional influences (e.g., heat waves; Founda & Santamouris, 2017), (c) damage potential, (d) high dependency on infrastructure services that might collapse in extreme events, and (e) adaptive capacity.

The city of Berlin has experienced significant heat stress from increasing regional temperatures exacerbated by the urban heat island effect (Behrens & Grätz, 2010). The German Weather Service and the Senate for Urban Development's analysis of mean annual air temperature found that it increased by 1°C between 1971 and 2000 and that the number of "tropical nights" (nocturnal air temperature above 20°C) also increased, particularly in the inner city (Behrens & Grätz, 2010). By 2050, the number of very hot days (maximum daytime temperature above 30°C) in the dense inner-city areas will increase to 25 days per year (Senate Department for Urban Development and Housing, 2011). Given Berlin's continental location, the summertime heat is often associated with challenges posed by water scarcity (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2008).

The city of Karlsruhe has large impervious cover and summer air temperature in the city than can be 10°C warmer than the surroundings (Beermann et al., 2014). Located within the Upper Rhine Rift Valley, this is the warmest region in Germany. Karlsruhe is considered to be a city with heat-related health risks, which are a key concern (Beermann et al., 2014). Considerable small-scale temperature differences occur within the various built-up areas, thus underlining the relevance of urban structure types, including the degree of sealing and green spaces (Hackenbruch, 2018).

4.1. City of Berlin

Climate adaptation and mitigation pose new challenges to sustainable urban development for the city of Berlin (Senate Department for Urban Development and Housing, 2011). On the one hand, these issues are relevant for the modification of existing urban structures (e.g., optimization of existing buildings, infrastructure, and green/open spaces). On the other hand, mitigation and adaptation issues need to be considered from the beginning when planning and implementing new urban areas. To improve the consideration of climate change adaptation and mitigation, Berlin has developed and approved a city climate development plan, which is updated occasionally (Senate Department for Urban Development and the Environment, 2016b). It examines spatially differentiated impacts of climate change in Berlin and identifies action for urban development. A core question addressed within the urban climate development plan is the following: How can Berlin strengthen its urban sustainability and resilience within a changing climate, focusing on citizens and infrastructure? (Senate Department for Urban Development and Housing, 2011). Special emphasis is given to heat stress and heavy precipitation events as these are hazards that may be critical in future climates. In the next section, we examine the settlement and building typologies used within this urban development plan for climate adaptation.

4.1.1. Typologies

The Senate Department for Urban Development and Environment developed an environmental atlas that classifies the city based on urban structure types. These are defined by their building structure and density, open spaces, and representative land use and building use typologies (e.g., industrial versus residential use). Grimmond (2007) and Hertwig et al. (2021) underscore that neighbourhood structure, built volume, and people's behaviour significantly modify the local urban climate (e.g., local air temperature, wind speed). Different neighbourhood compositions or archetypes will influence the adaptation measures that are needed or feasible (Ward & Grimmond, 2017). Against this background it is interesting to note that the environmental atlas for Berlin encompasses 52 area-types grouped into 16 settlement-structure types and six main groups (Senate Department for Urban Development and the Environment, 2016a). The main groups are:

- Group I: Dense residential development;
- Group II: Low-density residential development;
- Group III: Commercial, service use, small business, and industrial use;
- Group IV: Traffic areas;
- Group V: Public service and other special uses;
- Group VI: Green and open spaces.

The purpose of these types is to further differentiate the built areas, particularly to inform urban and environmental planning. Residential areas, for example, are further differentiated by indicators such as building density, height, and age within the classification used by the Senate (Senate Department for Urban Development and the Environment, 2016a).

4.1.2. Climate Adaptation in Urban Planning

Urban planning at city scale aims to define and implement broad and strategic development goals for the entire city. Hence, adaptation measures to strengthen the resilience in terms of climatic hazards have to consider the broader urban development goals, including issues of mitigation and the provision of housing for a growing population. The provision of green spaces and the protection of urban biodiversity are seen as important overall goals for urban development (Senate Department for Urban Development and the Environment, 2016a).

Berlin's climate adaptation plan defines adaptation measures for different settlement typologies. The adaptation plan makes use of five different structures and two area types (of the 52 area and 16 urban-structure types) of the environmental atlas to define adaptation needs (Senate Department for Urban Development and the Environment, 2016b). These typologies are:

- Compact perimeter block development;
- Re-densification of row houses;
- New apartment buildings;
- Commercial and industrial buildings;
- Infrastructure/schools;
- Streets and squares;
- Green and open spaces.

These classifications are used to distinguish adaptation needs, since these settlement typologies refer to areas that are: (a) already exposed to climatic stress today and/or particularly high stress is expected in the future, (b) undergoing (or expected to undergo) extensive changes, such as new construction and densification, (c) relatively homogeneous and therefore suggested measures are transferrable (no special cases), and (d) relevant for the entire city and cover a high proportion of the urban landscape as a whole (Senate Department for Urban Development and the Environment, 2016b).

The climate adaptation plan of Berlin primarily focuses on residential areas. The first two structure types (i.e., perimeter block development and town houses) are indicative of the proposed adaptation planning strategies of re-densification. Schools and technology parks are infrastructures with important functions extending beyond their specific ward (Senate Department for Urban Development and the Environment, 2016b).

To examine how the structure types are used to frame adaptation strategies and measures within Berlin, we selected the compact perimeter block development (Figure 1) as an example. About 15% of the residential housing is from the Wilhelminian Period (1890–1918), covering around 8% of the total area of Berlin (approximately 3,880 ha). This structure type is more common in inner-city districts (e.g., 65% of Mitte, 73% of Friedrichshain-Kreuzberg, 37% of Charlottenburg-Wilmersdorf districts; Senate Department for Urban Development and Housing, 2011). About 36% of Berlin's population (more than 1.2 million people) resides in perimeter blocks (Reusswig et al., 2014). These are largely dense areas, with limited access to green space and heterogeneous ownership patterns. With more frequent heat stress, these areas are likely to be affected, due to the relatively high density (exposure) and the limited adaptive capacity (e.g., access to green spaces). The urban adaptation plan suggests measures (Figure 1) focused on improving green infrastructure (e.g., greening façades, development of small parks) and increasing roof albedo to decrease short-wave radiation absorption (Senate Department for Urban Development and the Environment, 2016b). The proposed adaptation measures and goals in the urban adaptation plan for Berlin are closely coupled with selected settlement typologies used to characterize adaptation needs.

4.2. City of Karlsruhe

The development of an urban adaptation plan for Karlsruhe was triggered by the lack of a city-wide overview of where the city quarters most affected by heat stress were located (Beermann et al., 2013). The urban climate adaptation plan had two main phases of development and the formulation of adaptation measures. First, the plan identified and defined specific urban structure types according to their physical structure and aspects of stability and dynamics. Second, climate change "hot spots" were identified by assessing the structure types and their susceptibility to weather extremes and other important factors (e.g., demographic composition and access to green space). Using urban structure types aids transferability of adaptation measures across the city when the physical and social structures are brought together. This should help identification of locations of concern not yet exposed to heat stress (Beermann et al., 2013).

4.2.1. Typologies

Karlsruhe classified all of its 556 neighbourhoods (in German, *Stadtviertel*) into one of the 12 identified urban

Figure 1. Potential adaptation measure for a compact perimeter block development proposed in the urban development plan. Source: Authors' work adapted from Senate Department for Urban Development and the Environment (2016b).

structure types (Figure 2). A multi-criteria analysis combined the structural characteristics of the neighbourhood with human and societal characteristics, with the latter giving some hints on aspects of human vulnerability (Section 4.2.2). The urban adaptation strategy anticipates that nine of the 12 structure types will require adaptation measures by 2050 because of their relatively high vulnerability metrics (Beermann et al., 2014). The structure types are grouped into three classes (Table 2): medium to high climatic stress, low to no climatic stress, and low exposure to heat stress. These refer to different levels of concern and demonstrate differential adaptation needs to climatic hazards.

4.2.2. Climate Adaptation in Urban Planning

The identification of adaptation needs for specific neighbourhoods and settlement typologies in Karlsruhe also consider future changes, particularly: (a) high level of local climatic stress (e.g., heat stress) at present or in the near future (2046–2055); (b) sensitive land and building use in the area; (c) high population density (more than 250 inhabitants/km²); (d) high proportion of young children (less than four years of age), elderly people (65 or more years of age), and people living in one-person households; (e) no green space within walking distance; and (f) low energy efficiency of buildings in the area (Beermann et al., 2013, 2014).

The criteria include physical characteristics of the urban structure, but also aspects of human exposure and human vulnerability. Identification of hot spots and their adaptation measures within the urban structure adaptation measures are proposed for row development (Figure 3), which have these characteristics (Beermann et al., 2013):

- Four parallel six-floor residential buildings (age band: 1950s to 1960s);
- Population density of approximately 200 inhabitants/ha;
- Little vegetation around the buildings;
- Few publicly accessible green areas within 500 m that can provide shade or cooler area;
- Low energy standard of buildings;

Figure 2. Major urban structure types in Karlsruhe. Source: Authors' work adapted from Beermann et al. (2013).

Table 2. Structure type classes (Figure 2) in Karlsruhe are distributed across 556 neighbourhoods (*Stadtviertel*) with different levels of concern with respect to climatic stress now (2010) and in 2050.

Structure type class	Neighbourhoods	2010	2050
Medium to high climatic stress			
Closed perimeter block development	47	32	45
Industrial	13	6	10
Commerce	69	15	53
Town centre	19	One historic centre (nine ha, 1,200 inhabitants)	1
Low to no climatic stress			
Medium-density development	45	0	3
Areas with large structures	41	3	16
Row development	86	2	11
High-rise area	25	3	8
Low exposure to heat stress (not a priority for adaptation measures)			
Compact detached houses	64	0	0
Low-density development	116	0	0
Open perimeter block development	26	0	2
Special area	5	0	1
Karlsruhe (whole city)	556	61	150

- Proportion of senior citizens of 14.6%;
- Proportion of young children of 5.7%.

It is assumed that these areas already are significantly affected by heat stress (about 50 days per year) and expected to increase (58 days of heat stress and 10 days of tropical nights per year) by 2050 (Beermann et al., 2014). Urban structure types are identified as being a hot spot if neighbourhood vulnerability is classified as high due to its population structure and composition (Beermann et al., 2014). Adaptation measures to improve the resilience in a specific neighbourhood (Figure 3) of this type include adding pocket parks, improving or providing blue (water) infrastructure in public spaces, and reducing impervious areas. In addition to these physical measures, the adaptation concept also

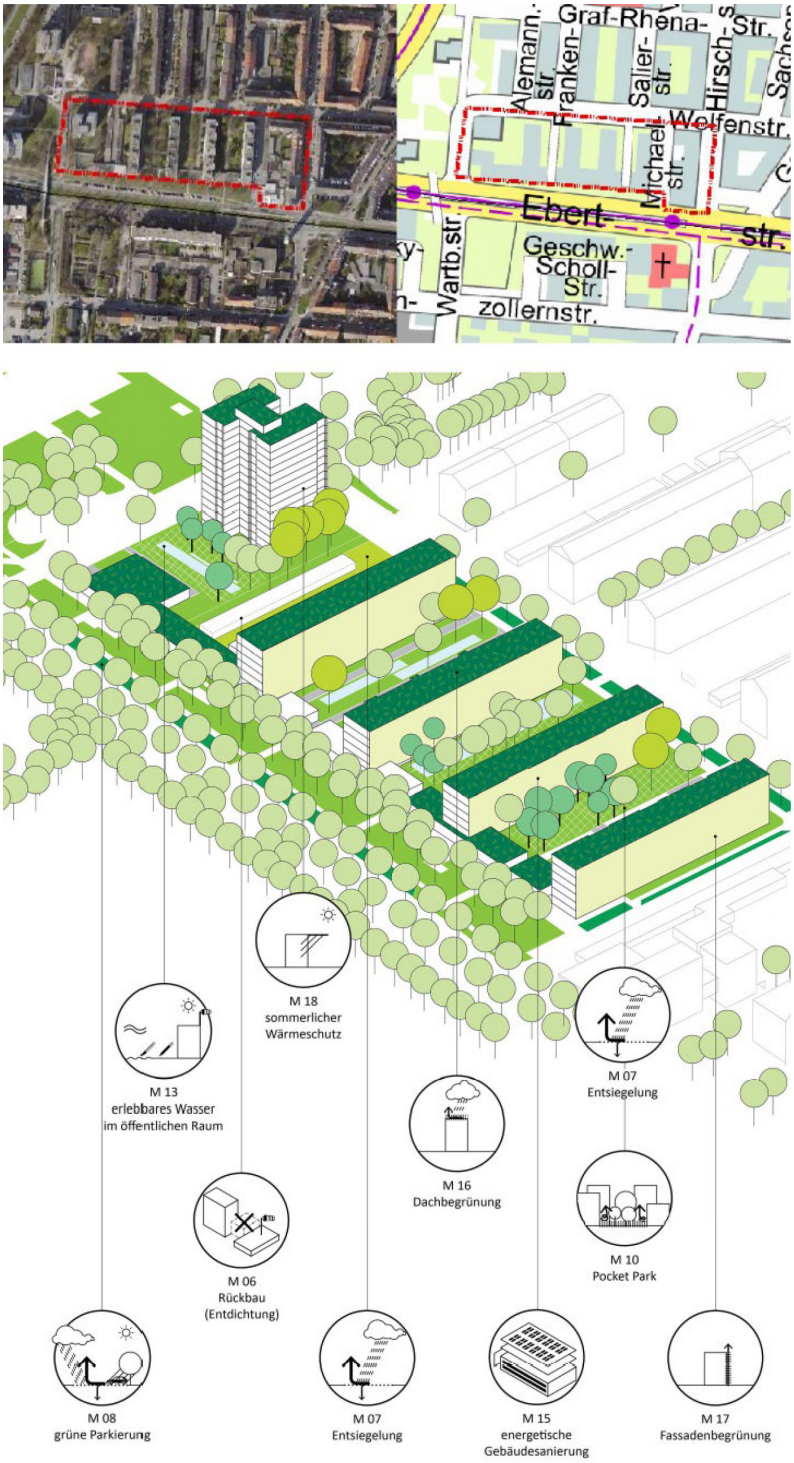

Figure 3. Proposed adaptive modifications for a neighbourhood with the row development (Figure 2) structure type in Karlsruhe. Source: Authors' work adapted from Beermann et al. (2014).

focuses on reducing human vulnerability (e.g., reducing isolation of elderly residents). Lastly, the adaptation plan suggests improving the energy efficiency of buildings and modification of building thermal properties (e.g., greening walls) to improve both adaptation and mitigation. The proposed adaptation strategies and actions need to: (a) consider the specific conditions in each neighbourhood, (b) promote vulnerability reduction of residents exposed, and (c) support adaptation measures appropriate for transfer to other areas with the same structure type (Beermann et al., 2013).

Overall, the city of Karlsruhe proposed 19 adaptation measures for different structure types focusing on three spatial scales of intervention: city, neighbourhood, and building (Beermann et al., 2014).

5. Discussion

The comparative analysis of the urban adaptation strategies linked to urban development and planning in Berlin and Karlsruhe shows that urban structure typologies are an important entry point for these cities to identify adaptation needs and measures. The two cities use various indicators (Table 3) within their definition of urban structure types. While the physical indicators used to characterize urban form are similar, the characterization of social aspects and use of social indicators differ. Although both use social indicators to identify hot spots and, in part, adaptation measures, they differ in the criteria they use for identifying specific adaptation measures (Table 3). Both cities use land cover characteristics, building typologies, population density, and the availability of green spaces to identify adaptation needs along different settlement typologies. While Berlin uses more detailed criteria (e.g., related to impervious area), Karlsruhe focuses more on the access to pervious (green) spaces.

In both cities, socio-economic indicators such as household income or unemployment are not explicitly integrated into the formulation and assessment of structure types. However, in Karlsruhe the proportion of young children (less than four years of age) and seniors living alone in specific neighbourhoods is part of the adaptation measures. Hence, Karlsruhe takes a more integrative approach to urban adaptation to climate change in terms of renewal and new urban development which includes goals and measures to safeguard a larger mix of different age groups within a ward and to avoid isolation of the elderly who are likely to be most vulnerable.

In Berlin, additional strategies and tools exist that account for differential human vulnerability, such as those related to health and civil protection (Reusswig et al., 2016). However, the urban typologies used do not sufficiently address these issues.

Table 3. Case study cities compared using material in Beermann et al. (2013, 2014) and Senate Department for Urban Development and the Environment (2016a, 2016b).

	Berlin	Karlsruhe
Indicators used to characterize urban structure types		
Building year of construction	Y	Y
Building height	Y	Y
Building arrangement	Y	Y
Building shape	—	Y
Building use	Y	—
Population density	Y	Y
Degree of sealing	Y	—
Open space characteristics	Y	Y
Area and Green/Open space use	Y	—
Access patterns	—	Y
Criteria for selecting areas needing climate adaptation		
Use	Intense	Sensitive
Stress	Present and future climate	Bioclimate
Land cover	Proportion of urban landscape	Green areas accessible Green area quality
Population	—	Density Fraction: seniors (≥65 years old), children (<4 years old), and seniors living alone
Energy	—	Energy standard of buildings
Transferability of measures	Y	Y

Note: Indicators used are identified with a Y (yes) or comments.

Both cities use urban structure types to help identify intra-city variations and adaptation needs using similar procedures and definition of adaptation measures (Figure 4). First, urban structures are classified using physical indicators (Tables 1 and 3). Second, present and future climatic stress is assessed by structure type and adaptation needs formulated with some quantitative analyses. Third, adaptation measures are formulated for specific structure types and hot spots. Societal and social indicators are sometimes used (Figure 4) to further specify adaptation needs and measures. Societal indicators capture mostly aspects of demography and population density, but sometimes they also capture social isolation (e.g., elderly in Karlsruhe). A broader integration of socio-economic indicators covering the functions within these neighbourhoods is still missing (Table 1).

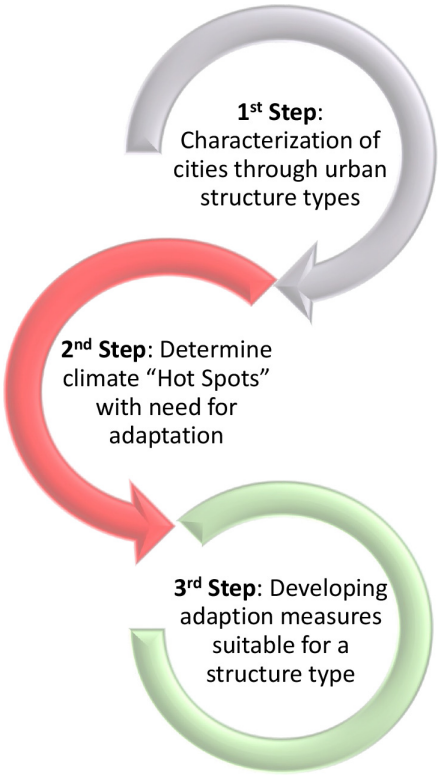

Figure 4. Planning sequence that is common in both case studies. Terms are defined in various places in the text.

In this regard, Capel-Timms et al. (2020) and Grimmond et al. (1996) underscore that socio-economic indicators are critical proxies of how neighbourhoods function and how humans interact with and affect the physical environment characteristics and dynamic behavioural patterns in each area (see also Grimmond & Oke, 1986; Kokkonen et al., 2018; Quattrone & Zannou, 1998; Ward & Grimmond, 2017). Therefore, there is a co-dependence between the physical and the socio-economic environment (Banzhaf & Hofer, 2008; Grimmond et al., 1996). Moreover, urban socio-economic structure is an essential driving force of urban climate change (Banzhaf & Hofer, 2008; Crenshaw & Jenkins, 1996; Grimmond, 2007; Krellenberg et al., 2011). However, the urban adaptation plans in Berlin and Karlsruhe capture these broader aspects and neighbourhood functions only partially, if at all.

6. Conclusion

Analysis of urban adaptation strategies used in urban planning reveals that urban structure types play an important role in assessing climate risks and formulating adaptation needs and actions. The review of strategies and planning documents for Berlin and Karlsruhe underscores that within the definition of urban structure types, physical indicators play a key role, while less attention is given to social indicators, particularly socio-economic aspects. However, some social indicators are included in the adaptation measures developed for both cities. While most attention is paid to the physical structure of the respective urban typology, socio-demographic aspects also receive attention, but significantly less or at a later stage within the assessment. While Berlin emphasises improving the physical structures to better adapt to climate change (e.g., improving green spaces or reducing impervious area), Karlsruhe gives greater importance to societal indicators in its formulation of adaptation goals.

We see an urgent need to further strengthen urban adaptation concepts and link these to formal and informal tools of urban development that allow those responsible for climate adaptation to address both physical and social structures within the city. In addition, interactions between different neighbourhoods and functions, for example in terms of mobility and commuting patterns, are at present not sufficiently captured and should receive more attention in future urban adaptation plans.

Overall, an integrated approach considering both urban physical and social structures can better support and inform urban planning, urban development, and climate adaptation. More research is needed on how to enhance an integrative assessment that can link physical and social characteristics of urban areas. In this regard, constraints and limitations of linking physical and social structures need to be better understood. In addition, a more dynamic understanding of cities and their exposure and vulnerability to climatic hazards is needed. This requires, among other issues, new data and new methods for the identification and development of urban archetypes (societal driven settlement structure typology) that also capture the dynamics of behaviour (work, travel, recreation, etc.) and dynamics of urban development (migration, densification vs. urban sprawl, economic development trends, etc.).

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Conflict of Interests

The authors declare no conflict of interests.

References

Adger, W. N. (2006). Vulnerability. *Global Environmental Change*, *16*(3), 268–281.

Banzhaf, E., & Hofer, R. (2008). Monitoring urban structure types as spatial indicators with CIR aerial photographs for a more effective urban environmental management. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, *1*(2), 129–138. https://doi.org/10.1109/JSTARS.2008.2003310

Beermann, B., Berchthold, M., Baumüller, J., Gross, G., & Kratz, M. (2013). *Städtebaulicher Rahmenplan Klimaanpassung für die Stadt Karlsruhe (Teil I)* [Urban framework plan for climate adaptation for the city of Karlsruhe (Part I)]. LUBW Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg.

Beermann, B., Berchthold, M., Baumüller, J., Gross, G., & Kratz, M. (2014). *Städtebaulicher Rahmenplan Klimaanpassung für die Stadt Karlsruhe (Teil II)* [Urban framework plan for climate adaptation for the city of Karlsruhe (Part II)]. LUBW Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg.

Behrens, U., & Grätz, A. (2010). *Berlin im Klimawandel: Eine Untersuchung zum Bioklima* [Berlin in the face of climate change: An investigation into the bioclimate]. Senate Department for Urban Development and Housing. https://www.stadtentwicklung.berlin.de/umwelt/umweltatlas/download/Berlin_Waermebelastung_der_Zukunft_Projektbericht.pdf

Bennett, N. J., Blythe, J., Tyler, S., & Ban, N. C. (2016). Communities and change in the anthropocene: Understanding social-ecological vulnerability and planning adaptations to multiple interacting exposures. *Regional Environmental Change*, *16*, 907–926. https://doi.org/10.1007/s10113-015-0839-5

Birkmann, J. (2013). *Measuring vulnerability to natural hazards: Towards disaster resilient societies*. United Nations University Press.

Birkmann, J., Vollmer, M., & Schanze, J. (2013). *Raumentwicklung und Klimawandel—Herausforderungen für die räumliche Planung* [Spatial development and climate change—Challenges for spatial planning]. Akademie für Raumentwicklung in der Leibniz-Gemeinschaft.

Bogardi, J., & Birkmann, J. (2004). Vulnerability assessment: The first step towards sustainable risk reduction. In D. Malzahn & T. Plapp (Eds.), *Disaster and society: From hazard assessment to risk reduction* (pp. 75–82). Logos Verlag.

Burton, C. G. (2010). Social vulnerability and hurricane impact modeling. *Natural Hazards Review*, *11*(2), 58–68. https://doi.org/10.1061/(ASCE)1527-6988(2010)11:2(58)

Burton, I., Huq, S., Lim, B., Pilifosova, O., & Schipper, E. L. (2002). From impacts assessment to adaptation priorities: The shaping of adaptation policy. *Climate Policy*, *2*, 145–159.

Capel-Timms, I., Smith, S. T., Sun, T., & Grimmond, S. (2020). Dynamic anthropogenic activitieS impacting heat emissions (DASH v1.0): Development and evaluation. *Geoscientific Model Development*, *13*(10), 4891–4924. https://doi.org/10.5194/gmd-13-4891-2020

Carreño, M. L., Cardona, O. D., & Barbat, A. H. (2007). Urban seismic risk evaluation: A holistic approach. *Journal of Natural Hazards*, *40*(1), 137–172.

Chrysoulakis, N., Feigenwinter, C., Triantakonstantis, D., Penyevskiy, I., Tal, A., Parlow, E., Fleishman, G., Düzgün, S., Esch, T., & Marconcini, M. (2014). A conceptual list of indicators for urban planning and management based on earth observation. *ISPRS International Journal of Geo-Information*, *3*(3), 980–1002. https://doi.org/10.3390/ijgi3030980

Chrysoulakis, N., Somarakis, G., Stagakis, S., Mitraka, Z., Wong, M.-S., & Ho, H.-C. (2021). Monitoring and evaluating nature-based solutions implementation in urban areas by means of earth observation. *Remote Sensing*, *13*(8), Article 1503. https://doi.org/10.3390/rs13081503

Collier, D., LaPorte, J., & Seawright, J. (2012). Putting typologies to work. *Political Research Quarterly*, *65*(1), 217–232. https://doi.org/10.1177/1065912912437162

Crenshaw, E. M., & Jenkins, J. C. (1996). Social structure and global climate change: Sociological propositions concerning the greenhouse effect. *Sociological Focus*, *29*(4), 341–358. https://doi.org/10.1080/00380237.1996.10570650

Cutter, S. L., Boruff, B. J., & Lynn Shirley, W. (2003). Social vulnerability to environmental hazards. *Social Science Quarterly*, *84*(2), 242–261. https://doi.org/10.1111/1540-6237.8402002

Eakin, H., & Bojórquez-Tapia, L. A. (2008). Insights into the composition of household vulnerability from multicriteria decision analysis. *Global Environmental Change*, *18*(1), 112–127. https://doi.org/10.1016/j.gloenvcha.2007.09.001

Fatemi, F., Ardalan, A., Aguirre, B., Mansouri, N., & Mohammadfam, I. (2017). Social vulnerability indicators in disasters: Findings from a systematic review. *International Journal of Disaster Risk Reduction*, *22*, 219–227. https://doi.org/10.1016/j.ijdrr.2016.09.006

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. (2008). *Deutsche*

Anpassungsstrategie an den Klimawandel [German strategy for adaptation to climate change]. Die Bundesregierung. https://www.bmu.de/fileadmin/bmu-import/files/pdfs/allgemein/application/pdf/das_gesamt_bf.pdf

Fekete, A. (2009). Validation of a social vulnerability index in context to river-floods in Germany. *Natural Hazards and Earth System Sciences*, *9*(2), 393–403. https://doi.org/10.5194/nhess-9-393-2009

Ford, J. D., Pearce, T., McDowell, G., Berrang-Ford, L., Sayles, J. S., & Belfer, E. (2018). Vulnerability and its discontents: The past, present, and future of climate change vulnerability research. *Climatic Change*, *151*(2), 189–203. https://doi.org/10.1007/s10584-018-2304-1

Founda, D., & Santamouris, M. (2017). Synergies between urban heat island and heat waves in Athens (Greece), during an extremely hot summer (2012). *Scientific Reports*, *7*(1), Article 10973. https://doi.org/10.1038/s41598-017-11407-6

Fragkias, M., & Seto, K. C. (2009). Evolving rank-size distributions of intra-metropolitan urban clusters in South China. *Computers, Environment and Urban Systems*, *33*(3), 189–199. https://doi.org/10.1016/j.compenvurbsys.2008.08.005

Frenkel, A., & Ashkenazi, M. (2008). Measuring urban sprawl: How can we deal with it? *Environment and Planning B: Planning and Design*, *35*(1), 56–79. https://doi.org/10.1068/b32155

Füssel, H. M., & Klein, R. J. T. (2006). Climate change vulnerability assessments: An evolution of conceptual thinking. *Climatic Change*, *75*(3), 301–329.

