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Urban Disaster Resilience and Security

Addressing Risks in Societies

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Editors

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Addressing Risks in Societies

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Preface

Resilience—is it still the hype when you read this book? It might depend on the background you have, the discipline, field of research or action, country or time. While some might have felt resilience is already past its hiatus, resilience has remarkably shown persistence. In some academic fields, resilience is burgeoning, in others mushrooming, in other fields, disputed. Even when we started planning this book, or on some conference sessions in 2012 when we first gathered authors for this book, disaster resilience was not a novel topic. However, over years, we heard demands to illustrate whether and how such a multifaceted concept of resilience could be put into practice or be operationalised when there existed so many different definitions. This book tries to contribute selected examples how resilience is conceptualised and how researchers and practitioners try to work with it.

The selection of topics, authors and chapters resulted from the editors' interests in recent research and policy fields; notably, critical infrastructure and civil protection as well as urban resilience in the context of Disaster Risk Reduction (DRR), Climate Change Adaption (CCA), man-made hazards and threats. On a methodological side, we were interested in measurability of resilience, but embracing both qualitative and quantitative approaches. We are very grateful that so many authors from our wish list agreed to contribute their interesting perspectives to this book. Authors come from various disciplines and countries (with a slight focus on Europe), but we also include perspectives from Iran, Nepal and the USA. This broad perspective is important to foster future discussions on this topic. To ensure the overall quality of this volume, all chapters were cross-reviewed by authors of other chapters and editor-reviewed.

We would also like to thank a number of authors who had intended to deliver a chapter but could not due to brevity of time in the end. We hope to stay connected for continuing research and knowledge transfer in this area.

Cologne, Germany — Alexander Fekete
Wuppertal, Germany — Frank Fiedrich

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Prof. Frank Fiedrich studied Industrial Engineering and received his Ph.D. from the Karlsruhe Institute of Technology, Germany, where he worked on Decision Support Systems and Agent-based Simulation for disaster response. From 2005 to 2009, he was Assistant Professor at the Institute for Crisis, Disaster, and Risk Management ICDRM at the George Washington University, Washington DC. Since 2009, he is chairing the Institute for Public Safety and Emergency Management at the University of Wuppertal. His research interests include the use of information and communication technology for disaster and crisis management, societal, organisational and urban resilience, interorganizational decision-making, critical infrastructure protection and societal aspects of safety and security technologies. Additionally, Professor Fiedrich is honorary member of the International Association for Information Systems in Crisis Response and Management (ISCRAM).

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Chapter 1
Introduction to ‘Urban Disaster Resilience and Security—Addressing Risks in Societies’

Alexander Fekete and Frank Fiedrich

Abstract Resilience as a term carries an emphasis on temporal development after an event. It also stresses the phase of rebounding after an impact. There is still a lack of disaster resilience operationalization or measurement, which impairs the credibility of the multi-facetted resilience concept, for both science and decision-making. On the other hand, measurability and bouncing back conceptualisations are criticised on multiple grounds; myopia on the range of holistic abilities commonly associated with resilience and neglect of context better to be captured with qualitative approaches. Addressing risks in societies prompts investigating all aspects of resilience conceptualisation and attempts at assessing it —and it is the ambition of this book to highlight examples and at the same time critically reflecting about their reach and limitations. Security and resilience are both terms used for framing a whole field of research and policy. Overlaps are hardly researched, however and the edited chapters will address certain recent aspects that will help to identify features for a common understanding and framework of risk, security and resilience. Urban areas are used here as a common denominator of human values and assets, exposed to different types of external and internal threats to security, which stimulate different types of resilience.

Keywords Disaster resilience · Resilience measurement · Risk parameters
Resilient cities

Urban areas of any size are centres of human values, achievements, culture and development. Urban areas are also are prone to natural and man-made crises and disaster impacts due to the concentration of human lives, assets and values. At the

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same time, urban areas are prone to changes, be it urban growth or decline, cultural and political regime shifts or climate change. This book investigates the interrelations of disaster impacts, resilience and security in an urban context. Urban as a term captures megacities, cities, and generally, human settlements, that are characterised by concentration of quantifiable and non-quantifiable subjects, objects and value attributions to them. Much focus and emphasis have already been cast on megacities and 'resilient cities'. However, mid-sized cities, urban rims and smaller towns are also in the scope of this volume as they deserve attention as well.

The scope of this volume is to narrow down resilience from an all-encompassing concept to applied ways of scientifically attempting to 'measure' this type of disaster-related resilience. The book will reflect opportunities and doubts of the disaster risk science community regarding this 'measurability'. Therefore, examples utilising both quantitative and qualitative approaches will be juxtaposed. This volume concentrates on features that are distinct characteristics of resilience; how they can be measured, and in what sense they are different to vulnerability and risk parameters. Resilience as a term carries an emphasis on temporal development after an event. It also stresses the phase of rebounding after an impact.

There is still a lack of disaster resilience operationalisation or measurement, which impairs the credibility of the multifaceted resilience concept, for both science and decision-making. This volume combines studies on a hypothetical pre-event estimation of resilience with studies on revealed resilience recorded after an event. Such post-event information can be helpful to identify benchmarks or margins of impact magnitudes and related recovery times, volumes and qualities of affected populations and infrastructure. Infrastructure is the physically built environment as well as lifelines and what is termed 'critical infrastructure services' for a settlement (Fekete 2011). Such information of post-event resilience measurements and benchmarks of impacts and recovery will be paramount to validate existing resilience and risk estimations such as spatial risk zonations, vulnerability indicators and surveys.

1.1 Research Field Domain

'Urban disaster resilience' is a sub-domain of urban resilience, which is a sub-domain of several domains such as urbanisation, global change and others. However, within the specific focus of this volume, 'urban disaster resilience' is mainly regarded as a sub-domain of what is termed here, Disaster Risk Research, but what is more commonly known as Disaster Risk Reduction or Disaster Risk Science.

1.2 Adopted Research Paradigm and Concept

The resilience concept used in this volume mainly adopts views of social–ecological systems research that includes perspectives of (general) system theory, hierarchy theory, complexity theory and adaptive systems. There is also a connection to what is often termed a technical or engineering view on resilience. But also action theory from social sciences is important within 'community resilience'.

Resilience in this volume, however, is embedded within a Disaster Risk Management (DRM) concept (related to Disaster Risk Governance) with a conceptual structure of underlying temporal phases before, during and after a crisis, which closely fits to the social–ecological systems understanding of resilience. Apart from such life cycle models, the DRM concept adopts a process view closely related to project management phases where resilience is one step within a process that includes stakeholder inclusion, communication, analysis, evaluation and action steps to be taken.

The umbrella concept for DRM in this volume is security which itself contains not just the aspects of epistemic uncertainty, but also aleatoric uncertainty. In the commonly used 'safety and security' terminology, security is often associated only with security measures such as surveillance cameras. In this book, we also aim at expanding this notion. Security contains more than dealing with uncertainty of knowing; it also includes uncertainty about futures, preferences and distributions of societal values (Frei and Gaupp 1978) (Fig. 1.1).

Resilience has become a major paradigm in disaster risk research. In the Yokohama strategy (United Nations 1994), resilience appeared only once, even in the review of the strategy in 2005 (United Nations 2005) only twice. Vulnerability, on the other hand, is found in both documents a great number of times. In the Hyogo Framework for Action (UNISDR 2005) and the follow-up recent Sendai Framework for Disaster Risk Reduction (SFDRR) (United Nations 2015), resilience is the predominating term. While it has become almost unavoidable to use it in

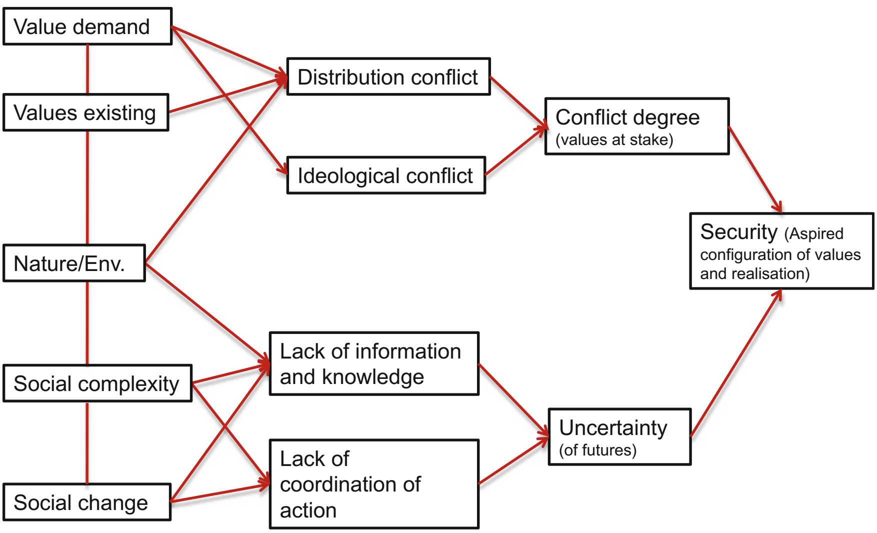

Fig. 1.1 Security components framework (translated and modified after Frei & Gaupp 1978)

work on DRR, the methodological application of resilience is fuzzy and often debated (Manyena 2006; Manyena et al. 2011; Alexander 2013). There appears to exist a demand to advance and apply resilience assessments (Kelman et al. 2016).

The etymology of the word 'resilience' is the Latin verb 'resilire' meaning to rebound or, more precisely, to jump back. According to the Merriam Webster dictionary, resilience is commonly defined as 'the capability of a strained body to recover its size and shape after deformation caused especially by compressive stress'. The IPCC and UNISDR (2009) define resilience as:

> The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.

The concept of resilience has origins in different disciplines (Alexander 2013), in relation to DRR and CCA notably, but not exclusively, to complex adaptive systems (Holling 1973) Resilience in this line is related to equilibrium concepts and stability (Berkes and Folke 1998). Feedback loops, non-linearities and adaptation are common features of such resilience concepts (Gunderson and Holling 2002). While vulnerability is more often conceptualised as static assessments (Adger 2006), resilience is more about the dynamics of a system and its recovery (Bruneau et al. 2003). Nevertheless, many overlaps between vulnerability and resilience exist, especially visible when comparing older definitions, for instance, used by UNISDR. Some authors have therefore stressed being more specific (Walker et al. 2004). The concept of resilience provides an appropriate framing for conceptualising cross-scale, cross-border and cross-sectoral interactions and provides more flexibility than common protection approaches (Landstedt and Holmström 2007). There are many interlocking influences of resilience from different origins and disciplines such as ecology, engineering sciences, psychology (Alexander 2013; Lorenz 2013; Fekete and Hufschmidt 2014). Apart from a system understanding, there are other conceptions of resilience such as a human capital understanding of resilience (Edwards 2009) which is often applied in so-termed community resilience approaches (Maguire and Cartwright 2008) or psychological conceptions of resilience, or behavioural and risk perception studies. In this volume, disaster resilience is understood as to what extent and degree systems recover from a disaster and reach a new state of existence (Holling 1973; Folke 2006; Gallopín 2006; UNISDR 2009).

1.3 Resilience and Vulnerability as Predominant Concurrent Concepts in Disaster Risk and Security Research

The Hyogo Framework for Action (UNISDR 2005) is an internationally recognised key document promoting the application of concepts and methods of achieving resilience and vulnerability in the context of natural hazard impacts. The first phase of the Hyogo Framework for Action (HFA) ran from 2005 to 2015 and has been evaluated, for instance, at the Geneva global platform for DRR, May 2013. Amongst many different DRM and CCA concepts, the HFA evaluation process has led to scrutinise how resilience and vulnerability have been put into action, and to critically analyse the benefits and pitfalls of these concepts and their application in practice. The Sendai Framework for Disaster Risk Reduction (SFDRR) is the follow-up strategy for the years 2015–2030 that incorporates lessons learned from the HFA. Resilience is the key overall paradigm, and vulnerability assessments are still promoted, infrastructure assessments emphasised.

Resilience and vulnerability have also been key concepts in the realm of climate change adaptation research in the recent past (Manyena 2006). There exist major conceptual overlaps, and a great number of documents analyse the interrelations of climate change to expectations of recent or future disaster impacts (IPCC 2012). In the climate change community, the concepts of resilience and vulnerability (R&V) and their applications in practice are increasingly questioned and challenged by alternative ideas and models. Recently, some researchers have explored alternative concepts, such as loss and damage measurements, in order to provide incentives for the troubled international climate change negations of the IPCC (Wrathall et al. 2015; Fekete and Sakdapolrak 2014). Now, many scientists who are purveyors of the resilience and vulnerability paradigm must return to long-abandoned concepts in order to propel delicate negotiations and debates in the international community forward. However, the vagueness of R&V, as compared to the more easily observed facts of loss and damage, has encouraged scholars and practitioners to put R&V to the test. Some countries, like Germany, have been eager to explore the benefits of R&V for national civil protection schemes (Workshop in Berlin 17–18. Feb. 2013 by acatech, Fraunhofer and Forum Öffentliche Sicherheit on resilience; Fekete & Hufschmidt 2014).

The recent prevalence of discussions about the topic of resilience provides an impetus to critically review this issue using different perspectives in order to obtain innovative results. New concepts at the heart of resilience theory push beyond the 'resistance, robustness and return to the previous state' mindset and also include perspectives on alternative futures and transformations that will modify and force the further development of human mindsets and systems.

Resilience is the new key term in many national governmental strategies for risk reduction, critical infrastructure and emergency management. Despite the widespread use of the term resilience, there is a burgeoning debate about how the popularity of the term represents new innovation in the fields of Disaster Risk Management (DRM) and Climate Change Adaptation (CCA) (Hudson-Doyle and Johnston 2011; Fekete and Hufschmidt 2014; Glavovic and Smith 2014). Some of these debates include the limitations of resilience as a bouncing back concept (Levine 2012) or unwanted resilience of malevolent networks (Zolli and Healy 2012). However, while the state of the art of this field becomes established (US NRC—National Research Council 2012), critique on the concept is growing (Deeming 2013) and stimulates critical scientific work on both benefits and challenges.

Likewise, the term sustainability represents a major paradigmatic impulse that is forcing the fields of DRM and CCA to move beyond short-term solutions, one-sided benefits and identifying limited geographical impacts of risks (Aitsi-Selmi et al. 2015). The present discussion of disaster, risk, climate change and critical infrastructure illustrates the importance of complex adaptive systems research for these fields and shows the manner in which it has actively pushed the search for long-term solutions while considering the dynamics of risk and risk measures at the same time. Furthermore, this burgeoning area of investigation explores interdependencies and global repercussions of local disaster events, and the risk-related countermeasures and stakeholders involved.

1.4 Resilience of Settlements and Resilient Cities as a Specific Research Topic

Resilience of settlements and resilient cities are prominent in contemporary disaster risk and systemic change research, policy and funding (Pelling 2003; Vale and Campanella 2005; The World Bank 2012; Serre et al. 2013; Coaffee and Lee 2016). Reports and analyses on the Nepal earthquake 2015, Hurricane Sandy in the USA 2012, the multiple events in Japan 2011, the Christchurch earthquakes of 2011, Haiti earthquake in 2010, or numerous other disasters that received worldwide public attention, are being investigated both with regards to pre-disaster resilience levels and post-disaster integration of resilience into recovery strategies. Terrorism, especially after 9–11, is another direction and driver of this topic (Godschalk 2003). This effort aligns with other endeavours such as ‘Making Cities Resilient’ (UNISDR 2012), a campaign endorsed at international level, yet targeting local decision-makers (Johnson and Blackburn 2014). Many other institutions devote themselves to the topic of resilience, often with an urban focus, such as UNISDR, UN/HABITAT (for example, the 2016 conference), United Cities and Local Governments (UCLG), ICLEI-Local Governments for Sustainability (ICLEI), the European Commission Community Humanitarian Office (ECHO), the World Bank, the International Institute for Environment and Development (IIED), The Rockefeller Foundation through the creation of the 100 Resilient Cities Network and many others. Urban resilience has also become a topic for urban planning worldwide. It is a relevant subject for UN/HABITAT, where urbanisation processes, vulnerable groups and infrastructure have long been relevant keywords already (UN/HABITAT 2002). But at the latest world conference in Quito 2016 in the ‘new urban agenda’ (UN/HABITAT 2016a), resilience has become an explicit component yet is integrated with other topics such as sustainability (for example, the Sustainable Development Goals of the UN), green economy, insecurity or urban density (UN/HABITAT 2016b).

1.5 Problem Fields in Summary

There is ample documentation for cities at risk (Joffe et al. 2013) and documentation about recovery of cities (Haas et al. 1977). For the urban resilience topic, especially more research on recovery is needed (Contreras Mojica 2015; Davis and Alexander 2015). But there is a lack of holistic analytic concepts and tools for 'disaster resilient societies' that integrate the technical perspectives of security with the fields of human error, organisational management and corporate culture, effects on society and the vulnerabilities and dependencies of societies on the daily functioning of technical (and organisational) services (Christmann et al. 2016). There is a need of more longitudinal studies on recovery and lessons to be learned studies after global (academic) attention ceases (Stephan et al. 2017).

The following problem fields are hypothesised in order to explain the scope of this volume.

Societally, and *normatively*, there is a demand to understand processes and effects of hazards and disasters better in order to mitigate negative effects on society (compare with HFA, SFDRR).

Academically, there is a gap in connecting knowledge acquired in the field of natural hazards and what is termed Disaster Risk Reduction with human crisis research that includes technical infrastructure failures but also intentional destruction such as wars.

Conceptually, there exist desiderata in these academic communities but also increasingly amongst security and safety professions and related governmental institutions to make more use of the concept of resilience and make it applicable.

Methodologically, there is still a lack of applicable (also termed: operationalisable) criteria and related semi-quantitatively measurements of resilience.

Amongst *case-study* selections, the current focus of integrative societal resilience studies is mainly either on large cities or on smaller communities. Middle-sized cities, however, receive relatively fewer attention within the research on so-called resilient cities or urban resilient so far. This volume draws upon topics currently eminent within the resilient cities theme (UNISDR 2012) and standardisation of methodology debate and development (Fritzsche et al. 2014).

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Part I
Planning Urban Resilience

Chapter 2
Nepal and the "Urban Resilience Utopia"

Johannes Anhorn

Abstract The normative concept of a resilient city is afflicted by the technocratic thinking that a desired—hence resilient—state of an urban area might be a) explicitly identifiable and b) uncertainties around it are controllable. Western principles of projectable future(s) and orderly reality, as well as (pre-) defined cause and effect chains, contribute to this overestimation. Based on the "vulnerable" status quo, resilience measures are suggested which often focus on one sector of the urban multi-cosmos and are trying to fix symptoms of said vulnerable state. This is particularly true for cities and urban areas in the global south. Oversimplified implementation strategies on "how to become resilient" fall short on the complexity of the urban risk landscape and leave those at risk in limbo. This 'Urban Resilience Utopia' poses a threat to the core of the resilience agenda as a transformative power. This chapter reaches out to the social resilience "capacities" concept and translates it into guiding questions for planning DRR development interventions. Key characteristics of the adaptive governance concept are used to evaluate the practicability of those questions using examples from Nepal. This chapter might be considered a plea for a thorough "rewind" of expectations once we try to practically operationalize resilience and for a critical self-assessment and thoroughgoing process of developing a common language among those involved in building resilience.

Keywords Institutional Transformation · Nepal · Resilience · Utopia
Urban Risk · Development

2.1 The 'Urban Resilience Utopia'

The normative concept of a resilient city is afflicted by the technocratic thinking that a desired—hence resilient—state of an urban area might be (a) explicitly identifiable and (b) uncertainties around it are controllable. Western principles of projectable

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future(s) and orderly reality, as well as (pre-) defined cause and effect chains contribute to this overestimation. Based on the "vulnerable" status quo, resilience measures are suggested which often focus on one sector of the urban multi-cosmos and are trying to fix symptoms of said vulnerable state (cf. Carpenter and Gunderson 2001). Often these measures are not embedded into a broader integrative institutional learning mechanism. Many urban areas at risk of disasters are left alone with an externally defined terminology around "urban resilience" and respective external intervention mechanisms are dominating the local development agenda. This is particularly true for cities and urban areas in the global south where today's dependencies on and interpretative authority of the so-called "developed world" are expressed in terms of unequal financial transfer mechanisms, development aid, and emergency funds. Oversimplified implementation strategies on "how to become resilient" fall short on the complexity of the urban risk landscape and leave those at risk in limbo. I term this, the "Urban Resilience Utopia," to express the short-sightedness of those working on a day-to-day basis with the term resilience, without having made sure their counterparts share a common understanding and to express the difficulties in a complex urban environment, to find such a common understanding. Both pose a threat to the core of the resilience agenda as a transformative power. It is also contradictious to the unpredictable nature and unknown cascading effects of some of the events those areas are aiming to become resilient for.

As the aim of this book is to narrow down resilience from an all-encompassing concept to applied ways of disaster resilience operationalization, which impairs the credibility of the multifaceted resilience concept, this chapter reaches out to the social resilience "capacities" concept of Keck and Sakdapolrak (2013) and translates it into guiding questions for planning DRR development interventions. Secondly, key characteristics of the adaptive governance concept (e.g. Djalante et al. 2011; Folke et al. 2005) are used to evaluate the practicability of those questions using examples from Nepal.

This chapter might be considered a plea for a thorough "rewind" of expectations once we try to practically operationalize resilience. Often decision-makers but also scientists go like a bull at the gate, missing the opportunity to call for people where they (under)stand. Paving the way for joint action.

Therefore, this chapter first tries to approach what have become core elements of the resilience understanding and formulating them into practical assessment questions; second, those will be evaluated against the concept of Adaptive Governance (Djalante et al. 2011; Folke et al. 2005; Folke 2006), with its four principles: polycentric and multi-layered institutions, participation and collaboration, self-organization and networks, as well as learning and innovation. Last but not least, the case study of Nepal will be used to identify current challenges for the country processing toward resilience. Finally, closing the chapter with a plea for critical self-assessment and thoroughgoing process of developing a common language among those involved in building resilience.

2.2 Disaster Resilience

From the first introduction of the term resilience in the field of ecology and the prominent writing of Holling (1973) till its multifaceted understanding today the term has undergone several adaptations, changes, and reinterpretations. This happened in almost all academic disciplines, following different scholars. During its adaptation to the field of natural hazard and disaster risk reduction/management (DRR/DRM), the difficulties of finding a common language among scholars and lately in the communication to practitioners have been a major challenge. The opinions vary on whether we are closer to or even further away from finding a common language among these players than before. The resilience concept is still challenged by what Fekete et al. (2014) call conceptual "haze." A useful discussion and attempt to clarify the meaning of the term in the field of DRR/DRM can be found in Béné et al. (2012) and Alexander (2013).

Despite the ongoing debates about the newest felicitous achievements, a few characteristics often built the core of more specific and complex resilience definitions (see e.g. Brand and Jax 2007; Folke et al. 2010, 2014; Lorenz 2013; Manyena 2006): a multilevel-system-based approach which is dynamic in nature encompassing resistivity, absorption, and recovery; and which acts "as an integrating narrative or discourse" (Béné et al. 2012, p. 12).

Certainly, there are challenges to the all integrating aspect of resilience: First, there are pitfalls to attempts to bridge the natural versus social scientist gorge. The contributions from Cannon and Müller-Mahn (2010) as well as Pelling and Manuel-Navarrete (2011) highlight one of the essential risks in oversimplified bridging attempts: to neglect power relations and therefore depoliticize social structures which are indeed important to be considered.

A second pitfall is best seen once the concept is transferred from an academic discursive exercise to practical implementation, where controversial measures are abundant. Davoudi (2012) calls it a "slippery concept" in order to express the difficulties to subsume different practical utilizations of the concept. For example, development projects leading to improved resilience on the one level, while reducing it on the next higher level or solving short-term vulnerable states, but opposing long-term resilience goals. Or as Walker and Salt put it "(o)ptimizing for one form of resilience can reduce other forms of resilience" (2012, p. 121).

Keck and Sakdapolrak (2013) put together three main capacities in order to understand social resilience comprehensively, namely coping-, adaptive-, and transformative capacities. The criteria to give explicit meaning to these terms are on the one hand "temporal scope" and "degree of change," and on the other hand "response to risks" and "outcomes." They use these four criteria as a matrix to categorize the three capacities' nature and distinguish various existing concepts.

If this is translated to a more practical-oriented approach, the criteria might be understood as a guiding system of building resilience measures and useful in order to develop and implement resilience interventions. If done so, the *temporal scope* defines the anticipated operating range from very short-term interventions to long-term social transformation programs and will most likely be defined by the budged timeline. The *degree of change* denotes the profoundness of the required measures and can be expressed as the distance of the intervention mechanism to current practice (actual performance to target performance), while the *response to risk* criteria defines whether measures are mainly aiming to "fix deficits" (ex-post) or if a certain change is anticipated by "necessity" (ex-ante). Finally yet importantly, the *outcome criteria* reflect the vision of what is desired to be achieved with the respective resilience intervention. As the authors already pointed out in their explanations, elements of social relation and networks structures, institutions and power relations, and knowledge and discourses determine "under what conditions […] the three dimensions of social resilience mutually enforce each other [..] And in what case might one capacity undermine another [..]" (Keck and Sakdapolrak 2013, p. 13).

The commonly used and widely accepted definition of resilience from the United Nations International Strategy for Disaster Risk Reduction reads "the ability of a system, community, or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions" (UNISDR 2009) and does not include the transformational aspect. Yet, there have been missed opportunities to adopt or change the widely quoted definition. For example, the post-2015 Sendai Framework for DRR (United Nations 2015) includes references to the concept of resilience, but still uses the old definition. This is considered a critical shortcoming by the author as the transformational character embraces the future beyond "building back better." An older concept that resurfaced in the Sendai Framework but does not include the proactive forward thinking necessary before building back is even necessary.

Another line of thought descends from various concepts (cf. adaptive management, comanagement, collaborative governance of environmental problems) subsumed as "adaptive governance" by Dietz et al. (2003) and Folke et al. (2005). Djalante et al. (2011), identifies four common principles of adaptive governance theories useful to discuss preconditions for managing resilience to natural hazards. Namely "polycentric and multilayered institutions, participation and collaboration, self-organization and networks, and learning and innovation" (2011, p. 1). The authors establish the links in-between the academic debates on environmental and natural resource governance in order to "highlight potential similarities and differences between Adaptive Governance (AG) and DRR and their discussion of designing adaptive governance systems that build resilience" (2011, p. 1). As resilience is used in various contexts (cf. Djalante and Thomalla 2011), it might be the appropriate choice to bridge the interdisciplinary gaps. The four principles will later serve to measure existing challenges of Nepal's resilience efforts together with the previously identified capacity criteria.

Polycentric and multilayered institutions in the AG comprehension provide the setup for redundant but accountable organizational units, which are able to continue their public service even if disrupted by a major disaster event. The challenge remaining is to balance the power relation between different level agencies and governments while providing reciprocal access to their resources (2011, p. 4). Meanwhile, *Participation and collaboration* allows to pool knowledge and favorably influences the capacity to deal with external shocks and conflicts (cf. Heikkila and Gerlak 2005; Holley 2010; Margerum 2008; Pahl-Wostl 2009). However, there are manifold challenges during this balancing act of getting relevant stakeholders to the table, maintaining participation, and coming up with agreed upon shared solutions, e.g., organizational, cultural, or procedural. Some studies also highlight the positive effect of external institutions "to opening a way to successful collaboration by creating the necessary incentives" (in Djalante et al. 2011, p. 6; cf. Raymond 2006; Roux et al. 2007; Tompkins et al. 2008). *Self-organization and networks* are to some extent providing the fertile soil for sharing experiences, learning, and mutual understanding. It is important to acknowledge, however, that networks often evolve spontaneous during or after disasters. Again, especially when it comes to sharing of supposedly limited or critical resources, coordination beyond formal mandates are rare (read e.g., Freeman and Farber (2005) on the "Modularity" concept). They mention as main obstacles: obstructing institutional cultures together with limited human and financial resources. Proposing "programmatic funding across issues and agencies" as one solution (2005, p. 901f). *Learning and innovation* embodies the binding element between the three previous mentioned principles, as a general positive inclination toward new approaches and the will to modify current behavior is required to successfully collaborate in multilayered, interconnected institutions. While organizational learning allows for enhancing resilience (Berkes and Folke 2002; Folke et al. 2005), it also provides the flexibility to "keep up with change and uncertainty in complex adaptive systems" (Djalante et al. 2011, p. 8; cf. Carpenter and Gunderson 2001).

Individually, those principles of AG seem easy to understand and to modify in order to enhance those preconditions of resilience. From a practical point of view, the challenge is to balance their characteristics and quality: All of them have individual "tipping points," where from a managerial point of view, better/more becomes worse and vice versa. As each of those principles follows certain cost-benefit paths, their interrelations need to be carefully monitored. For example, polycentric and multilayered institutions lead to higher transaction costs for decision-making processes and hence are challenged by time constraints during rapid-onset hazards. The broader the decision-making base is, the higher the complexities associated and hence solutions might fall short and doomed to become the lowest common denominator, contradicting the innovation principle by not taking the risk of something new. Likewise, learning and innovation require a strong culture of (self-) reflexive behavior embedded in norms and values which might personally and/or societally/politically not been aided in the respective context.

The AG principles might serve as an explanation why certain resilience measures fall short once they are maturing and are implemented. Hence, they provide hints to the processes and factors behind the resilience criteria. The logic would be that limited participation and little inter-institutional cooperation result in short-sighted outcome criteria with restricted chances to be implemented.

2.3 The Case of Nepal's Growing Cities

The former "Mountain Kingdom" of Nepal has often been mystified due to its long secluded history and the magnificent mountain ranges. The capital Kathmandu has long been praised as a culturally vibrant city with thousands of sacred places, temples, and people entangled into their day-to-day religious ceremonial lifestyle. This might from each individuals perspective still be true. However, most recent travel guides nowadays recommend to leave the capital quickly after seeing the main attractions like the *Hanuman Dhoka* with its ancient wooden temples and the ancient city of Bhaktapur, otherwise risking serious health threats, especially to the travelers respiratory and digestive systems. Since the Gorkha Earthquake in 2015, more and more foreigners also seem to be concerned about a potential "big one" happening (and this time right in Kathmandu), while enjoying their holiday in densely build-up *Thamel*.

The apparent necessity of Nepal's cities to become resilient toward natural hazards is mainly based on three interconnected facts: first, the countries location in one of the most active tectonic areas (*exposure and structural fragility*); second, the very high population growth (*urban-rural disparities and social vulnerability*); third, the decade's history of failed long-term planning and development efforts despite enormous investments from foreign governments and other donors (*development trajectory*). "Many people also think that the right time might just have come." "Making use of the slowly commencing political stability, after decades of political unrest, insurgency, and the so-called "People's War," which resulted in the removal of the monarchy and the establishing of a multiparty parliamentary democratic system in 2006 (Einsiedel et al. 2012; Gersony 2003)".

As part of the tectonically active Himalayan range, Nepal has one of the highest levels of earthquake potential (Mosquera-Machado and Dilley 2009). Till today in western Nepal, the absence of major earthquakes over a long time period has led to a high rate of stress accumulation and contributed to high-risk exposure (Bilham et al. 1995; Bilham 2004; Chamlagain and Gautam 2015; Fort 2011; Mukhopadhyay et al. 2011). The 2015 Gorkha Earthquake did not release enough of that stress, and scientists do agree that the potential for the next big one is still immanent (e.g. Bilham 2015). While enough evidence has been collected that a major earthquake would have devastating effects on the capital Kathmandu (EMI 2010; JICA and MoHA 2002), efforts to countermeasure fall short once the implementation stage is reached.

Over the last six decades, the population of Nepal has increased more than three times, from 8.3 million to 26.5 million people (CBS 2003, 2012). Most of that growth is visible in the intermontane basin of Kathmandu as well as in some expanding cities in the *Tarai* lowlands toward Indian. Nepal is the fastest urbanizing nation in the region (1970s–2010s increase of about 6% annually), but only 17% of the population live in urban areas (Muzzini and Aparicio 2013). Nepal's urban areas are defined as units of local self-government, based on the Local Self-Governance Act (HMG 1999) and demarcated according to the number of people administered by Village Development Committees (VDCs), formerly called *Panchayats*. For hilly and mountain areas, this administrative unit of a municipality is defined as "a population of at least ten thousand and annual source of income of minimum five hundred thousand rupees […] even if there is no road facility" (HMG 1999, p. 29). While in the *Tarai* and the Kathmandu Valley "semi-urban area[s] with a population of at least twenty thousand, and annual source of income of minimum five million rupees and with electricity, roads, drinking water, communications, and similar other minimum urban facilities" (HMG 1999, p. 29) are considered municipalities. Administrative functions are not necessarily decisive criteria. According to Sharma "political ad hocism" in the nomination process of these municipalities is apparent (2003, p. 377). Today there are 217 municipalities, most of them established after 2014 (CBS 2016). Based on the latest national census in of 2011 a total of 26.5 million inhabitants live in 5.4 million households (CBS 2012). The urban areas of Nepal comprise of the agglomeration in the Kathmandu Valley with the capital Kathmandu (Kathmandu Metropolitan City and Kirtipur Municipality), Patan (Lalitpur Sub-Metropolitan City), and Bhaktapur (Bhaktapur Sub-Metropolitan City and Madhyapur Thimi Municipality), which account for 5.38% of the total population. As there is no strict implementation of citizen registration, the number of inhabitants in Kathmandu and Lalitpur alone might be triple that number. Weak or often non-existing infrastructure for water and electricity supply as well as wastewater and solid waste treatment are among the greatest challenges for the densely populated areas of the Kathmandu valley (CHREOD 2012; Muzzini and Aparicio 2013). Groundwater depletion aggravates the critical water supply situation during the hot dry season, while long-planned water supply schemes face huge backslashes and/or are unlikely to meet the increased demand on the long run (The Himalayan Times 2016). Despite the challenging quality of infrastructure and life in the main capital, mid-size towns develop even more quickly into hazardous places due to uncontrolled expansion, influx of modern building material without the necessary knowledge base, and no stringent implementation of existing regulatory frameworks (Anhorn et al. 2015).

Those challenges are not new to experts, planners, and government officials in Nepal (e.g. ADPC and MoHA 2011a, b; Basnet et al. 1999; Blaikie 1980; CHREOD 2012; Dahal 2012; EMI 2010; JICA and MoHA 2002; Muzzini and Aparicio 2013; Skerry et al. 1991). Nevertheless, despite many well-thought consultancy reports, the big leap forward did not happen (e.g., Bell 2015). Nepal is still considered one of the poorest countries in the world, actually still ranking among the least developed countries in the world (The World Bank 2017).

It is not the aim of this chapter to provide an all-encompassing way of addressing these challenges, but to use the previous resilience capacity criteria differentiating coping, adapting, and transformation, as well as the principles of AG, to analyze the case of urban Nepal.

2.4 From Theory to Practice

The following table associates each of the four criteria proposed by Keck and Sakdapolrak (2013) with a key question. This will allow evaluating development intervention towards the chances to enable and foster resilience. The table also provides additional questions, which might help identifying potential constraints.

Temporal scope	When do interventions become effective? • Do project results foster policy change beyond the decision-makers' formal responsibility? • Do long-term development targets support those interventions?
Degree of change	How much does the current performance derive from the target performance? • Are there certain groups more/exclusively challenged with implementation?
Response to risk	How proactive are the intended development measures if it comes to risk reduction? • Does the project aim at fixing earlier disastrous outcomes, or at enhancing mitigation capacities?
Outcome criteria	What is the common vision and strategy? • Does everybody agree on that vision? • Who will be winners/losers of the strategic interventions?

The following section seeks to shed light on how the urban areas and the country of Nepal "perform" in terms of resilience efforts using these assessment questions. The AG principles, on the other hand, might help explaining processes and factors behind the findings.

This is not a detailed scientific full-scale evaluation exercise, but rather an attempt to use a specific theoretical lens on personal observations. Likewise, the author does not claim to be able to see all gradual developments in Nepal, but rather reflects on five years of (restricted) observations applying a specific frame of thoughts.

Starting in 2013, a team of scientists including the author conducted semi-structured interviews with key personnel from NGOs, local government representatives, and international development organizations in Nepal. The focus was on effectiveness of development interventions in the field of DRM/DRR as well as understanding resilience concepts. A self-evaluation scorecard tool was developed and used to assess risk and resilience based on qualitatively derived information at multiple levels (Anhorn et al. 2015). In 2013 and 2015, the same group of LGU representatives from Lalitpur Sub-Metropolitan District was interviewed to uncover changes in resilience thinking prior to and after the Gorkha Earthquake. Above-mentioned questions served as guiding questions. The results presented in the next sections are conclusions and findings based on the statements made by these sources.

The process of interviewing and discussing resilience concepts with various stakeholders in Nepal for this research itself can be understood as an (initial) step to increased participation and collaboration. This becomes clear by the fact that during the first scorecard session in 2013 with representatives from minority groups, city/district planners, and emergency response teams they had to admit that they never discussed risk reduction targets and implementation challenges among each others before. Despite such encouraging effects, simple organizational difficulties (getting the decision-makers attention and time), as well as more complex issues had to be dealt with: e.g. having women's representatives and male decision-makers at the same table in patriarchic systems. Also, procedural difficulties which include decision-making and voting mode, representation of minority opinions, etc. There are no catch-it-all solutions to these challenges, but one important factor to achieve an open and constructive dialogue was the facilitation by a local NGO which had managed to be a trustworthy partner for all participating groups for many years already.

Going back to the first criteria of coping-, adaptation-, and transformational capacity (*temporal scope*), looking at the various and long engagements of international development programs in Nepal, it might be appropriate to say that the country has long been (mis-)used as a playing field of western development interventions (cf. Skerry et al. 1991, p. 365). Talking about the four decades of USAID work in Nepal between 1950s and 1990s Skerry et al. conclude that "Politicians and government officials were more concerned with the control elements of Panchayats; they wanted to continue centralized decision-making and control. […] There have been problems with inconsistent government policies. In some cases, this was because government adopted a policy because of donor insistence, not because Nepali officials were convinced of its efficacy. […] The lack of consistent policies that were implemented reduced the chance of success of many activities and their sustainability after donor resources ended" (1991, p. 368). Translating this to the more recent discussions on urban resilience, it is evident that fluctuant governmental structures do not allow for long-term planning and commitment. To ask for resilience measures beyond the timeframe of a decision-makers' legislative/jurisdictive period, embracing the idea of sustainability, might be a first step. Now this is particularly difficult, where like in the urban periphery of Nepal, the whole decision-making process is highly centralised and political power is outside of Kathmandu almost nonexistent. The connection to polycentric and multilayered institutions is easily made, incorporating element of (democratic) participatory and self-organization. All of them being based on a culture of shared responsibility.

Most resilience interventions propose very incremental *degrees of change*, simply because they are embedded into existing structures, use the umbrella of prevailing socio-cultural institutions and are in general negotiated with the counterparts on "eye-level." Fundamental changes are not enforceable without altering present structures, hence asking to what extent the actual performance derives from the target performance (here: a more resilient condition) helps to understand who are the beneficiaries and possible victims. By keeping the urbanizing hinterland of

Nepal effectively cutoff from resources, the exchange of different perspectives and other forms of participation and collaboration do not happen. In general, resentments against the central government remain an issue and with corruption being a serious problem, a big transformational leap forward seems to be illusory.

With the onset of the earthquakes of 25 April and 12 May 2015, some reflective discourses on disaster resilience in Nepal among governmental officials, the public, scientist, and other patrons came to an abrupt end and were immediately overtaken by the international aid-delivery mechanisms. The *response to risk* criteria for Nepal and the question which phase of the "DRM cycle" should be focused on, was finally concluded: everything moved to fixing the disastrous outcomes (GoN 2015a). This clearly goes along with a relative short-term perspective and does not leave room for any more fundamental proposition for institutional change. A Post-Disaster Needs Assessment was quickly conducted with ambitious expectations in terms of implementation speed (GoN 2015a, b). According to the Prime Ministers, after generous pledges for recovery and reconstruction were made, unfortunately "an extended period of economic, social and political challenges [followed], which directly impacted on the effectiveness of the earthquake response. With the formal establishment of the National Reconstruction Authority on 25th December 2015, I signaled the intent of my administration to recover the momentum of post-earthquake reconstruction" (GoN 2016, p. III).

Despite the (almost historically) ill-fated reasons for the delay of earthquake response, the consecutive Post-Disaster Recovery Framework (PDRF) launched in May 2016, contains several connections to resilience. Interestingly there is a whole chapter on "Recovery Vision and Strategic Objectives". Hence addressing the *outcome criteria* of Keck and Sakdapolrak (2013). The vision is defined along the five themes: safe structures, social cohesion, access to services, livelihood support, and capacity building (GoN 2016, p. 4ff). The ambitious objectives stretch the whole range of resilience measures from short-term restoration interventions to long-term enhanced governmental services; from investing in participation of the public to innovative ways of recovery financing. Now the crux is not what is written in the document itself, but if the Nepalese Government together with all the donor organizations, NGOs and the civil society succeeds to implement it (and hence make the National Reconstruction Authority (NRA) obsolete again). It is too early to judge the implementation performance of the NRA, but learning from the past means also to acknowledge that such magniloquent broad-scale agendas (written with the help of 'tireless friends from the international community' (2016, p. V)) require all efforts to become reality. For now, the first beneficiaries of this new PDRF have the mandate to "leading and managing the earthquake recovery and reconstruction programme in a sustainable and planned manner for a safer and more resilient Nepal" (2016, p. 21). With that stated, the *outcome criteria* is at least clearly defined, spanning from restoration to enhancement of future well-being. The competence of improving governmental accountability during this development intervention and equally distributing the envisioned benefits among the society is still questionable and to be demonstrated.

2.5 Plea for a Performance-Based Self-Assessment Understanding of Resilience

There are various links between the highly relevant principles of resilience in the AG literature and the resilience-capacities' promoting criteria. Asking the right questions to analyze development interventions aiming for increasing urban resilience in regard to their transformative capacity is crucial. This chapter provides a limited selection of suggestions how to address this. After all, the most important question to be asked starts right at the beginning of the resilience process: What is our vision of resilience?

As the aim of this book is to narrow down resilience from an all-encompassing concept to applied ways of disaster resilience operationalization, which impairs the credibility of the multi-facetted resilience concept, I suggest to start measuring resilience by asking this question over and over again—as academics, intervention managers, donors, and local stakeholders. As written earlier, oversimplified implementation strategies on "how to become resilient" fall short on the complexity of the urban risk landscape. This 'Urban Resilience Utopia' poses a threat to the core of the resilience agenda as a transformative power. It seems that practitioners are more interested in doing something, instead of doing the right thing due to the perceived complexity. Without asking all those responsible and (!) those affected by any resilience/development intervention what they want to achieve, the decision-making will fall short on people's needs. Hence, the chapter ends with a plea to use people's collaborative knowledge and vision as the *ultima ratio* for resilience measures as it encompasses the multilayered richness of people's ambitions, which is particularly true for the urban sphere.

The continuous process of self-assessing the current resilience performance and the future envisioned resilience performance along individual values allows us hopefully to foster the development of institutions and processes along the principles of AG and shift from restoring on a short temporal scope to fundamentally enhancing long-term well-being.

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Chapter 3
Exploring the Role of Planning in Urban Resilience Enhancement—An Irish Perspective

Aoife Doyle, William Hynes, Stephen M. Purcell and Maria Rochford

Abstract Over the past two decades the concept of 'resilience', and more specifically 'urban resilience', has gained increasing attention within urban planning research, policy and practice. However, the pursuit of resilience encounters a series of grounded challenges for urban planning practitioners and associated stakeholders. Among the most commonly cited challenges is the 'fuzzy' nature of the resilience concept or its lack of conceptual clarity. Indeed 'resilience' has been employed in a range of diverse fields in varying ways. As such, there are increasing scholarly calls for a more thorough understanding of the term's migration into, and impact upon, planning practice. This chapter explores this critical question through an Irish lens, outlining the key challenges involved in 'translating' the concept from theory to practice. Specifically, this chapter focuses on the role of planning in urban resilience enhancement in the Irish context, with particular attention on large scale infrastructure projects (both critical and non-critical). In doing so, lessons are drawn from the findings of two large EU funded research projects, including INTACT and HARMONISE, both funded under the EU Seventh Framework Programme.

Keywords Urban resilience · Urban planning · Ireland · Governance

3.1 Introduction

Defence against people or natural elements has always been a factor influencing the shape of cities. With a global population of 7.4 billion persons, it is estimated that 50% of these people now live in cities. This trend is likely to continue into the future, with an estimated 70% of the world population expected to be urban dwellers by 2050 (United Nations 2012). Security planning, or what today may be termed 'resilience planning', has continually evolved and transformed to address different threats and events. Moreover, the rapid expansion of cities is exposing a

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larger number of people and critical infrastructures to a range of complex security threats and posing additional challenges for the design, planning and management of urban areas. Within this context, the enhancement of urban security and resilience has become a far more urgent and significant task, necessitating more innovative and integrated approaches to urban planning and development.

However, as White and O'Hare (2014) assert, the pursuit of resilience encounters a series of grounded challenges for urban planning practitioners and associated stakeholders. Among the most commonly cited challenges is the 'fuzzy' nature of the resilience concept or its lack of conceptual clarity. Indeed 'resilience' has been employed in a range of diverse fields in varying ways. As such, an increasing number of scholars (see Eraydin and Tasan-Kok 2013; Davoudi et al. 2012; White and O'Hare 2014) argue that there is a need to better understand the term's migration into, and impact upon, planning practice. This chapter explores this critical question through an Irish lens, outlining the key challenges involved in 'translating' the concept from theory to practice. Specifically, the chapter focuses on the role of planning in urban resilience enhancement in the Irish context, with particular attention to large-scale infrastructure projects (both critical and non-critical). Moreover, the authors argue for a more integrated approach to urban resilience enhancement—one which considers multiple risks and hazards in a holistic manner. In doing so, the paper draws from the findings of several large EU funded research projects, including INTACT and HARMONISE, both funded under the EU Seventh Framework Programme.

3.2 Urban Resilience—A Role for Urban Planning?

3.2.1 Challenges in 'Translating' Resilience from Theory to Practice

Over the past two decades, the concept of 'resilience', and more specifically 'urban resilience', has gained increasing attention within urban planning research, policy and practice. 'Urban resilience' is often considered a 'fuzzy' concept (Eraydin 2013), typically presented as the capacity of cities to 'bounce back' or even 'bounce forward' from a disturbance or crisis event. This 'fuzzy', pliable nature of the concept has aided its transferability across different disciplines and fields, but has also led to difficulties in operationalising 'resilience' in practice. Indeed, it has become clear that the rapid political ascent of the concept raises important questions around how resilience is understood, what it is designed to achieve and how this may translate into planning practice (White and O'Hare 2014). This section seeks to chart the evolution of the resilience concept in order to contextualise its more recent application within the urban planning domain, highlighting some of the primary challenges and opportunities around 'translating' the concept from theory to practice.

Although the term has expanded into a variety of disciplines, ‘resilience’ initially gained prominence in the 1970s with the work of C.S Holling, a theoretical ecologist. Holling utilises ‘resilience’ to examine the behaviour of ecological systems that are exposed to unexpected external changes and disruptions. Within his work, Holling drew an important distinction between engineering and ecological resilience—with engineering resilience defined as the ability of a system to return to an equilibrium or steady-state after a disturbance (Holling 1973; 1986). This engineering perspective understands resilience as a measure of the ‘speed of return’ to equilibrium (Pimm 1991). In essence, the quicker the system ‘bounces back’, the more resilient it is. In contrast, Holling (1996: 33) asserts that ecological resilience is concerned with the ‘magnitude of the disturbance that can be absorbed before the system changes its structure’. Thus, rather than speed being a defining feature, here ‘resilience’ is understood as how much disturbance a system can undergo while remaining within critical thresholds—how it can persist and adapt in the face of disturbance (Adger 2000:1).

While these perspectives each present a different understanding of ‘resilience’, both acknowledge the existence of equilibrium in systems, be it a pre-existing one to which a resilient system bounces back (engineering) or a new one to which it bounces forth (ecological) (Davoudi et al. 2012). Yet many scholars argue that such an equilibristic view may be somewhat problematic when applied to the urban context (Alexander 2013; Davoudi et al. 2012), giving rise to calls for an ‘evolutionary’ understanding of resilience (Davoudi et al. 2012; Majoor 2015).

This evolutionary perspective of resilience purports that resilience should not be understood as ‘bouncing back’ to normality (as with engineering perspectives of resilience), but as the ability of complex socio-ecological systems to change, adapt, and, crucially, transform in response to stresses and strains (Carpenter et al. 2005). This perspective views resilience as a proactive rather than reactive view to planning and policy making. It does not merely refer to readiness to sudden or isolated occurrences but also refers to long-term strategies to mitigate and adapt to challenges or disturbances.

Distinguishing between normative interpretations of equilibrist and evolutionary resilience (or alternatively ascertaining ‘which’ resilience is applicable) is essential to understanding the challenges of policy integration as, critically, they have contrasting aims and outcomes (White and O’Hare 2014). This is significant in the context of the planning domain, where ‘resilience’ has entered into discourse with different orientations. Although the focus has traditionally been placed on environmental issues, in particular the reduction or mitigation of environmental risks such as earthquakes, floods and global warming, there has been a rather significant increase of the fields where the concept is used. The expansion of the concept has also inevitably led to problems of certainty and clarity around what sense and meaning the concept actually assumes in urban planning discourses, as well as in its translation into planning policy and practice.

The following sections aim to highlight the evolution of ‘security’-based concerns within planning, commencing with an exploration of the works of Jane Jacobs and Oscar Newman—work which represents some of the earlier attempts to integrate security-based objectives within the urban planning domain. The chapter then examines the heightened concerns around urban security in the aftermath of 11 September 2001. Finally, planning for flood resilience is discussed, an area where the 'resilience' concept has perhaps gained most attention within the European context. This chapter is thus concerned with a multitude of urban threats and hazards and seeks to promote a more holistic and integrated approach to addressing them within urban planning. Such an approach recognises the increasingly complex and uncertain world in which planning operates—where urban decision-makers are faced with both known and unknown external circumstances, to use the former US Defence Secretary Donald Rumsfeld's well-known taxonomy.

3.2.2 The Evolution of Security and Resilience Thinking Within Urban Planning

From the perspective of built environment professionals, including planners, attaining resilience often requires the enhancement of urban planning and design techniques in order to make cities and associated critical infrastructure more resistant to exogenous shocks or disturbances. In recent decades, planners have become increasingly cognisant of many of the particular conditions which are likely to give rise to urban insecurity, most notably in the form of crime, due in large part to the contributions of Jane Jacobs and Oscar Newman in 'The Death and Life of Great American Cities' (1961) and 'Defensible Space' (1972), respectively. Indeed, this early work has informed the content of many planning strategies seeking mixed use communities and vibrant street life. Among Jacob's core arguments was that a city space is 'safe' if it is well populated, or has many 'eyes'. A steady flow of people through a particular space, she asserts, impacts the ability of users to take control or feel ownership of that space. This in turn increases surveillance of the space and reduces criminal opportunities. Her ideas have been widely appropriated by planning professionals, who often cite her theories as their authority for a variety of practices, from situational crime prevention to land use zoning.

Yet at the same time, some urban planning/design approaches directed at crime prevention and counter terrorism have raised questions around the extent to which cities can adopt protective policies without losing their openness, pluralism and vibrancy (Savitch 2015). Indeed, as Nemeth and Hollander (2010) note, the fortification of the built environment has become increasingly visible in cities across the world in the aftermath of the 9/11 terrorist attacks in New York in 2001—an event which is often regarded as a catalyst for greater consideration of security within urban planning and design processes. Marcuse (2004) argues that security, in the face of a declared threat of terrorism, dominates much of the discussion about city life in the USA today. He asserts that New York in particular has become a city of control—where the political authorities, rather than the people, determine how the city and its public spaces are used.

Yet such discussions have now spread to Europe, particularly in the wake of several devastating terrorist attacks in France and Belgium in 2015 and 2016. European cities are now increasingly facing the complex challenge of securing cities without undermining the democratic rights of their inhabitants—particularly as a greater range of perceived urban 'targets' emerge. While so-called hard targets such as Government buildings or iconic landmarks have been traditionally the focus of physical security measures, increasingly 'soft targets' (such as public spaces around cafes or urban markets) are seen as more attractive to potential terrorists due in part to the difficulty in securing these types of spaces (and the ultimate devastation impact). Thus, fragmented, physical approaches which are seen to focus on particular buildings, structures or local areas are increasingly less useful in an ever-evolving urban risk landscape (where a combination of hazards, both man-made and natural, converges). Crucially, there still remains a lack of more holistic, integrated approaches to urban security—a gap in which 'resilience' thinking is seen to address.

This need for holistic thinking has also been highlighted in terms of flood risk management, with many European countries seeking to move from solely flood hazard control to a wider approach which includes 'living with water' for example (Meijerink and Dicke 2008: 500; Johnson and Priest 2008), which places emphasis on reducing flood consequences as well as on preventative measures. Within the UK, such shifts have been connected to the impacts of the 'Storm Desmond' flooding in 2015, where many physical engineering approaches were shown to be ineffective. In many cases, floodwater overtopped physical barriers and flooded surrounding homes (The Guardian, 2015). Such events led to calls for less reliance on sole physical measures and a demand for more integrated and proactive approaches which utilise a full disaster cycle perspective—i.e. looking at mitigation, preparedness, response and recovery in combination.

As Coaffee and Clarke (2015) highlight, planning for resilience involves developing planning policy and practice that can respond in a flexible and integrated fashion to multiple risks across a range of scales. It also emphasises the need for more joined up and collaborative approaches to decision-making, which draws in a greater range of professional and community groups. Yet despite increasing interest in the resilience concept, Coaffee and Clarke (2015) further argue that tensions continue to exist regarding the extent to which principles underpinning resilience can become practically enmeshed within the formal planning processes of urban areas. Indeed, policies that promote urban resilience do not always arise from a specific or explicit resilience objective per se, and where they do the synergies often emerge in an ad hoc way through a combination of other initiatives which aim to secure against future adversity.

Indeed, this has been the case in the Irish context, where resilience is not a concept explicitly outlined in Irish urban policy, beyond initial applications in distinct policy streams—most notably flooding. Responsibility for various policy streams varies between national Government and Government agencies, to more locally centred policies, and the result is a patchwork of vertical and horizontal responsibilities. While Ireland has policies in place for preparedness, most notably the ‘Framework for Major Emergency Management’, which coordinates responsibilities for emergencies, there is presently little policy linkage, bottom-up engagement and resilience policies are generally disparate with little integration.

3.3 The Evolving Risk Landscape and the Irish Context

It is important to note that the emergence of idea and practices of resilience within academic and policy debates and their relative influence on practice are highly specific to institutional contexts and emergent security risks faced in particular countries and their urban areas (Coaffee 2013). This section focuses on Ireland—a country on the northwestern periphery of Europe, with a population of 4.7 million people.

Within the Irish context, a national risk assessment was published by the Government in 2016. The risks presented in the assessment document are divided into five risk categories—economic; environmental; geopolitical; social; and technological (Department of the Taoiseach, 2016). In relation to international terrorism (under the geopolitical category), the document states that domestically, the threat of an attack is rated as not likely—while acknowledging that the events in Europe (including the Paris and Brussels attacks) in 2015 and 2016 demonstrate that it is possible. Within the environmental category, more concern is raised. The scale and rate of climate change in Ireland is consistent with regional and global trends, and the document highlights the risks faced in recent years—including instances of prolonged cold in 2010, damaging windstorms in the winter of 2013/2014 and widespread flooding in late 2015/early 2016.

