Chapter 1
A Framework for Resilient Urban Futures

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Abstract Resilient urban futures provides a social–ecological–technological systems (SETS) perspective on promoting and understanding resilience. This chapter introduces the concepts, research, and practice of urban resilience from the Urban Resilience to Extremes Sustainability Research Network (UREx SRN). It describes conceptual and methodological approaches to address how cities experience extreme weather events, adapt to climate resilience challenges, and can transform toward sustainable and equitable futures.

Keywords Urban futures · Co-production · Resilience · Scenario visions · Positive futures

1.1 Introduction

If one were to imagine that each time a disaster or stress strikes people on the earth, a strong beacon would illuminate—like an alert board but extended across the globe—then the cities of the world would frequently light up. Cities would give such

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a strong signal because they are often the places most vulnerable to disasters. Cities concentrate people and infrastructure. They are often located along coasts or rivers and are thus exposed to floods or tropical storms, and are susceptible to drought, fire, and heat. This exposure combined with poor infrastructural and institutional adaptation can mean the difference between a hazard and a disaster. Furthermore, the frequency, intensity, and impact of such events are increasing as human-caused emissions of heat-trapping gases like carbon dioxide and methane continue to rise, spurring changes in the earth's climate system. The coupling of a major demographic transition to urban living with climate change, especially the increase in frequency and intensity of extreme events, presents an increasingly urgent challenge to urban society and decision makers.

In the context of climate risk for cities, interest in the concept of resilience and its application to urban systems has exploded. Resilience has many definitions (Meerow et al. 2016), but for our purposes we open with one that comes from ecology. Resilience is the capacity of a system to maintain its basic structure, function, and identity while undergoing change in the face of shocks and stresses (Walker et al. 2004; Folke et al. 2010). In this definition, resilience is seen as a property of a dynamic system (Elmqvist et al. 2019). Other definitions point to resilience as an outcome or process (Moser et al. 2019). The processes and outcomes that define resilience in an urban social–ecological–technological system (SETS) have to do with deliberate management of that system to build or promote its resilience through adaptation and transformation (Pelling 2010; Biggs et al. 2012).

1.2   An Approach to Urban Resilience Research-Practice

Resilience has gained status as a guiding concept in urban planning and management. In this book, a group of researchers from the Urban Resilience to Extremes Sustainability Research Network (UREx SRN) considers the past, present, and future challenges for cities to build resilience. The UREx SRN is a network of collaborating interdisciplinary researchers and practitioners from diverse world cities working together to promote, design, and implement urban infrastructure that is resilient in the face of future extreme events, provides ecosystem services, improves social wellbeing, and exploits new technologies in ways that benefit all segments of urban populations.

The network consists of over 180 researchers from 21 institutions working together with over 220 practitioners in nine cities of the United States and Latin America. Researchers, including faculty members, staff scientists, post-doctoral fellows, and graduate fellows and associates, represent disciplines within engineering, life, physical, and social sciences. Practitioners include governmental officials (city, county, and state level), community organization leaders, non-governmental organizations, business leaders, and others who are involved to varying extents in decision-making. The cities include Miami, FL; Baltimore, MD; New York, NY; Syracuse, NY; Portland, OR; Phoenix, AZ; and, in Latin America and the Caribbean, Hermosillo, Mexico; Valdivia, Chile; and San Juan, Puerto Rico.

The UREx SRN approach to resilient urban futures has two key elements: SETS and network interactions. The UREx SRN has developed SETS into a comprehensive epistemological framework for understanding and promoting resilience. In this framework, the social, ecological, and technological components of a system all are considered, and resilient strategies integrate all three domains and their interactions. For example, a coastal city like Miami that is experiencing sea-level rise and is exposed to hurricanes and associated storm surges and wind considers coastal fortification, elevating urban surfaces, and pumping out sea water (technological), but may also opt to restore coastal mangrove ecosystems (ecological). These strategies may be adopted by some municipalities but not others (governance; social), perhaps owing to differences in municipal revenue (economics; social). People living in the Miami area are differentially exposed to nuisance tidal flooding, in part as a function of the geographical/topographic setting (ecological) that may be associated with differences in housing prices (social) or the degree to which protective infrastructure (technological) is available. Vulnerability to more severe coastal flooding also varies, with lower-income, marginalized communities—often predominantly Black or Latinx—most at risk (social). These examples illustrate the high degree of spatial and social heterogeneity in who and what is most vulnerable, as well as variability in the number and types of interventions and their SETS interactions that are meant to build resilience against coastal inundation.

Most approaches to improving resilience are siloed, with efforts focused on one or, rarely, two domains. Yet extreme events often cause cascading impacts (Rocha et al. 2018). For example, flooding can simultaneously cause power and transportation disruptions, damage ecosystems, impact human health, and damage homes and critical infrastructure. Recent hurricanes demonstrated failures or inadequacies not only in built infrastructure but also in resources, institutions, and information systems—components of the urban SETS—to prepare for and respond to events of this magnitude (Eakin et al. 2018; Markolf et al. 2018). Solutions that address only one system domain are unlikely to prove resilient in the future. Because impacts occur among interdependent human, climate-biophysical, engineered systems, we suggest a fundamental rethinking, reanalysis, and remaking of cities as social–ecological–technological systems (SETS).

