1 Building Resilience to Natural Hazards in the Context of Climate Change—Introducing the Focus and Agenda of the Edited Volume

Gérard Hutter, Marco Neubert, and Regine Ortlepp

1.1 Purpose and Focus of the Volume

The decade from the year 2011 to the year 2020 was the "hottest" in history and the average global temperature by 2020 has risen by 1.2 °C since the start of the industrial era (see IPCC 2018 for more details). With extreme weather events becoming more frequent and prospects of the negative impacts of climate change intensifying, the need to enhance resilience is obvious.

Resilience has become the hope for many that cities and regions as well as whole societies are increasingly capable of dealing with risk and uncertainties related to natural hazards in the context of climate change, especially extreme events and their potentially disastrous consequences. Consequently, the bodies of literatures on resilience, natural hazards, and climate change are continuously growing. There are manifold references to resilience concepts like "urban resilience" (Coaffee and Lee 2016; Coaffee et al. 2018; Elmqvist et al. 2019; Meerow et al. 2016) and "urban disaster resilience" (e.g., Zhang et al. 2020).

This edited volume follows the purpose of making a focused contribution to these growing literatures. We as editors (and authors) and our collaborators want

G. Hutter (✉) · M. Neubert · R. Ortlepp
Leibniz Institute of Ecological Urban and Regional Development (IOER), Dresden, Germany
e-mail: g.hutter@ioer.de

M. Neubert
e-mail: m.neubert@ioer.de

R. Ortlepp
e-mail: r.ortlepp@ioer.de

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to provide a coherent set of conceptual and empirical contributions to the overall theme of the volume "Building resilience to natural hazards in the context of climate change—Knowledge integration, implementation, and learning". Theoretical and methodological arguments remain in the background of argumentation. The following explains further what coherence in our context of research and practice means.

Coherence results from the focus of this edited volume on issues of *climate change adaptation at local and regional level in cases from Germany*. Climate policy and governance are both based on climate change mitigation and adaptation. However, the contributions to this volume are more about the latter than the former. Policies and governance arrangements *above* local and regional level are important background conditions of efforts to build resilience in cities and regions (e.g., IPCC 2018; see Biesbroek and Swart 2019 on the adaptation strategy of the EU; Die Bundesregierung 2020; Vetter et al. 2017). We assume that cities and regions, especially actors in large cities, have significant leeway to establish their "own" specific efforts of building resilience to natural hazards. We understand building resilience as a core element of urban resilience. The expression "building resilience" refers to both (1) social processes of increasing resilience and (2) intended change of the building stock and related blue and green infrastructures (including open spaces and urban greenery) as well as intended change of grey infrastructures.

It has become common to consider the high diversity of understandings of resilience in research and practice.[1] Not surprisingly, readers will *not* find only one specific understanding of resilience in this edited volume. This is so not least because engineers, physical geographers, social scientists, and urban planners have contributed to this volume and resilience is therefore contextualized in diverse "messy histories" (Ansell 2019, p. 3) of research streams on dealing with crisis, catastrophe, risk, and uncertainty.

Coherence results especially from efforts of the contributors to argue about resilience with regard to specific natural hazards, actors involved in dealing with such hazards and their actual and possible consequences for the stock of buildings and infrastructures in cities and regions. Contributions mainly deal with river floods and risk related to heavy rain fall as well as rising temperatures, heat waves and associated droughts in urban areas. Hence, only selected issues of high

[1] Some even state that the resilience word may have only "low scientific status" (Jore 2020); see also Brand and Jax (2007) with regard to resilience as "boundary object" in contrast to resilience as narrowly defined concept of high scientific status that is useful in empirical analysis.

priority of the German strategy for climate change adaptation are addressed in this volume (Die Bundesregierung 2020).