Yet despite increasing work to identify and address major risks facing Irish society, there is no single agency responsible for major emergency management in Ireland. Rather, the relevant Government ministries and public authorities are responsible for maintaining appropriate emergency management functionality according to their statutory ambits. Ireland has 29 County Councils 5 City Councils. For the purposes of civil protection, each of the County and City Councils functions as principal response agencies (PRAs) and as such has developed major emergency response plans. These PRAs also comprise An Garda Síochána (the Irish police force), the Health Service Executive, the Irish Coast Guard in addition to the County and City Councils.

The County and City Councils also serve as the local planning authorities in Ireland. Traditionally however, urban planning has given little consideration to security and resilience issues in Ireland—at least in a direct or explicit manner. Yet, indirectly, planning plays an immediate role in safeguarding society—a role which perhaps requires greater recognition and attention. Indeed, each and every planning application has an impact, be it on the applicant, the adjoining property or landowner, the environment, the public in general, etc. The urban planner (in any context) must balance multiple considerations in the pursuit of sustainable development and the management of urban areas, not least the suitability of land uses, but of course the environmental, social and economic impact of a proposed scheme or master plan. Thus, the planner plays a natural role in ensuring that urban growth, development and renewal do not jeopardise the safety and security of present or future citizens. Yet despite this, it remains unclear how emergency planning and city planning principles can be practically integrated within the Irish context. However, this is not solely a problem associated with Ireland. Indeed, Coaffee and Clarke (2015) highlight the slow pace at which the connection between urban planning and resilience has emerged in Europe, with the concept predominantly associated with climate change adaptation and inland flooding.

3.3.1 Urban Planning and Flood Resilience in Ireland

The concept of 'resilience' is relatively new in the Irish urban policy sphere—and is used almost exclusively in terms of flood-related issues. Some of these issues, including challenges in enhancing flood resilience, have been explored within an EU Seventh Framework project entitled INTACT (Impact of extreme weather on critical infrastructures). INTACT seeks to improve the resilience of critical infrastructure (CI) in the face of extreme weather events by sharing best practices that are in use throughout Europe, and by providing visualisation and assessment tools and guidelines that will help local policy makers to better assess the impact of their practices, and improve their decision-making. In order to identify the most pressing issues regarding extreme weather and critical infrastructure, the INTACT project consortium is meeting with stakeholders and end-users who are involved in various aspects of these topics. A crucial part of the INTACT project is carrying out five case studies in five different countries. In these case studies, the project seeks to develop an inventory of the most pressing problems and best practices for solving these, and to evaluate INTACT concepts and tools.

One of the INTACT case studies is the functional area of the (former) South West Regional Authority (SWRA), Ireland. The southwest is amongst the most developed regions across the country and is the location of the second-largest urban centre in Ireland—Cork City. This case study focuses on instances of extreme weather which have impacted upon the ability of critical infrastructure to deliver the required services in a region which has experienced substantial disruption to services as a result of such events in recent years. Extreme weather events (unusually heavy rainfall and extremely low temperatures in comparison with climatic norms) appear to have become more frequent in recent years, adding to concerns of climate change and the need to take measures to address such issues. One such event occurred in November 2009, when substantial quantities of water were released from a large reservoir adjacent to Cork City, coinciding with a high tide and a period of significant rainfall over the previous number of days. The culmination of these events resulted in the flooding of a large proportion of the City Centre and its Western approaches through which the river flowed. Although the flooding subsided within 24 h, substantial damage was done to the city's freshwater infrastructure, when one of the main pumping stations which served the city was inundated. This pumping station was put out of service for almost two weeks (20 November 2009–03 December 2009), resulting in major disruption to water supplies throughout Cork City, and continuing boil water notices even after normal pumping operations had resumed.

Indeed, this event highlighted the challenges involved in the 'cascading effects' of flood events (or disasters more generally)—where a chain sequence of interconnected failures occurs. Cascading effects refer to the 'snowball effect' of crises that in their cumulative impact can cause more severe disruption or even disaster. Ireland's critical infrastructure, like systems across the developed world, is an increasingly complex interconnected system. It is this interconnected, interdependent nature which demands a shift in policy focus from mere 'protection' to enhanced 'resilience'. Over time, critical infrastructures across most of the developed world have become interconnected and mutually dependent in complex ways, both physically and through information and communication channels. Yet, unfortunately, the vulnerabilities generated by such inherent interconnectedness are often revealed only following crisis events such as natural disasters or man-made hazards.

At the first Irish stakeholder workshop for the INTACT project, understanding the potential cascading effects of flooding (particularly in terms of the interdependencies between infrastructure) was noted as a key issue for planners and other built environment professionals in the area. A number of possible solutions for addressing these challenges were also raised at the workshop including mapping the consequences related to cascading effects to help prioritise resilience measures, and providing recommendations for coordinating the protection of CIs. It was acknowledged that an integrated approach to the security and resilience of such infrastructure is needed to capture the levels of interdependence at the 'operational level'. This will allow enhanced understanding and more effective management of the interactions. It will also facilitate recognition of higher-order dependencies which impact upon and emerge from buildings/building complexes.

Furthermore, another key issue highlighted by the Irish stakeholders was related to the governance of resilience—who is responsible for this in Ireland, and in the south-west region? A key objective of the stakeholder engagement process within INTACT was to gain a comprehensive understanding of each stakeholder's role within the region, their level of responsibility and how each actor is addressing the issue of flood resilience within their respective organisations. The engagement and consultation process revealed that the level of responsibility differed according to stakeholder, from national flood risk identification and management to regional and local protection of a sole CI. All CI operators had flood procedures and protocols in place, and all CI operators were actively working to identify risk and vulnerabilities within their own CI in order to increase the resilience of their respective CI to flooding. However, there is limited cross-CI operator engagement with regard to addressing risk and vulnerabilities across multiple CI modes (INTACT D5.3 2016). An overview of the relevant stakeholders operating in the area is included in the table.

Stakeholder organisation	Level of responsibility	Role
Office of Public Works (OPW)	National	National agency for the delivery of flood risk management
Met Éireann	National	Irish national meteorological service
Transport Infrastructure Ireland (TII)	National	Roads (National and primary)
ESB Networks	National	Electricity supply service provider
Iarnród Éireann	National	Railway service provider
Irish Water	National	Water utilities
Southern Regional Assembly (SRA)	Regional	Regional planning authority
Cork City Council	Regional	Local authority for Cork City functional area
Cork County Council	Regional	Local authority for county Cork functional area (excl. Cork City functional area)
Kerry County Council	Regional	Local authority for county Kerry functional area
Cork City Fire Brigade	Local	Emergency services and management

Source INTACT D5.3 (2016)

3.4 Towards a More Holistic Approach to Urban Resilience Enhancement—Understanding the Core Gaps

Dealing with cascading impacts of crisis events, and an ever-evolving hazard landscape, as demonstrated by the Irish case, necessitates integrated and more innovative approaches to urban planning and development. This need for a more holistic approach to resilience enhancement was also highlighted by the findings of the HARMONISE project. HARMONISE—A Holistic Approach to Resilience and Systematic Actions to Make Large Scale Built Infrastructure Secure—also funded under the EU Seventh Framework Programme, commenced in 2013 and concluded in May 2016. The overarching aim of the project was to support urban decision-makers, including planners, in enhancing the resilience of (non-critical) large-scale urban built infrastructure against existing and emerging threats—both man-made and natural. Within this project, built environment professionals in five case study cities across Europe were engaged with—both in terms of establishing the current resilience context in each country and in order to test key ideas and tools developed as part of HARMONISE to aid decision-making. The case studies were Bilbao, Spain; Genoa, Italy; Dublin, Ireland; Vantaa, Finland; and London, UK.

This project, echoing many of the findings emerging from INTACT, found that resilience considerations within these cities are currently incorporated into the urban planning and management process through a number of disparate approaches. There was a general feeling among practitioners, however, that resilience is often incorporated 'without realising it' rather than through a more proactive, coordinated and holistic approach. An overall 'lack of strategic vision' for resilience was associated with a number of core challenges as below (HARMONISE D1.3 2013). These challenges represent the views of stakeholders across the five case study cities across Europe—including a range of urban decision-makers in Ireland:

- General lack of awareness of the urban resilience concept:
  - The term 'resilience' is not used in some member countries of the European Union, it has no appropriate translation in some languages and therefore its meaning has remained ambiguous.
- Lack of integration and coordination:
  - There is often a lack of horizontal and vertical integration between actors and agencies responsible for urban resilience.
  - Moreover, such integration can be hindered by differing conceptualisations of 'resilience' issues across disciplines and spatial scales.
  - Generally, stakeholders reported that architectural and planning liaison with the police and emergency rescue services occurs too late in the design process to have a meaningful impact on design. As a consequence, security considerations are often dealt with through a series of 'add-on' measures such as bollards rather than integrated into the design concept, which can compromise the design quality of a scheme.
  - This situation is exacerbated by a lack of a single point of ownership in Government, lack of leadership and political support and the need to consider multiple viewpoints in a transparent and participatory process.
- Need for a more comprehensive approach:
  - Resilience discourse (when used) is typically applied to the development management process in the form of sector-based risk assessments (e.g. flood risk assessment). Its application is most often hazard or event specific.

Similarly, related research has found that, although resilience is increasingly recognised as an emerging key consideration for sound management of the urban environment and CI systems, its status within relevant standards frameworks remains unclear, and there remain gaps in knowledge concerning risk assessment:

- Need to develop resilience standards:
  - The adaptability required by resilience concepts poses challenges for standards, their associated legal frameworks and those administering them. There is a need to further refine the interaction between standards and their supporting legislation and resilience within Member States and other countries.

- Improving the understanding of risk assessment:
  - Vulnerability assessments can be stand-alone or a part of full risk assessments. Due to the conceptual correlation between resilience and vulnerability reduction, it is appropriate that it is integrated into any adaptation of the risk management approach. Options of how to integrate risk management (e.g. based on ISO 31000/ISO 31100) to strengthen resilience intervention evaluation should be considered.

3.5 Concluding Reflections

This chapter sought to highlight some of the key challenges facing urban planners in operationalising the 'resilience' concept in practice. In doing so, it examined the evolution of the resilience concept in order to contextualise its modern application within the planning domain, and to demonstrate the rationale for moving towards a more holistic, integrated view of resilience. This rationale was demonstrated through an examination of the Irish context, and the key challenges experienced with regard to the cascading impacts of flooding events. Indeed, across the Western world, such an integrated approach is especially important due to the increasing system complexities and interdependencies associated with current infrastructure systems, where the cascading effects of a system breakdown on other interconnected systems (Rinaldi et al. 2001) could significantly affect public safety, security, economic activities or environmental quality of their coverage areas and in turn could negatively affect the overall well-being of the affected urban society.

A key challenge for urban decision-makers is thus to foresee the impact of sudden extreme events and the type of 'surprises' which may emerge from those impacts. These inherent uncertainties require a learning-based approach to both accumulations of knowledge and identification of vulnerabilities and opportunities. In order to achieve this, urban planners must be part of a more integrated urban management nexus. Indeed 'urban resilience' is a concept which is particularly useful for addressing such uncertainties—but it must be seen as a collective responsibility, one which is most effective when it involves a mutual and accountable network of civic institutions agencies and individual citizens working in partnership towards common goals within a common strategy (Siemens 2014).

In line with this, and in order to address the lack of strategic direction around resilience within forward planning, it is considered that a shared understanding of urban resilience must be developed, together with developing a holistic definition for the concept and providing guidance on how this concept applies at different spatial scales from national to local level and how it relates to the technical language in each of the related disciplines. This shared understanding can serve to both shape the way planners, urban designers and engineers who perceive the challenges cities face and provide a framework by which to respond (HARMONISE D1.1 2013).

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Maria Rochford is a qualified urban planner, environmental consultant and Senior Associate at FAC. Maria has gained significant experience participating in numerous European Commission-funded applied research projects, particularly in the areas of urban resilience, security and connected safety. She has been an active member of the coordination teams for both RESILENS and HARMONISE. Maria also led a Work Package for FP7 funded project BESECURE (Best Practices for Enhancing Security Policy in Urban Zones) which is concentrated on identifying best practices used throughout Europe to address crime and antisocial behaviour through a series of stakeholder consultation and engagement-based case studies.

Chapter 4
Toward Climate Resilience in the USA: From Federal to Local Level Initiatives and Practices Since the 2000s

Ebru A. Gencer and Wesley Rhodes

Abstract This chapter explores the evolving concept of disaster risk management and climate resilience building in the United States of America (USA) within the last two decades. The chapter starts by examining federal-level actions towards disaster risk management and climate adaptation and resilience and then delves into local-level actions through the case studies of Nashville, Tennessee, and Hoboken, New Jersey. The chapter concludes with a discussion on the future of climate resilience in the USA. The chapter illustrates that the availability of multiple layers of government has been an effective safety guard against any individual layer's potential unwillingness to undertake protective risk management or climate resilience building. At state and regional levels, where political will was lacking, federal-level support, particularly in the Obama era, and the initiatives of private foundations have been very valuable. Nowhere, though, have climate resilience building actions in the USA been proven more effective than at the city administrative level. As everywhere else, local-level governments in the USA are at the forefront of disasters and the impacts of climate change and try to take the initiatives of preparing their cities for protection.

Keywords US climate policy · Resilience planning · Hoboken, New Jersey Nashville, Tennessee · Hurricane Sandy

This chapter explores the evolving concept of disaster risk management and climate resilience building in the United States of America (USA) within the last two decades. The chapter starts by examining federal-level actions toward disaster risk management and climate adaptation and resilience and then delves into local-level

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actions through the case studies of Nashville, Tennessee and Hoboken, New Jersey. The chapter concludes with a discussion on the future of climate resilience in the USA.

4.1 Paradigm Change on Risk Management and Climate Resilience in the USA

Reminiscent of the changes that took place in the international arena, by the start of the twenty-first century, the concept of disaster risk management in the USA, which until then primarily relied on federal funds being provided for relief after disasters struck, started to shift toward risk reduction. The *Disaster Mitigation Act of 2000* (U.S. Congress 2000) was one of the initial steps in this transformation, as it required state and local communities to have an approved mitigation plan in place to be eligible for pre- and post- hazard mitigation funds; thus, emphasizing the importance of planning before disasters occur (Gencer 2008, p. 289; Gencer 2013, p. 33). Federal Emergency Management Institute's (FEMA) 2001 *How-to-Guide for State and Local Mitigation Planning* (FEMA 2001) for the first time provided guidance to local governments and proposed an inventory assessment to estimate losses from disasters (Gencer 2008 p. 289; Gencer 2013, p. 33). In addition to this guidance report, FEMA's 2006 guide on *Multi-Jurisdictional Mitigation Planning* (FEMA 2006) categorized the requirements on assessing vulnerability. Despite some shortcomings, these documents signaled the entry to a new era and paved the way for more comprehensive federal programs and legislations (Gencer 2008, p. 290; Gencer 2013, p. 34).

In part, these coordinated efforts were a result of institutional structuring following the September 11, 2001, terrorist attacks. In 2003, the Department of Homeland Security (DHS) was formed with the joining of FEMA together with 22 other federal agencies, programs, and offices to provide coordinated efforts on national security from disasters, both natural and man-made.

Within a few years of the forming of DHS, in 2005, Hurricane Katrina initiated a major turning point on the discussion of disasters inflicted by natural hazards in the USA. Hurricane Katrina struck one of the nation's largest metropolitan areas, causing severe flooding damage from Gulfport, Mississippi to New Orleans, Louisiana. The storm led to 1833 fatalities and became the costliest hurricane in USA history, causing $108 billion in direct and indirect damages. The severe damage caused by Hurricane Katrina and the socio-economic vulnerabilities associated with loss and recovery efforts further changed the discourse on disaster risk management in the USA, particularly in academic circles. The criticism surrounding response, recovery, as well preparation for the impacts of natural hazards, gave way to the enactment of the Post-Katrina Emergency Management Act (PKEMRA) (US Congress 2006).

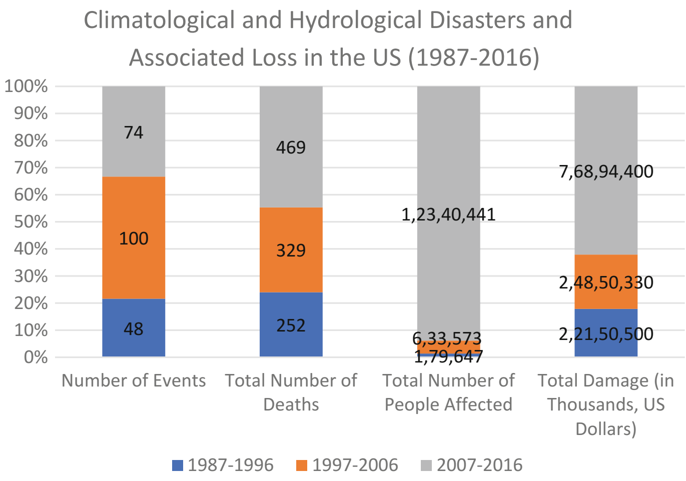

Fig. 4.1 Climatological and hydrological disasters and associated loss in the USA (1987–2016). *Source* CUDRR+R analysis based on raw data at EM-DAT: The CRED/OFDA International Disaster Database—www.emdat.be—Université Catholique de Louvain

On the other hand, the concept of climate change and its impacts did not rise to the legislative and institutional discussions, particularly with respect to adaptation actions, until after another damaging storm, Hurricane Sandy. In 2012, Hurricane Sandy, also called "Superstorm Sandy," became the second costliest hurricane in US history causing $75 billion in damages and 233 fatalities along its path through eight countries along the Caribbean and the Eastern US coast. The immense need for recovery efforts following Storm Sandy led to another Act by FEMA, the Sandy Recovery Improvement Act of 2013 (SRIA) (US Congress 2013). This new chapter in the recognition of resilience is further followed by a number of risk management documents, including very recently, a *Draft Interagency Concept for Community Resilience Indicators and National-Level Measures* that provide a baseline understanding of measures and indicators for resilience *(DHS 2015)*.

The increase in the impact of climatological and hydrological disasters in the USA (see Fig. 4.1), including that of Hurricane Sandy, led the incoming federal administration to take a major step forward in June of 2013, by releasing the *President's Climate Action Plan (White House 2014)*. The plan outlined three broad strategies to address climate change by cutting carbon emissions, increasing adaptation and resilience, and strengthening international climate accords.

The policy initiatives identified by the *President's Climate Action Plan* have trickled down, in part, through directives by various federal agencies to encourage climate considerations at the state, regional, and local levels. For example, the federal Department of Transportation (DOT) and the Federal Highway Administration (FHWA) have directed state DOTs and metropolitan planning organizations (MPOs, the regional entities that distribute federal transportation funds) to incorporate climate adaptation and resilience considerations into their evaluation of projects and long-range plans. The FHWA has also engaged state DOTs in pilot projects to conduct extreme weather vulnerability assessments.

Additionally, FEMA started requiring state and local emergency management agencies to consider future climatic conditions when applying for funds through the Hazard Mitigation Grant Program (HMGP), a major source of funding for adaptation efforts throughout the USA. While these federal directives are important, they often come with little in the form of guidance or assistance with how localities can comply. Instead, the federal government looks to the individual states and localities to identify methodologies. This is sometimes aided through funding for pilot projects to collect best practices and then make them available through online Web portals.

In many parts of the USA, despite federal legislation, state, regional, and local-level administrations may be faced with or hold different political standpoints, which do not prioritize climate resilience activities. In addition, local governments may be faced with opposing views with that of their state administrations, creating a conflict to promote a regional development or resilience program.

One such region is the non-coastal portion of the Southeast, which is usually home to communities that embrace a more skeptical view of climate change. For example, the state of Tennessee is one of the only two states that do not have a state climatologist. However, despite the lack of political will within the state legislature and at the Governor's office, risk reduction and resilience building efforts have been made with support from both the federal government and private foundations to fill the gap where political will has been lacking.

The section below will provide examples on two such cities that have taken individual initiatives to develop resilience programs. The first case is the city of Nashville, in the state of Tennessee, where support for climate resilience programs is limited. Another similar case illustrated is the city of Hoboken, New Jersey, where the local and state administrations have different political views, and the city has taken exceptional measures to develop a local resilience plan, leading to being recognized as a role model city by the United Nations in 2015.[1]

4.2 Resilience Efforts in the City of Nashville, Tennessee

The city of Nashville, Tennessee has been prominent in leading the resilience agenda in the region. The resilience work in Nashville started in earnest by Mayor Karl Dean, who took office in 2007 and served two terms before departing in 2015. Early in his first administration, Dean commissioned a Green Ribbon Committee to produce a report that would guide the city's environmental efforts throughout his tenure as Mayor. This resulted in the creation of the city's first-ever Mayor's Office

[1]Press Release. United Nations Office for Disaster Risk Reduction (UNISDR). 2015. "UN Recognizes Hoboken as a Role Model City." Accessed at https://www.unisdr.org/archive/42762.

of Environment and Sustainability, tasked with making progress on the Green Ribbon Report's goals.

The urgency of the work took on new meaning when the city experienced a major flooding event in May of 2010, resulting in more than $2 billion in damages. The city of Nashville created several initiatives in response to the flooding event, such as a home buyout program for houses located in flood zones. This program resulted in the purchase and demolition of over 225 properties, and the subsequent conversion of these spaces to park and open space. The city has also been aggressive in purchasing large tracts of open space whenever possible, such as the purchase of the 132-acre Cornelia Fort Airpark, located along the Cumberland River and adjacent to another large park property, Shelby Bottoms. The city has made infrastructure upgrades such as repairing and adding additional pumps to the Metro Center Levee. Furthermore, it has introduced two new technological upgrades to aid in disaster response. The first is the Situational Awareness of Flooding Events (SAFE) Program. This system provides the city with accurate, real-time information about current and future river stages and allows the city to respond quickly and efficiently during heavy precipitation and flooding events. The second is Nashville Emergency Response Viewing Engine (NERVE), which is a free online tool available to residents in Nashville that provides them with real-time information about road closures, evacuation areas, school closures, and locations of emergency shelters, food and water distribution centers, and disaster assistance centers.

In addition to these activities, in January 2013, Nashville released the Unified Flood Preparedness Plan (UFPP), which identified, among other projects, potential for the development of a flood wall to protect downtown Nashville (Metropolitan Government of Nashville and Davidson County, Tennessee 2015a, b). Along with physical infrastructure barriers, the city is also considering soft resilience measures such as implementing smart technology or installing blue–green infrastructure. For instance, it has developed a partnership with the Trust for Public Land (TPL) to participate in their Climate Smart Cities Initiative, which involves creating interactive mapping tools that help cities make more informed decisions about where to invest in green infrastructure. The city has also partnered with the Cumberland River Compact and the US Army Corps of Engineers to create 75 free rain gardens in one neighborhood. The project has not only helped with storm-water absorption and management and the minimization of pollution runoff into nearby streams, but also provided co-benefits by beautifying the alleyways and encouraging their use by pedestrians. This type of project could be replicated in many neighborhoods throughout the region and gives community members educational opportunities, encourages civic participation, and provides a sense of ownership.

In 2015, two additional plans helped shape Nashville's strategies for resilience into the future. The Nashville Area Metropolitan Planning Organization released a regional Climate Adaptation Plan entitled, "Building Resilience: A Climate Adaptation Plan" (Rhodes and Plummer 2015). The report identified future climactic threats and explained how the region's rapid growth and development have exacerbated them. The plan further explored the impacts to the regions ecosystem services, vulnerable populations, and infrastructure from these threats and

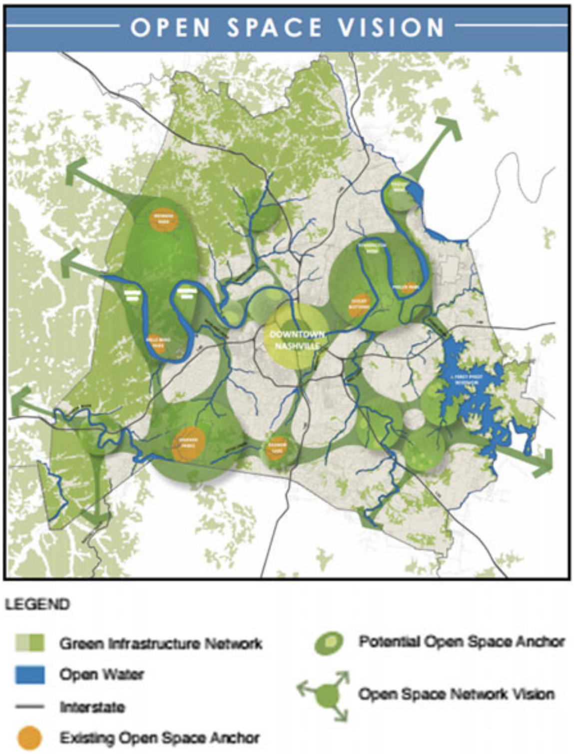

Fig. 4.2 Conceptual map on Nashville's open space vision. *Source* Metropolitan Government of Nashville and Davidson County, Tennessee 2015a, b. Nashville Next: A General Plan for Nashville and Davidson County

culminated with an action plan for adaptation and resilience. Also, the city released a new 25-year long-range comprehensive plan entitled, "Nashville Next," the culmination of a three-year planning process. The report includes a section on natural hazards and building resiliency as part of a broader chapter on Natural Resources and Hazard Adaptation. The section specifically addresses how the city will need to balance development with preservation to create resiliency, and includes, among other analyzes, an open space vision (Fig. 4.2).

Additionally, under current Mayor Megan Barry, the city is looking to ramp up its resilience building activities. Mayor Barry convened a Livable Nashville Committee to create a set of goals and recommendations to make Nashville the "Greenest City in the Southeast" during her tenure as mayor. Additionally, the city is participating in the Rockefeller Foundation's 100 Resilient Cities (100RC) initiative that will provide funding to hire a Chief Resilience Officer and receive technical support from peer 100RC participants and the Rockefeller Foundation. These multiple activities lead to Tennessee's being a pioneer of resilient development in the landlocked Southern part of the USA.

4.3 Resilience Efforts by the City of Hoboken, New Jersey

In a very different socio-economic and spatial part of the USA, the city of Hoboken in Northern New Jersey, located just across Manhattan, incurred one of the heaviest impacts from Hurricane Sandy that made landfall on October 29, 2012. Eighty percent of Hoboken's land flooded during the superstorm, leading to more than $100 million in property damage, in addition to severely degrading the region's transportation infrastructure (Gencer 2014). As most of the residents of Hoboken travel daily to Manhattan using either water transportation or the PATH train (the rapid transit railroad connecting New Jersey with Manhattan), there were indirect damages due to the closing of this pathway for six months following the storm (Fig. 4.3).

The city of Hoboken was flooded for four days as water covered all but three blocks of the city, leaving only one evacuation route along the 14th street viaduct. The presence of salt water from the storm surge meant that damage was much more extensive than freshwater flooding. Additionally, the combination of oil, gasoline, and sewage made for a toxic mix that severely damaged buildings. Most of the damage occurred in ground floor apartments and older structures, newer construction fared better.

The city had installed a flood pump following Hurricane Irene in 2011, which was designed to alleviate flooding due to high-tide. The pump is capable of pumping 50 million gallons of water a day; however, during Sandy, there were 500 million gallons of floodwater. The pump worked in the immediate aftermath of the storm surge, but quickly lost power due to outages in the city, leading to the immense damages.

Following Sandy, the city of Hoboken received $200,000 in the form of Community Disaster Block Grant Disaster Recovery (CDBG-DR) funding from the

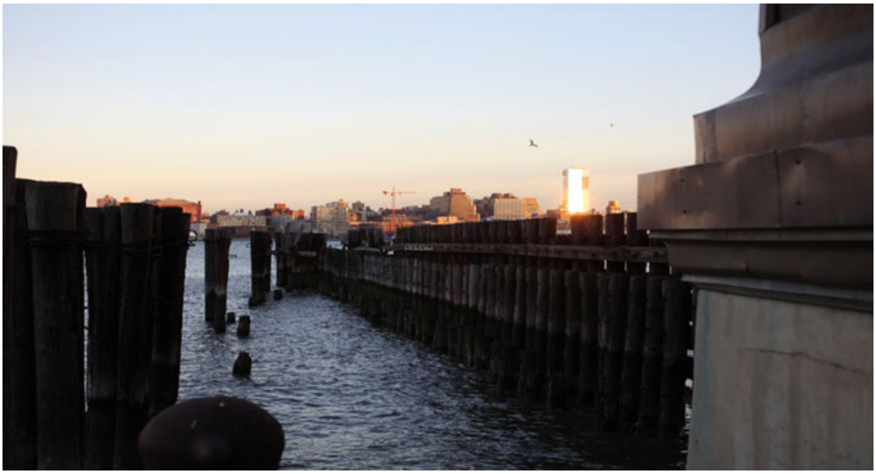

Fig. 4.3 Canalways of Hoboken across from Manhattan. *Photo Credit* Daniel Riley (for CUDRR+R)

Housing and Urban Development Department (HUD). The city used these funds to complete a five-step resiliency project in 2014, which consisted of:

1. Municipal hazard mitigation plans;
2. A Five-Year Capital Improvement Plan;
3. An update to the city's water management regulations;
4. Updates to the city's open space plan; and
5. Design guidelines for flood proofing buildings.

In addition, Mayor Dawn Zimmer created a "Resiliency Task Force" to advance community recovery and resiliency and coordinated all efforts. Hoboken created a Community Resilience Plan that addresses its vulnerabilities and mitigates the risk of future flooding and disaster events. The plan includes numerous actions, outlined below:

Energy Resiliency: The city of Hoboken is currently exploring the feasibility of a cutting-edge "Micro-grid" energy system, which will utilize energy surety design methodology technology. This would be the first non-military application of the technology for an entire community. The project includes the US Department of Energy, Sandia National Laboratory, the N.J. Board of Public Utilities, and Public Service Electric and Gas ("PSEG"). If implemented, the project would designate critical community facilities to deliver uninterrupted electrical service during disaster events, black-outs and brown-outs. The city is also exploring funds for upgrades to existing substations and the installation of additional emergency backup generators.

Shoreline Protection: The city of Hoboken is aggressively pursuing funds for the installation of seawalls and flood barriers and has requested the elimination/hardening of the Long Slip Canal, from which the flood waters entered the community. Additionally, it is incorporating flood barriers into redevelopment plans such as the Redevelopment Plan for Hoboken Rail Yards. The city is also advocating for other organizations such as the New Jersey Governor's staff, NJ Transit Executive, FEMA representatives, and the Army Corps of Engineers to include protection of its shoreline in their future plans and programs. It is furthermore investigating the feasibility of an armored levee or flood barrier at Weehawken Cove.

Flood Mitigation: The city of Hoboken supported the North Hudson Sewerage Authority's (NHSA) $20 million grant application for hazard mitigation funding to construct three new shovel-ready wet weather pump stations to alleviate flooding. The city intends to pay for the first pump with a low-interest loan from the New Jersey Environmental Infrastructure Trust, and plans to include a requirement for the developer to pay for a second pump as part of a revised Redevelopment Plan for Hoboken Rail Yards.

Storm-water Management: The city of Hoboken has applied to the state of New Jersey for $60 million in hazard mitigation funding to purchase three tracts of land in the flood hazard area. If funded, the tracts of land will be used for parks and open space with storm-water retention facilities incorporated into the design to reduce storm-water runoff. The city also received funding and technical assistance to design “green infrastructure” to reduce the effects of climate change and extreme weather events. Additionally, the city received a $20,000 grant from “Sustainable Jersey” to design a rain garden which will be used as a prototype for other sites around the city and has hired a landscape architecture firm to design green infrastructure for a 12-block neighborhood in Southwest Hoboken.

Critical Facilities/Infrastructure: Many of Hoboken’s municipal facilities sustained significant damage during Hurricane Sandy. The city of Hoboken submitted a $50,000 grant application to the NJ Department of Community Affairs (NJ DCA) for CDBG-DR funds to prepare a Municipal Hazard Mitigation Plan to supplement the 2008 Hudson County All Hazards Mitigation Plan; a $50,000 grant application to prepare an Open Space, Recreation, and Historic Preservation Plan; and a $30,000 grant application to prepare a Five-Year Capital Improvement Plan that will focus on municipal resiliency and hazard mitigation.

Emergency Notification and Public Education: The city of Hoboken has applied for funding to purchase programmable, solar-powered, mobile message boards which can be quickly deployed during emergencies to warn motorists of impending hazards or provide residents with information and instructions. Additionally, the city employs reverse 911, as well as Facebook, Twitter, and text alerts. The city is also engaged in a social media and public information and awareness campaign to advise residents of hazards and help citizens put together preparedness plans.

Resilient Building Codes: The state of New Jersey has a building code that applies to the whole state. It is not possible to change the building code in Hoboken without getting a state-wide appointment, even though Hoboken faces unique problems. For instance, Hoboken has a high density and it is the second biggest transportation hub in the state of New Jersey, embracing 250 thousand commuters per day. The city of Hoboken would like to change the design codes and elevate the power-stations. The city is working to reconcile its zoning code with state and federal regulations to allow for “wet flood proofing” and “dry flood proofing” of ground-level floors located below the base flood elevation (BFE), as it is not feasible for many building owners to raise their attached, multi-story structures to comply with FEMA’s National Flood Insurance Program (NFIP) regulations and requirements.

New Jersey is considered a home rule state where zoning rests with each authority, but there are regional aspects such as commuting, transportation, and real-estate interests that require regional collaboration. Such regional requirements, as explained in the issue of building codes, and the existing built-up space are the main barriers to resilience efforts in the city.

However, similar to the example in Tennessee, Mayor’s commitment in Hoboken has been the main enabling factor for the success of resilience planning. With the support of the Mayor, the Resilience Task force undertakes efforts in a coordinated manner. The five-point resiliency plan shapes the city’s resilience planning implemented by capable technical staff. All of these activities are further strengthened by public awareness and participation in planning and resilience building making Hoboken a good-case study in local resilience in the USA.

4.4 Conclusion

As this Chapter has illustrated, risk management and climate resilience building actions in the USA have been undertaken at different levels by various governmental organizations and where needed with the support of private foundations and organizations. The availability of multiple layers of government has been an effective safety guard against any individual layer's potential unwillingness to undertake protective risk management or climate resilience building.

This has been particularly true with the support provided by the Obama administration from 2008 to 2016 at the federal level, which acknowledged the need to develop climate resilience actions in the face of rising losses from climatological and hydrological hazards within the last two decades.

At state and regional levels, where the political will was lacking, federal-level support and the initiatives of private foundations have been very valuable. Nowhere, though, have climate resilience building actions in the USA been proven more effective than at the city administrative level. As everywhere else, local-level governments in the US are at the forefront of disasters and the impacts of climate change and try to take the initiatives of preparing their cities for protection. This is most true in cities, which have already experienced such disasters, such as the city of Nashville, Tennessee with flooding and the city of Hoboken, New Jersey with Hurricane Sandy. While these cities have taken extraordinary measures, they were mostly made possible with federal-level funding support.

At the time of the writing of this Chapter, there are signs that the new Trump administration will approach climate resilience and risk management from a different perspective than that of the previous Obama administration. It is not clear whether the existing laws and regulations will continue to be implemented and whether the federal-level support to local administrations will continue. It has already been observed that the new administration is considering to roll back on federal protections, such as environmental regulations, bringing power back to states to lift restrictions. In addition, there are significant budget cuts to leading national institutions, such as the National Oceanic and Atmospheric Administration (NOAA), which undertakes research on climate and projections on sea-level rise and climatological and meteorological hazards. The Trump administration is also currently reviewing its climate change policy including undertaking discussions on whether or not to pull out from the Paris Agreement on Climate Change.

With such changes taking place, mayors and governors are starting to ramp up their efforts to address climate action and resilience building locally. However, without the lack of institutional and financial support from the federal government, cities will require more stakeholder support to fund, develop, and implement such activities and become the actual leaders of climate resilience building in the USA.

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Chapter 5
Enhancing Resilience Towards Summer Storms from a Spatial Planning Perspective—Lessons Learned from Summer Storm *Ela*

Hanna Christine Schmitt and Stefan Greiving

Abstract Every year, convective extreme weather events like summer storms, hail and heavy precipitation cause enormous damages to assets, values and human lives, especially in urban areas. Although highly relevant for the field and expertise of spatial planning, so far those events are addressed rather poorly, if at all. This is mainly for two reasons: for one, convective extreme events are of ubiquitous character, meaning they have unknown probability and place of occurrence, i.e. are accompanied by great uncertainties. For another, spatial planning does not dispose of convenient concepts and instruments to address events with an intangible hazard component, as they are spatially not describable and therefore risk analyses presumably inapplicable. Ultimately, ubiquitous extreme weather events challenge urban disaster resilience and call for enhanced risk management approaches. This chapter discusses the strengths and limitations of spatial planning in dealing with ubiquitous extreme weather events, using the example of summer storm *Ela*, which devastated large parts of Western Germany in June 2014.

Keywords Spatial planning · Summer storm · Convective extreme event
Ubiquitous weather event · Risk management · Germany

5.1 Introduction

Spatial planning has the competency of deciding on if and how future land-use shall take place and is defined as comprehensive, over-sectoral planning. In order to be able to equitably weigh the consequences (chances and risks) that result from planning decisions, spatial planning has to anticipate potential *spatially relevant* and *spatial-planning relevant* hazards as well as the vulnerability of an area (Burby 1998;

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Deyle et al. 1998; Greiving and Fleischhauer 2006). Together, hazard and vulnerability are the key determinants of risk, which is defined as

> the combination of the probability of an event and its negative consequences. (UNISDR 2009, 25)

Generally speaking, any extreme event poses a risk to human beings and their properties. While nature and its ecosystems have always adapted at least to natural hazards, human activities have aggravated the risk in both the hazard and vulnerability component (Greiving et al. 2017).

When discussing spatial planning's competencies and restraints in risk management, the above-mentioned terms *spatially relevant* and *spatial-planning relevant* hazard are of key interest. According to Greiving (2011), a hazard is *spatially relevant* if it is possible to differentiate hazardous from non-hazardous areas. However, not all *spatially relevant* hazards become relevant for spatial planning. *Spatial-planning relevance* either requires the need for a cross-scale and cross-sectoral handling of a *spatially relevant* hazard (e.g. if a hazard turns into a disaster), or the ability to respond to it, using land-use-related spatial planning instruments. If hazards are not *spatial-planning relevant*, coping strategies traditionally focus on emergency management and building precaution (Glade and Greiving 2011).

Within the last decade, Germany had to face numerous damage-causing events that do not fit the definitions of *spatial* and *spatial-planning relevance*. To only name three prominent examples, hail storm *Andreas/Bernd*[1] caused damage costs of more than 1.9 billion in 2013, heavy precipitation event *Quintia* led to large-scale inundations in the city of Münster in 2014 with damage costs of more than 200 million and large-scale thunderstorm *Ela* swept over large parts of Western Germany, causing damage costs of more than 650 million (GDV 2014, 2015). As the hazard components of all three events were of ubiquitous character, meaning they could have occurred more or less anywhere, these events are considered not to be *spatially relevant* and accordingly also not *spatial-planning relevant* as their hazards cannot be managed by spatial planning (Greiving 2016).

However, the damages caused by the ubiquitous events reveal patterns of second- and third-order impacts (cascading effects) on other land-uses and critical infrastructure, which eventually are of importance for and partially influenceable by spatial planning.

This chapter discusses the strengths and limitations of spatial planning in managing risks from ubiquitous extreme weather events in the light of urban resilience, using the example of recent summer storm *Ela*. In the following, the ubiquitous summer storm event is presented in its characteristics, synoptic evolution and impacts (see Sect. 5.2). Subsequently, strengths and limitations of spatial planning in managing risks from ubiquitous extreme weather events are discussed (see Sect. 5.3). Last, risk management of ubiquitous extreme events is examined in the light of urban resilience (see Sect. 5.4) and concluding remarks regarding further needs for enhancing urban resilience through spatial planning are given (see Sect. 5.5).

[1]In Germany, cyclones and anticyclones are named by the German Meteorological Service.

5.2 Ubiquitous Summer Storm Event *Ela*

In the following, the characteristics and impacts of summer storm *Ela* are described in order to facilitate a better understanding of this challenging natural hazard. The spatial focus will be on the federal state of North Rhine-Westphalia,[2] although summer storm *Ela* also affected other German federal states as well as parts of France and Belgium.

5.2.1 Differentiation Between Summer Storms and Winter Storms

Storms can generally be differentiated as storms occurring during the meteorological winter half year (winter storms; October–March) and storms occurring during the summer half year (summer storms; April–September). In Germany, winter storms are predominantly cyclones and can be characterised as storm events of great geographic extent that may last for several hours or even days. Winter storms need multiple days to evolve and are relatively precisely and easily predictable in their storm tracks (DWD 2014).

Summer storms on the other hand predominantly result from convective events and appear in the form of thunderstorms. Thunderstorms are usually of rather small geographic extent, lasting for several minutes up to a few hours. They are phenomena that are especially difficult to forecast with numeric weather forecasting (DWD 2016) as they evolve within a few hours and are hardly predictable in their storm tracks.

In the last quarter-century, several hurricane-force winter storms swept over Germany and were associated with severe damages: especially most recent winter storm *Kyrill* (Fink et al. 2007). But in June 2014, it was summer storm *Ela*, which hit large parts of Western Germany and caused considerable damages.

[2]North Rhine-Westphalia is one of the 16 German federal states (*Bundesländer*) and is located in the mid-west of the country, to which the Netherlands and Belgium are adjacent to west. With about 18 million inhabitants (31.12.2015), North Rhine-Westphalia has the largest population of all German federal states. The state is home to the Ruhr Area (*Ruhrgebiet*), a post-industrial region in transition, which is Germany's largest agglomeration. It comprises eleven self-governed cities and four counties with smaller municipalities. About five million inhabitants of North Rhine-Westphalia live in the Ruhr Area, most of them within cities (NRW 2016).

5.2.2 Characteristics and Synoptic Evolution of Summer Storm Ela

Contrary to the above-mentioned characterisation of thunderstorms usually being of rather small geographic extent, summer storm *Ela* presented as a mesoscale convective complex (MCC), which basically is a large-scale thunderstorm cluster. MCCs are characterised as the strongest thunderstorm complexes possible, being the geographically most widespread and durable types of thunderstorms (DWD 2015). Although on average usual thunderstorms occur every two to three years in North Rhine-Westphalia, the federal state (*Bundesland*) had never since weather recordings[3] experienced a summer storm of *Ela's* geographic and enduring extent (Deutsche Rückversicherung 2015).

The days before summer storm *Ela*, North Rhine-Westphalia was meteorologically determined by large high-pressure area *Wolfgang*, extending from the western Mediterranean Sea to Middle and Eastern Europe. *Wolfgang* led to peak temperatures of more than 30 °C all over Germany and was reason for the hottest Pentecost since weather recordings. At the same time, low-pressure area *Ela* was located at the west coast of Ireland, starting to infiltrate hot, humid and unstable air masses in North Rhine-Westphalia, smoothening the way to heavy thunderstorms (DWD 2015).

On Sunday, 8 June 2014, several multi-cell thunderstorm clusters arose along *Ela's* first convergence line, which was accompanied by hail, causing the first damages of the weekend. The most severe weather developed on Pentecost Monday, 9 June 2014, above France, as the MCC formed. When the cold front of low-pressure area *Ela* approached with cloud temperatures of up to −70 °C, the hot and humid near-ground level air was elevated, arising distinct instability (lability). As a consequence of the enormous temperature difference, broad prefrontal convergence lines evolved, forming an intense bow echo of precipitation and strong wind gusts. Hurricane-force peak wind gusts of 12 Beaufort ($\geq$ 140 km/h) were measured at different weather stations[4] in North Rhine-Westphalia. At all stations, there had never been a summer storm of this intensity measured before (DWD 2015).

The police registered more than 5,000 weather-related operations in the night of 9 June 2014, being accompanied by an unrecorded number of fire brigade and aid agencies interventions (Deutsche Rückversicherung 2015). The state capital of North Rhine-Westphalia, the city of Düsseldorf, requested support from the German Armed Forces (*Bundeswehr*) (GDV 2015).

As *Ela* was the first MCC ever recorded in North Rhine-Westphalia, it is impossible to project possible future changes or even tendencies. Nevertheless, it has to be assumed that due to global climate change, average air temperature as well as temperature extremes (heat days, tropical nights) will increase in their number of

[3]In North Rhine-Westphalia, the German Meteorological Service started wind measurement in 1971.

[4]Measurement stations: Düsseldorf-Flughafen, Essen-Bredeney, Aachen (DWD 2015).

occurrence. Since warmer air contains more humidity and therefore is more energised, it may be assumed that also the probability of occurrence for extreme thunderstorm complexes rises (DWD et al. 2012). In a first reflection on summer storm event *Ela*, the German Meteorological Service stated that the return period for a comparable event probably amounts to far more than 50 years. Nevertheless, statements on the future situations are highly uncertain as climate change might drastically increase the frequency of extreme events (DWD 2015).

5.2.3 Impacts of Summer Storm Ela

The German Insurance Association (*Gesamtverband der Deutschen Versicherungswirtschaft e.V.*) recorded 350,000 damages caused by summer storm *Ela* in Germany, in total amounting 650 million[5] (GDV 2015). Besides insured losses, *Ela* caused an undocumented number of uninsured losses and, tragically, six fatalities, 30 serious injuries and 37 slight injuries among the affected population. The estimated total damage costs for Middle Europe accounted 2.1 billion (Deutsche Rückversicherung 2015; GDV 2015).

In comparison to all previous convective storm events in Germany, damages from summer storm *Ela* predominantly resulted from hurricane-force peak wind gusts and rather subordinately from hail or heavy precipitation. Yet, *Ela's* damage types were completely different from winter storms' damages as well, as especially deciduous city trees were damaged, triggering cascading effects on land-uses and infrastructures (Deutsche Rückversicherung 2015).

5.2.3.1 First-Order Impacts

First-order impacts from summer storm *Ela* concentrated on city trees. As city trees are predominantly deciduous trees, solitarily standing along roads or in green spaces, they provide great flow resistance during the summer months as they are in full leaf. In North Rhine-Westphalia, tens of thousands of city trees were unable to withstand the hurricane-force wind gusts and in consequence were severely damaged, broken or uprooted (Deutsche Rückversicherung 2015). Additional damages were recorded in forests, where again especially deciduous trees were damaged, despite presumably better habitat conditions. The city of Essen,[6] which was previously severely affected by windthrow from winter storm *Kyrill*, stated that the

[5]Thereof 400 million were related to property insurances and 250 million to vehicle insurances (Deutsche Rückversicherung 2015).

[6]The City of Essen is located in the heart of the Ruhr Area and is accounted Germany's seventh largest city with more than 580,000 inhabitants (31.03.2017) (City of Essen 2017).

combined costs from forest and city tree damages from *Ela* were about four times those of *Kyrill*[7] (Stadt Essen database 2014).

Further, minor first-order impacts were untiled roofs and local inundations due to torn off leaves congesting gullies (Deutsche Rückversicherung 2015).

The first-order impacts of summer storm *Ela* illustrate the strong significance of the intensity of a storm event, i.e. its peak wind gusts, rather than its duration. As wind pressure is proportional to square of the wind speed, damages increase with increasing wind speed (DWD and GFZ 2014). *Ela*'*s* 10-min middle-winds of 3–4 Beaufort were relatively low compared to *Kyrill's* 7–8 Beaufort, but as *Ela*'*s* peak wind gust was just as high as *Kyrill's*, the damage intensity was similar.

5.2.3.2 Second- and Third-Order Impacts

The expression *second- and third-order impacts* embraces all subsequent impacts (cascading effects) resulting from first-order impacts rather than directly from the hazard. In the case of summer storm *Ela*, second- and third-order impacts resulted from trees falling into and onto goods and assets. Regarding both the severity of damages as well as the relevance for spatial planning, those secondary and tertiary, indirect impacts of summer storm *Ela* are of higher relevance than the above-mentioned first-order impacts, as they visualise the (systemic) criticality of infrastructure. Criticality is defined by the critical infrastructure protection strategy (CIP) as

> a relative measure of the importance of a given infrastructure in terms of the impact of its disruption or functional failure on the security of supply, i.e. providing society with important goods and services (BMI 2009, 7).

The CIP strategy differentiates between systemic and symbolic criticality. Systemic criticality describes its structural, functional and technical position within the overall system of infrastructures, symbolic criticality its cultural significance (Greiving et al. 2017).

The following descriptions exemplify second- and third-order impacts of summer storm *Ela* on transport infrastructure and the emergency response system.

Within the system of transport infrastructure, rail transport and road transport were the most affected by summer storm *Ela's* windthrow. In the central Ruhr Area, one third of the tracks were damaged by fallen trees (see Fig. 5.1) (Deutsche Rückversicherung 2015). These rather local damages had the consequence that several main train stations in the Ruhr Area could not be approached for numerous days, causing supra-regional effects like delays and redirections of trains as well as the cancellations of passenger and freight transport, resulting in economic losses. The German Rail (*Deutsche Bahn*) estimated the damage costs to 20 million due to

[7]It is important to acknowledge the economic value of different tree species as well as their location factor; while city trees rate as city inventory and may have an economic value of more than 2,000 each, forest trees rate as timber with far less economic value. Accordingly, the city's statement does not allow to draw conclusions on the number of damaged trees.

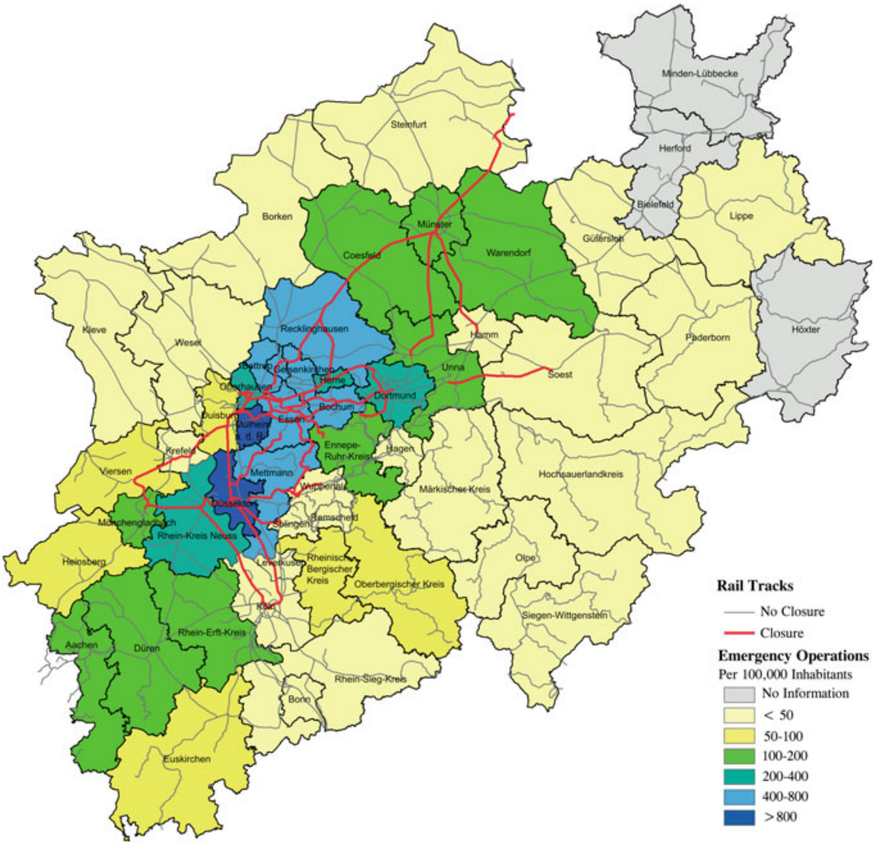

Fig. 5.1 Closure of rail tracks in North Rhine-Westphalia due to summer storm Ela. *Source* Deutsche Rückversicherung (2015, 23)

damages of tracks and overhead lines and additional 35 million due to loss of profits (Deutscher Bundestag 2014).

Regarding road transport, both public transport and private transport were highly restricted for several days. Public transportation, e.g. by tram or busses was impossible for several days in many cities, as trees blocked roads and damaged overhead lines and optical signalling systems. With private transport facing the same problem of federal and municipal roads being blocked, a large number of the Ruhr Area's population were unable to commute to work.

Besides the uncounted economical losses due to absenteeism, an even severer impact of summer storm *Ela* was that emergency response units were highly restricted in their operation capacity, which resulted from two circumstances: For one, the sum of tens of thousands of city trees blocked even the main emergency routes, making it difficult for the relief forces to reach their deployment sites. For another, in some cases a single fallen tree was the reason that fire brigade units or ambulances were unable to even leave their stations. Accordingly, these cases required clearing of the emergency units' properties prior to any on-site operation.

The given example illustrates only one line of cascading effects that may result from events like summer storm *Ela*. Many other were experienced by the affected cities (e.g. temporal closure of administrative and educational institutions) or are imaginable in slightly different scenarios (e.g. interruption of energy supply). Besides the illustration of cascading effects, the described impacts on transport infrastructure and emergency response capacities reveal that different land-uses and infrastructures have different levels of criticality. Moreover, as Fig. 5.1 illustrates, local damages may have systemic, large-scale effects on infrastructure systems, coming into conflict with the fact that the operational framework of a municipality ends at its administrative boarders (see Sect. 5.3). Therefore, the key question arising from the example of summer storm *Ela* is: does spatial planning have the responsibility and the ability to come into action in ubiquitous events, and if yes, how?

5.3 Strengths and Limitations of Spatial Planning in Managing Risks from Ubiquitous Extreme Weather Events

Risk management and spatial planning have a complex relationship. On the one hand, every spatial planning decision comprises decisions on the future distribution of risks, which is a form of risk prevention and therefore a part of risk management. On the other hand, both regional planning and local land-use planning tend to understanding risk management as a task beyond their jurisdiction and are likewise not perceived as risk managers by the public. A key challenge for spatial planning in managing risks seems to be that *risk* is a concept too vague, which suddenly becomes relevant in cases of imminent danger, but then it is headed by disaster relief forces rather than spatial planning, questioning spatial planning's overall responsibilities as well as abilities in managing risks (Pohl 2011).

In Germany, emergency management and consequently risk preparedness and response lie within the planning sovereignty of the municipalities and are self-government tasks within services of general interest (*Daseinsvorsorge*). Accordingly, risk prevention generally speaking is a politically and legally legitimised task of spatial planning (Pohl and Rother 2011).

More specifically, spatial planning influences the spatial distribution of risks with every land-use-related decision it takes within the frameworks of regional and land-use planning (Rumberg 2011). However, planning practice shows that so far risk management takes place rather indirectly, implicitly and sectorally, e.g. concerning flood risk protection. So far, there is a lack of an explicit statutory assignment for managing risks within spatial planning (Wernig et al. 2011), although risk assessment in regard to so-called *catastrophic risks* is required in accordance with the amendment of the EU environmental impact assessment

(EIA) Directive (2014/52/EU). However, for the addressees of this risk assessment, among others the municipalities, it remains unclear if and how second- and third-order impact that may exceed the areas covered by a plan or project could be addressed by this assessment.