Galster, G., Hanson, R., Ratcliffe, M. R., Wolman, H., Coleman, S., & Freihage, J. (2001). Wrestling sprawl to the ground: Defining and measuring an elusive concept. *Housing Policy Debate*, *12*(4), 681–717. https://doi.org/10.1080/10511482.2001.9521426

Grimmond, C. S. B., & Oke, T. R. (1986). Urban water balance: 2. Results from a suburb of Vancouver, British Columbia. *Water Resources Research*, *22*(10), 1404–1412. https://doi.org/10.1029/wr022i010p01404

Grimmond, C. S. B., & Souch, C. (1994). Surface description for urban climate studies: A GIS based methodology. *Geocarto International*, *9*(1), 47–59. https://doi.org/10.1080/10106049409354439

Grimmond, C., Souch, C., & Hubble, M. (1996). Influence of tree cover on summertime surface energy balance fluxes, San Gabriel Valley, Los Angeles. *Climate Research*, *6*, 45–57. https://doi.org/10.3354/cr006045

Grimmond, S. (2007). Urbanization and global environmental change: Local effects of urban warming. *The Geographical Journal*, *173*(1), 83–88. https://doi.org/10.1111/j.1475-4959.2007.232_3.x

Hackenbruch, J. (2018). *Anpassungsrelevante Klimaänderungen für städtische Baustrukturen und Wohnquartiere* [Adaptation-relevant climate changes for urban building structures and residential neighbourhoods]. KIT Scientific Publishing.

Hahn, M. B., Riederer, A. M., & Foster, S. O. (2009). The livelihood vulnerability index: A pragmatic approach to assessing risks from climate variability and change—A case study in Mozambique. *Global Environmental Change*, *19*(1), 74–88. https://doi.org/10.1016/j.gloenvcha.2008.11.002

Handayani, W., Rudiarto, I., Setyono, J. S., Chigbu, U. E., & Sukmawati, A. M. (2017). Vulnerability assessment: A comparison of three different city sizes in the coastal area of Central Java, Indonesia. *Advances in Climate Change Research*, *8*(4), 286–296. https://doi.org/10.1016/j.accre.2017.11.002

He, C., Zhou, L., Ma, W., & Wang, Y. (2019). Spatial assessment of urban climate change vulnerability during different urbanization phases. *Sustainability*, *11*(8), Article 2406. https://doi.org/10.3390/su11082406

Heiden, U., Heldens, W., Roessner, S., Segl, K., Esch, T., & Mueller, A. (2012). Urban structure type characterization using hyperspectral remote sensing and height information. *Landscape and Urban Planning*, *105*(4), 361–375. https://doi.org/10.1016/j.landurbplan.2012.01.001

Heink, U., & Kowarik, I. (2010). What are indicators? On the definition of indicators in ecology and environmental planning. *Ecological Indicators*, *10*(3), 584–593. https://doi.org/10.1016/j.ecolind.2009.09.009

Hertwig, D., Grimmond, S., Kotthaus, S., Vanderwel, C., Gough, H., Haeffelin, M., & Robins, A. (2021). Variability of physical meteorology in urban areas at different scales: Implications for air quality. *Faraday Discussions*, *226*, 149–172. https://doi.org/10.1039/d0fd00098a

Hrabovszky-Horváth, S., Pálvölgyi, T., Csoknyai, T., & Talamon, A. (2013). Generalized residential building typology for urban climate change mitigation and adaptation strategies: The case of Hungary. *Energy and Buildings*, *62*, 475–485. https://doi.org/10.1016/j.enbuild.2013.03.011

Intergovernmental Panel on Climate Change. (2012). *Managing the risks of extreme events and disasters to advance climate change adaptation. A special report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.

Intergovernmental Panel on Climate Change. (2014). *Climate change 2014: Synthesis report*. https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf

Intergovernmental Panel on Climate Change. (2018). *Global warming of 1.5°C: Summary for policymakers*. https://www.ipcc.ch/sr15/chapter/spm

Islam, M. S., Swapan, M. S. H., & Haque, S. M. (2013). Disaster risk index: How far should it take account of local attributes? *International Journal of Disaster Risk Reduction*, *3*, 76–87. https://doi.org/10.1016/j.ijdrr.2012.10.001

Jamshed, A., Birkmann, J., Feldmeyer, D., & Rana, I. A. (2020). A conceptual framework to understand the dynamics of rural–urban linkages for rural flood vulnerability. *Sustainability*, *12*(7), Article 2894. https://doi.org/10.3390/su12072894

Kappes, M. S., Papathoma-Köhle, M., & Keiler, M. (2012). Assessing physical vulnerability for multi-hazards using an indicator-based methodology. *Applied Geography*, *32*(2), 577–590. https://doi.org/10.1016/j.apgeog.2011.07.002

Kloosterman, R. C., & Lambregts, B. (2007). Between accumulation and concentration of capital: Toward a framework for comparing long-term trajectories of urban systems. *Urban Geography*, *28*(1), 54–73. https://doi.org/10.2747/0272-3638.28.1.54

Kokkonen, T. V., Grimmond, C. S. B., Christen, A., Oke, T. R., & Järvi, L. (2018). Changes to the water balance over a century of urban development in two neighborhoods: Vancouver, Canada. *Water Resources Research*, *54*(9), 6625–6642. https://doi.org/10.1029/2017wr022445

Krellenberg, K., Höfer, R., & Welz, J. (2011). Dinámicas recientes y relaciones entre las estructuras urbanas y socioeconómicas en Santiago de Chile: El caso de Peñalolén [Recent dynamics and relationships between urban and socio-economic structures in Santiago de Chile: The case of Peñalolén]. *Revista de Geografía Norte Grande*, *48*, 107–131. https://doi.org/10.4067/s0718-34022011000100007

Larondelle, N., Hamstead, Z. A., Kremer, P., Haase, D., & McPhearson, T. (2014). Applying a novel urban structure classification to compare the relationships of urban structure and surface temperature in Berlin and New York City. *Applied Geography*, *53*, 427–437. https://doi.org/10.1016/j.apgeog.2014.07.004

Lee, Y.-J. (2014). Social vulnerability indicators as a sustainable planning tool. *Environmental Impact Assessment Review*, *44*, 31–42. https://doi.org/10.1016/j.eiar.2013.08.002

Leichenko, R., McDermott, M., & Bezborodko, E. (2015). Barriers, limits and limitations to resilience. *Journal of Extreme Events*, *2*(1), Article 1550002. https://doi.org/10.1142/s2345737615500025

Li, Y., Schubert, S., Kropp, J. P., & Rybski, D. (2020). On the influence of density and morphology on the urban heat island intensity. *Nature Communications*, *11*(1), Article 2647. https://doi.org/10.1038/s41467-020-16461-9

Li, Y., Zhang, X., Zhao, X., Ma, S., Cao, H., & Cao, J. (2016). Assessing spatial vulnerability from rapid urbanization to inform coastal urban regional planning. *Ocean & Coastal Management*, *123*, 53–65. https://doi.org/10.1016/j.ocecoaman.2016.01.010

Lowry, J. H., & Lowry, M. B. (2014). Comparing spatial metrics that quantify urban form. *Computers, Environment and Urban Systems*, *44*, 59–67. https://doi.org/10.1016/j.compenvurbsys.2013.11.005

Malakar, K., & Mishra, T. (2016). Assessing socio-economic vulnerability to climate change: A city-level index-based approach. *Climate and Development*, *9*(4), 348–363. https://doi.org/10.1080/17565529.2016.1154449

McPherson, E. G., Nowak, D., Heisler, G., Grimmond, S., Souch, C., Grant, R., & Rowntree, R. (1997). Quantifying urban forest structure, function, and value: The Chicago urban forest climate project. *Urban Ecosystems*, *1*, 49–61. https://doi.org/10.1023/a:1014350822458

Mertz, O., Halsnæs, K., Olesen, J. E., & Rasmussen, K. (2009). Adaptation to climate change in developing countries. *Environmental Management*, *43*(5), 743–752. https://doi.org/10.1007/s00267-008-9259-3

Mustafa, D. (2003). Reinforcing vulnerability? Disaster relief, recovery, and response to the 2001 flood in Rawalpindi, Pakistan. *Global Environmental Change Part B: Environmental Hazards*, *5*(3/4), 71–82. https://doi.org/10.1016/j.hazards.2004.05.001

Nguyen, A. L., Dang, V. H., Bosma, R. H., Verreth, J. A. J., Leemans, R., & De Silva, S. S. (2014). Simulated impacts of climate change on current farming locations of striped catfish (Pangasianodon hypophthalmus; sauvage) in the Mekong Delta, Vietnam. *AMBIO*, *43*(8), 1059–1068. https://doi.org/10.1007/s13280-014-0519-6

Nijman, J. (2007). Introduction—Comparative urbanism. *Urban Geography*, *28*(1), 1–6. https://doi.org/10.2747/0272-3638.28.1.1

Novack, T., & Stilla, U. (2014). Classification of urban settlements types based on space-borne SAR datasets. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *2*(7), 55–60. https://doi.org/10.5194/isprsannals-ii-7-55-2014

O'Brien, K., Eriksen, S., Nygaard, L. P., & Schjolden, A. (2007). Why different interpretations of vulnerability matter in climate change discourses. *Climate Policy*, *7*(1), 73–88. https://doi.org/10.1080/14693062.2007.9685639

Panthi, J., Aryal, S., Dahal, P., Bhandari, P., Krakauer, N. Y., & Pandey, V. P. (2016). Livelihood vulnerability approach to assessing climate change impacts on mixed agro-livestock smallholders around the Gandaki River Basin in Nepal. *Regional Environmental Change*, *16*(4), 1121–1132. https://doi.org/10.1007/s10113-015-0833-y

Parsons, M., Glavac, S., Hastings, P., Marshall, G., McGregor, J., McNeill, J., Morley, P., Reeve, I., & Stayner, R. (2016). Top-down assessment of disaster resilience: A conceptual framework using coping and adaptive capacities. *International Journal of Disaster Risk Reduction*, *19*, 1–11. https://doi.org/10.1016/j.ijdrr.2016.07.005

Qaisrani, A., Umar, M. A., Siyal, G. E. A., & Salik, K. M. (2018). What defines livelihood vulnerability in rural semi-arid areas? Evidence from Pakistan. *Earth Systems and Environment*, *2*(3), 455–475. https://doi.

org/10.1007/s41748-018-0059-5

Quattrone, G., & Zannou, A. (1998). Interdependence in social and territorial planning theories and sustainable development principles. In *ESRA conference papers* (ersa98p364). European Regional Science Association.

Reusswig, F., Becker, C., Lass, W., Haag, L., Hirschfeld, J., Knorr, A., Lüdeke, M. K. B., Neuhaus, A., Pankoke, C., Rupp, J., Walther, C., Walz, S., Weyer, G., & Wiesemann, E. (2016). *Anpassung an die Folgen des Klimawandels in Berlin—AFOK* [Adaptation to the consequences of climate change in Berlin—AFOK]. Senate Department for Environment, Traffic and Climate Protection. https://www.berlin.de/sen/uvk/klimaschutz/anpassung-an-den-klimawandel/programm-zur-anpassung-an-die-folgen-des-klimawandels

Reusswig, F., Hischl, B., & Laas, W. (2014). *Klimaneutrales Berlin 2050—Ergebnisse der Machbarkeitsstudie* [Climate Neutral Berlin 2050—Results of the feasibility study] [Brochure]. Senate Department for Urban Development and Housing.

Roca Cladera, J., Marmolejo Duarte, C. R., & Moix, M. (2009). Urban structure and polycentrism: Towards a redefinition of the sub-centre concept. *Urban Studies*, *46*(13), 2841–2868. https://doi.org/10.1177/0042098009346329

Rößler, S., Wende, W., & Krüger, T. (2014). *Grundlagen für eine klimawandelangepasste Stadt- und Freiraumplanung* [Foundations for urban and open space planning adapted to climate change]. REGKLAM—Regionales Klimaanpassungsprogramm für die Modellregion Dresden.

Salas, J., & Yepes, V. (2018). Urban vulnerability assessment: Advances from the strategic planning outlook. *Journal of Cleaner Production*, *179*, 544–558. https://doi.org/10.1016/j.jclepro.2018.01.088

Scheuer, S., Haase, D., & Meyer, V. (2011). Exploring multicriteria flood vulnerability by integrating economic, social and ecological dimensions of flood risk and coping capacity: From a starting point view towards an end point view of vulnerability. *Natural Hazards*, *58*(2), 731–751. https://doi.org/10.1007/s11069-010-9666-7

Senate Department for Urban Development and Housing. (2011). *Stadtentwicklungsplan Klima—Urbane Lebensqualität im Klimawandel sichern* [Urban development plan climate—Safeguarding urban quality of life in the face of climate change] [Brochure]. https://www.stadtentwicklung.berlin.de/planen/stadtentwicklungsplanung/download/klima/step_klima_broschuere.pdf

Senate Department for Urban Development and the Environment. (2016a). *06.07 Urban structure. 06.08 Urban structure—Area types differentiated*. https://www.stadtentwicklung.berlin.de/umwelt/umweltatlas/e_text/eke607.pdf

Senate Department for Urban Development and the Environment. (2016b). *Stadtentwicklungsplan Klima KONKRET—Klimaanpassung in der wachsenden Stadt* [Urban development plan Klima KONKRET—Climate adaptation in the growing city]. https://scnat.ch/de/id/cm4wq

Shah, A. A., Ye, J., Abid, M., Khan, J., & Amir, S. M. (2018). Flood hazards: Household vulnerability and resilience in disaster-prone districts of Khyber Pakhtunkhwa province, Pakistan. *Natural Hazards*, *93*(1), 147–165. https://doi.org/10.1007/s11069-018-3293-0

Shrivastava, P. (2003). Principles of emergency planning and management. *Risk Management*, *5*(2), Article 67. https://doi.org/10.1057/palgrave.rm.8240152

Solecki, W., Seto, K. C., Balk, D., Bigio, A., Boone, C. G., Creutzig, F., Fragkias, M., Lwasa, S., Marcotullio, P., Romero-Lankao, P., & Zwickel, T. (2015). A conceptual framework for an urban areas typology to integrate climate change mitigation and adaptation. *Urban Climate*, *14*, 116–137. https://doi.org/10.1016/j.uclim.2015.07.001

Somarakis, G., Stagakis, S., & Chrysoulakis, N. (Eds.). (2019). *ThinkNature: Nature-based solutions handbook*. EU Horizon 2020.

Song, Y., & Knaap, G.-J. (2004). Measuring urban form: Is Portland winning the war on sprawl? *Journal of the American Planning Association*, *70*(2), 210–225. https://doi.org/10.1080/01944360408976371

Sorg, L., Medina, N., Feldmeyer, D., Sanchez, A., Vojinovic, Z., Birkmann, J., & Marchese, A. (2018). Capturing the multifaceted phenomena of socioeconomic vulnerability. *Natural Hazards*, *92*(1), 257–282. https://doi.org/10.1007/s11069-018-3207-1

Storch, H., & Schmidt, M. (2008). Adaptation planning framework to climate change for the urban environment in Ho Chi Minh City. In A. Möller, B. Page, & M. Schreiber (Eds.), *EnviroInfo 2008: Proceedings of the 22nd International Conference Environmental Informatics—Informatics for environmental protection, sustainable development, and risk management* (pp. 623–630). Shaker.

Theobald, D. M. (2001). Land-use dynamics beyond the American urban fringe. *Geographical Review*, *91*(3), 544–564. https://doi.org/10.1111/j.1931-0846.2001.tb00240.x

Torrens, P. M., & Marina, A. (2000). *Measuring sprawl* (CASA Working Papers 27). Centre for Advanced Spatial Analysis.

Turner, B. L., Kasperson, R. E., Matson, P. A., McCarthy, J. J., Corell, R. W., Christensen, L., Eckley, N., Kasperson, J. X., Luers, A., Martello, M. L., Polsky, C., Pulsipher, A., & Schiller, A. (2003). A framework for vulnerability analysis in sustainability science. *Proceedings of the National Academy of Sciences*, *100*(14), 8074–8079. https://doi.org/10.1073/pnas.1231335100

Ward, H. C., & Grimmond, C. S. B. (2017). Assessing the impact of changes in surface cover, human behaviour and climate on energy partitioning across

Greater London. *Landscape and Urban Planning*, *165*, 142–161. https://doi.org/10.1016/j.landurbplan.2017.04.001

Wende, W., Huelsmann, W., Marty, M., Penn-Bressel, G., & Bobylev, N. (2010). Climate protection and compact urban structures in spatial planning and local construction plans in Germany. *Land Use Policy*, *27*(3), 864–868. https://doi.org/10.1016/j.landusepol.2009.11.005

Weston, L. M. (2002). A methodology to evaluate neighbourhood urban form: A comparison to new urbanist principles. *Planning Forum*, *8*, 64–77.

Wilson, W. J. (2010). Why both social structure and culture matter in a holistic analysis of inner-city poverty. *The ANNALS of the American Academy of Political and Social Science*, *629*(1), 200–219. https://doi.org/10.1177/0002716209357403

Wisner, B., Blaikie, P., Cannon, T., & Davis, I. (2004). *At risk: Natural hazards, people's vulnerability and disasters* (2nd ed.). Routledge.

Wolf, T., & McGregor, G. (2013). The development of a heat wave vulnerability index for London, United Kingdom. *Weather and Climate Extremes*, *1*, 59–68. https://doi.org/10.1016/j.wace.2013.07.004

Xu, L., Cui, S., Tang, J., Nguyen, M., Liu, J., & Zhao, Y. (2019). Assessing the adaptive capacity of urban form to climate stress: A case study on an urban heat island. *Environmental Research Letters*, *14*(4), Article 044013. https://doi.org/10.1088/1748-9326/aafe27

Yoon, D. K. (2012). Assessment of social vulnerability to natural disasters: A comparative study. *Natural Hazards*, *63*(2), 823–843. https://doi.org/10.1007/s11069-012-0189-2

Zhao, M., & Chen, Q. (2015). Risk-based optimization of emergency rescue facilities locations for large-scale environmental accidents to improve urban public safety. *Natural Hazards*, *75*(1), 163–189. https://doi.org/10.1007/s11069-014-1313-2

Zhou, B., Rybski, D., & Kropp, J. P. (2017). The role of city size and urban form in the surface urban heat island. *Scientific Reports*, *7*(1), Article 4791. https://doi.org/10.1038/s41598-017-04242-2

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Article

Renewable Energy as a Catalyst for Equity? Integrating Inuit Interests With Nunavik Energy Planning

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Abstract
Nunavik's residents experience significant social and environmental disruptions due to climate change. These disruptions add to the widespread changes that the Inuit have encountered over the last century—changes that have left this community totally dependent on fossil fuels for heat and power. Over time, Nunavik's residents have taken control of petroleum resources and their distribution, transforming this energy source into a major regional economic asset. Recently, there has been a transition towards renewable energy technologies (RETs) in Nunavik. However, are these alternative sources of energy appealing to local residents? This article explores the potential of RETs through the lens of procedural and substantive equity in the context of Inuit interests and integrated sustainability. Based on informal discussions with Inuit residents, interviews with stakeholders of the energy transition in Nunavik, and a literature analysis, this article presents two main results: (1) The level of substantive equity depends mainly on the type of RET and on idiosyncrasies between communities, and (2) local governance and procedural equity need to be asserted so that RETs can become true catalysts for equity.

Keywords
climate change; energy transition; equity; indigenous; Inuit; Nunavik; perceptions; planning; renewable energy; sustainable development

Issue
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1. Introduction

Located north of the 55th parallel in the province of Quebec, Canada (Figure 1), Nunavik is home to some 12,000 people, mostly Inuit (Duhaime et al., 2015). Like many other circumpolar territories, Nunavik is already experiencing climate change impacts (Larsen et al., 2014). These are on top of the impacts that were caused by a sudden modernization period in the 1900s, during which northern villages developed a strong dependence on fossil fuels for heating and electricity production. These imported methods shaped the physical organization of the villages and impacted traditional aspects of the Inuit lifestyle (Duhaime, 1985). However, they also presented incredible economic potential: Today, petroleum distribution represents a growing business that is completely Inuit-owned, creating jobs and investment across the Nunavik region.

Northern villages remain fossil-fuel dependent (Rodon & Schott, 2014), but new projects are now aimed at using renewable energy technologies (RETs). However, RETs do not necessarily assure equity. The roles of the Inuit and the *qallunaat* (non-Inuit people) in the planning process—from defining people's needs to the services supplied by the built infrastructure—are often minimized, as shown by the dominant role of the federal and provincial governments over the last several decades (Breton & Cloutier, 2017; Chabot, 1995). In our study,

we consider the equity of both the planning process and the outcomes in the assessment of how planning for RET projects may benefit the communities and integrate Inuit perspectives. We aim to explore how the Inuit could benefit from RETs and evaluate how planning and decision-making processes incorporate local impacts and outcomes. More broadly, we examine the way these processes consider the Inuit communities' interest in these technologies. Based on informal discussions with Nunavimmiut (Nunavik's residents) in Kangiqsualujjuaq, interviews with key respondents and on-site observations, our findings show that if the current state of diesel dependence and the associated environmental harms are well understood, Nunavimmiut seem to prefer some RETs more than others. These preferences however vary between villages, which reinforces the importance of gaining insight into local interests and perspectives in the early stages of energy production projects.

Figure 1. Nunavik and its 14 Inuit communities. Source: Makivik Corporation (n.d.).

2. Climate Change and Energy Production in Nunavik

2.1. Climatic Precariousness and Inuit Culture

Northern Canada, including Nunavik, is undergoing rapid and major "climate-driven environmental, societal, and economic changes" (Larsen et al., 2014, p. 1572), such as high rates of warming. Nunavik is geographically isolated. It is only accessible by plane and twice a year, it receives shipments by boat. This isolation, in addition to other issues such as an escalating housing crisis, food insecurity and dependence on fossil fuels, make the Nunavimmiut highly vulnerable to climate change (Allard et al., 2012; Duhaime et al., 2015; Rodon & Schott, 2014).

The impacts of climate change are already apparent in Nunavik's communities (Cuerrier et al., 2015; Downing & Cuerrier, 2011; Rapinski et al., 2017). These impacts are not just a warning-bell for the environment, but they are also an alarm for threats to physical and psychological health, the subsistence economy, local spirituality, and the Inuit way of life (Durkalec et al., 2015; Ford et al., 2012). For example, the shorter ice season and reduced ice thickness that result from climate change are not only environmental concerns, but they also put Inuit hunters and ice-fishers at risk (Durkalec et al., 2015; Ford et al., 2018; Watt-Cloutier, 2019). Economic insecurity is caused by the limited access to once accessible icy territories (Ford et al., 2012), as well as a loss of the functional, spiritual, and aesthetic qualities of ice that is anchored in the Inuit culture (Heyes, 2011). Infrastructure is affected by the freeze-thaw events that affect the permafrost and disrupt the soil surface (Allard et al., 2012). The potential effects of climate change on Nunavik's fauna and flora, the very core of Inuit food sources and subsistence economy, are also alarming (Kendrick, 2013; Newell et al., 2020; Watt-Cloutier, 2019).

As some of our interviewees confirmed, the global scale of climate change is well understood by the Inuit. Despite Nunavik's low contribution to provincial greenhouse gas (GHG) emissions, "global warming is inherently a cumulative environmental problem" (Weis, 2014, p. 6), and the use of more RETs remains necessary. However, the transition to more environment-friendly alternatives must be applied as a means of sustainable development and implemented through local Inuit governance and must not impose non-Inuit solutions on these northern communities.

Some climate adaptation measures have already been implemented in circumpolar regions. These efforts occur mainly "reactively in response to observed change in climatic conditions" and "were initiated at the individual/household level" (Ford et al., 2014, p. 4) in more than half of the cases. However, only a handful of RET projects and prototypes have been carried out to completion in Nunavik. As discussed, such projects must not only represent an environmental gain to be truly sustainable (Klinsky et al., 2017). They must also be respectful of the Inuit culture and traditional activities, encourage local governance and empowerment, and stimulate local economic growth and diversification (Rodon, 2017). In order to have a better grasp of where energy production in Nunavik is headed, we must first understand where it comes from.

2.2. Fossil Fuel Dependence and Appropriation

Before *qallunaat* settled in Nunavik in the beginning of the 20th century, heating systems in the Arctic were versatile and were adapted for limited access to wood (Odgaard, 2003). This gave the Inuit the flexibility they needed during their periodic journeys as a semi-nomadic people (Hervé, 2019). After newcomers from areas located further to the south of the province (hereafter referred to as "the south") built their trading posts

and settlements, the Inuit went through a fast sedentism process. The Hudson's Bay Company (HBC) encouraged the Inuit to use their knowledge of the land to trap arctic foxes and trade their fur for commodities, drawing some families closer to the *qallunaat* installments (Duhaime, 1985). In the early 1930s, the fur-trade market crumbled and there were frequent epidemics and famine. The presence of basic medical care and a steady food supply in the proto-villages led Inuit families to permanently settle nearby and build rudimentary houses with materials that could be found on-site (Chabot, 1995). However, since the HBC did not sell construction materials, "the Inuit rarely had the financial means to build and if they did, they still couldn't afford to heat their homes" (Christensen, 1953, as cited in Duhaime, 1985, p. 20). The poor housing situation prompted the involvement of the federal and provincial governments in social housing programs in Nunavik (Breton & Cloutier, 2017), which now represents 96% of the region's real estate (Therrien & Duhaime, 2017).

