social sciences

MDPI

Viewpoint

Can Managing Climate Risks Be a Catalyst for Broader Transformative Change?

Rob Swart [1], Wim Timmermans [1], Eva Boon [2], Maarten Van Ginkel [3], Hasse Goosen [2], Felix Van Veldhoven [2], Jua Cilliers [4] and Emeka Ndaguba [4,5,*]

[1] Wageningen Environmental Research, Droevendaalsesteeg 3-3 A, 6708 PB Wageningen, The Netherlands
[2] Climate Adaptation Services, 1406 NZ Bussum, The Netherlands
[3] Municipality of Nijmegen, 6511 PS Nijmegen, The Netherlands
[4] School of Built Environment, University of Technology Sydney, Ultimo 2007, Australia
[5] Centre for Development Support, University of Free State, Bloemfontein 9301, South Africa
* Correspondence: emeka.ndaguba@uts.edu.au

Abstract: This essay addresses the long-term effectiveness of urban climate change adaptation approaches, based, inter alia, on work in the C40 city network. We argue that in most cities, the dominant framing of climate risk management almost exclusively focuses on short-term incrementalities and preventive solutions directly tackling hazards, vulnerability, and exposure. This approach has serious flaws, leading to missed opportunities for longer-term sustainable urban development. Until very recently, climate science usually provided only a marginal input to long-term urban planning and design. We argue that any analysis of urban climate risk management and the associated climate services should be broadened beyond solely climate focusing on impacts. In this context, the development of positive urban visions is a key gap for both research and practice. A change is required from negatively addressing risks to positively pursuing a positive vision of attractive, resilient, and sustainable cities. The emphasis on short-term incremental solutions should shift towards long-term transformation. This embodies a paradigm shift from "function follows system" to "system follows function". For many cities, this also means a change in procedural practice from siloed top-down to integrated, participatory urban transformation. Our main argument in this paper is that simple, longer-term sustainable urban transformation would not only reduce climate risks but also enhance overall environmental quality, economic opportunities, and social wellbeing.

Keywords: climate change adaptation; urban development; transformative adaptation; urban visions

Citation: Swart, Rob, Wim Timmermans, Eva Boon, Maarten Van Ginkel, Hasse Goosen, Felix Van Veldhoven, Jua Cilliers, and Emeka Ndaguba. 2023. Can Managing Climate Risks Be a Catalyst for Broader Transformative Change? *Social Sciences* 12: 158. https://doi.org/10.3390/socsci12030158

Academic Editor: Nigel Parton

Received: 1 September 2022
Revised: 17 February 2023
Accepted: 20 February 2023
Published: 6 March 2023

1. Introduction

This paper is one of the first to examine the potential for developing positive urban visions to fundamentally transform cities, capturing a broader spectrum of urban sustainability, resilience, and climate justice challenges. Many studies have recognized climate risks and taken steps to assess risk and develop incremental adaptive measures. However, few have looked beyond short-term responses, which risks the ineffectiveness of these measures over the long term. Drawing on practical examples from international urban networks in which the authors are involved, this paper advises cities to move beyond narrow, short-term measures and adopt a more comprehensive approach.

Urbanization, characterized by population growth and migration from rural to urban areas, has been a major trend in the 20th and 21st centuries. By 2050, it is estimated that two-thirds of the world's population will reside in cities, with higher percentages in industrialized nations. Cities face multiple challenges, including governance, resource supply, inequality, and rapid technological advancements, as well as environmental issues such as air and water pollution, waste management, and climate change. This paper specifically focuses on the system-defying nature of climate change adaptation in urban areas.

Competing with other objectives for attention and resources, climate change adaptation has been a "peripheral" agenda for urban policymakers and planners (Carter et al. 2015). However, for many cities, climate change is not just one additional entry on the menu of challenges that can be dealt with using a multi-objective policy development approach, balancing different issues against each other, but a defining driver requiring a more fundamental systemic approach. Not only are climatic hazards (flooding, heat, and drought) expected to pose an increasing threat to citizens and livelihoods, but cities' vulnerability is also being exacerbated by the degradation of natural protections such as floodplains and wetlands, as well as construction in natural drainage areas (Chu et al. 2019). Although there are significant differences between locations, we argue that long-term climate impacts can be expected to exceed the sufficiency of reactive and incremental responses in many cases, implying a repositioning of climate adaptation for transformative urban policy and planning.

Climate change is not only an environmental, but also a broad social and economic challenge (e.g., Ripple et al. 2020). Nevertheless, its origin in the meteorological and environmental sciences has often caused climate change to be allocated to government departments were initially solely charged with the management of environmental issues, such as waste management and air quality. In many cases, these departments are less powerful and have fewer resources than departments responsible for finance, infrastructure planning, urban green, transport, culture, health, and other economic and social matters. One could argue that this has slowed down the progress of development and implementation of both adaptation and mitigation responses at all governance levels since the late 1980s, when climate change entered the political agenda. Climate change is often still narrowly framed as a scientific, environmental issue, and this frame is not made explicit—it is taken for granted (de Boer et al. 2011).

Initially, climate change adaptation tended to focus attention on hazards (addressing climate risks such as floods and heat waves independently of the broader socioeconomic context) rather than on a broader set of stressors (Kelman 2015; Räsänen et al. 2016). Generally, adaptation had, and often continues to have, a "negative" focus on risks and vulnerability: on addressing current specific problems one-by-one, rather than on integrated solutions, e.g., addressing flood risk by designing local solutions such as heightening streets or dikes, rather than considering the root causes of flooding at a larger spatial scale, i.e., the city as a whole and the hinterland. Affected people were—and often still are—considered as passive victims rather than active and creative resources for shaping a sound urban environment (Cannon et al. 2003). If addressing solutions, the emphasis has been—and generally still is—on technical solutions and analysis of costs, ignoring less easily quantifiable aspects such as values (Ribot 2011). Therefore, responses to climate change often focus on short-term hazards rather than long-term resilience. Urban futures are often presented as dystopian, challenging decision-making and action (McPhearson et al. 2017). This limits the effectiveness of solutions as well as the motivation of citizens and the city government.

Here, we make a case for broadening the scope and rethinking the framing of climate change adaptation in urban policy development, planning, and design, from a response to natural hazards with a short-term focus, to the positive visioning and design of a future city that will also be attractive to inhabit in the long term. People are not convinced by facts; they are enticed by a beckoning perspective (Hajer 2017). We develop this perspective based on our experiences working with cities around the world. While we do not focus on mitigation, similar arguments can be made about mitigating responses.

2. Material and Method

In this perspective paper, we develop our arguments based on our experiences working with cities on a variety of projects, first in Europe and then around the world. We build on experiences from two projects in particular, the project INNOVA in the context of the European Joint Programming Initiative Climate (JPI Climate) and an urban development-

oriented effort in the context of the global C40 city network. First, we developed our initial ideas and concepts based on experiences in the Netherlands and Europe. Subsequently, we applied the ideas to cities in the developing world under the C40 framework contract. In this essay, we complement those experiences with a literature review.

INNOVA focused on improving climate services, aiming at codeveloping climate services using a bottom-up approach to support the climate change policy cycle for local adaptation. INNOVA worked with four distinct urban hubs: the French West Indies (Pointe-à-Pitre and Fort de France in Guadeloupe and Martinique), Kiel Bay (Germany), Valencia (Spain), and Nijmegen (The Netherlands). The main elements of INNOVA included user-driven climate services, innovation support and engagement with multiple stakeholders.

Several cities within the global network of the C40 Cities Climate Leadership Group have identified transformative climate actions as part of their climate action planning. eThekwini Municipality, the city of Durban, in South Africa lists transformative actions in their Durban climate action plan 2019 (Durban Environmental Planning & Climate Protection Department 2019), as well as in their Transformative Riverine Management Projects (C40 Cities Finance Facility 2019). Kuala Lumpur's Climate Action Plan describes roadmaps for delivering Kuala Lumpur's transformative actions (Kuala Lumpur City Planning Department 2021). Quezon City in the Philippines identified transformative climate actions in 2020 and, as of 2022, has started implementing them (Quezon City Municipality 2022). The C40 cities recognized the importance of a positive vision and transformative adaptation, trying to achieve positive change rather than preventing risks only. These cities generally were less advanced and experienced in adaptation, which is why in this essay we provide most detail on the European cities, in Box 1, complemented by an American example from the literature, as suggested by a reviewer.