In practice, planning authorities can (and should) take into account the physical component of different infrastructures and their susceptibility against various threats. Accordingly, planning authorities should protect critical infrastructure through allocation in a significant distance from hazardous areas and, vice versa, through separation of dangerous infrastructure from vulnerable land-uses (Greiving et al. 2017).

However, any risk management by spatial planning needs to be place-based within the (local) area of responsibility, which challenges especially the prevention and response towards extreme weather events in the light of systemic criticality of infrastructure systems. Systemic criticality of infrastructure is determined by its structural, functional and technical position within the overall system of infrastructure sectors. The necessity to focus on entire networks (e.g. electricity or transport network) evolves when investigating systemic risks or systemic components and potential cascading effects on other infrastructures. Thus, the systemic understanding is contrary to the areal-oriented view of land-use planning (Greiving et al. 2017).

Accordingly, a dilemma presents in the fact that a planning authority is responsible for its local area, but is rarely aware of and not entitled to deal with the network components of critical infrastructure that are located elsewhere in the region or even abroad (see Fig. 5.1). This limits the ability to deal with critical infrastructure in spatial planning to those system elements that are only of local (or regional) importance and within the municipal boundaries. Hence, there is a need for a national or even international risk assessment by those authorities which are in charge of managing a particular infrastructure network (Greiving et al. 2017).[8]

The most important international framework for disaster risk management is the Sendai Framework for Disaster Risk Reduction (UNISDR 2015). The Sendai Framework acknowledges several competencies of comprehensive, over-sectoral spatial planning in managing risks and points at the importance of the discipline for the recovery phase, although it has previously been seen as a key player only for preventive measures (see, e.g. Greiving et al. 2006).

In Priority 2 “Strengthening disaster risk governance to manage disaster risks”, the Sendai Framework promotes that:

> Clear vision, plans, competence, guidance and coordination within and across sectors as well as participation of relevant stakeholders are needed. (UNISDR 2015, 17)

[8]A good, although sectoral example for addressing risks on a national level is the Germany-wide spatial plan on flood protection (*Bundesraumordnungsplan Hochwasserschutz*), which is currently under discussion and aims at coordinating the regional plans of the federal states (*Bundesländer*). The nationwide plan may address potential cascading effects of large flooding events with respect to the criticality of infrastructure systems.

In Priority 4 “Enhancing disaster preparedness for effective response and to ‘Build Back Better’ in recovery, rehabilitation and reconstruction”, spatial planning’s importance becomes even more apparent:

> The steady growth of disaster risk, including the increase of people and assets exposure, combined with the lessons learned from past disasters, indicates the need to further strengthen disaster preparedness for response, take action in anticipation of events, integrate disaster risk reduction in response preparedness and ensure that capacities are in place for effective response and recovery at all levels. […] Disasters have demonstrated that the recovery, rehabilitation and reconstruction phase, which needs to be prepared ahead of a disaster, is a critical opportunity to “Build Back Better”, including through integrating disaster risk reduction into development measures, making nations and communities resilient to disasters. (UNISDR 2015, 21)

More specifically spatial planning is addressed as one prerequisite for achieving Priority 4. It is important to

> promote the incorporation of disaster risk management into post-disaster recovery and rehabilitation processes, facilitate the link between relief, rehabilitation and development, use opportunities during the recovery phase to develop capacities that reduce disaster risk in the short, medium and long term, including through the development of measures such as land-use planning, structural standards improvement and the sharing of expertise, knowledge, post-disaster reviews and lessons learned and integrate post-disaster reconstruction into the economic and social sustainable development of affected areas. (UNISDR 2015, 21f.)

Another important aspect in the discussion on responsibilities and abilities of spatial planning is the understanding and handling of uncertainties. Uncertainties are risk-immanent and arise as soon as future conditions cannot be predicted with certainty. Uncertainties may, e.g. exist regarding the occurrence of an anticipated hazard (does it occur at all and if yes, when?) or its magnitude (Wernig et al. 2011).

The complexity of dealing with uncertainties seems to peak in the discussion on the management of ubiquitous extreme weather events from a spatial planning perspective, as these are—per definition—indefinable in multiple characteristics. They can presumably occur anywhere at any time, i.e. are basically unpredictable in their probability, time and place of occurrence; possibly even in their precise character.

Associated with the aggravated predictability and forecasting of occurrence and magnitude of ubiquitous extreme weather events, warning management is highly restricted. Additionally, in the case of thunderstorms, peak wind gusts result from downbursts (DWD 2015), which presumably subordinates the consideration of orography and topography. And on top, there is great uncertainty on the potential future development, as extreme weather events are likely to be increased in intensity and frequency by global climate change (IPCC 2014).

For spatial planning, the uncertainty about the probability of occurrence of a certain event is one of the key challenges and often the strongest limitation to risk management actions. The question on whether an event requires (and legitimises) spatial planning actions is of normative, highly political nature and reflects the preferences and socio-political priorities of the definition of an acceptable residual risk (Greiving 2011).

Concluding, there are several strengths as well as limitations of spatial planning in managing risks, especially from ubiquitous extreme weather events. Regarding risk prevention, spatial planning proved to be responsible although the discussion showed that the awareness and execution of this responsibility are still of rather indirect nature. Due to its long-term planning horizon, the goals for sustainable development and its widely independence from political agendas, spatial planning may be regarded as one of the most important players in risk management, also beyond preventive measures (Pohl and Rother 2011).

5.4 Spatial Planning Using Risk Management for Enhancing Urban Resilience

The concept of *resilience* presents with a certain degree of vagueness, which on the one hand is beneficial for having a common objective, even from different disciplinary perspectives, but on the other hand makes it difficult to operationalise the term (Meerow et al. 2016).

In the field of spatial planning, there is a call for an understanding of urban resilience that goes beyond engineering resilience, i.e. further than the maintenance of efficiency and constancy of a system close to a single steady state (Holling 1996). Of special importance is the consideration that systems may change over time and that accordingly *bouncing-back* to a pre-disaster state may be inadequate. Instead, there is a call for preserving the potential for flexibility by considering systemic feedbacks, cross-scale dynamic interactions as well as opportunities for *institutional learning* (Bach et al. 2014).

In the understanding of socio-ecological resilience theory, a system is constantly changing in non-linear ways. This broader perspective on resilience increases the likelihood for desirable pathways under changing conditions, making it a highly relevant approach for dealing with uncertainties, e.g. from climate change, socio-economic or political changes (Walker et al. 2004; Adger et al. 2005; Boin and McConnell 2007; Tyler and Moench 2012; Rodin 2014).

In this chapter, urban resilience is understood as:

> 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 et al. 2016, 45)

So how can spatial planning contribute to enhancing urban resilience through risk management?

An assignment for enhancing resilience through risk management is provided in the Sendai Framework for Disaster Risk Reduction and the amended EIA Directive.

Within Priority 4 of the Sendai Framework, resilience of critical infrastructure (i.e. their safety, effectiveness and operation during and after disasters) is stated to be a prerequisite for enhancing disaster preparedness, response, recovery and reconstruction. The enhancement of the resilience of critical infrastructure is furthermore one of the Sendai Framework's seven global targets, aiming at a substantial disaster damage reduction (UNISDR 2015).

Additionally, the amended EIA Directive is of great importance when discussing the enhancement of urban resilience through spatial planning. Article 3 § 2 in accordance with recital 14 of the amended EIA Directive states:

> In order to ensure a high level of protection of the environment, precautionary actions need to be taken for certain projects which, because of their vulnerability to major accidents, and/or natural disasters (such as flooding, sea level rise, or earthquakes) are likely to have significant adverse effects on the environment. For such projects, it is important to consider their vulnerability (exposure and resilience) to major accidents and/or disasters, the risk of those accidents and/or disasters occurring and the implications for the likelihood of significant adverse effects on the environment. (Directive 2014/52/EU)

In Germany, EIA and strategic environmental assessment (SEA) are jointly implemented in the law on environmental assessment (*Umweltverträglichkeitsprüfungsgesetz, UVPG*). The UVPG is closely interwoven with the Federal Building Code, giving the latter priority regarding the environmental assessment of spatial planning documents[9] (see §§ 16–17 UVPG). Hence, the amendment of the EIA Directive entails an amendment of the Federal Building Code.

Both Sendai Framework and EIA Directive provide an assignment to spatial planning for enhancing resilience. While the Sendai Framework explicitly identifies risk management as an adequate approach but addresses spatial planning rather implicitly, the EIA Directive identifies environmental assessment as a procedure for considering catastrophic risks in the light of susceptibility of land-uses and critical infrastructure in spatial planning.

Another angle for enhancing resilience through spatial planning can be seen in the concept of *change-proof planning*. The term comprises the demands for (a) the preservation of flexibility in planning decisions and (b) the use of governance approaches, both in order to maintain the competency for taking spatial planning decisions and actions despite uncertainties. Promoting spatial planning in a change-proof way therefore means to keep the flexibility to accommodate extremes without failure and the robustness to rebound quickly from undesired impacts (Henstra et al. 2004).

[9]Historically, the Federal Building Code has priority over the UVPG, because land-use plans were already subject to environmental assessment procedures even before the SEA Directive was introduced by the EU. Reason for the consideration of environmental effects prior to any EU Directive was the realisation that a project's location is the key determinant for potential effects. Therefore, the decision on the location of new projects was made subject to an assessment on the level of spatial plans. By this, the German legislative secured a weighting process of potential environmental effects by considering the most suitable location for potentially hazardous projects prior to discussions on a project's realisation within EIA procedures.

The necessity for change-proof planning is exemplified by the following scenario: projections on future climate change-related effects (e.g. temperature and precipitation) bare great uncertainties, as they base on modelling of possible changes in their variables. Those future climate scenarios meet projections on other changes (land-use development, demographic changes, etc.), leading to even greater uncertainties and in sum, changing the perspective on the future situation from probabilities to just possibilities. With public decision-making not having any reliable information at hand, spatial planning actions as, e.g. restrictions of private property rights become unjustifiable.

At this point, change-proof planning needs to initiate the definition of goals and strategies in dealing with risks, i.e. needs to discuss thresholds for acceptable (residual) risks and to (normatively) gain consensus on the justification of response actions (or non-action). Basing spatial planning decisions on worst-case scenarios in accordance with the precautionary principle could be one possible option for legitimising spatial planning actions (BMVI 2017).

Moreover, *no-regret strategies* are an example for managing risks in a change-proof way. The goal of no-regret strategies is that planning decisions in the present do not restrict spatial planning's ability to act in the future, i.e. irreversibility of planning activities shall be prevented. No-regret strategies are especially useful if —as in the case of climate change-related impacts—a potential risk may take effect in the future, but its impact can presently not be assuredly predicted.

An example for a no-regret strategy, which is provided by German planning law, is temporary building lease (*Baurecht auf Zeit*). According to § 9 (2) No. 2 Federal Building Code, a designation of a certain land-use or critical infrastructure in a land-use plan stays valid only as long as certain circumstances arise. Therein, *certain circumstances* may, e.g. be defined as the occurrence of extreme events, which then may be used as an opportunity for reconstructions. However, currently temporal building lease is hardly realised in planning practice as alternatives to reconstruction on the very spot rarely exist (Zehetmair 2011).

5.5 Conclusion

Concluding, further prerequisites for enhancing urban resilience through spatial planning are compiled in the following.

First, spatial planning needs to become (more) aware of and exhaust the assignments and possibilities given. This especially requires an examination of how the amended EIA Directive and its call for considering catastrophic risks is transferred into the national planning laws. But it also requires further consideration of change-proof ways of spatial planning in order to cope with uncertainties and establish legitimacy for the management of risks. This is especially valuable for dealing with extreme weather events, where uncertainty of hazard and vulnerability is the norm. However, the requirement for a direct assignment of risk management to spatial planning in the Federal Regional Planning Act and the Federal Building

Code remains valid. And so does the discussion if *resilience* should become a guiding principle in planning law. Moreover, it needs for clear methodological guidance in order to facilitate the implementation of a risk assessment for municipalities.

Second, spatial planning needs to further elaborate its risk management tools, in order to be justifiably recognised as a key player not only in risk prevention but also in preparedness, response and recovery. In this context, an understanding of the susceptibility of different land-uses and critical infrastructure towards single (and multiple) hazards needs to be fostered. Susceptibility analyses should be designed for different hazard scenarios that reflect on the severity of impacts which can result from damages to certain buildings or infrastructures. In this context, considerations of systemic second- and third-order impacts (cascade effects) are of special importance. Additionally, tools like *pre-disaster development plans* seem to be worth formulating, so that no-regret strategies like temporal building leases may be pursued in planning practice.

Third, spatial planning needs to strengthen its key competencies in order to optimally participate in risk management. One key competency of spatial planning is its coordination and network function, which results from the comprehensive, over-sectoral perspective and its interconnectedness with other players and stakeholders involved in risk management. Using this interconnectedness, spatial planning can foster pre-event discussions of extreme scenarios ('imagining the unimaginable'), reflections on the system's existing response capacities, as well as post-event monitoring and evaluation activities; overall strengthening the system's ability to learn and *bounce forward*. Another key competency of spatial planning is its long-term alignment and ability of storing knowledge from previous events, which can serve as a basis for improved responses to the next event. An insight from summer storm *Ela* that should be memorised by spatial planning is, e.g. the suitability of snow-clearing and gritting plans for the prioritisation of clearing activities, as these plans already contain a classification of all roads according to their importance for the transport infrastructure system.

In the light of ubiquitous extreme weather events, a prerequisite for the execution of the above-described approaches is a revisited discussion (and adjustment) of the definition and conditional programming of *spatially relevant* and *spatial-planning relevant* hazards. The example of summer storm *Ela* showed that despite its ubiquitous character, i.e. the disability of demarcation of hazardous areas, *spatial-planning relevance* is given as the event's impacts display spatial patterns, oriented along the (systemic) criticality of land-uses and infrastructures. Conceivably, the second- and third-order impacts of a ubiquitous event may even reinforce the hazard component, unexpectedly providing *spatial relevance* at second glance. In the end, of course, the legitimacy and ability for spatial planning actions depend on the normative decision on the acceptability of risks (Wernig et al. 2011) as well as on the ability to consider the systemic component of criticality.

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Chapter 6
Measuring Urban Resilience to Natural Disasters for Iranian Cities: Challenges and Key Concepts

Solmaz Hosseinioon

Abstract The main aim of this chapter is to analyze the viewpoints and measures for urban resilience in case of natural disasters in Iran from an urban designer's point of view. The urban codes are among the anthropogenic agents of change in the built environments. Current Iranian urban regulations which are used for urban risk reduction are recently applied for achieving resilience. This chapter studies the effects of the formalizing codes which are implemented in a mid-sized city, Golestan, Iran. It concludes by analyzing if the existing measures have been successful for delivering resilience considering the multifaceted complexity of the concept. The author has conflated urban design points of view with socioecological systems' adaptive capacities to create a list of criteria for measuring resilience. The cities and neighborhood have gone through transformations imposed by the application of urban upgrading codes, and the question is: Have they become more resilient? In addition, if the socioeconomic, environmental, institutional, and cultural consequences of spatial interventions are not considered, we cannot claim to have proper resilience measures. Resilience is a relative concept, and so it is the measure for achieving it, but the main challenge is to consider the different aspects related to its meanings and implications incase of natural disasters.

Keywords Urban resilience · Urban codes · Iran · Multi-scale analysis
Informality

6.1 Introduction

Resilience thinking is a new lens for looking at the world we live in for dealing with the ever-changing unpredictable, complex problems (Ward 2007). The international urge to create "resilient cities" is part of the new agenda for many countries along with sustainable development goals. The applications of resilience have extended

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worldwide in all scales, from national and international levels to local levels. It is used for preparation of vision statements and presenting solutions for the world's complex urban problems. Resilience has gained significant attention because of its capacities for dealing with volatile challenges in the world.

The main aim of this research is to analyze the viewpoints and measures for urban resilience in cases of natural disasters in Iran from an urban designer's point of view. It introduces current Iranian urban regulations as agents of change which are used for urban risk reduction and are recently used for achieving resilience. It studies how these urban codes are implemented in a mid-sized city, Golestan, Iran. This article concludes by analyzing if the existing measures have been successful for delivering resilience considering the multifaceted complexity of the concept itself.

This study introduces key aspects and definitions of resilience which are applied as tools for thinking and analysis of the cases studies. The next step is an introduction to Iran's natural disasters. It gives a brief summary of disaster risk reduction measures in Iran. It is noteworthy to mention that Iranian urban codes for risk mitigation mainly consider earthquake hazard risk reduction although the author is aware of the vast range of challenges which can be and must be dealt with, regarding urban resilience.

Next, it studies how the urban regulations are incorporated into the context of Iran and Tehran Metropolitan Region. This research uses a multi-scale analysis as the main method for introducing applications of urban codes for resilience to natural disasters from national scale to mid-sized cities. The lower micro-scales comprise of cumulative changes in housing, interfaces, and materials. The main scale focuses on the city of Golestan. The upper scale in this study includes Tehran Metropolitan Area, and the lower scale are three neighborhoods within this mid-sized city. The author has conflated urban design points of view with socioecological systems' adaptive capacities to create a list of criteria for measuring resilience. The cities and neighborhood have gone through transformations imposed by the application of Iranian urban codes, and the question is: Have they become more resilient?

6.2 Resilience Key Concepts

Resilience is a much disputed concept, and the collected studies on resilience and its applications in the field of urban studies and practices are extensive. Its applications include a wide range of aspects from promoting risk reduction, urban farming, monitoring climate change effects or dealing with oil and economic crisis (Newman et al. 2009; 2011; Godschalk 2003; Pelling 2002, 2003; Paton and Johnston 2006; Otto-Zimmermann 2011; Newman et al. 2011). Resilience theory deals with dynamism, contingency, and absorbing shocks or disruptions in complex adaptive systems or parts of them in different scales, from the global scale to local ecosystems and communities. Being familiar with definitions of resilience which emphasize on separate aspects is important for every resilience specialist. The primary goal of resilience theory expansion is the growing need to develop ways for dealing with unpredictable and fast changes across different scales. Its significance comes from its capacity for adaptation to stressors, sudden or continuous. The emphasize on the importance of acknowledging different types of resilience depending on the stressors which affects the types of urban resilience is vital (Vale and Campanella 2005: 8, 12–14).

6.2.1 Definitions of Resilience

Resilience definitions has evolved from resistance and moved on to adaptation and evolvement shocks (Davoudi et al. 2012, 2013). Resilience concept has started a long journey from disciplines such as engineering, psychology, and ecology and has spread its use in urban and development debates. Resilience definitions refer to a wide range of close yet different aspects: "its meaning and measurement are still contested (Adger 2003: 347)."

One of the main definitions of resilience comes from engineering sciences. It is about "elasticity and storing strain energy and maintaining equilibrium without breaking or being deformed". The psychological approach to the concept of resilience includes the resilience of individuals in the face of stress or threat (Norris et al. 2008). Socioecological resilience is the closest definition to development debates. It has few concerns, one emphasizes on the ability to bounce back to the original state. Its usage has moved further to involve socioecological systems (Walker and Salt 2006; Carpenter et al. 2001; 2007) Resilience is the capacity to remain within a specific state during a phase of change and retain the same function, structure, identity, and feedbacks (Holling 1973; Walker et al. 2004).

The third view introduces evolutionary resilience which indicates rising to a higher state with expanded capacities after changes or shocks (Davoudi et al. 2013) as transformation and evolvement of socioecological systems. We should focus on transformation rather returning to the pre-disaster status (Vale and Campanella 2005).

6.2.2 Resistance and Resilience

Resistance and resilience are closely related and synonym to each other, especially in the fields of vulnerability reduction, disaster management, and engineering. Carpenter et al. (2001) emphasize on the importance of distinguishing between resilience (which is measured by the size of basins of attraction) and resistance (measured by external forces or pressure needed to disturb or displace a system by a given amount). Stress resistance means being able to lessen and mitigate the sudden consequences of a shock in a way that the system continues to go on functioning, resilience is a return in functioning, adaptation, or transformation in the system due to change (Norris et al. 2008; Handmer and Dovers 1996: 504). Resistance in case of disaster readiness is consistent when the resources are sufficiently robust, redundant and can encounter the effects of the stressors (Norris et al. 2008).

Resilience is relative in many ways, it can be advantageous or disadvantageous. Measuring resilience is a sensitive issue, especially regarding its relativity (Carpenter et al. 2001). For measuring resilience, we should evaluate,

> The amount of disturbance a system can take before it shifts to another set of variables and relationships that dominate another stability region.

Resilience cannot be measured via the state of stability and constancy but through its variability.

6.2.3 Resilience, Vulnerability, and Disaster Management

Vulnerability and resilience are two sides of the same coin (Haimes 2009). The concept of vulnerability reduction is entwined with resilience (Pelling 2002, 2003; Haimes 2009; Miller et al. 2010; Pelling 2011) although there are many discussions on distinctions between resilience and vulnerability reduction (Godschalk 2003; Berkes 2007; Miller et al. 2010). Carpenter et al. (2001) define vulnerability as lack of a suitable level of robustness and redundancy in the resources that will lead to the dysfunction of a system. The purpose of resilience is to help vulnerable people deal with unforeseeable disruptions (Fainstein 2013).

> Resilience is the capacity of hazard-resistant buildings or adaptive social systems to adjust to threats and mitigate or avoid harm (Pelling 2003: 8).

Vulnerability reduction is safeguarding a system from damage and disruption; it is an ongoing process which can contribute to recovery in cities as they got through and survived traumas such as Mexico City and New York. In this sense, resilient cities are those with the capacity to rebound to the previous situation (Vale and Campanella 2006).

6.2.4 Multi-scale and Cross-Scale Dynamics

This is a multi-scale analysis (Deleuze and Guattari 1987; Walker and Salt 2006; Hillier 2007) because the dynamics of change and interactions flow through different scales and levels. There are strong reciprocal relationships among different scales of the study as dynamic and ever-changing assemblages (Deleuze and Guattari 1987) which are significant in resilience studies (Carpenter et al. 2001; Gunderson and Holling 2002). One has to consider that higher and lower levels have substantial roles in affecting the focus scale for any resilience study. The correlations between scales go beyond the focus areas through networks of

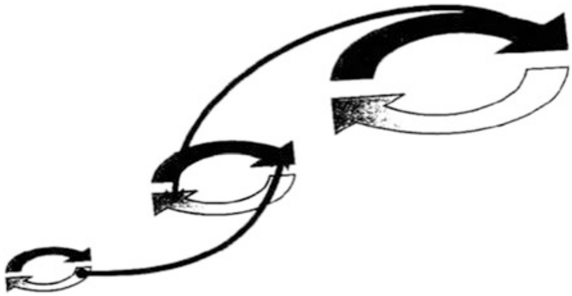

Fig. 6.1 Hierarchies of linked adaptive cycles in different scales (Walker and Salt 2006)

dependence and livelihood from global scales (in case of climate change, migration, and terrorism) to local scales (neighborhoods). Gunderson and Holling (2002) emphasize on the importance of scale interactions across time and space in relation to adaptive renewal cycles of exploitation, conservation, release, and reorganization (Fig. 6.1).

Hence, cross-scale interaction is an important aspect of complex adaptive systems. Understanding and measuring the resilience of systems is not possible in just one scale. At least three scales are necessary: the focal scale, one above, and one below (Carpenter et al. 2001; Walker et al. 2004). Resilience can vary in different scales, being resilient in one scale does not mean resilience in another in the same system (Walker et al. 2006).

6.3 Urban Resilience Measures

Resilience has become a priority among the significant urban issues, from international levels to local scales. Many countries, regions, and cities consider resilience as one of the main aims in their strategic plans. Studying the process of managing urban form in relation to adaptation capacities is an important priority in the global scene.

The applications of delivering resilience in the cities vary from promoting risk reduction, urban farming, reducing climate change effects or dealing with oil and economic crisis. A city is resilient when it has developed capacities to help absorb future shocks and stresses to its social, economic, and technical systems and infrastructures so as to still be able to maintain essentially the same functions, structures, systems, and identity.

Resilience has recently found its established place in urban studies, although we have to remember that manifestations of urban resilience are not unified for all urbanists, many present distinct aspects and challenges. Resilience is used to find answers for dealing disasters management and mitigation: Godschalk (2003), Pelling (2003), Paton and Johnston (2006), recovery and revival (Vale and Campanella 2005) climate change, peak oil and adaptation (Newman et al. 2009), Otto-Zimmermann (2011), Davoudi (2012) urban food and farming and confronting terrorism. In addition, the process of urban planning itself has to prepare itself for transformations and future of planning including strategic planning: (Hillier 2007, Wilkinson 2011a, 2011b) and even moving to issues such as governance (Hartzog 2005; Carmin et al. 2011), urban justice, and resilience (Fainstein 2013). The prominence of uncertainty and constant change in this world are among the main challenges which has made the key resilience concepts to evolve from resistance to adaptation and even transformation. This study considers urban regulations and codes as elements of change which are transforming a small city toward resilience to natural disasters.

6.4 Natural Disasters in Iran, an Overview

Iran has had a relatively long history of natural (earthquakes, floods, drought, and landslides) and man-made disasters (wars and attacks) which have destructed its cities yet life have always continued.

The main natural hazard in Iran which the authorities have tried to deal with so far is earthquake hazard. Iran is located on a very seismically active zone with a history of frequent occurrences of large magnitude earthquakes (over 6.0 on Richter scale). The cities are located on active faults to access underground water sources which has exacerbated their vulnerability. With a population of about 80 million people, Iran has a very vulnerable country. Since 1978, at least 100,000 people lost their lives to devastating earthquakes due to several earthquakes which have caused considerable damages.

Until very recently, the effects of environmental hazards such as drought, due to lack of attention to interrelation of natural and built environment, have not been counted in risk mitigation or better said resilience plans. Hence, measures for resilience to natural disasters are only limited to earthquake hazard.

6.5 Urban Resilience Measures in Iran

There has been a rising interest in resilience concept in Iran, and the main reason is its popularity in the global scene and the urge in Iranian DRR society to catch up with the trend. There have been efforts for introducing resilience in the country in the last few years. There have been few book translations and university thesis with resilience theme. One of the institutional actions towards delivering resilience has been founding of “Tehran Resilience Center” as a branch of Tehran’s Disaster Management and Mitigation Center (TDMMO) whose main focus is earthquake risk reduction and natural disasters. A few Tehran-based workshops and national drills with resilience themes held by UDRO,[1] TDMMO,[2] etc., with the help of UN-Habitat and UNISDR. Most of these undertakings are a continuum of what has been done under the name of disaster risk reduction; hence, many aspects of resilience literature, characteristics of resilient systems, and related issues are neglected from any activity or plan undertaken under the name of resilience in Iran. It is essentially understood as a new form of disaster risk reduction. Hence, the multifaceted and multi-scale nature of resilience studies which considers different aspects of built environment and their interactions is still missing from these viewpoints. The author's research, as well as a recent study in BHRC[3] (2016) regarding resilience-related activities in Iran gathered from different urban and municipal organizations, shows that the nature of measures and actions implemented under the name of resilience to natural disasters are a continuum of what has previously been conducted under the title of Disaster Risk Reduction. Hence, it is more a matter of name shift rather than introduction of new perspectives for dealing with complex unexpected issues in times of disasters.

6.5.1 National Statutory Regulations for Dealing with Natural Disasters

Numerous efforts have been made to plan for disaster management and natural hazard mitigation in Iran. Disaster management has been mentioned in several statutory documents from national to local levels. But no holistic broad program concerning country's disaster management, covering all hazard mitigation aspects, has been devised. The codes are implemented by municipalities, executive agencies or organizations, governmental offices, and NGOs in Iran. Although these documents include executive policies for different phases of disaster cycle, they are not comprehensive and interrelated and each set of rules is devised separately. They do not really incorporate all resilience aspects, and don't consider economic, cultural, social, and environmental issues. In the same manner Iran's administrative structure toward resilience lacks organizational integration of different aspects.

[1]Urban Development and Revitalization Organization.

[2]Tehran Disaster Management and Mitigation Organization.

[3]Building and Housing Research Centre in Iran, Part of ministry of Roads and Housing.

6.5.2 Urban Regulations for Delivering Resilience to Natural Disasters in Iran

In response to the Iranian constitution which stipulates the government's responsibility for providing assistance to Iran's population in coping with disaster-related effects, few master plans have been prepared. Although there have been some efforts to extend risk reduction measures in Iran, but the main codes for built environments have focused on structural retrofitting and building more standardized structures built environment. Applying these policies has encouraged reconstruction and renovation as well as promoting safe construction for reducing urban risk, especially in residential zones.

The main urban interventions for delivering resilience (previously called disaster risk reduction plans) include morphological and structural alterations by what are called, "regeneration of obliterated urban fabrics". Specific areas in many cities are marked as obliterated because they are claimed to be the most vulnerable against disasters. There are four types of urban areas targeted for upgrading which include historical neighborhoods, informal settlements, rural-urban zones, and inner city neighborhoods.

This process is conducted as a generic solution to all the so-called distressed urban fabrics with the assumption of revitalization and reduction of their vulnerability and probable resilience. They are set in 2005 by The High Commission of Urbanism and Architecture (which is now a part of Ministry of Roads and Housing).

Based on these standards, all the plot sizes should be more than 200 m^2, the width of existing access ways must be more than 6 m wide, and the buildings should be less than 20 years old. If any of the mentioned standards are not present in 50% of an urban block, the area will be marked as obliterated fabric and subject to reformation plans. These criteria are also measures for interference in urban areas. The alterations are based on implementing the same measures meaning the streets less than 6 m wide are widened, the plots smaller than 200 m^2 are consolidated, and buildings older than 20 years are torn down and rebuilt. These processes are based on projects delivered by municipalities or assigned organizations. The first two criteria directly affect the urban form since the plots are consolidated and access ways are widened. They have caused morphological changes which have consequences in other aspects of urbanity leading to changes in identity, socioeconomic segregation, and social exclusion in many of these settlements which in many cases lead to expelling the poor from official city boundaries and formation of informal settlements (Athari 2002, 2003, 2011).

The spatial and morphological transformations caused by the regularization processes in these areas affect the resilience of cities in case of disasters because the built form is the carrier, the product and the context in which the social, economic, and cultural flows emerge from (Lefebvre 1992) which significantly affect different aspects of resilience capacities. Urban regulations for delivering resilience in Iran are devoid of these interrelated aspects and their correlations which are caused by lack of insight into built environment as complex adaptive systems.

6.6 Multi-scale Analysis of the Case Studies

This is a multi-scale analysis which studies applications of urban codes for resilience to natural disasters from national scale to a mid-sized city (Golestan) and its neighborhoods. Since Golestan is located in Tehran Metropolitan Region, it is chosen as the upper scale, the city of Golestan is the focal scale, and the lower scale includes three neighborhoods in this city which have been affected by the "regeneration urban codes" at different levels.

6.6.1 Tehran Metropolitan Region and Its Main Natural Disasters

Tehran conurbation has a highly exposed situation to earthquake risk due to rapid growth of population and vast constructions on critical faults and hazardous areas which have increased the city's vulnerability. Tehran Metropolitan Region is located in a seismic-prone region in southern parts of Alborz Mountain ranges and is surrounded by several active faults. This region has faced many disasters and has experienced many destructive earthquakes throughout history (Fig. 6.2).

Cities in Tehran Metropolitan Region have gone through growth and transformation phases matching those of adaptive cycles (Gunderson and Holling 2002; Walker and Salt 2006; Walker et al. 2004). In 27 years, TMR's population has increased unequivocally, most of which living outside and along Tehran official borders.

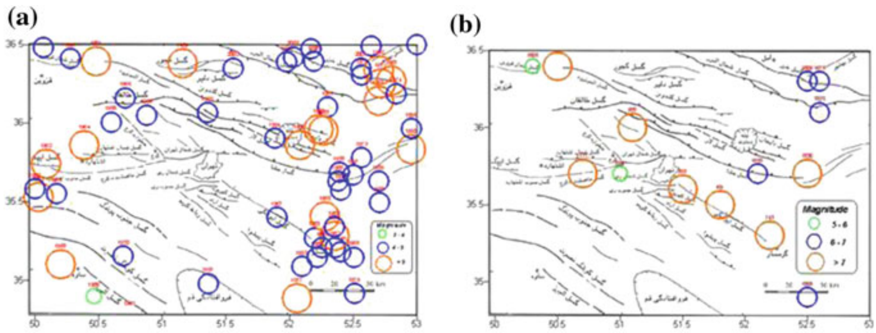

Fig. 6.2 Schematic view on existing faults in Tehran and the previous earthquakes epicenters; **a** epicenter of twentieth century earthquakes, **b** epicenters of historical earthquake (Amini Hosseini and Hosseini 2013)

At the moment, it has grown and developed far beyond its ecological footprints due to mass migrations and overcrowding which has led to extensive developments in hazardous areas. As a result, its vulnerability has increased significantly and so its resilience to all kinds of chronic and sudden natural disasters is reduced. It is also threatened by liquefaction as well as landslides, and there have been cases of floods around the region. In addition, land subsidence, increasing drought, and severe imbalance in water sources due to profit-oriented vast developments in and around Tehran have led to extreme fragility and vulnerability facing natural disasters. In addition, Tehran and its metropolitan region suffer from numerous chronic problems such as air pollution, loss of local flora and fauna and widespread heat island effects and environmental issues which have exacerbated its situation when facing sudden or chronic natural disasters. A major reason for lack of resilience in Tehran Metropolitan Regions is because of failing to see urban areas as complex adaptive systems.

6.6.2 The City of Golestan

The city of Golestan (previously called Soltanabad), is a mid-sized city of 300,000 population located in Tehran Metropolitan Area. It is located 17 km southwest of Tehran. The city of Golestan has transformed from a rural area to an informal settlement which later on became an official city. Golestan has transformed from a village to a large city as an amalgamation of rural, formal, and informal areas.

Golestan has grown rapidly in the last few decades because it is an affordable place for migrants from rural areas as well as the impoverished middle and working classes from the capital. It was an informal settlement in the 1970s and its rapid formation ever since has resulted in many unstable weak buildings which are mainly self-built by the residents and the inefficient infrastructure and lack of open spaces has made many parts of the city vulnerable to disasters, especially earthquakes (Fig. 6.3).

Golestan has gone through different phases of growth in the last 50 years. A study of its transformations through the adaptive cycles lens shows that it has gone through phases of rapid growth, reorganization, conservation (Walker and Salt 2006; Gunderson and Holling 2002). The rapid growth phase matches the fast or overnight growth, building social bonds when sudden migrations shaped it as an informal settlement. In the second phase, Golestan became a city in the 1970s and went through the reorganization phase and stabilization, land seizure, occupation, and shelter building. The conservation phase indicates stability, social solidarity, and fixing situation of settlements in the 1980s and 1990s. The reorganization phase included, including the preparation of its master and structure urban plans in the last two decades which included marking the obliterated areas and implementation of the so-called codes to transform the morphology and hence the socioeconomic status of the residents.

Considering the heterogeneous context of the city is a prerequisite for studying resilience of Golestan to natural disasters. It has neighborhoods with different

Fig. 6.3 City of Golestan is an amalgam of different areas with different morphologies and socioeconomic characteristics (National Geographical Names Database of Iran, accessed 14.11.2017)

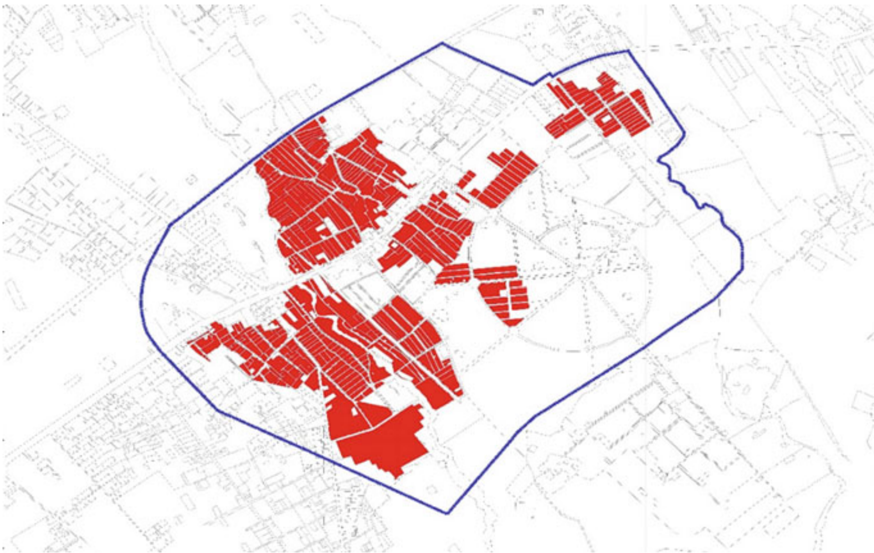

Fig. 6.4 Marked areas for upgrading in Golestan called distressed urban fabrics from Golestan urban master plan (Parsumash 2013)

morphological socioeconomic characteristics which are affected differently when formal urban regulations are applied in them.

The urban plans for betterment of this city have marked the so-called obliterated areas in Golestan in its master and structure plans in order to apply the designated urban codes in them (Fig. 6.4). The implementation of these codes are conducted under the name of regeneration and upgrading actions.

The urban regulations and the dynamics which cause their implementation are the 'key slow variables' (Holling and Gunderson 2002; Walker et al. 2004; Holling 1973: 17) in Golestan's systems. They have caused changes the urban environments, patterns of interactions among residents, and the socioeconomic characteristics of the neighborhoods. They alter the characteristics of public spaces and patterns of interactions among agents/actors including leadership, political and power relations, associated organizational and institutional arrangements. Golestan's morphological characteristics have changed facing the so-called upgrading codes which demonstrate different adaptation traits. The official alterations have occurred in different spatiotemporal scales, from the introduction of urban plans, as well as localized street widening and plot consolidation inside neighborhoods.

The institutional features in each area define the emergent practices and actualization of codes. Formalization in Iran is a top-down process established and executed by the municipality and UDRO (Urban Development and Revitalization Organization). However, fieldwork observations, archival studies, and interviews with officials and locals depict that the regularization procedures do not happen unless certain external and internal forces support the process. Considering the dynamics which permeate through multiple layers is a prerequisite for understanding transformations toward resilience.

6.6.3 Comparison of Three Neighborhoods in Golestan

The next step of this study is to gain a more in-depth knowledge of transformations caused by urban codes in a finer scale within the context of Golestan city. Three neighborhoods are chosen in the city of Golestan (Fig. 6.5) which are affected at different levels by the urban codes for revitalization of the obliterated urban areas. The comparison between them depicts how neighborhoods inside Golestan are altered differently by urban codes for the purpose of vulnerability reduction.

This study has compared the morphological, socioeconomic features and lifestyle of the residents in the three neighborhoods in a period of one year. Only a short summary of the extensive comparative studies between the three neighborhoods will be reflected in this chapter.

The spatial and structural interventions in Golestan's three neighborhoods have changed the type of functions, flows, traffic, and modes of movement. The way the residents use and perceive the public space and hence their sense of place and community is also changed by formalization of the spatial attributes. The urban

Fig. 6.5 Location of three neighborhoods in the city Golestan. (Parsumash 2013) marked by the author

upgrading processes have had cultural and socioeconomic consequences in different levels.

Retrofitting the old buildings has helped with disaster risk reduction, especially in the case of earthquakes because of improvement of their structural status. This study has shown that this process of widening the streets has facilitated car access but in return it has led higher property prices and hence less affordability.

Consolidation of the plots not only reduces the morphological heterogeneity, but also decreases the variety of the activities in the public realm and the social and institutional diversity. Observations have shown that people's age and gender groups, activities, and uses of public spaces are most versatile in the least upgraded neighborhoods.

The age of buildings decreases significantly by application of retrofitting criteria, which is one the best indicators of change and rate of renewal processes. Rebuilding the buildings older than 20 years old with the assumption of structural retrofitting is one of the upgrading criteria in Iran to increase their structural durability.

The more in-depth study of finer scales in Golestan depicts that application of urban codes for the purpose of upgrading has decreased their adaptability and capacity to cope with stress. The fieldworks have shown that the so-called obliterated areas usually include inefficient infrastructure and unsafe self-built buildings, whose conditions are improved by official top-down interferences in these areas. The more traditional neighborhoods have high levels of social capital and self-organization, which are reduced as the codes are implemented.

Fig. 6.6 Comparison of the three neighborhoods' characteristics (Solmaz Hosseinioon 2014)

High levels of self-organization and self-sufficiency which are observed in the older parts of Golestan are reduced by application of urban codes. For example, the residents arrange and pay for the upkeep of their alleys and care for maintenance and alterations in public spaces which are reduced as urban codes dominate the urban areas. The shared concerns and attachment are more in traditional neighborhoods. The social capital fortified by shared cultural norms and behaviors decreases as strong local networks and bonds are reduced by application of urban rules. Redundancy in the neighborhoods which are less modified in by urban codes is more, and it can be exemplified in self-made solutions by the people for dealing with the deficiencies of infrastructure networks because electricity and water networks are not reliable (Fig. 6.6).

The opportunities for learning in communities mean increasing chances of interaction and encounter between people. The level of local community knowledge in Golestan decreases by application of disaster reduction measures. It seems the top-down control facilitates detachment of the people from the neighborhood as maintenance, construction, and safety of public spaces are taken over by the officials.

The fieldwork studies and the observations and interviews conducted for a year in Golestan and its neighborhoods depict that the urban codes for obliterated areas are transforming Golestan's neighborhoods in every aspect. These "urban regeneration" codes which are used in all the cities in Iran are set and implemented for the purpose of disaster risk reduction. They are now conducted under the name of resilience plans but the fact is they lack many aspects which are necessary to consider according to the resilience literature which is introduced in the first part of the article. Although these codes transfer the morphological aspects of the neighborhoods, cities, and regions, their execution transforms the socioeconomic, environmental, and institutional characteristics of the areas. This important fact is not considered in any resilience programs and although some social plans are introduced for DRR and resilience purposes, they are conducted separately and hence the outcomes do not result in delivering resilience.

This study shows that although vulnerability to natural disasters needs physical and social preparations, neglecting the institutional and legislative codes as anthropogenic agents of change in built environments can hinder the purpose of delivering resilience. Hence, I believe that any plan for resilience should consider the role of urban codes and plans in disaster risk reduction and resilience to natural disasters.

6.7 Conclusion

This article has analyzed the measures for delivering resilience to natural disasters in Iran. The main focus of these measures has been on earthquake risk reduction as the most important and devastating natural hazard in Iran. It has followed the changes brought upon by application of the urban codes for vulnerability reduction of cities. In the case of Golestan, the most significant urban intervention for reducing vulnerability and risk reduction (now resilience) has been implementing the three criteria for revitalization of vulnerable urban fabrics.

The upgrading codes and the dynamics which cause their implementation are considered as state variables (Holling and Gunderson 2002; Walker et al. 2004; Holling 1973). The key slow variables which cause change and transformation can be interpreted as formalization, economic forces, land and rental value, morphological traits, and stakeholders' desires. They change the urban environments, patterns of interactions among people included leadership and political and power relations, and associated organizational and institutional arrangements (Dovey 2012: 6). This can lead to emergence of new environmental identities in areas which in the case of informal settlements can be upgrading or demolition.

The urban codes chosen as tools for increasing resilience to natural disasters must be considered as anthropogenic agents of change and hence thoroughly considered in this context. In addition, if the socioeconomic, environmental, institutional, and cultural consequences of spatial interventions are not considered, we cannot claim to have proper resilience measures.

6.8 The Way Forward: A Comprehensive Resilience Framework of Action for Iran

The general emphasis on resilience in Iran is on dealing with management of sudden natural disasters rather than adaptive attributes. Hence, the measures as well as processes for improvement of resilience follow the same frames of action for disaster risk reduction under a new name. The fact that the concept of resilience is perceived as disaster management against earthquakes without considering the other interrelated aspects of resilience thinking works against the full use of resilience framework potentials. Changing the Iranian urbanist' limited viewpoint about earthquakes can help dealing with not only abrupt hazards but also the chronic changes such as drought and climate change which need to be considered as well. One of the other deficiencies of disaster management regulations in Iran is that they miss the multi-scale nature of resilience concept. The management/institutional side of DRR in Iran misses the wholesome viewpoint of resilience which considers cities, regions and countries as complex adaptive systems. It also needs to deal with different aspects of cities separately rather than viewing the relationship between different aspects.

Mastering how resilience is defined and used in different cases and its uses is key for dealing with the pressing issues rising from the versatile aspects which have to be confronted in case of natural disasters since each brings up different priorities, in some cases such as earthquakes structural retrofitting is a primacy whereas in the case of floods or drought, ecological issues have the most importance. In the case of Iran, the relationship between the ecological systems and urban areas which are deeply intertwined with each other is not perceived by the specialists and decision makers. The interventions are conducted separately and remotely without assessing the interacting effects on each other.

This study shows that the urban codes for regeneration and vulnerability reduction of the cities have helped with structural retrofitting and increase durability of the physical structures against the earthquake risk reduction. But traits such as self-organization, social capital, adaptability and sense of community are reduced as the study shows. Although the city of Golestan and its neighborhoods have become less vulnerable from structural point of view with better emergency access, social and perceptual traits which can help the residents help themselves and adapt and cope with pressures and shock have been reduced.

It is time to consider the multifaceted and complex nature of resilience concept for setting urban codes and measures with the purpose of coping with natural hazards in Iran whether sudden or chronic. Resilience is more than mere resistance to sudden shocks as is perceived in the majority of disaster management society now.

Iranian urban managers and specialists must change their viewpoints to comprehend resilience as a dynamic process rather a set of rigid actions in separate fields. A true deliverance of resilience to natural disasters in Iran requires new ways of dealing with the built environment in multiple scales. The rippling effects of what is happening in the global scene as well as in the region and even in different parts of the country should be considered. In addition, different aspects of resilience as well as multiple layers of urban life and cities and their interrelations should be considered in policy making, plans and actions for promoting resilience in Iran.

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Chapter 7
Resilience History and Focus in the USA

Ronald Fisher, Michael Norman and James Peerenboom

Abstract The USA operates and maintains a vast array of critical infrastructure (CI), from energy and water systems to transportation systems and communication nodes. Operating and maintaining this CI is a complex challenge, particularly as infrastructure continues to age and overall investments continue to decline. It is within this context that resilience is discussed. The roots of resilience in the USA go back for decades with a focus on disaster mitigation of infrastructure damage, developing plans and procedures, assessing vulnerabilities, hardening systems, building in redundancies, etc.; as well as developing standards, policies, and technologies for this purpose. The USA has a history of responding well in times of crisis, including national mobilization during the World War II and steps taken following the terrorist attacks of 9/11. The US formally recognized resilience in national doctrine with the issuance of the 2010 National Security Strategy, which states that we must enhance our resilience—that is, our ability to adapt to changing conditions and prepare for, withstand, and rapidly recover from disruption (Obama in National security strategy of the United States, The White House, Washington, DC, 2010). Resilience policy has existed in various forms in other domains; however, this official declaration of strategy broadened the terminology to national security and helped reframe the focus. The US resilience focus is moving from a myopic physical security posture to a holistic resilience framework. Several key programs are increasing US CI resilience.

Keywords Critical infrastructure protection · Cyber-physical
Infrastructure interdependencies · Infrastructure resilience
Regional resilience assessment program · All hazards

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7.1 USA Resilience Background

The USA operates and maintains a vast array of critical infrastructure (CI), from energy and water systems to transportation systems and communication nodes. Operating and maintaining this CI is a complex challenge, particularly as infrastructure continues to age and overall investments continue to decline. It is within this context that resilience is discussed.

The US Department of Homeland Security defines resilience as, "the ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies (Obama 2011)." Whether it is resilience toward acts of terrorism, cyber attacks, pandemics, or catastrophic natural disasters, our national preparedness is the shared responsibility of all levels of government, the private and nonprofit sectors, and individual citizens. This definition of resilience is used throughout this chapter as well as the concept of resilience as a shared responsibility.

The roots of resilience in the USA go back for decades with a focus on disaster mitigation of infrastructure damage, developing plans and procedures, assessing vulnerabilities, hardening systems, building in redundancies, etc., as well as developing standards, policies, and technologies for this purpose. The USA has a history of responding well in times of crisis, including national mobilization during World War II and steps taken following the terrorist attacks of 9/11. The USA formally recognized resilience in national doctrine with the issuance of the 2010 National Security Strategy, which states that we must enhance our resilience—that is, our ability to adapt to changing conditions and prepare for, withstand, and rapidly recover from disruption (Obama 2010). Resilience policy has existed in various forms in other domains; however, this official declaration of strategy broadened the terminology to national security and helped reframe the focus.

An ongoing challenge in the USA is the adoption of a proactive stance as it pertains to Critical Infrastructure Security (protection and prevention) and Resilience (CISR). CISR represents the most recent national policy terminology of the USA and more broadly represents all hazards and holistic resilience. This new focus spotlights key elements of the disaster lifecycle, including preparedness, response, recovery, and pre- and post-event mitigation. This chapter discusses the evolution of resilience in the USA and focuses on a range of programs and activities designed to reshape resilience strategy in the USA today. The chapter concludes with some recent research in resilience measurement, the results of which are significant.

Figure 7.1 topically illustrates the evolution of resilience in the USA since the late 1980s. For purposes of discussion, this evolution includes physical security, cyber security, terrorism, all hazards, interdependencies, physical/cyber, and holistic resilience. Each of these phases is summarized below. Figure 7.1 shows how resilience focus has evolved in the USA and illustrates the evolution in thinking and actions in regard to the USA approach to resilience. It also shows an increasing emphasis on linkages among infrastructures (i.e., interdependencies).

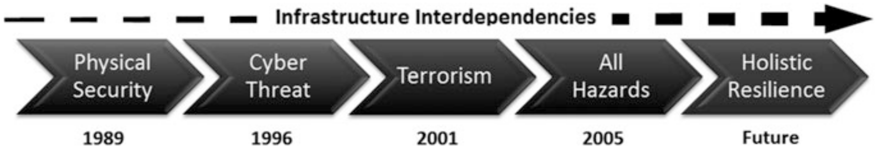

Fig. 7.1 Topics of focus (phases) during evolution of resilience in the USA

7.1.1 Physical Security

In 1989, Senate Hearings were held on Vulnerabilities of Telecommunications and Energy Resources to Terrorism. The motivation for these hearings was a combination of terrorism incidents (e.g., hijacking of Lufthansa Flight 181), (United States 1989) along with multiple infrastructure disruptions that gained worldwide attention that year, including, a major power disruption in Seattle, a major telecommunications disruption in the Chicagoland area, and a significant refinery outage in Louisiana. These events came on the heels of the 1988 report, "Fragile Foundations: A Report of America's Public Works," where a national council gave the Nation's critical infrastructure a C-grade (National Council 1988). Additionally, a GAO (US Government Accountability Office) report in 1979 "Key Crude Oil and Product Pipelines are Vulnerable to Disruptions," documented physical security concerns at these facilities (Comptroller General of the United States 1979).

7.1.2 Cyber Threat

The topic of critical infrastructure protection gained further momentum with the World Trade Center Bombing (February 26, 1993) and the Oklahoma City bombing (April 19, 1995) (US Department of Energy 2001). This led to Executive Order 13010, signed by President William J. Clinton on July 15, 1996, and formed the President's Commission on Critical Infrastructure Protection (PCCIP) (Clinton 1996) (PCCIP). The PCCIP was charged to look at critical national infrastructures so vital to the Nation that their incapacity or destruction would have a debilitating impact on the defense or economic security of the USA. The CI considered were telecommunications, electrical power systems, gas and oil storage and transportation, banking and finance, transportation, water supply systems, emergency services (including medical, police, fire, and rescue), and continuity of government. PCCIP concluded that although the physical security threat was still evident, a newer and more ominous threat, the cyber threat, was rapidly emerging and needed to be addressed. PCCIP referred to this as the change from sticks and stones to bits and bytes (Brown 2006). A national research and development roadmap was also produced by the PCCIP.

7.1.3 Terrorism (Return to Security)

The attacks on 9/11 by terrorists on USA soil quickly switched USA priorities to vulnerabilities from terrorist activities (United States, 2001). This led to the Homeland Security Act of 2002 along with the creation of the US Department of Homeland Security (DHS), stood up in March 2003. The DHS mission was to prevent further terrorist activities from occurring in the USA. The initial DHS security strategy assumed a predominantly physical focus with minimal attention paid to cyber threats. A key policy document during this period was Homeland Security Presidential Directive 7 (HSPD-7) (Bush 2003), which established the US national policy of identification, prioritization, and protection of critical infrastructures. HSPD-7 also specified roles of critical infrastructure protection such as sector-specific agencies. An example of this was in the late 1990s when a key focus of the US Department of Energy was on improving the reliability of the Nation's energy grid. This included risk assessments of critical energy infrastructure, workshops with owners and operators, and critical infrastructure studies (Lesar 2001).

7.1.4 All Hazards

The all hazards period (2005–2016) expanded the USA focus in resilience from terrorist events (man-made), to all hazards, which includes natural disasters as well as man-made events. During this phase, resilience increased focus on physical/cyber and infrastructure interdependencies. The trigger to this change came in 2005 when Hurricanes Katrina, Rita, Dennis, Emily, and Wilma devastated the Gulf Coast. Hurricane Katrina alone was one of the five deadliest hurricanes in the history of the USA (Blake and Landsea 2011), and criticism quickly arose about Federal Emergency Management Agency's (FEMA's) response. This criticism permeated throughout DHS since FEMA had been absorbed into DHS as part of the 2002 creation of the Department. This led to DHS taking a risk-based management approach that included the adoption of an all hazards analysis threat approach. Looking at CI protection through only a terrorist lens was too myopic since critical infrastructure is vulnerable to other threats such as natural disasters. This direction under DHS Secretary Chertoff in 2006 significantly changed the mission of DHS. The first National Infrastructure Protection Plan (NIPP) was introduced in 2006 and introduced the term resilience into the DHS lexicon. The USA focus changed to CI protection and resilience. The 2009 NIPP emphasized resilience even more and shifted several DHS programs to resilience from protection (USA, 2009).

Prior to 2007, there were differing schools of thought in the USA regarding the overlap between physical and cyber systems. A fairly large industry and public community believed the two were isolated and independent. The Aurora test in 2007 highlighted not only the interconnection between these systems, but also how new vulnerabilities such as Aurora could be exploited (Meserve 2007). Over the next few years, the concern of the physical/cyber (or cyber/physical) relationship grew. Both government and industry learned from the Aurora vulnerability that physical and cyber systems need to be examined together. DHS Science and Technology (S&T) established a Cyber Physical Systems Security (CPSSEC) program, and the National Protection and Programs Directorate (NPPD) embarked on a single methodology assessment initiative to incorporate physical and cyber into their risk assessment methodologies. Presidential Policy Directive-21 (PPD-21) in 2013, "Critical Infrastructure Security and Resilience," called out the need for physical and cyber to be integrated in conjunction with security and resilience (Obama 2013).

7.1.5 Infrastructure Interdependencies

Dependencies and interdependencies are displayed in Fig. 7.1 as part of the USA resilience timeline. The dotted line in the timeline represents the continued emphasis on infrastructure interdependencies throughout the continuum. The increase in the line gradient relates to the increase in national attention paid to the topic. Infrastructure dependencies and interdependencies were acknowledged in the PCCIP report in 1997; however, very limited research was conducted in this area. Rinaldi, Peerenboom, and Kelly provided a foundational piece on infrastructure dependencies (one-way dependencies) and interdependencies (bidirectional dependencies). Their 2001 publication called out the importance of interdependencies and included dimensions for describing infrastructure interdependencies (see Fig. 7.2) (Rinaldi et al. 2001).