It is interesting to see that one of the most widely mentioned arguments *for* resilience is the positive connotation of the word in the context of uncertainty and crisis (Meerow et al. 2016; Abeling et al. 2018; Die Bundesregierung 2020). In policy contexts and at the interface of policy, practice, and research, resilience in general, climate and building resilience in particular, may serve as a somehow fuzzy or ambiguous reference point for communication among public, private, and intermediary actors. Compared to this, the agenda of the volume is relatively focussed. Contributions deal with issues of knowledge integration, implementation, and learning in cities and regions. The following further elaborates on this agenda.

1.2 Introducing the Agenda

An agenda summarizes the main topics of a communication format and indicates why the selected topics are in the foreground of discussion. It may entail priorities between topics. The agenda of this edited volume encompasses four main topics:

- Building resilience as a core element of urban resilience,
- Knowledge integration,
- Implementation at local level,
- Learning in the context of participation and multi-level governance.

The following briefly comments on each point in turn.

1.2.1 Building Resilience as a Core Element of Urban Resilience

The term "resilience" is used in many research efforts, policy discourses, and practices of climate change adaptation. The term is related to a broad spectrum of phenomena. For instance, psychologists focus on the resilience of individual persons (Masten 2014). Management and organizational scholars highlight the conditions and social processes of organizations in the context of volatile markets and unexpected events (Weick and Sutcliffe 2015). Governance researchers address the resilience of public administrations and governance arrangements (Duit 2016). Economic geographers are interested in resilience as capability and condition of regional growth pathways (Boschma 2015). Researchers that engage

in research on Social-Ecological Systems (SES) follow the most encompassing view on processes of resilience in which diversified, but nested systems are related through dynamic processes that generate social-ecological resilience (or not) (Elmqvist et al. 2019; Folke et al. 2010; Deppisch 2017). Scholars interested in the question how cities and regions deal with past crises and catastrophes as well as future risks and uncertainties may prefer the concept of "urban resilience" (e.g., Coaffee and Lee 2016; Coaffee et al. 2018). Some scholars argue that high diversity of resilience understandings has turned the term into something of "poor scientific status" (Jore 2020, p. 15) or—even worse—into something that is "vulnerable" to ideology-driven misuse and over-biased policy-making (e.g., neoliberal policies of allocating responsibility to private actors, for instance, citizens that need to prepare for low-probability events in the context of climate change, Coaffee and Lee 2016; Tierney 2015; see also the contribution of Zimmermann and Lee in this volume).

We assume that the term "resilience" helps, if the multiplicity of possible meanings of the word is taken into due account (Davoudi 2018) and if contributors to the volume consider the historical context[2] of how they understand resilience in their argumentation. We understand building resilience as one core element of urban resilience. "Urban Resilience refers to the ability of an urban system—and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales—to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity" (Meerow and Newell 2016, p. 7). Some comments on this understanding are in order (see also Elmqvist et al. 2019): Firstly, urban resilience is framed as an *ability* (or capacity) to deal with disturbance and change. Hence, this definition does not highlight the usage of resilience for ideological and political purposes (e.g., resilience as a "myth", Kuhlicke 2013). Of course, we do not deny that such usage of the term is possible (e.g., Hutter and Lorenz 2018). Secondly, resilience refers to an urban *system.* The term "system" also has multiple meanings, for instance, with regard to a specific system theory (e.g., systems as closed or open systems). In this introduction, "system" simply means that urban resilience emerges from complex processes that relate manifold

[2]With regard to the general problem of "conceptual pluralism", Ansell (2019) speaks of partly overlapping, partly different entailments of one term in the context of "messy histories" of research streams that use the same word in different scientific disciplines, debates, and policy discourses. Conceptual pluralism happens in many research streams and policy discourses (e.g., strategy, governance, and knowledge, to name just a few terms). Ansell (2019) underlines that conceptual pluralism is here to stay, so we have to deal with it without oversimplification of diverse contexts and messy histories.

physical and social elements and multiple spatial and temporal scales—more or less directly coupled. Thirdly, this definition of urban resilience is a broad one, because it refers to the ability to maintain functions, to adapt to future change, and to transform for more resilience in the future (Elmqvist et al. 2019).