We note that the cases that we included started acting on adaptation to climate change without necessarily being obliged or encouraged to do so for legal reasons. In other cities or other regions, legal obligations may encourage and/or steer such adaptation activities (e.g., see Turner and Burger (2021) for a US example). We also note that various methods are available to plan for adaptation in an urban context, in addition to those used in the INNOVA and C40 work covered by this paper. One very promising example is the usage of serious gaming, such as in New Zealand (NIWA 2022).

Box 1. Examples of city visioning and integrated, transformative adaptation in urban spatial policy.

The Dutch city **Nijmegen** is part of the Covenant of Mayors/Mayors Adapt network, integrating the national Room for the River program to create greater resilience to climate change with a major urban development project and many small-scale co-creation urban development efforts. In the case of Nijmegen, the Waal dike in Lent (northern part of the city) was moved and an ancillary channel was dug in the flood plains, the so-called Spiegelwaal (Mirror Waal), creating a new island in the Waal and an attractive urban river park with opportunities for leisure, culture, water, and nature. These developments have a long history, from before concepts such as adaptation or climate services emerged. Over time, new and better projections of river flows and flood risks were increasingly integrated into the broader land-use policy process, as one of many inputs. This process was characterized by the development of a positive, appealing vision for the long-term, resilient development of the expanding urban area, taking the varied perspectives of a wide range of stakeholders into account.

Box 1. *Cont.*

An example from **Rotterdam** is described in the Rotterdam Climate Change Adaption Strategy (RCI 2013), recently complemented by Rotterdam Weatherwise, which lays out a climate-resilient urban vision for 2050 (Municipality of Rotterdam 2020). The Rotterdam long-term strategy connects climate change adaptation measures to other municipal programmes and projects such as regular management and maintenance of the roads and public areas. With less money available for implementing ambitious plans than before in the current unstable economic times, working together with other parties that are investing in Rotterdam is seen as an opportunity to connect with other area development plans, the maintenance of infrastructure networks, the transformation of buildings, or with small-scale citizen and business initiatives. Innovative local examples include water squares, which combine water storage with the improvement of the quality of urban public space, and tidal parks, which restore nature's ability to cope with extreme weather while at the same time improving the opportunities for leisure.

An example from **Denmark** is the "Climate Harbour" in Middelfart, related to the "Climate City" and the "Climate Waterfront" projects, which focus on urban development coupled with both the management of rainwater and protection against sea level rise. The Climate Harbour Development Strategy describes not only how the area can be protected against climate impacts, but also how at the same time the area's maritime and urban qualities and activities can be supported and the connections between the harbour area and the city centre strengthened, integrating various urban land-use policy objectives in a positive way. In addition to reducing flood risk, the projects create more value for the population though the multifunctional design of urban spaces and structures. The strategy to manage rainwater ground while complementing pipes underground leads to a town that is "more beautiful, more fun and vibrant" (Middelfart Municipality 2017).

In **Copenhagen**, in 2011 a Cloudburst Plan was developed, mainly as a response to extreme rainfall events (City of Copenhagen 2011). The following Climate Adaptation Plan explicitly includes climate change adaptation to green growth, resilience of roads and buildings, more recreational opportunities, new jobs, and an improved local environment with more green elements. The Copenhagen strategy aims to take advantage of the adaptation work to simultaneously improve the quality of life of its citizens. Implementing this process, the analysis of risks and opportunities is performed simultaneously rather than subsequently. In Copenhagen, climate adaptation and the development of an attractive and green capital are seen as two sides of the same coin. Going even one step further, the programme 'Co-create Copenhagen' aims to design a vision for creating "A Liveable City", "A Bold City", and "A Responsible City" together with the citizens of Copenhagen and everybody else who uses the city. In this programme, Copenhagen's climate risk management is one of multiple objectives, and the city set itself the goal "to remain in the premier league of the world's most vibrant cities in 2025", involving "a radical rethinking of the nature of urban development" (City of Copenhagen 2015).

A pertinent example from the United States is the **San Francisco Bay Area**. After Hurricane Sandy destroyed over 650,000 homes and businesses in New York, New Jersey and other areas along the north-eastern coast, the Rebuild by Design challenge was set up by President Obama to help rebuild damaged cities and communities and make them resilient to future storms. This programme inspired other places vulnerable to climate change to proactively work on enhancing their resilience. The Bay Area around San Francisco took up this challenge by developing an ambitious plan. Local governments collaborated with local communities, agencies, academic institutions, other stakeholders and international design teams. While the main focus of this initiative is sea level rise and flooding in San Francisco Bay, during the process other sometimes even more pressing challenges were integrated, like seismic risks, wetland and habitat restoration, and socioeconomic issues such as lack of housing, displacement, gentrification, limited access to public land and outdated transportation. Much attention is paid to stakeholder involvement, with an initial Collaborative Research Phase serving as a springboard for a Collaborative Design Phase in which final design concepts and an implementation roadmap will be developed (Siegel et al. 2018; ABC 2018).

3. Results

This section summarizes our findings from a number of urban case studies and provides resources for enhancing the understanding of the challenges of and associated strategies towards combating climate risk in urban contexts. It deals with the mismatch and disconnectedness between policies and the realities in communities. Furthermore, we explore strategies that connect an inspiring narrative integrating incremental climate response with transformative urban policy development, planning and design.

3.1. The Challenge: Disconnect and Mismatch between Urban Policy and Climate Risk Communities

Mainstreaming climate adaptation in sectoral plans and policies—with major implications for urban policy—requires major efforts from local authorities (Reckien et al. 2019). A lack of financial resources and limited coordination and cooperation between departments are commonly reported barriers for mainstreaming adaptation in policy (Runhaar et al. 2018). Especially in large municipalities, municipal tasks and responsibilities can be distributed over many departments with tight budgets and limited time. But, even in small municipalities with a limited capacity and knowledge on how to address climate change, climate change responses are often not very well integrated with other policy areas (Carter et al. 2015). Attempts to integrate climate risk management in other policy areas can be seen by those responsible for those other areas as an additional organizational and financial burden, distracting from their core business The long-term nature of climate change concerns is frequently perceived as incompatible with the many other, often urgent, challenges that must be addressed. It can be questioned if current governance structures that are often silo-based (ignoring the intersectional nature of risk, i.e., how different risks interact and reinforce each other), are suitable to develop effective adaptation responses (Carter et al. 2015). Even if frames are made explicit and opportunities for joint action are identified, breaking down these silos is hampered by likely policy trade-offs and entrenched powerful political and economic interests (Chu et al. 2017). Furthermore, the integration of climate risk management into these other goals can be hindered by policy conflicts (Driscoll 2010).

Some cities are already connecting climate change adaptation to other goals that existed before, e.g., water management, transport infrastructure, health care, and housing (Runhaar et al. 2018). Indeed, there is a long history of multi-objective urban policy development and planning. However, examples suggest the focus is on integration and balancing of short-term priorities rather than a long-term vision on climate-resilient transformation. The most recent assessment report of the Urban Climate Change Research Network (UCCRN) notes that integration of mitigation and adaptation (reducing greenhouse gas emissions while increasing resilience) and coordination of disaster risk reduction and climate change adaptation are first steps towards broader integration (Rosenzweig et al. 2018). Only one chapter of this authoritative international assessment on cities and climate mentions the delivery of "a high quality of life for urban citizens ... as well as climate benefits" as a possible outcome of long-term response strategies, thus providing, as of yet, scant attention to integrating climate risk management into a wider set of policy issues (Raven et al. 2018). Because of the above barriers, there are not very many good practice examples of the integration of long-term climate change adaptation in transformational urban policy development yet.

3.2. The Solution: An Inspiring Narrative Integrating Incremental Climate Response into Transformative Urban Policy Development, Planning, and Design

While integration with other climate-related areas such as mitigation and disaster risk reduction are first steps, we emphasize that not only integration with even more environmental, economic, and social policy areas important from a sustainable development point of view, but also that for many cities vulnerable to heat, drought, and flooding, climate change can become a system-wide driver of change rather than just one additional concern. How does this affect urban policy? To address this question, first we summarize some relevant historical developments in urban policy development in which climate challenges are to be incorporated. Then we proceed with discussing the development of positive urban visions, and how these can be promoted by transformative adaptation, reframed guidance, and stakeholder engagement via codesign. In this way, the planning process is opened up from incremental to transformative change.