The infrastructure dimensions (Fig. 7.2) include state of operation, types of interdependencies, environment, coupling and response behavior, type of failure, and infrastructure characteristics. These dimensions collectively provide a framework for analyzing these complex adaptive systems. Each dimension is broken down into components. Collectively, this framework brought to light the issue of infrastructure interdependencies and the complex analysis challenge this presented. Much research has been conducted after this article was written, although this area is still considered to be nascent. Our increasingly growing interconnected infrastructures, and especially our increased reliance on telecommunications and information technology, drive the complexity of understanding and measuring the impact of infrastructure interdependencies on resilience.

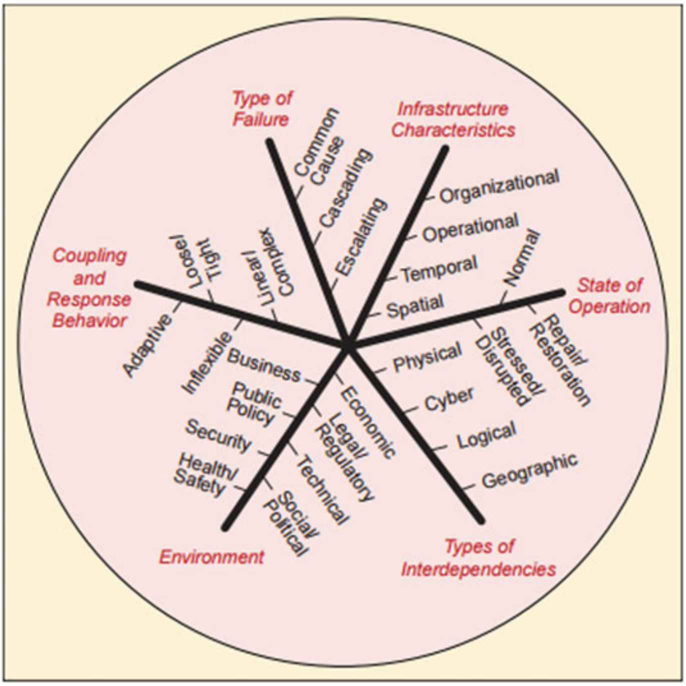

Fig. 7.2 Dimensions for describing infrastructure interdependencies

7.1.6 Holistic Resilience

Just as the evolution of resilience has grown from physical security to a more holistic physical/cyber and dependencies/interdependencies focus, a more holistic, regional, and community-based resilience approach is needed in order to fully examine the current state of resilience in the USA. The components of a holistic resilience approach include infrastructure resilience, community resilience, organizational resilience, social resilience, and personal resilience (Fig. 7.3). These components examined together provide a holistic approach to understanding and measuring resilience.

- Infrastructure Resilience—Considers the continued operations/resilience of lifeline infrastructures (e.g., energy, water, and telecommunications) critical to national economy and safety. This includes prevention and detection (pre-event) as well as mitigation and response (post-event).
- Community Resilience—Considers the resilience of a community (e.g., city, town, county, geographic area) to come together in support of pre-event and post-event incidents. This includes activities such as joint planning with utilities and citizens on restoration priorities, as well as joint assistance programs.

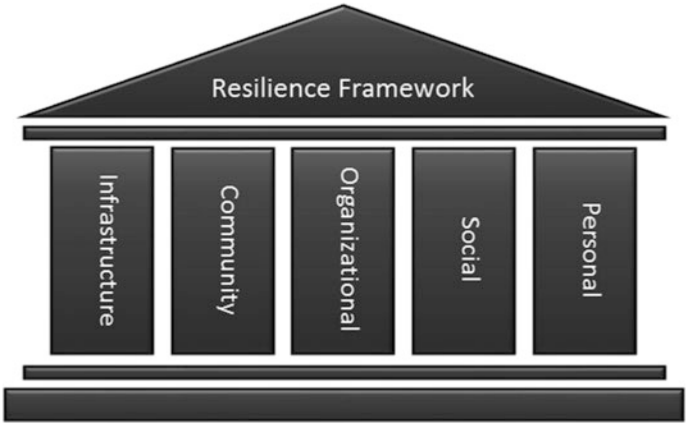

Fig. 7.3 Holistic resilience framework

- Organizational Resilience—Considers the ability of organizations (profit and nonprofit) to continue operating regardless of external circumstances. Organizational resilience also applies to local, state, tribal, and federal governments. This includes risk management, contingency planning, tabletop exercises, and redundancy.
- Social Resilience—Recognizes that we work, think, and succeed as groups/teams as well as individuals. Similar to animals such as wolves and lions that hunt in teams to bring down prey as part of their survival instinct, human civilization rests on the specialization, differentiation, and orchestration of human expertise. People who have diverse interests, skills, and resources and who can work together make it more likely the group as a whole can respond adaptively to unforeseen problems and challenges (Cacioppo 2010).
- Personal Resilience—Considers the personal aspects of resilience, including psychological aspects. For example, during Hurricane Rita, many law enforcement staff did not arrive to work when requested. They were dealing with the personal effects of the disaster. It is natural behavior for people to take care of themselves, their families, and even their pets before they prioritize the assistance of others. Proactive companies and organizations encourage their staff to become personal resilient and provide personal and family assistance during crisis. Personal resilience includes having an emergency supply kit, a family emergency plan, and evacuating loved ones when needed.

To properly understand and measure resilience, each of the pillars of resilience illustrated in Fig. 7.3 must be considered. Just as we have observed the increasing infrastructure interdependencies over the past 20 years and the necessity to consider impacts to our CI from an interdependencies framework, a holistic framework to resilience that includes all five pillars is critical in moving forward.

7.2 Understanding and Measuring Resilience in the USA

There are many ongoing resilience programs and activities in the USA that are examining various aspects of resilience. Some of these programs focus on multiple pillars of holistic resilience. Tool development and analysis is another growing area in resilience research. This section highlights some key resilience activities and analyses. Additional coverage is provided by the Infrastructure Survey Tool (IST) and All Hazards Analysis (AHA) Framework due to their applicability to resilience assessment.

7.2.1 DHS Regional Resilience Assessment Program

The Regional Resiliency Assessment Program (RRAP) is a cooperative assessment of specific critical infrastructure within a designated geographic area, providing a regional analysis of the surrounding infrastructure to address a range of infrastructure resilience issues that could have significant consequences, both regionally and nationally. These voluntary, nonregulatory RRAP projects are led by the Office of Infrastructure Protection (IP) within the Department of Homeland Security's National Protection and Programs Directorate and are selected each year by the Department with input and guidance from Federal, State, tribal, territorial, and local partners. IP, a subcomponent within the National Protection and Programs Directorate (NPPD), leads the national effort to mitigate terrorism risk to, strengthen the protection of, and enhance the all-hazard resilience of the Nation's critical infrastructure (United States 2016).

The RRAP evolved from earlier DHS initiatives focused on the protection of high consequence clusters of critical infrastructure. Beginning in 2009, IP began addressing broader, more regionally based issues through the RRAP. Since the RRAP's inception, projects have been conducted in regions throughout the USA and have focused on sectors such as energy, transportation, commercial facilities, and food and agriculture.

The goal of the RRAP is to generate greater understanding and action among public and private sector partners in order to improve the resilience of a region's critical infrastructure. To accomplish this, the RRAP:

- Resolves infrastructure security and resilience knowledge gaps;
- Informs risk management decisions;
- Identifies opportunities and strategies to enhance infrastructure resilience; and
- Improves critical partnerships among the public and private sectors.

Strong partnerships with Federal, State, local, tribal, and territorial government officials and private sector organizations across multiple disciplines are essential to the RRAP process. This includes private sector facility owners and operators, industry organizations, emergency response and recovery organizations, utility providers, transportation agencies and authorities, planning commissions, law enforcement, academic institutions, and research centers. Each RRAP project typically involves a year-long process to collect and analyze data on the critical infrastructure within the designated area, followed by continued technical assistance to enhance the infrastructure's resilience. Individual projects can incorporate opportunities for valuable information and data exchanges, including voluntary facility security surveys, first responder capability assessments, targeted studies and modeling, and subject matter expert workshops.

The culmination of RRAP activities, research, and analysis is presented in a Resiliency Assessment documenting project results and findings, including key regional resilience gaps and options for addressing these shortfalls. DHS provides the Resiliency Assessment, along with supporting documents and information, to select RRAP participants in the form of a multimedia presentation. Facility owners and operators, regional organizations, and government agencies can use the results to help guide strategic investments in equipment, planning, training, and infrastructure development in order to enhance the resilience and security of facilities, surrounding communities, and entire regions.

7.2.2 Resilient Cities

Pioneered by the Rockefeller Foundation, 100 Resilient Cities (100RC) is dedicated to helping cities around the world become more resilient to the physical, social, and economic challenges that are a growing part of the twenty-first century (City of Oakland 2016) (Resilience 2016). 100RC supports the adoption and incorporation of a view of resilience that includes not just the shocks—earthquakes, fires, floods, etc.—but also the stresses that weaken the fabric of a city on a day-to-day or cyclical basis. By addressing both the shocks and the stresses, a city becomes more able to respond to adverse events and is better able to deliver basic functions in both good times and bad to all populations.

Cities in the 100RC network are provided with four core offerings: (1) Financial and logistical guidance for establishing an innovative new position in city government, a Chief Resilience Officer (CRO), who will lead the city's resilience efforts; (2) Expert support for the development of a robust resilience building strategy; (3) Access to solutions, service providers, and partners from the private, public, academic, and NGO sectors who can help implement these resilience strategies; (4) Membership in the global network of member cities, designed to allow CROs to help and learn from each other, thereby accelerating the development of the field.

Through these offerings 100RC aims not only to help individual cities become more resilient, but also to facilitate the creation of a global practice of urban resilience (Resilience 2016).

Oakland is one such 100RC city that currently released its resilience report. Oakland's three themes for advancing resilience are (1) to build a more trustworthy and responsive government; (2) to stay rooted and thrive in our town; and (3) to build a more vibrant and connected Oakland.

Some of the actions outlined under these three themes were already underway (such the Mayor's Community Safety Plan) and are included here due to their clear resilience value. Some have been adapted with a resilience lens in mind, and others have been fast-tracked due to the resources available through the 100RC program (such as digital improvements to the Rent Adjustment Program, the City's green infrastructure plan or sea level rise roadmap), and others have come about as a result of stakeholder engagement through Resilient Oakland's two-year process.

7.2.3 Role and Contribution of Public/Private Partnerships

At the state and local level in the USA, there has been a growing focus in developing cross-sector, multi-jurisdiction, and discipline partnerships to identify and address resilience gaps. Most recently, there has been a focus on "operationalizing" resilience, using Urban Area Security Initiative (UASI) grant funds and other federal resources, including providing Federal "seed money" to regional collaborations for this purpose. Public/private partnerships and regional initiatives have sprung up in many regions focused on infrastructure interdependencies and holistic resilience. The earliest such initiative developed in the Pacific Northwest starting in 2002 and was based on concern over cross-border infrastructure interdependencies and potential economic consequences. From 2003 to present, many different types of these public/private collaborations have been developed in the Southeast, Pacific Northwest, West, and South, in states including New Jersey, Iowa, California, Colorado, Washington, and Minnesota. Resilience initiatives have moved forward in Maryland, the District of Columbia region, Texas, Florida, etc.

These public/private partnership groups identify key resilience focus areas and bring appropriate stakeholders together. For example, the Bay Area Center for Regional Disaster Resilience in Northern California was established to unite disaster relief efforts and focuses on lifeline infrastructures. One key focus is the sharing of best practices and improving awareness of CI security. ChicagoFIRST connects financial firms in Chicago and focuses on financial services emergency planning and operations. It engages in activities such as annual tabletop exercises and workshops (Terzich and Moran 2014).

7.2.4 DHS Infrastructure Survey Tool

In 2009, the DHS and its protective security advisors began assessing high-risk CI assets using a targeted questionnaire: the Infrastructure Survey Tool (IST). The IST produced individual protective measure and vulnerability values through protective measure and vulnerability indices (PMI/VI). As sites continue to be assessed using the PMI/VI, academic research, practitioner emphasis, and public policy formation have increasingly focused on resilience as a necessary component of risk management and infrastructure protection. This increased attention led to a detailed study and report by the National Infrastructure Advisory Council, which called for an increased focus on resilience for US infrastructure protection programs. The report also underlined the importance of an increased understanding of resilience to an overall risk management strategy for both public and private CIKR (Fisher and Norman 2010).

Enhancing the resilience of critical infrastructures requires owners/operators to determine the ability of the system to withstand specific threats and to then return to normal operations following degradation. Thus, a resilience methodology requires comprehensive consideration of all parts of critical infrastructure systems—from threats to consequences. The methodology must generate reproducible results that can support decision making in risk management, disaster response, and business continuity. DHS has developed a comprehensive methodology that uses uniform and consistent data to develop a resilience index (RI) on the basis of data collected through the IST. Table 7.1 provides the major components and subcomponents constituting the RI (Fisher et al. 2010).

The RI is derived from three categories: robustness, resourcefulness, and recovery. The RI ranges from 0 (low resilience) to 100 (high resilience). A high RI does not mean a specific event will not affect the facility and will not cause severe consequences. Conversely, a low RI does not mean a disruptive event will automatically lead to a failure of the critical infrastructure. The RI instead compares the level of resilience at specific critical infrastructure sites and guides prioritization of limited resources for improving resilience. The RI also provides valuable information to owners/operators about their facility's standing relative to those of similar sector assets, providing relevant strategies and methods for increasing resilience.

Having a quantitative index provides a straightforward way to show the results of each component and subcomponent of the RI in a dashboard format. Figure 7.4 provides an illustration of this dashboard at the component level. The bar value represents the site having been assessed and the low, average, and high dots represent the comparison value against like facilities. This allows facility officials to quickly see they are slightly above average in the overall RI, have a very high robustness level, rank near the average in resourcefulness, and slightly below

Table 7.1 Major components and subcomponents of RI

Robustness	Resourcefulness
a. Redundancy (8)	a. Training/exercises (7)
b. Prevention/mitigation (7)	b. Awareness (3)
c. Maintaining key functions (3)	c. Protective measures (3)
Recovery	d. Stockpiles (2)
a. Restoration (3)	e. Response (3)
b. Coordination (2)	f. New resources (2)
	g. Alternative sites (4)

(*) Denotes number of subcomponents

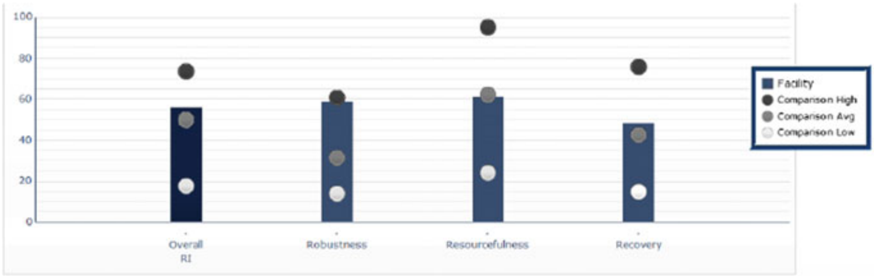

Fig. 7.4 Dashboard showing values of RI components for a sample facility

average in recovery. The facility administrators can then analyze this further by diving into the subcomponent dashboard view for more details. This provides insights to the company on how their facility compares to like facilities, allowing this information to help provide a metric for making risk-informed decisions.

7.2.5 All Hazards Knowledge Framework (AHA)

The driver for developing AHA was the gap in the ability to assess vulnerabilities and resiliency and identify priorities for protective and support measures for interdependent CI systems from an all hazards perspective. This problem has remained an open and difficult problem. In response, INL developed the AHA, which is a hybrid data- and expert-driven framework that enables the transformation and loading of existing data sources (e.g., geospatial, assessments, etc.) into dependency models. These types of models have the advantage of allowing administrators to learn from data in order to provide highly accurate models, offering the capability to adapt to new information via online learning. The AHA framework is composed of three components: (1) facility level dependency profiles; (2) dependency models; and (3) a text analysis system (TAS).

Dependency Profiles at the basic level are optimized facility level data models for infrastructure. They are adaptive to new attribution information and changing network topologies in order to support dependency analysis. In addition, this extensibility provides the ability to capture and model abstract system functions, which can enable robust sector and consequence analysis.

The dependency models are linked dependency profiles of actual infrastructure, which provide an effective capability for conducting cross-sector critical infrastructure analysis across all spatial scales. Leveraging AHA as a knowledge framework also means these information models can be reused and aggregated depending on assessment type or analysis. A major challenge in infrastructure resilience analysis is data collection. There is seldom enough data available on CI and especially on interdependencies. Through these dependency profiles, AHA allows analysts to either ingest these dependency profiles into their respective tools/models or to use the AHA framework outright.

The TAS component incorporates natural language processing (NLP) and information extraction techniques to collect, ingest, and transform both structured and unstructured data relevant to critical infrastructure analysis, enabling the rapid population of the dependency models. TAS is based on algorithms and heuristics in the open source that have been customized to the all hazards area.

AHA directly supports the knowledge discovery and decision support function and provides analysts and decision makers a capability to quickly evaluate and understand critical dependencies and impacts of hazards on critical infrastructure. The AHA Knowledge Framework also provides an effective platform to inform other critical infrastructure modeling efforts. This also increases the amount of resiliency data available for analyses.

Due to the requirement to be able to model local, national, and even global dependencies, the AHA Framework was designed for maximum flexibility. This flexibility, coupled with the ability to account for abstract systems and their function, provides a methodology to simultaneously use both a bottom-up and top-down approach. This capability makes the AHA Framework a possible ideal solution for conducting local and regional analyses and assessments. Figure 7.5 demonstrates how AHA is being used. Utilizing a top-down approach, the analyst would start with identifying the region of interest. Once the area has been defined, a logical next step is to identify the lifeline sector service providers for the region, which are shown as the light blue rectangles in the middle row. Once these

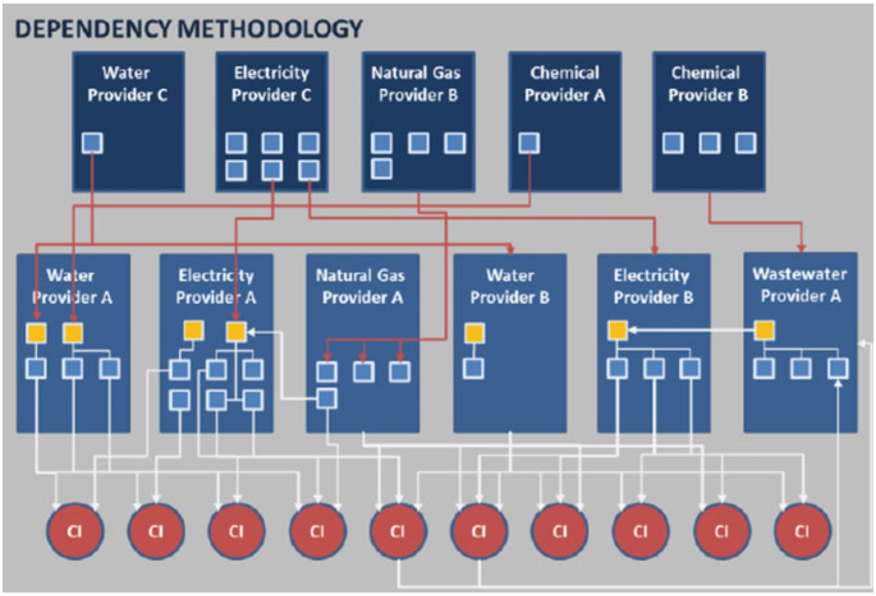

Fig. 7.5 AHA dependency methodology

providers have been identified, their critical system assets can be mapped into the framework (shown as orange squares). An example may be a large electric generation station. At this point, an analyst could potentially begin using a bottom-up approach to identify the key dependencies (dark blue rectangles) for those facilities or identifying known critical infrastructures (red circles) within the region and mapping their dependencies back to the assets of the lifeline service providers.

This approach was effectively used to support the pilot effort conducted by the DHS's Office of Infrastructure Protection (IP). The pilot focused on three cities; Salt Lake City, Tampa, Fla., and Portland, Ore. The pilot used AHA as an open source analysis framework and later employed protective security advisors to analyze the data for completeness and accuracy. The results showed the pilot saved DHS hundreds of hours of data collection time using the open source data engine and the open source data were over 80% accurate—minimizing the cleanup time. The pilot included owner/operators, service providers, and state and local stakeholders. Four key lessons learned came from the pilot:

1. Multi-source information collection efforts enhance knowledge about regional infrastructure and their dependencies with a high degree of accuracy.
2. Significant amounts of infrastructure information existed in open source materials for all three pilot areas across lifeline infrastructures. Examples in the USA include data from federal organizations such as Energy Information Administration, Environmental Protection Agency, and Department of Transportation.
3. Open source information can be used to flag existing validated data for review.
4. Owner/Operators benefited through better understanding of their dependencies on lifeline infrastructures (level of service, contracts, etc.).

Additionally, specific comments about the value of the AHA pilot included:

- The results provided significant value in analyzing business continuity and resiliency.
- The direct focus on dependencies clearly demonstrated the value of the dependency information to inform state and local critical infrastructure criteria for Steady State, Special Event and Domestic Incident activities.
- While the sectors selected for the pilot project scope were limited to support predetermined timelines, owner/operators contacted during field collection activities desired expansion to include Communications and Supply Chain.
- Several owner/operators raised their concerns with cyber security to include the impact of critical cyber services on dependencies.
- Specific owner/operator threat concerns related to key dependencies would help inform the field visit discussion and local/state Prevention, Protection, Mitigation, Response and recovery efforts.

AHA is unique in its approach as it provides both data collection and analyses capabilities together. Infrastructure resilience is a data intensive problem. AHA assists through ingesting open source information, comparing and analyzing it against dependency profiles and existing data sources, all designed to provide a comprehensive data set. The resilience and interdependency analyses capabilities of AHA assist government as well as owners and operators. They also provide a framework to discuss resilience issues and mitigation strategies.

7.3 Conclusion and Outlook

Resilience in the USA has been an active topic for both government and academic researchers for decades, but it has had a variety of different names that adopt varying objectives. While considerable research is needed to fully resolve the calculus of holistic resilience, many methodologies are contributing to the growth in this challenging area, including the consideration of infrastructure interdependencies. For example, the Resilience Index in the IST provides a first step at quantifying infrastructure resilience. There are several ongoing programs, tools, and capabilities that are contributing to a more resilient USA; however, there remains much yet to be accomplished in understanding and measurement.

A holistic approach to resilience should take into consideration all the components of resilience mentioned in the paper. The equation below proposes a holistic resilience measurement approach:

$$\mathrm{Res} = f(\mathrm{aIR}, \mathrm{bCR}, \mathrm{cOR}, \mathrm{dSR}, \mathrm{ePR})|_{\mathrm{r}},$$

where

Res	Resilience;
f	Function of;
a, b, c, d, e,	Scaling constants that vary from 0 to 1, depending on the risk being considered;
r	Risk, considering interdependencies that potentially affect all risk components (threat, vulnerability, and consequence); and
$\|_{\mathrm{r}}$	Evaluated at varying levels of risk.

This equation states that resilience is a function of infrastructure resilience (IR), community resilience (CR), organizational resilience (OR), social resilience (SR), and personal resilience (PR). The weighting of each of these components varies based on factors that change, such as geography, sector, scope, type of incident, and time. Risk is a function of threat, vulnerability, and consequence that needs to be considered as part of measuring resilience. Although we typically think of threat, vulnerability, and consequence associated with risk, resilience must be measured in context of risk considerations. Interdependencies also must be considered in this resilience framework (via risk). For example, an infrastructure dependency between the electric power sector and communication sector can cause cascading and escalating failures that increase outage times and reduce resilience. Collectively, however, considering threat, vulnerability, and consequence across the resilience spectrum, a more holistic approach to measuring resilience is provided pertaining to interdependencies.

Lastly, resilience is not the problem for a few people or one government agency (DHS) to solve. Resilience is a shared problem that needs to be addressed by a joint public/private partnership. Over 85% of critical infrastructure in the USA is owned and operated by the private sector (Perrow 2007). These owners and operators have a critical role as well, in addition to the role of local, state, and federal government and citizens. In the 1950s, resilience was called civil defense and citizens took on the responsibilities of protecting themselves and their families individually. Many citizens took actions including building personal bomb shelters at their own expense. Today in the USA, most citizens operate on the entitlement principle that since they pay taxes, the government should handle resilience/security. One way to increase resilience is to inspire a culture shift that strikes the proper balance among all stakeholders in working together to make the USA a more resilient Nation (Fisher 2012). Figure 7.6 highlights the components of this enhanced resilience model. The Culture Roadmap brings together all stakeholders, and through their beliefs and attitudes, develops a strategic plan on how to enhance resilience along with roles and responsibilities for each stakeholder group. The Change Model creates the transformational change needed to do things differently. This provides the awakening and impetus to start the change and implement the roadmap. The Culture Model is critical to the sustainment of the plan. Identifying those elements needed to keep the plan moving ahead and keeping focus is what the Culture Model is about. The last component, Action Research, provides feedback so the Culture Roadmap, Change Model, and Culture Model are modified if needed based on needs. These are dynamic plans that are adjusted over time.

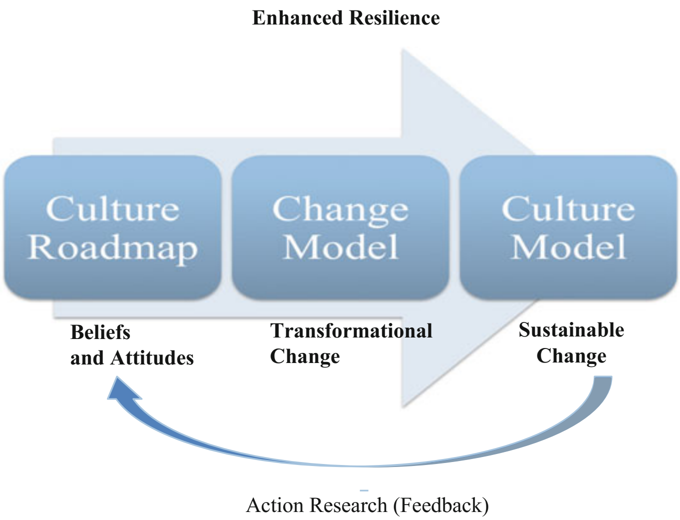

Fig. 7.6 Resilience culture model

The Culture Roadmap should be the focus point. There are many resilience plans that the government, private companies, and communities have in place. These provide a great foundation for the Nation to build upon. The Culture Roadmap can provide a national focus on developing consistent and holistic plans. Educating stakeholders on the roadmap and their specific roles and responsibilities is critical to the overall success. Metrics will be a key part of implementation to understand progress and to help in prioritizing resources.

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Part II
Organizing Professionals and the People

Chapter 8
Integrating Volunteers in Emergency Response: A Strategy for Increased Resilience Within German Civil Security Research

Jens Hälterlein, Linda Madsen, Agnetha Schuchardt, Roman Peperhove and Lars Gerhold

Abstract New forms of volunteering in events of emergencies and crisis are connected to the political goal of resilience within a growing number of applied research projects. This chapter offers an analysis of how factors such as long-term national research strategies, funding programmes supporting user- and market-driven applied research, expectations of a testable innovation, events such as the European 2013 flooding in Germany, citizens' engagement and new social media work together in the formation of new approaches to volunteering within emergency and crisis response systems. By defining the population as being potentially active and engaged, these new forms of volunteer involvement aim to move beyond self-help in order to increase societal resilience. This chapter does also illustrate how resilience is operationalised within corresponding applied research projects in Germany. In order to do so, we will present the results of a full-scale scenario-based emergency exercise carried out as part of one of these projects. A comprehensive mapping of the research landscape is outside the scope of this chapter. However, we aim to address how a variety of factors are making up complex relations rather than linear and decisive patterns towards a predefined goal; the way the goal—the project outcome—is reached and the shape the innovation takes may be seen as an assemblage of structural, societal, environmental and technical conditions.

Keywords Emergency volunteering · Applied research · Innovation
Social media · Exercise

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This chapter offers insights into the content and context of the recent research on volunteering for emergency and crisis response in Germany. Within a growing number of applied research projects, new forms of volunteering are connected to the political goal of resilience. This chapter offers an analysis of how factors such as long-term national research strategies, funding programmes supporting user- and market-driven applied research, expectations of a testable innovation, and events such as the European 2013 flooding in Germany, citizens' engagement and new social media work together in the formation of new approaches to volunteering within emergency and crisis response systems. By defining the population as being potentially active and engaged, these new forms of volunteer involvement aim to move beyond self-help in order to increase societal resilience. This chapter does also illustrate how resilience is operationalised within the corresponding applied research projects. In order to do so, we will present the results of a full-scale scenario-based emergency exercise carried out as part of one of these projects. A comprehensive mapping of the research landscape is outside the scope of this chapter. However, we aim to address how a variety of factors are making up complex relations rather than linear and decisive patterns towards a predefined goal; the way the goal—the project outcome—is reached and the shape the innovation takes place may be seen as an assemblage of structural, societal, environmental and technical conditions.

8.1 Volunteerism in Practice

Increased resilience has become an overall aim of the national emergency response system headed by the Federal Ministry of Internal Affairs of Germany (BMI 2016: 8). Within this system volunteers play an important role, and the value of volunteer contributions in events of emergencies and crisis is widely recognised. The Federal Ministry of Internal Affairs characterises honorary volunteering[1] as "the foundation and the backbone" of the national emergency response system—a system further strengthened by the occupational task forces[2] of the respective organisations, such as the fire departments, the *German Red Cross* (GRC), and the *Technisches Hilfswerk* (THW) (BMI 2016, p. 19). According to official numbers (e.g. BMI 2016; BBK 2016), more than 1.7 million honorary volunteers are already trained and engaged in volunteer work. The contributions of these honorary volunteers—with a formal membership and duties on behalf of their organisation—are regarded essential for a comprehensive emergency response in Germany (BMI 2016). However, the Federal Ministry of Internal Affairs recognises that it must prepare for

[1]In this chapter "honorary volunteers" and volunteering refers to what is termed "Ehrenamt" in the German context. It refers to an unpaid service carried out on behalf of an organisation or public institution.

[2]That is what in the German context is termed "Hauptamtliche".

a changing situation where the numbers and the capacities of honorary volunteers will decline (BMI 2016, p. 16). Given the important position of honorary volunteers as "the foundation and backbone" of the national emergency response system, this expected decline poses a challenge towards civil society resilience.

The declining number of honorary volunteers in Germany has been addressed in various studies over the last decades, and demographic changes are regarded one of the major current challenges of honorary voluntarism in Germany (Petersen 2012; Reichenbach 2012). For example, the aging population and an aging stock of honorary volunteers cause worries. An aging population might mean that more honorary volunteers will have to retreat. Simultaneously, there will be more (elderly) in need of volunteer assistance in the years to come (Reichenbach 2012). To remove existing age limits for certain types of honorary volunteer work is one suggested solution (BMBF 2016). This would turn a substantial but currently excluded group of the population into potential human resources. Volunteerism is also seen as increasingly in "competition" with other obligations and interests such as family duties, work and career that often requires mobility and flexibility as well as spare time activities (BMBF 2016).

Already two decades ago, Germany was diagnosed as being in an honorary volunteering crisis according to various surveys (e.g. Gaskin et al. 1996).[3] This diagnosis triggered debate and critical attention on the (as of 1996) decreasing volunteer engagement and it contributed to nuance the state of the art of volunteering in Germany. Some did strongly reject the diagnosis. It was argued that it was not citizens' engagement but rather the organisational structures and models for volunteer work that was in a crisis (Hacket and Mutz 2002; Nörber and Sturzenhecker 2002). Currently, we can trace new forms of citizen engagement. Or more precise, we can now witness a growing *awareness* about citizens' engagement among disaster responders, relief organisations and policy makers (BMBF 2016). Some of them are currently deliberating on alternative and more flexible ways to account for so-called spontaneous or unaffiliated volunteers.

While traditional honorary volunteers dedicate themselves to an organisation and typically sympathises' with its values, activities and aims, the so-called spontaneous helpers do rather tend to be motivated and mobilised by an event, by a current issue at stake, by an ongoing emergency or by an evolving crisis. What is referred to as spontaneous helpers or as convergent-, episodic-, ad hoc-, unbound-, unaffiliated- or spontaneous-volunteers in current literature and ongoing research projects correspond to those addressed more than three decades ago as members of "emergent citizens groups" or simply "emergent groups". Then US-based sociologists Robert A. Stallings and E. L. Qarantelli addressed the "groups of citizens (…) that emerge around perceived needs or problems associated with both natural and technological disaster situations. We as sociologists", they wrote "call them

[3]A historical account of the honorary volunteering is outside the scope of this chapter, but as shown by Hacket and Mutz (2002), citizens' decreasing willingness to help had also been raised in a decade earlier.

"emergent groups" to highlight their newness, absence of formalisation and lack of tradition." (Stallings and Quarantelli 1985) "Emergent groups", they detail, "can be thought of as private citizens who work together in pursuit of collective goals relevant to actual or potential disasters but whose organisation has not yet become institutionalised". In order to avoid any controversies in regards to the ad hoc or spontaneous nature of their engagement, or in regards to their (un)affiliatedness, we will, in this chapter, simply refer these as *volunteers*—at a difference to the honorary volunteers with a formal affiliation with an organisation.

Especially the absence of formalisation among citizens and "emergent groups" thereof, as pointed out by Stallings and Quarantelli, is a commonly voiced challenge in recent crisis and disaster management as well (see e.g. Kloyber 2011; Neubauer et al. 2013). The major implications relate to coordination of the work both within the group of spontaneous helpers as well as in relation to the official crisis and disaster management. Stallings and Quarantelli appear to be right when they—more than 30 years ago—claimed that, "emergent citizen groups [will] become even more salient". They warned about the predominant focus on organised groups of citizens and urged for more knowledge about emergent citizen groups as well; that in order to, as they write, "deal with them more efficiently" (Stallings and Quarantelli 1985, p. 94).

With only few references to Stalling and Quarantelli's work, attention has recently been drawn to volunteers. More flexible forms for participation are suggested in order to adjust to the current situation (BMBF 2016, p. 4). The so-called teams initiated by some of the regional Red Cross associations in Germany as well as the Austrian Red Cross (ARC) represent some recent attempts to adapt to the presumed demands for flexibility among the citizens of today in order for them to contribute as volunteers. The models, e.g. of the Team Hessen, Team Bayern and Team Mecklenburg-Vorpommern, are similar to that of the Team Austria, which was initiated by the ARC and the national hit radio station, Ö3 already in 2007. By registering for one of the teams online, citizens can sign up for a less binding affiliation than what a traditional honorary membership would imply. The regional GRC associations, on the other hand, may request team members to support their honorary volunteers in case of a large-scale emergency or crisis. Volunteer coordinators from the GRC would then contact these team members by calling them or sending them a text message. By establishing these teams, and thereby enable and encourage citizens to register ahead of an event, the GRC does, similar to the ARC, offer alternative modes for event-based volunteering.

In this way the teams may contribute to overcome the so-called paradox of spontaneous, unaffiliated volunteers (Kloyber 2011, p. 4; see also Harris et al. 2016; Wenger 1991). As explained in one report, this paradox manifests when "spontaneous unaffiliated volunteers and their willingness to help challenge the emergency services' capacity to utilise them effectively" (Kloyber 2011, p. 4). In relation to the 2013 flooding of the rivers Danube and Elbe in Germany, the GRC experienced massive citizens' engagement and willingness to help (GRC 2013). The extent of citizens' support resembles what was experienced in a comparable event in 2002. To coordinate and to manage the help offered was a common challenge in both occasions, and they serve as typical examples of this paradox; it was a challenge for the organisations in charge to coordinate the volunteers and to fully utilise the help offered.

In 2013, however, the GRK noticed what they characterise as a “new quality” in the citizens’ involvement in the emergency response (GRC 2013, p. 1). At a difference to the previous event, people did now make use of social media such as Facebook and Twitter as means for mobilising and coordinating help offers and demands on their own initiative.[4] In this way, private volunteer initiatives were organised in addition to the official disaster response efforts. New social media may thus bring in an additional dimension to the spontaneous helper paradox: They offer effective tools for mobilisation, and to a certain extent also for coordination, among citizens. However, it has posed a challenge in the way that the activities carried out by these emergent citizen groups are not aligned with those of the formal organisations.

Citizens’ use of new social media in emergencies and disasters has gained scholarly attention during the last decade. Studies have addressed, for example, how volunteers utilise the social media tools they are already acquainted with and with which they are already networking for mobilisation and for coordinating their relief efforts (see e.g. Fritze and Kray 2015; Kaufhold and Reuter 2016). This has also been confirmed by volunteers involved on the refugee situation in Germany in 2015[5] (Group interviews Sept. 29. and 30. 2016; Lessig workshop presentation Jan. 24. 2017) and in relation to the severe rainstorm in Münster in 2014 (Balder, workshop presentation Jan. 24. 2017).[6] Social media, such as Facebook and WhatsApp, offer a useful tool for self-organised volunteering and tend to be used for communication within flexible networks of volunteers in addition to e-mail, telephone and face-to-face contact. In their cooperation and communication with official crisis management committees, citizens and honorary volunteers do, to date, still rely strongly on telephone. Therefore, it has been stressed that a “holistic disaster response” depends on the combination of traditional and new means for communication (Fritze and Kray 2015).

8.2 The Volunteer as an Object for Civil Security Research

These developments and considerations also form one of the recent key areas of the framework programme “Research for civil security” that was set up by Germany’s Federal Ministry of Education and Research (BMBF) in 2007. The main goal of the

[4]Ibid. (http://www.b-b-e.de/fileadmin/inhalte/aktuelles/2013/10/NL22_DRK_Definition.pdf).

[5]Within the project RESIBES several individual as well as group interviews were conducted in 2016. All interviewees were volunteering in the context of the refugee crisis.

[6]Katrin Balder and Marina Lessig participated in the panel discussions on Jan. 24. 2017, at the workshop, „“Eisatzkräfte und Spontanhelfer: Gemeinsam und auf Augenhöhe?!”, organised by the project PRAKOS—Praktiken und Kommunikation zur aktiven Schadensbewältigung (Christian-Albrechts-Universität zu Kiel and Universität der Bundeswehr München) in Munich.

program is to equip selected research projects with extensive funding to stimulate applied research in an area that is gaining importance in political debates and offers market opportunities. Thus, by defining a strategy to deal with the public perception of risks such as terrorism, organised crime, natural disasters and large accidents, the BMBF aims to strengthen the competitiveness of Germany's security economy. This aim is one of the main reasons for the dominant role of technological solutions within the projects, since technological solutions are easy to commodify by translating them into security devices or security services.[7]

A call for project proposals entitled "Security economy and security architecture",[8] announced in 2010, invited ideas for new forms of volunteering for civil security—without explicitly mentioning any such form. It problematises the current changings in civil security as leading to an unclear distribution of responsibility: while the state is not any more exclusively in charge of security, new structures are still missing. Thus, the call encourages innovative research that contributes to defining new structures of responsibility for the civil security.

Two of the projects that were funded within this call laid the groundwork for an emerging field of applied research. Running from 2012 to 2015, the project "Professional integration of volunteers in crisis management and disaster control" (INKA)[9] was the first one in Germany addressing the topic "volunteering for crisis prevention". The original scope of the project was on honorary volunteers directly affiliated to emergency organisations and it aimed to find new ways of making this kind of membership more attractive to people from different sections of the population. However, the 2013 European flooding in Germany, including the flooding of the river Elbe, happened and had an immediate influence on the project in terms of agenda setting.

Having an official mandate to contribute in the emergency response, the GRC (among other organisations at place) had to deal with the aforementioned so-called spontaneous unaffiliated volunteer paradox, since a huge number of volunteers was offering their help and at the same time presenting the GRC with a huge logistics and planning task. From the stance of the INKA project, however, this situation did at the same time offer an opportunity to find out more about the motivations and the self-organising capabilities of these volunteers and to study their interactions with the emergency organisations and authorities at place.

Thus, within the INKA project, and accompanying their own operations, the GRC conducted a qualitative study. A number of explorative interviews with volunteers and honorary members of the GRC emergency task force were conducted by the GRC security research group (GRC 2014, 2015, 2016). As it is put in a nutshell by the author of a report on the effects of the INKA project on the work of

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[7]The framework programme "Research for civil security" is part of the German "High Tech Strategy" that aims to streamline all policies affecting research and innovation in order to position Germany as global leaders in future markets.

[8]https://www.bmbf.de/foerderungen/bekanntmachung.php?B=597.

[9]http://www.sifo.de/de/inka-professionelle-integration-von-freiwilligen-helfern-in-krisenmanagement-und-1963.html.

one the emergency response, organisations associated with the project (Albert 2016), "practice overtook theory" in the sense that the integration of volunteers was lacking any paramount concept or strategy. Instead, these concepts and strategies evolved out of the local emergency response practices and are now building the groundwork of a systematised and coordinated approach (a process which applies to other German emergency response organisations as well).

Another project emerging from the 2010 call, "catastrophe lighthouses as point of contact for the population in crisis" (Kat-Leuchttürme),[10] was following the approach of relating to the population as an active element in crisis response. The aim of the project was to develop infrastructures of communication (including organisational as well as technical system components) that allow for self-organising of mutual help within the population in case of a long-lasting blackout. The project was based on the assumption that such a blackout would not only result in an urgent need for help but would also prevent the self-organisation of help from happening, since all electrical means of communication are out of operation. Hence, the project focused on the instalment of local points of contact that would not only provide for first aid and relevant information from authorities, but also for electricity, free Wi-Fi and a pin board for requests for help as well as offers to help. Towards the end of the project, the technical system components were tested. Around 150 visitors (all of them experts with various professional backgrounds) were asked to participate in the test by

(a) demanding for certain information generated by the system component that has been integrated into the control centre or
(b) downloading a smartphone app that was developed within the project, to register in the system via the app, and then to retrieve and to send information to/from a third party involved in the test.

However, no details about the evaluation of this test have been published so far, except the fact that there were some minor technical difficulties and some reservation among most of the visitors that such a system would be used by the population in case of a crisis. This led to the conclusion that more preparation and information is needed beforehand (Berliner Feuerwehr 2016, pp. 19–20).

Even though the integration of volunteers was not mentioned in the 2010 call at all, the two projects INKA and KAT-Leuchttürme explored the conditions for a successful integration of spontaneous volunteers: the first one, INKA, by reflecting on the emerging strategies and organisational concepts that aim at a better integration of and cooperation with volunteers; the second one, KAT-Leuchttürme, by investigating the infrastructures and technological solutions that are needed to support the self-organisation of mutual help within the (urban) population. Both organisational and technological solutions became central aspects in subsequent calls and projects. The call "Civil security—protection and rescue within complex

[10]http://www.sifo.de/de/kat-leuchttuerme-katastrophenschutz-leuchttuerme-als-anlaufstelle-fuer-die-bevoelkerung-in-1965.html.

situations of operation",[11] announced in 2013, not only requested to address citizens "either as trained personnel within the frames of honorary volunteer contribution, or as spontaneous helper in the event of a crisis" but also aims at providing emergency task forces, both professional and voluntary, with organisational and technological solutions.

Another crucial development within the framework programme was the rise of the concept *resilience* now becoming a major issue. While the concept was not mentioned in the first period of the framework programme (ranging from 2007 to 2012), things changed with the second period (ranging from 2012 to 2017). In the general description of the framework program it is stated that, "civil security can only be guaranteed in the long term if the resilience of society is strengthened." (BMBF 2012, p. 13) and it is declared to "focus security research on the entire resilience cycle (crisis prevention, precautions, crisis reaction, recovery and evaluation)" (ibid. p. 8). A more detailed description of the concept *resilience* is given in a call entitled "Civil Security—Increased Resilience in the Events of Emergencies and Crisis",[12] announced in 2014. Here, *resilience* is defined as the *capability* to prepare for and prevent, to recover from and to learn from any foreseen or unforeseen emergency and disaster scenario with the further aim to be better prepared for future events. This definition assumes emergencies and crisis to be recurring, and resilience is imagined as a spiral process where the capability to handle the various phases will indicate or even decide to which degree a society can be regarded increasingly resilient. Furthermore, the responsibility for achieving increased resilience is being explicitly distributed onto the population. As the call states, "[t]he population should not anymore be considered only affected by a crisis, but as well be involved as stakeholder in the emergency provision and mitigation work". However, it was already the call "Urban Security"[13] announced in 2012 that linked the resilience of urban areas with the self-help capacity of urban populations as well as their activation as helpers in crisis. Thus, whereas in previous calls the population should primarily be protected and provided for, the role of the population as active contributors to societal resilience was first clearly acknowledged in the 2014 call.

8.3 High-Tech Solutions for Flexible Volunteering

Following the 2012 call, the project "ENablement of urban citizen SUpport for crisis REsponse" (ENSURE),[14] running from 2013 until 2016, aimed at developing a systematic approach to the integration of volunteers. The general approach of the

[11] https://www.bmbf.de/foerderungen/bekanntmachung.php?B=821.

[12] https://www.bmbf.de/foerderungen/bekanntmachung.php?B=950.

[13] https://www.bmbf.de/foerderungen/bekanntmachung.php?B=734.

[14] http://www.sifo.de/de/ensure-verbesserte-krisenbewaeltigung-im-urbanen-raum-durch-situationsbezogene-2064.html.

ENSURE project was to coordinate potential volunteers via a technological system. In this way, public alerting infrastructures, such as KATWARN[15] and NINA,[16] should be made more participative. The project team developed a mobile app for smartphones that would be implemented into control centres of public authorities and organisations that perform security tasks.[17] In this way, these organisations (such as fire departments) would be able to request preregistered volunteers for specific operations. Volunteers who want to help spontaneously in an emergency could download the mobile app and register ad hoc or in advance, but they would not be required to indicate personal data. They could, however, specify their skills such as speaking a certain language or having medical knowledge. In an emergency, they would be positioned according to location-based services on their smartphones[18] and asked to help if they are located nearby and in accordance with their personal skills. Ideally, they would reach the emergency location immediately —maybe even before occupational task forces—and contribute with their skills. They would take preventive measures autonomously and support occupational task forces, if these are already available on site. The potential of volunteers for supporting respective operations could thus be better exploited.

One of the main goals of the ENSURE system was to support disaster protection and public safety and thereby to strengthen community resilience. Within the project description, resilience was considered within the framework of holistic preventive approaches and protective measures, raising security for all citizens. Resilience in the sense of robustness and resistance, as well as the capacity for adaptability to unforeseeable situations should be increased by emergency concepts for urban regions. Coordination and connectedness of both private and public security agents should ensure the fastest restoration of urban functionality in disasters.

Similar to other projects and along with the framework programme, the civilian population should be enabled to help itself. Following this perspective, the urban population is considered a helper in times of crisis and not a victim. The idea of the project INKA was to generate new incentives and forms of appreciation in order to integrate and commit more volunteers into crisis management structures. Whereas new forms of organisations played a major role, ENSURE recognised that it could be more attractive for spontaneous volunteers that the option of ad hoc registration does not entail the obligations of long-term honorary offices. Thus, according to the ENSURE approach smartphone-based mobile communication tools should be used as a method for the recruiting and ad hoc activation of volunteers.

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[15]https://www.katwarn.de.

[16]http://www.bbk.bund.de/DE/NINA/Warn-App_NINA.html.

[17]It should be taken into account that the final use and implementation of the ENSURE app remain uncertain, since the project ended in December 2016 and the funding within the research program did not aim at the development of marketable products.

[18]Location-based services are not the same as GPS location, but they have a similar function so that the owner of the smartphone can be located within the range of 1 km.

A situation-dependent activation of volunteers was a promising approach for the incorporation of a bigger share of the civilian population into disaster management. This idea emerged from the same considerations that lead to the aforementioned GRC initiatives (e.g. Team Hessen, Team Bayern). This goal should be achieved in two steps: first, a theory-driven approach was conducted, covering inter alia a representative telephone survey on the competence to act during disasters in Berlin in 2014 (Schulze et al. 2015) and the development of training concepts for the cooperation of occupational task forces and volunteers (Schulze and Voss 2016).

The gained implications and insights were tested in two full-scale exercises that were conducted in October 2015 and October 2016. Preventive measures and urban emergency concepts were a core aspect of the project and shaped the tasks that had to be fulfilled during the full-scale exercises. Above all, (a) the functionality of the technological solution (smartphone app and editorial system) to coordinate the civilian helpers, (b) their performance, (c) the effect of a previously conducted training for the volunteers and (d) the interaction between the task forces and the volunteers were measured and evaluated. While the evaluation of the first exercise is completed and its results were incorporated into the planning of the second exercise, the evaluation of the second exercise is still pending.

In order to operationalise the holistic notion of resilience, the exercises were developed by means the scenario method (Von Reibnitz 2013; Gausemeier et al. 1998; Wilson and Ralston 2006; Schoemaker 1995) that opens up different future possibilities and, in doing so, makes resilience more tangible and, eventually, almost measurable. Possible influences on a disaster situation were identified, assessed and interrelated to each other in order to identify different worst- and best-case scenarios that present several options for a successful integration of registered volunteers in disaster responses. The scenarios were used as analytical tools, combining the neuralgic aspects of the whole system (e.g. technical, environmental and social aspects) (Schuchardt and Peperhove 2016; Peperhove 2015). Through this theoretically reasoned planning of the full-scale exercises, different challenges could be anticipated since the scenarios were used to create a realistic script with a story and timeline and several different tasks.

The first full-scale exercise took place in a special police training area in Berlin. The goal of the exercise was to show how negative impacts of a natural hazard can be reduced. It was carried out with the participation of members of emergency organisations (120 occupational task forces from German Red Cross and Berlin Fire Department) and 23 volunteers (not associated with any of these organisations at the time of the exercise). All participants were working together on 14 different tasks such as forwarding warnings and other information, evacuating buildings and firefighting. Among the 23 volunteers, aged between 21 and 68 (average age: 34.7 years), there were 12 men and 11 women.

The evaluation was conducted by scientific observations and (mostly) post-hoc, face-to-face-interviews (with both closed and open questions) with all participants. Trained observers decided whether a task was fulfilled correctly or not on the basis of a standardised questionnaire (yes/no). Most tasks were assessed as "conducted correctly": out of 33 tasks, only 2 tasks were carried out wrong.[19] So, task fulfilment and performance of the volunteers (b) were very successful. After the exercise, the involved occupational task forces stated in qualitative interviews that the volunteers supported them effectively. All volunteers described their employment as supporting and judged their experiences favourably (n = 23). These results show that these volunteers are able to act in a supporting way in emergency situations. By including their resources and skills, community resilience increases—especially in the immediate recovery phase after a hazard.

Concerning the functionality of the app (a), it is important to state that out of 23 volunteers, 17 noticed the notification from the ENSURE app immediately on their smartphones and reacted accordingly. Eighteen volunteers understood the information presented, whereas three indicated some piece of information (e.g. location on the map) was not clear to them. One person did not answer the question. The reaction time of the volunteers was fast (2 min 10 s on average), so that 85% of all alerts were answered within the relevant time span for ad hoc operations. Nevertheless, the volunteers knew that they would receive notifications during the exercise and looked at their smartphones constantly. The technical evaluation concluded that the app reacted steadily and consistently for all users. The big majority of all participants stated that the app was easy to use and not overly complex—a feature that they would approve for stressful situations.

Prior to the first exercise, half of all volunteers received a training that was evaluated afterwards (c)—the other half served as control group (Schulze et al. 2017). Topics of the training were inter alia disaster management in Germany, teamwork and communication as well as First Aid. Overall, the effectiveness of the training has to be assessed as indifferent. Overall, only two out of 33 conducted tasks were carried out incorrectly and task performance did not vary between trained and untrained volunteers. However, the six untrained volunteers felt slightly more insecure and 60% of them would have preferred to participate in a training next time. Moreover, during the second full-scale exercise, many volunteers stated that an emergency training would be an incentive for them to participate in similar operations.

Finally, the interaction between the task forces and the volunteers was evaluated as well. In this domain, the highest potential for improvements can be seen. All observers noted that there was barely any communication between the task forces and the volunteers. The groups rarely worked in mixed teams (Schulze and Voss 2016). Volunteers emphasised that they were uncertain with whom they should communicate, and more specifically, who their concrete contact person was. However, they accepted instructions expressed by the task forces—if given. The task forces, on the other hand, stated in interviews after the exercise that several tasks (giving First Aid and filling sandbags) would have lasted longer without the volunteers and they felt supported.

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[19]The task was "forwarding information". One trained and one untrained person did not manage to share all relevant information so that the message they had to forward was incomplete.

The project team's evaluation of the first exercise was overall very positive, proving the benefit of volunteers in coordinated collaboration with public authorities. These insights influenced the development of the second exercise in October 2016. In the second exercise, the volunteers had to solve fewer tasks independently and the tasks were changed in order to promote cooperation and communication with task forces. Concerning the task performance, out of 48 tasks, only three tasks were carried out incorrectly. In addition, the participating task forces had received a short briefing in advance, sensitising them for the cooperation with volunteers. This briefing seemed to have resulted in more successful teamwork between both parties. Again, the helpers were asked whether they knew who their contact person was and 19 out of 25 answered positively. Furthermore, they were asked whether the instructions given to them by the task forces were clear, and this time, 20 out of 25 answered "yes".

Summing up, the results of the two exercises show that volunteers could perform safety-relevant tasks, in cooperation with occupational task forces and even on their own. However, the communication between task forces and volunteers presented a challenge in the first exercise when both parties had to work together without prior sensitisation for the demands and functioning of one another. Except for this challenge, the positive findings must still be tested in the real world and cannot be automatically transferred to other contexts. Apart from that, it could be critically discussed whether it is justified to transfer responsibility from the public/political sphere to civilians and what consequences this shift could have.

Still, a number of projects funded within the framework programme—namely AHA, KOKOS, KUBAS, REBEKA and RESIBES—are currently following this approach by addressing a volunteer-based crisis management as a means to strengthen resilience.[20] Besides, many differences regarding technical components and infrastructures, functionalities, target groups (among both, emergency response organisations and types of volunteers), the idea is to activate potential volunteers when their help is needed. In most of these projects, the registration of volunteers and their allocation to certain tasks is supported by a technological system. For example, one aim of the RESIBES project is to develop an algorithm that is capable of processing information such as proximity of preregistered volunteers to site of operation as well as resources, capabilities, qualifications and times of availability indicated during the registration process, while the final decision remains with the member(s) of the emergency organisation in charge. These technologies are then to be tested in exercises comparable to the one carried out within the ENSURE project and described above. However, this strategy of integrating volunteers has to go hand in hand with new organisational concepts and new forms of perceiving, addressing and empowering civil society. There are several obstacles among both,

[20]Furthermore, the two projects K3 and PRAKOS added the topic integration of volunteers to their initial research tasks. It should also be mentioned that numerous research projects in Germany are currently following a similar approach without being funded by the BMBF. Finally, a growing international research on volunteering in the context of emergency services is emerging but is outside of the scope of this chapter.

emergency organisations and (networks of) volunteers, that must be overcomed: while emergency organisations have developed a culture of "preparedness" in order to face the risks of "low probability, high impact" events (Collier 2008; Anderson 2010; Anderson and Adey 2011; Ellebrecht et al. 2013), they are far less prepared to face the shifting conditions of civic engagement. More flexible forms of volunteering can only be integrated within the existing system of emergency response when less hierarchical, time consuming (without frequent trainings and exercises) and standardised ways of contributing to crisis response are offered. On the other side, volunteers need to develop or meet a certain level of reliability (binding commitment without formal membership) and professionalism (for example following health and safety regulations) in order to avoid posing a threat to the effectiveness of the emergency response system, to their own safety, and to the safety of others. Since it has become a common scheme of applied research to operationalise the political concept *resilience* as the integration of volunteers by means of technological systems and to evaluate the effectiveness of these systems by carrying out exercises modelling "real life" emergencies, further research on the organisational culture of emergency organisations and on the culture of "self-organised" volunteering is needed.