The expression "building resilience" refers to both *social processes* and *physical outcomes*. As outcome, building resilience means intended change of the building stock and related blue, green, and grey infrastructures in urban areas. As social process, building resilience refers to process patterns through which urban systems develop more resilience in the future. Building resilience as social process corresponds with strategies for the mid- to long-term (e.g., Comfort et al. 2010; Chelleri et al. 2015). We cannot provide a comprehensive picture of many process patterns that are important for building resilience. We focus on *goal-driven* processes of building resilience ("goal-driven" is similar to "teleological", Van de Ven and Poole 1995): Actors involved in urban systems are (to some extent) dissatisfied with the status quo. They envision improvements and formulate goals. They undertake individual and collective efforts of knowledge integration and implementation, and they seek to learn from experience (including "anticipated experience", for instance, through scenario-based learning). We highlight three process patterns[3]: (1) Knowledge integration, (2) implementation on the level of the local building stock, related infrastructures and open spaces, and (3) learning in the context of participation and multi-level governance.

1.2.2 Knowledge Integration

Tell (2011) distinguishes between three approaches to knowledge integration: Knowledge integration as (1) sharing or transferring knowledge, (2) as use of similar/ related knowledge in a specialized knowledge domain, and (3) as the combination of specialized, but complementary knowledge. In this volume, we emphasize *knowledge integration as the purposeful combination of specialized and complementary knowledge to accomplish specific tasks.* Knowledge integration in this understanding is especially important for building resilience, because

[3]This does not necessarily mean that every contribution to the volume addresses issues with regard to all three process patterns. Usually, there is an emphasis on one selected pattern (e.g., see the contribution by Hutter et al. in this volume on knowledge integration). Sometimes, authors address issues of knowledge integration and implementation (practicability), e.g., see the contributions by Olfert et al. in this volume on sustainability and resilience and of Ortlepp et al. on building heat-resilient neighborhoods).

enhancing the ability to persist, adapt, and transform in the face of disturbances and changes often requires the inclusion of actors from different knowledge domains, with different interests, and different responsibility (e.g., citizens from a specific neighbourhood, spatial planners responsible for this neighbourhood, local politicians as members of the city council, and experts from water and crisis management research and practice). Manifestations of knowledge integration may be found in inter- and transdisciplinary research projects (Hirsch Hadorn et al. 2008). Furthermore, contributions to the resilience literatures often highlight the challenge of overcoming "knowledge silos" based on institutionalized responsibility and accountability, administrative procedures and politics. They point into the direction of enhancing collaboration and knowledge integration to meet the challenge of "urban resilience implementation" (e.g., Coaffee et al. 2018).

Building resilience to natural hazards in the context of climate change is a knowledge-intensive process across multiple social, spatial, and temporal scales. Of course, integrating *all* knowledge (or as much knowledge as possible) in the sense of an intended maximum of sharing and transferring knowledge is *inefficient*. Specialization of knowledge domains on the one hand and knowledge integration on the other need to go "hand in hand", but this does not easily happen in cities and regions. As project examples on climate change adaptation in cities and regions in the Dresden region show (see Neubert & Schinke, Ortlepp and colleagues, as well as Hutter & Olfert in this volume), researchers and practitioners alike may experience difficult times trying to integrate knowledge and to learn how to build resilience over the mid- to long term. Limitations in efforts of knowledge integration have many causes and consequences and the contributions to the volume explore this complexity to some extent (see below).

Integrating scientific and professional knowledge that focuses on descriptive and explanative knowledge is an important effort in building resilience. However, knowledge integration also encompasses efforts of integrating "facts" and "values" (e.g., systems knowledge, target knowledge, and transformation knowledge, Hirsch Hadorn et al. 2008). Facts may continuously be the object of update and reconsideration. In contrast, values are often embedded in "messy histories" (Ansell 2019, p. 3) of complex justifications and institutions in society—as the contribution of Thaler on resilience and justice in flood risk management shows (Chap. 3, see also the contribution by Zimmermann and Lee, Chap. 9 in this volume). As editors, we can quite easily contend that issues of justice in building resilience to natural hazards need more in-depth consideration. However, much remains to be accomplished to establish justice as a core element of building resilience to natural hazards in urban areas (Davoudi 2018; Ziervogel et al. 2017). Furthermore, we need practical approaches that show how the complexity

of value-related criteria of sustainability and resilience can be considered "on the ground" in urban systems (see the contribution of Olfert and colleagues in this volume).