3.2.1. Integrating Sustainability Issues and Climate Change into Urban Land-Use Policy Making

Integration of adaptation with other policy areas requires collaboration between various sectors and institutions at different levels of spatial scale (from river catchment to urban plot level). Only recently have tools been developed to support this process, such as the Adaptation–Mitigation Interactions Assessment methodology of the C40 Cities Climate Leadership Group. This methodology supports cities in flagging potential trade-offs and conflicts between domains, between adaptation and mitigation; and in identifying opportunities for linkages (C40 2020). We recognize that differences in spatial policy and planning cultures between different countries exist. However, the literature in general reflects a shift from single fixed quantitative targets to multiple, dependent, composite themes to multistakeholder interaction guidance and, finally, fuzzy planning approaches (De Roo and Silva 2010). The level of complexity has been rising substantially since World War II, in line with the rise in societal complexity (De Roo and Porter 2007). The development of sustainable urban planning research and practice followed this trend (Roggema 2012). Since the early seventies, architects and cities have started sustainable, often thematic experiments. The themes were often related to problems experienced locally, such as soil pollution in old brownfield areas, traffic and noise in metropolitan areas, heat in city centres and greening in urban areas. These also include problems felt regionally or nationally, such as the threat of water surplus in the deltaic Netherlands, shortages of water in Mediterranean areas, specific island situations and the threat of typhoons and hurricanes in some tropical regions. Tjallingii (1995) described this phase as "learning by doing". Based on the experience of a rising number of practical approaches, he developed a conceptual ecological approach for a strategy connecting water, energy, and resource streams integrated with spatial planning and the participation of a wide variety of relevant actors. Around the same time, Girardet (1996) developed an integrated approach to sustainable urban policy and planning and connected the last century's urban planning schools with emerging sustainability principles. Step by step and one by one, many sustainability aspects were integrated into the urban spatial policy development and planning process. The stepwise development and implementation of plans towards a positive vision also allow for dealing with uncertainties and accounting for new scientific knowledge.

However, the integration of climate adaptation into urban spatial policy appeared to be difficult due to the uncertainties related to its wicked and long-term character. Two schools developed. First, design-oriented approaches emerged, such as water-sensitive design (Wong 2016), swarm planning for climate-proof design (Roggema 2012), and climate adaptation governance (De Waegemaker 2017). Second, design as a policy development and planning tool can research and visualize different scenarios, such as desirable futures, accounting for projected futures on different time scales for the consequences of different scenarios of climate change. The disadvantage of design is qualitative. Quantitative analysis and data-based monitoring and evaluation of climate adaptation effectiveness are in their infancy and are not yet widely practiced (examples include I-Tree, ENVI-met and methods made accessible via the monitoring and evaluation step of the European Climate-Adapt tool (Climate-Adapt 2023).

Since about a decade ago, "climate services" have set up to support policymakers, decision-makers, and practitioners in addressing climate change risks (WCC-3 2009; EC 2015a). Until now, these climate services have mainly focused on making climate data available (e.g., Buontempo et al. 2014), which reinforces the allocation of responsibility for climate change response to environmental departments, posing a barrier to the development of wider transformative approaches.

We argue that future climate services should inform the open-ended design of different future urban scenarios in what could be called "evidence-based design". It must be acknowledged that not only policy preferences for desirable futures are likely to change over time, but also the availability of climate risk data and the development of the climate itself will change in the long term in as yet uncertain ways. This implies that climate

services are required to aid policy development by defining future needs considering climate change and providing monitoring schemes. This means that next to traditional, hard, mainly meteorological climate data there is also a need for another kind of information that can support urban spatial policy development and planning for regions that will differ from each other in terms of physical, social, and economic characteristics, and desired futures. For example, threats, opportunities, and preferences differ for harbour cities and service-oriented cities, for the US Silicon Valley and the Dutch Food Valley, for cities in deltas and mountainous cities, and for cities in different climate zones.

3.2.2. A New Positive Narrative: The City We Want

The usual short-term focus of policy development implies that only a few municipalities take the time to develop coherent and comprehensive long-term visions of where they want to go in the long term, i.e., which future the citizens would prefer. In some cases, such visions are developed focusing on specific issues such as transportation or energy systems, or on a broad set of socioeconomic themes (e.g., City of Calgary 2007). For the very long-term problem of climate change risks, municipalities—especially those with little resources—may resort to coping with climate-related hazards when they occur. At most, they may develop preparedness measures, such as early warning systems or emergency plans. In case they pay attention to prevention as well, often they prefer incremental solutions, narrowly framed to address only risks of extreme weather events while maintaining the existing infrastructure and institutional arrangements and adding modest measures that would enhance resilience (choosing larger drainage pipes to reduce flood risk, buying air conditioners against heat). This may reduce short-term risks, but in many cases will be insufficient to deal with longer-term risks associated with ongoing climate change. This narrow focus can also obscure opportunities for more sustainable and inclusive urban development. We note that some scholars have proposed moving "beyond sustainability" to focus on "resilience" because the concept of sustainability would have failed (Benson and Craig 2014). We observe that this debate has not been settled (Marchese et al. 2018). A second perspective is that resilience and sustainability are distinct but complementary concepts. A third perspective is that resilience is an important component of sustainable development. This view still appears to dominate urban development science and practice. This debate and associated specific definitions of the concepts of sustainability and resilience are beyond the purview of this paper.

To break free from the silos of climate risk management, a new narrative of sustainable and resilient urban transformations is needed: from the climate hazards we fear to the city we want. Changing from a negative, risk-averse frame of cities as culprits and victims of unsustainability and climate change, a new positive framing of opportunities to rethink urban design is required, with appealing new ways of using and producing energy, mobility patterns, water and land use, and human social behaviour (Hölscher 2019). Paraphrasing the principle from architecture that "form follows function", we suggest that long-term climate change forces urban spatial policy development to move from "function follows system" (addressing climate risks within the constraints of existing urban systems) to "system follows function" (redesigning the urban system to address pervasive long-term challenges such as climate change).

To reverse the trend to frame the future as risky or even dystopian, in contrast, positives visions can explore alternative plausible and desirable urban futures, including urban resilience and sustainability. Sustainability issues such as climate change adaptation are value-laden, complex, and uncertain, a situation for which visioning and backcasting are suitable (McGrail and Gaziulusoy 2014). McPhearson et al. (2017) stressed the importance of a participatory approach to developing such visions accounts for marginalized perspectives and the identification of tensions. Moving away from sustainable urbanism (shifting the focus of cities and the practises used to build them towards promoting long-term viability by reducing environmental impacts on people and place while improving overall wellbeing), and "climate urbanism", Long and Rice (2018) suggested that cities can be positively seen

as "the most viable and appropriate sites of climate action", prioritizing protection of the urban infrastructure and economy against climate hazards, while addressing inequality and injustice. Addressing climate justice is becoming increasingly important in this context. Dixon et al. (2018) provided an overview of different foresight methods that can be used for developing urban visions and provide an example combining elements of a smart and sustainable city (Reading, United Kingdom). Notwithstanding the pertinence of these proposals, they are not yet widely implemented.

The value of constructing a positive vision for a future city is threefold. The first asset is related to framing. The traditional framing of climate adaptation is negative: to reduce risks. Changing this to a positive exploration of opportunities for urban development improves not only the nature but also the attractiveness of solutions. The second asset relates to the outcome level. In this context, Ortegon-Sanchez and Tyler (2016) suggested that for a vision to support a sustainable transformation, it should not be defined "in terms of projects, budget or foreseen trends or indicators but as a conceptual characterization of a future city where its people can live and be well". A recent example in a climate change adaptation context is the Capability Framework of Adaptation Scotland, which marks a change from a risk-based to an outcome-based approach in which the development of a future vision considering various desired social outcomes is one of the core elements (Hagg et al. 2019).

3.2.3. Transformative Adaptation

Transformative adaptation is about addressing the root causes of climate risk and avoiding lock-ins for unsustainable development (EEA 2016). The aim is to fundamentally change the systems of the city and try to use the ability of the natural system to absorb or mitigate climatic extremes. Transformative adaptation is a relatively new concept (for an overview see Fedele et al. 2020), while more often reactive (or coping) and incremental (or preventive) approaches to adaptation are reported about (EEA 2016). Reactive adaptation refers to fighting the immediate negative consequences of weather and climate extremes. Incremental adaptation refers to those actions that make changes within the city's systems to prevent the negative consequences of weather and climate extremes (see Figure 1). In transformative adaptation, the solutions go beyond typical engineering solutions such as embankments, drainage, and irrigation work. Compared to reactive and incremental adaptation, transformational adaptation requires higher investments, the inclusion of a more diverse set of stakeholders, and is associated with higher degrees of uncertainty (Fedele et al. 2019). But in the longer term, the pay-off in terms of both resilience and urban sustainability, wellbeing, and climate justice can be significantly larger (see Figure 2). In practice, the three approaches are not mutually exclusive, as they can have overlapping components (e.g., see Kates et al. 2012). They can also be regarded as phases in a process, with reactive and incremental measures implemented first to address short-term risks but then supplemented by the development of longer-term transformative approaches. Incremental adaptation builds on business-as-usual urban policies, facing the challenge that the functional lifetime of adaptation measures decreases over time (Haasnoot et al. 2020). Transformative adaptation focuses on deeper, long-term systemic changes (e.g., see Chu et al. 2019). In this process, learning-by-doing and "design-by-experiment" can play an important and inspiring role, as can the consideration of "safe-to-fail" options (Ahern 2011; Kim et al. 2017, 2019). Also, the "adaptive management" literature discusses how a structured, iterative process can inform decision making in the face of uncertainty (e.g., Marmorek et al. 2019). Cosens and Gunderson (2018) provided various examples of applications of adaptive management in the water sector in the US.