By adopting the SETS framework, the UREx SRN places priority on integrating equity considerations into all projects. Consideration of equity asks us to examine the legacies and continued impact of discrimination, such as redlining in urban planning or discriminatory banking or housing policies and practices, that have produced differential vulnerability today. It also demands that voices of those most affected by potential actions to build resilience are privileged, and that actions proposed or taken do not exacerbate unfair practices.

UREx SRN researchers have advanced the concept of safe-to-fail infrastructure (Ahern 2011; Kim et al. 2017, 2019), which may incorporate natural elements but principally is a new way of thinking about infrastructure under uncertain and changing probabilities of extreme events. In this framing, instead of being designed to withstand events of a certain magnitude, infrastructure systems are conceived as flexible, multifunctional, and able to adapt or transform through the interactions of

S, E, and T. In fact, these interactions are key to thinking about the future and ways to manage for or enhance resilience to increasing frequency and magnitude of extreme events under the SETS framework. For example, green gentrification may accompany the establishment of nature-based strategies (an example might be green swales and rain gardens for stormwater management), a process by which historically disenfranchised populations are pushed out by neighborhood improvements that increase cost of living, or are excluded from green infrastructure planning processes (Kabisch and Haase 2014; Locke and Grove 2016; Hobbie and Grimm 2020). Thinking in terms of SETS requires that future makers consider the social implications of ecological or technological interventions, as well as how social institutions at various scales influence the success of such interventions. Future makers include the wide variety of actors and the governance venues in which residents engage in creating change. These policy actors work with historical narratives, current conditions, and imaginative tools to create visions for the future. A primary research question that the UREx SRN project asks of urban systems science is: how do SETS domains interact to generate vulnerability or resilience, and how can urban SETS dynamics be guided along more resilient, equitable, and sustainable trajectories?

The UREx SRN has developed a strong network of researchers while promoting interaction between researchers and practitioners, and among practitioners from different cities. A focus on positive futures is achieved through scenarios co-produced in each city through participatory workshops engaging diverse practitioners. This co-production of knowledge and action enables incorporation of diverse sectoral, cultural, and disciplinary viewpoints into plausible and desirable future visions for each city. Because UREx SRN has included Latin American cities, shared learning across all UREx SRN cities provides increased capacity and diversity of perspectives on resilience (e.g., information to cities that are experiencing a rise in Hispanic populations), and network-level opportunities for collaboration and collective action (e.g., sharing best practices across international networks).

1.3   Linking the Past, Present, and Future

Throughout this book, the authors discuss conceptual and methodological approaches to address how cities experience extreme weather events, adapt to resilience challenges, and can transform toward sustainable and equitable futures while contributing to urban systems science. This book seeks to advance an urban system research-practice that brings together diverse knowledge, skills, tools, perspectives, and ideas. The objective of this transdisciplinary approach is to build actionable, anticipatory knowledge for decision-making. Each city in the UREx SRN has a researcher–practitioner team that works together to plan research and participatory scenario workshops to co-produce positive visions of those cities' futures. These scenario visions are meant to provide information on how different goals, strategies, and targets can work in synergy or may require trade-offs in decision-making. The first section, Chaps. 2–5, focuses on understanding urban S, E, and T vulnerabilities and resilience.

The second section, Chaps. 6–12, then applies these insights to an innovative framework that guides city stakeholders toward integrating the three domains along more sustainable, equitable, and resilient trajectories.

In Chap. 2, Hamstead argues that we cannot transform cities for future generations unless we unpack ways in which economic and political institutions have created the climate crisis and inscribed climate inequity into the urban built environment. She describes these trends broadly, and uses the example of Puerto Rico to trace ways in which colonialism, land use change, and scientific and political narratives all work together to reinforce societal inequity.

In Chap. 3, Kim et al. describe a methodology to characterize how cities define and prioritize climate adaptation strategies in governance. The SETS framework is used as a lens to explore the dynamics and interrelationships of the goals, solutions, and targets put forth in formal planning documents. This chapter provides a codebook for doing content analysis of municipal planning documents to explore the diverse SETS strategies cities are employing to address climate resilience, specifically related to extreme weather events such as heat, drought, and flooding. The proposed SETS governance analysis helps stakeholders understand how urban planning addresses current and future climate vulnerabilities and explores the various adaptation options that cities have prioritized for the community.

In Chap. 4, Hamstead and Sauer look at how spatial patterns of vulnerability to extreme events are manifestations of structural injustice that leave their mark on the built environment, and the ways in which socio-spatial segregation patterns are aligned with patterns of exposure to extreme events. Spatial vulnerability assessments can be powerful tools for prioritizing where and how cities should make investments for mitigating the impacts of extreme events, and can provide an entry point for asking more fundamental questions about the processes that produce patterns of climate inequity. Using commensurate indicators of exposure, sensitivity, and adaptive capacity, flood and heat vulnerability mapping is used to convey distributional patterns (e.g., mapping urban landscapes and extreme event injustice) that enable communities to identify hazardous biophysical conditions and residents who are most at risk of exposure to those conditions.