1.2.3 Implementation at Local Level

Implementation in this volume means, first and foremost, that specific measures to physically and intentionally change the building stock as well as related blue, green, and grey infrastructures have been accomplished in the "real world". We cannot provide a survey of measures that have been realized in a population of cases (Gerringson and Christenson 2017).[4] The contributions to the volume focus on selected cases of implementation and report on these cases in vivid detail (e.g., see contributions by Ortlepp and colleagues as well as Eisenberg and colleagues). They show that incremental changes for building resilience may require intensive communication processes and resource allocations of the actors involved. Furthermore, contributions ask how participatory and communicative instruments can motivate private actors such as residents of flood-prone urban areas to make structural changes in their homes (e.g., Grothmann & Michel).

As mentioned, this volume focuses on conceptual and empirical contributions. Hence, theory-justified explanations of implementation issues are not of high priority. However, the empirical accounts point to some important factors for future studies. Adopting the perspective of collaborative policy making, Ansell and colleagues (2017) distinguish between four typical failures of policy implementation: Design failure, top-down-failure, bottom-up failure, and limits of steering capacity of public actors with regard to private and intermediary agents. The contributions to the volume give manifold insights how to avoid design failure on the local level with regard to specific contents of building resilience. They point to factors that limit public steering capacity (e.g., spatially and socially fragmented property rights of buildings). We address issues of top-down- and bottom-up failure under the topic of learning.

[4]Some survey information on the "state of work" of implemented measures for climate change adaptation on local level (municipalities in a formal sense) can be found in the „Zweiter Fortschrittsbericht zur Deutschen Anpassungsstrategie an den Klimawandel " (Die Bundesregierung 2020, especially part B.3 on implementation).

1.2.4 Learning in the Context of Participation and Multi-level Governance

Learning is a manifestation of "human agency" (Emirbayer and Mische 1998). Many scholars would probably agree that learning happens, if actors show efforts of reflection and deliberate change in knowledge on relations between the content, processes, and context conditions of action (e.g., Carroll et al. 2003). Different theories and models seek to differentiate between how this happens, the degree of deliberateness of change, various types of knowledge, and so forth (Biggs et al. 2015). Learning can refer to experience in the past and anticipated "experience". Learning may also mean learning when and why *not to change* knowledge (Weick and Westley 1996).

The edited volume is open with regard to the learning patterns addressed, but tries to focus on *similar occasions for learning*. In the context of climate change adaptation policy in Germany, a significant number of pilot projects and innovative actions have been undertaken at local and regional level (see Die Bundesregierung 2020; see Turnheim et al. 2018 for case studies in European member states). Some pilot projects were justified and established through referring to the notion of resilience. Other projects may have contributed to building resilience without explicitly using the term. In the edited volume, we are interested in both types of pilot projects and innovative actions (see, for instance, the contributions by Neubert & Schinke, Ortlepp and colleagues as well as Hutter & Olfert on pilot projects in the Dresden region).

Learning as a social process is related to the context conditions and contents of building resilience to natural hazards. The contributions to the edited volume address issues of learning at local and regional level. For instance, the contribution by Grothmann and Michel investigates the effectiveness of participation processes for building resilience in four German cities (Bremen, Kempten, Lübeck, Worms), focusing on learning effects regarding knowledge gains, behaviour change and building of social capital. Karsten Zimmermann and Dahae Lee address the dynamics of building resilience at multiple governance levels in the Ruhr region.