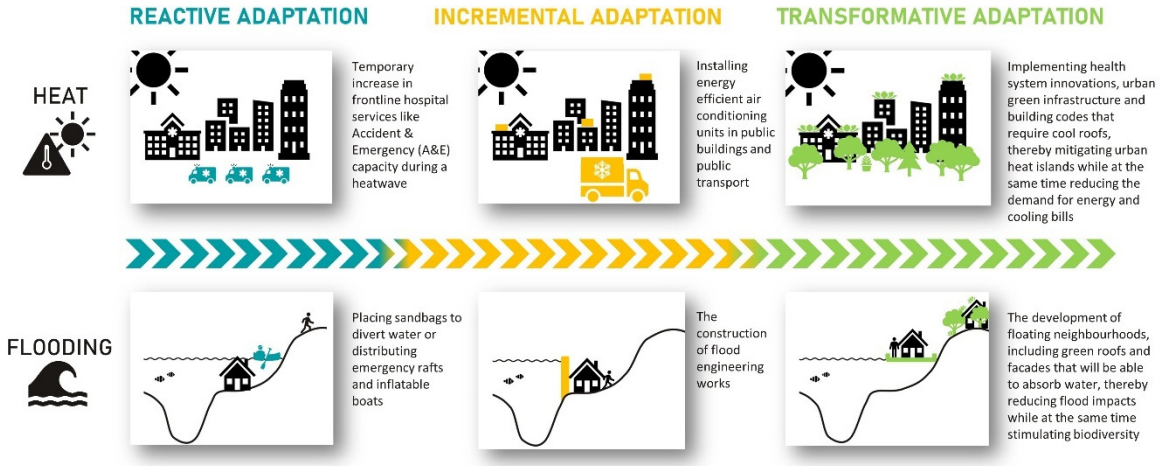

Figure 1. Some examples of reactive, incremental, and transformative adaptation strategies for urban land-use policy development (C40/CAS 2020).

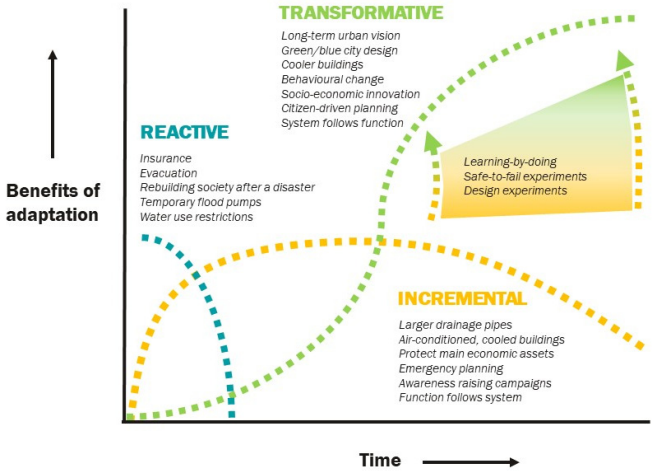

Figure 2. Benefits of transformational adaptation as compared to incremental (preventive) and reactive adaptation.

In an inventory of 100 cities, Castán Broto and Bulkeley (2013) found that experiments are important for cities in their response to climate change, but still place an emphasis on incremental rather than transformational experiments, and on mitigation rather than adaptation. Putting too much emphasis on incremental measures with associated resource commitments may obstruct the development of more transformative approaches, which may have larger and more diverse benefits in the long term.

Several examples illustrate our point that the management of climate risks can contribute to a long-term vision of positive and sustainable urban development, with lower vulnerability and greenhouse gas emissions, in addition to higher wellbeing and employment opportunities. While we found most examples of positive visioning in urban land-use policy in Europe, the catastrophic impacts of hurricanes Katrina (New Orleans) and Sandy (New York) have led to an increase in attention to climate risk management in the US (e.g., see the San Francisco case in Box 1). Another North American example of positive sustainability-oriented visioning can be found in the Central Arizona–Phoenix Long-term Ecological Research programme (CAP LTER). The latter developed transformative and strategic scenarios for six themes: flood resilience, drought adaptation, heat mitigation, food and energy security, eco-city, and zero waste (Iwaniec et al. 2020). While many other cities in the U.S. started to adapt to climate change integrated with other urban development objectives, most are still at the stage of vulnerability assessment and have a relatively short time horizon for measures (e.g., see for an inspiring example City of Boston 2016).

Some American cities (Duluth, Minnesota; Buffalo, New York; and Cincinnati, Ohio) see opportunities to brand themselves as attractive relocation destinations ("climate refuges") for those seeking a haven to the increasing heat (Pierre-Louis 2019).

While there are many examples of climate risk management approaches and integrate it with other urban objectives, the combination of transformative requirements of long-term climate risks and the interconnectivity of cities and their hinterlands requires that visioning urban futures also increase the spatial scale. A good example of this is work exploring what the Netherlands could look like in 2120, when an increased number of people and economic activity must be accommodated in a highly urbanized country of limited scale that is highly sensitive to pluvial flooding, drought, and sea level rise (Roskamp 2019). "The Netherlands 2120" is not a blueprint, but a positive vision to generate a debate about long-term spatial and socioeconomic developments, suggesting novel ways to spatially redesign a full country by integrating urban areas with agriculture and nature, involving the return of green back into the cities.

3.2.4. Reframing Climate Change Adaptation Guidance, Which Can Be a Barrier to Transformative Adaptation

We consider dominant international frameworks and guidance documents in support of climate change adaptation to often be a barrier to transformative policy approaches. Typically, cities follow the IPCC framework in which actions are identified that reduce either the hazard itself, or vulnerability to or exposure to the hazard (see Figure 3). After cities have identified climate risk as a potential problem that needs to be addressed, most cities start by undertaking climate risk and vulnerability assessments. Most guidance frameworks include a direct step from climate risk assessment to action identification. Examples include the iterative risk management process of the IPCC (2014), the "adaptation cycle" (Willows et al. 2003), the Adaptation Support Tool provided on the European Adaptation Portal (Climate-Adapt), the phases of the adaptation process by Moser and Ekstrom (2010), and the recently published ISO standard 14091 (ISO 2021). In the Netherlands, for example, the Delta Plan has specifically targeted local adaptation of towns and cities since 2014. Cities are not forced to develop and implement adaptation strategies, but are encouraged and supported by tools, a web portal, as well as financial and community support. All municipalities have committed to performing a climate risk assessment—the so-called Climate Stress Test. Following the adaptation cycle, the identification of climate risks is followed by the identification of adaptation options.

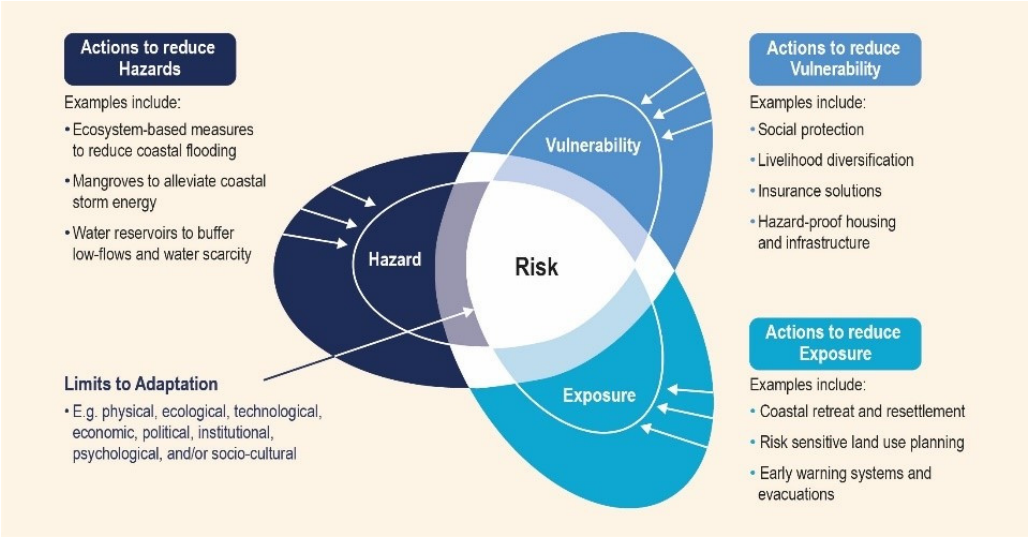

Figure 3. The framing of IPCC links hazard–vulnerability–exposure directly to solutions, and thus promotes single-issue incremental adaptation approaches over transformative solutions. Source: (Abram et al. 2019).