During that time, the area experienced a shift in energy sources. The once versatile and impermanent hearths and oil lamps of the Inuit semi-nomadic lifestyle were replaced by heavy stoves. Heat, once transportable and temporary, became fixed and constant (Figure 2). As explained by Duhaime (1985, p. 37), "the Inuit excitedly looked to the homes of whites, because they were warm."

Soon after, these heating systems and newly installed communal powerplants were all producing energy through fossil fuel combustion (fuel oil for heating, diesel for electricity). They depended on government subsidies to operate at a reasonable cost, as mentioned by some interviewees. Nunavimmiut still remain 100% dependent on fossil-fuel-generated energy (Rodon & Schott, 2014), which requires yearly petroleum shipments and the regional management of this resource (Figure 3). In the 1960s, petroleum was managed by the Quebec government, the HBC, and the Shell fuel company. However, 20 years later, the Inuit began to manage the petroleum themselves. The Fédération des Coopératives du Nouveau Québec (FCNQ), an Inuit-owned entity, gained control following an agreement with the three stakeholders and started buying most of the villages' oil tanks (FCNQ, 2018). From that point on, diesel and fuel oil supplies have been operated by and for the Inuit people, bringing in capital for all their communities.

2.3. Towards a Renewable Transition

Some RET projects are starting to appear in Nunavik. A run-of-river hydroelectric powerplant is being built in Inukjuak, solar panels have been installed in Quaqtaq, an operational biomass-heated sports center has been built in the Cree community of Whapmagoostui and two wind turbines are in use at Raglan mine between Salluit and Kangiqsujuaq. Other projects have been considered, such as connecting the northern villages of Nunavik to power grids south of its borders, installing underwater turbines in Kuujjuaq and introducing the use of tidal power, but these have been put on hold (Kativik Regional Government & Makivik Corporation, 2012). Regardless of the well-documented environmental benefits of these technologies (Owusu & Asumadu-Sarkodie, 2016), the way in which Inuit communities would benefit from the planning of these RETs is not yet understood. Are such planning interventions equitable, both in terms of the process and the outcomes?

Figure 2. Young Kangiqsualujjuamiut playing under powerlines, a sign of a now sedentary lifestyle.

Figure 3. Local management of fossil fuels: Community tanks in Kangiqsualujjuaq (left) and a Kangiqsualujjuamiut employee filling a residential tank with fuel oil (right).

3. Addressing Equity in Planning

3.1. What Makes Planning Equitable?

Since local and regional governments are now required to plan for sustainability, in addition to the economy and environment, equity has become a fundamental part of planning (Campbell, 1996). In climate action planning, social and racial equity is often evaluated based on the number of green initiatives and jobs created, or through the investments in low-income neighborhoods and communities (Agyeman, 2005; Schrock et al., 2015). In this way, planning for sustainability often focuses on concrete outcomes and tends to overlook aspects related to the dynamic nature of the planning process, such as self-affirmation, capacity, and learning (Young, 1990).

However, focusing solely on the planning process does not fully address the stakes in terms of power dynamics, especially in contexts that are marked by domination, such as that of the indigenous population. Even when the planning process aims at inclusive social representation, it can lead to inequitable outcomes (Chu et al., 2017; Fainstein, 2005). In participatory processes, experts and elites tend to receive the most attention; this also applies to climate action plans (Meerow & Woodruff, 2020).

To achieve equitable planning, both the planning process (procedural equity) and the outcomes (substantive equity) must be integrated (Innes & Booher, 2015). Participatory and community-based approaches to climate action planning are essential to ensure that planning practices are based on local needs, values, capacities, and priorities (Cloutier et al., 2015). Such approaches lead to developing a shared understanding of issues and outcomes and result in a greater capacity for climate change action over time (Archer et al., 2014; Finn & McCormick, 2011).

An equitable approach to planning also benefits from intersectional and decolonized perspectives (Kovach, 2009; Porter et al., 2020). This type of post-structuralist perspective considers how environmental risk and economic inequality interact with gender identity and race. When examined on a micro-scale, as in our study, this addresses the specific context that characterizes these northern indigenous communities. To ensure equitable planning, it is essential to acknowledge the specific intentions of Inuit, and the new methods they are developing for living in and planning the territory (Desbiens, 2017).

Sustainable development is generally represented as the area in which three independent spheres—environmental, social, and economic—overlap (Figure 4). However, this representation is mainly sectorial: it implies that all the individual spheres can exist on their own. Adapting this concept to an integrated form that is more coherent with an indigenous perspective (Matunga, 2013) can be a step towards integrated procedural equity.

3.2. Rethinking Sustainable Development

Henderson (2000, p. 268), a member of the Chickasaw Nation, states that indigenous people "share an ecological vision of society that is enfolded in a view of interactive harmony" and that "if we are to live in harmony, we must accept the beauty and limits of our ecology." The indigenous worldview considers all forms of life as being connected, which is reflected in the concept of relationality (Matunga, 2013). The notions of interaction, harmony, and relationality therefore appear to be key in the way indigenous people perceive the world. These concepts should be adapted into the western sustainable development model.

With this in mind, in our study, we interpret sustainable development differently from its general conception. Adapted from the model of Cosmic Interdependence by Mebratu (1998), our interpretation (Figure 4) integrates relationality as projects, and choices are defined by the relationship between three nested cosmoses: land, social, and economic. The intersection between the three cosmoses "is the area where we have millions of combinations of conflict and harmony serving as a seedbed for the process of coevolution of the

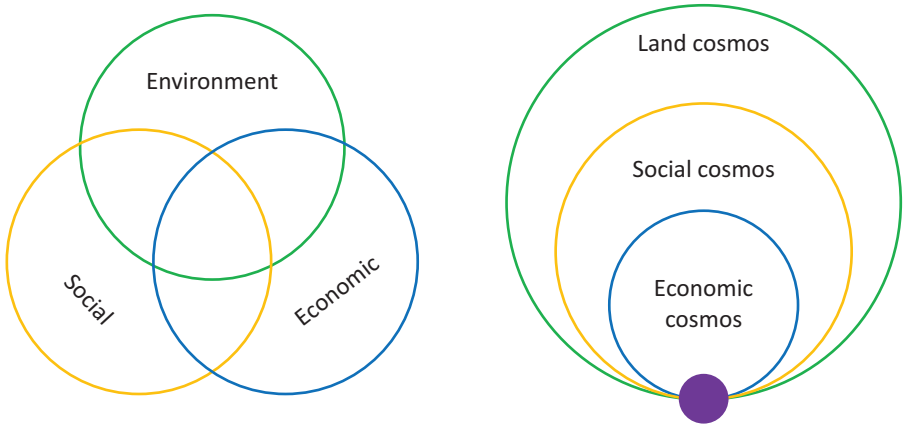

Figure 4. From a sectoral model of sustainable development (left) to an integrated one (right). Source: Authors' work, adapted from Mebratu (1998).

natural and human universe" (Mebratu, 1998, p. 514). In planning, these possible interactions shape projects and can be represented by a governance system.

4. Methodology

This research is part of a broader, multidisciplinary research project that aims to evaluate alternatives to diesel and fuel oil for electricity production and heating in Nunavik in the context of the ongoing energy transition. This venture was mainly centered on applied methods in the fields of engineering, economics, and architecture. The research presented in this article applies a social lens to what are typically technical perspectives in order to better understand Inuit interests and perceptions on matters concerning the energy transition.

This program is also part of a partnership between Inuit and Innu organizations and public organizations and researchers (Sentinel North—Doing Things Differently) based out of areas south of Nunavik. Through the years, researchers have developed collaborative relationships with many indigenous communities in the province of Quebec, including the northern village of Kangiqsualujjuaq (see Trottier et al., 2020; Vachon et al., 2019). In February 2020, a team of people established through this partnership stayed in Kangiqsualujjuaq and collected on-site data.

The project was subject to a full examination by the Ethics Committee at Université Laval. The aims of our research and our methods were officially approved by the organization, providing us with the opportunity to move forward (approval number 2020–034). All residents and respondents verbally consented to taking part in this research prior to participating.

The study was conducted based on the triangulation of data obtained through multiple qualitative methods. First, we participated in informal discussions with Inuit residents of Kangiqsualujjuaq (hereafter referred to as "residents," see Table 1). We conducted on-site observations of daily life in the village and took notes on the functioning of the energy system. Our multidisciplinary team of researchers specializing in urban design and architecture stayed in the village for one week in late February 2020. Discussions with residents mainly took place at the local Coop Store (Figure 5) and addressed issues listed in Table 1. Notes were taken during the discussions, but conversations were not recorded. Additional visits to Kangiqsualujjuaq and other northern villages were initially planned but had to be cancelled due to the Covid-19 pandemic. Unfortunately, further discussions with Nunavimmiut were not possible due to the sanitary restrictions and a lack of a reliable internet connection in many Nunavik households. Second, we focused on the actual decision-making process and on the perspectives of stakeholders on the transition to RETs that had already begun in Nunavik. Semi-structured interviews were conducted virtually with energy transition stakeholders (hereafter referred to as "respondents," see Table 1), who mostly work and live in the southern part of Quebec. These interviews were recorded, transcribed verbatim, and coded using two content analysis methods: a multi-category approach that groups respondent answers according to theme and resemblance and an analysis focused on the opinions of the interviewees on certain subjects. Six principal categories were used during the analysis: (1) procedural equity, (2) substantive equity, (3) local knowledge and resources, (4) external resources and relation with the community, (5) perceptions and interest in energy and its role in Nunavik development, and (6) technical elements and scale of intervention. Third, a content analysis was conducted for the current energy programs, planned energy projects, Inuit consultation reports and literature, and peer-reviewed articles. The triangulation of these three methods provided perspective on cultural discourse about the energy transition (content analysis and interviews), Inuit habits (observations), Inuit worldviews and perceptions (informal discussions with Inuit residents), and characteristics of the planning process (content analysis and interviews). This, in turn, provided an understanding of how

Table 1. Participant profiles and addressed issues.

	Participant profiles	Addressed issues
Informal discussions in Kangiqsualujjuaq (residents)	Brief discussions with 38 Inuit residents: • 20 men and 18 women; • Eight youth, 21 adults, nine elders.	• Areas of interest in and around the village and what makes them special (social space, traditional activities…); • Housing issues; • Aspects of daily life (electricity, heat, internet…); • Knowledge of RETs.
Semi-structured interviews (respondents)	60-minute interviews with nine of the Nunavik energy transition stakeholders (codes R1 to R9): • Seven men and two women; • Eight *qallunaat* and one Inuit; • Three researchers, three organisations based in the south, and three based in the north.	• Personal experiences related to energy in Nunavik; • Organisational engagement in the transition; • Existing and upcoming RET projects; • Governance approaches.

sustainable development cosmoses interact with RET projects in Nunavik and the ability to assess their level of integration. This project can therefore be categorized into the interpretative paradigm of qualitative research (Yin, 2011).

We analyzed RET projects based on procedural equity (the integration of Inuit interests in the decision making and planning processes) and substantive equity (the impacts and benefits for the Inuit). This assessment allows us to highlight the potential inequitable impacts that energy projects may have for Inuit communities and the key elements that shape RET projects into catalysts for equity.

Figure 5. Informal discussions with Inuit residents at the Coop Store in Kangiqsualujjuaq, February 2020. Source: Trottier et al. (2020).

5. Results and Discussion: Equity, Outcomes, Processes, and Inuit Interests

As stated, equity in planning corresponds with an evolving planning process and the resulting outcomes. Both are important to determine whether the transition towards RETs is equitable and in the best interest of the Nunavimmiut. However, the characteristics that are unique to each Inuit community must first be considered to ensure the integrity of our analysis.

"It depends on the community." This statement from an interviewee summarizes a concern about energy planning in Nunavik that is shared by all respondents. Though many Inuit share a common epistemology and way of thinking based on relationality, as do other indigenous nations (Wilson, 2008), perspectives may differ from one village to another. Some communities have strong rivers, while others have strong winds. Some may be reluctant about RETs, while others may embrace them. The diesel powerplant might be located right by the school or far up a hill depending on the village and its surroundings. The list goes on. This highlights one of our initial observations: There is no universal solution. The impacts as well as the feasibility and acceptability of a project will differ from place to place (see Makivik Corporation et al., 2014; McDonald & Pierce, 2013), meaning that planning must be done at the community level to address the specific hopes and needs of that community. Such singularities are considered in the following analysis, both by looking at the current energy situation and by exploring renewable alternatives.

5.1. Renewable Energy and Substantive Equity

5.1.1. The Energy Situation Today

Respondents were unanimous when asked about the state of fossil fuel dependence in Nunavik: it is now strongly rooted in the communities' practices. One respondent agreed that "diesel is here to stay" (R4) because it's a known and reliable energy source. This respondent was supported by another, R3, who somewhat pessimistically said that "you'll always have the need for diesel." As previously mentioned, the lucrative local management of fossil fuel resources was seen as a benefit, although from the southern perspective, R1 and R7 said that operating northern thermal powerplants is an economic "black hole." Regardless, all nine respondents were in favor of transitioning towards renewable energy sources, mainly because of the environmental impacts of diesel-produced electricity, such as GHG emissions, air pollution and soil contamination ("everybody knows that," as one Inuit said).

One Inuit resident of Kangiqsualujjuaq stated unambiguously that "the village needs something other than dirty energy." These words were based on environmental concerns but were also about energy security. Currently, houses in Nunavik are heated by electrically operated fuel oil furnaces. This raises two points of concern: (1) Heating requires a double intake of fossil fuels, with diesel-generated electricity powering fuel-oil furnaces, and (2) when there is a power outage, the heating system shuts down. As R3 indicated, "you run out of fuel, your house can freeze within 24 hours or so, the plumbing bursts, you have big water damage all over the house… that's bad news." An elderly resident stated that "without electricity, we suffer." An alternative to diesel generators, even just as a back-up energy source, would therefore be greatly appreciated.

The impacts of diesel and fuel oil are diverse. One Inuit resident pointed out that even when the olfactive impact is small, there is still an auditive impact, saying, "when it's quiet, it's like a giant mosquito is coming." Three respondents also indicated that in villages where the power stations are in the town center, odors and sounds can become a "nuisance" (R4) to nearby residents. R8 experienced a significant difference after a powerplant was relocated farther away from the village. The risks associated with petroleum leaks in the environment (see McDonald & Pierce, 2013; Mercer et al., 2020; Weis, 2014) were also mentioned multiple times.

5.1.2. Possible Alternatives

Table 2 presents a triangulation of data collected during informal discussions, on-site observations, interviews, and from literature reviews on the interest of Inuit in various RETs. As mentioned, this triangulation included data that were obtained from multiple methods and then integrated to detect contradictions or repetitions concerning the interest of the Inuit or those living to the south regarding RETs. On most occasions, answers overlapped, reinforcing the respondents' degree of approval or disapproval of the RETs' outcomes. All data were interpreted from the perspective of Inuit interests: statements from Inuit sources were given more weight than statements from the literature. For example, a non-Inuit source indicated that the Inuit found wind power to be respectful of their traditional activities, while an Inuit source implied that there were important nuances to consider regarding the complaints about this technology. The outcome is therefore recorded as moderately negative instead of positive or neutral.

These interests are divided into the three cosmoses of sustainable development and the governance system that regulates their interactions, as presented in Figure 4. This representation allows for a general overview of the interest of Inuit and non-Inuit in RETs.

Two levels of information are presented in Table 2. First, the table compares alternative RETs in terms of Inuit interests. Second, it compares the attitudes and perspectives that Inuit and southerners (composed of *qallunaat* and organizations based in the south) have on RETs, allowing us to examine some cultural differences in perception.

According to our results, solar panels are the most appreciated alternative energy source. Despite the economic and governance interests being less certain among Inuit, the land and social cosmoses are positively perceived. However, one respondent specified that building-mounted solar panels are preferable to solar farms, which monopolize land for only one purpose and require more roads and gravel pad foundations to be built. Another respondent referred to a case in Quaqtaq where both types of solar installations exist and stated that the residents seem to appreciate when the equipment is less visible.

The *qallunaat* consider wind power to be a great solution for Nunavik, but the Inuit see this energy source as creating more uncertainty. The Inuit understand that wind turbines emit less GHG emissions but find other issues worrying. Notably, the potential impacts on birds and their migration patterns were mentioned during interviews and are documented in the literature (Makivik Corporation et al., 2014; McDonald & Pierce, 2013). Hydroelectricity powerplants and hydrokinetic power elicited concerns about the migration patterns of different fish species. However, run-of-river hydroelectricity was viewed more positively, mainly because it did not require flooding land and ecosystems that can be used for traditional activities (Makivik Corporation et al., 2014).

There are strong feelings of inequity surrounding the current off-grid situation in Nunavik. Some respondents confirmed that connecting their region to Quebec's main power grid is an onerous project that would leave few-to-no local governance or economic benefits in Inuit communities. Others see this as lacking fairness and

Table 2. Inuit and southerners (composed of *qallunaat* and organizations based in the south) interest in diesel and RET projects in Nunavik. Outcomes are color-coded. Green: positive or neutral outcomes, yellow: moderately negative outcomes, red: strong negative outcomes, grey: a lack of information. Other alternatives include biomass, hydrokinetic and geothermic energy.

		Diesel	Wind power	Solar panels	Hydroelectricity (dams)	Hydroelectricity (run-of-river)	Connexion to Quebec's grid	Other alternatives
Land cosmos *Respect for the land and the environment and fight against climate change/adaptation to its impacts*	*Inuit*							
	Southerners							
Social cosmos *Respect for traditional activities, quality of life and harmonization of spatial use*	*Inuit*							
	Southerners							
Economic cosmos *Local economic benefits and economic viability*	*Inuit*							
	Southerners							
Governance *Decision power in planning and local management*	*Inuit*							
	Southerners							

equity. Inuit participants in the 2013 Parnasimautik pan-Nunavik consultation stated that "the electricity produced in Nunavik should benefit Nunavik Inuit first," and that they "live close to the hydroelectric dams but the power is sent to Americans" (Makivik Corporation et al., 2014, Appendix 4). Although a feasibility study was completed by a private firm in 2003 (Kativik Regional Government & Makivik Corporation, 2012), R4 indicated that the project has been abandoned for now.

Other alternatives, such as biomass, hydrokinetic and geothermic energy, were only sporadically mentioned in discussions and interviews. Only a few residents of Kangiqsualujjuaq seemed aware of those alternatives, specifically of the use of tidal energy. However, answers on that topic were too fragmented and the technology itself was not understood well enough to be able to demonstrate a convincing degree of interest in its implementation.

Inuit and *qallunaat* interests were similar in the land and social cosmoses but mostly differed in the economic and governance spheres. The differing economic perspectives can be explained by the potential loss of Inuit jobs in the diesel distribution sector as well as by the lack of local scientific and technical skills to understand and properly maintain RETs. This also impacts local governance by reducing the role of Inuit-managed petroleum supply and potentially creating a new dependence on the south for specialized knowledge. R5 stated that when issues with solar panels arose, it took about three weeks for specialized maintenance staff from Ottawa to arrive.

5.2. Procedural Equity Over Time

In Table 2, procedural equity is mainly represented through the governance system. However, this depiction only shows achievable governance outcomes in possible futures. Figure 6 depicts the evolution of this governance over the last 50 years or so. Data were treated in a similar way as they were in Table 2, but with an added temporal dimension.

Three main observations can be made from this sustainability timeline. First, there is a marked improvement in environmental and social outcomes over time. According to R4, this improvement can be attributed to cleaner diesel energy production methods. It might also be due to the rising concern among project developers for social acceptability in planning, especially in indigenous contexts (Barry & McNeil-Cassidy, 2019). Second, economic outcomes also increased with the creation of jobs following the local control of petroleum distribution. Third, regardless, local governance followed a different trend. It went from being nearly nonexistent to having great importance in the diesel era. However, with

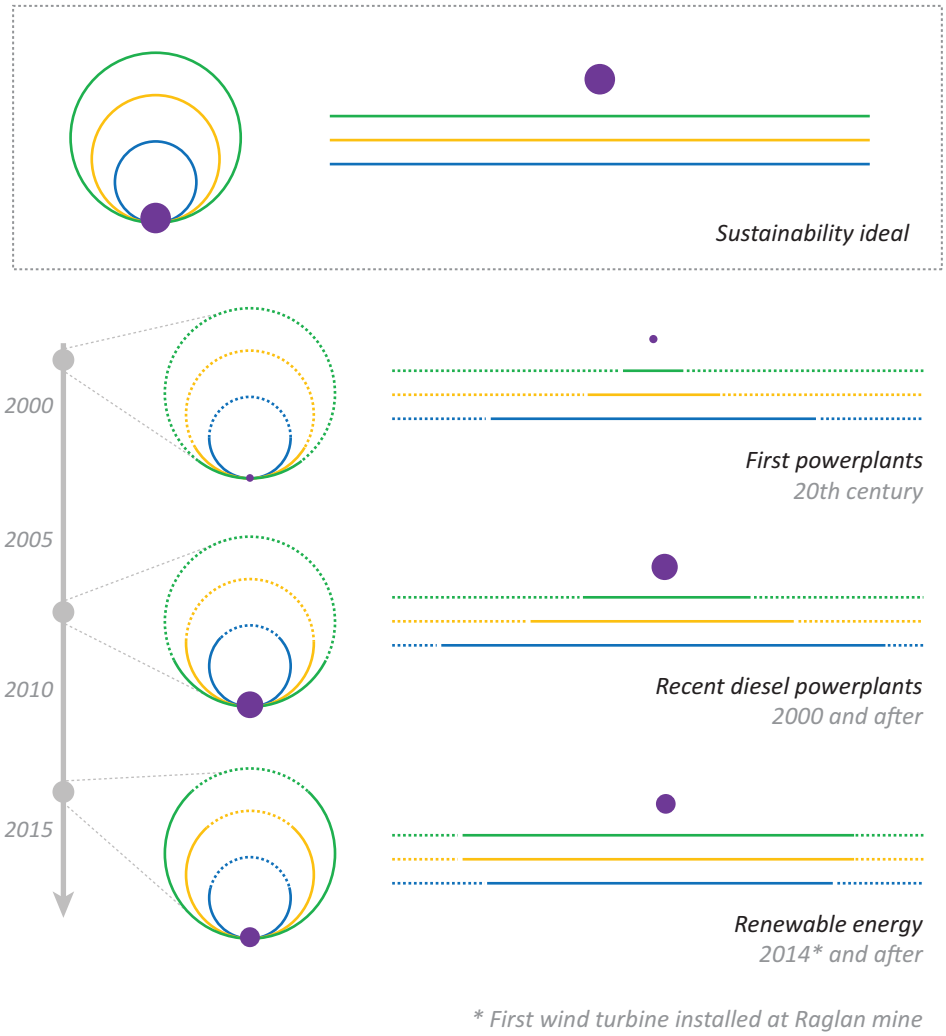

Figure 6. Evolution of durability and procedural equity for energy production projects in Nunavik. The top depiction shows an ideal scenario with total sustainability and equity. The following depictions show the categories of sustainability through time as they relate to different technologies and sources of energy.

the arrival of complex RETs, local governance may take a step backwards.

Most respondents mentioned the importance of local will in order to have equity in RET planning. The example of Inukjuak's run-of-river hydroelectric powerplant, the result of a community-led idea, was often used to support that statement.

Four respondents also indicated the crucial role of providing proper training so that Nunavimmiut can perform maintenance on these new amenities. R3 said that "preventative maintenance should be done, but most of the time we're doing corrective maintenance, more like emergency repairs." The importance of government (both federal and provincial) subsidies for RET projects in Nunavik's remote villages was also emphasized by respondents. This financial support is needed to ensure the completion of projects and their resulting favorable impacts on the community. Respondents also stressed the importance of understanding and adapting to Inuit temporality and work methods for large-scale planning projects.

5.3. What's Next?

Some stakeholders of the energy transition in Nunavik foresaw this potential gap in local governance. In 2017, a joint venture between Makivik Corporation and the FCNQ called Tarquti Energy Corporation (hereafter Tarquti) was established. This entirely Inuit-owned enterprise specializes in RET project development in Nunavik. By becoming a major player in the energy transition, they hope to create jobs, local expertise, and economic benefits for all Nunavik communities (Makivik Corporation, 2019).

Such an initiative could strengthen local governance and the local economy in a clean-energy era. Being Inuit-controlled, Tarquti could compensate for losses in the diesel sector. However, because it is fairly new, Tarquti was not part of any of the RET projects we have mentioned. Nevertheless, Tarquti represents a step towards regional empowerment and local governance for Inuit. This corporation should therefore be involved in

upcoming projects and become a cornerstone for equity in Quebec's northern RET sector.

Inuit entities such as Tarquti could bring local collaboration and indigenous perspectives into energy planning. Through Tarquti's focus on public consultation, RET projects would not only be developed by an Inuit enterprise, but they would work together with Inuit communities to better serve Inuit people.

6. Conclusion

This study aimed to evaluate how equitable RET project planning is for Inuit communities. By assessing current and potential energy projects in Nunavik through the lens of procedural and substantive equity, we addressed the unique position of these northern communities and acknowledged the intentions and aspirations of the Inuit residents with respect to their relationship with the land.

In terms of substantive equity, our results suggest that solar panels are a well-appreciated alternative to fossil fuel, especially when planned as building-mounted infrastructure. Hydroelectric dams were associated with the destruction of the land, while run-of-river infrastructure and wind turbines were the subject of concern for wildlife, an essential component of the Inuit subsistence economy. However, overall, these latter two alternatives were deemed feasible and of interest.

In terms of procedural equity, shifting the control of petroleum distribution to the FCNQ and the creation of local jobs in the energy sector helped increase the roles and responsibilities of Inuit organisations in the governance of energy production. However, because this empowerment is reliant on fossil fuels, it is put at risk without a careful transition to RETs. Past energy projects have often resulted in an inequitable distribution of power in the eyes of many residents. To avoid repeating past mistakes, future energy projects should be planned directly with the communities, operated by Inuit organisations, and centered around the three interrelated cosmoses of sustainable development.

Procedural and substantive equity are fundamental aspects that should be considered in every stage of planning; the promise of equity cannot be limited to energy transition projects alone. There should be equity in all aspects of planning throughout the social ecosystem, from housing and land use to public health. As indigenous ontology has suggested for centuries, "each ecosystem encapsulates and enfolds many forces or parts, none of which can enfold or encapsulate the whole" (Henderson, 2000, p. 260). Efforts to incorporate this philosophy into RET projects could be an important step towards sustainable, equitable and well-governed planning that respects the indigenous worldview.