Taken together, these contributions show that design choices based on "facts and figures" are not sufficient for building resilience to natural hazards in the context of climate change. Even intended incremental changes do not happen easily and without continuous efforts of actors in urban regions to build resilience in the mid- to long-term. Pathways of transformations to increase the resilience of urban systems entail much higher complexity and much more dynamic relations at multiple social, spatial, and temporal scales (e.g., Birkmann et al. 2016; Elmqvist

et al. 2019; Endlicher and Kress 2008; Köhler et al. 2019; Pelling, 2011; Wolfram, 2016). We understand this edited volume as a coherent set of conceptual and empirical contributions that facilitate future studies on pathways to increase adaptive and transformative capacity for building urban resilience and for dealing with the consequences of climate change.

1.3 Overview Over the Contributions to the Volume

We structured the contributions to the volume roughly in accordance with two ideas: Firstly, we followed the trinity of knowledge integration, implementation, and learning. All contributions seek to consider contents, processes, and context conditions of building resilience. However, chapters that address issues of knowledge integration and implementation emphasize contents, whereas chapters that follow a learning orientation highlight processes and context conditions like participation, multi-level governance, and project-based learning. Secondly, contributions are clustered according to the natural hazards that are in the foreground of argumentation. We begin with three chapters that highlight river floods, especially low-probability flood events. Chapters on heat stress and associated droughts as well as on managing the risk of heavy rain fall follow.

Gérard Hutter and colleagues focus on the topic of *"Knowledge integration for building resilience—The example of flood risk maps"*. This conceptual contribution emphasizes knowledge integration as purposeful combination of specialized and complementary knowledge to accomplish a specific task. The example of developing flood risk maps illustrates knowledge integration. Thereby, the authors use the well-known distinction between specified and general resilience. They understand developing flood risk maps as manifestation more of the former than the latter, especially with regard to low-probability flood events. The chapter shows how to combine concepts of (interdisciplinary) knowledge integration and concepts of urban resilience (including secondary effects of floods through increases in groundwater levels in urban areas).

Thomas Thaler provides a conceptual contribution on the topic of *"Justice and resilience in flood risk management: What are the socio-political implications?"*. He argues that flood risk management requires to comprehensively assess how policies may affect individuals and communities, but actual policies and practices often downplay or even increase social inequality. His contribution critically questions the roles of social justice and their political implications for flood risk management with regard to resilience. The chapter considers a broad range of concepts as well as different perspectives on justice (e.g. social, environmental and

climate justice). The author urges us to take concepts of justice more seriously when discussing issues of resilience and flood risk management.

Marco Neubert and Reinhard Schinke analyse the topic of *"House lifting to improve resilience in Settlement Areas—an example from the Elbe village Brockwitz (Saxony, Germany)"*. They empirically compare the traditional flood protection measure of dyke construction with the measure of house lifting including land filling for a small-scale area (the Elbe village of Brockwitz/Coswig in Saxony, Germany). The interdisciplinary analysis of the two alternatives considers a complex set of criteria of sustainability and resilience and shows that house lifting has, among others, specific advantages with regard to the consequences of low-probability flood events. The chapter shows how to apply efforts of knowledge integration "on the ground" of building resilience at the local level.

The challenge of integrating criteria of sustainability and resilience is also in the foreground of the chapter provided by Alfred Olfert and colleagues on *"Sustainability and resilience—A practical approach to assessing sustainability of infrastructures in the context of climate change"*. Based on extensive empirical work, they propose a new evaluation tool for in-process sustainability assessment of local infrastructure innovation designed for early stage phases of development. This tool treats resilience as integral part of sustainability. They focus on the resilience of socio-eco-technical infrastructure systems at the local level to external disturbances such as climate change-influenced weather extremes. As a reference for the sustainability check, an operational stability-oriented understanding of resilience ("bounce back") based on "engineering resilience" is adopted. Among others, they argue that the sustainability assessment tool helps to mediate between diverse professional perspectives and, hence, supports, knowledge integration.