This approach, however, has a serious pitfall. By moving directly from climate risk to solutions or response actions, a city is likely to fall victim to a siloed approach. This could result in a collection of ill-connected, partial solutions (a flood wall for flood defence, an irrigation channel for fresh water supply, airconditioned office buildings), whereas transformational adaptation might result in a more integrated and comprehensive solution (reforestation, water storage upstream, and urban greening). By moving straight towards action, valuable co-benefits may be missed, merely because they escape the attention of urban planners assigned to address climate risks alone. Vieweg and Noble (2013) already noted that the commonly used framework hinders the consideration of transformative adaptation, suggesting adding a step in which the question "do incremental measures remain sufficient?" is addressed. We propose to operationalize such an additional step between assessment of risk and identification of options by amending not only the goal of the solutions (from incremental short-termism to transformative futures), but also the process of developing them and the framing of the solutions. By thinking about a shared, innovative, integral, and long-term vision for the city, the future we want, a multitude of ideas are created (divergent thinking) before focusing on and identifying specific solutions or actions (convergent thinking). This allows for generating new ideas, identifying, and evaluating multiple possible adaptation solutions, often in unexpected combinations. This divergence is in line with the appreciation of the variety of competing guiding principles of what constitutes "cities fit for climate change" in a study exploring the transformative changes required in German cities to respond to climate change (GIZ 2018). One pertinent example of transformative urban change for urban policy development in support of climate-resilient cities is urban greening, for which we summarize some key concepts in Box 2.

Box 2. Greening cities using nature-based solutions—combining urban transformation, citizen engagement, and positive visioning.

An important example of an integrated long-term approach to urban land-use policy is the "greening of cities" that can combine elements of urban transformation, citizen engagement, and positive framing. Different similar, overlapping concepts emerged, such as—subsequently—ecosystem-based adaptation, popular with ecologists; green infrastructure, a concept used by planners; and most recently, nature-based solutions (e.g., Escobedo et al. 2019). While these concepts all address wider sustainability considerations, arguably, NbS encompasses a wider variety of interventions that consider environmental, economic, and social criteria (Dorst et al. 2019). "Renaturing of Cities" is a strategy "to maximise the ecosystem service provision of urban green infrastructure (UGI)", combining habitat services and a biodiversity-led approach with multifunctionality addressing community needs and policy learning. Connop et al. (2016) add the important point that rather than if GI has generic benefits, land-use policy requires close attention to the local context for both green and multifunctionality objectives, including but not limited to enhancing biodiversity, reducing heat stress, carbon sequestration, reduction of air pollution, water management, and human health and wellbeing. In Europe, green infrastructure (GI) is promoted by the 2013 European Commission (EC 2013) as "a strategically planned network of natural and semi-natural areas with other environmental features designed and managed so as to deliver a wide range of ecosystem services", enhancing not only ecological values but also the health and quality of life of citizens and a green economy with new job opportunities. This can also include "blue" (water) areas (EEA 2015).

Box 2. *Cont.*

Responding to the need to develop a systemic approach that combines technical, business, finance, governance, regulatory, and social innovation, more recently, nature-based solutions (NbS) were introduced in Europe, defined as "Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions" (EC 2015b). NbS can offer an integrative framework for transformational urban greening and climate change adaptation. The EC (2015b) identifies four goals: (i) enhancing sustainable urbanisation; (ii) restoring degraded ecosystems; (iii) developing climate change adaptation and mitigation enhancing resilience and carbon storage, and (iv) improving multiple risk management and resilience. It should be adapted to local circumstances and can be developed locally in conjunction with local stakeholders, e.g., to address challenges in local neighbourhoods. But, only if developed at the (peri-)urban scale, it allows for transformative solutions and can most effectively address the combination of climate risks with other environmental social and economic challenges that contemporary city governments must address.

3.2.5. Codesign: Engaging Stakeholders Accounting for Their Values

The formulation of transformative solutions requires a deeper understanding of the natural system of the city and the linkages with its surroundings (hydrology, soil composition, ecology, water quality, and land use) as a basis for spatial policy developments, but this is insufficient to develop and implement lasting solutions accepted by local citizens. One reason it is difficult to develop integrative solutions to climate risk and other problems is that—when confronted with a new problem—"people tend to focus first on identifying alternatives rather than on articulating values, placing the emphasis on mechanics and fixed choices instead of on the objectives that give decision-making its meaning" (Keeney 1996). In transformative adaptation, it is not easy to identify a best possible solution through optimization or analysis of the cost effectiveness of alternatives: not only the future impacts of climate change are uncertain, but also the functioning of the natural system and the effectiveness of adaptation measures in addressing future climatic hazards are uncertain. Trading off alternative solutions becomes complicated, and one runs into the risk of almost endlessly trying to improve the science, with one answer leading to a next question (how effective are trees compared to air-conditioning, how many trees do we need, of which type, how fast do they grow under which scenario, and so on). This may result in a situation of deadlock because the science will always be incomplete. Better science and more facts alone will not help get out of the deadlock.

In such cases, it helps to reach agreement on the underlying fundamental values that stakeholders have and to translate those into an appealing vision and design: a green city that is rich in biodiversity with clean air that is capable to absorb future shocks. Transformative urban policies require a broad stakeholder support base. If the fundamental values of the various stakeholders are identified and articulated before jumping to solutions this can lead to the creative development of more appealing alternatives (value-focused thinking, Keeney 1996). So, transformative solutions also require collaboration between a wide range of stakeholders. As a result, and as put in its historical context above, the decision-making process becomes more fuzzy and less straightforward compared to, for example, decisions about optimal flood wall height. de de Boer et al. (2010) argued that in such fuzzy and less structured decision-making contexts, an inspirational strategy might prove more effective as opposed to a computational approach. One can optimize the height of an embankment, but one cannot simply calculate the best design of a city within a catchment, considering ecosystem functioning, social wellbeing, and the economy under a changing climate. Therefore, citizen participation in a transdisciplinary co-development process, codeveloping effective and acceptable solutions should go beyond the simple consultation process that is often chosen. Overall, a positive, opportunity-focused vision is more likely to engage and reach the great variety of city stakeholders and may provide

access to a broader range of finance than solutions narrowly focusing on risks related to extreme weather events only.

Figure 4 synthesizes this idea, based on a module that has recently been developed by the authors of this essay for C40 cities, aiming at climate-proofing cities in three steps: analysis, ambition, and action (C40/CAS (2020)). When the risks are known from the risk assessment, cities diverge their scope to develop long-term sustainable solutions for the climate risks as well as for other priorities and goals. This enables the creation of a shared narrative for the future with possible integral solutions. These solutions are more likely to support transformational pathways. After the phase of divergence, the long-term vision can be translated into more concrete short-term and medium-term actions (convergence). With this extra step, we move away from the narrow focus on climate risks in the adaptation management cycle towards a broader vision of urban development. Repositioning of adaptation in urban spatial policy development and intensification of collaboration between climate specialists and urban policymakers and planners is key to moving forward.