In Chap. 5, Hobbins et al. argue that, for a knowledge system to produce quality knowledge for decision-making, it requires more than the best scientific data and the most sophisticated technology; the distribution of power and authority also dramatically influences the quality, legitimacy, and accuracy of the knowledge claims produced by a knowledge system. This chapter demonstrates the value of knowledge systems analysis as a method to stress-test and identify weaknesses of a knowledge system that warrant attention. Knowledge systems analysis can inform potential solutions to upgrade or redesign a knowledge system in support of building resilient cities. This is illustrated through an analysis of the United States Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map knowledge system and sheds light on the underlying social and political dynamics involved in how we know, review and validate, communicate, and use flood risk knowledge.

In Chap. 6, Iwaniec et al. present the UREx SRN framework for scenario development of positive urban futures. Three distinct scenario approaches are used to

explore potential outcomes of existing planning goals (strategic scenarios), to craft visions that address pressing resilience challenges (adaptive scenarios), and to artic-ulate visions of radical departures from the status quo in the pursuit of resilience, sustainability, and equity (transformative scenarios). The scenarios are developed in participatory workshop settings designed to build anticipatory capacity, or very long-term forward thinking. A series of creative and analytical processes are used to engage the community in imagining, articulating, and scrutinizing visions and pathways of positive futures. The approach offers an alternative and complement to traditional forecasting techniques by applying inspirational stories to resilience research and practice.

In Chap. 7, Cook et al. describe the process of co-production in which UREx SRN participatory scenario development takes place. Key characteristics of mean-ingful co-production are highlighted to draw attention to the benefits of engaging in collaborative knowledge production and co-generation of resilient urban futures with diverse perspectives. The chapter focuses on centering a collective commit-ment, enhancing credibility, legitimacy, and accountability, and empowering diverse perspectives through an iterative, flexible process. It also reflects on challenges that must be considered in an engagement, co-production process and the lessons learned from the UREx SRN project.

In Chap. 8, Berbés-Blázquez et al. demonstrate an approach to assess and compare co-produced scenario visions, which consists of a multi-criteria assessment used to explore the resilience, equity, and sustainability dimensions reflected in scenario visions in a qualitative manner (RESQ). This is illustrated by applying the assessment to compare heat and drought visions from Hermosillo and Phoenix. However, the approach described in this chapter is not intended merely as a tool to assess the strengths and weaknesses of a given vision. Qualitative evaluation of a scenario vision (and comparisons among scenario visions) offers an opportunity for reflection and dialog on underlying values and aspirations. The RESQ assessment is also presented as an initial step toward developing futures-oriented indicators of resilience, equity, and sustainability for cities.

In Chap. 9, Ortiz et al. introduce land use modeling techniques to produce and evaluate spatially explicit urban futures via the UREx SRN scenario co-production process. Weather hazards, projected to become more frequent and intense, pose critical threats to cities and the people in them. The complexity and scale of these threats will require adaptation strategies that meet their scale. This chapter presents data-driven techniques to estimate impacts of land use change on heat and flood risks in cities that combine statistical and process-based approaches. These approaches quantify heat and flood hazard as a function of the urban landscape that responds to a large-scale climate signal. Co-produced future land use scenarios can then be evaluated on their impacts on heat and flood hazard following the techniques provided in the chapter.

In Chap. 10, Sauter et al. present a data visualization approach as an interactive web application to visualize urban SETS. The platform was conceived as a tool to produce anticipatory knowledge, bridging the gap between quantitative social, ecological and infrastructure data, and the rich and layered qualitative insights compiled from local

stakeholder scenario visioning workshops. The objective is to support the exploration and understanding of complex geospatial relationships for use in research and decision support, and to do so in a simple and organized way while avoiding visual outputs that cognitively overwhelm the viewer.

In Chap. 11, Muñoz-Erickson et al. make the case for anticipation as a critical component of building resilience and the need to embed anticipatory thinking in urban planning practices and knowledge systems. This chapter introduces "anticipatory resilience" as a futures-oriented knowledge system that intentionally explores alternative, desirable future states and suggests a portfolio of tools suitable for building long-term foresight capacity in urban planning. Examples of knowledge systems interventions are presented to explore the trade-offs, constraints, possibilities, and desires of diverse future scenarios co-generated in settings with people from different perspectives, knowledge, and expectations.

The book concludes with a vision for advancing the science and practice of co-producing positive, urban futures. This final chapter discusses the importance of systems thinking, the need to advance development of an urban systems science but also an urban systems practice, and why positive visioning is key to counter the dystopian narratives and scenarios that dominate discourses of our shared urban future. The need for inclusive and diverse engagement and the recognition of the privilege of both those who are able to do urban futures work and also those that tend to be included in co-production is provided as a key learning from the UREx SRN work as well as a call to action for more just and inclusive processes in envisioning and planning more resilient urban futures.

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