8.4 Conclusion

Within funding schemes for applied research and corresponding research projects complex, contested and multi-faceted theoretical concepts are turned into clearly defined problems, doable tasks and useful solutions. Translated in the rationality of a research practice that is both, user-oriented and market-driven, the concept resilience is narrowed down from an all-encompassing concept to an organisational as well as technological approach to new flexible forms of volunteers' engagement in crisis response: a socio-technical network of activated citizens, cooperative organisations and tailor-made communication tools—degrees of activity, cooperativeness and usability that have yet to be verified. Following the tradition of large-scale field exercises in crisis and disaster prevention and given the need for testing the quality of innovations, corresponding forms of scenario-based exercises have been developed. However, there is no straightforward path from innovation to implementation. Despite the huge network of emergency services, researchers, preregistered volunteers, organisational concepts, apps and the all over positive testing results it cannot be guaranteed that this solution will be implemented in future emergency response practices. Volunteers as well as emergency organisations are still following their own agendas, and the future will show whether these agendas can (and should) be streamlined for the sake of a certain concept of resilience.

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Chapter 9
Contributions of Flood Insurance to Enhance Resilience–Findings from Germany

Annegret H. Thieken

Abstract In 2002, a severe flood caused financial losses of EUR 11.6 billion in Germany and triggered many changes in flood risk management. This chapter focuses on flood insurance, which is a voluntary supplementary insurance in Germany: it is explored how flood insurance has contributed to enhance resilience of flood-prone residents. The analyses are based on empirical data collected by post-event surveys in the federal states of Saxony and Bavaria and refer to the three pillars upon which the concept of flood resilience usually builds in the natural hazards context: recovery, adaptive capacity and resistance. Overall, the penetration of flood insurance has increased since 2002 and there is strong empirical evidence that losses of insured residents are more often and better compensated than those of uninsured despite the provision of governmental financial disaster assistance after big floods. This facilitation of recovery is, however, not the only contribution to flood resilience. Insured residents tend to invest more in further flood mitigation measures at their properties than uninsured. Obviously, flood insurance is embedded in a complex safety strategy of property owners that needs more investigation in order to be addressed more effectively in risk communication and integrated risk management strategies.

Keywords Flood losses · Recovery · Climate change adaptation
Saxony · Bavaria

9.1 Introduction

In recent years, traditional flood policies, which were heavily based on structural defences such as dikes, have been more and more substituted by integrated flood risk management which is based on the cycle of disaster management. The cycle

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usually starts when a severe event has hit a society with (1) emergency response to limit the impacts of the damaging event. It further consists of (2) recovery and reconstruction to regain the society's pre-event status; (3) event and risk analysis, and (4) planning and implementation of risk-reducing measures (e.g. Kienholz et al. 2004; Thieken et al. 2007; Samuels et al. 2009).

Frameworks and legislation with a focus on prevention like the European Floods Directive (2007/60/EU) or the Sendai Framework for Disaster Risk Reduction 2015–2030 (SFDRR) require that such a process starts with a systematic risk identification and analysis–without necessarily having experienced a triggering event in the recent past. The analysis is followed by an assessment and prioritisation of risks as well as (transparent) decisions on adequate and efficient measures to reduce risks and their implementation. A final step includes monitoring and reporting which may result in a reassessment of risks that might require altered or new risk-reducing measures. Risk management in this sense is seen as an iterative optimisation process (e.g. Kienholz et al. 2004; Thieken et al. 2014).

One particular characteristic of modern flood risk management is the diversification of risk-reducing strategies and measures. In urban areas, three main risk reduction strategies can be combined:

- loss prevention by adapted use of flood-prone areas, e.g. by prohibiting urban development in high-risk areas or by flood-adapted design and use of buildings in medium- and low-risk areas,
- flood control to avoid inundation of (urban) areas by (hard) engineering works and retention areas, and
- preparedness for response, e.g. by a tailored warning system and an effective emergency response plan for the city at hand.

If all preventive, protective and preparatory measures fail to prevent losses, risk transfer mechanism help to distribute financial losses from the affected region to a larger population (e.g. the whole society of the affected country), and hence, lessen the individual burden. Risk transfer systems in Europe comprise of different (flood) insurance schemes (compulsory insurance, supplementary contract, etc.), catastrophe funds or governmental disaster assistance (see Maccaferri et al. 2011, for an overview). Such measures can be integrated into a flood risk management system as preparedness for recovery.

Since flood losses are expected to increase in Europe due to climate change as well as increasing urbanisation and exposure (e.g. Jongman et al. 2014), risk transfer mechanisms are becoming more important as indicated by the European Green Paper on the Insurance of Natural and Man-made Disasters (EC 2013). However, increasing losses may also result in failing or unaffordable risk transfer mechanisms. Therefore, they should ideally be designed in such a way that they contribute to mitigate the overall losses and to enhance the overall resilience of urban societies against natural hazards. Using Germany as an example, the aim of this paper is to explore how flood insurance has contributed to the resilience of residents in flood-prone urban areas since 2002 when a severe flood hit Germany, particularly the catchments of the rivers Elbe and Danube and thus the federal states of Saxony and Bavaria, respectively, caused an unprecedented loss of EUR 11.6 billion and triggered many changes in flood risk management in Germany (see Thieken et al. 2016a). Taking the year 2002 as a starting point, it is first questioned whether insurance coverage leads to better loss compensation and thus recovery of flood-affected residents. Secondly, it will be investigated whether and in what extent individual learning from past events takes place in insured and uninsured households, especially with regard to the implementation of damage reducing measures at the property level. Finally, the uptake of flood insurance and property-level mitigation measures by residents who have lived behind dikes and might hence feel safer than other flood-prone households will be analysed.

These analyses are motivated by the three pillars upon which the concept of flood resilience usually builds in the natural hazards context: recovery, adaptive capacity and resistance (see Thieken et al. 2014). The recovery aspect of resilience refers to the word's Latin origin "resiliere" literally meaning "to bounce/jump back". Recovery is measured by the time a system needs to return to its original state after a shock (e.g. Klein et al. 2003; Füssel and Klein 2006). The quicker the pre-event growth-path is (re-)achieved, the more resilient a community or a system is considered to be. Since the reference pre-event status is often difficult to determine, the return to an acceptable level of functioning and structure of the affected system can be used instead. With regard to flood insurance and recovery, we will analyse whether insurance coverage leads to better loss compensation of flood-affected residents in terms of the extent of loss compensation and hence speed of repair works and the residents' satisfaction with the administrative processes.

Since many systems are able to adjust to external changes, a simple return to the pre-event status is not regarded as a preferable option, since the affected system has missed to advance in its capacity to cope with shocks (e.g. Klein et al. 2003). This leads us to a further aspect of resilience that has emerged in recent years: creativity or adaptive capacity as the ability of a system to learn from past events and to adapt in such a way that it develops beyond the pre-event status. According to Dovers and Handmer (1992), this proactive understanding of resilience accepts upcoming changes in the system and aims to develop a regime that is able to adjust to new conditions. It also includes the willingness and the ability of a society to learn (e.g. Klein et al. 2003). This process is usually not restricted to past experiences, but could also include anticipated potential future changes. Accordingly, Park et al. (2013) understand resilience as the outcome of a repeated process of sensing, anticipation, learning and adaptation. In addition to risk management, resilience analysis can improve "the system response to surprises" (Park et al. 2013: 365). In this respect, individual learning from past events (and during events) is a characteristic of resilience that will be explored in this paper highlighting the role of insurance coverage when implementing property-level mitigation measures.

In contrast to this proactive understanding of resilience, there is also a reactive aspect of resilience: resistance, which is understood as the ability of a system (i.e. a city) to resist a disturbance caused by a natural event. This aspect of resilience is usually measured by the amount of disturbance the system under study can withstand or absorb before any changes occur. Dikes, augmented design levels and improved ability to prevent dike breaches and consequent adverse effects might serve as typical examples for enhancing resilience by strengthening resistance. However, dikes generally tend to increase the safety feeling of residents living behind such structures. As a consequence, they may lessen their efforts to prepare for floods and to implement precautionary measures at the property level. Therefore, this paper also analyses whether the uptake of flood insurance and property-level mitigation and preparedness measures by households affected by dike breaches differ from other flood-affected households.

To better understand the outcomes of this resilience analysis, the flood insurance system in Germany will be introduced in the next section.

9.2 Flood Insurance in Germany

In contrast to losses caused by windstorms or fires that are covered by any building insurance in Germany, flood losses are usually only compensated if a natural hazards supplement to a building or contents insurance was signed. This voluntary supplement has been provided by property insurers in Germany since 1991 and covers not only flood-related losses, but also losses from earthquakes, land subsidence, avalanches or snow build-up (e.g. Thieken et al. 2006). The overall market penetration has risen from 19% in 2002 to 37% in 2015 (GDV 2016). There are, however, two regions in Germany with peculiarities: Baden-Wuerttemberg, a state in the south of Germany, and the territory of the former German Democratic Republic (GDR) in eastern Germany. In Baden-Wuerttemberg, flood loss compensation was generally included in a compulsory building insurance until 1994. Due to EU regulations, this monopoly insurance had to be abandoned. Currently, more than 90% of the property owners in Baden-Wuerttemberg still have flood insurance coverage (GDV 2016). In the former GDR, flood losses were covered by the household insurance. Up to 45% of residents in eastern Germany still have comparable contracts or have signed the above-mentioned supplement (GDV 2016).

To avoid negative selection, i.e. to avoid that only homeowners in flood-prone areas contract the natural hazards supplement, the German Insurance Association (GDV) set-up a flood hazard zoning system (ZÜRS) in 2001 that at first consisted of three flood probability zones: in the high-risk zone flooding occurs on average once in 10 years, in the medium-risk zone every 10–50 years, and in the low-risk zone on even rarer occasions. After the severe flood in 2002, the low-risk zone was split up into areas with flood probabilities of once in 50–200 years and areas that are flooded less than once in 200 years. The zoning system has increasingly been used to assess the insurability of a property (Thieken et al. 2006; Thieken and Pech 2015). In the high-risk zone, insurance coverage is commonly impossible, but exceptions have been made, e.g. if homeowners have implemented property-level mitigation measures (Thieken and Pech 2015).

Since official flood hazard maps have recently become available for all flood-prone urban areas in Germany due to the implementation of the European Floods Directive, the insurance-related zoning system has been updated leading to the fact that the more detailed maps reduced the high-risk areas (GDV 2016).

Due to the low flood insurance penetration rate, the suitability of the voluntary insurance against natural hazards has been intensively discussed in the recent past. The discussion started after the severe flood in 2002 when a governmental relief fund of EUR 7.1 billion was launched to finance reconstruction (Thieken et al. 2006). On the one hand, this vast governmental aid facilitated people to recover quickly; on the other hand, it provided little incentives for private investments in mitigation measures or flood insurance. It is also feared that such (recurrent) governmental intervention might ultimately lead to a market failure of the voluntary insurance. As a consequence, the introduction of compulsory flood insurance was discussed, but finally abandoned (Schwarze and Wagner 2004). After another big flood in 2013, the same debate flourished again, with, however, the same outcome although another EUR 8 billion was provided as governmental disaster assistance (Thieken and Pech 2015; Thieken et al. 2016a).

Nevertheless, the public and political debate on flood insurance in combination with recurrent damaging flood events has triggered some changes in the provision of flood insurance and governmental disaster assistance. In 2005, a damaging flood hit the south of Germany, particularly Bavaria. Again, governmental aid was provided, this time from the Bavarian state, but discussions started how the uptake of flood insurance could be fostered and how the governmental aid should interact with insurance provision and pay-outs. It was decided that only residents who could prove that flood insurance coverage had been denied should receive governmental disaster assistance. In Bavaria, a corresponding directive came into effect in 2011. In the same year, a similar directive was passed in Saxony that had been affected by flooding not only in 2002 and 2013, but also in 2006, 2010 and 2011.

In addition, risk communication was intensified to foster conclusions of flood insurance. Starting with Bavaria in 2009, the GDV launched in cooperation with the state water authorities risk awareness campaigns that informed property owners about their flood exposure and insurance options. A similar campaign was conducted in Saxony in 2012. Meanwhile, eight of the 16 federal German states have performed such a campaign together with the GDV, some already several times; in two further states campaigns are in preparation. As a further measure, the GDV supported the building certificate "Hochwasserpass" which was developed by civil and water engineers and was launched in 2014 to advise homeowners on adequate property-level mitigation measures. A survey among building insurers in 2012/2013 revealed that such measures have recently been rewarded in the insurance contracts, e.g. by providing insurance in high-risk areas or by a reduced premium or deductible (Thieken and Pech 2015).

In what follows, the interplay between flood insurance, governmental disaster assistance and properly-level mitigation will be analysed using flood-affected households from Saxony and Bavaria as examples.

9.3 Data and Methods

To analyse the three aspects of resilience among flood-affected residents in Germany data from several post-event surveys were used. The survey was first set-up after the flood of 2002. The questionnaire captured many aspects that revealed how residents coped with the flood and explained flood losses (see Thieken et al. 2005, 2007). Since then, the questionnaire has been repeatedly used in adapted versions after big flood events as well as after some pluvial floods in Germany (Kienzler et al. 2015; Rözer et al. 2016; Thieken et al. 2016b).

For this paper, only data from residents in the Freestates of Saxony and Bavaria are used. Both states were hit by river floods in 2002 and 2013 and have a different tradition with regard to flood insurance (see above). In addition, Bavaria experienced major flooding in 2005, while Saxony was affected by a major event in 2010 (and minor events in 2006 and 2011).

Figure 9.1 illustrates the share of insured residents in the post-event surveys in comparison to the market penetration according to GDV (2016). It reveals that insurance penetration (before the damaging event occurred) has increased in both federal states between 2002 and 2013. However, market penetration in Saxony is considerably higher than in Bavaria due to the different availability of flood insurance prior to 1991 (see above). Furthermore, the share of insured residents tends to be higher in the post-event surveys than in the figures provided by GDV (2016); this holds especially for Saxony (see Fig. 9.1) and indicates that negative selection is still an issue, i.e. homeowners in flood-prone areas are more likely to buy the supplementary natural hazards insurance than others.

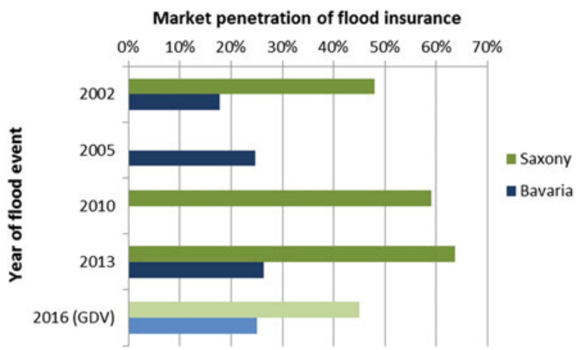

Fig. 9.1 Percentage of flood-affected residents that were insured against flood damage before the damaging flood event occurred as given in the survey data collected after the floods of 2002, 2005, 2010 and 2013 in comparison to the market penetration of flood insurance in Saxony and Bavaria according to GDV (2016)

9.4 Flood Insurance and Resilience–Empirical Findings from Germany

Post-event surveys among flood-affected residents in Saxony and Bavaria were used to investigate the behaviour of insured and uninsured households with regard to loss compensation and recovery as well as to adaptation to the flood risk.

9.4.1 Recovery

With regard to recovery, it was analysed how many insured and uninsured households received payments to compensate their repair works at damaged buildings, how well the state of their damaged and repaired home was at the time of the interview in comparison to the pre-event status and finally how they evaluated the compensation procedure. The results are summarized in Table 9.1.

Table 9.1 reveals that in all flood events a higher percentage of uninsured households did not receive payments to compensate their flood losses in comparison to insured households. Insured households that did not receive payments

Table 9.1 Share of uninsured and insured households that received no payments to compensate flood losses caused by different flood events in Saxony (SN) and Bavaria (BY), the average perceived restoration of their building at the time of the interview assessed on a scale from 1 (=the building is already completely restored/repaired in comparison to the pre-event status) to 6 (=the building is still considerably damaged), and the average satisfaction with the compensation procedure assessed on a scale from 1 (=very satisfied) to 6 (=not satisfied at all)

Flood event	State	Sample	Sample size	Share of households that received no payments [%]	Average restoration of building at the time of the interview	Average satisfaction with the compensation procedure
August 2002	SN	Uninsured	494	23	2.97	2.39
		Insured	468	10	2.74	1.92
	BY	Uninsured	354	41	2.40	2.36
		Insured	80	29	2.03	2.02
August 2005	BY	Uninsured	201	65	2.23	4.59
		Insured	68	44	2.09	2.26
August 2010	SN	Uninsured	114	53	2.38	2.68
		Insured	180	21	2.21	2.13
June 2013	SN	Uninsured	173	4	3.29	3.19
		Insured	333	3	2.77	2.48
	BY	Uninsured	163	3	3.22	2.41
		Insured	63	2	3.38	2.36

typically experienced losses that did not exceed their deductible or costs were not eligible, e.g. own working hours. The percentage of uninsured households that didn't receive any payments was particularly high for the floods of 2005 (Bavaria) and 2010 (Saxony), where only little governmental disaster assistance was provided. Due to the regional character of these floods, the federal government did not provide any disaster assistance. The state governments provided some help but were reluctant due to the cumulation of floods in recent years. Instead, they tried to foster private precaution. This attitude changed again in 2013: the governmental disaster assistance of EUR 8 Billion eventually almost exceeded the overall losses (Thieken et al. 2016b). Consequently, the percentage of uninsured households that did not receive any pay-outs was exceptionally low for the 2013-flood (Table 9.1). However, at the time of the interviews, i.e. around nine months after the flood event, not all decisions on loss compensation payments had been made. Therefore, the real share of households that did not receive loss compensation payments might be higher than is currently indicated by the survey data.

The data further reveal that the average pay-outs to insured households were considerably higher–sometimes two or three times–in comparison to the average pay-outs that uninsured households received (data not shown, see examples in Thieken et al. (2006) for the 2002-flood and Thieken and Pech (2015) for the 2013-flood). As a consequence, the average restoration of damaged buildings of insured households was always higher than the restoration of uninsured buildings (see Table 9.1), except for 2013 flood in Bavaria, where one dike breach caused heavy oil contamination and hindered repair works. Likewise, the satisfaction with the compensation procedures was higher among insured residents (Table 9.1). Altogether, the data indicate that—despite the huge governmental assistance in 2002 and 2013—insured households were compensated more often, recovered sooner and were more satisfied with the procedures. These findings are in line with previous work by Thieken et al. (2006) and Thieken and Pech (2015) that provides more insights into insured and uninsured households revealing that socio-economic characteristics as well as flood impact and damage do not differ much between these subgroups.

9.4.2 Adaptation to Flood Risks

As loss compensation is guaranteed by an insurance contract, it is often assumed that insured households do not further invest in the mitigation of flood losses. Figure 9.2, however, illustrates that this assumption is not backed by empirical data. In all six cases, insured households were better informed about flood hazards and mitigation options and had implemented equal or even more mitigation measures at the property level than uninsured residents. Figure 9.2 further reveals that the level of property-level mitigation has improved since 2002 in both regions, Saxony and Bavaria. In 2013, the level of private precaution was particularly high among insured Saxon households: around 75% of them had informed themselves about flood hazards and mitigation options and around 45% used their building in a flood-adapted manner and used water-resistant interior decoration (Fig. 9.2). This high level of precaution is only overtopped by flood-prone residents in the Rhine catchment, of whom around 65% stated that they used and equipped their building in a flood-adapted manner (Kienzler et al. 2015).

To further investigate whether uninsured and insured households behave differently after an event, Fig. 9.3 exemplarily illustrates the percentages of surveyed households that used their home in a flood-adapted manner before and after the damaging flood event using flood insurance coverage as a further distinction. The data reveal that after the floods of 2002, 2005 and 2010 between 19 and 25% of the households have started to use their home in a flood-adapted way regardless of the existence of flood insurance coverage. After the most recent flood of 2013, this share dropped to 8–13% indicating a saturation or fatigue among flood-affected residents. This indicates that there might be a certain share of residents that cannot

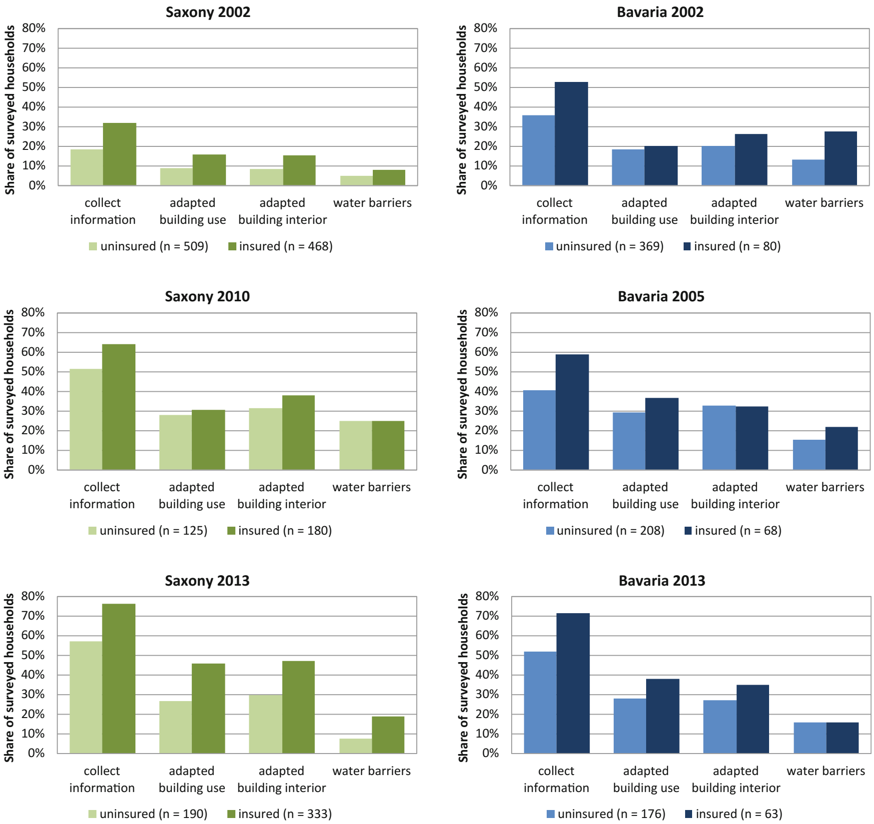

Fig. 9.2 Implementation of precautionary measures at the property level before the respective flood events, distinguishing uninsured and insured households that were damaged by the flood events

be motivated to invest in precaution. Psychological models could help to further explain these findings. It is known that some residents perceive their self-efficacy as low and develop other ways to cope with the flood thread, e.g. fatalism or ignorance (see Grothmann and Reusswig 2006; Bubeck et al. 2012). If the implementation of flood-adapted use before and after the damaging flood events is summed up, it still has to be concluded that insured households, in general, do more to mitigate flood damage than uninsured (Fig. 9.3). To fully explain this pattern is beyond the scope of this contribution. However, the results suggest that households that actively mitigate losses at the property level might assess insurance coverage as an additional layer of a safe home and not as an alternative to flood-proofing their home. More research on attitudes, personal traits and decision-making of flood-prone residents is needed to understand the whole picture.

9.4.3 Resistance

As a last aspect of resilience, it is analysed whether residents who live behind dikes and thus might feel safe show a different behaviour with regard to flood adaptation than residents who live in other flood-prone areas. For this, the data were divided into households that had been damaged due to a dike breach and households that had been damaged by other types of flooding (fluvial and pluvial floods or

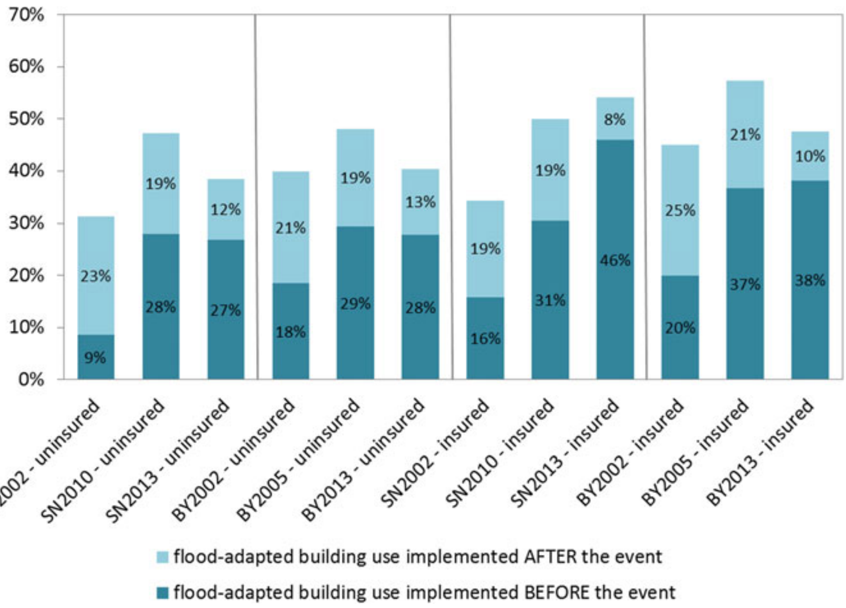

Fig. 9.3 Level of implementation of flood-adapted building use using different sub-samples from flood events in Saxony (SN2002, SN2010, SN2013) and Bavaria (BY2002, BY2005, BY2013)

groundwater flooding). Similar to Figs. 9.2 and 9.4 shows the percentages of households that undertook different precautionary measures including collection of information, contracting flood insurance and implementing adaptation measures at their properties.

Data from Saxony reveal that residents who had been affected by dike breaches were almost as well informed as other flood-affected residents. In addition, the insurance penetration was comparable. In contrast, adapting a building to the flood hazard was more popular among residents in flood-prone areas than among residents who have been living behind dikes. The implementation gap between these two groups is however closing over time: in 2013, already more than 30% of residents affected by dike breaches used or equipped their home in a flood-adapted manner in comparison to 40% of residents in other flood-prone areas. The share of Saxon households that had water barriers available was nearly equal in the two subgroups for the events of 2010 and 2013 (see Fig. 9.4, left column). It is likely

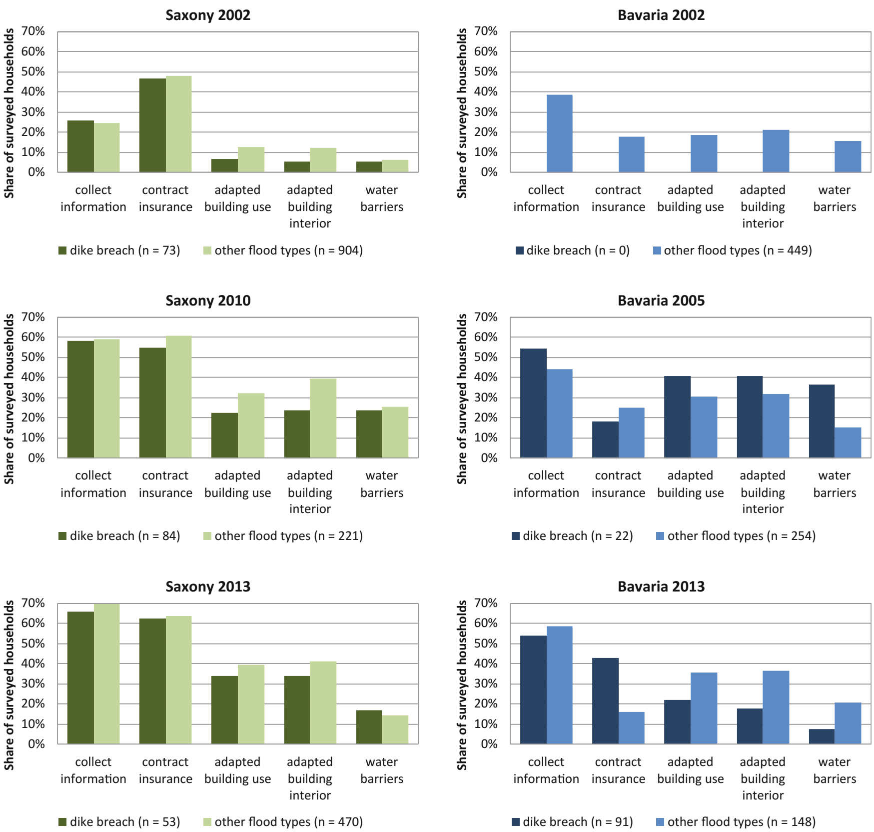

Fig. 9.4 Implementation of precautionary measures at the property level before the respective flood events, distinguishing households that were affected by inundation after dike breaches or by other types of flooding

that risk communication and the experience from the flood in 2002 with more than 100 dike breaches along the rivers Mulde and Elbe in Saxony had an effect on the safety feeling and preparedness of residents living behind dikes. Finally, recurrent flooding in 2006, 2010 and 2011 kept awareness and preparedness alive.

In Bavaria, the results are not as clear as in Saxony owing to the smaller sample sizes of residents who had been affected by dike breaches, particularly in 2002 ($n = 0$) and 2005 ($n = 22$). The results for the 2013 flood (Fig. 9.4, right column, at the bottom), however, highlight an interesting pattern: while the percentage of households that informed themselves about flood hazards and mitigation options is comparable in the two data subsets, considerably more households that were affected by a dike breach in 2013 had flood insurance coverage than other flood-prone residents. In return, they implemented less flood-adapted property measures.

Whether such patterns of private precaution are mainstreaming in the future, needs more investigation and long-term monitoring of private precaution. As a starting point, the implementation of flood-adapted building use before and after the flood events is illustrated in Fig. 9.5 (upper panel), as is the conclusion of flood insurance (Fig. 9.5; lower panel).

The analysis demonstrates that regardless of the type of the damaging flood around 20% of the affected households used their home in a flood-adapted way. Only residents affected by the flood of 2013 showed less adaptation. This may again point to symptoms of saturation or fatigue among flood-affected residents. In general, a clear distinction between the behaviour of residents behind dikes and of residents in other flood-prone areas is not easy to make: by 2013, residents living behind dikes in Saxony have shown a similar behaviour than other flood-affected residents, and the data from Bavaria are too heterogeneous for a sound conclusion.

With regard to flood insurance, Fig. 9.5 is dominated by the different uptake of flood insurance in Saxony and Bavaria. Again there is a tendency to similar behaviour of residents living behind dikes and in other flood-prone areas in Saxony, while flood insurance seems to be more frequently demanded by residents behind dikes in Bavaria. For these households, flood insurance might be judged as an affordable and cost-effective mean of precaution, whereas costlier mitigation measures are not implemented due to the low probability of a dike breach.

9.5 Conclusions

Since 2002, the penetration of flood insurance among residents has increased in Germany, although there are still considerable differences between different federal states: while flood insurance penetration is high in Saxony (>60%), it is considerably lower in Bavaria (around 25%). However, Bavarian residents living behind dikes seem to prefer flood insurance to other adaptation options highlighting insurance as an affordable precautionary option, a low-cost adaptation to possible dike failures, or in accordance with Park et al. (2013) as a low-cost response to

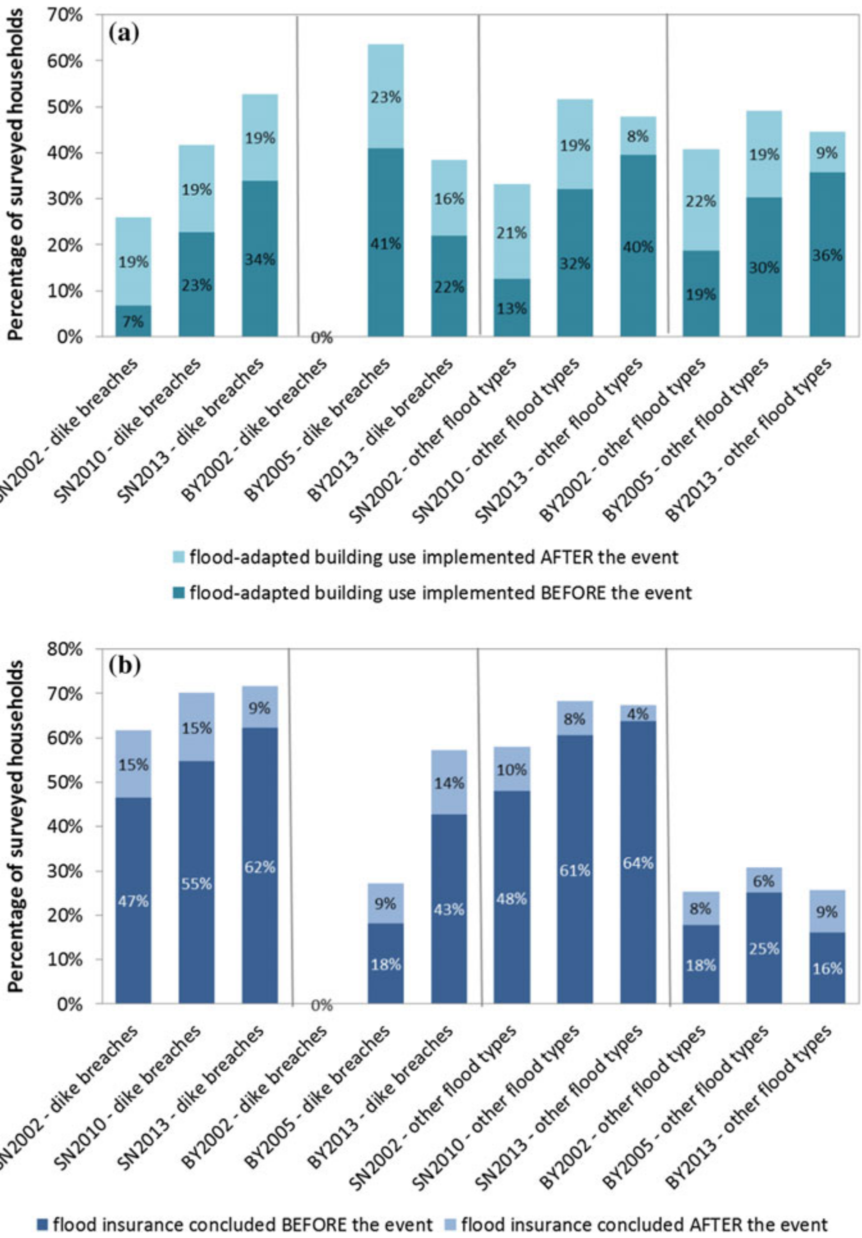

Fig. 9.5 Implementation of precautionary measures at the property level before and after different flood events in Saxony (SN) and Bavaria (BY), distinguishing households that were affected by dike breaches or other types of flooding; upper figure: flood-adapted building use; lower figure: conclusion of flood insurance

system surprises. Whether this strategy clearly differs from adaptation and resilience strategies in other flood-prone areas needs, however, more investigation. Insurance is usually not available for residents in high-risk areas that are not protected by dikes or is only provided in combination with the implementation of property-level mitigation measures. On the one hand, this indicates that insurance can be used as a mean to incentivise the implementation of property-level mitigation measure in Germany and thus to strengthen the resilience of highly flood-prone residents. On the other hand, the high (potential) losses in cases of dike breaches seem to be excluded from this mechanism, which is a lost opportunity of disaster preparedness.

There is strong empirical evidence that losses of insured households are more often and better compensated than those of uninsured despite the huge governmental disaster assistance after flooding in 2002 and 2013. In addition, insured people are more satisfied with the compensation process. However, flood insurance does not only contribute to flood resilience with regard to recovery. There is further evidence that insured residents do invest more in other flood mitigation measures at the properly level than uninsured since they regard insurance as a further layer of safety for their home. The reasons for this behaviour need more detailed analysis including psychological models and theories such as the protection motivation theory or the five-factor model of personality traits.

Still, it has to be acknowledged that the German insurance industry has done some efforts to raise flood hazard and risk awareness and to inform homeowners about mitigation and insurance options. As a consequence, German insurers consider precautionary measures now more often by incentives than they did back in 2002 which is a strong asset for enhancing the overall societal resilience. Whether this or other approaches can further foster the uptake of property-level mitigation measures and increase resilience in flood-prone areas on the longer term, needs to be seen.

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Chapter 10
Collaborative Emergency Supply Chains for Essential Goods and Services

Marcus Wiens, Frank Schätter, Christopher W. Zobel and Frank Schultmann

Abstract Focal actors in disaster relief logistics are predominantly public authorities, emergency organizations, and NGOs, whereas private firms rather play a subordinate role—at least in the context of direct crisis intervention. Although it is entirely clear that engaging in public crisis management is not among the original tasks of commercial firms there is a substantial—and so far still unexploited—potential for public–private cooperation in a disaster situation. In this contribution, we outline the scope of a Public–Private Emergency Collaboration (PPEC) with a focus on the provision of essential goods and services. We discuss the different objectives and strategies of the partners and evaluate the potential for a PPEC for each phase of a disaster from an economic perspective with a primary focus on logistics operations. Based on a simple model, we identify the chance to improve crisis management operations by information sharing and coordinated allocation of resources and capacities for both the escalating and de-escalating phase of a disaster. Interestingly, a PPEC can also help to overcome public acceptance problems which could be occasionally observed in historic disasters. As key requirements of a PPEC, we identify a clear allocation of responsibilities between the public and the private partners together with sufficient incentives for commercial firms to engage in a PPEC on a sustainable basis.

Keywords Crisis management · Humanitarian logistics · Public–private emergency collaboration · Public–private partnership · Relief supply chain Resilience · Risk management · Crisis management

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10.1 Introduction

Over the last decades, the direct and indirect damage caused by natural disasters throughout the world increased steadily in frequency and severity (World Bank 2010). This tragic trend resulted in the emergence of disaster relief logistics as a growing and indispensable discipline with high relevance for both theory and practice (Afshar and Haghani 2012). Focal actors in disaster relief logistics are predominantly public authorities, emergency organizations, and non-governmental organizations (NGOs), whereas private firms rather play a subordinate role—at least in the context of direct crisis intervention. By "public authorities," we mean governmental agencies of all levels (city level to federal or state level) which are responsible for civil defense operations together with the respective operative units (e.g., fire departments, ambulances, or official technical support agencies such as the German technical relief organization THW). In what follows, we do not analyze the role of NGOs or volunteers.

Why should private firms be involved in crisis management operations? Although it is entirely clear that engaging in public crisis management is not among the original tasks of commercial firms, there is much to indicate a substantial—and so far still unexploited—potential for cooperation between the private and public sector in a disaster situation. This is for at least two reasons: First, private firms dispose of critical resources (e.g., storing and transport capacities) together with the relevant logistical competence (Qiao et al. 2010). In contrast, public authorities do not dispose of these capacities because just few logistical operations belong to their key tasks in normal practice and even this minor corner of competence is decreasing due to the continuing trend toward privatization. Second, commercial players make intense use of information and communications technology (ICT) systems to cope with regular disturbances and even significant supply chain disruptions. As they are experts in "reading" normal and abnormal market behavior, they can proficiently contribute to a quick assessment of the disaster situation. As public authorities are less market-orientated and miss the competitive pressure, they usually either do not dispose of these technologies or the applied technology is not state of the art.

Although there is a rich account of comparisons between commercial and humanitarian supply chains, there are just few attempts which focus on the scope and limitations of a public–private cooperation for the context of crisis management, in short: A public–private emergency collaboration (PPEC). To the best of our knowledge, there is no contribution which explicitly analyzes the cooperative advantages of a PPEC in a model-based framework.

The remainder of the chapter is organized as follows: In Sect. 10.2, we describe the unique characteristics of humanitarian logistics from a general point of view, define the concept of PPEC, and give a brief overview of the state of the art. In Sect. 10.3, we present some arguments in favor of a PPEC out of a risk management perspective. Section 10.4 represents the main section which elaborates the key operative advantages based on a simplified dynamic model of crisis management. Apart from an explicit analysis of the cooperative potential of public and private actors during a crisis situation, another novel feature of this model lies in the interesting interaction effects between a directly affected region A and an indirectly affected neighboring region B. These interaction effects together with the resulting challenges illustrate the strength of a PPEC. We summarize and discuss our results in Sect. 10.5.

10.2 Public–Private Partnerships in the Context of Humanitarian Logistics

10.2.1 Specificities of Humanitarian Logistics

If the provision of essential supplies to the population cannot be guaranteed by the private market in the course of a catastrophic event, there is need for relief logistics. Due to an increasing number of catastrophic events in the course of the last decades, humanitarian logistics steadily gained in importance. Thomas and Kopczak (2005) define humanitarian logistics as a process which aims at an effective and efficient supply of the affected population during a catastrophic event. Challenging features of humanitarian supply chains are that these relief processes have to be planned and realized under conditions of extreme uncertainty and high time pressure (Altay and Green 2006, Charles et al. 2016). In particular, relief supply chains are characterized by effectively no lead time, high stakes, and extreme uncertainty, for example regarding the state of infrastructure in a disaster-affected region (Holguín-Veras et al. 2012; Gösling and Geldermann 2014; Beamon 2010).

In the last years, researchers developed a large variety of methods and tools, particularly in the area of Operations Research (OR), to support decision-making in the context of relief logistics and humanitarian SC management. The range of applications covers transport planning, facility location, resource allocation, and others (Altay and Green 2006; Galindo and Batta 2013; Natarajarathinam et al. 2009). Decision-makers in the domain of humanitarian logistics are—in addition to civil protection agencies—NGOs, the military, and distinctive private firms. These firms are mainly specialized in long-distance transportation and logistics and they take on the tasks of delivering equipment and emergency supplies into the affected regions (Thomas and Fritz 2006). Well-known examples are DHL or UPS (Wang et al. 2016).

10.2.2 Definition and Thematic Classification of a PPEC

We define a *Public–Private Emergency Collaboration (PPEC)* as a special form of public–private partnership (PPP) which is deliberately designed for the purpose of

Table 10.1 Traditional tasks and responsibilities between private and public actors

	Private firms	Public authorities
Regular supply chains	- Economic: *key actors* of supply chains and drivers of market allocation - Operational: CRITIS operator	- Legal: regulator - Economic: client - Operational: CRITIS operator
Relief supply chains	- Mainly passive role - Cooperation in the role of CRITIS operator - Occasional support (e.g., large distance transportation)	- *Key responsibility* for public crisis management and civil protection - Cooperation with NGOs - Military support

improved crisis management by joint coordination and cooperation between private and public representatives.

The unique characteristic is that a PPEC comprises (or even integrates) both the regular supply chains of essential goods and services as well as relief supply chains. Challenging features of a PPEC are the "latent presence"-property of this type of cooperation together with the discrepancy in the objectives of the partners. By "latent presence," it is meant that such type of cooperation needs to be planned, coordinated, and contracted well in advance while the execution of the crisis management procedures depends on the occurrence of a disaster. The discrepancy of objectives between the partners is due to the fact that the objectives of relief supply chains and commercial supply chains are different. This point will be further addressed in Sect. 10.4.

In a PPEC, there is a far stronger role for commercial firms in crisis management compared to the current situation where private firms are at best occasionally involved in relief operations. A potential cooperation is particularly relevant for those firms which are specialized on the supply of essential goods and services as water, food, and medicine (Fang and Norman 2014). The range of applications also extends to the supply of hygienic, communication, and security as these goods are of vital importance during a disaster too. They help to avoid epidemics, looting activities, and emotional distress.

Table 10.1 gives an overview of the different roles of public and private representatives in either commercial supply chains (upper line) or in a relief supply chain (lower line). The upper left and the lower-right part of the table represent the standard division of labor between the public and the private domain. Private firms are the dominating players in regular supply chains, whereas public authorities are in charge of crisis management operations. In regular supply chains, the state is predominantly in the role of a customer but is influencing the rules of the game in the role of a regulator. As far as public authorities are *critical infrastructure* (CRITIS) operators, they provide part of the necessary infrastructure all supply chains inevitably depend on. As already said, firms traditionally have a rather subordinate role in the context of a relief supply chain. Their main regular contribution is surely their role as CRITIS operators motivated by their obligation to cooperate with public authorities to keep the infrastructure running. A PPEC is basically integrating all four parts of this table as both types of supply chains are involved as well as private and public entities.

10.2.3 Brief Account of the Scientific Work on Forms of Public–Private Cooperation

The discipline of economic contract theory focusses on the *incentives* of both partners to commit to the relationship by designing optimal contractual arrangements which reduce or even overcome the conflict of interest between the two parties. The Economics of PPPs analyzes herein the incentives of the cooperating parties in the context of incomplete contracts (Hart 2003). The main focus of this research is the financing as well as the delegation of tasks and risks in the course of joint project execution by public and private partners (Iossa and Martimort 2008; Morasch and Tóth 2008). Taking the incomplete contracting perspective, there is a comprehensive account of the rationale for aligning public and private objectives as in large construction projects for public infrastructure or in the case of critical infrastructure operation. The main three reasons are bundling of tasks, optimal risk transfer, and the long-term nature of the relationship which allow for stable relational contracts. From a methodological point of view, economic contract theory and game theory are the predominant tools. In the domain of supply chain management, PPPs are seen as potential alternatives to outsourcing of activities (or services) by the public sector as the principal (Eßig and Batran 2005). In the domains of crisis management and humanitarian supply chain management, there are just few contributions which look at forms of public–private collaboration out of an incentive perspective.

From a conceptual point of view, the approach of (Stewart et al. 2009) is similar to the objectives of this chapter: The authors investigate to what degree communal resilience—albeit used in a somehow broad sense—can be improved by public–private partnerships. They evaluate the current scientific literature but remain rather descriptive and vague in drawing conclusions. The investigation of Kapucu et al. (2010) puts more emphasis on the organization-theoretic perspective and discusses problems of coordination embodied therein. The main focus is the improvement of (inter)governmental cooperation and crisis networks. Although they do not look at the integration of private firms in the first place, the authors work out the basic requirements for interoperability and effective inter-organizational communication. The contribution of Koliba et al. (2011) provides valuable insight into the failure of crisis management of both public and private actions using the example of Hurricane Katrina in 2005. The authors identify as the main reason for this failure that the established networks between firms, state, and NGO’s were too provisional, partly ill-considered, and incomplete by design to cope with a disaster of such heavy impact and this high degree of complexity.

The papers which are closest to our approach are the contributions of Qiao et al. (2010) and Wang et al. (2016). In Qiao et al. (2010), the authors set up a game-theoretic model, derive conditions for the optimal investment levels of the public and private agents, and hint at the limits of public–private cooperation. Although the model generates precise results, it remains restricted to the single dimension of investment levels. In Wang et al. (2016), the authors integrate a private firm into a public rescue supply chain and analyze the supply chain’s effectiveness with respect to selected characteristics of the shelf life of goods. They also look at the social optimality of the in- versus outsourcing decision and compare reactive and proactive disaster response. Their model is rich in insights about the optimal condition for the integration of private firms and represents thus a first analytical step toward a comprehensive account of a PPP.

From a practical- and application-orientated perspective, there already exist some forms of public–private cooperation in the domain of crisis management which can serve as an orientation for a PPEC. The first example refers to the internet platform UP KRITIS which is a joint initiative of the German Federal Office of Civil Protection and Disaster Assistance (BBK) and the German Federal Office for Information Security (BSI). The objective of this initiative is the protection of Critical Infrastructure (CRITIS) and most private operators of critical infrastructure in Germany are part of this network (e.g., power companies). The main activities relate to the exchange of information and experiences in eight CRITIS sectors. To facilitate communication and to aggregate the information, firms out of each sector establish a Single Point of Contact and direct the information to one central evaluation unit (KRITIS 2013).

A second example of public–private cooperation refers to the Swiss project National Economic Supply (NES). In NES, the public and private sectors cooperate to ensure that short-term supply shortages do not result in significant disruptions. The NES framework comprises supply units (food, energy, and therapeutic products) as well as infrastructure units (transport, industry, ICT infrastructure, and manpower). The units integrate 300 representatives of all major sectors of the Swiss economy. NES is coordinated by the public sector and is operationally led by an honorary official of the private sector. The representatives of the participating firms contribute their specialist knowledge and contact networks, discuss the current supply situation in Switzerland, and participate in both the planning and implementation of measures that have been determined.

To sum it up, all research results and practical insights which are available so far stress the importance of an incentive-based framework of public–private emergency collaboration which takes into consideration the conflicts of interest as well as the restrictions of the parties involved and which allows for an efficiency analysis. In order to fill this gap, we are proposing such a framework.

10.3 Identifying the Need for Public–Private Cooperation in Crisis Management

10.3.1 Overriding Crisis Responsibility of Public Authorities

There are many reasons why public and private competencies, resources, and strategies can complement each other in the context of crisis management. The first relates to their risk competence with respect to disasters and supply chain disruptions. Some authors argue that public authorities will inevitably fail to establish efficient operations due to missing (regular) experience and lack of market pressure (Koliba et al. 2011). On the one hand, it is evident that the public sector can hardly keep pace with all technological and procedural innovations which are drivers of modern logistics and supply chain management. This alone would justify the outsourcing of logistical operations to private partners (Wang et al. 2016). However, the prevention of and reaction to any extreme situation like a large-scale disaster which causes a nation's state of emergency is within the responsibility of civil protection authorities. In such an extraordinary situation, it is not only impermissible for the state to delegate its primary responsibility as a "rescuer of last resort" to private agents, but in most cases, it is simply impossible for practical reasons: In the extreme event of a supply crisis, large parts of private supply chains are actually non-functional. In such a situation of a (partial) market failure, the state is forcefully bound to fulfilling its legal and factual obligation to provide emergency support by establishing a parallel and temporary relief supply chain.

Recent experience shows that public authorities and NGO's have continuously gained more and more expertise in coping with extreme disasters and in establishing and managing humanitarian relief supply chains. In other words: The core competence of public crisis management is about relief logistics which is put in place in the event of extreme disasters.

10.3.2 Complementary Risk Competence

It follows that the state and private firms are responsible for different domains of risk and crisis management but that they can effectively complement each other in a crisis situation. Information, know-how, infrastructure, and network integration are all critical resources for which public authorities have significant need in the event of a disaster. Private firms have expertise related to their respective markets and to their "normal mode of operations," and they accumulate large amounts of market data stemming from their day-to-day operations. Of primary interest to them tend to be market-related risk factors such as the movement of prices (e.g., prices for raw material, prices for the final product, interest rates, and wages) and quantities (volatility of demand, fluctuating staff, etc.). Assuming the *structural stability of markets*, i.e., that there are no systematic and drastic changes of demand or supply conditions, these data provide a sufficiently valid basis for estimating future levels and trends of the considered risk factors.

Risks that are characterized by regular occurrence but that are not too difficult to manage can be categorized as "high frequency—low impact" (HFLI) risks (also commonly called "high probability—low consequence" risks). In general, firms typically have enough expertise to deal with HFLI risks because they are used to handling them on a day-to-day basis, and this risk category thus belongs to the core competencies of those firms. Firms have developed very effective ways of mitigating HFLI risks, and favorable forecasting conditions allow for an effective anticipation of and preparation against these risks. Firms also tend to have a deep knowledge of the level and the behavior of demand under regular conditions and this can serve as an important reference or baseline value in the case of a crisis. Furthermore, they dispose of an (in economic and technological terms) optimized logistics infrastructure and they have valuable commercial contacts and therefore largely more scope for immediate action within their supply chain networks.

More difficult to handle, but still a key focus of enterprise risk management, are risks that have a lower frequency but cause significantly higher damage. In this case, risk factors display extreme movements so that standard risk management provisions are not sufficient to prevent disruptive effects on their operations. For example, persistent price shocks for raw material or a heavy wave of flu in a region can cause a significant and enduring shortage of staff, so that flexible work schedules that are able to buffer staff fluctuations in normal times reach their limit. Similarly, weather extremes (e.g., heavy rain or heat waves) or enduring strikes also can cause large temporary disruptions and deviations from normal modes of operations. We call such events "medium frequency—medium impact" (MFMI) risks. There is also a third type of risk that we call "low frequency—high impact" (LFHI) risks. Although these types of risk are not typically an everyday consideration for a business, they ultimately can pose a threat to the organization's existence because of the magnitude of the impacts.

Although MFMI risks, in particular, are relatively rare events, they are a well-known issue for businesses because preparing for them can require considerable expenses. For example, the project SEAK (funded by the German Federal Ministry of Education and Research) dealt with shortages of food and water due to disrupted supply chains. In the project, firms were interviewed and asked to state their perception of these risks and to discuss their mitigation strategies with regard to them. The result was double-edged: Many firms did not see any reason to prepare against such threats, primarily because of a seemingly unacceptable cost-benefit ratio with respect to prevention measures. This was particularly true for small firms which were active in highly competitive markets. However, a second group of firms that had actually survived an MFMI event subsequently showed strong efforts to cope with these risks because their experience had clearly indicated the extent of the threat. Ultimately, the best practice was shown to be a combination of an early warning system and increased flexibility of operations. A firm can increase flexibility by implementing support and fallback structures such as multiple sourcing or the activation of alternative routes, or by making additional warehouse capacity available. Although such measures appear straightforward and are easily comprehensible, they nevertheless represent a significant investment to these firms. The main reason for this is that the most effective measures are not "once and for all" expenses but instead they require a process of continuous development and long-term contractual arrangements regarding maintenance and support.

Although we consider all types of risk, the focus of our discussion is on the set of firms that have survived an MFMI event and thus are more proactive in their risk management. This group of firms are potential candidates for a PPEC for at least two reasons: First of all, firms which are partners in a public–private emergency

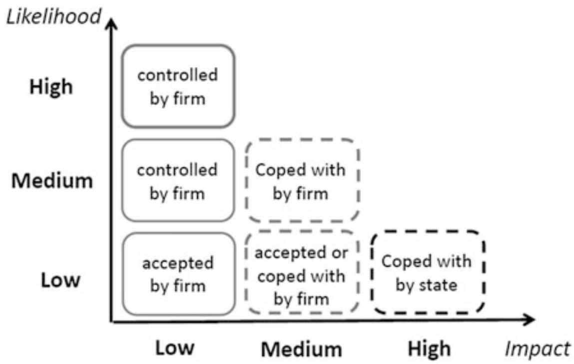

Fig. 10.1 Complementary risk competence of private firms and civil protection agencies

collaboration need to be highly competent in risk and crisis management. Secondly, these firms need to have a clear, long-term understanding of this particular type of cooperation and they should be willing to provide sufficient commitment for such an arrangement. To sum it up, firms and state authorities have different responsibilities and competencies with respect to the different risk types. However, to a certain limit, these differences can complement each other and this is true for all categories of risks—although to a different extent and for different reasons. Figure 10.1 illustrates the responsibilities and competencies of firms and state with respect to different categories of risk.