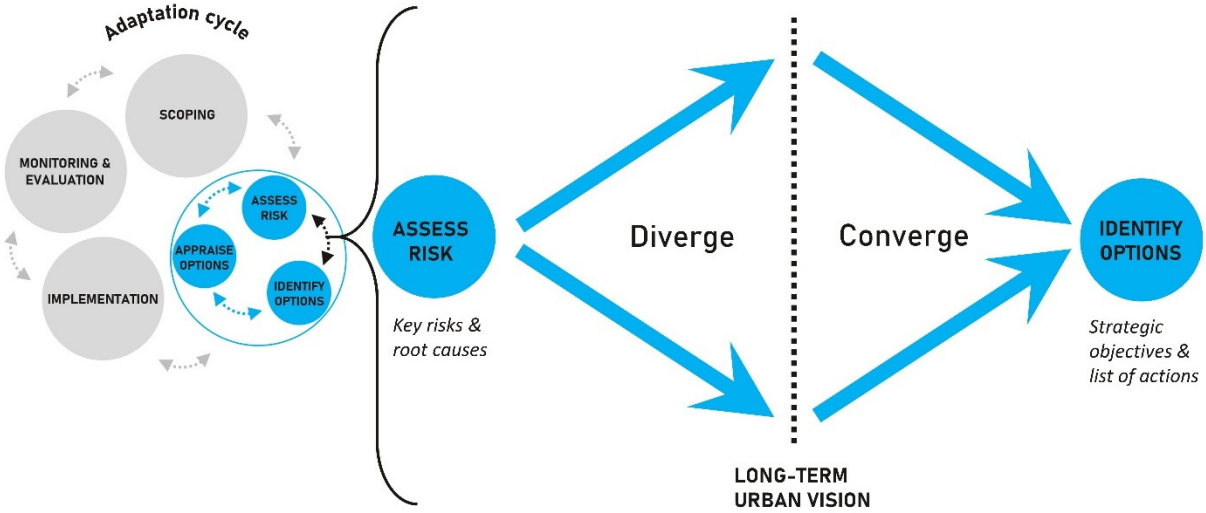

Figure 4. Visioning urban development, integrating social, ecological, and economic opportunities with resilience to climate change. Adding to the classic adaptation management cycle, an additional step is proposed in which long-term urban visions are created that consider social, environmental, and economic opportunities and desires. This step is introduced after the assessment of risks, but before moving to specific solutions or actions. In all steps (risk assessment, vision creation, choice, and design of specific solutions), a broad range of stakeholders should be engaged.

4. Conclusions

In this paper, we argue that the currently dominant framing of climate risk management in urban areas (focusing on short-term incremental, preventive solutions directly addressing hazards, vulnerability, and exposure) has serious flaws in many circumstances and leads to missed opportunities for longer-term sustainable urban development, which would not only reduce risks but also enhance overall environmental quality, economic opportunities, and social wellbeing. To develop urban spatial policies consistent with a deep transformational adaptation strategy, cities are advised to turn (negative) "risks" into (positive) "opportunities" associated with a long-term, appealing perspective that is codeveloped in a transdisciplinary fashion with various stakeholders, enhancing public acceptance. The tendency to jump from identified risks straight to solutions can lead to an ineffective and inefficient, technocratic, potentially inequitable, and siloed approach, in which single-purpose technological solutions are chosen to address a narrow set of risks, failing to consider opportunities for overall urban development.

For a transformational adaptation strategy, it is important to broaden the solution space. We suggest including an additional step in the generally recommended adaptation

policy cycle, with which the city develops an overarching vision or long-term perspective, together with local citizens and businesses. The nature of climate change suggests that a time horizon of at least several decades or a century is appropriate.

Finally, we would like to note that this paper is based on the work on adaptation done by the proactive C40 group of cities. The exploration of which factors drive cities to plan for climate change (like legal, political, or financial issues) and which full menu of methodological approaches is available to implement the proposed approach was beyond the scope of this essay. These are interesting subjects for complementary or follow-up work.

Author Contributions: Conceptualization, R.S. and W.T.; methodology, E.N., F.V.V., M.V.G. and J.C.; validation, W.T., J.C. and F.V.V.; formal analysis, R.S.; investigation, W.T., E.N., F.V.V. and H.G.; data curation, E.B.; writing—original draft preparation, M.V.G. and R.S.; writing, visualization, review and editing, F.V.V.; supervision, J.C. and W.T.; project administration, E.N. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the European Research Area for Climate Services project INNO-VA (Grant Agreement no. 690462).

Institutional Review Board Statement: Not applicable.

Acknowledgments: We acknowledge the C40 Cities Climate Leadership Group for offering support under the Climate Action Planning (CAP) Programme. Some of the ideas and concepts in this paper have been developed under the Technical Assistance to the cities of Kuala Lumpur, Quezon City, Jakarta, Bangkok, Ho Chi Minh City and Hanoi (2018–2021).

Conflicts of Interest: The authors declare no conflict of interest.

References

ABC. 2018. *The Estuary Commons: People, Place, and a Path Forward*. All Bay Collective. ABC. Available online: http://www.resilientbayarea.org/s/Final-Report-Excerpt_ABC_In-It-Together.pdf (accessed on 24 September 2022).

Abram, Nerilie, Jean-Pierre Gattuso, Anjal Prakash, Lijing Cheng, María Paz Chidichimo, Susan Crate, Hiroyuki Enomoto, Matthias Garschagen, Nicolas Gruber, Sherilee Harper, and et al. 2019. Framing and context of the report. In *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*. Edited by ans-Otto Pörtner, Debra C. Roberts, Valérie Masson-Delmotte, Panmao Zhai, Melinda Tignor, Elvira Poloczanska, Katja Mintenbeck, Andrés Alegría, Maike Nicolai, Andrew Okem and et al. Geneva: IPCC.

Ahern, Jack. 2011. From fail-safe to safe-to-fail: Sustainability and resilience in the new urban world. *Landscape and Urban Planning* 100: 341–43. [CrossRef]

Benson, Melinda Harm, and Robin Kundis Craig. 2014. The End of Sustainability. *Society & Natural Resources* 27: 777–82. [CrossRef]

Broto, Vanesa Castan, and Harriet Bulkeley. 2013. A survey of urban climate change experiments in 100 cities. *Global Environmental Change* 23: 92–102. [CrossRef]

Buontempo, Carlo, Chris D. Hewitt, Francisco J. Doblas-Reyes, and Suraje Dessai. 2014. Climate service development, delivery and use in Europe at monthly to inter-annual timescales. *Climate Risk Management* 6: 1–5. [CrossRef]

C40 Cities Finance Facility. 2019. Transformative Riverine Management Projects in Durban. Available online: https://cff-prod.s3.amazonaws.com/storage/files/s1Js6cQiTg7m4x393utegmODlxW05oVuGniwjneS.pdf (accessed on 10 January 2023).

C40. 2020. Adaptation-Mitigation Interactions Assessment Methodology. C40 Cities Climate Leadership Group. Available online: https://resourcecentre.c40.org/resources/interaction-between-adaptation-and-mitigation-actions (accessed on 23 September 2022).

C40/CAS. 2020. *Towards Triple-A Adaptation—Adaptation Action Identification Module (AIM)*. C40 & Climate Adaptation Services.

Cannon, Terry, John Twigg, and Jennifer Rowell. 2003. *Social Vulnerability, Sustainable Livelihoods and Disasters*. London: Report to the Department for International Development. Conflict and Humanitarian Assistance Department and Sustainable Livelihoods Support Office. Available online: https://www.researchgate.net/profile/J-Twigg/publication/254398816_Social_Vulnerability_Sustainable_Livelihoods_and_Disasters/links/56656a1308ae4931cd621574/Social-Vulnerability-Sustainable-Livelihoods-and-Disasters.pdf (accessed on 31 August 2022).

Carter, Jeremy G., Gina Cavan, Angela Connelly, Simon Guy, John Handley, and Aleksandra Kazmierczak. 2015. Climate change and the city: Building capacity for urban adaptation. *Progress in Planning* 95: 1–66. [CrossRef]

Chu, Eric, Anna Brown, Kavya Michael, Jillian Du, Shuaib Lwasa, and Anjali Mahendra. 2019. *Unlocking the Potential for Transformative Climate Adaptation in Cities*. Background Paper prepared for the Global Commission on Adaptation. Washington, DC and Rotterdam: Global Commission on Adaptation. Available online: ww.gca.org (accessed on 1 June 2022).

Chu, Eric, Isabelle Anguelovski, and Debra Roberts. 2017. Climate adaptation as strategic urbanism: Assessing opportunities and uncertainties for equity and inclusive development in cities. *Cities* 60: 378–87. [CrossRef]

City of Boston. 2016. *Climate Ready Boston: Final Report*; Boston: Imagine Boston 2030, City of Boston. Available online: https://www.boston.gov/sites/default/files/file/2019/12/02_20161206_executivesummary_digital.pdf (accessed on 31 August 2022).