Issues of building resilience to heat stress and droughts are addressed in the chapter of Regine Ortlepp and colleagues on *"Heat-resilient neighbourhoods—Testing the implementation on buildings and in open spaces in two sample quarters Dresden and Erfurt"*. The chapter reports on measures that were implemented in two sample quarters in the cities of Dresden and Erfurt. A complex set of measures addresses intended change on the building scale and with regard to green and open spaces. The selection of measures for evaluation and implementation took place on the basis of an inter- and transdisciplinary process to consider both scientific effectiveness analysis and how measures are perceived and accepted by residents. The chapter also reports on measures that were planned to be implemented, but could not be implemented due to various reasons. Like the chapter of Marco Neubert and Reinhard Schinke, the chapter takes us "on the ground" of building resilience to natural hazards in urban areas. The chapter is relevant for issues of knowledge integration and implementation.

Bernd Eisenberg and colleagues report on *"The Impulse Project Stuttgart—Stimulating resilient urban development through blue-green infrastructure"*. They argue that, given increasing temperatures and less summer precipitation due to climate change, the maintenance and management of green spaces is essential and challenging. The chapter describes the development and implementation of a one-on-one model for urban resilience on the building scale. Designed as both a public space with high aesthetic value and an open lab, it also serves as a starting point for a debate about resilient urban development through blue-green infrastructure in Stuttgart and elsewhere. The Impulse Project Stuttgart shows how compact blue-green infrastructure can be successfully implemented in densely populated urban spaces, thereby significantly contributing to the urban microclimate, flood protection during stormwater events, and alleviating the demand for drinking water through its substitution with rainwater and greywater.

Scholars and practitioners alike argue that building resilience involves participation. In this context, Torsten Grothmann and Theresa Michel report empirical findings on *"Participation for building urban climate resilience? Results from four cities in Germany"*. They observe a lack of evaluation studies that empirically validate the many expected positive effects of participatory approaches. The authors develop a new resilience concept differentiating three dimensions: resilience knowledge, action and network. They apply this concept to the evaluation of eight government-led public participation events on adaptation to climate change, particularly to increasing heavy rain events, in four cities in Germany (Bremen, Kempten, Lübeck, Worms). Results of the participant questionnaires indicate that the events were effective in increasing participants' knowledge (particularly knowledge integration), action (supporting rather than triggering action) and networks. But increases were only moderate and could not be achieved for all participants. Hence, Grothmann and Michel conclude that the positive effects of participatory approaches on building resilience should not be overestimated. The chapter also addresses the important issue of assigning and sharing responsibilities for building resilience between public and private actors.

Karsten Zimmermann and Dahae Lee approach the topic of *"Building resilience in the context of multi-level governance—Insights from a living lab in the Ruhr"* from a critical perspective. Like others, they observe that the term "resilience" is used in an inflationary way and recent publications discuss resilience critically. They acknowledge that much of the criticism of the fashionable notion of resilience does make some sense, but they still argue that the resilience word has theoretical and practical value as it points to the capacity to change a city or region. This includes collective learning and multilateral forms of governance and a stronger recognition of city-region governance. However, what is

missing in debates is a stronger consideration of the political science literature on governance, decentralization and public policy analysis. They illustrate their argumentation through referring to a case study from the project "Future of the City-Region Ruhr" (Zukunft-Stadt-Region-Ruhr, ZUKUR).

Gérard Hutter and Alfred Olfert provide a conceptual contribution on *"Project-based learning for building urban resilience—Reflecting on project examples of climate change adaptation in the Dresden region"*. They ask how partners in projects on climate change adaptation contribute to building urban resilience, if such resilience is understood as ability of permanent evolutionary urban systems and if projects are understood as temporary designed collective actions. The authors develop the outline of a new typology that considers two dimensions: Learning options may vary with regard to whether learning agents consider whole systems or only sub-units of a system. Opportunities further vary with regard to whether agents aim to increase adaptive capacity or also transformative capacity. They illustrate this learning approach through two project examples on climate change adaptation in the Dresden region (REGKLAM with a duration from 2008 to 2013 and HeatResilientCity (HRC) with a duration from 2017 to 2021).

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