10.4 PPEC—A Model-Based Illustration

In this section, we illustrate potential synergies of public and private disaster management which are achievable in the framework of a PPEC. Without pre-empting the results, we can say that the firm incurs efficiency gains through participation in such a partnership, whereas the state is able to improve the supply coverage for the affected population. In particular, the state is able to prevent delays in emergency supplies which is a critical factor for the most vulnerable groups. These overall improvements are made possible by the systematic integration of (parts of) the commercial supply chain into the humanitarian supply chain. The flipside of this integration is higher cost for public crisis management as the state has to compensate the firms for the additional activities and timely delivered goods. Therefore, many potential improvements which are achievable by a PPEC hinge on the legal and regulatory requirements that are needed to make these compensations feasible. As a result, an improved supply of resources to the affected population, made possible by a strong but remote private supply chain behind the scenes, fosters urban resilience.

10.4.1 The Basic Setting

One major challenge in crisis management is that people and regions are hit differently by a disaster. Some regions are hit harder than others, and within these regions, some people are more vulnerable than others. Civil protection agencies have to respond to this heterogeneous picture by giving top priority to the regions and people which are directly affected and which therefore are also suffering as victims of the disaster. We label these hot spot regions as "A-regions." It will regularly be the case, however, that the effects of a disaster spread to neighbor regions of the hot spot which can thus also be heavily influenced—albeit not directly affected. Such types of crisis externalities are reflected by increased scarcity leading to unavailability of goods or to higher prices. Similarly, it is also possible that the breakdown of critical infrastructure (e.g., energy or transportation) extends to connected neighbor regions. Population movements constitute another channel too. In this case, neighbor regions are influenced by an inflow of professional and voluntary helpers who choose their accommodation and logistical hubs in a safer neighbor region, as well as potential inflows of evacuated people. We label these indirectly affected neighbor regions to a disaster hot spot as "B-regions." Although B-regions should not be given top priority for rescue activities, effective crisis management requires a profound understanding of the interactions between A- and B-regions. This aspect becomes even more important in the context of a PPEC since private supply chains in the B-regions will still be running and can—if integrated into public emergency planning—flank and ease the burden of public operations.

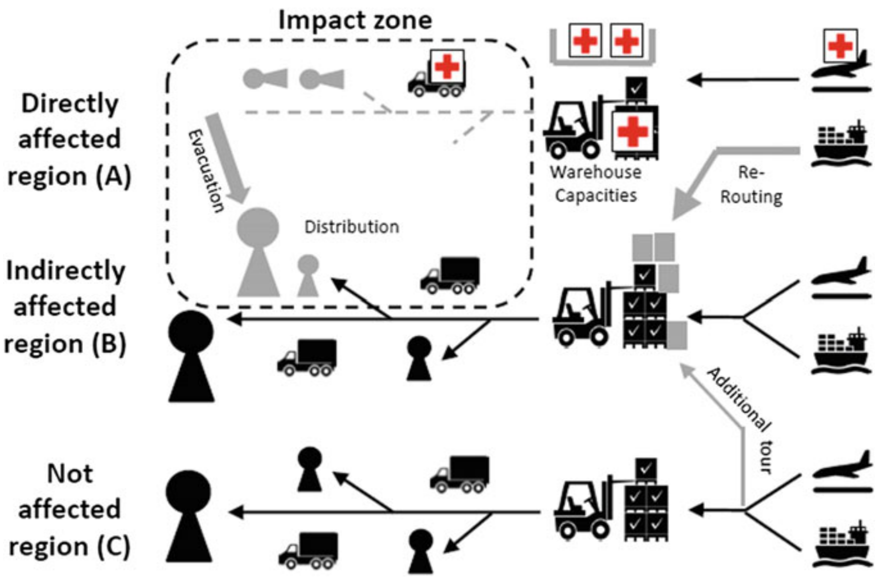

Fig. 10.2 Interdependencies of crisis operations across regions with different degrees of affectedness

Figure 10.2 illustrates potential interactions between an A- and a B-region in the context of a disaster. In the picture, we also added a C-region as a fully unaffected region which reflects the normal mode of operations and just serves as a comparison.

The picture is read from right to left: The goods are first transported from the region of origin to a central warehouse (forklift truck symbol) and then—via last mile delivery (truck symbol)—distributed to the local population. The size of the depicted figure reflects the population density. In the crisis region A, parts of the population are directly affected and have to be supplied by essential goods as well as medicines. As an example, suppose that region A is hit by an extreme heat wave and the population is in urgent need of water. Hence, in region A, there is an extreme and immediate need of water. When this crisis threatens to arise, civil protection authorities as well as NGOs supply water and put it into an interim emergency storage. In the context of a PPEC, it is basically possible that the government and NGOs use the commercial warehouses for the relief supplies. This option is indicated by a red cross-sign on the commercial warehouse symbol. Part of the population can be evacuated out of the crisis region and temporarily (i.e., until the end of the crisis) hosted in the neighbor region B. During a crisis, private firms are inactive in region A. Therefore, they can reroute the bottled water into region B.

10.4.2 The Model-Setup

In the following, we provide a more detailed analysis of the setting described above and illustrate the crisis dynamics with the help of a numerical simulation. This makes it possible to elaborate the strategic and operational options of both the state and the firm in a more distinct manner. To simplify the analysis, we restrict the analysis to just one firm which supplies bottled water to the regions. Extending the model to the case of two or more firms leads to the interesting question of how firm competition affects the strategic options and incentives of the private sector in the context of a PPEC. At this point, however, we take a step back to get an initial understanding of the interoperability options of a commercial and public rescue supply chain during a crisis event.

Unless otherwise stated, most assumptions and structural equations refer to both regions. We intentionally choose an exactly symmetric setting between region A and B in order to be able to focus on the key effects which are driven by the crisis event and the crisis management and not by—for our purposes—analytically irrelevant differences between the two regions.

10.4.2.1 Demand

Let x_0^D be the normal demand level in region A and B, respectively, which corresponds to an unaffected situation at time $t = 0$. For the sake of simplicity, this number corresponds to the number of people in either region, i.e., under normal circumstances, each inhabitant needs exactly one unit per period of the essential good (e.g., one gallon of water). If a crisis event occurs, the demand evolves in the form of a reversed U, i.e., it first increases, reaches a maximum, and moves back to the normal level. We assume that the demand doubles at the peak of the crisis which implies that every inhabitant of the affected region needs two units instead of one at the worst moment of the crisis. Hence, if we consider a crisis lasting T periods, the demand at time t is given by:

$$x_t^D = x_0^D \left(1 + \frac{4t(T-t)}{T^2}\right) \tag{1}$$

10.4.2.2 The Firm's Decision

The firm reacts to the current demand but prepares the operations of the next period on the basis of the *expected demand* $E_t\left(x_{t+1}^D\right)$. The index t of the expectation operator $E_t(\cdot)$ indicates the period in which the expectation is formed. In this case, there is a lag of one period between the expectation and the realization of actual demand. The expectation formation process is an adaptive one: The firm bases its guess of next period demand on the current level but corrected by the percentage error of the last forecast, hence:

$$E_t\left(x_{t+1}^D\right) = x_t^D \left(1 + \varphi \frac{x_t^D - E_{t-1}\left(x_t^D\right)}{x_t^D}\right) \tag{2}$$

The parameter φ determines the strength of the error correction; for the sake of simplicity, we assume $\varphi = 1$.

In addition to its order policy ($\Delta x_t^{\text{order}} \geq 0$), the firm faces a stock level ($x_t^{\text{stock}} \geq 0$) and a potential rerouting decision ($\Delta x_t^{\text{reroute}} \gtreqless 0$) in each period. The symbol Δ indicates flow values, whereas the stock represents a position value as usual. The decision on these three operations is influenced by the expected demand and together they affect the number of goods which are available to be put on the market in the next period. Hence, the supply available at time t is given by:

$$x_t^S = x_{t-1}^{\text{stock}} + \Delta x_{t-1}^{\text{order}} + \Delta x_{t-1}^{\text{reroute}} \tag{3}$$

The order costs per unit ordered are given by c^{order} and we ignore order fixed costs. The order cost can also be interpreted as "average provision cost." Seen from this perspective, it is secondary whether the firm also produces the good (in some other distant region) or rather takes the role of a market intermediary and trades it. As already outlined in Sect. 10.3, the firm disposes of a warehouse in each region.

The inventory cost is comprised of a fixed component, $c_{\text{fix}}^{\text{stock}}$, to keep the warehouse open during the respective period and a variable stocking cost component, $c_{\text{var}}^{\text{stock}}$. The warehouse capacity is given by $\hat{X}$. Any amount which is dedicated to storage but which exceeds this limit can either be rerouted into the neighbor region or the firm must rent additional warehouse capacity at a unit price $q^{\text{stock}} \gg c_{\text{var}}^{\text{stock}}$ which significantly exceeds the variable stocking cost. The rerouting cost amounts to c^{reroute} per unit.

The difference between the available supply and the demand equals the excess supply Δx_t^S of the same period.

$$\Delta x_t^S = x_t^S - x_t^D \tag{4}$$

Excess supply in a given period reduces the order quantity for the next period but the excess supply must be stored until then. The question is whether it should be stored at the local warehouse or whether (parts of) the excess supply should be rerouted to the neighbor region and stored in the warehouse of the other region. Rerouting can be optimal for two reasons: First, rerouting allows the firm to cover demand in the neighbor region without the need to place new orders. This strategy saves provision cost. The preconditions for this strategy are that the expected demand in the region of origin must be lower than the excess supply (under this condition, it is highly improbable that we can sell the excess supply on the local market) together with the reverse condition for the target region (i.e., the target region must be able to absorb the excess supply instead). Second, rerouting is part of the warehouse capacity planning: By this strategy, the firm can prevent cost of under- and overcapacity. In our simple setting, it can be optimal to reroute very low quantities in order to close the warehouse and save fixed costs (undercapacity) or to reroute quantities in excess of the warehouse maximum capacity which would be subject to renting additional capacity otherwise (overcapacity).

After the rerouting decision, the remaining excess supply is placed in the warehouse of the respective region. Stock replenishment corresponds to the stock level in period t, as given by Eq. (5).

$$x_t^{\text{stock}} = Min\left\{\Delta x_t^S \pm \Delta x_t^{\text{reroute}};\ \hat{X}\right\} \tag{5}$$

Finally, the remaining difference between the expected demand and stock level determines the new order quantity (which is available in the next period).

$$\Delta x_t^{\text{order}} = E_t\left(x_{t+1}^D\right) - x_t^{\text{stock}} \tag{6}$$

The firm's per period profit π_t is given by the difference of revenue and all cost components (provision cost, inventory cost, and routing cost). The revenue is given by the selling price p—which is assumed to be fixed in the short run—times the amount sold, which is in turn determined by the demand and the supply available.

$$\pi_t = p \cdot Min\{x_t^D; x_t^S\} - c^{\text{order}} \cdot \Delta x_t^{\text{order}} - c_{\text{var}}^{\text{stock}} \cdot x_t^{\text{stock}} - c_{\text{fix}}^{\text{stock}} - c^{\text{reroute}} \cdot \Delta x_t^{\text{reroute}} \quad (7)$$

The firm maximizes the period profit which is achieved by minimizing cost at constant prices. On overall, this is a realistic assumption—even during a crisis. In such a critical situation, the firm will certainly switch to some kind of emergency mode but this is done to protect the company from losses in the first place. To a certain limit, firms are also distributing goods for free to the affected population either for altruistic motives or for reputational concerns. Both effects are difficult to disentangle from an empirical point of view. We consider both aspects as interesting and important extensions to our approach. Reputational issues should be analyzed in a repeated game-setting (Fudenberg and Tirole 1991) which is well beyond the scope of our illustrative framework. Before integrating altruistic motives into the analysis, we need to know more about the psychological characteristics such as their activation condition, the strength, and degree of persistence. This is certainly a promising research agenda on its own which we leave for further research.

10.4.2.3 The State's Decision

The logistical operations of the state are similar to those of the firm with two exceptions: First, as the state just intervenes in region A, there is no rerouting decision. Second, both components of inventory cost are higher for the state because the public agencies must establish the warehouses at the first place (higher fixed cost $c_{\text{fix}}^{\text{stock}}$) and must keep them running under exceptional conditions (higher variable cost $c_{\text{var}}^{\text{stock}}$). As outlined in Sect. 10.2, establishing a local relief supply chain from scratch is a more complex and resource-intensive task than to keep running an already existing and optimized logistical system (Schätter 2016).

Apart from the operational aspects, the main difference between private and public crisis management lies in their different objectives. While the firm tries to maximize profits, the state seeks to minimize the number of affected people at a given level of resources. Hence, public cost κ comprises both *material or financial cost* ("budget") on the one hand and *deprivation cost* on the other with the clear emphasis on the second. Deprivation costs represent an immaterial cost category which captures all kinds of individual impediments as well as physical and psychic distress of people (Holguín-Veras et al. 2012; Holguín-Veras et al. 2016). For our setting, it is directly evident that deprivation cost is due to unmet demand for the essential good but the key determinants of the deprivation cost lie in two forms of escalation or deterioration. In concrete terms, we distinguish between *unmet demand of different degree* on the one hand and *subsequent underprovision* on the other. The first category makes a difference between different constellations of underprovision. In our simple setting, there is a maximum need of two units per person which leaves us with three possibilities of unmet demand: People who have an unmet need of one unit (0/1-victim), people who have a need of two units but just one of two could be supplied (1/2-victims), and the worst case where people are left with an unmet demand of two units (0/2-victims). As far as the first two constellations are concerned, it is difficult to say whether it's worse to be in a position of a 0/1-victim compared to that of a 1/2-victims so that we treat both cases as one which causes deprivation cost of κ_1. However, the situation of a 0/2-victim is clearly more hazardous to the affected individual: Already the fact that this person needs two units of the essential good indicates a critical state of need and a higher degree of personal vulnerability and physiological stress. If it is not even possible to provide this person with just one unit, the 0/2-constellation represents a major health risk leading to deprivation cost $\kappa_2 \gg \kappa_1$.

The second category takes into consideration that the crisis context is dynamic and that a person's situation can quickly get worse if this individual remains unprovided for more than one period. A deficiency of essential goods over subsequent periods can quickly cause acute danger to life. We take this aspect into consideration by multiplying the per-period deprivation costs. For example, in order to record the 0/2-affectedness of the population over three periods in succession, we multiply the expected deprivation cost of three periods.

$$\gamma_t \cdot \gamma_{t+1} \cdot \gamma_{t+2} \cdot (\kappa_2)^3 \tag{7}$$

The variable γ_t represents the average expected proportion of 0/2-victims in the population in period t. Both the expected proportions of 0/1-, 1/2-, and 0/2-victims as well as their aggregation, i.e., the proportion of people who are subsequently underprovided for Δt periods are calculated under the assumption of stochastic independence. More specifically, the mechanism which determines all victim types per period does not consider correlation—neither over periods nor over victim types. Needless to say that this is a purely simplifying assumption and fully debatable as this mechanism does not account for the people's vulnerability, whereas highly vulnerable people will more probably suffer from chronic underprovision, for example, due to reduced mobility, limited social contacts, reduced self-help capacities and the like. Taking "correlated affectedness" and vulnerability into account would result in higher aggregated deprivation cost near the peak phase of the crisis.

As for every humanitarian supply chain, one important decision variable of the state is the operational criterion for public intervention. Since the emergency status must be justified, the state first needs to identify an exceptional situation. Therefore, in the model, the *emergency criterion* relates to the proportion of 0/2-victims of a period. If this proportion exceeds a critical threshold ($\gamma > \tilde{\gamma}$), the state declares the crisis status and is—from now on—in charge of all logistical operations. If a crisis status is declared, the firm is inactive (in the model the firm-relevant demand drops to zero) with the exception of supporting operational activities in the context of a PPEC. Finally, we assume that the state decides about *evacuation* of parts of the population if the regional "degree of affectedness" reaches a critical threshold too.

In each period, the state seeks to minimize the sum of all deprivation cost under the restriction that it cannot exceed its budget for the supply of essential goods as well as for the necessary logistical operations. In the model simulation in Sect. 10.4.3, we do not implement a budget restriction for analytical reasons: It is more insightful to run the model with unhindered state activities and the full range of possible cost levels. We leave the interesting and more realistic analysis of varying budget restrictions on the state's activities for future research.

10.4.3 Model Results

This section illustrates the interaction of a commercial supply chain and a humanitarian supply chain. The simulation shows the effects on key variables such as demand, unmet need, firm supply, and state supply for region A and B (Fig. 10.3). The simulation is run under the following assumptions and for the following parameter values: The regular demand level in both regions equals $x_0^D = 100$ and the crisis lasts $T = 10$ periods. The selling price is $p = 5$ [monetary units] and the cost parameters are given by $c_{\text{fix}}^{\text{stock}} = 100$, $c_{\text{var}}^{\text{stock}} = 1$, and $c^{\text{reroute}} = 2$ for the firm as well as $c_{\text{fix}}^{\text{stock}} = 200, c_{\text{var}}^{\text{stock}} = 2$, $\kappa_1 = 2$, and $\kappa_2 = 5$ for the state. The firm's warehouse has a capacity of 150 units in either region, whereas the emergency stock which is provided by the state and/or NGOs just has a capacity of 50 units. This difference in capacities is well in line with the real-world conditions (cf. Wang et al. 2016). Common cost parameters of the firm and state, respectively, are given

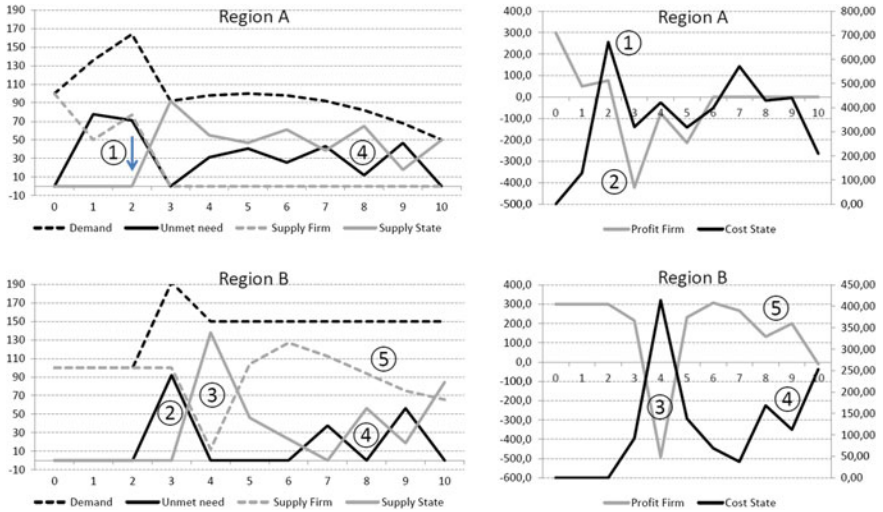

Fig. 10.3 Evolution of demand, supply, profit, and cost in crisis region A and neighboring region B

by $c^{\text{order}} = 2$ and $q^{\text{stock}} = 3$. The criterion for crisis intervention is set to $\tilde{\gamma} = 15\%$. In order to avoid a too optimistic picture of the commercial supply chain, we assume that the firm's operations are also affected by the crisis event in region A: For a duration of five periods, the firm is just able to deliver 50% of its regular supply in region A. The hampered operations can be due to a temporary disruption of critical infrastructure (e.g., transportation in the event of an earthquake) or reduced staff availability (e.g., in the case of a heat wave).

The upper left graph of Fig. 10.3 shows the evolution of demand and supply in the crisis region A. Due to the crisis impact, the demand is increasing in period 1 and period 2. In these two periods, the firm faces difficulties to meet the demand for two reasons: First, the firm does not expect this shock in period 1 but it can't fully react to it in period two either due to its impaired operations. Consequently, unmet need rises during these periods. The increase of unmet need reaches the critical threshold of crisis intervention in period three so that the state takes over. The state's immediate measures are twofold: It provides emergency supplies to the population of region A and evacuates 50 individuals to the neighbor region B. Henceforth, just the state provides goods to region A (crisis status). The demand of the remaining population in region A decreases steadily with the fading impact.

Despite the constant provision of relief goods by the state, there is a permanent level of unmet need until the last period of the crisis. State supply and unmet need show an oscillating pattern with a downward trend. This pattern is due to the fact that the state reacts to the *current level of unmet need* and, in particular, to the proportion of 0/2-victims. While the state focuses on the current victims, it overlooks the future "*potential*" victims of the next period: As the private market is down, the state has to supply the entire population. However, relief operations focus on victims. Therefore, if a large fraction of non-victims is not receiving water in the current period, some of these people turn to victims in the next period.

The upper-right diagram shows the profits of the firm as well as the cost of the state. Note that both objectives are not of the same scale. The left scale refers to the firm's profits (just monetary values), whereas the right scale refers to the sum of provision cost and deprivation cost of the state. The firm experiences a sharp drop in profits, and losses remain significant even until period six although the firm is no longer active in region A since period three. The reason for the persistence of losses is that the firm has to cope with excess supply which cannot be brought to market but must be rerouted to region B in order to relieve the load of the warehouse. As far as the state is concerned, its costs increase dramatically during the initiation phase of the crisis. This increase is exclusively due to a sharp increase of the deprivation cost (the state does not supply any goods until period three) and triggers the quite early intervention of the state.

The lower diagrams refer to the non-disaster neighboring region B. Until period two, the firm supplies a constant amount of 100 units. The effects of the heat wave in region A start to spillover to region B at the moment when the state initiates the evacuation of 50 individuals in period three (temporarily, the demand is even higher than 150 units because some of the evacuated people need two units of water).

As the firm is not yet prepared to face this extra demand, there is also a temporary increase of unmet need in region B. This increase is strong enough to trigger a second state intervention in region B. The problem is that also the firm has quickly adjusted its supply to the higher demand (partly by rerouting excess supply from region A) but is now pushed out of the scene by the state. In economic terms, this corresponds to classic *crowding out* of private activity by the government. It can be seen at the lower-right diagram that this effect is clearly detrimental to both, the firm *and* the state: In period four, the period of the state intervention, the firm's profits experience a sharp drop and simultaneously the cost of the state show a strong increase. After this problematic crowding-out period, it is the firm which predominantly supplies the region. However, when approaching the last periods, the supply of the firm decreases and the supply of the state increases again. Albeit not evident, this is also a (long-run) consequence of the crowding-out effect in period four: The supply of the state reduces the "firm-relevant demand," and if the firm-relevant demand is lower than the expected demand, the firm adjusts its supply downwards. However, the state does not fully compensate this deficit in private supply because the state just reacts to unmet need (in particular, 0/2-victims), not to unmet demand. This leads to a dynamic and gradual crowding-out effect and to the same pattern of persistent underprovision as in region A. Note that this gradual decline could have been avoided if the state had been reluctant to intervene in period four: From the expectation dynamics of expression (2), it follows that the firm would have quickly adjusted to the higher demand level of 150 units which equals the firm-relevant demand.

10.4.4 How Can a PPEC Help to Overcome the Described Problems?

Based on the simple illustration, there are—at least—five key levers for a public–private emergency collaboration to improve the entire situation for both the state and the firm. The numbers are also depicted at the relevant curves in Fig. 10.3.

(1) *Early warning* based on market data

Although the state intervention in region A occurs quite early, the intervention can still be accelerated by one period. As it has already been said, the trigger for the state intervention is not a noticeable increase in demand but in expressed need. But before "need information" is publicly available, the firm already registered an abnormal increase of demand which can serve as a leading indicator. The firm's analysis of market data works as an early warning system. An early provision of information about abnormal market behavior makes it possible to prepare for the intervention and to provide the first relief units earlier. This one period ahead will have a strong mitigating effect because the intervention occurs at a very sensible point of time in a crisis. This aspect will be of particular relevance for crisis events which evolve gradually, such as heat waves or epidemics. However, in the case of a shock event like an earthquake, it will be perfectly clear from the earliest minute that relief is required. Furthermore, in such a situation, information about victims and urgent need is also quickly spread by social media so that the early warning function of the firm is not needed.

(2) *Information sharing* and joint evacuation planning

The detrimental crowding-out effect in region B is due to the lagged reaction of the firm to the abnormally high additional demand of the evacuated people. The decision to evacuate a large part of the population out of the crisis zone is a very effective means to protect people against the crisis impact and to provide help under easier conditions in a non-affected region. However, the chances to overcome the lack of supply in the target region B hinge on the capability of public and private actors to provide these abnormally high quantities in region B. The case of an evacuation is a good example to illustrate the coordinative benefits of a PPEC: If the private firm is informed about the evacuation plans in time, it can prepare for the provision of additional quantities. Interestingly, the firm does not even need to order large extra amounts since it faces the problem of large overstock in region A. Rerouting to region B is a straightforward and cost-saving measure. In turn, this takes some burden from public crisis management which now can concentrate on the relief in region A.

(3) *Avoidance of crowding-out effects due to abrupt state intervention*

Even if there is no point for a joint evacuation planning, firm and state can still coordinate an intervention. Basically, from a pure efficiency point of view, there is no need for the state to intervene if the firm is able to provide the needed quantities. However, this argument can raise serious ethical issues. Although region B is not affected, the evacuated population is. It would no longer be crisis relief but rather economic exploitation of highly dependent people if the firm provided the good under normal market conditions to affected people. There is an instructive example referring to Hurricane Gustav in 2008 in Louisiana which shows how an uncoordinated interaction of public relief and commercial market activities can lead to serious problems (Stewart et al. 2009): The city of Lafayette was at this time comparable with a B-type region where private operations were still intact but there were some affected people in need of relief supplies. People could buy food and water at supermarkets but—figuratively—around the corner GOs and NGOs distributed emergency packages to the affected groups. This led to stark protest among those affected people who paid for water simply because they did not know that it could have been provided to them elsewhere. In the end, this was detrimental to the supermarket's reputation too. In addition to this, such uncoordinated parallel activities give rise to parasitic arbitrage activities: "Clever" people pretended to be affected, collected the emergency packages for free, and sold them around the corner—slightly cheaper than at the supermarket.

Such a problem can be overcome by the following procedure: First, the state has to provide a clear definition of an affected region and a non-affected region. There would not be any problems for regions of category A or C: In a non-affected region (such as region C), the commercial supply chain should take over because this is most efficient, and in the (directly) affected region A, the state must intervene anyway. But the described problems arise in regions of type B and also in A-regions when the crisis deescalates. Here we have to deal with an important trade-off: On the one hand, it is important that the private supply chain takes over the early as possible in order to reestablish efficient logistic operations. On the other hand, it is important to strictly avoid price discrimination with respect to affected people. One solution could be to keep the private supply chain running (i.e., people get water at the supermarket and not at NGOs) and to distribute priced water and non-priced "relief"-water over the supermarket counter. The allocation to affected people can be realized by ration cards. This way, the supermarket can run its operation in a (nearly) regular mode under the condition that a free-water-compensation is paid by the state.

(4) *Correct anticipation of upcoming unmet need ("future victims") based on market data*

As described above, the oscillating pattern between unmet need and supply of the state is due to the fact that the state seeks to satisfy the unmet need of the current period and underestimates current unmet demand—which in turn evolves to tomorrow's unmet need over time. In order to avoid to constantly lag behind, the state needs more information about the regular demand basis. The solution of this problem is related to the first approach because it requires information sharing and the provision of market data analysis by the firm. In the context of a PPEC, both partners compare their estimates about demand changes, unmet demand, and unmet need. Based on this, they can derive a forecast of both variables. In addition to this, they can also coordinate on ways how to distribute these quantities to the population.

(5) *Avoidance of dynamic crowding-out effects during the deescalation phase*

The model-based analysis illustrated a further risk in region B which is actually due to a combination of (3) and (4): The static crowding out in period four together with the persistent underestimation of future victims create a gradual, dynamic crowding-out effect. The problematic point here is that the crowding out of private activities goes hand in hand with a systematic undersupply of the affected population. This is all the more remarkable because this undersupply occurs at a point of time when the crisis almost faded out. In other words: This effect would be even more serious if the crisis event does not deescalate so fast. This is an indication that considering (3) and (4) together can avoid detrimental dynamic effects which would be far costlier than a coordination failure in one single period.

In addition to these five points, there is still further potential to reduce cost and to improve the effectiveness of crisis management. For example, one further option is shared warehouse capacities. If the firm does not need its warehouses in region A, it can leave it to the state. Instead of establishing relief stock under enormous time pressure, the state could use already existing and large capacities. In turn, the firm has to be compensated for this service.

10.5 Discussion and Conclusion

If a disaster hits an urban region, both the immediate and the subsequent effects can be severe for the affected population and destructive for the regional infrastructure, including markets. In such a situation, crisis management must provide a fast, extensive, and competent relief which requires an intelligent orchestration of measures. A public–private emergency cooperation (PPEC) can be a key component. In the framework of a PPEC, the commercial supply chain for essential goods and services complements the public relief supply chain in a way that crisis relief can be significantly improved. Thus, the implementation and operation of a PPEC can be an additional element in fostering urban resilience.

In our analysis, we focused on the complementary risk competence of firms and public authorities as well as on the advantages of joint planning, joint knowledge management, information sharing, and joint use of resources. By aggregating data about market and population variables, the partners can get a clearer picture of the situation which allows for a timely and effective intervention. The simple model highlighted the frequently neglected problems of coordination failure and, in particular, the dynamic and persistent effects of a crowding out of private activities. By avoiding these inefficiencies, there will be more resources available for the population in need. It is important to see that both partners in a PPEC have a good chance for improvement so that each of the two should have the necessary incentives for such an arrangement. After all, a PPEC offers a variety of options and its potential depends on the willingness or capability of the actors to make use of these options. As the model primarily focused on the logistical procedures, it could just roughly hint at important further questions such as the optimal allocation of contractual tasks and the requirements and options for an effective alignment of interests in a collaborative crisis management network.

However, in contrast to other approaches, the objective of a PPEC is not the joint profit maximization but rather the minimization of deprivation cost by considering two restrictions: The budget constraint of the state and the participation constraint of the firm. The primary objective of a PPEC is to improve crisis management. Furthermore, it could be interesting to consider any hybrid forms of organization between public or private, such as corporatization (cf. Klien 2014).

It is needless to say that the presented framework is just the first step of a promising concept. Practically, there is a wide range of different forms of a PPEC thinkable depending on the type of disaster, the firm or sector which should be integrated into crisis management, and the time perspective. A PPEC can be an interesting option for firms which provide essential goods and services, such as food, water, and medicines. But even beyond this, it could be interesting for logistic firms and providers of logistic services as well as for firms which provide maintenance services for critical infrastructure. As far as the time perspective is concerned, it is possible to arrange PPECs of different degrees, i.e., with different size tasks and also different levels of commitment of the involved partners. For example, it is possible to realize some of the mentioned tasks, such as information sharing, spontaneously on a short-run basis without the need of a deeper arrangement. Other elements, such as sharing of logistic capacities or even arranging forms of distribution, require contractual arrangements and also compensations or subsidies paid by the state. Apart from questions of legal admissibility, such an arrangement also needs a sufficient commitment of both partners. If the relationship is sufficiently attractive for the firm and has a long-term orientation, it is possible to establish a *relational contract* between the parties. If a PPEC is based on a relational contract, the relationship will be more stable and allows for the development of trust between the partners (Wiens 2013). Trust in turn could greatly simplify information exchange and coordination (Kapucu et al. 2010). Finally, such a stable long-term arrangement could foster both the crisis competence as well as the reputation of the participating firms.

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Part III
Urban Resilience Assessment: Methods and Challenges

Chapter 11
Competence as Enabler of Urban Critical Infrastructure Resilience Assessment

Florian Brauner, Marie Claßen and Frank Fiedrich

Abstract Providers of urban critical infrastructures are often relying on indicator-based approaches for resilience management. While science is developing more and more intelligent resilience indicators, the application and interpretation of such indicators might lead to new challenges and questions. Since models always reduce the complexity of real world systems, users of the developed indicators need to understand the underlying assumptions. Otherwise, simplifications may lead to misinterpretations and severe consequences for the infrastructure providers and the society. In this chapter the authors discuss the difficulties related to the development and usage of resilience indictors and present relevant quality criteria for their evaluation and selection. Additionally, proper resilience assessment requires expert skills and an advanced knowledge and competence profile. Bloom's learning taxonomy provides the theoretical underpinning which may be used to develop such profiles.

Keywords Critical infrastructure protection · Resilience indicators
Ethical consequences · Competence-oriented resilience assessment
Quality management · Resilience engineering · Implementation challenges

11.1 Introduction

In this chapter, the authors display an integrated understanding of resilience and required competences to handle the interpretation of new resilience approaches. While science is providing more and more intelligent resilience indicators, the

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application and interpretation of such indicators might lead to new challenges and questions: e.g. who can handle such indicators and understand the different scientific models? What happens if resilience indicators are used in a wrong way, what consequences have to be expected?

Today resilience indicators are used to reduce the complex reality for quantifiable figures. Different scientific methods and models are used for this reduction and the resulting figures are often the basis for actions, such as the implementation of a different security design/ set-up or changes in the processes.

The quality of this procedure relies on different factors (a) a holistic understanding of the "world"/system the end-user wants to assess, (b) resilience indicators which address the problem the end-users want to be solved and (c) the competences of the end-users to understand the methodology behind the created indicator to reduce contextual deficiency.

While a lot of literature addresses the first two factors, the authors of this chapter focus on the last factor which is relevant for a valid outcome of the operationalisation of the resilience indicators.

11.2 Urban Critical Infrastructure and Their Social Importance

Today's western society is strongly dependent on products and services of Critical Infrastructures (CI). The US Department of Homeland Security identified 16 CI sectors "[…] whose assets, systems, and networks, whether physical or virtual, are considered so vital to the United States that their incapacitation or destruction would have a debilitating effect e.g. on security, national economic security, national public health or safety, or any combination thereof" (DHS 2016).

While CI themselves are changing continuously and face challenges such as changing paradigms, emerging new technologies, demographic change, etc., there are additional risks and threats facing these infrastructures such as natural disasters, (un-)intentional human misconduct and/or (cyber-)terrorism, etc. The consequences of long-time disturbances are manifold on the affected society. Therefore, many efforts are invested to decrease vulnerability and increase the resilience of CI [e.g. cp. NIPP—US National Infrastructure Protection Plan (DHS 2017)].

In order to influence the resilience positively, a broad understanding of CI and the internal processes is necessary. CI knowledge is not only a precondition for developing comprehensive methods of measurement and mathematical techniques to assess resilience, but also for an understanding of society as part of CI resilience. But what does "knowledge" or "comprehension" mean in context of resilience and critical infrastructure? Do we know enough about this complex system to be able to assess resilience in a qualitative manner?

11.3 The Challenge of Resilience Understanding

Before the authors start the discussion about resilience indicators and quality criteria, two different examples of resilience shall open the view of resilience and the different contexts:

In Germany—as well as in Europe—there will be different resilience challenges due to different threats and risks, e.g. the development of smart grids of electricity, gas and water supply, and different new technologies were implemented into the urban infrastructure such as smart metre and household devices to monitor and regulate the different demands according to the end-user needs. The "intelligent" information flow enables providers to react quickly to any changes in the smart grid systems. While the new technology offers a variety of possibilities to increase the resilience of supply chain processes, new threats such as cyber attacks, sabotage and data abuse can arise. To achieve a high level of resilience considering possible side effects, technology application may have to change the view. So, what factors influence the resilience of urban infrastructure positively and negatively? How do you assess the development in context of resilience thinking?

The second example focuses on the societal developments such as the demographic changes in the society. According to statistics and calculations from the Federal Statistical Office, in 2060 more than 20% of the population in Germany will be 65 years or older (approximately 23.6%) (DeSTATIS 2015). Along with this development, an increase of elderly population needs can be expected. What does this mean for societal "*resilience*"?

These two introducing examples reveal the challenge for understanding resilience depending on the point of view, the role and the context. Defining "resilience" from the former Latin word "*resilire*", which means "*bouncing back*", resilience describes the ability of a system to react to stress and to then revert back into the former condition. Today, many different definitions are publicized depending on the research discipline and/or the subject of resilience (e.g. human being, nature, environment, critical infrastructure…). The different views enrich the discussion about this topic, but also make research results difficult to compare. In our paper, "resilience" is defined as "the ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies. Whether it is resilience towards acts of terrorism, cyber attacks, pandemics and catastrophic natural disasters, our national preparedness is the shared responsibility of all levels of government, the private and non-profit sectors and individual citizens" (DHS 2015). Like most risks, resilience can be described through different influencing factors. These factors are mostly measurable using empirical research methods and displayed as indicators which describe the resilience of a system. Based on these indicators, decision-makers choose different measures in order to influence the resilience of the system positively and strengthen the processes.

These assessment processes are however difficult due to possible misunderstanding and misjudgement. Knowledge and the competence to use these indicators are often neglected key factors of resilience assessment. In the next section, the authors describe the concept of resilience indicators and how corresponding data can be collected.

11.4 Resilience Indicators—A Method of Measurement

To be able to investigate the phenomenon of resilience in the context of critical infrastructure, there is the necessity for an empirical approach to it. An empirical approach provides the opportunity to collect data about resilience in real-world environments, which is crucial for a better understanding and further progress in this area. This empirical access for resilience researchers can be enabled by indicators, which constitute a method to operationalize and measure resilience.

An indicator can be defined as a measurable/operational variable that can be used to describe the condition of a broader phenomenon or aspect of reality (Øien 2001, p. 130). As it is not possible to measure aspects of reality directly, we need to operationalize a theoretical construct or theoretical variable through the use of indicators (Jovanović et al. 2016). This operationalization enables us in turn to check the developed theoretical constructs through empirical evidence (Fig. 11.1). Transferring a theoretical construct into an indicator always means simplifying the complexity of reality, so that sometimes one theoretical variable needs to be measured by multiple indexes indicators (Cardona 2005).

As resilience is a broad phenomenon, which includes various dimensions, it remains a conceptual and technical challenge to be operationalised, especially when the measurement uses a system based on composite indicators, thereby several indicators linked to each other. Because of the various existing dimensions of the phenomenon resilience, it can be operationalised by indicators in many different ways. The "integrated resilience cycle" (Fig. 11.2), for example, visualizes the four dimensions of "mitigation", "preparedness", "response" and "recovery" of resilience, which are, as shown in a circle, time-bound phases of a resilience process

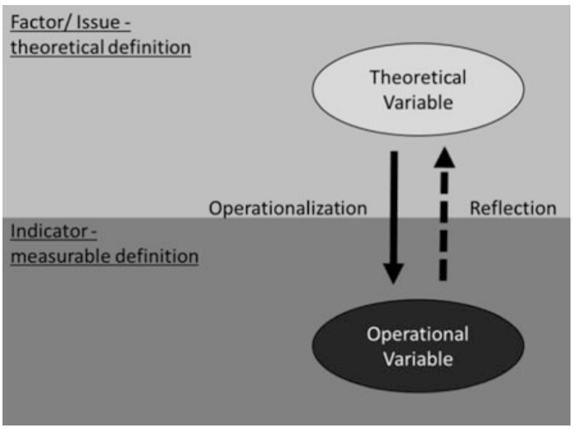

Fig. 11.1 Measurement model. (*Source* authors according to Øien 2001, p. 131)

(Edwards 2009) and each indicator usually only represents one aspect of resilience. Before referring to the concept of resilience, this model of a cycle with its diverse dimensions has been originally labelled as "disaster cycle" or "disaster management cycle" in disaster and risk management research (Alexander 2002).

Resilience indicators vary in their ability for representing the desired aspects of resilience. Therefore, it is of great importance to examine the suitability of a developed resilience indicator. For this purpose, various quality criteria or indicator requirements can be used as a tool to check the applicability of the indicator under consideration during, as well as after, the research process. These quality criteria ensure that the developed resilience indicator will be in accordance with a certain required quality level in order to label the indicator as an appropriate one.

11.5 Evaluating the Quality of Resilience Indicators

To develop an indicator to measure resilience without any quality control would withdraw the scientific character of the research process. The objective of scientific research is not only to gain a research outcome, but also to achieve an outcome which matches a standard of quality requirements. Not evaluating an indicator by quality criteria, as well as "inappropriate utilization of research findings outside

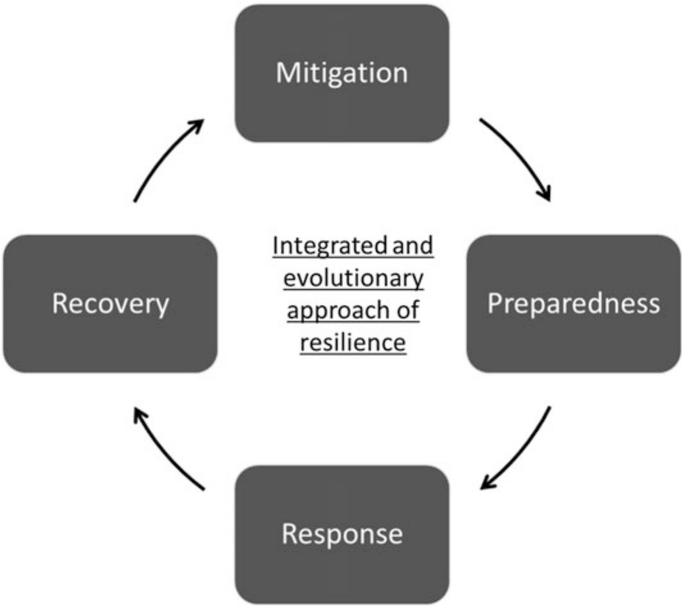

Fig. 11.2 Resilience cycle. (*Source* authors according to Coaffee et al. 2013, p. 9; Edwards 2009, p. 20)

clearly stated boundary conditions, can have serious and far-reaching methodological and ethical consequences" (Kimmel 1998, p. 40).

The best known and most fundamental criteria primarily connected with quantitative research are objectivity, reliability and validity. These three quality criteria have hierarchical links between them (Diekmann 2012). Objectivity is a necessity but not a sufficient precondition for reliability (Frauendorf 2006). Reliability in turn is a necessity but not a sufficient precondition for validity (Häder 2015). For a better understanding of their interdependencies, it is first necessary to comprehend each of them separately.

The criteria for *objectivity* are discussed controversially in literature. Some researchers argue that a state of objectivity can never be achieved—as science always involves a degree of interpretation—and they prefer the term of intersubjective agreement (Smaling 1992; Swanborn 1996). "Reaching for objectivity" means in its simplest form, as the authors want to use it here, to free research results from impacts by researchers. This then leads to researcher-independent outcomes. A distinction can be drawn between objectivity in *measurement* and objectivity in *evaluating*. Objectivity in measurement "can only be guaranteed if the person conducting the study has as little influence as possible on the respondents" (Frauendorf 2006, p. 181). In this sense, full objectivity is reached when two different researchers gain consistent results with the same measuring instrument (Diekmann 2012). Objectivity in the evaluation of the data obtained has normally no concern regarding resilience indicators because, in quantitative research designs, violations of this principle can only occur in relation to encoding errors (ibid). However, the interpretation and presentation of the results should be controlled as they "should merely refer to the facts of the findings" (Frauendorf 2006, p. 181) and not be manipulated by a researcher's subjective opinion.

Reliability can be defined as "a research procedure [that] should respond to the same phenomena in the same way regardless of the circumstances of its implementation" (Wolf 2008, p. 75). In other words, outcomes from an indicator should be accessible/ replicable by other researchers using standard methods (UN 2008). So objectivity in the sense of researcher independency has to occur here as well as the independency of a certain research occasion as "reliability relates to a stable and consistent measurement instrument" (Frauendorf 2006, p. 182). To determine the extent of reproducibility for the achieved research results, correlation coefficients can be calculated. So for the criteria of reliability, the reproducibility of the research outcomes has to be implemented through stability and measurability. Here, stability relates to "the research methods to be stable over time and as valid in the widest circumstances possible" (UN 2008, p. 7). In our case, measurability means that the description and interpretation of indicators have to be clear and reliable to avoid ambiguity and misinterpretation (ibid.). This leads to the possibility of a renewed measurement of the same indicator in a different setting.

To just have a certain level of objectivity and reliability (so that different researchers on two different occasions can gain consistent research results with the same research method) does not guarantee that a resilience indicator measures what it is supposed to measure. "*Validity* means, in a very general sense, that our propositions describe and explain the empirical world in a correct way; in a stricter sense: that they are free from random as well as systematic errors" (Swanborn 1996, p. 22). There can be distinctions drawn between diverse forms of validity (Wolf 2008). *Content validity* "is the extent to which all features that define the concept are measured" (ibid). This means the degree by which the chosen operationalization of the indicator represents the characteristics that were intended to be captured. Another form of validity is termed as *construct validity*. Construct validity "refers to the extent to which a measure is correlated with other measures of the same construct" (Wolf 2008, p. 80) and is used to verify or reject certain theoretical propositions, which are assumed to be linked to each other. This is of great importance to reveal new variables for further theory development. Furthermore, it can be distinguished between internal and external validity. *Internal validity* occurs when there is a variable due to the independent variable and alternative explanations can be excluded (Diaz-Bone and Weischer 2015). *External validity*, also termed as *generalizability*, "refers to the assumption that the research can be transferred to other business contexts and situations" (Frauendorf 2006, p. 80). The external validity of research findings increases by the number of replications conducted (Diaz-Bone and Weischer 2015).

The United Nations Secretariat of the International Strategy for Disaster Reduction stated on top of the already mentioned quality criteria *objectivity*, *reliability*, *validity* and some of their preconditions further requirements specifically for the quality of indicators (UN 2008).

One of them is *comparability* and defined by the UN (2008, p. 7) as follows, "the indicator measurement should enable comparison over the different lifecycle stages of the policy or project as well as between different policies or projects". This quality criterion addresses the benefit of comparing one's own research between different points and to interconnect with other findings of similar research, which then leads to a broader and better understanding of the subject matter.

Furthermore, the list of indicator requirements published by the UN (ibid.) contains the aspect of *relevance*: "Indicators should be directly relevant to the issue being monitored or assessed and should be based on clearly understood linkages between the indicator and the phenomena under consideration". By using this definition of relevance, the quality criteria of *currency* and *social benefits*, also considered by the UN, and the quality criterion of *applicability* referred to in other sources can be summed up together as parts of relevance.

Currency can be thematized in two dimensions: firstly, that the information of the indicator is as up to date as possible (UN 2008), and secondly, that the need of this indicator still exists. Social benefits relate to relevance insofar as there should be a societal profit due to the indicator or at least it should be stated for whom profit can be generated. Applicability as "the characteristic […] to be directly useful in a given context" (Eppler 2006, p. 79) is of great importance, as there can be only a sense or use of a developed indicator when it can be applied in practice.

Four additional indicator requirements discussed by the UN are *sensitivity*, *attainability*, *cost and time-boundness*, which the authors cluster together in the category called *maintainability*. Maintainability can be defined as "the characteristic […]

to be manageable over time at reasonable cost" (Eppler 2006, p. 79). Consequently, to gain maintainability it includes the aspect of sensitivity—"indicators should be able to reflect small changes in the things that the actions intend to change" (UN 2008, p. 7) as well as the aspect of attainability, which also includes sensitivity as "the measurement of the indicator which should be achievable by the policy or project and thus should be sensitive to the improvements the project/policy wishes to achieve" (ibid., p. 7). The aspect of costs arising from the operationalised indicator remaining reasonable and affordable (ibid.) and the aspect of time-boundness as "the time of an indicator's measurement, or the interval to which it applies, should be appropriate and clearly stated" (ibid.) are also crucial to gain maintainability of indicators.

Additionally, the UN (ibid., p. 7) proposes the indicator requirement of *comprehensibility*, which they define as "the definition and expression of the indicator should be intuitively and easily comprehensible to others". As it refers to potential users of a developed indicator, the authors prefer the general term of *convenience* which designates the ease-of-use for others not involved in the research. For the general term of convenience, the authors associate besides *comprehensibility* also *consistency* and *conciseness*. Consistency and conciseness enable data to be free of contradiction and convention breaks as well as to be expressed clearly and succinctly.

Lastly, the authors finalise the list of quality criteria with the criterion of *credibility* of the information which the indicator is based on. In this context, the UN (2008, p. 7) list refers to the aspect of *completeness* as "the data should be complete and free of missing values". Furthermore, the authors classify the already mentioned criterion of *consistency*, as well as *correctness* and *traceability,* as sub-criteria of credibility. Correctness means the data is free from error or fault and traceability ensures the possibility to trace back the whole research process and to check on its trustworthiness. The credibility of the information used, as well as the data generated, impacts automatically on all the other discussed quality criteria, as this criterion is the foundation for a successful application.

To fully apply all these quality criteria with resilience indicator is idealistic and cannot therefore be converted in practice. Some of them are even positioned as tradeoffs. For instance, conflicts can occur between the aim of completeness and the aim of clarity or conciseness of information (Eppler 2006). However, it is desirable to fulfil the quality criteria to the largest possible reasonable extent. Therefore, it has to be considered carefully, which criteria should and can be included and to which degree the criteria can be implemented by researchers. "In practice, indicators do not need to contain every characteristic. Depending on the indicator's nature and use, only a subset may be relevant" (UN 2008, p. 7). As some quality criteria are preconditions for others, like for example correctness for credibility or currency for relevance, characteristics overlap others to varying extents. Therefore, difficulties arise when separating them from each other to obtain a structured overview. Figure 11.3 shows the approach to arrange the discussed quality criteria in a reasonable and understandable way.

Evaluating and ensuring a certain quality level for a resilience indicator requires not only the existence of essential quality criteria, but also the knowledge and competence by a researcher and/or researchers to apply these correctly.

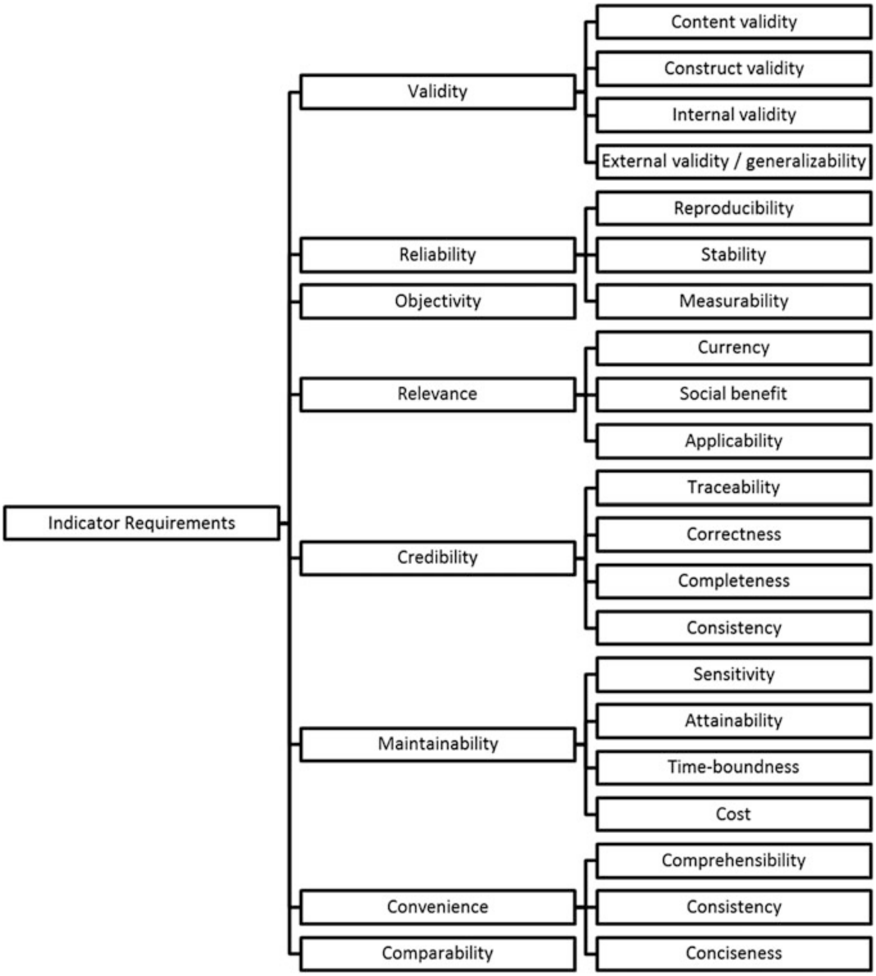

Fig. 11.3 Quality criteria of resilience indicators. (*Source* authors)

11.6 Knowledge and Competence to Ensure the Application of Resilience Assessment

In this section, the authors describe the meta-level of resilience understanding. Knowledge as an enabler requires a comprehension about content and context. Therefore, the different steps of learning according to the taxonomy of Bloom (1956) are used to analyse a resilience assessment competence profile. In the last section, the authors provide a set-up for the assessment of the quality of a resilience indicator. These criteria have to be taken into account for the application of resilience indicators, especially in the decision-making process for measures. But besides the existence of quality criteria, the process of compliance is still defective based on human misjudgement. So how can this risk be reduced to an acceptable level?

Firstly, the business processes and there influencing resilience factors of, e.g., critical infrastructures have to be understood (cp. Edwards 2009). Therefore, the process quality depends on all involved factors including the understanding of the structural requirements, knowledge about the methodology of resilience indicators as well as the competence of conducting/applying an indicator correctly.

In the following section, the authors focus on the competencies and skills of indicator-based resilience application. Educational sciences define skills as an ability based on knowledge, practice and/or aptitude to do something. This definition does not include the condition of being capable. A set of correct skills, knowledge and qualification leads to competences and to the capacity of actions. “Competence indicates sufficiency of knowledge and skills that enable someone to act in a wide variety of situations” (Business Dictionary 2017).

This implies that competence is more than just knowledge, abilities or skills; it enables actions in open and complex situations, even with an uncertain set of information. Therefore, it includes resolute actions within the framework of skills, knowledge and qualifications (Erpenbeck and Rosenstiel 2007).

In the 50s, Benjamin Bloom invented a model of competencies called Bloom’s taxonomy in the context of education systems. In six different hierarchical steps, knowledge can be categorized according to the skills and application level. The model clearly explains the different levels of abstraction. It starts with the lowest level of competence, “the knowledge”. Students on this level can easily repeat knowledge that has been taught by a teacher. On the second level, called “the comprehension”, students have a higher understanding for being able to recall facts or information. The comprehension level allows an understanding of facts with a specific background, so knowledge can be described and discussed in one´s own words.

The next level, “the application”, leads to first actions of knowledge. In addition to the second level, students are able to use the knowledge and information to solve a specific problem. For the first time, knowledge is used or applied to create new information. The autonomy of the individual students increases with this level, towards the fourth level called the “analysis”. Students now have the ability to see patterns and to analyse problems. The investigation around the problem increases self-reliance that can be highly motivating in learning processes. In the next level of “synthesis”, knowledge can be used to create new theories, predictions and conclusions. Therefore, information from various sources is processed into a new problem. This requires also the ability of imagination and creativity that empowers this competence.

In the last and highest level, “the evaluation”, the ability for assessing information is elaborated. This enables information to be concluded according to its value or bias and to judge processes.