City of Calgary. 2007. *Imagine Calgary. Plan for Long-Range Urban Sustainability*. City of Calgary Report. Copenhagen: City of Copenhagen.
City of Copenhagen. 2011. *The City of Copenhagen Cloudburst Management Plan 2012*. Copenhagen: City of Copenhagen.
City of Copenhagen. 2015. *Co-Create Copenhagen—Vision for 2025*. Copenhagen: Technical and Environmental Administration, City of Copenhagen.
Climate-Adapt. 2023. The Adaptation Support Tool—Getting Started. Available online: https://climate-adapt.eea.europa.eu/knowledge/tools/adaptation-support-tool (accessed on 14 June 2022).
Connop, Stuart, Paula Vandergert, Bernd Eisenberg, Marcus J. Collier, Caroline Nash, Jack Clough, and Darryl Newport. 2016. Renaturing cities using a regionally-focused biodiversity-led multifunctional benefits approach to urban green infrastructure. *Environmental Science & Policy* 62: 99–111. [CrossRef]
Cosens, Barbara, and Lance Gunderson. 2018. *An Introduction to Practical Panarchy: Linking Law, Resilience, and Adaptive Water Governance of Regional Scale Social-Ecological Systems*. Cham: Springer. [CrossRef]
de Boer, Joop, Arjan Wardekker, Jeroen van der Sluijs, and Rien Kolkman. 2011. *Frames in Climate Change Communication and Decision-Making (IC10)—Synthesis*, The Dutch National Research Programme Climate Change Spatial Planning.
de Boer, Joop, J. Arjan Wardekker, and Jeroen P. Van der Sluijs. 2010. Frame-based guide to situated decision-making on climate change. *Global Environmental Change* 20: 502–10. [CrossRef]
De Roo, Gert, and Elisabete A. Silva, eds. 2010. *A Planner's Encounter with Complexity*. Farnham: Ashgate Publishing, Ltd.
De Roo, Gert, and Geoff Porter. 2007. *Fuzzy Planning: The Role of Actors in a Fuzzy Governance Environment*. Ashgate: Ashgate Publishing, Ltd.
De Waegemaker, Jeroen. 2017. Climate-Proof through Design. Research and Design for Climate Adaptation in Peri-Urban Territories. Ph.D. thesis, University of Antwerp, Antwerp, Belgium.
Dixon, Tim, Jenni Montgomery, Nigel Horton-Baker, and Lorraine Farrelly. 2018. Using urban foresight techniques in city visioning: Lessons from the Reading 2050 vision. *Local Economy* 33: 777–99. [CrossRef]
Dorst, Hade, Alexander Van der Jagt, Rob Raven, and Hens Runhaar. 2019. Urban greening through nature-based solutions—Key characteristics of an emerging concept. *Sustainable Cities and Society* 49: 101620. [CrossRef]
Driscoll, Patrick Arthur. 2010. Climate Change Mitigation, Adaptation and Sustainable Urban Development: A Case Study of Copenhagen and Portland. Master's thesis, Aalborg University, Aalborg, Denmark.
Durban Environmental Planning & Climate Protection Department. 2019. Durban Climate Action Plan 2019. Available online: https://cdn.locomotive.works/sites/5ab410c8a2f42204838f797e/content_entry5c8ab5851647e100801756a3/5e5e3f71469c8b00a735fbac/files/Climate_Action_Plan_web.pdf (accessed on 10 January 2023).
EC. 2013. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions 'Green Infrastructure (GI)—Enhancing Europe's Natural Capital'*. (COM/2013/0249 Final). Brussels: European Commission DG Research and Innovation.
EC. 2015a. *A European Research and Innovation Roadmap for Climate Services*. Brussels: European Commission DG Research and Innovation. [CrossRef]
EC. 2015b. *Towards an EU Research and Innovation Policy Agenda for Nature-Based Solutions & Re-Naturing Cities*. Final Report of the Horizon 2020 Expert Group on 'Nature-Based Solutions and Re-Naturing Cities'. Brussels: European Commission DG Research and Innovation.
EEA. 2015. *Exploring Nature-Based Solutions—The Role of Green Infrastructure in Mitigating the Impacts of Weather- and Climate Change-Related Natural Hazards*. EEA Technical Report No 12/2015. Copenhagen: European Environment Agency.
EEA. 2016. *Urban Adaptation to Climate Change in Europe 2016: Transforming Cities in a Changing Climate*. EEA Report No 12/2016. Copenhagen: European Environment Agency.
Escobedo, Francisco J., Vincenzo Giannico, Chi Yung Jim, Giovanni Sanesi, and Raffaele Lafortezza. 2019. Urban forests, ecosystem services, green infrastructure and nature-based solutions: Nexus or evolving metaphors? *Urban Forestry & Urban Greening* 37: 3–12. [CrossRef]
Fedele, Giacomo, Camila I. Donatti, Celia A. Harvey, Lee Hannah, and David G. Hole. 2019. Transformative adaptation to climate change for sustainable social-ecological systems. *Environmental Science & Policy* 101: 116–25. [CrossRef]
Fedele, Giacomo, Camila I. Donatti, Celia A. Harvey, Lee Hannah, and David G. Hole. 2020. Limited use of transformative adaptation in response to social-ecological shifts driven by climate change. *Ecology and Society* 25: 25. [CrossRef]
Girardet, Herbert. 1996. *Gaia Atlas of New Cities: New Directions of Sustainable Urban Living (Gaia Future)*. Nairobi: UN Habitat, ISBN 13:978-1856750974.
GIZ. 2018. *Guiding Urban Concepts and Climate Change in Germany's Urban Planning Practice: A Review of the Recent Academic Discourse*. Berlin: Cities Fit for Climate, Deutsche Gesellschaft Für Internationale Zusammenarbeit.
Haasnoot, Marjoleinb, Jaap Kwadijk, Jos Van Alphen, Dewi Le Bars, Bart Van Den Hurk, Ferdinant Diermanse, Ad Van Der Spek, Gualbert Oude Essink, Joost Delsman, and Marjolein Mens. 2020. Adaptation to uncertain sea-level rise; how uncertainty in Antarctic mass-loss impacts the coastal adaptation strategy of the Netherlands. *Environmental Research Letters* 15: 034007. [CrossRef]

Hagg, Joseph, Elly Murtagh, Mark Morris, and Anna Beswick. 2019. Scotland Adapts: A Capability Framework for a Climate Ready Public Sector. Adaptation Scotland. Available online: https://www.adaptationscotland.org.uk/how-adapt/tools-and-resources/capability-framework-climate-ready-public-sector (accessed on 30 November 2022).

Hajer, Maarten. 2017. *Zin in de Toekomst: Tijd voor Verbeelding*. Keynote Speech Nationaal Delta Congres. Available online: https://magazines.deltaprogramma.nl/deltanieuws/2017/05/keynote-maarten-hajer-in-vier-sheets-en-twee-tweets (accessed on 31 August 2022).

Hölscher, Katharina. 2019. *Transforming Urban Climate Governance: Capacities for Transformative Climate Governance*. Rotterdam: Erasmus University Rotterdam.

IPCC. 2014. Summary for Policymakers. In *Climate Change 2014: Impacts, Adaptation and Vulnerability—Contributions of the Working Group II to the Fifth Assessment Report*. Cambridge: Cambridge University Press, pp. 1–32. [CrossRef]

ISO. 2021. *ISO/DIS 14091. Adaptation to Climate Change—Guidelines on Vulnerability, Impacts and Risk Assessment*. Geneva: International Organization for Standardization.

Iwaniec, David M., Elizabeth M. Cook, Melissa J. Davidson, Marta Berbés-Blázquez, Matei Georgescu, E. Scott Krayenhoff, Ariane Middel, David A. Sampson, and Nancy B. Grimm. 2020. The co-production of sustainable future scenarios. *Landscape and Urban Planning* 197: 103744. [CrossRef]

Kates, Robert W., William R. Travis, and Thomas J. Wilbanks. 2012. Transformational adaptation when incremental adaptations to climate change are insufficient. *Proceedings of the National Academy of Sciences* 109: 7156–61. [CrossRef]

Keeney, Ralph L. 1996. Value-Focused Thinking: Identifying Decision Opportunities and Creating Alternatives. *European Journal of Operational Research* 92: 537–49. [CrossRef]

Kelman, Ilan. 2015. Climate Change and the Sendai Framework for Disaster Risk Reduction. *International Journal of Disaster Risk Science* 6: 117–27. [CrossRef]

Kim, Yeowon, Daniel A. Eisenberg, Emily N. Bondank, Mikhail V. Chester, Giuseppe Mascaro, and B. Shane Underwood. 2017. Fail-safe and safe-to-fail adaptation: Decision-making for urban flooding under climate change. *Climatic Change* 145: 397–412. [CrossRef]

Kim, Yeowon, Mikhail V. Chester, Daniel A. Eisenberg, and Charles L. Redman. 2019. The Infrastructure Trolley Problem: Positioning Safe-to-fail Infrastructure for Climate Change Adaptation. *Earth's Future* 7: 704–17. [CrossRef]

Kuala Lumpur City Planning Department. 2021. Kuala Lumpur Climate Action Plan 2050. Available online: https://www.dbkl.gov.my/wp-content/uploads/2021/07/C40_KLCAP2050_viewing-only-MR-single_compressed.pdf (accessed on 10 January 2023).