So, are RETs a catalyst for equity in Nunavik? As shown, under the right circumstances, they can be.

New Inuit organizations aim to put Nunavimmiut, their worldview, and their interests at the center of the transition to RETs. With a process that focuses on Nunavimmiut, aspects of the environment and the Inuit lifestyle that are linked to climate change, land protection, game hunting, fishing, and collecting berries could be better incorporated into planning. Implementing a planning process that is accepted by the Nunavimmiut would thus lead to a reduction in diesel dependence. Moreover, traditional activities and knowledge could even become pillars around which projects are conceived, developed, and implemented—an aspiration for many Inuit (Blais & Pinard, in press; Vachon et al., 2017).

The Covid-19 pandemic led to significant constraints for this project. The most significant limitation was the restricted amount of time that the research team was able to spend in northern villages. More time would have allowed the team to gain more insight into Inuit perspectives on RETs and the energy transition. However, the methodology we used still allowed for our analysis to focus on the views of the Inuit in Kangiqsualujjuaq and non-Inuit in southern public organizations. In the future, validation of our data by the Kangiqsualujjuamiut and other Nunavimmiut would be beneficial. Such validation could help us to identify region-specific patterns in our results, as well as provide information about the evolution of these perspectives over time. The data we have already gathered provides a snapshot of the current perceptions of the energy transition and its production alternatives, which could then be compared with future data. For example, after the first projects by Tarquti Energy have been implemented, our data could be used to demonstrate how perceptions may have changed. More research on this subject would allow for a better understanding of the impact of these new innovative endeavours on Nunavimmiut.

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Conflict of Interests

The authors declare no conflict of interests.

References

Agyeman, J. (2005). *Sustainable communities and the challenge of environmental justice*. New York University Press.

Allard, M., Lemay, M., Barrett, M., Sheldon, T., Brown, R.,

& Whiteley, S. (2012). Science to policy in Nunavik and Nunatsiavut: Synthesis and recommendation. In M. Allard & M. Lemay (Eds.), *Nunavik and Nunatsiavut: From science to policy. An integrated regional impact study (IRIS) of climate change and modernization* (pp. 28–30). ArcticNet.

Archer, D., Almansi, F., DiGregorio, M., Roberts, D., Sharma, D., & Syam, D. (2014). Moving towards inclusive urban adaptation: Approaches to integrating community-based adaptation to climate change at city and national scale. *Climate and Development*, *6*(4), 345–356.

Barry, J., & McNeil-Cassidy, J. (2019). Les droits des autochtones et l'urbanisme: De la reconnaissance à une coexistence significative? [Indigenous people's rights and urbanism: From recognition to significant coexistence?]. *Plan Canada*, *59*(1), 52–56.

Blais, M., & Pinard, E. (Eds.). (in press). Construire et habiter l'Inuit Nunangat/Building and dwelling in Inuit Nunangat. *Études Inuit Studies*.

Breton, M.-P., & Cloutier, G. (2017). Cadre institutionnel et pratiques locales de l'aménagement en territoire nordique: Un dialogue en trois temps illustré par le cas de Kuujjuaq [Institutional framework and northern territory local planning practices: A three-part dialogue illustrated by the case of Kuujjuaq]. *Recherches Amérindiennes au Québec*, *47*(1), 87–99.

Campbell, S. (1996). Green cities, growing cities, just cities? Urban planning and the contradictions of sustainable development. *Journal of the American Planning Association*, *62*(3), 296–312.

Chabot, M. (1995). *Les "Nunavimiut" et les "Quliriit" à la conquête de l'espace : Participation des citoyens, logements sociaux et aménagement du territoire dans la région Kativik* ["Nunavimiut" and "Quiliriit" at the conquest of space: Citizens participation, social housing, and land planning in the Kativik region] [Master thesis, Université Laval]. CorpusUL.

Chu, E., Anguelovski, I., & Roberts, D. (2017). Climate adaptation as strategic urbanism: Assessing opportunities and uncertainties for equity and inclusive development in cities. *Cities*, *60*, 378–387.

Cloutier, G., Joerin, F., Dubois, C., Labarthe, M., Legay, C., & Viens, D. (2015). Planning adaptation based on local actors' knowledge and participation: A climate governance experiment. *Climate Policy*, *15*(4), 458–474.

Cuerrier, A., Brunet, N. D., Gérin-Lajoie, J., Downing, A., & Lévesque, E. (2015). The study of Inuit knowledge of climate change in Nunavik, Quebec: A mixed methods approach. *Human Ecology*, *43*(3), 379–394.

Desbiens, C. (2017). Un nouveau sens du lieu? "L'effet urbain" dans les communautés du Nunavik [A new sens of space? "The urban effect" in Nunavik communities]. *Recherches Amérindiennes au Québec*, *47*(1), 151–154.

Downing, A., & Cuerrier, A. (2011). A synthesis of the impacts of climate change on the First Nations and Inuit of Canada. *Indian Journal of Traditional Knowledge*, *10*(1), 57–70.

Duhaime, G. (1985). *De l'igloo au H. L. M.—Les Inuit sédentaires de l'État-providence* [From igloo to H. L. M.—Sedentary Inuit from the welfare state]. Centre d'Études Nordiques.

Duhaime, G., Caron, A., & Lévesque, S. (2015). *Le Nunavik en chiffres 2015: Version de poche* [Nunavik in numbers 2015: Pocket version]. Chaire de recherche du Canada sur la condition autochtone comparée. http://www.chaireconditionautochtone.fss.ulaval.ca/documents/pdf/Nunavik-en-chiffres-vf-fr.pdf

Durkalec, A., Furgal, C., Skinner, M. W., & Sheldon, T. (2015). Climate change influences on environment as a determinant of Indigenous health: Relationships to place, sea ice, and health in an Inuit community. *Social Science & Medicine*, *136/137*, 17–26.

Fainstein, S. S. (2005). Cities and diversity: Should we want it? Can we plan for it? *Urban Affairs Review*, *41*(1), 3–19.

Fédération des Coopératives du Nouveau Québec. (2018). *Petrol*. http://www.fcnq.ca/en/petrole

Finn, D., & McCormick, L. (2011). Urban climate change plans: How holistic? *Local Environment*, *16*(4), 397–416.

Ford, J. D., Bolton, K. C., Shirley, J., Pearce, T., Tremblay, M., & Westlake, M. (2012). Research on the human dimensions of climate change in Nunavut, Nunavik and Nunatsiavut: A literature review and gap analysis. *Arctic*, *65*(3), 289–304.

Ford, J. D., Couture, N., Bell, T., & Clark, D. G. (2018). Climate change and Canada's north coast: Research trends, progress, and future directions. *Environmental Reviews*, *26*, 82–92.

Ford, J. D., McDowell, G., & Jones, J. (2014). The state of climate change adaptation in the Arctic. *Environmental Research Letters*, *9*(10), Article 104005.

Henderson, J. S. Y. (2000). Ayukpachi: Empowering aboriginal thought. In M. Battiste (Ed.), *Reclaiming indigenous voice and vision* (pp. 248–278). University of British Columbia Press.

Hervé, C. (2019). Services publics et autonomie chez les Inuits du Nunavik (Arctique québécois): Perspectives ontologiques sur la gouverne des communs sociaux [Public services and autonomy among Nunavik Inuit (Arctic Quebec): Ontological perspectives on the governance of social commons]. *Anthropologies et Sociétés*, *43*(2), 131–151.

Heyes, S. A. (2011). Cracks in the knowledge: Sea ice terms in Kangiqsualujjuaq, Nunavik. *The Canadian Geographer*, *55*(1), 69–90.

Innes, J., & Booher, D. (2015). A turning point for planning theory? Overcoming dividing discourses. *Planning Theory*, *14*(2), 195–213.

Kativik Regional Government, & Makivik Corporation. (2012). *Plan Nunavik*. Avataq Cultural Institute. https://parnasimautik.com/wp-content/uploads/2013/02/Plan_Nunavik_06_20.pdf

Kendrick, A. (2013). Canadian Inuit sustainable use and management of Arctic species. *International Journal of Environmental Studies*, *70*(3), 414–428.

Klinsky, S., Roberts, T., Huq, S., Okereke, C., Newell, P., Dauvergne, P., O'Brien, K., Schroeder, H., Tschakert, P., Clapp, J., Keck, M., Biermann, F., Liverman, D., Gupta, J., Rahman, A., Messner, D., Pellow, D., & Bauer, S. (2017). Why equity is fundamental in climate change policy research. *Global Environmental Change*, *44*, 170–173.

Kovach, M. (2009). *Indigenous methodologies: Characteristics, conversations and contexts*. University of Toronto Press.

Larsen, J. N., Anisimov, O. A., Constable, A., Hollowed, A. B., Maynard, N., Prestrud, P., Prowse, T. D., & Stone, J. M. R. (2014). Polar Regions. In V. R. Barros, C. B. Field, D. J. Dokken, M. D. Mastrandrea, K. J. Mach, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea, & L. L.White (Eds.), *Climate change 2014: Impacts, adaptation, and vulnerability. Part B: Regional aspects. Contribution of working group II to the fifth assessment report of the Intergovernmental Panel on Climate Change* (pp. 1567–1612). Cambridge University Press.

Makivik Corporation. (n.d.). *Nunavik maps*. https://www.makivik.org/nunavik-maps

Makivik Corporation. (2019). *Tarquti energy corporation*. https://www.makivik.org/tarquti-energy-corporation

Makivik Corporation, Kativik Regional Government, Kativik School Board, Nunavik Landholding Corporations Association, Saputiit Youth Association of Nunavik, Nunavik Regional Board of Health and Social Services, & Avataq Cultural Institute. (2014). *Parnasimautik: Consultation report on the consultations carried out with Nunavik Inuit in 2013*. https://parnasimautik.com/2014-consultation-report

Matunga, H. (2013). Theorizing Indigenous planning. In D. C. Natcher, R. C. Walker, & T. S. Jojola (Eds.), *Reclaiming Indigenous planning* (pp. 3–32). McGill-Queen's University Press.

McDonald, N. C., & Pearce, J. M. (2013). Community voices: Perspectives on renewable energy in Nunavut. *Arctic*, *66*(1), 94–104.

Mebratu, D. (1998). Sustainability and sustainable development: Historical and conceptual review. *Environmental Impact Assessment Review*, *18*, 493–520.

Meerow, S., & Woodruff, S. C. (2020). Seven principles of strong climate change planning. *Journal of the American Planning Association*, *86*(1), 39–46.

Mercer, N., Parker, P., Hudson, A., & Martin, D. (2020). Off-grid energy sustainability in Nunatukavut, Labrador: Centering Inuit voices on heat insecurity in diesel-production communities. *Energy Research & Social Sciences*, *62*, Article 101382.

Newell, S. L., Doubleday, N. C., & Community of Chesterfield Inlet, Nunavut. (2020). Sharing country food: Connecting health, food security and cultural continuity in Chesterfield Inlet, Nunavut. *Polar Research*, *39*, Article 3755.

Odgaard, U. (2003). Hearth and home of the Palaeo-Eskimos. *Études Inuit Studies*, *27*(1/2), 349–374.

Owusu, P. A., & Asumadu-Sarkodie, S. (2016). A review of renewable energy sources, sustainability issues and climate change mitigation. *Cogent Engineering*, *3*(1), Article 1167990.

Porter, L., Rickards, L., Verlie, B., Bosomworth, K., Moloney, S., Lay, B., Latham, B., Anguelovski, I., & Pellow, D. (2020). Climate justice in a climate changed world. *Planning Theory & Practice*, *21*(2), 293–321.

Rapinski, M., Payette, F., Sonnentag, O., Herrmann, T. M., Royer, M.-J. S., Cuerrier, A., Siegwart Collier, L., Hermanutz, L., & Guanish, G. (2017). Listening to Inuit and Naskapi peoples in the eastern Canadian Subarctic: A quantitative comparison of local observations with gridded climate data. *Regional Environmental Change*, *18*(1), 189–203.

Rodon, T. (2017). Development in Nunavik: How regional and local initiatives redefine sustainable development in Nunavik. *American Review of Canadian Studies*, *47*(2), 176–188.

Rodon, T., & Schott, S. (2014). Towards a sustainable future for Nunavik. *Polar Record*, *50*(254), 260–276.

Schrock, G., Bassett, E. M., & Green, J. (2015). Pursuing equity and justice in a changing climate. *Journal of Planning Education and Research*, *35*(3), 282–295.

Therrien, A., & Duhaime, G. (2017). Le logement social au Nunavik: Pouvoirs et responsabilités [Social housing in Nunavik: Powers and responsibilities]. *Recherches Amérindiennes au Québec*, *47*(1), 101–110.

Trottier, F., Bayle, M., & Paquet, A. (2020). *Pinasuqatigiitsuta: Community planning in Nunavik*. Pinasuqatigiitsuta. https://www.pinasuqatigiitsuta.org

Vachon, G., Boudreault, S., Côté, A., Lambert, É., Proulx, S., & Dionne, M.-È. (2019). *Imagining the North in 50 projects: Creation, collaboration, action*. École d'Architecture de l'Université Laval.

Vachon, G., Rivard, E., Avarello, M., & St-Jean, L. (2017). Imaginer l'aménagement soutenable des villages Innuits du Nunavik: Le design pour réfléchir aux possibles [Imagining sustainable planning for Nunavik villages: A design approach for thinking the possible]. *Recherches Amérindiennes au Québec*, *47*(1), 137–150.

Watt-Cloutier, S. (2019). *Le droit au froid: Le combat d'une femme pour protéger sa culture, l'Arctique et la planète* [The right to be cold: One woman's story of protecting her culture, the Arctic, and the whole planet]. Éditions Écosociété.

Weis, T. (2014). *Implementation of wind energy projects in the autonomous networks and their coupling with diesel powered generators: Barriers, solutions and elements for a roadmap to success*. Regroupement des Organismes Environnementaux en Énergie. http://publicsde.regie-energie.qc.ca/projets/232/

DocPrj/R-3864-2013-C-ROE%C3%89-0044-Preuve-RappExp-2014_05_15.pdf

Wilson, S. (2008). *Research is ceremony: Indigenous research methods*. Fernwood Publishing.

Yin, R. K. (2011). *Qualitative research from start to finish*. Guilford Press.

Young, I. M. (1990). *Justice and the politics of difference*. Princeton University Press.

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Article

Collaborating With Communities: Citizen Science Flood Monitoring in Urban Informal Settlements

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Abstract
Concerns regarding the impacts of climate change on marginalised communities in the Global South have led to calls for affected communities to be more active as agents in the process of planning for climate change. While the value of involving communities in risk management is increasingly accepted, the development of appropriate tools to support community engagement in flood risk management projects remains nascent. Using the Revitalising Informal Settlements and their Environments Program as a case study, the article interrogates the potential of citizen science to include disadvantaged urban communities in project-level flood risk reduction planning processes. This project collected more than 5,000 photos taken by 26 community members living in 13 informal settlements in Fiji and Indonesia between 2018 and 2020. The case study documents the method used as well as the results achieved within this two-year project. It discusses the method developed and implemented, outlines the main results, and provides lessons learned for others embarking on citizen science environmental-monitoring projects. The case study indicates that the engagement model and the technology used were key to the success of the flood-monitoring project. The experiences with the practice of monitoring floods in collaboration with communities in Fiji and Indonesia provide insights into how similar projects could advance more participatory risk management practices. The article identifies how this kind of approach can collect valuable flood data while also promoting opportunities for local communities to be heard in the arena of risk reduction and climate change adaptation.

Keywords
citizen science; climate change; community-based methods; Fiji; flood monitoring; Indonesia; informal settlements

Issue
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1. Introduction

The notion that disaster studies must better account for the needs of disadvantaged communities has been gaining traction since the 2030 Agenda for Sustainable Development’s call for “leaving no one behind” (UN, 2015, p. 5). This is reflected in arguments for the involvement of communities in data collection to respond to important challenges in the sustainable development agenda (Fritz et al., 2019). Among growing concerns with floods and other environmental hazards, citizen science has emerged as a promising approach for involving communities in disaster risk management (Cooper et al., 2021). Investigating how community members can contribute to more inclusive risk management practices is particularly important in the context of informal

settlements, which are expected to be disproportionately affected by the impacts of climate change (French et al., 2020; Hoegh-Guldberg et al., 2018).

Risk management is formally understood as the assessment, evaluation, and intervention on the potential of a particular threat to cause results that differ from expected outcomes in a specific system (ISO/TC 262, 2018). Since the conceptualisation of risk, the practice of risk assessment has been a key stage in the process of managing uncertainty and mitigating the impacts of disasters (Renn, 1992). Historically, at the turn of the 21st century, the work of thinkers such as Beck (1992) and Giddens (1999) shed light on how risk management had defined cities and shaped planning practices globally. These seminal works denounced, for the first time, the limitations of the "risk society" while calling for a more reflexive and inclusive practice in the management of uncertainty. Now, decades later, these discussions gain traction again as societies struggle to address the growing and increasingly uncertain risks in the wake of the climate crisis.

It has been argued that the policies and practices of risk mitigation have been primarily defined by a few risk experts whose recommendations play a disproportionate role in decision-making processes (Knowles, 2011). In flood-prone areas, for instance, traditional risk management frameworks suggest that land use should be guided by the assessment of water level fluctuations, which are quantified and assessed through the methods and language of risk (Olesen et al., 2017). Emerging perspectives claim that these frameworks limit the involvement of local communities and might not be easily applicable in understudied contexts (Kuhlicke et al., 2020). As such, the use of citizen-generated data enabled by the democratisation of the internet has gained traction within the field of disaster studies. These changes in the field suggest that approaches to risk management are being gradually transformed to better account for the challenges of informal settlements, for which flood data is often unavailable.

Characterised by insecure land tenure, lack of access to infrastructure, and non-conformity with regulatory frameworks (UN-Habitat, 2017), informal settlements are also expected to be disproportionately impacted by climate change due to their rapid urban growth over areas at high risk from extreme weather (Bettini et al., 2017; Chandler, 2019; French et al., 2020; Revi et al., 2014). Some works have critiqued the social and political implications of the application of traditional risk management in informal settlements (French et al., 2020; Sandoval & Sarmiento, 2020; Yarina, 2018), which have historically been severely affected by floods and tropical cyclones. Emerging as an alternative, community-based approaches consider communities not as clients or external consultants, but as central agents in risk identification, monitoring, and communication (Shaw, 2014).

In response to these conditions, there have been growing calls for more direct involvement of local communities in risk management (Kelman, 2019). A reconsideration of the practices through which risks have been conceptualised and managed is particularly necessary for the context of low- and middle-income countries. This has been recognised, for example, in the UN's Sendai Framework for Disaster Risk Reduction which acknowledges that special attention should be dedicated to providing resources and expertise for the management of disasters in the Global South, particularly in island nations (UN International Strategy for Disaster Reduction [UNISDR], 2015).

In this context, this article explores an empirical case study of a citizen science project conducted in Indonesia and Fiji from the perspective of Revitalising Informal Settlements and their Environments (RISE) community fieldworkers directly involved in the implementation of the project. Having a unique perspective of the project, the experiences of fieldworkers are critical to investigate how risk management practices can effectively involve disadvantaged urban communities in the process of making sense of disasters. In doing so, this article aims to provide insights into the operation and implementation aspects of community-based flood-monitoring practices by discussing the firsthand lessons from a citizen science project within the broader RISE program.

2. The Emergence of Citizen Science

The expertise to map, understand, and monitor environmental hazards has been increasingly considered a strategic asset in a world characterised by growing risks. The application of risk management as a practice to address environmental hazards, such as landslides, floods, and cyclones, has become ubiquitous in high-income countries, but comparatively less progress has been made in the provision of basic infrastructure to marginalised communities (UN-Habitat, 2015). For over two decades now, UN organisations have been calling for more resources to address the challenges of infrastructure provision and risk management in informal settlements (UN-Habitat, 2003; UN-Habitat, 2015; UNISDR, 2015; UN Office for Disaster Risk Reduction & Centre for Research on the Epidemiology of Disasters, 2020). Researchers have also been suggesting that the unequal access to the resources, political power, and expertise to manage hazards affects the just distribution of opportunities and risks in the city (Anguelovski et al., 2016). In response to these concerns, the field of disaster studies has been increasingly interested in involving communities in the process of collecting environmental data to inform climate adaptation projects (See, 2019; Sy et al., 2020).

Researchers studying the emergence of smart cities argue that the democratisation of communication technologies, such as mobile internet and smartphones, has created new possibilities for the use of citizen-generated data (Townsend, 2015). Among these approaches, the involvement of citizens in the process of gathering environmental data through citizen science projects is seen as particularly promising (See, 2019; Starkey et al., 2017;

Wolff & Muñoz, 2021). The use of citizen science within the field of hydrology and flood risk management is based on involving non-scientists in the process of characterising and monitoring floods, commonly under the supervision of a scientific body or practitioner (Haklay, 2015). The growing popularity of citizen science can be attributed not only to the capacity of these methods to generate cheap, up-to-date and accessible disaster risk data but also to the perceived social engagement benefits of participatory approaches (Haklay et al., 2018).

While digital technologies have increasingly facilitated the collection of citizen-generated data (Karvonen, 2020), the literature shows that the participation of community members in the process of monitoring and assessing risks is not a recent phenomenon. In practice, the concepts of citizen science and community-based monitoring can be traced back to the notion of civic science (Kruger & Shanno, 2000) or to the early concept of people's science (Wisner et al., 1977), which encouraged communities to contribute to the documentation of a particular phenomenon of scientific interest. The group of approaches that seek to collect data in partnership with citizens include volunteered geographic information (Haworth et al., 2018), crowdsourced data (Lowry & Fienen, 2013), community science (Carr, 2004), and citizen science (Haklay, 2015).

Although citizen-generated datasets are considered promising within the flood risk assessment literature (Le Coz et al., 2016; See, 2019; Voinov & Gaddis, 2008), their use is still limited to simple applications. The literature shows that this kind of data has been used in the context of disaster management primarily for validating prediction models (Starkey et al., 2017). Other applications rely on citizen-generated data for conducting emergency assessments of the intensity and extent of occurrences for post-disaster planning (Fohringer et al., 2015; Smith & Rodriguez, 2017). As the notion of participatory science gains currency, however, it is important to consider that community-based approaches can play other roles and foster a more people-centred approach to disaster risk management.

Projects dedicated to mapping water level fluctuations with local-scale precision and continued engagement with community members are expected to become increasingly common. Despite a growing interest in this approach, the practical and operational aspects of employing citizen science to monitor floods in urban informal settlements are still largely undocumented to date. In an effort to address this deficit in knowledge, this article reflects on the operational aspects of RISE's flood-monitoring project in Fiji and Indonesia to document the methods and tools used and to provide lessons on how to implement citizen science in urban informal settlements.

3. Case Study: Flood Monitoring in Fiji and Indonesia

The RISE program is a transdisciplinary research initiative implementing nature-based infrastructure systems in the Asia-Pacific (Brown et al., 2018; Ramírez-Lovering et al., 2018). Its primary research aims to investigate the human health and environmental effects of nature-based infrastructure in 12 settlements in Suva (Fiji) and 12 settlements in Makassar (Indonesia). Using a randomised control trial model, RISE selected settlements that would allow researchers to study the benefits of the infrastructure systems in both countries. The selected sites represent a diversity of characteristics with varying biophysical, socioeconomic and land tenure conditions (Leder et al., 2021). Varying considerably in terms of size and physical settings, the population of the settlements ranges between 50 and 700 people each and include sites with coastal, riverine, and flood plain characteristics.

Developed within the broader RISE program, the flood-monitoring project was designed to document floods in the most flood-prone sites: seven settlements in Suva and six settlements in Makassar. This project was key to informing the design of RISE's nature-based infrastructure since the wetland systems need to be protected from direct damage caused by flooding (Asian Development Bank & RISE, 2021). Furthermore, it was critical to monitor floods in the sites because water level variations were identified as a potential source of contamination capable of affecting human health in the settlements (French et al., 2021). Considering the limited information available for modelling floods on the sites, RISE researchers developed this project to systematically monitor floods in the participating settlements.

The model used is similar to several other data-crowdsourcing and distributed intelligence initiatives that invited citizens in the collection and analysis of flood data over the last decade (Fava et al., 2018; Kankanamge et al., 2020; Le Coz et al., 2016; Mobley et al., 2019; Smith & Rodriguez, 2017). Other projects conducted in low- and middle-income countries influenced the data collection model used as they provided important insights into the challenges of collecting flood data in "data-poor" contexts such as informal settlements (Adomah Bempah & Olav Øyhus, 2017; Glas et al., 2020; Hazarika et al., 2018). In Indonesia, the PetaBencana project (https://petabencana.id) was an important precedent because it exemplifies how citizen-generated data can inform decision-making processes during and after floods (Fadmastuti, 2019; see Figure 1).

Adapting the methods utilised in these projects to the context of RISE, the researchers conceptualised this initiative as a repository of flood photos that would later be interpreted to provide evidence of flood levels, as shown in Figure 1. As such, the project was conceptualised as a data crowdsourcing initiative in the sense that it involved residents in a role analogous to that of a "sensor'' collecting flood data (Haklay, 2013). After its implementation, however, it became evident that citizens were playing other roles in the project as they supported the analysis of the photos and actively contributed to disseminating the results among the communities.

Figure 1. Flood gauge in Makassar, Indonesia, photographed by residents in different conditions during floods in 2018 and 2019.

The preparation for the project consisted of the installation of a gauge and a crest level indicator in each of the flood-prone settlements in a position where the participants could safely photograph the gauges and register water level fluctuations. The participants were instructed to use their personal smartphones to send photos of the flood gauges daily (see Figure 2) in order to keep a record of the water levels throughout the whole season. The RISE staff members that engaged the communities instructed the participants to photograph the gauges at least once a day and periodically at two-hour intervals during floods.