Bloom’s taxonomy levels are a model for competence learning but, what started out as a model for teachers in a classroom setting, can be transferred to our case of

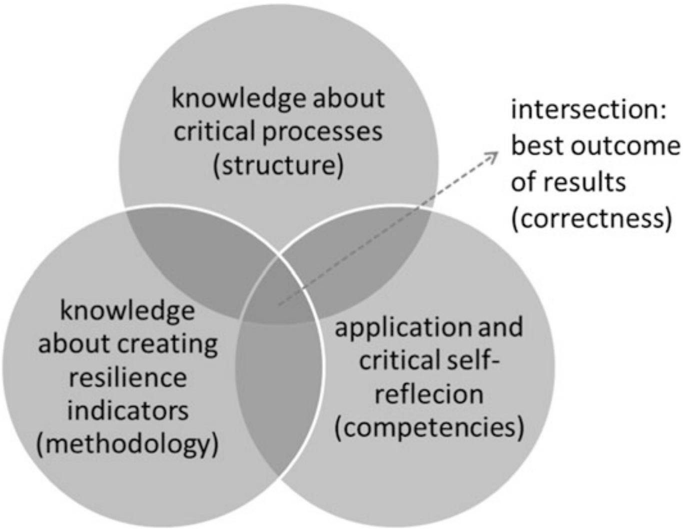

Fig. 11.4 Integrated knowledge understanding of resilience assessment. (*Source* authors)

indicator-based resilience assessment. *This leads to the research question, what is the right set off competences for resilience assessment of urban infrastructures?*

As shown in Fig. 11.4, the assessment of resilience indicators requires knowledge about the structure/environment as well as methodology, the knowledge needs to be processed (applied) and evaluated in the context of the research subject. As a result, the person who conducts resilience investigations needs competences at the highest level of Bloom's taxonomy hierarchy. The evaluation of results is absolutely essential, because the results are then used to prepare critical decisions e.g. for the implementation of different security designs, the consequences from mistakes may be manifold. While Bloom's taxonomy model helps to develop training and educational programs for qualifying as an expert, there is still an important factor missing in this discussion.

Besides the categorization of competences (taxonomy), the complexity of information and knowledge has to be considered as well in the discussion about resilience assessment. Although, the model displays a kind of increasing complexity and abstraction for information along the different levels of competencies, the processed information itself can have different grades of complexity.

Depending on the methodology for creating resilience indicators, the processed knowledge has different complexity itself. Therefore, the complexity has to be reduced according to the relevant systems boundaries (Allen 2001).

An advanced "knowledge database" is recommended to structure the used data as well as for guidelines to check the use of indicators according to the quality criteria as described above.

11.7 Conclusion—Advanced Resilience Assessment

Indicator-based resilience assessment is crucial due to the complexity and manifold consequences of misjudgement. Nevertheless, it creates great opportunities for a new understanding and control of resilience thinking. Therefore, a critical consciousness is needed in the execution and assessment of such indicators in three ways:

1. A holistic knowledge about the system and its critical processes is necessary!
2. The choice of methodology (resilience indicator making) has to strictly match the research question!
3. Users need the right set of competences to conduct the process of resilience assessment and reflect decisions and actions critically (self-monitoring)!

In this chapter, the authors introduced a set of quality criteria to assess resilience indicators and to ensure the process of indicator building. Furthermore, the experts themselves have been in the focus of the authors. The inspection of competence profiles revealed that resilience assessment requires expert skills in a high taxonomy level “evaluation” (cf. Bloom 1956).

To prevent an overload of information, the system boundaries have to be used carefully and documented in a structural manner such as guidelines and data management systems. In the future, evaluation of decision-making shall be included in the quality process of resilience assessment as well as training concepts for achieving the required competence profile for the analysts.

Lastly, urban infrastructures are complex systems containing many processes and interdependencies; the measurement of resilience requires continuous reflection for making decisions according to changing basic and environment conditions.

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Marie Claßen is a research assistant at the faculty of Safety Engineering of the University of Wuppertal focusing on resilience indicators in urban areas. In 2016, she graduated with a Bachelor degree in Sociology and started afterwards her Master in Sociology both at University of Wuppertal. As a scholarship holder of the Deutschlandstipendium, she gets supported by the German government and the company Vorwerk. She gained educational experiences abroad during her High School Year in Queensland, Australia, and her Erasmus year in Italy.

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Chapter 12
Resilient Disaster Recovery: The Role of Health Impact Assessment

James K. Mitchell

> Governmental organizations … continue to spend heavily on hardening levees, raising existing homes, and repairing damaged facilities despite ***evidence that social, not physical, infrastructure drives resilience*** (Aldrich and Meyer 2015).
>
> …although there is growing emphasis on incorporating resilience-building efforts into the recovery process, such ***efforts tend to focus on hardening critical infrastructure and not on strengthening the health and resiliency of individuals and communities*** (Institute of Medicine 2015).

Abstract Health Impact Assessments (HIAs) offer an important way of improving infrastructure decision-making during the post-disaster recovery period. Although increasingly used in support of non-emergency planning decisions HIAs have not yet been widely adapted for disaster recovery contexts. The growing acceptance of broader definitions of health and the setting of future health goals, informed by lay preferences and perspectives as well as expert ones, are assisting the transition to new more holistic policies. Experience in New Jersey, following Hurricane Sandy, provides illustrations of infrastructure impacts and the challenges they pose to local communities. Traditional definitions of physical infrastructure are expanding to include categories like "green infrastructure" and "economic infrastructure"; experts and laypersons are also making different assessments of both the character and the salience of infrastructure needs. Multiple competing priorities for attention by survivors further constraint the degree to which infrastructure issues can be addressed by individual survivors and their families. Opportunities and barriers for the use of HIAs in disaster recovery are identified and explored. The coproduction of policies that capture varieties of knowledge and preferences about infrastructure among experts and laypeople is encouraged.

Keywords Knowledge · Co-production · Local decision-making
Super storm Sandy · New Jersey · Infrastructure

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12.1 Introduction

Resilience may be interpreted as the ability to absorb, recover from, and adapt to external shocks without impairing long-term sustainability. The creation of resilience in the wake of natural disasters is a much sought after goal of public policy (National Academy of Sciences 2012, National Research Council 2011), but there is a strong difference of opinion about how this should be accomplished. Of the two main theoretical approaches, one emphasizes the importance of physical infrastructure and privileges the role of experts in the decision-making process; the other focuses on creating social capital and elevates the role of laypersons (Chen et al 2013; Cagney et al. 2016). The first approach currently dominates the scholarly and professional literature and is heavily represented among the policies and programs of many governments. Yet, disaster-related failures of critical infrastructure ultimately affect individuals, households, and other occupants of local communities. These local groups bear a disproportionate burden of disruptions, damage, and other losses, but they have little involvement in the planning and management of infrastructure systems (de Oliveira and Fra Paleo 2016). That responsibility tends to fall within the purview of technical specialists in large public agencies, and private utility companies as well as professional engineers and planners plus transportation and communication specialists (Chang et al 2014).

This paper suggests that there is much to be gained from employing the second approach during the disaster recovery process, in this case by foregrounding local knowledge about hazards that threaten damaged places and by incorporating local lay perspectives into decision-making about infrastructure through processes of active community engagement (Wells et al 2013). Health Impact Assessments (HIAs) offer an important but neglected way of doing this.

Health Impact Assessment is a decision-support tool that employs "a systematic process that uses an array of data sources and analytic methods, and considers inputs from stakeholders to determine potential effects of a proposed policy, plan, program, or project on the health of a population and the distribution of those effects within the population" (NRC 2011). In recent years, researchers and policy makers have been broadening the definition of health that is employed in public discourse. Rather than being solely an attribute of individuals that is signaled by the absence of disease, health is increasingly viewed as also pertaining to the general well-being of groups and extending beyond the purely biophysical realm of the body to include environmental and economic health that contributes to collective survival and a sustainable quality of life. Health Impact Assessment (HIA) employs these wider perspectives and gives laypeople a central role in the planning and implementation of public projects. HIAs have not yet been adapted for disaster recovery contexts although they are increasingly used in support of non-emergency planning decisions. Experience in New Jersey, following Hurricane Sandy, provides illustrations of their utility and the challenges they pose to local communities that are engaged in recovery, with special attention to implications for critical infrastructure.

12.2 Public Policies for Critical Infrastructure

Definitions of critical infrastructure refer to phenomena (e.g., systems, processes, facilities, networks, assets, services) that are regarded as essential to the health, safety, security, or economic well-being of entire nations or societies (May and Koski 2013; Pescaroli and Alexander 2016; Pesch-Cronin and Marion 2016). Specific examples vary from country to country but generally include transportation and communications, energy and resource utilities (e.g., water and power systems), food, chemicals, financial services, certain manufacturing, and service industries. The protection of 16 different sectors of critical infrastructure is a high-priority goal of national government policy in the USA (U.S. Department of Homeland Security 2016).

Advocates for privileging the protection and recovery of infrastructure facilities like power stations, which are engaged in the *production* of public services, bring a number of influential arguments to the public policy table. These generally emphasize the nodality of critical infrastructures in resource networks that serve large human populations and the potential that a denial of service will set in motion a cascade of distributed consequences for myriad users (Pescaroli and Alexander 2016). The concentrated capital costs of damage and loss of income incurred by such facilities are also of significance for operating firms and their investors (Kelly 2015). Spending on infrastructure has long been viewed as a way of priming the pumps that drive economies, especially in developing countries (Anon 2014). Furthermore, the repair and development of critical infrastructure systems are fast becoming high-priority items of economic planning in affluent countries because they are perceived to offer means for generating jobs and investing surplus capital that are attractive to governments seeking ways of stimulating economic growth. Hazard management professionals who argue that spending on better protective facilities will repay dividends in the form of fewer deaths and injuries and lower costs of damage and recovery during future extreme events have often embraced this latter theme (Larson 2009).

Despite these arguments, and in contrast to them, problems at the *consumption* ends of infrastructure systems should not be judged less deserving of public attention; they too signal important disruptions, flaws, and failures, this time of the adaptive mechanisms on which individuals, families, and households rely most directly to achieve sustainable self-sufficiency and resilience.[1] The success of major public policies and programs for infrastructure depends on the degree to which the behavior of users is at variance with the assumptions and/or predictions of infrastructure system planners and managers. Disconnects between managers and users may be more than flaws in need of correction; if sufficiently troublesome, they may stimulate reassessments that open the way to entirely new ways of thinking and

[1]Individuals and collectives may be either producers or consumers, depending on the function of the infrastructure system; for example, individuals and families that *consume* water, electricity etc. also produce waste that is "consumed" by recycling and disposal sinks.

doing. In the words of complex adaptive systems theorists, such disjunctions may first trigger so-called small loop learning that aims to bring vernacular practice into line with expert-recommended actions, but then set off “large loop” learning that provokes more fundamental changes in problem conceptualization and management (Preston et al. 2016).

Infrastructure vulnerabilities became national and international concerns as a result of the terrorism attacks of September 11, 2001, in the USA and attained renewed prominence in a succession of later events including Hurricane Katrina (August 2005), the Tohoku earthquake–tsunami–nuclear radiation disaster (2011), and Super Storm/Hurricane Sandy (October 2012).

12.3 Infrastructure Impacts of Hurricane Sandy[2] in New Jersey

Hurricane Sandy is widely regarded as the second most costly hurricane to affect the USA (National Oceanic and Atmospheric Administration 2016). Most of the losses were incurred in the states of New York and New Jersey. This paper focuses on New Jersey rather than the more widely publicized experience of New York (especially New York City). The magnitude of New Jersey’s economic losses due to Sandy was similar to that of New York’s, but the mix of effects was different as well as the amount of reconstruction aid received from the federal government (Gurian 2015). In New Jersey, most of the storm-impacted infrastructure served small residential and resort towns with underfinanced local governments and a limited range of public services (Leckner et al. 2016). In contrast, New York is the country’s largest and most densely populated urban center, administered by an impressive municipal government apparatus, and it contains a vast range of flagship facilities, many with global outreach.[3] Yet, one of the advantages of studying New Jersey is that its oceanfront communities are more representative of places elsewhere along the US coast and beyond. Their infrastructure experiences are likely to have wider relevance for more people than those of New York City.

New Jersey’s aggregate economic losses during Sandy included capital costs ($37 Billion) and business losses ($30 Billion). Critical facilities such as hospitals, government offices, sewerage treatment plants, and hazard protection works were

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[2]Hurricane Sandy lost intensity as it passed over New Jersey, reverting to a tropical cyclone in the process. For convenience, this paper employs the single label “hurricane” to both stages of the storm.

[3]New York City’s position as the country’s mass media capital, its status as a world financial hub, its densely populated streets, and its architectural heritage of iconic high-rise buildings all helped to attract media attention. The degree to which New York monopolized public attention is the wake of Sandy is similar to the dominance of New Orleans in accounts of the devastation wreaked by Hurricane Katrina and the low salience of storm-impacted areas in Mississippi and Alabama as well as other places (Lowe and Shaw 2010).

affected as well as transportation systems. Millions of gallons of spilled fuel oil and sewage were also washed into rivers and bays. The impacts were still being felt four years after Sandy when an infrastructure Report Card for New Jersey, issued by the American Society of Civil Engineers, awarded many of its poorest grades to energy, transportation, water, and green infrastructure systems that remained compromised by the storm (American Society of Civil Engineers 2016).

Although Sandy inflicted damage to large infrastructure facilities in New Jersey, most of the state's losses were sustained by housing and small businesses. For example, 2.4 million New Jersey households lost electrical power for significant periods and diminished water supplies affected many communities for a year or more after mains connections were broken or otherwise inoperable (Van Abs 2016; Felder and Chandramowli 2016). Over 70,000 of homes in the state were flooded with long delays in reoccupancy because of the need to replace compromised utility systems, carry out safety checks, and acquire necessary public approvals.

12.4 The Popularity of Infrastructure Measures in Post-Sandy Rebuilding

Shortly after Sandy occurred, President Obama established a Task Force to chart a path toward recovery and make recommendations about priority tasks that would improve the area's resilience. (Hurricane Sandy Rebuilding Task Force 2013) Infrastructure-related projects comprised the single largest category of recommendations. By my count, eleven of the 69 recommendations in the final report focused wholly on infrastructure and a Congressional Research Service Report identified 22 infrastructure-related recommendations (Brown 2014). A separate set of guidelines for ensuring that infrastructure resilience would be a major goal of all projects was also published (Finucane 2014). In addition, the US Department of Housing and Urban Development sponsored a Rebuild by Design program that invited interdisciplinary and international teams of professionals (planners, landscape architects, engineers, architects, ecologists, social scientists, and others) to submit innovative proposals as models of best practices that others might emulate. Six of these, that were located in or near New York City, were eventually chosen for funding (Grannis et al. 2016). All of them sought to encourage combinations of "gray" infrastructure (e.g., walls, retention basins, and other traditional engineered structures) with "green" infrastructure (e.g., wetlands, permeable surfaces, rain gardens).

The Sandy experience and its implications for infrastructure also featured prominently as foundational reference points of President Obama's Climate Action Plan that was published less than a year after the storm occurred. Although that plan's future is now in doubt (Temple 2017), the report serves as an indicator of the prominence accorded infrastructure investments throughout the country and in relation to a broad swathe of climate change risks.

Decisions about rebuilding infrastructure are among the most consequential for future generations because they establish the physical framework to which all subsequent development becomes tied. Whereas individual buildings might be modified or replaced relatively easily, the high capital costs, extended planning periods, and long projected life spans of major infrastructures make them difficult to change once embarked upon. Recovery programs also shape the health, safety, and well-being of entire communities for decades to come, not just by protecting against future physical risks but by improving health and raising the quality of living through enhancement of local environments, economies, and societal relations and, in other words, by pursing disaster recovery as a holistic process.

Given the salience, number, and variety of infrastructure recovery programs and projects that are possible, it would be highly desirable to employ a tool for assessing their likely impacts before choosing among the alternatives. Such an instrument would help to avoid recreating the potential for future disasters by avoiding actions that either add to preexisting vulnerabilities, or do not reduce them. Yet, no such tool is currently available. Decisions about recovery are increasingly made with the intention of "building back better", but exactly what "better" means and how it is to be achieved are matters rarely subject to systematic assessment (Hampen et al. 2016).

Engineers are increasingly aware of the need to design physical infrastructures to be disaster resilient from the outset (Chang 2009), but the kind of painstaking work that is necessary to select and fit specific designs to local situations generally is not possible in the wake of disasters. Moreover, even if better-designed facilities and networks were available at the appropriate time after a disaster, the environmental, sociocultural, and political economic contexts in which they will be embedded are themselves subject to change as survivors seek to fashion new replacement communities. An infrastructure system that is intended to function under "business-as-usual" assumptions about the future is likely to be inadequate if the community elects to change its growth and development trajectory. Assessment techniques and methods of many kinds are available as decision-support tools suitable for use before committing to action (Mitchell 2016) (Table 12.1). Most of these are undertaken well in advance of the project or program that is being evaluated. Very few have been developed for or are appropriate for use in post-disaster settings. Health Impact Assessments are an exception to which we will return for further analysis below.

Table 12.1 Types of assessment tools for the support of major public decisions

Assessment tool
Environmental Impact Assessment (EIA)
Strategic Environmental Assessment (SEA)
Social Impact Assessment (SIA)
Sustainability Assessment
Climate Impact Assessment
Ecological Impact Assessment
Cultural Heritage Impact Assessment
Regulatory Impact Assessment
Integrated Impact Assessment
Health Impact Assessment (HIA)
Health Equity Impact Assessment

Sources Mitchell (2016), Mindell et al. (2003), Renda (2006), Public Health England (2007), Haber (2010), Mendell (2010), Centers for Disease Control and Prevention (2012), Pope et al (2013), World Bank (2011), Acharibasam and Noble (2014)

12.5 Infrastructure and Infrastructure Issues: Differences Among the Assessments of Lay Residents, Local Leaders, and Experts Involved in Sandy Recovery

The assumptions on which infrastructure planning and management are based should be clear before such actions commence. Moreover, the concerns and expectations of individuals, families, and households that are scheduled to play their part in recovery actions should not be widely divergent from those of the experts and public leaders expected to oversee infrastructure initiatives. To what extent were the parties to Sandy recovery possessed of similar knowledge bases?

Data and findings from a study of risk redefinition among different municipal populations of Monmouth County, New Jersey, in the wake of Hurricane Sandy cast light on the process of infrastructure recovery (Leckner et al 2016; Mitchell et al 2016). Three case study communities were exposed to different types and degrees of risk and experienced Sandy in different ways (Figs. 12.1, 12.2 12.3 and 12.4). In Manasquan, on the oceanfront, Sandy's storm surge arrived at high tide and damaged more than 800 homes and small businesses. Somewhat later, the surge reached Union Beach, located on a more sheltered part of Raritan Bay, and damaged or destroyed 1400 houses. Thereafter, rising water pushed inland up the Shrewsbury River to Oceanport where 400 more houses recorded damage.

Six months after, the storm extended interviews were carried out with ten municipal leaders and six focus group discussions were convened involving forty-five residents. Analysis of data from these sources revealed significant differences in storm surge flood risk assessment between locals (leaders and residents)

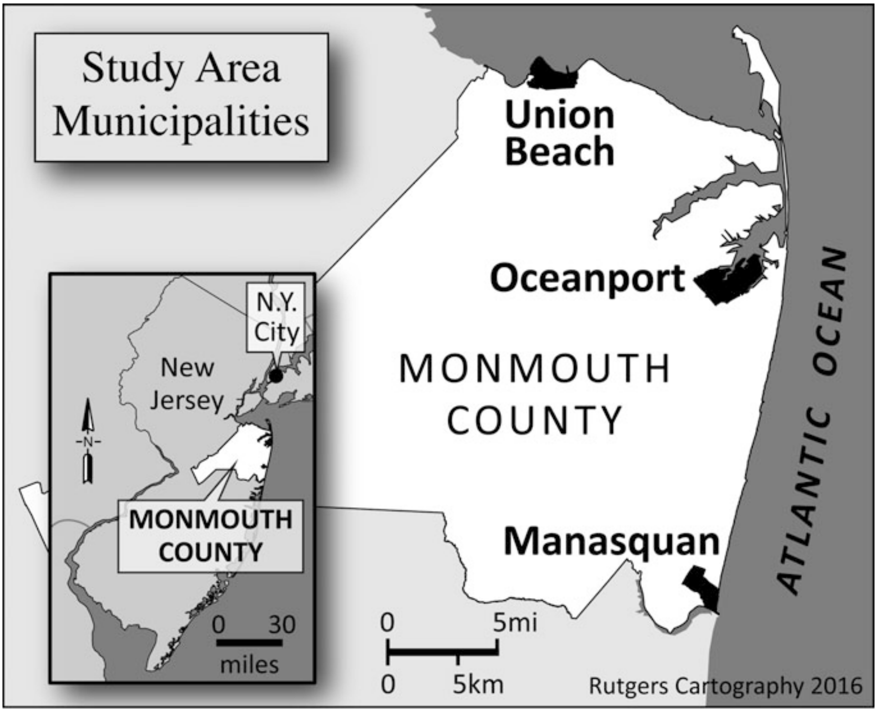

Fig. 12.1 Case study municipalities. *Source* Mitchell et al (2016)

and the experts whose knowledge underlies the main public policy instruments for regulating flood risks (Mitchell et al. 2016). These are summarized as follows:

- Compared to the expert knowledge system, the local hazard knowledge system is **more retrospective and qualitative**, as well as more **conceptually and methodologically expansive**. It routinely incorporates a **wider range of risks**, employs **more risk indicators**, **weights them differently,** and attaches more importance to microscale considerations that are often unique to specific sites. The **locals' spatial gaze is narrower** than the experts', being generally confined to a homeowner's lot and its immediate neighborhood.
- Expert and local (vernacular) risk assessment systems both privilege information about water depths and flood zones, but **the local system also incorporates knowledge about a wide variety of other (non-hydrological) variables**.
- In the local system, **information about previous floods dominates and provides emotional cues** that mobilize and reinforce personal meanings of flood events; the expert system employs retrospective information mainly as a basis for assessing future risks.
- **Relocation is a recessive risk-reduction alternative.** Remaining in place is much preferred. **Higher = safer is a widely accepted rule of thumb**. Experts

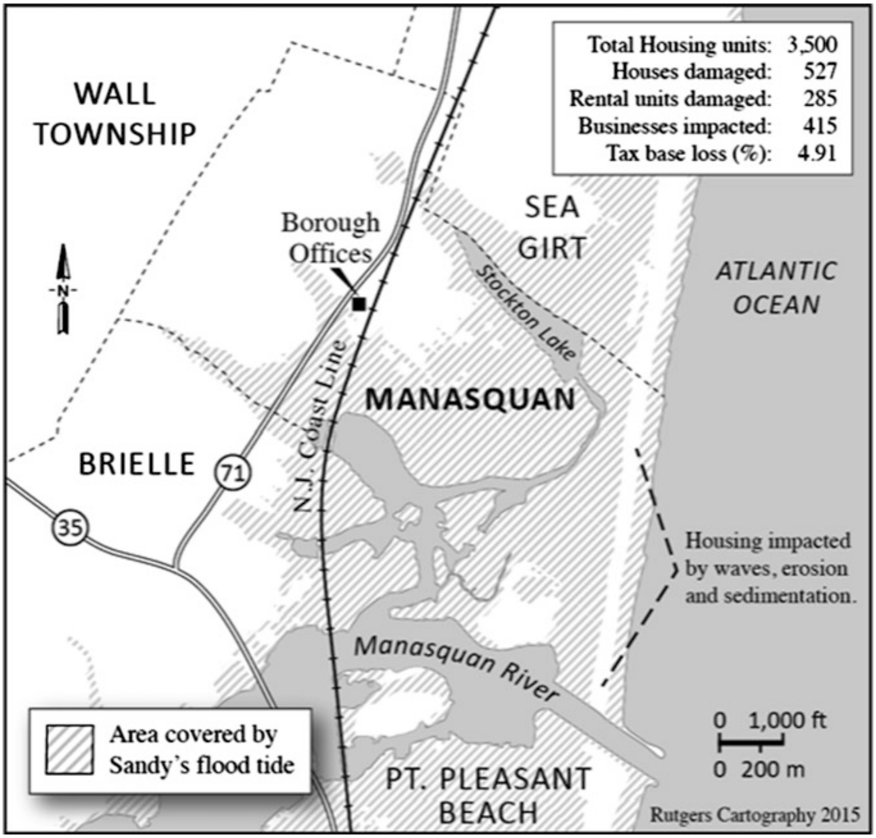

Fig. 12.2 Hurricane Sandy impacts on Manasquan, New Jersey, October 2012

and locals perceive elevation as an open-ended variable, permitting continuous vertical adjustments by raising structures progressively higher as inundation risks increase. By comparison, risk zones on FIRMs (Flood Insurance Rate Maps) are viewed as imposing fixed (in/out, horizontal) limits on adjustment.

Further analysis of the texts of interviews and discussions shows that the term "infrastructure" is not widely understood by residents and is subject to a variety of interpretations, many of which fall outside the definitions generally employed by professionals. For example, though many adopt the (traditional) view that equates infrastructure with "hard" engineered systems (e.g., transportation and utility networks), a substantial number also includes "green infrastructure" (e.g., maintained or managed sand dunes), together with tourism-related public facilities such as boardwalks and public restrooms, and privately owned recreation service facilities such as restaurants and marinas. In other words, the implicit definition of infrastructure refers to any collectively provided service that is viewed as necessary for the community to remain secure and healthy as well as supplied with the physical

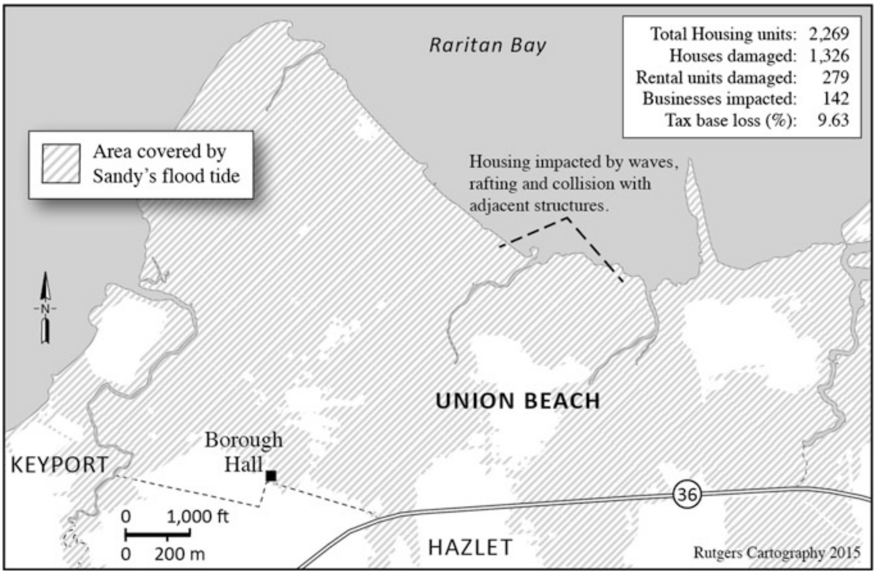

Fig. 12.3 Hurricane Sandy impacts on Union Beach, New Jersey, October 2012

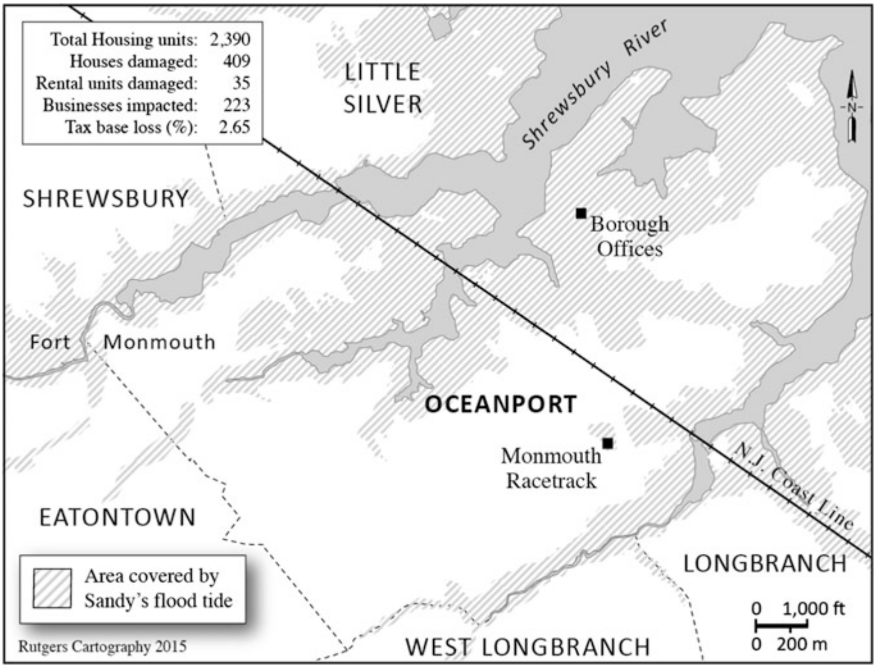

Fig. 12.4 Hurricane Sandy impacts on Oceanport, New Jersey, October 2012

resources that permit it to function. From this perspective, failures of environmental, tourism, and recreational support systems are failures of infrastructures.

Local leaders are more likely to be knowledgeable about infrastructure matters than are other local residents. The term infrastructure appears much more frequently in the interviews with local leaders than it does in focus group discussions among residents[4] (Table 12.2). Residents and local officials also focus on different types of infrastructure. The examples of infrastructure most commonly mentioned among focus groups of residents were electricity systems, followed by telephones, cooking and heating systems, and roads and streets (Table 12.2a). Among local officials, the most commonly mentioned examples of infrastructure were roads and streets, followed by garbage and debris removable systems, telephones, and electricity systems (Table 12.2b).

To a significant degree, the leaders' priorities reflect the legal responsibilities of municipal governments. In New Jersey, local leaders are acutely conscious of their statutory responsibilities for maintaining roads and streets; even the smallest municipalities usually possess a Public Works Department that executes this task. Although garbage collection and disposal is typically contracted out to private firms, municipalities still retain overall responsibility for those services. On the other hand, telephones and electricity are much more completely in the hands of private companies, overseen by state regulatory bodies like the New Jersey Board of Public Utilities. Yet it is the electrical and communications services that feature most often in resident's stories about infrastructure issues during and after disasters. Perhaps this should not be surprising since loss of electronic services not only turns off lights and appliances but inhibits igniting furnaces, boilers, and stoves for heating, cooking, and cleaning or pumping water, gasoline, and other fuels or wastes. It also deprives users of essential public news and information about their communities as well as their private social support networks. Finally, there is evidence that among laypersons the conceptual boundaries between human-made infrastructures and natural or quasi-natural systems are fading. Residents and local leaders now view dunes as elements of infrastructure though other protective structures (e.g., seawalls, bulkheads) are referenced far less frequently. This demonstrates that among both leaders and laypersons in communities at risk to coastal flooding the integrity of natural (or managed) sand dunes is perceived to be as worthy of protecting as are other infrastructures that provide safety-related services.

It is important not to overstate the salience of infrastructure problems for disaster-affected individuals and families. They were but one among many hurdles faced by storm survivors in the months following Sandy, and perhaps not the most troubling. Residents reported almost 40 different kinds of uncertainties that

[4]Ten local leaders mentioned infrastructure 211 times in open discussions of the experience of Sandy, whereas 45 focus group members mentioned infrastructure 152 times.

Table 12.2 **a** Frequency of infrastructure mentions in focus groups of residents ($N = 45$), **b** Frequency of infrastructure mentions in interviews with local leaders ($N = 10$)

(a)					
	Electricity	Telephones	Gas (heat)	Roads	Others
Manasquan	9	7	9	7	7
Oceanport	13	8	1	1	4
Union Beach	25	6	1	3	8
	29%	21%	15%	13%	22%
(b)					
	Roads	Garbage/debris	Telephones	Electricity	Others
Manasquan	25	8	1	10	8
Oceanport	5	3	9	0	6
Union Beach	32	13	8	4	6
	45%	17%	13%	10%	15%

Also mentioned Dunes (35); seawalls and floodgates (8)
Also mentioned Dunes (73)—frequently referred to as "green infrastructure"

constrained their decisions about post-storm recovery (Table 12.3). Infrastructure issues were conspicuous by their paucity.[5] This does not mean they were unimportant to lay residents during the recovery period, merely that other matters took precedence, mostly having to do with the physical and economic security of homes, the stability of the regulatory regime, and the physical and social contexts of the community in which the resident lived. It may be that, beset as they are by some other calls on their attention, residents are content to leave many of the decisions about infrastructure in the hands of community leaders and external experts. Such a conclusion might underline the continuing importance of experts in infrastructure recovery decision-making, but it also strengthens the case for making better use of local knowledge to create co-produced guidelines for post-storm redevelopment.

In summary, evidence suggests that local knowledge about storm risks, and about uncertainties that create barriers to post-disaster recovery, may diverge from expert knowledge. It is also clear that, during the process of recovery, the nature and roles of infrastructure may not be interpreted in the same way or accorded similar significance by lay residents, local leaders, and experts in disaster management institutions. The implications of such differences for efforts to achieve greater resilience are difficult to measure, but the possibility that they are significant should alert management interest groups to the need for clarification. This raises the question of how best to gather the kind of information that would provide optimal clarification.

[5]Uncertainties about infrastructures are clearly implicit in items # 5, 33, 36 but may also be associated with others.

Table 12.3 Uncertainties about recovery identified by focus groups

#	Class	Topic	Typical questions
1	Environment	Landforms	How will (creeks, dunes, beaches, channels, etc.) change?
2		Weather	How will storms (magnitudes, frequencies) change?
3		Sea level	Will sea level rise; at what rate?
4	Hidden risks	Mold	Will mold persist and damage health or destroy property?
5		Fire	Will soaked but not replaced electrical wires ignite?
6		Debris	Will beach users step on nails, glass, metal, or storm debris?
7	Costs/finances	Property value	What is my home worth since the storm?
8			What will it cost to repair/rebuild?
9			Will there be a market for my house?
10		Insurance	How much will insurance reimburse?
11			How long before the funds will be available?
12			Will banks and mortgage companies block use of funds?
13			Will insurance be available in the future?
14			What will future insurance cost?
15		Other aid	Eligibility for SBA (Small Business Administration) loans?
16			Eligibility for ICC (Increased Cost of Compliance) grants?
17			Eligibility for HMGP (Hazard Mitigation Grant Program)?
18			Will town get CDBGs (Community Dev. Block Grants)?
19			Will local taxes be substantially increased?
20	Replacement	Accommodation	Purchase or rent?
21			Same location as original home?
22			Smaller house?
23			Stick-built/prefabricated/modular construction?
24			Availability of alternative accommodations?
25	Regulations	NFIP-related	How high will my home have to be raised?
26			Will Advisory Base Flood Elevations become permanent?
27			Will interim Flood Insurance Rate Maps change?
28			What are LOMAs (Letter of Map Amendment)?
29			When are the cutoff dates for compliance?
30			Will recent NFIP changes be legally binding?

(continued)

Table 12.3 (continued)

#	Class	Topic	Typical questions
31	Social impacts	Demography	Will (neighbors, elderly, vulnerable) move away?
32			Will elderly (and others) be able to access elevated homes?
33		Services	How soon will schools and other services return to normal?
34		Aesthetics	Will the town's appearance change unacceptably?
35		Ambiance	Will the town regain its congeniality?
36	Other	Mitigation	Will public protective works be installed?
37			Will there be an accessible record of past and current risks?
38			Will risk information (delays, conflicts, flaws) improve?
39			How long will present turmoil last?

12.6 Better Local Information for Recovery Decision-Making: Co-production of Knowledge and Action

In institutions of democratic governance, it is broadly accepted that the most successful public policies are those that attract widespread public participation. This is no less true for hazard and disaster management institutions, including those charged with responsibilities for recovery. (Handmer and Dovers 2013; Pearce 2003) Possible forms of participation range from the perfunctory to the profound, from those that involve passive acceptance by publics that are merely kept informed about the actions of executive decision-makers to those that require continuous partnerships among various kinds of stakeholders and result in knowledge that is a joint product of experts and laypeople (Ostrom 1996; Jasanoff 2004; Wood et al. 2012; Homsy and Warner 2013; Wamsler 2016). Perhaps the most sought after of all are partnerships that solicit and employ the vernacular knowledge of local laypersons in conjunction with the specialized knowledge of professionals at all stages of decision-making from project initiation to completion and even thereafter in the form of continuous post-action assessment and monitoring programs.

Collecting local knowledge, opinions, attitudes, expectations, and preferences about disaster recovery measures, and feeding them into, the existing public policy apparatus (or designing modified alternatives) is a major undertaking at the best of times. It is even more problematic in the time-pressured and conflicted circumstances that attend disasters. At such times, conventional methods for collecting such information may also be difficult to execute because personnel and records have been damaged, victims are displaced from their homes, people are preoccupied with what they perceive as more expedient matters, and there are strong convictions in favor of a speedy return to the *status quo ante* (i.e., "normal"). Recently, a range of new decision-support tools has sprung up to assist decision-making, mostly during the immediate post-disaster *emergency* stage of disasters. Among others, these include remotely sensed imagery of disaster-affected communities and "crowd-sourced" information about the rapid assessment of damage and needs for assistance (Gao et al 2011; McCormick 2016; Haworth et al. 2016). There are also a growing number of predisaster tools for measuring and mapping risks and vulnerabilities with a view to improving disaster *preparedness and mitigation*. Some of these also depend on co-produced information (Cinderby and Forrester 2016). However, thus far, there has not been a reliable vehicle for systematically collecting and assessing local views about *recovery* alternatives and for employing this information expeditiously in support of post-disaster rebuilding and redevelopment policy decisions. Health Impact Assessments are promising candidates for that role.

12.7 Health Impact Assessment

12.7.1 Evolution and Status

As noted above, Health Impact Assessment is first and foremost a decision-support tool. But HIAs go further than assessment; they are also intended to encourage the adoption of alternatives that reduce existing health inequities and foster better health outcomes for entire communities as well as individuals. The HIA process is, in effect, a process of community engagement, usually voluntary, that involves expert and lay stakeholders in a collaborative exchange of their knowledge, concerns, and expectations and their aspirations for improved health. These objectives are sought via a systematic procedure that begins with the selection and bounding of specific decisions and concludes with evaluations of recommendations for achieving improved health objectives after the decisions are taken. Its six steps include (1) screening, (2) scoping, (3) assessment, (4) recommendations, (5) reporting, and (6) monitoring and evaluation.

HIAs were inspired by the advent of Environmental Impact Statements (EIS) required under the US National Environmental Policy Act (1970). However, the first formal ones emerged in Europe during the 1990s and it was not until the beginning of the twenty-first century that they began to appear in the USA. (Dannenberg et al 2008) Since that time, over four hundred HIAs have been completed or are ongoing in the USA. (Pew Charitable Trusts 2015) Only a handful of these have addressed issues of natural disaster explicitly, and an even smaller number—fewer than half a dozen—have been undertaken with a view to informing and aiding the process of disaster recovery. The benefits of expanding their use in support of disaster recovery are many.

HIAs that assess alternative measures for achieving improvements permit communities that are recovering from disaster to understand the long-term health and well-being implications of their choices and allow them to start down a new path toward resilience and sustainability. For example, they may adopt housing, shopping, and transportation arrangements that encourage healthy behaviors such as increased human exercise, consumption of locally grown foods, reductions in the use of hazardous materials as well as access to healthcare facilities and social support networks. In the screening and scoping phases of HIAs, local populations define the futures that they desire across a range of sectors, from safety in the face of floods and storms, and access to public facilities that enhance lifestyles, to mixes of land uses that reduce pollution burdens and expand employment opportunities that are sustainable.

To date, the emphasis in many HIAs has been on assessing the (immediate) health effects of increased risks and vulnerabilities associated with climate change and other human-forced natural hazards (Centers for Disease Control and Prevention 2014). Long-term consequences and the impacts of proposed coping measures are rarely addressed. The assumption seems to be that society already knows what to do and that the application of existing best practices of good health and hazard management will be sufficient. However, this is not necessarily so. Not only are there new kinds of risks (e.g., sea level rise), but the range and pace of technological change, the degree to which humans are reshaping the physical environment, the electronic information revolution, globalization, a broadening of the definition of health and widening economic gaps between the haves and have-nots are all calling into question the suitability of existing measures and expanding the range of choice among new alternatives. Better health is no longer a fortuitous outcome but something that can be consciously sought and achieved through effective design and societal arrangements.

12.7.2 Opportunities and Barriers for Recovery HIAs

Funded by the Robert Wood Johnson Foundation and the Pew Charitable Trusts, researchers at Rutgers University undertook an 18-month-long test (September 2014–February 2016) of the suitability of the HIA process as a means of supporting decisions about recovery from Hurricane Sandy. This included three main components: (1) a pair of case study HIAs in communities that had suffered significant losses during Sandy; (2) preparation of a municipal toolkit suitable for integrating HIA into local decision-making as part of the Sustainable Jersey certification process; and (3) an assessment of prospects for integrating HIAs into post-disaster planning and decision-making in the USA. One case study focused on the green infrastructure component of a municipal storm-water management plan for the City of Hoboken and the other on a possible buyout and clearance of flood susceptible housing in the community of Mystic Islands, in Little Egg Harbor, Ocean County. The case study communities provided data from published sources, interviews with local leaders, public meetings, focus groups, and questionnaire surveys, among others. Similar sources were tapped for the toolkit. The inquiry into mainstreaming HIAs into post-disaster planning and decision-making relied on a detailed analysis of published literature, meetings with thought leaders from academic and professional communities of specialist health, impact analysis, and hazard management. The project is reported in detail elsewhere (Mitchell 2016), and only the highlights are addressed here.

Health Impact Assessments were positively received by professionals and laypersons in the case study communities and a wide range of health, safety, and well-being-related institutions at all levels of government that participated in the research consultation process. Findings underscored the attractiveness of health as a rubric for articulating and integrating diverse interests. Health improvement was found to be a high-priority goal of local leaders and residents, despite receiving only limited attention in the US federal disaster recovery system. In other words, there exists a strong, presently unsatisfied demand for health-centered recovery support tools.

The case studies demonstrated that it was possible for disaster-affected communities to successfully execute an HIA, in support of recovery decision-making, within a period of six months after the disaster. Large amounts of valuable information about health status and outcomes were gathered and analyzed and a range of new health-centered interest groups brought into the recovery process. The salience of mental health problems and issues was particularly noteworthy. However, important gaps and barriers to adoption of disaster recovery HIAs were also uncovered. Two of these are particularly significant. First, awareness of HIAs is low, and there is a lack of communication and mutual interaction between health interest groups and disaster management ones. This calls for the removal of institutional barriers to sharing information and a broad campaign of public information and education. Second, the range of alternatives that can be considered in an HIA may be constrained by commitments made by local governments and others to secure initial approvals and funding for proposed actions. Once there is significant support for a proposed action, local leaders may be reluctant to revisit the decisions that produced agreement. This argues strongly for early introduction of HIA into the process of recovery, when initial plans are being identified and debated. Moreover, the key to successful introduction of HIAs as a decision-support tool lies in applying the results more generally at certain pivotal moments in the recovery process when appropriate avenues for employing them are opening up (e.g., Federal Rebuilding Task Forces are being organized; changes to National Flood Insurance Program regulations are being contemplated; Community Development Block Grant submissions are being prepared).

12.7.3 On the Threshold of Better Resilience

In light of accelerating global and national losses, the improvement of disaster resilience is both desirable and feasible. Compared with emergency response and preparedness alternatives, inserting resilience-promoting measures into the process of post-disaster recovery is an underutilized strategy. But the present context of disaster recovery is highly fluid because of broad societal and environmental shifts.

Many countries are developing national strategies for addressing disaster recovery as a holistic task that brings together actions that had formerly targeted separate physical, ecological, economic, and social sectors. Infrastructural initiatives loom large within these. Health Impact Assessment belongs to a set of decision-support tools that reflects the drive for holism, in this case organized around expanded definitions of health and a desire to democratize decision-making. The new definitions go beyond the notion that good health is synonymous with the absence of disease in individuals to include collective, community-wide, and area-wide dimensions. HIAs provide a vehicle for linking local citizen-driven, bottom-up decisions into national recovery strategies, and they take advantage of an emerging new division of work between experts and laypersons. When equipped with guidance about appropriate timing that enhances their nimbleness in an increasing dynamic and complex post-disaster context, they are a potentially valuable addition to the arsenal of resilience-building tools that is now emerging.

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Chapter 13
DS3 Model Testing: Assessing Critical Infrastructure Network Flood Resilience at the Neighbourhood Scale

Damien Serre

Abstract The behaviour of the urban network infrastructures, and their interactions during flood events, will have direct and indirect consequences on the flood risk level in the built environment. By urban network infrastructures we include all the urban technical networks like transportation, energy, water supply, waste water, telecommunication… able to spread the flood risk in cities, qualified as critical infrastructures due to their major roles for modern living standards. From history, most of cities in the world have been built close to coast lines or to river to beneficiate this means of communication and trade. Step by step, to avoid being flooded, defences like levees have been built. The capacity of the levees to retain the floods depends on their conditions, their performance level and the capacity of the authorities to well maintain these infrastructures. But recent history shows the limits of a flood risk management strategy focused on protection, leading to levee breaks these last twenty years, for example in the South of France. Then, in case of levee break, cities will be flooded. The urban technical networks, due to the way they have been designed, their conditions and their locations in the city, will play a major role in the diffusion of the flood extent. Also, the flood risk will have consequences in some not flooded neighbourhoods due to networks collapses and complex interdependencies. This chapter describes some methods to design spatial decision support systems in that context.

Keywords Critical infrastructure · Urban resilience · Flood risk
Decision making · DS3 model

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13.1 Introduction

Flood is one of the major natural hazards that have caused loss of lives, significant economic damage, environmental pollution and the built environment, loss of cultural heritages, and even caused community disorder and health problems. Global emerging flood emergency events caused by climate change in combination with other types of natural or man-made disasters, and community development based on the traditional concepts for planning, design and operation call for better understanding of the emerging external driving factors. In this context, internal failures of the physical system networks and the interdependency between the major and the induced disasters and the different types of critical infrastructure have to be taken into account. It calls for suitable analytical approaches to identify the potential hazards and vulnerabilities for decision-makers in different levels.

Approaches to risk analysis and assessment have existed for several decades and have been applied globally in different areas (Altman 1970; Amendola 1989; CSA 1991; NTS 1998). The traditional approach for risk assessment is an expert estimation based on their experience (e.g. DSB 1994; AGO 2006). Software tools have been developed (e.g. Vatn 2007); however, they do not increase the assessment accuracy, indeed the uncertainty remains high because of the coarse nature of the input data and inaccurate methods for assessment (Nie et al. 2009). Recently, more and more risk and vulnerability assessment studies have been implemented based on numerical models, which are able to provide more accurate results (e.g. Cancado et al. 2011; Zhou et al 2011; Nie et al. 2012). The users can usually decide to apply either a simple approach or a complicated/advanced model, according to their requirements for analysis results, and also depending on available data and resources. However, the traditional risk analysis methods do not take into account the interdependence between the analytical system and the infrastructure. This lack is particularly relevant in analyses of critical infrastructure (CI).

At the core of every list of CI are the large-scale technical grids of energy, water, communication and transportation (De Bruijn and Van Eeten 2007). Evaluating network infrastructures for potential vulnerabilities is thus an important component of strategic planning, particularly in the context of managing and mitigating service disruptions (Matisziw et al. 2008). For instance, the reliability and rapid restoration of the electric grid, in particular, are necessary to support the needs of the population within the disaster area effectively (Winkler et al. 2010).

In fact, for a critical infrastructure, getting dysfunctional is a phenomenon that transcends by far the failure of any, even major, single component. The often incomprehensible cause of system crash stems from the inherent features of the critical infrastructures: they are multicomponent systems, prone to cooperative behaviour and typically responding in a nonlinear fashion to stimuli and perturbations. There is an urgent need for appropriate and credible solutions to address such systems in the areas of vulnerability and risk assessment.

Modelling interdependencies between these infrastructures is a relatively new field of research. From a methodological point of view, most methods concerning interdependencies modelling propose mathematical modelling through network theory (Ouyang et al. 2009; Eusgeld et al. 2009). Graphs are implemented to represent the topology of the infrastructures and their interdependencies. In addition to network theory, Lewis (2006) uses principles of logic, probability and cost minimization. Others propose the elicitation of expert judgment (Parks and Rogers 2009; Ezell 2007) and qualitative assessments (Baker 2005; Haimes and Longstaff 2002). Safety methods can also be applied to study vulnerability of critical infrastructures and their interdependencies (Lhomme et al. 2011). However, new tools are needed to implement these methods in order to finally help the design of efficient critical infrastructure protection plans. In the first part, critical infrastructure issues with regard to flood risk management are described, as well as the methods used to analyse their interdependencies. In the second part, the model is tested using the example of a neighbourhood.

13.2 Flood Risk and Critical Infrastructure

Defining "critical infrastructure" is a challenging task, as no international consensus exists on the topic.

An infrastructure is often described as a set of basic facilities, services and installations that are necessary for the functioning of a community or society. The detailed list of actual objects that should be included within this context varies, and it can include, for example, transportation and communications systems, water and power supplies, employment centres, medical facilities and public institutions, including schools, post offices and prisons. They are qualified critical because a disruption would threaten the security, economy, public health, safety and way of life of a community or society. Thus, a critical infrastructure can be defined as an array of assets and systems that, if disrupted, would threaten national security, economy, public health and safety and way of life (McNally et al. 2007).

This is a very broad definition with no accurate meaning. Indeed, critical infrastructure systems often cross-geographical, political, cultural and organizational boundaries and may be either built, natural or virtual (Pederson et al. 2006). Physical critical infrastructure includes energy; water and wastewater treatment, distribution and collection; transportation; and communications systems. Natural critical infrastructure systems include lakes, rivers and streams that are used for navigation, water supply or flood water storage, as well as coastal wetlands that provide a buffer for storm surges. Virtual critical infrastructure includes cyber, electronic and information systems (Pederson et al. 2006). Nevertheless, there is no common list and each country has defined its own list.

Despite no common list exists, many attempts to qualify critical infrastructures have been made. According to LaPorte (2007), the specific characteristics of these systems make them: tightly coupled technically, with complex organizational and management imperatives prompted by operating requirements designed into the system; unsubstitutable services to the public; with few competing networks delivering the same service; the objects of public anxiety about the possible widespread loss of capacity and interrupted service; the source of alarm about the consequences of serious operating failures to users and outsiders and subsequent public expressions of fear (De Bruijn and Van Eeten 2007).

The definition of what critical infrastructure actually means is constantly evolving, because of its dependence on the historical, political and cultural contexts. The limitations in finding a consensus are highlighted by the variety of definitions given by various societies, as well as by the fact that important areas of the world (namely South America, Africa or Asia) do not exhibit important literature on the topic, while others, as the USA, show dense information. When considering the investment policies, the trend towards discriminatory policies is obvious, which highlights the fact that suspicion towards foreign entities is a concern when dealing with critical infrastructure. Although this suspicion is probably less relevant when the threat on critical infrastructure is of natural origin as a flood, the existence of suspicion still suggests one additional possible reason making it difficult to define critical infrastructure in a universal way. Nevertheless, whatever the exact definition, it remains that as civilizations have become more complex and engineered solutions more sophisticated, the public has come to rely on the integrity of physical projects for safety and well-being. When those projects fail, the consequences have become commensurately more devastating, calling for subsequently complex methods to assess their vulnerability and the risk to which they are submitted. Notable infrastructure disasters that have occurred over the past century serve as a stark reminder of the importance of critical infrastructure to public safety, health and welfare.

Through direct connectivity, policies and procedures or geospatial proximity, most critical infrastructure systems interact. These interactions often create complex relationships, dependencies and interdependencies that cross infrastructure boundaries. The modelling and analysis of interdependencies between critical infrastructure elements is a relatively new and very important field of study. Thus, in the past few years, many researchers have concentrated on the modelling and analysis of interdependent infrastructures. As a result, many methods have been proposed to facilitate such analysis, providing different interpretations of infrastructure vulnerability.

The infrastructures are interconnected and interdependent on multiple levels. To understand the cascading failures among infrastructure systems under random incidents, man-made attacks and natural hazards, many researchers have proposed different methods for modelling and simulation of interdependent infrastructure systems. Notable examples include: Agent-Based Methods; Inoperability Input–Output Methods; System Dynamics Methods; Network or Graph-Based Methods; Data-Driven Methods (Ouyang et al. 2009).

Identifying, understanding and analysing such interdependencies are significant challenges. These challenges are greatly magnified by the breadth and complexity of critical infrastructures, and by a broad range of interrelated factors and system conditions. These ones are often represented and described in terms of six dimensions (Rinaldi et al. 2004). These six dimensions include: the technical, economic, business, social/political, legal/regulatory, public policy, health and safety and security concerns that affect infrastructure operations.

Interdependent infrastructures also display a wide range of spatial, temporal, operational and organizational characteristics, which can affect their ability to adapt to changing system conditions. And finally, interdependencies and the resultant infrastructure topologies can create subtle interactions and feedback mechanisms that often lead to unintended behaviours and consequences during disruptions (Rinaldi et al. 2004).

13.3 Development of the DS3 Model

13.3.1 A Resilience Concept-Based Approach

Derived from ecology, the first definition of the concept of resilience has been given as “the measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables” (Holling 1973). Nowadays, resilience is in use in many other disciplines (like physics, psychology, economy, environment, etc.). But for risk management this concept is relatively new, especially concerning natural hazard. We study number of other disciplines in order to well understand resilience concept and to define this concept concerning urban risk management. It appears that resilience is usually used in the continuity of existing terms in these various disciplines. The abundance of definitions of disaster resilience and the fact that this concept is shared by many disciplines makes it difficult to have a common definition. Disaster management has typically focused on analysing the hazard. Yet climate-related risks have been increasing in frequency and severity, researchers and few decision-makers recognize the need to not only analyse the hazard but also try to prepare the plan B like it seems the concept of resilience can bring. That is why disaster management has been moving away from solely emergency response, initiated during and after a flood event, towards mitigation and preparedness, initiated before an event, in order to reduce impacts more effectively. The DS3 model has been developed to give some knowledge about these major issues.

13.3.2 The DS3 Model

In our research, the concept of resilience is defined as “the ability of a system to absorb a disturbance and recover its functions following the disturbance” (Lhomme et al. 2010). Indeed, in the resilience concept, the object studied is a system. Assuming that the city can be considered as a system, the resilience definition can be transposed to the urban context as: “the ability of a city to operate in a degraded

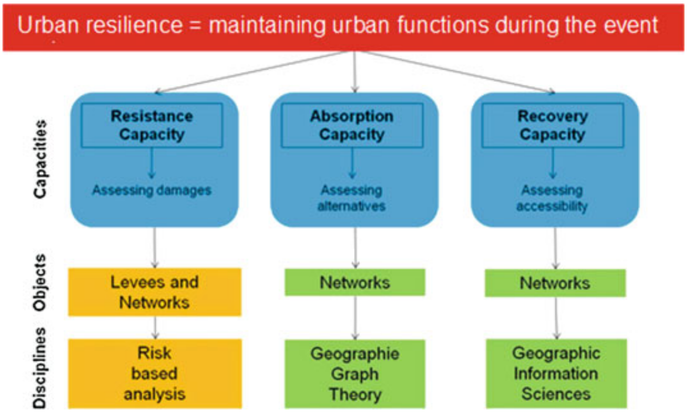


Fig. 13.1 DS3 model representation, including urban resilience objectives and associated disciplines

mode and recover its functions while some urban components remain disrupted" (Lhomme et al. 2010). Serre (2011), according to its urban resilience definition, has developed a conceptual model to analyse the resilience of urban networks: the DS3 (spatial decision support system) model. In this model, three capacities have been defined as essential to study the resilience of urban networks (Serre 2011): resistance, absorption and recovery (Fig. 13.1). This approach is based on the performance of the urban interconnected systems analysis at the city level and focuses on a physical urban dimension, particularly on technical aspects (Balsells et al. 2013).