Long, Joshua, and Jennifer L. Rice. 2018. From sustainable urbanism to climate urbanism. *Urban Studies* 56: 992–1008. [CrossRef]

Marchese, Dayton, Erin Reynolds, Matthew E. Bates, Heather Morgan, Susan Spierre Clark, and Igor Linkov. 2018. Resilience and sustainability: Similarities and differences in environmental management applications. *Science of The Total Environment* 613–614: 1275–83. [CrossRef] [PubMed]

Marmorek, David, Marc Nelitz, Jimena Eyzaguirre, Carol Murray, and Clint Alexander. 2019. Adaptive Management and Climate Change Adaptation: Two Mutually Beneficial Areas of Practice. *Journal of the American Water Resources Association* 55: 881–905. [CrossRef]

McGrail, Stephen, and A. Idil Gaziulusoy. 2014. Using Futures Inquiry to Create Low-Carbon, Resilient Urban Futures: A Review of Practice, Theory and Process Options for the Visions and Pathways Project. Working paper for the Visions & Pathways. Available online: https://apo.org.au/sites/default/files/resource-files/2016-03/apo-nid70334.pdf (accessed on 31 August 2022).

McPhearson, Timon, David M. Iwaniec, and Xuemei Bai. 2017. Positive visions for guiding urban transformations toward sustainable futures. *Current Opinion in Environmental Sustainability* 22: 33–40. [CrossRef]

Middelfart Municipality. 2017. Development Strategy for the Climate Harbour. Middelfart Municipality and Middelfart Wastewater Utility in Collaboration with Danish and Dutch Architects (Bascon, Orbicon, Effekt, De Urbanisten and Boris Brorman). Available online: http://www.klima-byen.dk/~/media/klimabyen/biennale%202016/the%20climate%20city%20and%20the%20climate%20harbour.pdf?la=da (accessed on 2 August 2022).

Moser, Susanne C., and Julia A. Ekstrom. 2010. A framework to diagnose barriers to climate change adaptation. *Proceedings of the National Academy of Sciences* 107: 22026–31. [CrossRef]

NIWA. 2022. Serious Games as a Tool to Engage People. Available online: https://niwa.co.nz/natural-hazards/our-services/serious-games-as-a-tool-to-engage-people (accessed on 20 November 2022).

Ortegon-Sanchez, Adriana, and Nick Tyler. 2016. Constructing a Vision for an 'Ideal' Future City: A conceptual model for Transformative Urban Planning. *Transportation Research Procedia* 13: 6–17. [CrossRef]

Pierre-Louis, Kendra. 2019. Want to Escape Global Warming? These Cities Promise Cool Relief. *New York Times*, April 15.

Quezon City Municipality. 2022. QC, C40 Cities Launches Action Plan vs. Climate Crisis. Available online: https://quezoncity.gov.ph/qc-c40-cities-launches-action-plan-vs-climate-crisis/ (accessed on 10 January 2023).

Räsänen, Aleksi, Sirkku Juhola, Anja Nygren, Mira Käkönen, Maarit Kallio, Adrián Monge Monge, and Markku Kanninen. 2016. Climate change, multiple stressors and human vulnerability: A systematic review. *Regional Environmental Change* 16: 291–302. [CrossRef]

Raven, Jeffrey, Brian Stone, Gerald Mills, Joel Towers, Lutz Katzschner, Mattia Federico Leone, Pascaline Gaborit, Matei Georgescu, Maryam Hariri, James Lee, and et al. 2018. Urban Planning and design. In *Climate Change and Cities: Second Assessment Report of the Urban Climate Change Research Network*. Edited by Cynthia Rosenzweig, William D. Solecki, Patricia Romero-Lankao, Shagun Mehrotra, Shobhakar Dhakal and Somayya Ali Ibrahim. New York: Cambridge University Press, pp. 139–72.

RCI. 2013. *Rotterdam Climate Change Adaption Strategy*. Rotterdam: Rotterdam Climate Initiative.
Reckien, Diana, Monika Salvia, Filomena Pietrapertosa, Sofia G. Simoes, Marta Olazabald, Sonia De Gregorio Hurtado, Davide Geneletti, Eliška Krkoška Lorencová, Valentina D'Alonzo, Anna Krook-Riekkola, and et al. 2019. Dedicated versus mainstreaming approaches in local climate plans in Europe. *Renewable and Sustainable Energy Reviews* 112: 948–59. [CrossRef]
Ribot, Jesse. 2011. Vulnerability before adaptation: Toward transformative climate action. *Global Environmental Change* 21: 1160–62. [CrossRef]
Ripple, William J., Christopher Wolf, Thomas M. Newsome, Phoebe Barnard, and William R. Moomaw. 2020. World Scientists' Warning of a Climate Emergency. *BioScience* 70: 8–12. [CrossRef]
Roggema, Rob, ed. 2012. *Swarming Landscapes: The Art of Designing for Climate Adaptation*. Berlin: Springer Science & Business Media, vol. 48.
Rosenzweig, Cynthia, William D. Solecki, Patricia Romero-Lankao, Shagun Mehrotra, Shobhakar Dhakal, and Somayya Ali Ibrahim, eds. 2018. Pathways to urban transformation. In *Climate Change and Cities: Second Assessment Report of the Urban Climate Change Research Network*. New York: Cambridge University Press, pp. 3–26.
Roskamp, Hanny. 2019. *This Is How Green the Netherlands Could Be in 100 Years*. Wageningen Climate Solutions. Available online: https://magazines.wur.nl/climate-solutions-en/the-netherlands-in-2120/ (accessed on 2 August 2022).
Runhaar, Hens, Bettina Wilk, Åsa Persson, Caroline Uittenbroek, and Christine Wamsler. 2018. Mainstreaming climate adaptation: Taking stock about "what works" from empirical research worldwide. *Regional Environmental Change* 18: 1201–10. [CrossRef]
Siegel, Zoe, Amanda Brown-Stevens, Emma Greenbaum, and Resilient by Design Teams. 2018. The Bay Area Challenge. A Blueprint for Resilience That Harnesses Bay Area Innovation. Resilient by Design. Available online: https://drive.google.com/open?id=1dhR_W19A6uSpDc1Ww_PoTIEP1Vq9o3GI (accessed on 20 November 2022).
Tjallingii, Sybrand P. 1995. Strategies for Ecologically Sound Urban Development. In *Ecopolis*. Leiden: Backhuys.
Turner, Amy E., and Michael Burger. 2021. *Cities Climate Law: A Legal Framework for Local Action in the U.S*. New York: Sabin Center for Climate Change Law, Columbia Law School. Available online: https://scholarship.law.columbia.edu/sabin_climate_change/2 (accessed on 4 January 2022).
Vieweg, Marion, and Ian Noble. 2013. Options for Resource Allocation in the Green Climate Fund (GCF). Incentivizing Paradigm Shift within the GCF Allocation Framework. Background Paper 2. Available online: https://current-future.org/wp-content/uploads/2013_GCF-Allocation-Options_Background-Paper-4.pdf (accessed on 31 August 2022).
WCC-3 (World Climate Conference-3). 2009. Conference Statement—Summary of the Expert Segment. Paper presented at WCC-3, Geneva, Switzerland, August 31–September 4.
Willows, Robert, Nick Reynard, Ian Meadowcroft, and Richenda Connell. 2003. *Climate Adaptation: Risk, Uncertainty and Decision-Making*. UKCIP Technical Report. Oxford: UK Climate Impacts Programme.
Wong, Tony. 2016. *Human Settlements: A Framing Paper for the High-Level Panel on Water*. Canberra: Australian Water Partnership/eWater Ltd. Available online: https://waterpartnership.org.au/wp-content/uploads/2016/08/HLPW-Human-Settlements.pdf (accessed on 31 August 2022).