The photos were shared through a common messaging smartphone application where all volunteers were able to communicate and comment on each other's photos in a shared group. The work of monitoring water levels was done voluntarily and the only compensation offered was a monthly reimbursement to cover the access to the internet for sharing the images. Once received, the images were downloaded into a database,

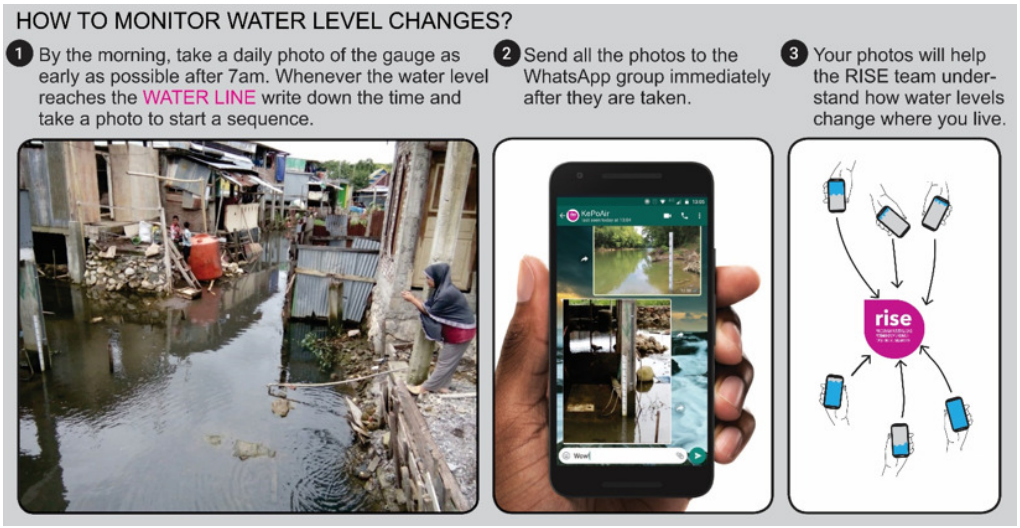

Figure 2. RISE's community-based flood-monitoring project guidelines. These instructions were delivered and explained to participating community members in local languages to ensure data quality in the project. Source: RISE program, drawn by Daša Spasojević.

the water levels assessed, and then recorded in a spreadsheet by the leading author as part of an action-research approach (Ramírez-Lovering et al., 2020).

Over the duration of the project, a total of 5,301 photos were received from community members in Indonesia and Fiji (n = 2,433 for Fiji, n = 2,868 for Indonesia; see Table 1). The photos allowed for comprehensive documentation of water levels in different settlements across the same catchment and, therefore, provided useful evidence of flood levels in the area (see Wolff, 2021, for additional information on the data collected).

The local residents who contributed to the flood-monitoring project with photos included 11 participants in Indonesia and 15 participants in Fiji (Table 1). In both countries, the groups were primarily composed of women; men only represented around a third of the collaborators, despite efforts to diversify the participants. The project was first conducted between December 2018 and the end of the wet season of 2019 and achieved significantly different outcomes in each of the countries. Following positive results of the first year in the Indonesian group, the project was repeated between December 2019 and March 2020 in Makassar.

Reflecting on these experiences, this article reflects critically on the lessons learnt during the implementation and management of the project in both countries. The methodology used to draw lessons from this project is discussed in the next section.

4. Method: Reflecting on the Implementation of the Citizen Science Project

Aiming to better understand the challenges and to refine the practices used in citizen science projects, this article employs an inductive approach to identify trends that emerge from the combined analysis of multiple research materials (Hodkinson, 2008). This approach is particularly suited to examine projects in which the authors are involved because it frames the investigation in a way "in which intimate knowledge and depth of understanding of the case is legitimately seen to enter the research process" (May, 2011, p. 230). As such, it is important to note the positionality of the authors as we have all been involved in different conditions with the implementation and management of the project.

Our direct involvement with the flood-monitoring project also allowed us to frame this research as a reflexive investigation (O'Reilly, 2012). Reflexive approaches are particularly important in the context of climate change studies and adaptation research as it requires researchers to be "responsive to learning and critically reflective of not only what a researcher is doing, but… why, how, and to what effect" (Preston et al., 2015, p. 128). More generally, reflexive case studies that draw from context-specific knowledge are championed by researchers that argue that this kind of approach sits "at the centre of the case study as a research and teaching method; or to put it more generally, still: as a method of learning" (Flyvbjerg, 2006, p. 5). Approaching the project through a reflexive position is, therefore, a unique opportunity to draw practical lessons that can inform future similar projects. As such, the framing as a reflexive and inductive case study is not centred on the interest of providing universally generalised outcomes, but on the interest of providing lessons of particular interest to the field (Simons, 2009) derived from our own reflections and experiences.

The insights from the community fieldworkers that underpin this article build primarily on our notes from the project and a series of discussions among ourselves and between ourselves and other RISE fieldworkers. The RISE staff members involved in the project included a group of seven RISE community fieldworkers in Fiji and four in Indonesia (Table 1), as well as four researchers based in Australia directly involved with the management and analysis of the photos. These discussions were initiated as some of us collaboratively reflected on our experiences of monitoring floods within the RISE program. Building upon this initial discussion, a semi-structured questionnaire (Gilbert, 2008) was created to further explore the different experiences in both countries. This questionnaire consisted of eight open-ended questions to encourage the members of the teams in Fiji, Indonesia, and Australia to reflect on the stages of implementation, engagement, and analysis of the results of the project.

The answers to the questions were analysed to identify the differences between the Indonesian and Fijian experiences with the project. They were analysed separately to identify common themes and later compared

Table 1. Metrics of the flood-monitoring project conducted within the RISE program in Indonesia and Fiji.

Location	Number of Settlements Monitored	Number of Participants Involved	Number of RISE Fieldworkers	Number of Gauges Installed	Total Duration of Project and Monitoring Period	Number of Photos Obtained
Suva, Fiji	7	15	7	13	Approx. 6 months Dec 2018–Jun 2019	2,433
Makassar, Indonesia	6	11	4	7	Approx. 8 months Dec 2018–Apr 2019 Dec 2019–Apr 2020	2,868

to draw on the lessons pointed out by the teams in each country. These experiences were then compared to the results of the project in terms of the total number of photos obtained and community engagement. Since the participants were asked to contribute with photos every day, we considered that the frequency of photos is the main indication of community engagement in the flood-monitoring project. To ensure that the results of this analysis were representative they were synthesised in the next section and reviewed by members of RISE fieldworkers' teams in both countries, who co-authored this article.

The experiences of RISE fieldworkers, who were in direct contact with the participants throughout the project, were particularly important to identify the main challenges and insights from the project. The fieldworkers are all citizens of the countries in which they work and are familiar with the language and cultural context of the communities. They come from a range of disciplinary backgrounds, including architecture, engineering, and community development. Beyond other responsibilities within RISE, they were involved in the flood-monitoring campaign through activities such as flood gauge installation and community engagement (training and managing daily reporting). Based on their experiences, we discuss how effective the initiative was at engaging community members and collecting frequent flood data. The names of participants and fieldworkers involved are not disclosed in this article to protect their identities.

5. Results

The analysis of the answers provided by the Indonesian and Fijian fieldworkers' teams revealed important differences in the approaches used in the implementation of the project in both countries. Figure 3 illustrates the duration of the flood-monitoring project in Indonesia and Fiji and highlights the days in which participants monitored each of the gauges. This analysis of the engagement in the project shows that while the flood-monitoring project in Fiji had received photos from all gauges by the end of January of 2019, the daily updates were significantly more irregular in this group throughout the whole monitoring period. The fieldworkers involved in the project in both countries shared insights into some of the practical and operational aspects behind these results which were grouped into four main findings, discussed in the following sections.

5.1. Pre-Existing Relationships and Interests

In both countries, the communities were enthusiastic and demonstrated significant interest in the project. The Fijian fieldworkers mentioned that the project was initially well received by the communities because they were excited about the RISE program. According to them, the communities fully supported the efforts and goals of the flood-monitoring project because they were aware that the monitoring would be used to inform the design of infrastructure systems. In Indonesia, the fieldworkers shared that due to other engagement activities conducted within the broader RISE research agenda, there were pre-existing relationships between the fieldworkers and the communities. As a result, the team had been in contact with the residents for more than a year before the beginning of the flood-monitoring project which might have facilitated the communication with community members. These reflections suggest that the broader RISE program and pre-existing relationships with the communities made training and initial engagement of community members in the activity easier than expected.

Participating community members also shared with the fieldworkers that they had an interest in the flood-monitoring initiative because they were already aware of the flood-prone nature of the sites. According to the fieldworkers in both countries, the interest in monitoring floods was already present in the communities as evidenced by the fact that community members were already sharing anecdotal flood descriptions and sending flood photos to RISE engagement team even before the project. According to fieldworkers in Indonesia, most of the participants understood the main purpose of registering frequent water level variations for the RISE program. As such, they were in general supportive of the activity and approached it as a platform for improving communication and sharing flood information. The fieldworkers also suggested that the severity of the floods experienced by the communities in Makassar might have resulted in a greater interest in the project in Indonesia. The flood-monitoring project, therefore, can be seen as a platform that allowed for a more systematic collection of data related to an already existing interest within the community.

5.2. Participant Selection

In both Suva and Makassar, the fieldworkers found that the selection of participants played an important role in the success of the project. In both countries, the selection of participants was primarily conducted by the fieldworkers with the support of local community leaders and considered, first of all, the proximity of participants to a particularly flood-prone area. In Fiji, the fieldworkers highlighted that the participant selection was challenging because they had to consider whether residents had access to a smartphone capable of joining the messaging application. Additionally, they mentioned that most community members approached were not able to participate in the flood-monitoring project due to work commitments and competing priorities.

The Indonesian fieldworkers identified that the popularity of mobile internet and social media in the country were central to the success of the project. The pre-existing interest in sharing flood photos and accounts through social media meant that the flood-monitoring

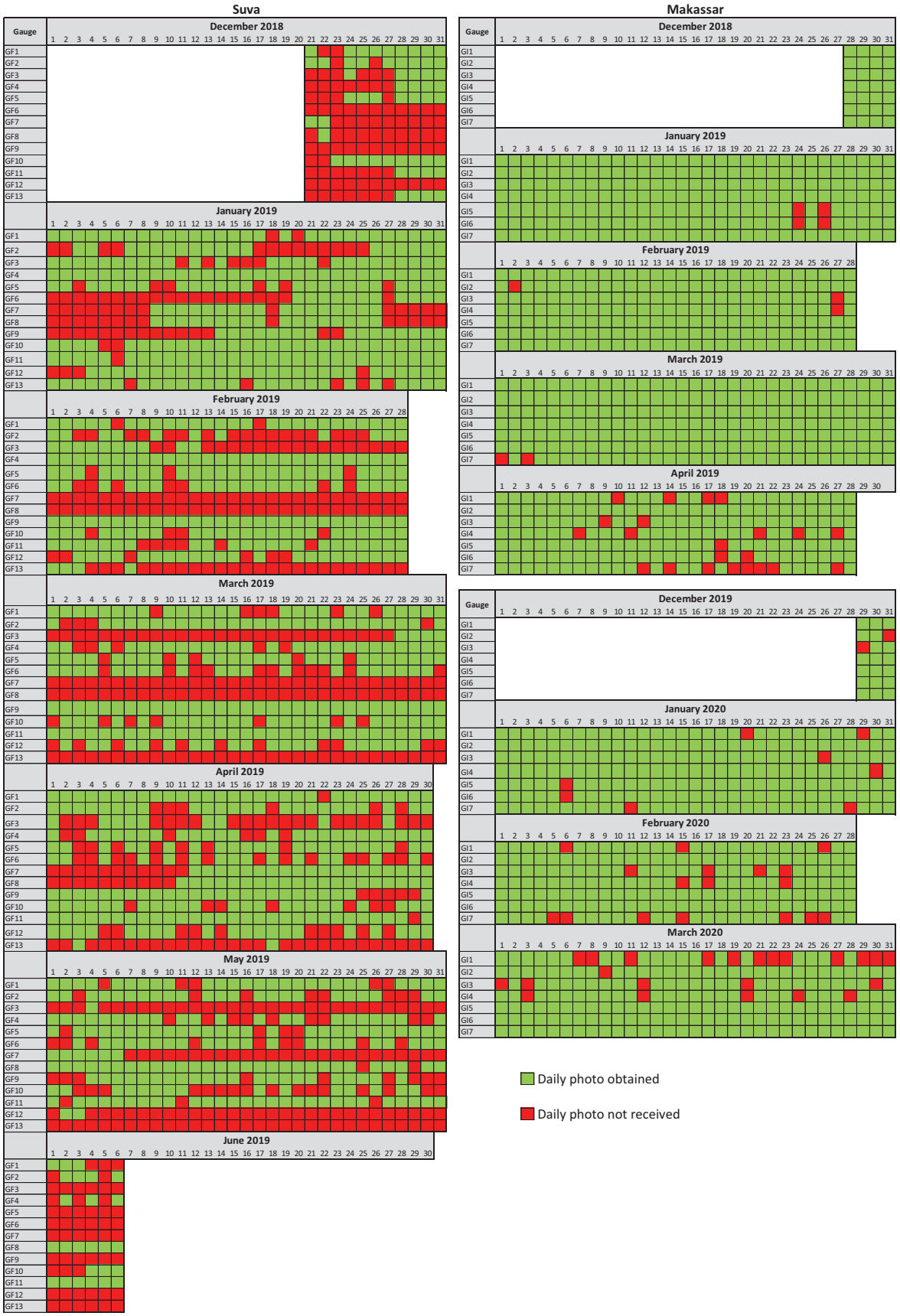

Figure 3. Engagement in RISE's flood-monitoring project in Suva and Makassar. The rows represent the different gauges and the columns represent the days of monitoring. The cells shaded in green illustrate days in which a photo was received for a particular gauge and are, therefore, representative of the engagement in the project.

project became an additional platform for a practice that was already part of the local response to floods. The use of an accessible and familiar platform, which was already commonly used by the participants, also facilitated the process. These accounts suggest that the equity of access, familiarity with the platform, and availability of resources were still obstacles for the project and, as a result, not all residents were equally interested or able to join the initiative.

5.3. Group Dynamics and Support From Fieldworkers

The frequency of interactions through the monitoring group was also considered an important factor influencing the engagement in the flood-monitoring project in both countries. While the Indonesian team mentioned that daily feedback and participation in the sharing platform was an important strategy to ensure positive results, the Fijian team followed up with the participants weekly when they noticed signs of disengagement. The Fijian fieldworkers shared that the engagement model could be improved in a future iteration of the project by assigning fewer fieldworkers to mediate the activity and by more closely communicating with residents. During the implementation in Fiji, each fieldworker was assigned to follow up with the participants of one settlement. This was a significant contrast in relation to how the project was conducted in Indonesia, where the communication with participants was conducted primarily by a couple of fieldworkers who were in charge of the engagement of all participants in the activity. According to the team, the involvement of several staff members in the project in Fiji meant that there were times in which certain RISE staff were not available to follow up on their communities creating a discontinuity in the monitoring. The fieldworkers in the Indonesian project, however, would follow up with community members very frequently and encourage engagement by sharing weather and flood-related information of interest in the group daily.

Additionally, other aspects not previously foreseen might have influenced the varying degrees of engagement observed in the two groups. According to the fieldworkers, the compensation for the internet usage and acknowledgement of the participant's contributions was generally enough to ensure that community members were able to participate. In Fiji, however, the fieldworkers identified that participants would sometimes be unable to contribute to the initiative if they did not have any support in their home or community to take pictures on their behalf when they were unavailable. The weekly provision of phone credit recharges (for internet access) was also considered a challenge for the fieldworkers in Fiji. The fieldworkers revealed that the recharge credits would sometimes expire before the end of the week preventing participants from sharing photos consistently. It is important to highlight that the Fijian flood-monitoring group was also considerably larger, monitoring 13 gauges, while the Indonesian was overseeing seven gauges. These accounts reiterate the importance of considering the unequal access to technology and the accessibility of the platform used in citizen science projects.

5.4. Value for Communities and Participants

Fieldworkers in Indonesia suggested that engagement in the project played an important role in strengthening local flood response mechanisms. Following a major flood in early 2019 that was registered by the flood-monitoring project, residents were able to reach out to local support networks such as the aid from higher-income neighbours and local institutions. They described the community's interest in having access to the results, and their belief that monitoring floods would be important not only for decision-makers but also for the communities suggesting that the data-collection is not unidirectional in benefit.

The fieldworkers also shared the belief that comprehensive and structured documentation of water level fluctuations is valued by the community. Their accounts suggest that the flood-monitoring project can be a tool to understand the local flood dynamics and advocate for governmental support using the collected evidence. As such, the fieldworkers communicated needs and interests between communities and RISE researchers, revealing that the project has the potential to contribute to future advocacy with decision-makers in local government. Since the citizen science project made the results accessible to the community, we believe this will serve as a household decision-making tool for future buildings and community action in the years to come. The flood documentation is now also accessible to elected community leaders and can be used as a resource to support political action.

6. Discussion

The findings indicate that the pre-existing relationship between the RISE program and these communities and the selection of participants was critical for the success of the flood-monitoring project. The differences observed between Fiji and Indonesia suggest that the sustainability of the project in the long term is highly dependent on access to resources and familiarity with the technology used. These findings are commensurate with the recommendations identified by other authors who explored the challenges of citizen science (Conrad & Daoust, 2008) and mapped how communities can participate in flood governance (Mees et al., 2017).

While the project was restricted to a predetermined duration in the case of RISE, the fieldworkers identified other local stakeholders that could be able to support the continuation of a future iteration of the project locally. Fieldworkers in Indonesia argued that citizen science projects would be of

great interest to local authorities, following the precedent of the PetaBencana project (Fadmastuti, 2019). The National Disaster Management Authority and the Regional Disaster Management Authority, in particular, are natural partners for such projects. This is aligned with the findings of other authors who highlight the need to identify local stakeholders that can further support citizen science projects in the long term (Conrad & Hilchey, 2011; Legg & Nagy, 2006).

The findings also suggest that it is essential to carefully consider how citizen science projects offer the data back to the community. In order to design the project to works as a platform for mutual knowledge transfer, the community should have access to all relevant results of the project. This is particularly relevant if the results can help residents manage disaster risk at the local scale by being incorporated within local community-based disaster risk reduction strategies (Shaw, 2016). The reflections of the fieldworkers involved in RISE flood-monitoring project indicate that further strategies should be developed to make reports more accessible, ensuring that they are available and easy to understand by the wider community. To date, the fieldworkers agreed that the main legacy of the project in the long term is the designed infrastructure located above flood levels, which is directly beneficial to the community.

Critical analysis of the project also reveals other aspects not previously foreseen that influenced the varying degrees of engagement observed in the two groups. According to the fieldworkers, most participants in Fiji reported not being familiar with the messaging application nor with the process of sharing photos through the internet before the project. The participants from Makassar, conversely, demonstrated being more comfortable and adept at using the messaging application. This situation reiterates the importance of considering the unequal access to technology and the accessibility of the platform used in citizen science projects (Assumpção et al., 2018; McCallum et al., 2016). This indicates that the process of engaging participants in citizen science must take into consideration existing communication practices and technologies that community members already use in their everyday lives.

It is also worth noting that to improve engagement and ensure that more gauges were monitored consistently, RISE's flood-monitoring framework gradually transformed to better communicate with the participants. The need to adapt frameworks and practices to local contexts is well-documented in the field of planning (Healey, 2007) and has gained traction within the field of citizen science (Cheung & Feldman, 2019; Porto de Albuquerque & Albino de Almeida, 2020). In the case of RISE, the fieldworkers noticed that Indonesian participants valued receiving monthly reports in which their contributions were acknowledged. Learning from the feedback from participants, the team recognised one of the participants as the "contributor of the month" who was acknowledged publicly. This was identified as one of the reasons why the project managed to effective gather flood data in Indonesia.

7. Conclusions

This article provided insights into how projects can engage communities in the management of floods based on the experiences of a citizen science project within the RISE program. It did so by documenting the process of implementation of the project and reflecting on the experiences of the fieldworkers that involved communities in the monitoring of floods in Indonesia and Fiji between 2018 and 2020. Our findings contribute to the growing body of literature regarding the potentials of citizen science as a valuable tool to promote local action and local knowledge creation.

This case study suggests important operational aspects to fulfil the potential of participatory flood monitoring and mapping practices to make room for vulnerable communities to have an active voice in city planning (Miraftab, 2009). According to the fieldworkers, the approach significantly expanded local knowledge of environmental threats and provided the community with a structured flood record, which could be continued independent of RISE using the gauges installed by the project.

The analysis of the engagement in the sharing platform was also useful to reveal how effective the project was in creating a collaborative and purposeful platform. For instance, the frequent exchange of messages between participants of the flood-monitoring group in Makassar before and during floods suggests that the platform performed other roles other than serving as a repository of photos. This situation is evidenced by the use of the citizen science group as a sharing platform through which participants warned others about the weather forecasts, discussed news, and exchanged information relevant to the surrounding settlements.

The findings suggest that citizen science can support data collection, but it requires resources, technical expertise, and mediation that might not be fully available in the most disadvantaged contexts. As such, the study highlights that citizen science can support data collection, community engagement, and risk awareness (Cheung & Feldman, 2019; Marchezini et al., 2017), but it should not be seen as a "solution" to the systemic and structural issues that underpin existing vulnerabilities. Consequently, the benefits of community engagement in flood data collection should not be seen as an opportunity to transfer responsibilities for flood management from governments to already vulnerable and historically disadvantaged communities.

These conclusions are particularly relevant for other projects that propose the use of citizen science for leaving "no one behind" in the context of communities living in vulnerable conditions. The experiences of the flood-monitoring project within RISE suggest that citizen science projects must be oriented by an interest in inclusive

planning practices that account for the unequal access to resources and expertise in particular contexts. While citizen science is not expected to resolve the systemic roots of vulnerability in informal settlements (Rocco & van Ballegooijen, 2018), it can contribute to addressing data gaps that are expected to be further aggravated by the interactions between climate change and rapid urban development. Contributing to a growing body of knowledge that argues for a "citizenship from below" (Marfai et al., 2015; Roy, 2005), citizen science can be a successful tool in the process of raising awareness and creating momentum for more inclusive practices in flood risk management.

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Conflict of Interests

The authors declare no conflict of interests.

References

Adomah Bempah, S., & Olav Øyhus, A. (2017). The role of social perception in disaster risk reduction: Beliefs, perception, and attitudes regarding flood disasters in communities along the Volta River, Ghana. *International Journal of Disaster Risk Reduction*, *23*, 104–108. https://doi.org/10.1016/j.ijdrr.2017.04.009

Anguelovski, I., Shi, L., Chu, E., Gallagher, D., Goh, K., Lamb, Z., Reeve, K., & Teicher, H. (2016). Equity impacts of urban land use planning for climate adaptation: Critical perspectives from the Global North and South. *Journal of Planning Education and Research*, *36*(3), 333–348. https://doi.org/10.1177/0739456X16645166

Asian Development Bank, & RISE. (2021). *Water-sensitive informal settlement upgrading: Description of technologies*. Asian Development Bank and Monash University. https://www.rise-program.org/__data/assets/pdf_file/0011/2603486/RISE_ADB-Knowledge-Products-3_FA4-hires.pdf

Assumpção, T. H., Popescu, I., Jonoski, A., & Solomatine, D. P. (2018). Citizen observations contributing to flood modelling: Opportunities and challenges. *Hydrology and Earth System Sciences*, *22*(2), 1473–1489. https://doi.org/10.5194/hess-22-1473-2018

Beck, U. (1992). *Risk society: Towards a new modernity*. SAGE.

Bettini, G., Nash, S. L., & Gioli, G. (2017). One step forward, two steps back? The fading contours of (in)justice in competing discourses on climate migration. *The Geographical Journal*, *183*(4), 348–358. https://doi.org/10.1111/geoj.12192

Brown, R., Leder, K., Wong, T., French, M., Ramírez-Lovering, D., Chown, S. L., Luby, S., Clasen, T., Reidpath, D., El Sioufi, M., McCarthy, D., Forbes, A., Simpson, J., Allotey, P., & Cahan, B. (2018). Improving human and environmental health in urban informal settlements: The Revitalising Informal Settlements and their Environments (RISE) programme. *The Lancet Planetary Health*, *2*, Article S29. https://doi.org/10.1016/S2542-*5196*(18)30114-1

Carr, A. J. L. (2004). Why de we all need community science? *Society & Natural Resources*, *17*(9), 841–849. https://doi.org/10.1080/08941920490493846

Chandler, D. (2019). Resilience and the end(s) of the politics of adaptation. *Resilience*, *7*(3), 304–313. https://doi.org/10.1080/21693293.2019.1605660

Cheung, W., & Feldman, D. (2019). Can citizen science promote flood risk communication? *Water*, *11*(10), Article 1961. https://doi.org/10.3390/w11101961

Conrad, C., & Daoust, T. (2008). Community-based monitoring frameworks: Increasing the effectiveness of environmental stewardship. *Environmental Management*, *41*(3), 358–366.

Conrad, C., & Hilchey, K. (2011). A review of citizen science and community-based environmental monitoring: Issues and opportunities. *Environmental Monitoring and Assessment*, *176*(1/4), 273–291. https://doi.org/10.1007/s10661-010-1582-5

Cooper, C. B., Hawn, C. L., Larson, L. R., Parrish, J. K., Bowser, G., Cavalier, D., Dunn, R. R., Haklay, M., Gupta, K. K., Jelks, N. O., Johnson, V. A., Katti, M.,

Leggett, Z., Wilson, O. R., & Wilson, S. (2021). Inclusion in citizen science: The conundrum of rebranding. *Science*, *372*(6549), 1386–1388. https://doi.org/10.1126/science.abi6487

Fadmastuti, M. (2019). Selfies save lives (Digital strategies for flood response in Indonesia). *IOP Conference Series: Earth and Environmental Science*, *338*, Article 012040. https://doi.org/10.1088/1755-1315/338/1/012040

Fava, M. C., Abe, N., Restrepo-Estrada, C., Kimura, B. Y. L., & Mendiondo, E. M. (2018). Flood modelling using synthesised citizen science urban streamflow observations. *Journal of Flood Risk Management*, *12*(S2), Article e12498. https://doi.org/10.1111/jfr3.12498

Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry*, *12*(2), 219–245. https://doi.org/10.1177/1077800405284363

Fohringer, J., Dransch, D., Kreibich, H., & Schröter, K. (2015). Social media as an information source for rapid flood inundation mapping. *Natural Hazards and Earth System Sciences*, *15*(12), 2725–2738. https://doi.org/10.5194/nhess-15-2725-2015

French, M., Fiona Barker, S., Taruc, R. R., Ansariadi, A., Duffy, G. A., Saifuddaolah, M., Zulkifli Agussalim, A., Awaluddin, F., Zainal, Z., Wardani, J., Faber, P. A., Fleming, G., Ramsay, E. E., Henry, R., Lin, A., O'Toole, J., Openshaw, J., Sweeney, R., Sinharoy, S. S., . . . Leder, K. (2021). A planetary health model for reducing exposure to faecal contamination in urban informal settlements: Baseline findings from Makassar, Indonesia. *Environment International*, *155*, Article 106679. https://doi.org/10.1016/j.envint.2021.106679

French, M., Trundle, A., Korte, I., & Koto, C. (2020). Climate resilience in urban informal settlements: Towards a transformative upgrading agenda. In R. de Graaf-van Dinther (Ed.), *Climate resilient urban areas: Governance, design and development in coastal delta cities* (pp. 129–153). Springer. https://doi.org/10.1007/978-3-030-57537-3

Fritz, S., See, L., Carlson, T., Haklay, M., Oliver, J. L., Fraisl, D., Mondardini, R., Brocklehurst, M., Shanley, L. A., Schade, S., Wehn, U., Abrate, T., Anstee, J., Arnold, S., Billot, M., Campbell, J., Espey, J., Gold, M., Hager, G., . . . West, S. (2019). Citizen science and the United Nations Sustainable Development Goals. *Nature Sustainability*, *2*(10), 922–930. https://doi.org/10.1038/s41893-019-0390-3

Giddens, A. (1999). Risk and responsibility. *The Modern Law Review*, *62*(1).

Gilbert, G. N. (2008). *Researching social life* (3rd ed.). SAGE.

Glas, H., De Maeyer, P., Merisier, S., & Deruyter, G. (2020). Development of a low-cost methodology for data acquisition and flood risk assessment in the floodplain of the river Moustiques in Haiti. *Journal of Flood Risk Management*, *13*(2), Article e12608. https://doi.org/10.1111/jfr3.12608

Haklay, M. (2013). Citizen science and volunteered geographic information: Overview and typology of participation. In D. Sui, S. Elwood, & M. Goodchild (Eds.), *Crowdsourcing geographic knowledge: Volunteered geographic information (VGI) in theory and practice* (pp. 105–122). Springer. https://doi.org/10.1007/978-94-007-4587-2_7

Haklay, M. (2015). *Citizen science and policy: A European perspective*. Woodrow Wilson International Center for Scholars.

Haklay, M., Mazumdar, S., & Wardlaw, J. (2018). Citizen science for observing and understanding the Earth. In P.-P. Mathieu & C. Aubrecht (Eds.), *Earth observation open science and innovation* (pp. 69–88). Springer. https://doi.org/10.1007/978-3-319-65633-5_4

Haworth, B. T., Bruce, E., Whittaker, J., & Read, R. (2018). *The good, the bad, and the uncertain: Contributions of volunteered geographic information to community disaster resilience*. Frontiers in Earth Science. https://doi.org/10.3389/feart.2018.00183

Hazarika, N., Barman, D., Das, A. K., Sarma, A. K., & Borah, S. B. (2018). Assessing and mapping flood hazard, vulnerability and risk in the Upper Brahmaputra River valley using stakeholders' knowledge and multicriteria evaluation (MCE): Assessing and mapping flood hazard. *Journal of Flood Risk Management*, *11*, S700–S716. https://doi.org/10.1111/jfr3.12237

Healey, P. (2007). *Urban complexity and spatial strategies: Towards a relational planning for our times*. Routledge.

Hodkinson, P. (2008). Grounded theory and inductive research. In G. N. Gilbert (Ed.), *Researching social life* (3rd ed., pp. 80–100). SAGE.

Hoegh-Guldberg, O., Jacob, D., Bindi, M., Brown, S., Camilloni, I., Diedhiou, A., Djalante, R., Ebi, K., Engelbrecht, F., & Guiot, J. (2018). Impacts of 1.5° C global warming on natural and human systems. In V. Masson-Delmotte, P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, & T. Waterfield (Eds.), *Global warming of 1.5°C* (pp. 175–311). IPCC. https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Chapter3_Low_Res.pdf

ISO/TC 262. (2018). *ISO 31000 risk management: Guidelines* (2nd ed.). https://www.iso.org/standard/65694.html

Kankanamge, N., Yigitcanlar, T., Goonetilleke, A., & Kamruzzaman, Md. (2020). Determining disaster severity through social media analysis: Testing the methodology with South East Queensland flood tweets. *International Journal of Disaster Risk Reduction*, *42*, Article 101360. https://doi.org/10.1016/j.ijdrr.2019.101360

Karvonen, A. (2020). Urban techno-politics: Knowing, governing, and imagining the city. *Science as Culture*, *29*(3), 417–424. https://doi.org/10.1080/09505431.

2020.1766011

Kelman, I. (2019). Axioms and actions for preventing disasters. *Progress in Disaster Science*, *2*, Article 100008. https://doi.org/10.1016/j.pdisas.2019.100008

Knowles, S. G. (2011). *The disaster experts: Mastering risk in modern America*. University of Pennsylvania Press.

Kruger, L. E., & Shanno, M. A. (2000). Getting to know ourselves and our places through participation in civic social assessment. *Society & Natural Resources*, *13*(5), 461–478. https://doi.org/10.1080/089419200403866

Kuhlicke, C., Seebauer, S., Hudson, P., Begg, C., Bubeck, P., Dittmer, C., Grothmann, T., Heidenreich, A., Kreibich, H., Lorenz, D. F., Masson, T., Reiter, J., Thaler, T., Thieken, A. H., & Bamberg, S. (2020). The behavioral turn in flood risk management, its assumptions and potential implications. *WIREs Water*, *7*(3), Article e1418. https://doi.org/10.1002/wat2.1418

Le Coz, J., Patalano, A., Collins, D., Guillén, N. F., García, C. M., Smart, G. M., Bind, J., Chiaverini, A., Le Boursicaud, R., Dramais, G., & Braud, I. (2016). Crowdsourced data for flood hydrology: Feedback from recent citizen science projects in Argentina, France and New Zealand. *Journal of Hydrology*, *541*, 766–777. https://doi.org/10.1016/j.jhydrol.2016.07.036

Leder, K., Openshaw, J. J., Allotey, P., Ansariadi, A., Barker, S. F., Burge, K., Clasen, T. F., Chown, S. L., Duffy, G. A., Faber, P. A., Fleming, G., Forbes, A. B., French, M., Greening, C., Henry, R., Higginson, E., Johnston, D. W., Lappan, R., Lin, A., . . . RISE Consortium. (2021). Study design, rationale and methods of the Revitalising Informal Settlements and their Environments (RISE) study: A cluster randomised controlled trial to evaluate environmental and human health impacts of a water-sensitive intervention in informal settlements in Indonesia and Fiji. *BMJ Open*, *11*(1), Article e042850. https://doi.org/10.1136/bmjopen-2020-042850

Legg, C. J., & Nagy, L. (2006). Why most conservation monitoring is, but need not be, a waste of time. *Journal of Environmental Management*, *78*(2), 194–199. https://doi.org/10.1016/j.jenvman.2005.04.016

Lowry, C. S., & Fienen, M. N. (2013). CrowdHydrology: Crowdsourcing hydrologic data and engaging citizen scientists. *Ground Water*, *51*(1), 151–156. https://doi.org/10.1111/j.1745-6584.2012.00956.x

Marchezini, V., Trajber, R., Olivato, D., Muñoz, V. A., de Oliveira Pereira, F., & Oliveira Luz, A. E. (2017). Participatory early warning systems: Youth, citizen science, and intergenerational dialogues on disaster risk reduction in Brazil. *International Journal of Disaster Risk Science*, *8*(4), 390–401. https://doi.org/10.1007/s13753-017-0150-9

Marfai, M. A., Sekaranom, A. B., & Ward, P. (2015). Community responses and adaptation strategies toward flood hazard in Jakarta, Indonesia. *Natural Hazards*, *75*(2), 1127–1144. https://doi.org/10.1007/s11069-014-1365-3

May, T. (2011). *Social research: Issues, methods and process* (4th ed.). Open University Press.

McCallum, I., Liu, W., See, L., Mechler, R., Keating, A., Hochrainer-Stigler, S., Mochizuki, J., Fritz, S., Dugar, S., Arestegui, M., Szoenyi, M., Bayas, J.-C. L., Burek, P., French, A., & Moorthy, I. (2016). Technologies to support community flood disaster risk reduction. *International Journal of Disaster Risk Science*, *7*(2), 198–204. https://doi.org/10.1007/s13753-016-0086-5

Mees, H., Crabbé, A., & Driessen, P. P. J. (2017). Conditions for citizen co-production in a resilient, efficient and legitimate flood risk governance arrangement. A tentative framework. *Journal of Environmental Policy & Planning*, *19*(6), 827–842. https://doi.org/10.1080/1523908X.2017.1299623

Miraftab, F. (2009). Insurgent planning: Situating radical planning in the Global South. *Planning Theory*, *8*(1), 32–50. https://doi.org/10.1177/1473095208099297

Mobley, W., Sebastian, A., Highfield, W., & Brody, S. D. (2019). Estimating flood extent during Hurricane Harvey using maximum entropy to build a hazard distribution model. *Journal of Flood Risk Management*, *12*(S1), Article e12549. https://doi.org/10.1111/jfr3.12549

Olesen, L., Lowe, R., & Arnbjerg-Nielsen, K. (2017). *Flood damage assessment: Literature review and recommended procedure. Socio-technical flood resilience in water sensitive cities—Quantitative spatio-temporal flood risk modelling in an urban context (Project B4.1)*. Australian Government—Department of Industry and Science.

O'Reilly, K. (2012). Writing, reflexivity and autobiography. In K. O'Reilly (Ed.), *Ethnographic methods* (2nd ed., pp. 205–228). Routledge.

Porto de Albuquerque, J., & Albino de Almeida, A. (2020). Modes of engagement: Reframing "sensing" and data generation in citizen science for empowering relationships. In T. Davies & A. Mah (Eds.), *Toxic truths: Environmental justice and citizen science in a post-truth age* (pp. 267–281). Manchester University Press. https://doi.org/10.7765/9781526137005.00028

Preston, B. L., Rickards, L., Fünfgeld, H., & Keenan, R. J. (2015). Toward reflexive climate adaptation research. *Current Opinion in Environmental Sustainability*, *14*, 127–135. https://doi.org/10.1016/j.cosust.2015.05.002

Ramírez-Lovering, D., Prescott, M. F., Josey, B., Mesgar, M., Spasojevic, D., & Wolff, E. (2020). Operationalising research: Embedded PhDs in transdisciplinary, action research projects. In R. Barnacle & D. Cuthbert (Eds.), *The PhD at the end of the world: Provocations for the doctorate and a future contested* (pp. 45–64). Springer.

Ramírez-Lovering, D., Prescott, M. F., & Kamalipour, H. (2018, September 27-28). *RISE: A case study for design research* in informal settlement revitalisation [Paper presentation]. Annual Design Research Conference, Sydney, Australia.

Renn, O. (1992). Concepts of risk: A classification. In S. Krimsky & D. Golding (Eds.), *Social theories of risk* (pp. 53–79). Praeger.

Revi, A., Satterthwaite, D. E., Aragón-Durand, F., Corfee-Morlot, J., Kiunsi, R., Pelling, M., Roberts, D., & Solecki, W. (2014). Urban areas. In C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea, & L. L. White (Eds.), *Climate change 2014: Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. Contribution of Working Group II to the fifth assessment report of the Intergovernmental Panel on Climate Change* (pp. 535–612). Cambridge University Press and IPCC. https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap8_FINAL.pdf

Rocco, R., & van Ballegooijen, J. (2018). The political meaning of informal urbanization. In R. Rocco & J. van Ballegooijen (Eds.), *The Routledge handbook on informal urbanization* (pp. 1–10). Routledge. https://doi.org/10.4324/9781315645544

Roy, A. (2005). Urban informality: Toward an epistemology of planning. *Journal of the American Planning Association*, *71*(2), 147–158. https://doi.org/10.1080/01944360508976689

Sandoval, V., & Sarmiento, J. P. (2020). A neglected issue: Informal settlements, urban development, and disaster risk reduction in Latin America and the Caribbean. *Disaster Prevention and Management: An International Journal*, *29*(5), 731–745. https://doi.org/10.1108/DPM-04-2020-0115

See, L. (2019). A review of citizen science and crowdsourcing in applications of pluvial flooding. *Frontiers in Earth Science*, *7*, Article 44. https://doi.org/10.3389/feart.2019.00044

Shaw, R. (2014). Disaster risk reduction and community approaches. In R. Shaw (Ed.), *Community practices for disaster risk reduction in Japan* (pp. 3–20). Springer. https://doi.org/10.1007/978-4-431-54246-9_1

Shaw, R. (2016). Community-based disaster risk reduction. In R. Shaw (Ed.), *Oxford research encyclopedia of natural hazard science* (pp. 1-21). Oxford University Press. https://doi.org/10.1093/acrefore/9780199389407.013.47

Simons, H. (2009). *Case study research in practice*. SAGE.

Smith, B., & Rodriguez, S. (2017). Spatial analysis of high-resolution radar rainfall and citizen-reported flash flood data in ultra-urban New York City. *Water*, *9*(10), Article 736. https://doi.org/10.3390/w9100736

Starkey, E., Parkin, G., Birkinshaw, S., Large, A., Quinn, P., & Gibson, C. (2017). Demonstrating the value of community-based ('citizen science') observations for catchment modelling and characterisation. *Journal of Hydrology*, *548*, 801–817. https://doi.org/10.1016/j.jhydrol.2017.03.019

Sy, B., Frischknecht, C., Dao, H., Consuegra, D., & Giuliani, G. (2020). Reconstituting past flood events: The contribution of citizen science. *Hydrology and Earth System Sciences*, *24*(1), 61–74. https://hess.copernicus.org/articles/24/61/2020

Townsend, A. (2015). Cities of data: Examining the new urban science. *Public Culture*, *27*(2), 201–212. https://doi.org/10.1215/08992363-2841808

UN. (2015). *Transforming our world: The 2030 agenda for sustainable development* (A/RES/70/1). https://sdgs.un.org/sites/default/files/publications/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf

UN-Habitat. (2003). *The challenge of slums: Global report on human settlements, 2003*. Earthscan Publications.

UN-Habitat. (2015). *Habitat III issue papers: 22 — Informal settlements*. https://unhabitat.org/habitat-iii-issue-papers-22-informal-settlements

UN-Habitat. (2017). *New urban agenda* (A/RED/71/256).

UN International Strategy for Disaster Reduction. (2015). *Sendai framework for disaster risk reduction 2015–2030*.

UN Office for Disaster Risk Reduction, & Centre for Research on the Epidemiology of Disasters. (2020). *The human cost of disasters: An overview of the last 20 years (2000–2019)*. https://www.undrr.org/publication/human-cost-disasters-overview-last-20-years-2000-2019?fbclid=IwAR3T2Pln4ra46zQMRD09qARzGLWU5oMF9UQlUMuQucA26mQydWJBRTzSLcE

Voinov, A., & Gaddis, E. J. B. (2008). Lessons for successful participatory watershed modeling: A perspective from modeling practitioners. *Ecological Modelling*, *216*(2), 197–207. https://doi.org/10.1016/j.ecolmodel.2008.03.010

Wisner, B., O'Keefe, P., & Westgate, K. (1977). Global systems and local disasters: The untapped power of people's science. *Disasters*, *1*(1), 47–57. https://doi.org/10.1111/j.1467-7717.1977.tb00008.x

Wolff, E. (2021). The promise of a "people-centred" approach to floods: Types of participation in the global literature of citizen science and community-based flood risk reduction in the context of the Sendai Framework. *Progress in Disaster Science*, *10*, Article 100171. https://doi.org/10.1016/j.pdisas.2021.100171

Wolff, E., & Muñoz, F. (2021). The techno-politics of crowdsourced disaster data in the smart city. *Frontiers in Sustainable Cities*, *3*, Article 695329. https://doi.org/10.3389/frsc.2021.695329

Yarina, L. (2018). Your sea wall won't save you: Negotiating rhetorics and imaginaries of climate resilience. *Places Journal*. https://doi.org/10.22269/180327

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Article

Identifying the Social Urban Spatial Structure of Vulnerability: Towards Climate Change Equity in Bogotá

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Abstract
The constant modification of land use, economic instability, environmental factors, and social behaviour changes among the inhabitants of big cities characterize current urbanism. In Colombia, land-use planning processes supported by geographical information systems are a recent phenomenon and the legal instruments of spatial planning are inadequate in most municipalities. Moreover, socio-spatial equity represents a challenge for Latin American cities in which there is increasing awareness of the role that spatial planning plays. Consequently, the question arises as to how the urban spatial structure and organization contribute to an inclusive and equitable socio-spatial evolution, considering climate change impacts. The case study analysed in this article focuses upon the northern limits of the city of Bogotá. Therefore, this research aims to define the ideal balance of urban land-use distribution between social stratum classification and the vulnerability of the communities seeking to better adapt to climate change. We propose a methodological approach of analysing spatial syntax and the (social) intensity of activities and infrastructure, which enables us to characterize the urban structure itself and identify vulnerable urban instances. As a result, we find that the urban network with low values presents spatial unpredictability in its pattern, constraining equitable development based on the urban morphology of the city. This research allows us to conclude that the degree of vulnerability encountered by the social urban spatial structure is higher in expansion areas than in central areas of the city.

Keywords
Bogotá; climate change; social space; spatial vulnerability; urban morphology; urban structure

Issue
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1. Introduction

Urban metropolises and peripheral areas have experienced pressures and changes in land-use, infrastructure, and loss of agricultural land (Shen et al., 2019), continuing prioritization of short-term growth as opposed to alternative approaches to sustainable urban growth to compact forms (Ahern, 1995; Menzori et al., 2021), or through strategic spatial planning (Hersperger et al., 2018). These peripheral areas of urban sprawl have witnessed the greatest transformation dynamics (Aguilar, 2008; Guo et al., 2020). The peripheral cities (in the context of metropolises, neighbouring communities) usually have a propensity for lower economic cost of land-use, regardless of their future urban functions. These characteristics can be related to elements that support the

spatial build-up of urban space, namely accessibility and connectivity through the mobility axes that make up the urban network (Jayasinghe et al., 2019). Furthermore, the urban structure, defined as the urban morphology that seeks to identify how the city is organized and its alterations, acquires an important role (Benita & Piliouras, 2020; Ouyang et al., 2021).

The growth of the world's urban population has increased the effects of climate change due to high urbanization and agglomeration. Consequently, urban centres suffer long-term and far-reaching effects, not only on their immediate boundaries, but also on the entire region in which they are located (While & Whitehead, 2013). Depending upon the socio-spatial structure of cities, the effects of physical processes (urbanization, urban planning, infrastructure provision, or transport), and of human processes (lifestyle choices and consumption patterns) lead to vulnerability (Otto et al., 2017). Communities will always face natural hazards, but today's disasters are generated by human activities, poor land-use planning, lack of environmental management, and regulatory mechanisms that increase risk and exacerbate impacts (Birkmann et al., 2010). Moreover, urban planning is relevant as an instrument of urban development in its various dimensions, therefore municipalities need to draw up municipal land-use plans which are as equitable as possible. An understanding of urban morphology facilitates the projection of future growth on a municipal scale (Ariza-Villaverde et al., 2013). The urban informality partially characterizes the evolution of spatial structures in Latin America, such as in the case of natural hazards, that is, accidents that render some populations and zones of cities subject to greater human vulnerability (Gonzales & Magnaye, 2017; Unceta et al., 2020).

Thus, this manuscript tackles the theme of urban vulnerability according to a new spatial dimension, that is, through urban morphology and street network, against the background of climate change. It is desirable that this element could be introduced into the municipal urban planning discourse in future because the climate emergency and its impacts are real (Yan et al., 2021). Basu and Das (2021) highlight the need to integrate the environment into urban planning. Are public policymakers involved in urban planning allocating areas or land uses appropriately and equitably? Considering the reality of climate change and its direct impact on populations, how is urban planning affected?

1.1. Review Literature

Social vulnerability and equity in the context of climate change are important because some populations may have less capacity to prepare for, respond to, and recover from climate-related hazards and impacts. These peripheral populations may be disproportionately affected by climate change (Gencer, 2013). The Intergovernmental Panel on Climate Change (2007, p. 6) describes vulnerability as "the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate change, including variability and extremes." Areas of urban expansion are territorial units that serve urban management and are based on a plot structure. They are also urban zones that allow for urban development with socio-economic functionality (Dadashpoor & Ahani, 2021; Weldearegay et al., 2021).

In the case study of the municipality of Chía, peripheral to the capital of Colombia, Bogotá, these areas of expansion are located along or close to two existing rivers, among other characteristics of the city. These expansion areas are defined in Bogotá's municipal planning legal instrument, called the Plan de Ordenamiento Territorial (POT). These expansion areas are in urban zones with a high incidence of poverty as measured by the Multidimensional Poverty Index of the Colombian statistics office (National Administrative Department of Statistics of Colombia [DANE], 2021a). This urban context, faced with social and spatial dimensions and overlapping spatial attributes, identifies a potential risk to urban development. Moreover, sustainable and equitable development is sought with a focus on urban resilience (Du et al., 2020). There is a high risk of spatial vulnerability, according to the urban structure that defines the city, and which features the growth of its urban area. A real urban problem of considerable scale arises when in the future a major natural incident occurs in the context of climate change, which is framed by the constant urban changes that cities have experienced (Hill, 2016). Moreover, urban road mobility is a major driver of urban growth, so that the importance of better identifying the characteristics of the road structure is even more relevant to urban planning.

In a more critical vein, there are numerous studies on urban sprawl (Jaeger et al., 2010). Alfasi et al. (2012) evaluate the current performance of municipal land-use plans, whereas Inostroza et al. (2013) and Madlener and Sunak (2011) monitor growth patterns, effects of urbanization, and identify spatial metrics to characterize urban development without integrating urban mobility infrastructure. Several attempts have been made to contextualize the relationship between urban vulnerability and climate change. However, several approaches complement each other. Most of these relate to the environment, natural hazards, political economy, and ecological resilience (Bulkeley & Tuts, 2013). Environmental studies conceive urban vulnerability as the result of, or exposure to, climate hazards affecting the population, infrastructure, and urban activities in general (Eakin & Luers, 2006; Romero Lankao & Qin, 2011). Finally, studies focusing upon urban resilience seek to identify short or long-term coping mechanisms to deal with these effects (Zhang et al., 2020). These vulnerability challenges highlight the need for cities to rethink how people are protected, how infrastructure investments are prioritized, and how to include climate in cities' long-term growth and development plans (Rani et al., 2020).

More recent studies analyse urban expansion and population growth, patterns of land-use-land-cover changes, or the impacts spatial growth generates in relation to socio-spatial vulnerability (Barros et al., 2018; de Espindola et al., 2017; Matsa et al., 2021; Padeiro, 2016). However, these studies do not introduce urban mobility as a configuring element of the urban space. Similar results occur when authors develop a system of indicators to evaluate the level of integration of urbanization (Gan et al., 2020). Conversely, studies regarding node-place analysis as a tool to define the characteristics of transport nodes in terms of transport quality and intensity and diversity of land-use of the surrounding areas are widely developed (Jayasinghe et al., 2019; X. Liu et al., 2021; Nigro et al., 2019). Urban vulnerability is currently addressed from the perspective of ecosystem assessment or urban conversion zones to improve the management of specific areas such as coastal regions (Bianco & García-Ayllón, 2021; Ghosh & Das, 2019; Li et al., 2016), without an analysis of the urban morphology in relation to the mobility network, such as infrastructure axes and urban development. These studies essentially focus upon the environment and do not contain the in-depth socio-spatial dimension as an analytical component.

Furthermore, climate change studies correlated with urban planning have been intensively developed in recent years, from urban climate change adaptation and mitigation measures (Santos et al., 2021; Sharifi, 2021) to evaluations of the impacts of urban growth and urbanization processes (Ahmed et al., 2020; Lee & Kim, 2021; Salimi & Al-Ghamdi, 2020), climate governance (Giordano et al., 2020; M. Liu & Lo, 2021), assessments of climate change risk at an urban scale (Ye et al., 2021), and public health (de Oliveira Lemos et al., 2021).

Nevertheless, these studies highlight the common shortcoming of not integrating spatial vulnerability and urban morphology, as they do not enable a global understanding of the social behaviour of cities and how urban expansion areas can contribute to the mitigation of urban vulnerability. Thus, one of the challenges of the research is to spatialize the interrelation of these aspects, namely urban expansion areas, spatial vulnerability, and street network to support the perception of urban vulnerability by land-use planners against the background of climate change. This study focuses upon the following research questions: Considering climate change impacts, how does urban spatial structure and organization contribute to an inclusive and equitable socio-spatial evolution? Does the understanding of the articulation of these urban factors and vulnerability play an essential role in achieving an urban planning that allows for social equity?

The present study seeks to formulate a new approach to the spatial analysis of the urban form (urban morphology) by integrating climate change into the analytical framework. The possibility of implementing the practice and insertion of climate change in the legal instruments of municipal planning, in this case the POT, as an exercise of the urban planning field is found to be an advantage. Against this background, space syntax, which observes the social logic of space in cities through natural movement theory and behaviour, appears to be an appropriate method (Hillier & Hanson, 1989; Penn, 2003; Yamu et al., 2021). Space syntax also relates to street network through the analysis of a specific set of parameters explored further below. This article proposes a new approach that makes two contributions: (a) to mitigate the degree of socio-spatial vulnerability of the citizens, and (b) to redirect new strategies of definition, delimitation, and location of the city's expansion areas in the context of urban informality. It is necessary to understand and evaluate the location of urban expansion areas to realize new possibilities of ensuring urban development without exacerbating the citizens' degree of vulnerability. In the current context of urban resilience, it is desirable that the level of vulnerability is still considered reversible. Against this background, the main objective of this article is to define the ideal balance of urban sprawl distribution between social stratum classification and the troubled prospect of communities obtaining better adaptation to climate change, and thus to determine social urban spatial structure vulnerability. The article is organized as follows: Section 2 describes the study area and the social-spatial units considered in the research. The results and discussions are presented in Section 3, followed by Section 4 summarizing the key findings as main conclusions.

2. Methodology

2.1. Study Area

Colombia has the following instruments to manage climate change at municipal, departmental, and national level: the nationally determined contributions, the national climate change policy, integrated sectoral and territorial climate change management plans, the development plans of territorial entities and land-use plans and national communications, national greenhouse gas inventories, biennial update reports, and others reports. This article studies the urban area of the municipality of Chía (Figure 1). The case study is located between the northern limit of the city of Bogotá and the municipalities of Chía and Cota that are part of the Sabana Centro region. This area is characterized by a municipal border location and spatial pressure due to its proximity to the metropolis (Jimenez Aguilar & Thoene, 2021). Due to this spatial context, this case study allows for a comparison with other metropolitan cities, their interrelationships, and spatial dynamics. Chía is a municipality in the metropolitan area of Bogotá and is located on the northern edge of the city. It is part of the department of Cundinamarca and represents 1.2% of the Colombia's production and 0.97% of the national population (Cámara de Comercio de Bogotá, 2015). It is also part of the Sabana Centro province, with 10 municipalities

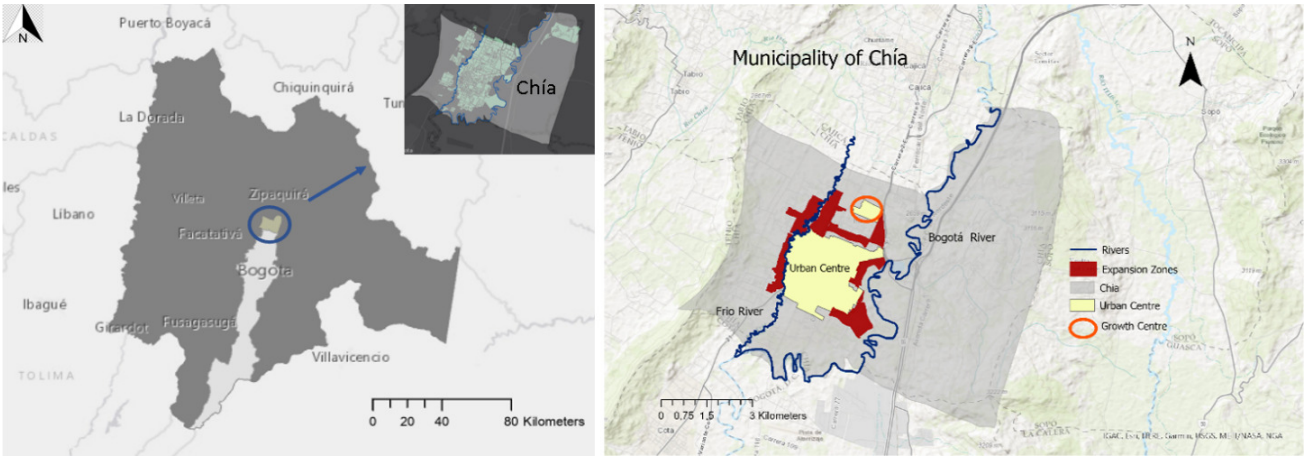

Figure 1. Location of the municipality of Chía (left) and the map of the city (right).

located in the area bordering the north of Bogotá. Chía has experienced an important population evolution in recent years due to large real estate developments and an increase in economic activity, which have caused territorial changes and impacted its urban growth. The city's development model is based on the fact that it is considered a peripheral municipality. It seeks to focus its development mainly on the occupation of land use with a residential function to attract more population from the metropolis. The expansion areas and their allocated uses are mostly for residential construction. It has a population of 105,509 inhabitants in the urban area and 26,672 inhabitants in the populated centres according to the 2018 census of the DANE and an area of 7,900 ha, of which 630.17 ha (7.83%) are urban land; 299.84 ha (3.73%) are urban expansion land, and 7,114.90 ha (88.44%) are rural land according to the 2016 land-use plan (Consejo Municipal de Chía, 2016). One of the most important effects of climate change in the municipality of Chía is related to flooding. The urban area of the municipality and two expansion zones are located between the Frío and Bogotá rivers. Changes in land use, as well as dispersed real estate growth and economic activities developed in buffer zones of the river, are one of the main causes of vulnerability and flood risks in the municipality. Particularly, the floods of 2010 and 2011 showed the importance of assessing the vulnerability of the inhabitants located near the rivers (Duran Giraldo & Suárez Jaraba, 2013).

The new metropolitan processes of urban sprawl or conurbation, for example, have resulted in the movement of middle- and high-income population from the city of Bogotá to the municipalities in its immediate urban surroundings in search of a better quality of life. This has generated changes in the territory, in the transformation of residential areas, and in the way of life of local inhabitants. Particularly in Chía, there are processes of residential segregation, especially in the sectors where urbanization is isolated from the traditional centre, or in the areas of around the Frío and Bogotá rivers (Osorio Ardila, 2012). This process presents an important challenge in terms of habitat, economic development, and environmental sustainability, and implies the modification of territorial and urban planning processes in the short, medium, and long term (Contreras Ortíz, 2017). The area occupied by the territory and population of Chía is affected by the strong functional relationship with Bogotá, intensifying its daily mobility flows either for work or study and generating urban relations of a metropolitan nature. Migration to Chía has led to a dispersed socio-spatial phenomenon, especially in rural areas, and an imbalance in the development of the services and facilities needed to serve residential use as there is no structural articulation (Cámara de Comercio de Bogotá & Alcaldía de Bogotá, 2015).

2.2. Conceptual Approach to Social Urban Spatial Structure Vulnerability

A framework is required to obtain a conceptual understanding of social urban spatial structure vulnerability (Figure 2). The conceptual proposal addresses urban planning that responds to the emerging needs of climate change adaptation. Thus, the social sphere is considered as the main vector of integration. Hence, we spatialized the various social data with the urban morphology by means of geographic information systems and space syntax. The vulnerability of the socio-spatial structure is projected as follows. On the social side, three sub-themes have been defined which are associated with quantitative data. However, the sub-themes include the socio-qualitative dimension. Thus, the data relationship is: urban communities have population density data; urban vulnerability factors integrate Multidimensional Poverty Index data, the demographic vulnerability index, and vulnerability by age group; and social distribution integrates social stratum type data. On the spatial structure side, a single quantitative data type is presented. The data relationship can be expressed as follows: The area of urban expansion includes the data of the city. Therefore, the socio-spatial structure intersects with the urban morphology to allow an integrated

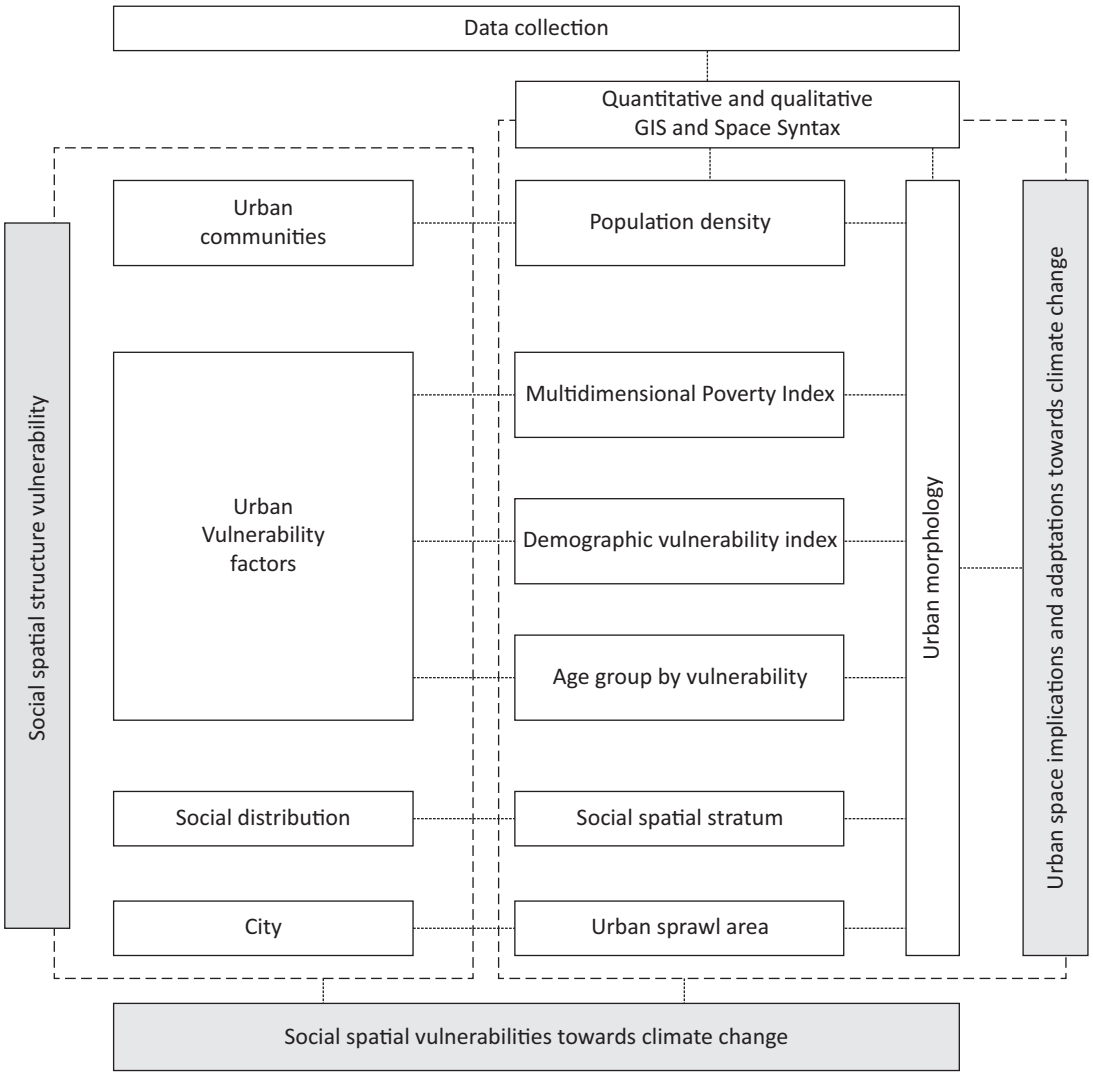

Figure 2. Conceptual framework of social urban spatial structure vulnerability.

reading of the socio-spatial characteristics of the urban space. The development of this conceptual approach rests on two aspects of the data typology that enables us on the one hand to locate and spatialize the social vulnerabilities to climate change, and on the other to seek to understand the implications of, and necessary adaptations in, the expansion areas against the background of climate change.

2.3. Social and Urban Data

2.3.1. Social Dimension

In this research, a diagnosis of the municipality of Chía has been carried out at the cadastral block level using official information from the 2018 population census (DANE) to show how the territory of the municipality behaves with respect to social vulnerability. Vulnerability has different meanings that are approached using different theories and epistemologies either in a general way or in its different modalities (natural, demographic, social, socio-demographic, or others). Vulnerability encompasses three different dimensions: risks (events), inability to respond to such risks, and the inability to adapt to the new situation generated by such risks (Rodríguez Domenech, 2016). In this article we seek to emphasize some social aspects of vulnerability related to demography, which are encapsulated in the Multidimensional Poverty Index. To give a socio-economic focus to the analysis, socio-economic strata are included. The following briefly explains how these indices are defined and what the social strata mean in the context of Colombia.

2.3.1.1. Multidimensional Poverty Index

This indicator is used by the Colombian government to assess poverty. It has five dimensions and involves 15 variables: educational conditions; children and youth conditions; work; health; and housing conditions and public services. According to the 2018 census, as a department Cundinamarca has the second lowest

Multidimensional Poverty Index value in the country (DANE, 2021a). At the municipal level, Chía has a Multidimensional Poverty Index of 4.7%, which places it among the municipalities with the lowest poverty rate in the country (a municipality is considered to have a high multidimensional poverty rate if the index has a value greater than or equal to 33%). This index is used in this research to show the areas of the municipality that require greater attention in urban planning processes due to the vulnerability of inhabitants in different dimensions (DANE, 2021b; Department of National Planning, 2017).

2.3.1.2. Demographic Vulnerability Index

The impact of natural hazards is not the same for all people and not all people have the same capacity to adapt; thus, it is necessary to anticipate these events (Brie, 2019). This leads us to define social vulnerability as the set of characteristics that help communities to adapt and become resilient, which includes demographic vulnerability considering demographic characteristics and population dynamics according to age distribution (Hogan & Marandola, 2005). Other elements can be considered, but in this research the socio-demographic vulnerability index identifies the density of population over 60 years old living in the municipality that harbours risks associated with ageing and monetary poverty that need to be included within planning policies.

2.3.1.3. Socio-Economic Stratification in Colombia

Socio-economic stratification in Colombia is an approximate representation of the income level of citizens and is meant to provide a degree of equity in the system of residential public utilities that inhabitants pay. In other words, socio-economic stratification facilitates the differentiated charging of residential public services, obliging families with greater economic capacity to subsidize those with fewer resources (DANE, 2021a; Guevara & Shields, 2019). We subsequently studied urban elements according to the hotspot technique (N. Liu & Morawska, 2020; Qi et al., 2020), a frame with a set of spatial variables referring to space syntax. These variables are explained in detail below.

2.3.2. Urban Morphology

We propose a methodology of spatial syntax and an analysis of the (social) intensity of activities and infrastructure usage, which enables characterization of the urban structure itself and at the same time identify vulnerable urban zones. Space syntax sprang from the observation that space is the common ground of physical and social cities. In syntactical terms, spatial configuration means relations between spaces which consider other relations, hence in effect relations between all the various spaces of a system (Remali et al., 2015). Axial analysis is one of the fundamental components of space syntax. Proponents of space syntax suggest that it picks up the qualities of configurational relationships between spaces not illuminated by other representations (Turner, 2007). As a first step, an axial map is built over all the urban accessibility routes in the area under study, in this case Chía's urban area (Figure 3).

Figure 3. Support for and institutionalization of direct democracy. Source: Geissel (2016).

Space syntax analysis reveals knowledge of the connectivity, choice, control, entropy, and integration parameters required to understand the global structure of the urban network (R Core Team, 2021). One of the strengths of space syntax is its parsimony as it only considers the geometry of the street pattern without any other contents (land-use, aesthetics, transport, etc.), allowing for fast, cheap, and objective analysis (D'Acci, 2019). Attending to the special context of the city under scrutiny, these were the parameters considered most appropriate if we were to formulate questions on the area of expansion and the vulnerability of the urban structure. Subsequently, the concepts of the space syntax parameters under analysis are explained. Connectivity is defined in space syntax theory as the number of nodes that connect directly to a given node in the dual graph *G*. Space syntax considers the accessibility of a space as a key determinant of its spatial interaction and its analysis is based on an implicit graph-theoretic view of the dual graph. In graph theory, the space syntax connectivity (Equation 1) of a node is called the 'node degree':

$$\text{Connectivity}\,(i) = \deg(i) = \sum_{j=1}^{N} \left(\mathbf{A}_{\mathfrak{G}}\right)_{ij} \qquad (1)$$

The calculation behind choice (or between-ness) *C*, of an axial line i is derived by the following equation (Equation 2), where $g_{jk}(i)$ is the number of shortest paths between lines *j* and *k* containing *i*, and g_{jk} is the number of all shortest paths between *j* and *k* as:

$$\text{Choice } C_i = \sum_j \sum_k \frac{g_{jk}(i)}{g_{jk}(j < k)} \quad (2)$$

Control value (*CV*) is another local measure used in space syntax theory. It evaluates the degree to which a space controls access to its immediate neighbours considering the number of alternative connections that each of these neighbours has. The *CV* is determined according to the following equation (Equation 3), where the diagonal matrix is D = diag (deg(1), deg(2), . . . , deg(N)):

$$CV(i) = \sum_{i \sim j} \frac{1}{\deg(j)} = \sum_{j=1}^{N} \left(\mathbf{A}_{\mathfrak{G}}\, \mathbf{D}^{-1}\right)_{ij} \quad (3)$$

The estimation of entropy for spatial systems is based on the frequency distribution of the point depths (Turner, 2007). The point depth entropy of a location, *si*, is expressed by utilizing Shannon's formula of uncertainty as shown in Equation 4, where *dmax* is the maximum depth from [vertex] *vi* and *Pd* is the frequency of point depth *d* from the [vertex]:

$$si \sum_{d=1}^{dmax} -Pd \log 2Pd \quad (4)$$

The integration (I) of an axial line i is a function of its depth related to all the other axial lines (how many steps are distant from all others). The latter (Equation 5) is calculated by assigning a depth value to each space according to how many spaces it is away from the original space, summing these values and dividing by the number of spaces in the system less one, where n is the number of axial lines in the urban street area considered, d_{ij} is the shortest distance (least number of steps) between two axial lines i and j (D'Acci, 2019):

$$\text{Integration } I_i = \frac{2\left(n\left(\log_2\left(\frac{n+2}{3}\right) - 1\right) + 1\right)/(n-1)(n-2)}{2\left(\left(\frac{\sum_{j=1}^{n} d_{ij}}{n-1}\right) - 1\right)/(n-2)} \quad (5)$$

At the end of the calculation of the axial measures explained above, the accessibility value is determined by calculating the correlation between the choice measures and overall integration (Dou & Zhan, 2011; Morales et al., 2019). This calculation is relevant since it enables identification of the degree or accessibility value of an urban system, thus furnishing an understanding of spatial organization as urban mobility.

3. Results and Discussion

Most of the population of Chía occupies the urban area, although the villages of the western zone such as Fagua, Tíquiza, and Fonquetá, and the villages of the central zone such as Bojacá and Samaria, have sectors of high population density (Figure 4a). These population density areas are very close to the expansion zones defined in the POT of 2016. Each of these instances of growth has particular characteristics. In the western area there are still several agricultural and vacant land plots and natural environment, whereas the urbanized area is located on the river Frío. The population density of the central zone corresponds to a process of urban consolidation. In this sector there are also flower farms on both banks of the river and other plots are used for rural housing. To analyse the levels of multidimensional poverty (Figure 4b), an incremental spatial autocorrelation analysis was used, which shows that the sectors located in the northern part of the municipality in the villages of Fagua and Tíquiza between the river Frío and the Fagua–Cajicá road and the sector located in the village of Bojacá that borders the river Frío and Samaria village are those that present a concentration of people with the highest Multidimensional Poverty Index. On the other hand, it is observed that the urban centre is the least vulnerable. Similar to the previous autocorrelation analysis, in this research the demographic vulnerability corresponds to people over 60 years old. The results show that the traditional urban sector is the one that presents a positive concentration of people over 60, which indicates that this zone is vulnerable at a demographic level, like the Yerbabuena district. The sectors of Fagua, Tíquiza, and Bojacá are not vulnerable.

Social vulnerability (Figure 4d) in this research refers to a combination of demographic variables, comorbidities of the population, and population density. Social vulnerability is analysed at the block level and classified into five levels of vulnerability: low, medium-low, medium, medium-high, and high. The highest levels of vulnerability in the municipality of Chía are located in the urban centre and especially in some sectors of the different hamlets. Finally, in terms of stratification (Figure 4e), in the Western zone, specifically in the villages of Piedra and Fonquetá, there is a higher percentage of strata 1 and 2, which are the lowest strata. The villages of Bojacá, Yerbabuena, and La Balsa have the highest percentage of strata 5 and 6. In the traditional urban area, approximately 0.8% of the properties are classified as stratum 1, with a predominance of strata 2 and 3. Analyses were conducted at the census block level; the data used for the social vulnerability analysis are up to date as of June 2021. The Multidimensional Poverty Index and demographic vulnerability analysis was conducted using data from the 2018 census (DANE, 2021a). The social strata were obtained from the cadastral base (DANE, 2021a).

Concerning the urban morphology data, different colours mark different values as the results (Figure 5). The Connectivity axis map (Figure 4a) shows spatial results that are considered limiting. For all maps, the results are represented in the legend by a colour scale corresponding to red (high values) and blue (low values). The central and least central axes of the urban area present higher values of connectivity, and the surrounding areas lower values, that is, with minimum values. They coincide with urban areas of expansion, that is, these are remote areas with difficult connections to

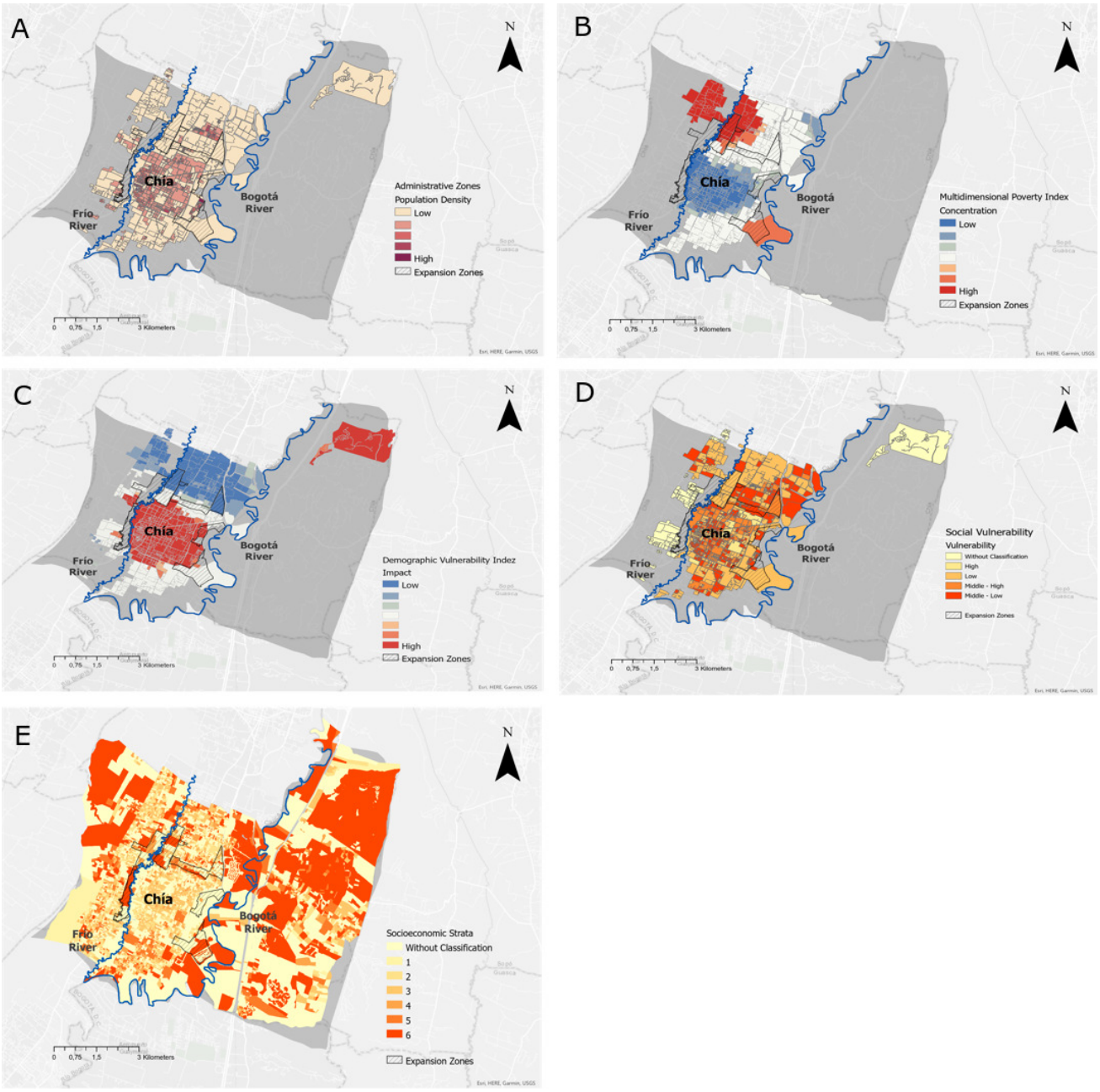

Figure 4. Social urban spatial structure vulnerability: (a) population density, (b) Multidimensional Poverty Index, (c) demographic vulnerability index, (d) social vulnerability, and (e) socioeconomic stratum.

the city. It is in these areas that the most vulnerable groups are located. Therefore, the results enable us to assess that the urban structure is somewhat ineffective with respect to the interconnecting road between the proposed expansion areas and the main road axis of the city located in the central zone. From the axial map referring to the Choice variable (Figure 4b), one of the results obtained is that a road located in the north-west, along the river Frío and across the expansion area, presents a medium-high value. This means a medium-high probability that this road will be chosen as a route, increasing the pressure of urban traffic on an area of the city which is environmentally sensitive owing to its proximity to the rivers Frío and Bogotá where a low social stratum is located. The central zone displays two parallel roads and a diagonal road with the highest values compared to the rest of the urban system. This suggests a concentration of urban mobility that is not efficient in terms of urban planning. Regarding the axial map Control (Figure 4c), the main result that can be identified is that most values are less than 1, that is, it is possible to identify a high number of axes in blue. The degree of choice among immediate neighbouring axes is low. This means that there are several possibilities of road interconnection at short range, which gives a certain diffusion of the urban network. This same diffusion coincides with the expansion

Figure 5. Axial maps of Chía's urban space with the spatial variables: (a) connectivity, (b) choice, (c) control, (d) entropy, and (e) integration global (HH).

areas and on the north-west side with the proximity of the river as a natural element. This context allows the identification of an urban risk zone as the spatial vulnerability. The axial Entropy map (Figure 4d) reveals a global result of low values, suggesting a reading of the city as spatial disorganization, or unorganized spatial pattern, considering that only one urban area having high values is located to the north-east. The rest of the city area displays opposite values. Moreover, the two expansion areas are located towards the west and north. From the result, we can observe that the urban network with low values presents spatial unpredictability in its pattern, constraining an equitable development based on the urban morphology of the city. The result for the variable Integration (Figure 4e) highlights the central area, that is, the old part of the city, and the diagonal axis with

higher integration values. The north-east area, where the river and one of the most socially vulnerable zones are located, displays low integration values in the global system of urban axes. This urban structure lacks homogeneity in its spatial pattern. These areas with low values are located alongside one of the largest expansion areas adjacent to the river, and as such are potential areas of risk in urban management.

In the connectivity mode variable (Table 1), the average value is 2.00, which means that the urban area has little effective connectivity in relation to the spatial pattern of urban axes that allow road accessibility. This is visible between the minimum value of 1.00 and the maximum value of 20.00. The coefficient of variation is greater than 50%, which indicates asymmetry in the structure of urban axes. Regarding choice, the coefficient of variance is high at 242.41. This value refers to the whole urban system and indicates that there are few roads that are apt to be elected as preferred road infrastructure. The overall integration values HH are low. The coefficient of variance is less than 50%, namely 25.37. Therefore, the result indicates integration based on structural urban axes that are not very attractive or accommodate urban mobility.

The data of the connectivity variable as a function of the control variable seem to increase proportionally (Figure 6). This means that there is a spatial structure of roads with connectivity values such as control, when compared to the global area. The variance values enable us to gauge a numerical approximation, thus equilibrium in these variables, when referring to the behaviour of connections between urban axes. As a function of integration, the entropy variable shows a negative correlation, that is, a spatial pattern of global integration of urban axes opposed to local integration in central and northern areas of Chía. As a function of connectivity, all variables concentrate their values. The figure shows that when relating the integration variables to connectivity the integration data is concentrated in the range 0 and 10.

The accessibility of the overall urban structure (Figure 7), calculated using the correlation between the variables choice and integration (HH), obtains the value of R = 0.024. This is a low value in the range 0 and 1. This result shows that urban accessibility presents difficulties owing to the few alternative routes that Chía possesses, which can predict a structure of urban axes that is not effective. This result can support urban planning decision-making for the specific issue of road mobility.

The discussion must be framed by the attempt to interpret the data of set variables analysed within the

Table 1. Descriptive statistic of connectivity, choice, control, entropy, and integration global HH.

Variable	Connectivity	Choice	Control	Entropy	Integration [HH]
Mean	2.46	59,660.71	1.00	5.14	0.42
Median	2.00	10,456.00	0.83	5.12	0.42
Mode	2.00	0.00	1.00	5.10	0.41
Standard deviation	1.65	144,621.50	0.83	0.13	0.11
Variance	2.73	20,915,378,716.50	0.68	0.02	0.01
Skewness	3.48	4.24	3.58	0.38	−0.24
Minimum	1.00	0.00	0.05	4.89	0.12
Maximum	20.00	1,273,556.00	10.67	5.45	0.65
Coeficient of variation (%)	67.13	242.41	82.60	2.56	25.37

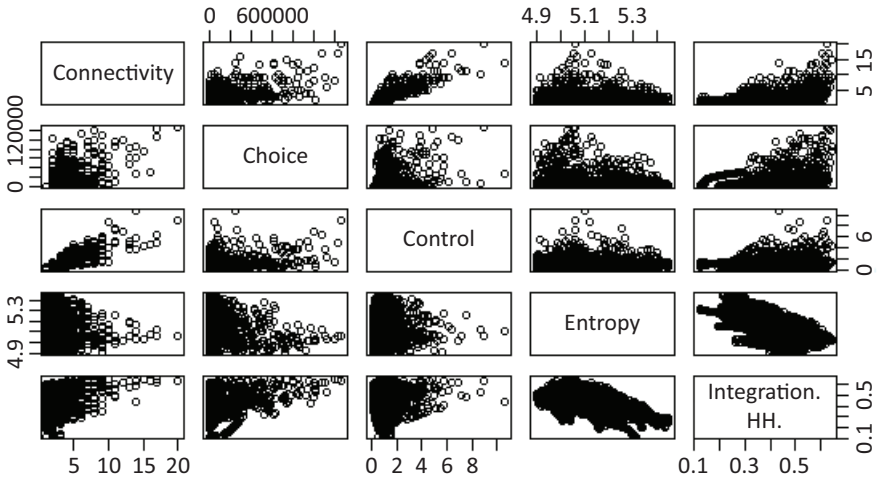

Figure 6. Plot descriptive statistic of urban space variables.

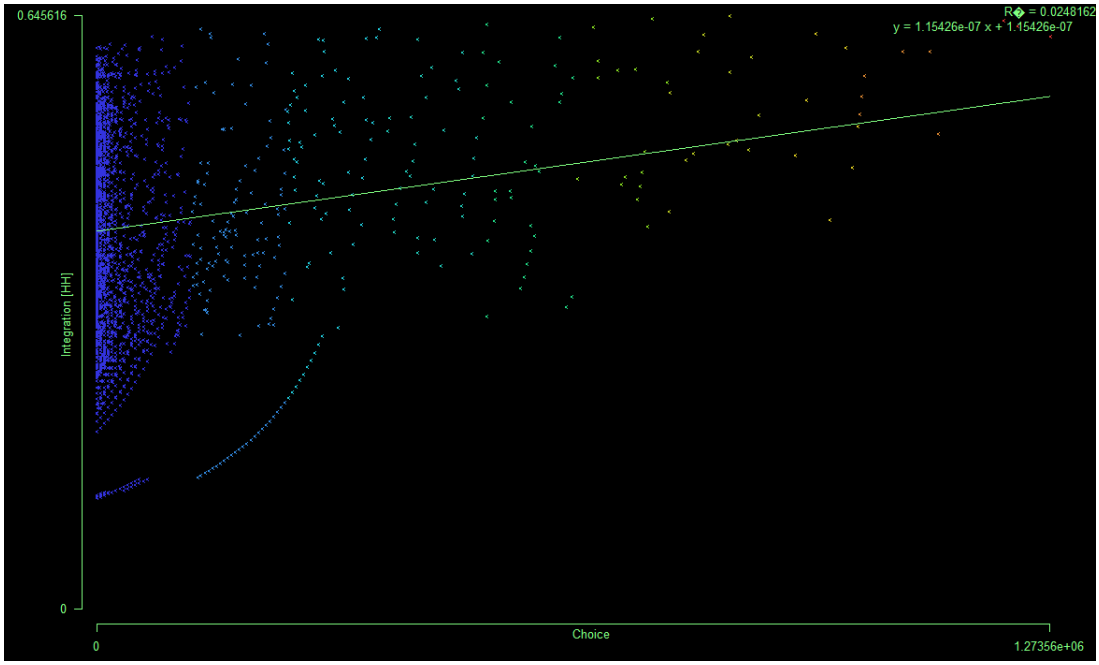

Figure 7. Accessibility: Correlation plot between choice and integration variables.

"urban form" itself. The results construed from the maps of these same variables seem to indicate that the spatial organization is composed by two different urban zones: central and peripheral. The urban areas of expansion are located in the latter. In this context, the results show higher or more positive values of the connectivity and choice variables in the central zone of the urban area than the remaining variables. The fact that the overall integration value is low in the peripheries where there is more urban land area allows us to construe that the value of the control variable is homogeneous in its overall urban space, revealing a symmetrical spatial pattern, while the connections between the roads, which also explain the result of the entropy map, display low values in almost the entire urban area. When matching this data with the social vulnerability map, in which the highest degree of vulnerability can be found in the proximity of the river Frío and the south-western part of the city, we can deduce the fragility to which some communities of citizens may be subjected in a future natural risk scenario, given the proximity to the river. According to the data obtained, both in terms of social structure and urban morphology, it is possible to discuss the degree of social urban spatial structure vulnerability, and to what extent the expansion areas correspond to zones at risk. The results indicate urban peripheries of greater vulnerability in accordance with the social stratum. Similar results can be obtained with the connectivity and Integration data. However, in the inverse case this correlation is lower. The results are inversely related, which may indicate that these expansion areas are not adequately located. The fact that there is a high value of Multidimensional Poverty Index in expansion zones and adjacent to the river Frío allows us to determine that this area is at high risk as far as its socio-spatial vulnerability is concerned. Thus, in the case of any natural climate change incident it will have a direct impact on populations residing in this urban area. Given the data of greater social vulnerability in areas close to the river Frío, this allows us to infer the importance of spatial organization in this case study. Given the results, there is a segregated spatial area near the expansion area of the river. This same space presents a greater social urban risk in the future occurrence of climatic intensity episodes and hence more risk in the face of climate change effects.

4. Conclusions

The main research objective was to determine the social urban spatial structure vulnerability in the municipality of Chía, one of the peripheral localities of the Bogotá metropolis. As the new conceptual approach was able to explore the intersection between the social dimension and urban morphology, it can support urban planning processes. Additionally, the conceptual approach proposed would help in the understanding of future impact and adaptation strategies to climate change. The spatial analysis shows the vulnerability of the municipality of Chía based on factors selected for each dimension. Spatial patterns with differentiated behaviours were established to guide decision-makers towards effective and efficient intervention in those sectors where vulnerability is significant.

Patterns of concentration, that is, highs and lows in all variables, were defined, which conform to statistical processes. At the local level, the highest incidence of factors having a direct impact on the Multidimensional Poverty Index is found in sectors in the northern part

of the municipality in the villages of Fagua, Tíquiza, and Bojacá, in the sector bordering the river Frío. Social and demographic vulnerability is located in certain sectors of the urban area and in some sectors of the hamlets in general.

From the results of the social sphere, it can be concluded that the current areas of urban expansion are in zones of low-level stratification. Therefore, these are areas of high social vulnerability owing to their proximity to the rivers Frío and Bogotá. Regarding the urban morphology dimension, it is possible to deduce a non-standard spatial pattern of contrast between the central and peripheral zones, so that it is possible to state that the existing expansion zones are not evidence of a dubious urban planning strategy because they are in urban areas which are not consolidated in their formal urban structure. From the values obtained in the connectivity and integration maps, it can be concluded that the municipality presents an urban area with a high degree of socio-spatial vulnerability considering the difference between the central and peripheral areas in, respectively, the extreme Northwest and Northeast.

The maps used in this research enable us to conclude that the social urban spatial structure vulnerability degree is higher in expansion areas than in central areas of the city, given that these areas are located adjacent to the river, constituting a high risk for vulnerable urban communities. In this way, a new approach to the location of future urban areas should be considered in the context of adaptation to climate change.

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Conflict of Interests

The authors declare no conflict of interests.

References

Aguilar, A. G. (2008). Peri-urbanization, illegal settlements and environmental impact in Mexico City. *Cities*, *25*(3), 133-145. https://doi.org/10.1016/j.cities.2008.02.003

Ahern, J. (1995). Greenways as a planning strategy. *Landscape and Urban Planning*, *33*(1/3), 131–155.

Ahmed, H. A., Singh, S. K., Kumar, M., Maina, M. S., Dzwairo, R., & Lal, D. (2020). Impact of urbanization and land cover change on urban climate: Case study of Nigeria. *Urban Climate*, *32*, Article 100600. https://doi.org/10.1016/j.uclim.2020.100600

Alfasi, N., Almagor, J., & Benenson, I. (2012). The actual impact of comprehensive land-use plans: Insights from high resolution observations. *Land Use Policy*, *29*(4), 862–877.

Ariza-Villaverde, A. B., Jiménez-Hornero, F. J., & Ravé, E. G. D. (2013). Multifractal analysis of axial maps applied to the study of urban morphology. *Computers, Environment and Urban Systems*, *38*, 1–10. https://doi.org/10.1016/j.compenvurbsys.2012.11.001

Barros, J. L., Tavares, A. O., Monteiro, M., & Santos, P. P. (2018). Peri-urbanization and rurbanization in Leiria city: The importance of a planning framework. *Sustainability*, *10*(7), Article 2501.

Basu, T., & Das, A. (2021). Systematic review of how eco-environmental transformation due to urbanization can be investigated in the sustainable development of Indian Cities. *Environmental Challenges*, *11*(22), Article 100099.

Benita, F., & Piliouras, G. (2020). Location, location, usage: How different notions of centrality can predict land usage in Singapore. *Physica A: Statistical Mechanics and Its Applications*, *540*, Article 123221. https://doi.org/10.1016/j.physa.2019.123221

Bianco, F., & García-Ayllón, S. (2021). Coastal resilience potential as an indicator of social and morphological vulnerability to beach management. *Estuarine, Coastal and Shelf Science*, *253*, Article 107290. https://doi.org/10.1016/j.ecss.2021.107290

Birkmann, J., Garschagen, M., Kraas, F., & Quang, N. (2010). Adaptive urban governance: New challenges for the second generation of urban adaptation strategies to climate change. *Sustainability Science*, *5*(2), 185–206. https://doi.org/10.1007/s11625-010-0111-3

Brie, M. (2019). Population aging. A demographic vulnerability for the societal security of the European Union. *Relaţii Internationale şi Studii Europene*, *11*, 167–179. https://www.ceeol.com/search/article-detail?id=838980

Bulkeley, H., & Tuts, R. (2013). Understanding urban vulnerability, adaptation and resilience in the context of climate change. *The International Journal of Justice and Sustainability*, *18*(6), 646–662. https://doi.org/10.1080/13549839.2013.788479

Cámara de Comercio de Bogotá. (2015). *Caracterización económica y empresarial de diecinueve municipios de Cundinamarca* [Economic and business characterization of nineteen municipalities of Cundinamarca]. https://bibliotecadigital.ccb.org.co/handle/11520/14584

Cámara de Comercio de Bogotá, & Alcaldía de Bogotá. (2015). *Somos un territorio metropolitano* [We are a metropolitan territory].

Consejo Municipal de Chía. (2016). *Acuerdo 100 de 2016 "Por medio del cual se adopta la revisión general y ajustes al plan de ordenamiento territorial—POT—del municipio de Chía, Cundinamarca, adoptado mediante acuerdo 17 de 2000"* [Agreement

100 of 2016 "Through which the general review and adjustments to the land use plan—POT—of the municipality of Chía, Cundinamarca, are adopted, by agreement 17 of 2000].

Contreras Ortíz, Y. (2017). *Estado de la vivienda y del espacio público en el municipio de Chía* [State of housing and public space in the municipality of Chía]. Universidad Nacional de Colombia, Instituto de Estudios Urbanos.

D'Acci, L. (2019). Orientational versus esthetical urban street morphology parameterization in space syntax. *Spatial Cognition & Computation*, 19(3), 172–189.

Dadashpoor, H., & Ahani, S. (2021). Explaining objective forces, driving forces, and causal mechanisms affecting the formation and expansion of the peri-urban areas: A critical realism approach. *Land Use Policy*, *102*, Article 105232. https://doi.org/10.1016/j.landusepol.2020.105232

de Espindola, G. M., da Costa Carneiro, E. L. N., & Façanha, A. C. (2017). Four decades of urban sprawl and population growth in Teresina, Brazil. *Applied Geography*, *79*, 73–83.

de Oliveira Lemos, L., Oscar Júnior, A. C., & de Assis Mendonça, F. (2021). Urban climate maps as a public health tool for urban planning: The case of dengue fever in Rio De Janeiro/Brazil. *Urban Climate*, 35, Article 100749. https://doi.org/10.1016/j.uclim.2020.100749

Department of National Planning. (2017). *Panorámica regional. Pobreza monetaria y multidimensional departamental: Necesidad de politicas públicas diferenciadas* [Monetary and multidimensional departmental poverty: The need for differentiated public policies]. https://colaboracion.dnp.gov.co/CDT/Desarrollo%20Territorial/Portal%20Territorial/KitSeguimiento/Pobreza/Publicaci%C3%B3n%20Ipm%20deptal.pdf

Dou, K., & Zhan, Q. (2011, June 24-26). *Accessibility analysis of urban emergency shelters: Comparing gravity model and space syntax* [Paper presentation]. 2011 International Conference on Remote Sensing, Environment and Transportation Engineering, Nanjing, China.

Du, M., Zhang, X., Wang, Y., Tao, L., & Li, H. (2020). An operationalizing model for measuring urban resilience on land expansion. *Habitat International*, *102*, Article 102206. https://doi.org/10.1016/j.habitatint.2020.102206

Duran Giraldo, C., & Suárez Jaraba, M. A. (2013). *Gestión ambiental de las zonas afectadas por inundaciones en el municipio de Chía* [Environmental management of the areas affected by floods in the municipality of Chía] [Master's thesis, Pontificia Universidad Javeriana]. https://repository.javeriana.edu.co/bitstream/handle/10554/13507/DuranGiraldoCarolina2013.pdf?sequence=1

Eakin, H., & Luers, A. (2006). Assessing the vulnerability of social environmental systems. *Annual Review of Environment and Resources*, *31*, 365–394. https://doi.org/10.1146/annurev.energy.30.050504.144352

Gan, L., Shi, H., Hu, Y., Lev, B., & Lan, H. (2020). Coupling coordination degree for urbanization city-industry integration level: Sichuan case. *Sustainable Cities and Society*, *58*, Article 102136.

Gencer, E. A. (2013). Natural disasters, urban vulnerability, and risk management: A theoretical overview. In E. A. Gencer (Ed.), *The interplay between urban development, vulnerability, and risk management: A case study of the Istanbul metropolitan area* (pp. 7–43). Springer. https://doi.org/10.1007/978-3-642-29470-9_2

Ghosh, S., & Das, A. (2019). Urban expansion induced vulnerability assessment of East Kolkata Wetland using fuzzy MCDM method. *Remote Sensing Applications: Society and Environment*, *13*, 191–203. https://doi.org/10.1016/j.rsase.2018.10.014

Giordano, R., Pilli-Sihvola, K., Pluchinotta, I., Matarrese, R., & Perrels, A. (2020). Urban adaptation to climate change: Climate services for supporting collaborative planning. *Climate Services*, *17*, Article 100100. https://doi.org/10.1016/j.cliser.2019.04.004

Gonzales, L. P., & Magnaye, D. C. (2017). Measuring the urban biodiversity of green spaces in a highly urbanizing environment and its implications for human settlement resiliency planning: The case of Manila City, Philippines. *Procedia Environmental Sciences*, *37*, 83–100.

Guevara, S. J. D., & Shields, R. (2019). Spatializing stratification: Bogotá. *Ardeth*, *2019*(4), 223–236. http://journals.openedition.org/ardeth/544

Guo, Z., Hu, Y., & Zheng, X. (2020). Evaluating the effectiveness of land use master plans in built-up land management: A case study of the Jinan municipality, eastern China. *Land Use Policy*, *91*, Article 104369.

Hersperger, A. M., Oliveira, E., Pagliarin, S., Palka, G., Verburg, P., Bolliger, J., & Grădinaru, S. (2018). Urban land-use change: The role of strategic spatial planning. *Global Environmental Change*, *51*, 32–42.

Hill, K. (2016). Climate change: Implications for the assumptions, goals and methods of urban environmental planning. *Urban Planning*, *1*(4), 103–113.

Hillier, B., & Hanson, J. (1989). *The social logic of space*. Cambridge University Press.

Hogan, D. J., & Marandola, E., Jr. (2005). Towards an interdisciplinary conceptualisation of vulnerability. *Population Space and Place*, *11*(6), 455–471. https://doi.org/10.1002/psp.401

Inostroza, L., Baur, R., & Csaplovics, E. (2013). Urban sprawl and fragmentation in Latin America: A dynamic quantification and characterization of spatial patterns. *Journal of Environmental Management*, *115*, 87–97.

Intergovernmental Panel on Climate Change. (2007). *Climate change 2007: Impacts, adaptation and vulnerability*. https://www.ipcc.ch/site/assets/uploads/

2018/03/ar4_wg2_full_report.pdf
Jaeger, J. A., Bertiller, R., Schwick, C., & Kienast, F. (2010). Suitability criteria for measures of urban sprawl. *Ecological Indicators*, *10*(2), 397–406.
Jayasinghe, A., Sano, K., Abenayake, C. C., & Mahanama, P. K. S. (2019). A novel approach to model traffic on road segments of large-scale urban road networks. *MethodsX*, *6*, 1147–1163. https://doi.org/10.1016/j.mex.2019.04.024
Jimenez Aguilar, C. M., & Thoene, U. (2021). Associativity in the Bogotá metropolitan region: Coordination challenges in a fragmented region. *Area Development and Policy*, *6*(4), 451–469. https://doi.org/10.1080/23792949.2020.1848441
Lee, S., & Kim, Y. (2021). A framework of biophilic urbanism for improving climate change adaptability in urban environments. *Urban Forestry & Urban Greening*, *61*, Article 127104. https://doi.org/10.1016/j.ufug.2021.127104
Li, Y., Zhang, X., Zhao, X., Ma, S., Cao, H., & Cao, J. (2016). Assessing spatial vulnerability from rapid urbanization to inform coastal urban regional planning. *Ocean & Coastal Management*, *123*, 53–65.
Liu, M., & Lo, K. (2021). Governing eco-cities in China: Urban climate experimentation, international cooperation, and multilevel governance. *Geoforum*, *121*, 12–22. https://doi.org/10.1016/j.geoforum.2021.02.017
Liu, N., & Morawska, L. (2020). Modeling the urban heat island mitigation effect of cool coatings in realistic urban morphology. *Journal of Cleaner Production*, *264*, Article 121560. https://doi.org/10.1016/j.jclepro.2020.121560
Liu, X., Wu, J., Huang, J., Zhang, J., Chen, B. Y., & Chen, A. (2021). Spatial-interaction network analysis of built environmental influence on daily public transport demand. *Journal of Transport Geography*, *92*, Article 102991. https://doi.org/10.1016/j.jtrangeo.2021.102991
Madlener, R., & Sunak, Y. (2011). Impacts of urbanization on urban structures and energy demand: What can we learn for urban energy planning and urbanization management? *Sustainable Cities and Society*, *1*(1), 45–53.
Matsa, M., Mupepi, O., & Musasa, T. (2021). Spatio-temporal analysis of urban area expansion in Zimbabwe between 1990 and 2020: The case of Gweru city. *Environmental Challenges*, *4*, Article 100141. https://doi.org/10.1016/j.envc.2021.100141
Menzori, I. D., Sousa, I. C. N. d., & Gonçalves, L. M. (2021). Urban growth management and territorial governance approaches: A master plans conformance analysis. *Land Use Policy*, *105*, Article 105436. https://doi.org/10.1016/j.landusepol.2021.105436
Morales, J., Flacke, J., Morales, J., & Zevenbergen, J. (2019). Mapping urban accessibility in data scarce contexts using space syntax and location-based methods. *Applied Spatial Analysis and Policy*, *12*(2), 205–228.
National Administrative Department of Statistics of Colombia. (2021a). *Estratificación socioeconómica: Preguntas frecuentes* [Socioeconomic stratification: Frequently asked questions]. https://www.dane.gov.co/index.php/116-espanol/informacion-georreferenciada/2421-estratificacion-socioeconomica-preguntas-frecuentes
National Administrative Department of Statistics of Colombia. (2021b). *Visor de vulnerabilidad* [Vulnerability viewer]. http://visor01.dane.gov.co/visor-vulnerabilidad
Nigro, A., Bertolini, L., & Moccia, F. D. (2019). Land use and public transport integration in small cities and towns: Assessment methodology and application. *Journal of Transport Geography*, *74*, 110–124. https://doi.org/10.1016/j.jtrangeo.2018.11.004
Osorio Ardila, G. (2012). Aspectos culturales de la segregación residencial. Barrios cerrados en el área rural de Chía [Cultural aspects of residential segregation. Closed neighborhoods in the rural area of Chía]. *Ciudad Paz-ando*, *5*(1), 49–64. https://revistas.udistrital.edu.co/index.php/cpaz/article/view/7275
Otto, I. M., Reckien, D., Reyer, C. P. O., Marcus, R., Le Masson, V., Jones, L., Norton, A., & Serdeczny, O. (2017). Social vulnerability to climate change: A review of concepts and evidence. *Regional Environmental Change*, *17*(6), 1651–1662. https://doi.org/10.1007/s10113-017-1105-9
Ouyang, X., Wei, X., Li, Y., Wang, X.-C., & Klemeš, J. J. (2021). Impacts of urban land morphology on PM2: 5 concentration in the urban agglomerations of China. *Journal of Environmental Management*, *283*, Article 112000.
Padeiro, M. (2016). Conformance in land-use planning: The determinants of decision, conversion and transgression. *Land Use Policy*, *55*, 285–299.
Penn, A. (2003). Space syntax and spatial cognition or why the axial line? *Environment and Behavior*, *35*(1), 30–65.
Qi, J., Ding, L., & Lim, S. (2020). Ontology-based knowledge representation of urban heat island mitigation strategies. *Sustainable Cities and Society*, *52*, Article 101875. https://doi.org/10.1016/j.scs.2019.101875
R Core Team. (2021). *The R project for statistical computing*. https://www.R-project.org
Rani, W., Kamarudin, K., Razak, K., & Asmawi, Z. (2020). Climate change adaptation and disaster risk reduction in urban development plans for resilient cities. *IOP Conference Series: Earth and Environmental Science*, *409*, Article 012024. https://doi.org/10.1088/1755-1315/409/1/012024
Remali, A. M., Porta, S., Romice, O., Abudib, H., & Vaughan, L. (2015). Street quality, street life, street centrality. In L. Vaughan (Ed.), *Suburban urbanities: Suburbs and the life of the high street* (pp. 104–129). UCL Press.
Rodríguez Domenech, M. A. (2016). Vulnerabilidad

demográfica en las regiones europeas NUTS-2. El caso de Castilla-La Mancha [Demographic vulnerability in the European regions NUTs-2. The case of Castilla-La Mancha]. *Papeles de Población*, *22*(89), 165–200. https://dialnet.unirioja.es/ejemplar/449373

Romero Lankao, P., & Qin, H. (2011). Conceptualizing urban vulnerability to global climate and environmental change. *Sustainability*, *3*(3), 142–149. https://doi.org/10.1016/j.cosust.2010.12.016

Salimi, M., & Al-Ghamdi, S. G. (2020). Climate change impacts on critical urban infrastructure and urban resiliency strategies for the Middle East. *Sustainable Cities and Society*, *54*, Article 101948. https://doi.org/10.1016/j.scs.2019.101948

Santos, M. M., Lanzinha, J. C. G., & Ferreira, A. V. (2021). Review on urbanism and climate change. *Cities*, *114*, Article 103176. https://doi.org/10.1016/j.cities.2021.103176

Sharifi, A. (2021). Co-benefits and synergies between urban climate change mitigation and adaptation measures: A literature review. *Science of the Total Environment*, *750*, Article 141642. https://doi.org/10.1016/j.scitotenv.2020.141642

Shen, X., Wang, X., Zhang, Z., Lu, Z., & Lv, T. (2019). Evaluating the effectiveness of land use plans in containing urban expansion: An integrated view. *Land Use Policy*, *80*, 205–213.

Turner, A. (2007). From axial to road-centre lines: A new representation for space syntax and a new model of route choice for transport network analysis. *Environment and Planning B: Planning and Design*, *34*(3), 539–555.

Unceta, P. M., Hausleitner, B., & Dąbrowski, M. (2020). Socio-spatial segregation and the spatial structure of 'ordinary' activities in the Global South. *Urban Planning*, *5*(3), 303–318.

Weldearegay, S. K., Tefera, M. M., & Feleke, S. T. (2021). Impact of urban expansion to peri-urban smallholder farmers' poverty in Tigray, North Ethiopia. *Heliyon*, *7*(6), e07303. https://doi.org/10.1016/j.heliyon.2021.e07303

While, A., & Whitehead, M. (2013). Cities, urbanisation and climate change. *Urban Studies*, *50*(7), 1325–1331. https://doi.org/10.1177/0042098013480963

Yamu, C., van Nes, A., & Garau, C. (2021). Bill Hillier's legacy: Space syntax—A synopsis of basic concepts, measures, and empirical application. *Sustainability*, *13*(6), Article 3394.

Yan, Y., Wu, C., & Wen, Y. (2021). Determining the impacts of climate change and urban expansion on net primary productivity using the spatio-temporal fusion of remote sensing data. *Ecological Indicators*, *127*, Article 107737. https://doi.org/10.1016/j.ecolind.2021.107737

Ye, B., Jiang, J., Liu, J., Zheng, Y., & Zhou, N. (2021). Research on quantitative assessment of climate change risk at an urban scale: Review of recent progress and outlook of future direction. *Renewable and Sustainable Energy Reviews*, *135*, Article 110415. https://doi.org/10.1016/j.rser.2020.110415

Zhang, J., Yu, Z., Cheng, Y., Chen, C., Wan, Y., Zhao, B., & Vejre, H. (2020). Evaluating the disparities in urban green space provision in communities with diverse built environments: The case of a rapidly urbanizing Chinese city. *Building and Environment*, *183*, Article 107170. https://doi.org/10.1016/j.buildenv.2020.107170

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