The resistance capacity of a system begins with a system damage analysis. Resistance capacity is considered as the starting point for any resilience analysis. It is necessary to know the potential damages so that the failure which the system must be able to absorb and from which it needs to recover. On the other hand, the absorption capacity is a function that involves the assimilation of a disturbance that needs to accommodate the disturbance rather than to oppose it, thereby introducing the disturbance in the system's performance. The study of the absorption capacity refers to the alternatives that can be offered by the system following the failure of one or more of its components (Lhomme et al. 2011). This requires studying its redundancy properties. Indeed, the redundancy is defined as one of the properties characterizing the resilience of different systems (Clarke et al. 1998), (Bruneau et al. 2003) and (Ahern 2011). Usually, if a component of a system ceases to work (it does not achieve its function), a redundant system can mitigate this failure with an alternative (Serre 2011). Finally, the recovery capacity is the most representative of the resilience concept (Serre et al. 2013). Recovery does not mean returning to a previous state but rather a functional recovery of the system. The recovery leads the system to recover a state, a structure or a property.

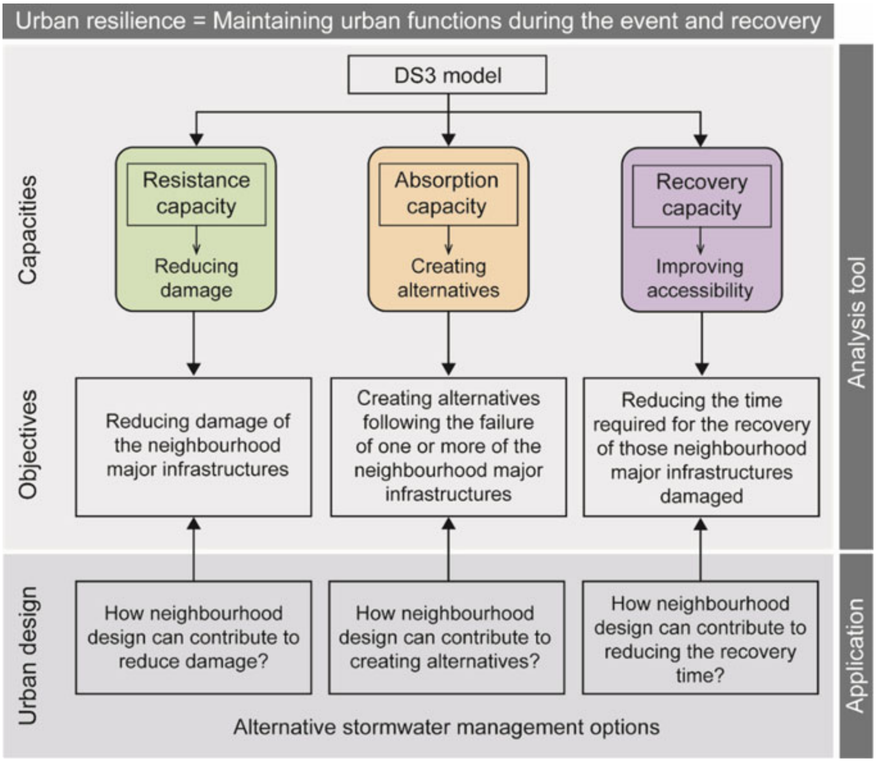


Fig. 13.2 DS3 model adapted to the study of neighbourhood flood risk resilience (Serre et al., 2016)

The DS3 model was initially designed for large infrastructure network resilience assessment. The initial DS3 model inspired the DS3 model design specifically for the neighbourhood scale (Fig. 13.2), and a crucial spatial scale to make cities more resilient, as it is at this scale that urban plans are developed.

13.4 A Case Study at Neighbourhood Scale: Am Sandtorkai/Dalmannkai

Using the DS3 model and considering the three capacities proposed, we proceed to study a particular neighbourhood of Hamburg (Am Sandtorkai/Dalmannkai). We briefly present the main hydrogeomorphologic characteristics of the specific neighbourhood and then the results of the study.

13.4.1 Site Description

The study area is an urban neighbourhood in the northwest of HafenCity, a new district located on the waterfront of the City of Hamburg. HafenCity is one of the most remarkable urban redevelopment schemes on a waterfront worldwide, where the Am Sandtorkai/Dalmannkai was the first neighbourhood to be completed.

The Am Sandtorkai/Dalmannkai neighbourhood is characterized by a dense mix of different uses: housing, workplace and leisure uses (shops, cafés, galleries, etc.). Young working singles and families live side by side with empty nesters and seniors: 1500 people live and work in the neighbourhood. Actually, the coexistence of urbanity with village-like life on the waterfront is what gives this neighbourhood its real charm.

The area is a lowlying island in the river Elbe, intended by several harbour basins; there is an intensive interaction between land and water. Hence, the neighbourhood is located within an area that is subjected to flooding and it is outside the Hamburg's dike line.

High tide together with extreme storm surge in the North Sea produces hazardous flood situation in the neighbourhood and generally in the City of Hamburg. Moreover, last years it has been demonstrated that the area is also affected by pluvial floods. The highest flood in Hamburg was in 1976, when the city was submerged by 6, 45 m of water which is the reference water level (Kluge 2008).

Important transportation connections have been identified, concerning infrastructures as well as modes of transport. The neighbourhood is connected with the city centre through four bridges. One of them is flood secure; it has been laid out higher than the reference water level, and therefore, in the case of a storm surge flood, this bridge would be available to rescue vehicles as well as pedestrians. Furthermore, there are multiple modes of transport connecting the neighbourhood with its environment: by foot, bicycle, bus, ferry and private transport. Particularly, there is an extensive network of "soft" modes of transport that fully integrates the neighbourhood with its adjacent parts.

For example, the fact that a connection infrastructure between the neighbourhood and its environment is higher than the reference water level provides an alternative when the other bridges do not achieve their function, and therefore, it contributes to improved absorption capacity. Furthermore, the time required for the neighbourhood recovery can be reduced because it provides accessibility to the neighbourhood even under flooding conditions. Consequently, it is also involved in improving the recovery capacity.

We have also identified green areas and public open spaces that serve as links between the neighbourhood and its adjacent environment. A green area enables the absorption and/or detention of water; a public open space creates the place for water. Thus, the water speed and the amount of water transmitted between two adjacent urban areas can be reduced. Consequently, these connections contribute to reduce damage in the neighbourhood and so to improved resistance capacity. Fig. 13.3 shows connections between the neighbourhood and its environment described.

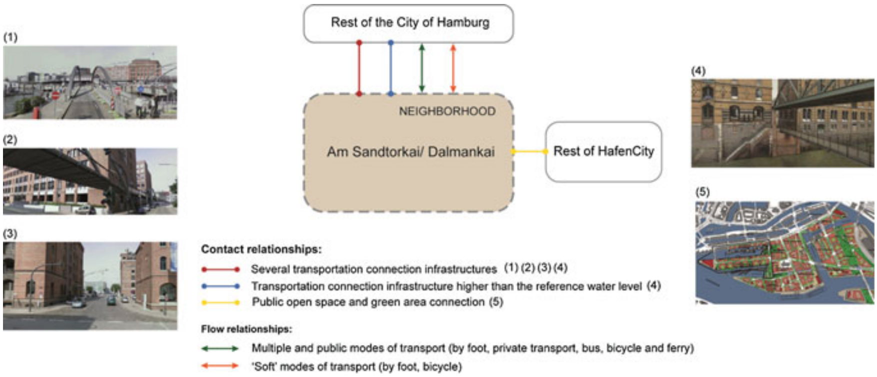


Fig. 13.3 Connections contributing to improved resilience

We now present the urban design strategies which have been selected. Concerning the transportation network, the neighbourhood is innerved by multiple and public modes of transportation interconnected with an extensive network of "soft" modes of transport through different types of roads: i.e. a main road connects with secondary roads (collector roads, residential streets, foot and path cycles, etc.). Furthermore, some of the roads and/or pathways are being built above the floodline of reference (at 7, 5 m above sea level).

For example, an extensive network of "soft" transportation modes reduces dependency on motorized transports and consequently, on energy resources, to get around the neighbourhood. It reduces the number of motorized transport in the neighbourhood and thus, possible damage they could cause in it. Moreover, it provides an alternative when other transport networks do not achieve their function under flooding conditions. The time required for the neighbourhood recovery can also be reduced. Indeed, as pedestrian flood safe accesses were designed, it allows immediate displacements in the neighbourhood in order to recover from possible damage.

Otherwise, some significant land use strategies have also been analysed. The neighbourhood is characterized by an open multidimensional topography: urban spaces extend over different levels. While all buildings and most of roads are built on artificially raised flood protected bases, around 8 m above sea level, embankment promenades remain at 4–5, 5 m. All open public spaces, weather green areas or promenades, are on the waterside and closely interlocked. In these lower areas, occasional flooding will be acceptable. Furthermore, the neighbourhood integrates public amenities into ground floors of most of buildings. This open multidimensional topography provides to the neighbourhood the same protection level that compared to the areas of the city surrounded by dikes.

Still concerning land use, the neighbourhood creates a high density of uses with a high proportion of public spaces and low proportion of access roads. Indeed, there is a fine-grained horizontal and vertical mix of various urban uses.

A high density and mix of urban uses, for example, make the neighbourhood more autonomous, reducing its dependence on other urban areas. It can reduce damage in the neighbourhood, especially when it is not directly affected by flooding but rather when other areas of the city are flooded. Indeed, a highest level of the neighbourhood autonomy can reduce possible negative impact on its operation (critical infrastructures) caused by other urban areas damaged. Consequently, it contributes to improved resistance capacity.

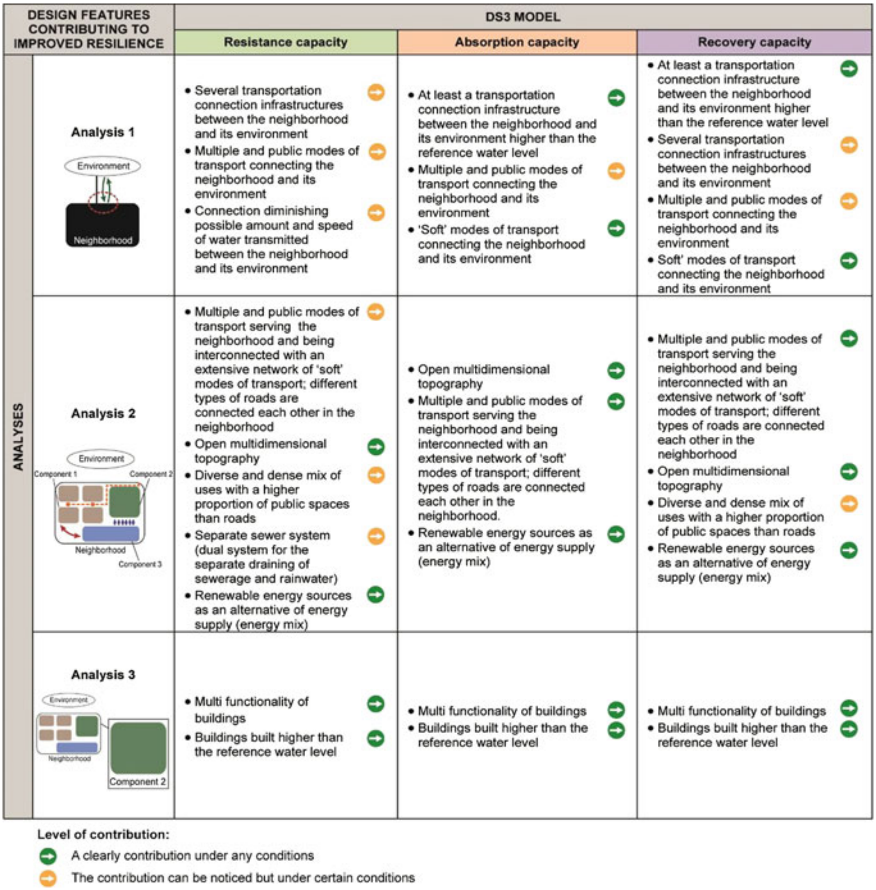
Finally, regarding energy and water networks, some relevant characteristics have also been selected. On the one hand, the neighbourhood's sewer system consists of dual system for separate draining of sewerage and rainwater. On the other hand, buildings are supplied with remote district heating and heating generated locally: e.g. from decentralized geothermal or solar thermal plants. They complement each other for an effective energy mix.

A dual sewer system allows more water conveyance, reducing possible damage of wastewater pipelines. Consequently, it contributes to improve the resistance capacity. The use of renewable energy sources which do not depend on the remote district heating can reduce damage of neighbourhood's components (critical infrastructures) depending on energy to operate. It can also provide an alternative when remote district heating ceases to work, and the time required for the neighbourhood recovery (critical infrastructures) can also be reduced.

Buildings are the only type of component that has been considered interesting to be analysed. A relevant characteristic of buildings is their elevation. They stand on artificial bases out of reach the most extreme flooding. Furthermore, their multi-functionality has also been considered. Indeed, the basements inside the buildings provide flood underground parking for cars. In the case of high water, parking entrances do have to close their floodgates. They are waterproof doors and protect the area behind them from flooding. On the other hand, public amenities (shops, bistros, galleries, etc.) are located into ground floors of most of buildings and apartments and offices are located in the highest levels of buildings. Moreover, the upper part of the buildings (roofs) supports an energy production system. For example, the fact, that the buildings are built higher than the reference water level, provides flood protection and allows urban functions in the buildings, even under flooding conditions. It reduces possible damage in the neighbourhood and also its recovery time. Moreover, when transportation network ceases to work, buildings can be an alternative for people evacuation. Thus, it contributes to improved resistance, absorption and recovery capacities.

13.4.2 Results and Discussion

The results described above are synthesized in Fig. 13.4. The different design features identified are classified according to the analyses and the capacities. Moreover, two types of contribution are distinguished: we show a clearly positive



DESIGN FEATURES CONTRIBUTING TO IMPROVED RESILIENCE	DS3 MODEL		
	Resistance capacity	Absorption capacity	Recovery capacity
ANALYSES — Analysis 1 (Environment; Neighborhood)	• Several transportation connection infrastructures between the neighborhood and its environment • Multiple and public modes of transport connecting the neighborhood and its environment • Connection diminishing possible amount and speed of water transmitted between the neighborhood and its environment	• At least a transportation connection infrastructure between the neighborhood and its environment higher than the reference water level • Multiple and public modes of transport connecting the neighborhood and its environment • 'Soft' modes of transport connecting the neighborhood and its environment	• At least a transportation connection infrastructure between the neighborhood and its environment higher than the reference water level • Several transportation connection infrastructures between the neighborhood and its environment • Multiple and public modes of transport connecting the neighborhood and its environment • Soft' modes of transport connecting the neighborhood and its environment
Analysis 2 (Environment; Component 1; Component 2; Neighborhood; Component 3)	• Multiple and public modes of transport serving the neighborhood and being interconnected with an extensive network of 'soft' modes of transport; different types of roads are connected each other in the neighborhood • Open multidimensional topography • Diverse and dense mix of uses with a higher proportion of public spaces than roads • Separate sewer system (dual system for the separate draining of sewerage and rainwater) • Renewable energy sources as an alternative of energy supply (energy mix)	• Open multidimensional topography • Multiple and public modes of transport serving the neighborhood and being interconnected with an extensive network of 'soft' modes of transport; different types of roads are connected each other in the neighborhood. • Renewable energy sources as an alternative of energy supply (energy mix)	• Multiple and public modes of transport serving the neighborhood and being interconnected with an extensive network of 'soft' modes of transport; different types of roads are connected each other in the neighborhood • Open multidimensional topography • Diverse and dense mix of uses with a higher proportion of public spaces than roads • Renewable energy sources as an alternative of energy supply (energy mix)
Analysis 3 (Environment; Neighborhood; Component 2)	• Multi functionality of buildings • Buildings built higher than the reference water level	• Multi functionality of buildings • Buildings built higher than the reference water level	• Multi functionality of buildings • Buildings built higher than the reference water level

Level of contribution:

A clearly contribution under any conditions

The contribution can be noticed but under certain conditions

Fig. 13.4 Synthesis of the results achieved

contribution under any flood conditions with a green arrow and a positive contribution but under certain flood conditions (under certain level of water).

The results suggest that several design features of the neighbourhood are relevant to improved resilience to floods. Particularly, the design features concerning the transportation network, the land use and the buildings seem to highly contribute to incorporate flood resilience in the neighbourhood operation. Even if we present the results separately, according to the three levels of analysis, it is important to highlight the relationships between the results at these different levels.

In our opinion, there are some main success factors that should be learned from this waterfront neighbourhood. The open multidimensional topography provides to the neighbourhood the same protection level as the other areas of the city surrounded by dikes. Instead of keeping water out, the neighbourhood is designed to allow flood water over or around it in a controlled and predetermined manner.

In addition to the contribution of improved resilience, this can help to reduce the maintenance costs associated with protective systems, reduce residual risk and increase awareness. Indeed, the urban design of the neighbourhood creates wider benefits for the sustainable development and the community such as sustainable modes of transport, renewable energy, spaces for outdoor recreation, etc. Furthermore, the multifunctionality and the diversity in the neighbourhood are also relevant factors, which result by design actions such as the multifunctionality of the buildings, the multiple and public modes of transports serving the neighbourhood and connecting it with its environment, etc.

Finally, we want to emphasize the robustness of the DS3 model in this research. We consider that it is a good conceptual tool to identify what design actions at the neighbourhood scale contribute to improved urban resilience to floods taking into account critical infrastructure interdependencies. Indeed, the application of the DS3 model to this particular neighbourhood has allowed us to identify several design features involving improved resilience. However, it will be possible to completely validate the model through more experiences like this one.

13.5 Conclusion

As a preliminary conclusion, we have highlighted the network interdependencies and the propagation of the effect of failures in this linked system. This approach allows evaluating the capacity of resistance of the networks, one of the capacities we consider to design resilient cities. Then, we have used graph theories to assess the redundancy of the urban networks. This approach allows finally assessing another capacity, and we take into account in our urban resilience assessment method: the capacity of absorption or the capacity of the city to operate in a degraded mode. We have linked the results of our models with GIS to produce spatial decision support systems to enable the managers of these infrastructures to improve their management to make cities more resilient through the capacity of recovery. Initially, the DS3 model has been developed to studying and assessing the resilience of critical infrastructure (Lhomme et al. 2013). Applying this model for the first time to the neighbourhood scales demonstrates that the model is supplying useful results to analyse ex-post the results of a policy of resilience to flood at an operational scale, and ex-ante to draw the next steps of an urban process in perspective of achieving resilience to floods.

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Chapter 14
Enhancing Flood Resilience Through Collaborative Modelling and Multi-criteria Decision Analysis (MCDA)

Mariele Evers, Adrian Almoradie and Mariana Madruga de Brito

Abstract The concept of urban resilience has emerged in the context of flood risk management (FRM) from the need to consider the capability of the society to cope with floods. Whilst there has been much discussion about flood resilience, challenges still remain on how to enhance it. Participation of key stakeholders in the decision-making process has the potential to enrich the resilience of communities as they become more informed, learn from each other and trust is built amongst them. Despite the advantages of participation, community members and decision-makers usually do not play an active role in flood resilience studies. Therefore, inter- and transdisciplinary approaches may help to overcome these limitations whilst promoting social learning towards resilience building. This chapter describes a framework for FRM that can improve urban resilience through participation of local stakeholders with the use of multi-criteria decision analysis (MCDA) tools. First, a systematic review of MCDA studies that tackle flood resilience is presented to provide a better understanding of how participatory MCDA is being conducted. Then, we introduce an innovative FRM participatory approach termed collaborative modelling (CM), which integrates MCDA tools in its process-driven decision-making. Furthermore, the CM-MCDA is supported by user customized Web-based tools to support information dissemination, social learning and negotiation amongst stakeholders. The developed framework was applied in the Cranbrook catchment (London, UK) and in the Alster catchment (Hamburg, Germany). The results show that the CM-MCDA provides an innovative and promising approach to enhance resilience through social learning.

Keywords Collaborative modelling · Transdisciplinarity · MCDA
Social learning

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14.1 Introduction

The concept of urban resilience has emerged in the context of flood risk management (FRM) from the need to consider the capability of the society to adapt, resist and recover from the potential negative impacts of floods. Since it is not feasible to completely eliminate the adverse effects of floods (Akmalah and Grigg 2011), the current approach for FRM emphasizes the reduction of vulnerability by promoting the resilience of communities (Schelfaut et al. 2011). This paradigm shift towards an integrated FRM is reflected in the European Union Flood Directive—2007/60/EC (CEC 2007), which highlights the importance of mitigating the exposure and vulnerability. A proactive promotion of resilience by, e.g. increasing the coping capacity, safeguard systems and relevant critical infrastructure is, however, only implicitly integrated into the flood directive.

Proper information dissemination can help to increase awareness amongst citizens and thus foster resilience (UKCO 2013). Nevertheless, information alone is not sufficient to enhance resilience through inter alia increased coping capacity. Very critical is to promote active public and stakeholder participation in all steps of the decision-making process (Mägdefrau and Sprague 2016). In this sense, Ravera et al. (2011) highlight that stakeholders' involvement needs to be considered by researchers who wish to improve the adaptive capacity of the communities they work with. The importance of the collaboration of key stakeholders to promote resilient communities and strengthen disaster risk governance is also reiterated in the Sendai Framework for Disaster Risk Reduction—SFDRR (UNISDR 2015).

Participation can effectively enhance resilience through mutual learning and collaborative decision-making (Evers et al. 2016). This increases stakeholders' knowledge and understanding of the problem, the system and the planned measures. Participation also provides an opportunity to gain their trust by sharing their experiences, needs and concerns as well as by understanding conflicting views and interests. Moreover, through these, the implementation of planned FRM measures will be more successful and sustainable (Abbott 2007; Steinführer et al. 2008; Watson et al. 2009; Evers et al. 2012).

The prioritization of FRM alternatives to enhance resilience tends to be rather complex since several criteria and stakeholders with opposing views have to be considered (Kenyon 2007). Therefore, to harmonize stakeholders contrasting interests, the selection of FRM options could be aided by the use of participatory multi-criteria decision analysis (MCDA) tools. MCDA is an umbrella term used to describe a set of techniques that can consider multiple stakeholders' opinions, alternatives, conflicting objectives and criteria.

Even though MCDA is widely used in FRM (e.g. Giupponi et al. 2013; Lee et al. 2015; Taib et al. 2015), a review by de Brito and Evers (2016) highlights that insufficient attention has been given to the participation of multiple stakeholders in the decision-making process. Participation is generally fragmented and restricted to information dissemination and consultation at specific stages. In addition, crucial aspects of the decision-making process such as the definition of the problem, identification of stakeholders and selection of criteria and alternatives are usually restricted to researchers conducting the study.

In this context, inter- and transdisciplinary approaches that endorse stakeholder participation combined with MCDA techniques could provide an alternative framing on how to improve the urban resilience for FRM. Participatory MCDA promotes transparent, fair and understandable processes, facilitates compromise and group decisions, and provides an adequate platform for stakeholders to communicate their personal preferences (Pohekar and Ramachandran 2004; Nordström et al. 2010). These characteristics enable the development of real collaborative processes, which are crucial for the implementation of successful and long-lasting FRM programs (Affeletranger 2001).

Taking into account the mentioned challenges, this chapter presents a participatory MCDA framework for urban FRM that could enhance resilience. In Sect. 14.2, the importance of participatory FRM in building resilience is described. Then, Sect. 14.3 highlights the findings of a systematic review of MCDA applications to FRM, seeking to provide a better understanding of the current status of how participatory MCDA is being conducted. Section 14.4 presents an innovative approach, termed collaborative modelling (CM) that integrates MCDA, participatory methods and user customized Web-based tools. Finally, Sect. 14.5 presents reflections and outlooks for future research.

14.2 Enhancing Resilience Through Participatory FRM

Realizing that participatory approaches are essential to build resilient communities, a number of guidelines, legislations and directives highlight this importance. Examples include: (1) the EU Flood Directive (CEC 2007), which demands the development of FRM plans with the involvement of concerned parties; (2) the World Bank guidelines in integrated FRM (World Bank 2012), which supports multi-stakeholder collaborative participation and communication to increase awareness and reinforce preparedness for more resilient communities; and more recently, (3) the Sendai Framework for Disaster Risk Reduction (UNISDR 2015), which states that the promotion of resilience could benefit from the participation of relevant stakeholders.

The benefits of participation for FRM are differentiated by Evers (2012) from two perspectives: the benefits for individuals and the benefits for the process. Examples of benefits for individuals are: more transparent decision-making; better control of decisions and their implementation; reduction of the media monopoly on influence; empowerment of the public as participants can express their interests and influence the decisions; and finally, enhancement of participants' coping capacity. The benefits for the process include: extension of the stakeholders' and citizens' room of action by reflecting and putting issues in a broader context; social learning as the parties involved can learn from each other through constructive dialogues; support of a common discourse as a basis for long-term perspectives; less litigation, misunderstandings and fewer delays; more effective implementation and monitoring; increased public awareness and acceptance, legitimising the decisions taken; and consideration of different kinds of knowledge.

Active involvement and collaborative decision-making can also foster social learning that increases stakeholders' knowledge and understanding, enhancing their resilience. Social learning is the mutual exchange and learning processes in different societal and administrative settings (Evers et al. 2016).

However, also, a couple of risks of participation have to be considered such as potential costs, time and resources consumption, risk of losing control of the process of authorities or domination by certain persons or institutions (Evers 2012). These aspects have to be considered, and trade-offs have to be made between the available resources and the expected outcomes. Participation in FRM, though, is crucial for enhancing resilience.

Participation can be categorized based on the level of engagement and shared responsibility into four classes: (1) information dissemination; (2) consultation; (3) active involvement; and (4) shared decision-making and collaboration (Evers 2012). Participation through collaboration is recognized to be one of the most appropriate approaches for designing FRM plans. Collaboration in decision-making can be complemented by using models as stakeholders gain more interest to participate when they are to some extent engaged in modelling activities (Voinov and Bousquet 2010; Whatmore and Landström 2011). The nature of this involvement depends on the available expertise of the stakeholders, but a common level of understanding of the modelling assumptions can lead to active involvement in setting-up the modelling objectives and analysis of the results.

14.3 MCDA in FRM: The Challenge of Handling Stakeholder Participation

Recognizing that participatory MCDA could contribute to a more transparent decision-making process towards resilience, a comprehensive literature review of MCDA applied to FRM was undertaken, as fully described by de Brito and Evers (2016). The goal was to highlight recent trends and identify research gaps with regard to stakeholder participation. With this scope in mind, six databases were systematically searched, including Scopus, ProQuest, Science Direct, SpringerLink, Emerald Insight and Web of Science. Only peer-reviewed papers written in English were considered. A total of 128 papers were found to be relevant and were included in the analysis.

Following the selection, the papers were classified based on the overall emphasis of the application discussed. There has been an increasing interest in flood MCDA studies from 1997 to June 2015 (Fig. 13.1). In fact, over 82% of the compiled papers were published since 2009. A wide range of applications was identified, with most papers focusing on ranking structural and/or non-structural alternatives to

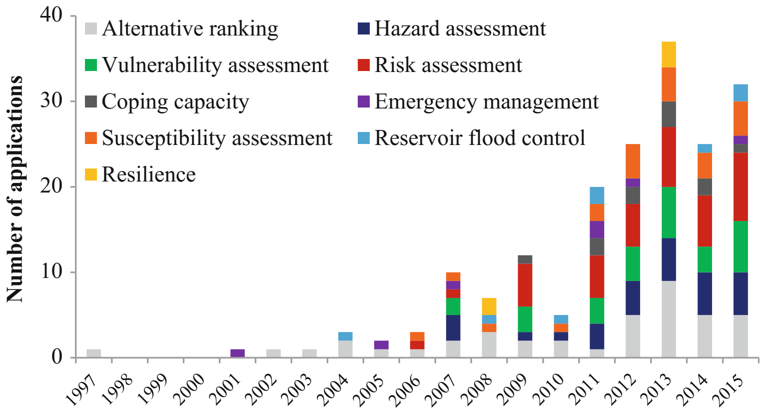


Fig. 13.1 Distribution of MCDA applications by topic between 1997 and June 2015 (Some papers analysed two or more FRM problems, simultaneously. Thus, the number of applications (n = 185) is higher than the number of papers (n = 128) elaborated based on de Brito and Evers (2016)

reduce flood impacts (22.16%), followed by risk assessment (20.54%). Few papers (3.78%) used MCDA as a decision support tool in resilience studies (e.g. Giupponi et al. 2013). This is probably because resilience is difficult to measure as its indicators vary from system to system (Schelfaut et al. 2011). In addition, flood resilience studies are quite new in comparison to other topics, with the first paper published in 2008.

As for the participating stakeholders, a total of 65 (50.78%) studies have explicitly acknowledged the involvement of multiple actors in the decision-making process. Policy makers and experts from universities and research institutes were the most participated stakeholders. This was expected since they are normally the ones who initiate the MCDA process. Only 16 papers mentioned the involvement of local community members (e.g. Evers et al. 2012; Roy and Blaschke 2015). The consideration of the community and its citizens' opinion may improve their resilience and coping capacity when confronting floods (Affeletranger 2001).

Regarding the participatory techniques applied, questionnaires and face-to-face interviews were the most used tools (Fig. 13.2). Although these methods allow for opinions to be conveyed without influence from dominant individuals, the participants are not able to share different perspectives through open dialogue. However, understanding each other's conflicting views is essential for achieving a negotiated common agreement. It is worth to mention that there was a study on the use of a MCDA Web-based platform in which stakeholders rank FRM alternatives interactively (Evers et al. 2012; Almoradie et al. 2015). These platforms have the potential to overcome hindrances in participatory MCDA such as the participants' spatial distribution, providing full transparency of information and results.

There were surprisingly few studies that effectively considered stakeholders' participation throughout the entire decision-making process (e.g. Ceccato et al. 2011; Evers et al. 2012). Participation was generally fragmented and restricted to

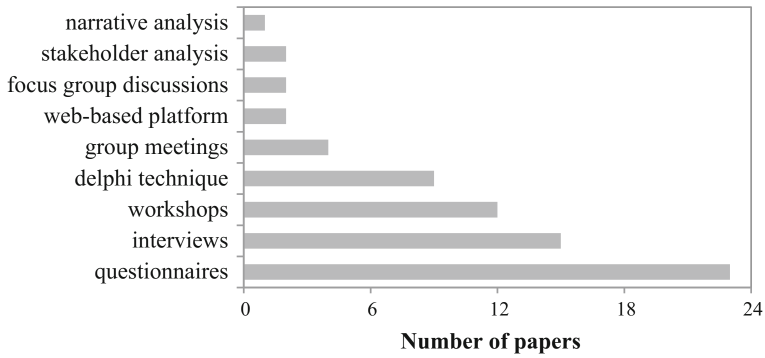


Fig. 13.2 Methods used to incorporate stakeholders' views in MCDA FRM applications de Brito and Evers (2016)

consultation at specific stages, such as the selection of evaluation criteria and the definition of criteria weights. Collaboration processes in which stakeholders and the modelling team act as partners to take decisions were rarely conducted. This segmentation may be related to methodological and time constraints since participatory processes are time-consuming. Crucial aspects of the decision-making process like the definition of objectives, identification of the alternatives and estimation of its consequences were usually restricted to researchers, which inhibits the achievement of genuine collaboration.

Another issue is that only four studies sought to obtain consensus and that decisions were often made by averaging the results. Nevertheless, enhancing mutual understanding for consensus building is essential for a sustainable and successful FRM. It allows decision-makers to derive meaningful solutions that fulfil their own needs whilst at the same time satisfying the requirements of other actors, legitimating participation as a learning process to solve complex problems.

Considering these challenges, a greater rigour in endorsing an active involvement and collaboration in all stages of the decision-making process should be undertaken in future studies, aiming to increase the feasibility and subsequent implementation of chosen measures. Future research could be directed towards developing Web-based platforms to elicit stakeholders' preferences. In addition, potential exists to apply consensus building methods such as the Delphi technique and the nominal group technique (NGT), which are widely accepted tools for achieving convergence of opinion on complex problems in a systematic and transparent way. The Delphi technique uses a series of questionnaires with controlled feedback to determine consensus from a large group of experts. NGT, on the other hand, entails a highly structured face-to-face group discussion in small groups (McMillan et al. 2016).

14.4 MCDA Collaborative Modelling

14.4.1 Collaborative Modelling Framework

The collaborative modelling (CM) framework presented here integrates MCDA and Web-based tools in its process-driven participatory approach. It engages participants through the use of models, and other communication tools to understand the flooding problems and how measures influence the flooding patterns. The CM framework is an interactive and iterative process, which aims to stimulate and support social learning about FRM. Such learning elevates the overall flood risk awareness within the communities and opens up the possibilities for deriving commonly agreed FRM strategies which enhances their resilience. In addition, the CM framework aims to achieve a common understanding of the system and the problem, identify realistic management alternatives, and its subsequent ranking according to individual stakeholders as well as the whole group (Evers et al. 2012).

The developed framework consists of five main steps, in which the stakeholders are engaged through a series of workshops and the use of a Web-based platform. These steps are: (0) system definition, to understand the study area, problems and existing legislations; (1) development of shared understanding of current flood risk and identification of FRM objectives; (2) definition and evaluation of external scenarios; (3) identification and evaluation of alternatives for FRM; (4) ranking of alternatives through MCDA (Fig. 13.3). Workshops were organized within steps 0

Fig. 13.3 Collaborative modelling framework Evers et al. (2012)

to 1, 2, 3 and 4, respectively. Given that these activities are carried out in a fully transparent manner amongst stakeholders, this can possibly lead to a negotiated selection of FRM alternatives for implementation.

14.4.2 MCDA Method

There are many MCDA methods that can support decision-making on the ranking of alternatives. Such examples are the simple additive weighting, value-utility method, analytic hierarchy process and technique for order preference by similarity to ideal solution (TOPSIS). The selection and application of a MCDA method depend on the case study's objectives and data requirements. In the CM framework, formulating judgement for the ranking of FRM alternatives is based upon the combination of the beliefs and attitudes of stakeholders with scientific facts. In such cases, ideal solution point approaches such as the TOPSIS method offer advantages in formulating judgements due to its simplicity, transparency and easy adaptation (Simonovic 2009).

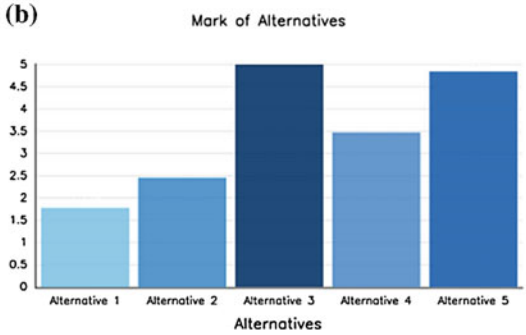
The MCDA technique TOPSIS, developed by Hwang and Yoon (1981), was implemented in the final step of the CM framework with the aim of ranking FRM alternatives. The ranking process was structured into two components: (1) individual profile, where stakeholders evaluate the proposed alternatives in a decision matrix with respect to identified objectives to obtain their individual rank of alternatives (Fig. 13.4); and (2) group profile, where individual rankings are aggregated to develop a group ranking.

As explained in Fig. 13.4, to obtain their individual ranking, each stakeholder needs to: (1) provide weights of relative importance to the identified objectives, by distributing points from a maximum of 100; and (2) evaluate the alternatives according to the objectives. Evaluations can be quantitative or qualitative. Quantitative evaluation is based on the results of the hydrological or hydraulic models, thus users cannot modify these (e.g. flood extent area). Qualitative evaluations are expressed in linguistic terms (e.g. bad, fair and good). Stakeholders evaluate the alternatives by choosing from these linguistic terms based on their point of view on how a certain alternative performs. Since the qualitative evaluation is expressed in linguistic terms, these are converted into crisp numbers by using conversion scales based on the fuzzy set theory (Chen and Hwang 1992). With the evaluation outcomes for all alternatives, the TOPSIS method is applied to obtain the individual ranking. The derived final scores are subsequently aggregated to create a group profile. Additional plots for presenting individual positions versus the group are provided to present the results in a way that individual positions within the group are made as clear as possible.

(a)

DECISION MATRIX						
OBJECTIVES (INDICATOR)/ ALTERNATIVES	Obj 1: Magnitude of surface flooding (Flooded hectares)	Obj 2: Damage to properties (Number of properties flooded)	Obj 3: Damage to critical infrastructure (Damage to critical infrastructure)	Obj 4: To salvage belongings inside properties and businesses (Opportunity of salvaging belongings)	Obj 5: To select FRM alternatives easy and feasible to implement (Feasibility of implementation in Redbridge)	RANKING OF ALT.
Alternative 1 Do nothing	28.02	987	High damage	High opportunity	High feasibility	5
Alternative 2 Rainwater harvesting	24.06	816	Medium damage	Low opportunity	Medium feasibility	4
Alternative 3 Improved and targeted maintenance regimes for the sewer system	25.8	904	Low damage	Medium opportunity	Medium feasibility	1
Alternative 4 Improved resistance for preventing water from entering properties	28.02	535	Medium damage	Medium opportunity	Medium feasibility	3
Alternative 5 Improved rainfall and flood forecasting and warning	28.02	987	Medium damage	Very high opportunity	Very high feasibility	2
GOAL OF THE OBJECTIVE	Minimised	Minimised	Minimised	Maximised	Maximised	Sum objectives' weight
WEIGHT OF THE OBJECTIVE	10	25	25	15	25	100

(b)



Alternative	Rank	Score
1	5	1.78
2	4	2.45
3	1	5.00
4	3	3.47
5	2	4.84

CLOSE RANKING GRAPH!!!

Fig. 13.4 Individual profile: **a** decision matrix; **b** alternatives ranking Almoradie et al. (2015)

14.4.3 Application of CM-MCDA to Case Studies

It was the aim to develop and test the MCDACM framework in two catchments with significant flood risk: one small urban catchment and one medium size catchment with rural and urban characteristics. The following were chosen as case study areas: (1) the Cranbrook catchment, UK; and (2) the Alster catchment, Germany.

The Cranbrook catchment (9 km^2) is located in an urban area, in London borough of Redbridge, UK. The catchment experiences both pluvial and fluvial flooding. Two types of physically based and dual drainage surface flood models for the pluvial flooding simulation were set up and calibrated to support discussion and engagement with the participants. Stakeholder analysis was employed to identify key actors. Stakeholder analysis was developed and implemented through systematic analysis of actors using an organi- and sociograms. Participants were then categorized into general public, planners and government organization, emergency managers and flood management professionals. Key representatives were invited to participate in four workshops that were carried out in combination with the collaborative Web-based platform. The workshops were held over a period of 1.5 years (2010–2011), with the number of participants varying between 8 and 15. The alternatives identified together with the stakeholders were the following: (1) do nothing; (2) rainwater harvesting; (3) improved maintenance of sewer systems; (4) resistance of properties; and (5) improved flood forecasting and warning. The objectives of the FRM for enhancing resilience were: (1) reduce the flooding magnitude; (2) minimize damage to properties; (3) minimize damage to critical infrastructure; (4) maximize salvaging of belongings, and (5) feasibility of implementation. A total of eight participants took part on the last workshop that aimed at ranking the alternatives.

The Alster catchment (578 km^2) is located in Hamburg and Schleswig Holstein, northern Germany. The Alster River is a tributary of the river Elbe and has a length of 56 km. The lower part of the catchment has a high damage potential from fluvial flooding given its population density and the high exposure of the centre around the city town hall. A 1D hydraulic model was set up to investigate the scenarios and measures. Based on stakeholder analysis, five groups of stakeholders were identified: (1) administrative and governmental authorities at federal and regional level; (2) non-governmental organizations; (3) political bodies; (4) larger business companies; and (5) affected people from the general public. A total of four workshops were carried out in combination with the Web-platform with participation of key representatives of each stakeholder group. The workshops were held over a period of 1.5 years (2010–2011), with the number of participants varying between 12 and 30. The alternatives identified together with the stakeholders were: (1) do nothing; (2) technical measures; (3) catchment activities; and (4) preventive measures. The objectives identified comprehend: (1) flood protection effectiveness; (2) impact to ecology; and (3) cost of implementation. Twelve stakeholders attended the workshop that focused on ranking FRM alternatives.

14.4.4 Case Studies Results

In summary, the results for Cranbrook show that all alternatives (except Alternative 1— 'do nothing') had a similar overall ranking with a slight preference for Alternative 4 ('improved resistance for preventing water from entering properties').

For Alster, there was a clearer preference for Alternative 4 (‘preventive measures’) with eight stakeholders ranking it as first. In both cases, there is a distribution of the positions of individual participants across the proposed alternatives, often depending on the stakeholder category to which they belonged.

It is evident that the social learning process somehow influenced stakeholders’ perceptions and views. The stakeholders’ preferences were influenced during the identification of possible alternatives and the individual and group assessment ranking of alternatives. Some stakeholders changed their perception and understanding of some measures as observed during the face-to-face workshops. Although this change in perception was not quantified in the process, it has been observed during the stakeholder discussion and activities from the first until the final workshop. This was, to some extent, also reflected in a feedback questionnaire with the question ‘is the individual ranking presented close to your representation of preference?’. The majority answered that the ranking is close to their preference and perception. Moreover, it can be noticed in the group ranking that the change in perception and understanding of FRM somehow has taken place since preferences for alternatives seem to converge during the final stage of collaborative decision-making activity. Figure 13.5 shows an example, in the Alster case study, the positions or ranking scores of individual stakeholder are closer for Alternative 4 (the most preferred).

We do not claim that the results obtained are conclusive and optimal. First, the change in perception was not quantified but was only observed and documented in a questionnaire. In addition, the number of participating stakeholders was quite small and the activities did not proceed further with active negotiations. Nevertheless, CM gave a first indication of the attitudes of the stakeholders towards the proposed FRM alternatives and can serve as a starting point for further collaboration in deciding which measures may be commonly accepted by the respective communities.

Our analysis shows that through fostering social learning and engagement in the decision-making processes with MCDA, participating stakeholders enhanced their resilience by becoming more aware of the problem, proposed measures, about their personal values and interest and those of others. Also, the CM-MCDA process potentially increased the quality of decisions by resolving conflicting interests through constructive discussion and by having a common understanding of the problem, current situation and planned alternatives/measures. This process could produce FRM solutions of higher overall stakeholder acceptance.

Further details on the implementation of the modelling system, Web-platform, stakeholder analysis and the workshops are provided by Almoradie et al. (2015) and Evers et al. (2012), (2016).

Fig. 13.5 Alster group profile results. The 'balloon' markers are the positions of individual stakeholder; the colours correspond to his/her stakeholder group. The 'human' marker presents the position of the current user. The 'clustered' marker (in yellow) presents the number of individuals with the same position Almoradie et al. (2015)

14.5 Reflection and Outlook

The evaluation of the case studies revealed that the CM-MCDA framework was, in general, well appreciated by the stakeholders. It illustrated how social learning could enhance resilience by resolving conflicting interest and promoting collaboration and cooperation amongst stakeholders for effective management of flood risk. The process-driven decision-making approach for which stakeholders identify and rank alternatives for flood risk reduction is seen as an integral part for social learning in this case study. By this social learning process, we can assume that the preparedness and coping capacity of the participants and respective institutions have increased and appropriate interventions were identified. The main advantage of the MCDA approach compared to an only verbal discursive approach is to provide tangible information and concrete ideas to act in the respective geographic and societal context, showing cause–effect relationships, illustrating the individual and group-based ranking and reflecting about the objectives for different options by the TOPSIS tool.

Moreover, the MCDA approach allows the documentation of divergent framing assumptions without suppressing dissenting voices. We believe that showing such contrasting views and the underlying reasons for different interpretations in a systematically way is a more transparent approach. This allows comprehending the sometimes rather unexpected outcomes in the performance of certain FRM alternatives. Furthermore, stakeholders are more motivated to participate and may change their perceptions when stakeholders with conflicting interest are included and acknowledged in the CM framework.

Although this framework could enhance community resilience, it is still necessary to test and implement it in a broader community or stakeholders. This need is reflected in the statements of the participants:

> In order for it to be intensively used in the future, we would need to create a “culture” of using this framework and platform.

> It would be interesting to have more people involved in order to have a broader view.

In relation to the statements, it is worth to mention that there were ongoing activities during the research periods besides the face-to-face workshops such as training of local champions, adaptation of the Web-based platform and provision of e-learning tool. The TOPSIS method was useful in formulating judgements on the proposed alternatives, by combining the scientific facts with the beliefs and attitudes of the stakeholders in the decision-making process. The TOPSIS method provided a close representation of the stakeholders’ preferences regarding the measures and alternatives. Furthermore, it was seen to be the right technique to be implemented for this case because it can incorporate quantitative and qualitative information using the ideal solution point approaches. This was validated when stakeholders were asked if their ranking of alternatives presented close on their representation or views of preferences. However, for further research, it will be of interest to look at other MCDA methods such as the ones implemented in other FRM studies as shown in the first section of this chapter.

In the overall process, it was observed that the changing of attitudes and perceptions of the stakeholders may have led to a possible consensus on the selection of proposed measures. This changing of attitudes and views and being more aware of the situation can be attributed to the CM framework that fosters social learning. Social learning has been a critical aspect of how the participants changed their perception in a holistic and integrative thinking about the flooding problem and the proposed measures.

In summary, the CM-MCDA framework can be considered as a promising approach as a supporting tool for decision-making, for enhancing stakeholders’ role in FRM and to increase community resilience. Although the quantification or measurability of resilience was not addressed or was only superficial in this research study, the framework could provide an alternative framing in assessing resilience, coping and adaptive capacity, e.g. by looking into the evolution of stakeholder perception, attitudes and evaluation and ranking of alternatives.

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Part IV
Urban Critical Infrastructure and Security

Chapter 15
An Approach for Quantifying the Multidimensional Nature of Disaster Resilience in the Context of Municipal Service Provision

Christopher W. Zobel, Milad Baghersad and Yang Zhang

Abstract This research effort introduces the idea of capturing the varying impacts of a disaster on an urban area by analyzing the nature of the public's changing requests for municipal services. By examining the relative number and timing of such requests, across a variety of different services, we can get an indication of how resilient the infrastructures are that are supported by those services, as well as how resilient the population is that relies upon them. In particular, we adopt a method for calculating resilience that characterizes both the observed impacts of a disaster and the time needed to recover from it by using such service request data. In order to explore the potential for characterizing multiple dimensions of urban disaster resilience in this way, we specifically leverage an empirical data set of non-emergency 311 service calls made in New York City between 2010 and 2012. This allows us to compare the relative performance of several types of service requests with respect to a set of different disaster events that impacted the New York metropolitan area during that time period and thus to characterize the different ways in which resilience was exhibited in response to those events.

Keywords Resilience quantification · Multidimensional resilience
Data analytics · 311 calls · Nonemergency call data

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15.1 Introduction

Urban areas can provide significant opportunities for many people to improve their quality of life. By concentrating populations in specific locations, however, cities also lead to the likelihood of more people being impacted by a natural disaster event affecting that particular location, such as a tropical storm or an earthquake. The resulting impacts can be very complex on a number of different levels. In large cities, for example, the impacts of a given natural hazard can vary significantly across different neighborhoods, not only because of geographic diversity (i.e., neighborhoods near bodies of water are more likely to be flooded) but also because of socioeconomic diversity and disparities (i.e., certain populations may have more exposure to flooding because of lack of resources for hazard mitigation).

The US National Academies define disaster resilience to be the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events (National Academies 2012). This definition can be applied at an individual level, or at the community level, or even at the level of an entire metropolitan area. If one wishes to assess the potential resilience of such an urban area to a natural hazard, however, it is important to consider not just the complexity of the hazard itself, but also the complexity of the population's many possible vulnerabilities and the varying extent to which that population is exposed to, and responds to, the hazard between different neighborhoods. This implies that different parts of a city may exhibit resilient behavior in a variety of different ways. Furthermore, such resilient behavior can be characterized with respect to a number of different aspects of each community. For example, one can consider the resilience of physical infrastructure, such as roads, ports, or bridges, or the resilience of organizations that operate within the social fabric of those communities, or one can even consider the psychological resilience of children and their families. Each such perspective can provide valuable information about how effectively the community reacts and responds overall to the occurrence of a disaster.

One of the primary responsibilities of a municipality to all of its citizens is to provide and maintain appropriate public services, even in the wake of a disaster event. Some services, such as maintaining roadways or providing access to the water and sewer systems are important to manage without significant interruption. Other services, such as cleaning up debris or responding to noise complaints, might only be provided upon request by one or more residents. In either case, however, the ability to continue providing services will likely be negatively impacted in the event that a natural hazard occurs.

The following discussion proposes using the loss of such service provision during a disaster as the basis for characterizing a new aspect of urban resilience: the ongoing interaction between a municipality and its citizens. By examining the extent to which services are maintained during a disaster event, we can get an indication of both the resilience of the infrastructure that supports the service provision and the resilience of the families that rely on those services. Our specific focus in this paper is on demonstrating the potential of using data generated from service calls in order to characterize the disaster resilience of a municipality through this lens of service provision.

We begin our discussion with a brief review of the literature, and then introduce the empirical data set upon which our analysis is based: the complete set of non-emergency 311 service calls made in New York City between 2010 and 2012. Following an overview of data collection and transformation issues, we describe the variable selection process and then present our analysis of the set of individual measures. In particular, we compare and contrast the extent to which each component measure is able to characterize the resilience of the 311 system to several different disaster events occurring during this time period. This analysis is followed by a discussion of implications, and then by our conclusions and a statement of future work.

15.2 Background

Realizing that protecting a system from all potential disruptive events is impossible, a paradigm shift recently has been applied within US government policy from an emphasis on prevention to one on resilience, i.e., preparedness and response (Vugrin et al. 2011). This paradigm shift has resulted in new programs which aim to enhance the resiliency of the US critical infrastructures. For example, in 2009, the US Department of Homeland Security (DHS) launched a new program called the Regional Resiliency Assessment Program (RRAP) (DHS 2015). The aim of the new program is assessing US critical infrastructure resiliency within defined geographic areas to address resilience issues that could have significant consequences.

With increasing attention focused on the concept of disaster resilience, developing appropriate methods to evaluate the resiliency of systems in different contexts becomes more crucial. One of the first attempts to do this was provided by Bruneau et al. (2003), who proposed to use a response curve to measure changes in system performance over time, as a way to calculate that system's resilience to a disruptive event. Figure 15.1 provides an example of such a curve where the functionality at time t is given by $Q(t)$ and the disruption occurs at time t_0. Bruneau et al. (2003) then used the area above the curve to measure the *loss of resilience* in the system due to the disruption. They named the triangle above the response curve the *resilience triangle* and argued that when this triangle is smaller, the system is more resilient.

Cimellaro et al. (2010) and Zobel (2010, 2011a) each extended this original concept by introducing a measure of resilience that can be calculated directly instead of indirectly. Zobel's new measure is known as *predicted resilience* (R), and it is defined to be the area beneath the response curve after it is normalized by the corresponding area that would have been realized if there had been no disruption. For example, if we assume a sudden-onset disaster as illustrated in Fig. 15.1, and set X equal to the loss suffered at time t_0, then the predicted resilience is given by the following formula:

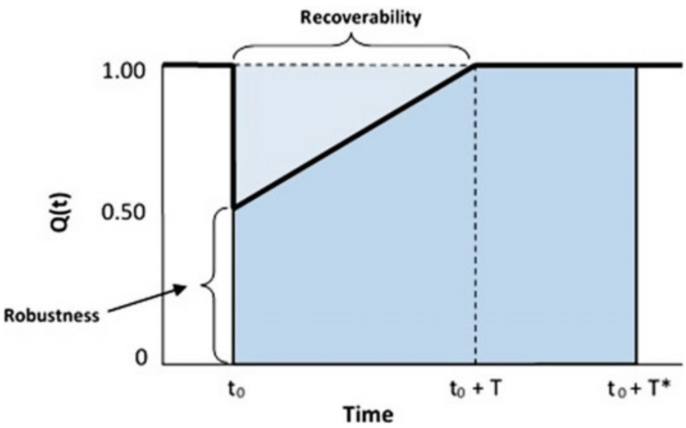

Fig. 15.1 Predicted resilience. (adapted from Zobel 2011a)

$$R = 1 - [(XT)/(2T^{*})]$$

where T^* is a user-defined upper bound on the length of recovery time.

Zobel and Khansa (2012) subsequently generalized this formula so that the concept would also apply to slow-onset disruptions and to disruptions that resulted in non-monotonic recovery behavior. This simply involves calculating and incorporating the generalized average loss per unit time into the equation, instead of using the instantaneous loss at time t_0:

$$R = 1 - [(\bar{X}T)/T^{*}]$$

Noting that a single measure cannot capture the resilience behavior of a system completely, Zobel (2010, 2011b) proposed expanding the characterization of resilience in this general context to also include the system's robustness and recoverability as explicit sub-measures. Following Zobel and Khansa (2012), we thus use the term robustness to refer to the extent to which a system withstands a disruption (represented by $\overline{X}$) and recoverability to refer to the ability of the system to recover to a normal level of functionality (represented by T). This subsequently leads us to use three distinct measures for evaluating the resiliency of a community that is subjected to a series of disaster events. Each of these measures is constructed from a time series of daily service call volumes, which can be seen as a response curve that captures the impact of each disaster event. With this in mind, the three resilience-related measures include: (1) the average daily deviation of the number of service calls from normal levels due to a disaster event (i.e., robustness), (2) the total number of days that an abnormal number of service calls are received, due to a given disaster event (i.e., recovery time), and (3) the total resilience of the community with respect to that type of service and in the context of the given disaster event, as represented by the normalized, time-varying deviations in call volumes.

Each of these measures is then calculated with respect to different types of service calls in order to characterize different aspects of the community's resilience. This use of multiple types of calls to gain a broader view of resilience behavior echoes the work of Dottore and Zobel (2014), who used a simplified form of the resilience equation to characterize a set of different economic indicators of disaster resilience after Hurricane Katrina. The richness of our current data set and the multi-measure view of resilience, however, provide support for a significant step forward in analytically characterizing the resilient characteristics of an urban community.

15.3 Data Collection

New York City is the most densely populated city in the USA, and one of the most socially and economically diverse (City of New York 2016a). It is located at the mouth of the Hudson River and is made up of five different boroughs: Manhattan, Queens, Brooklyn, the Bronx, and Staten Island. Each borough has a varying mixture of both businesses and residential neighborhoods, with Brooklyn being the most heavily populated borough, followed by Queens and then Manhattan, which serves as the center of many of the more well- known financial and cultural activities in the city (City of New York 2016b).

New York City has an Open Data service (https://opendata.cityofnewyork.us/) that makes a large number of different municipal data sources freely available to the public. Among these is a data set that details each of the non-emergency service calls made through the city's 311 service. From this data set, we collected individual data on municipal service calls in New York City for the period covering years 2010–2012. A total of around 5.7 million call records were retrieved, in CSV format, each including characteristics such as the time and date of the call, the agency called, the complaint type, the street address, the borough, how and if the call was resolved, the resolution date, and the latitude and longitude of the incident, as shown in Table 15.1.

The data was transformed and uploaded to a PostgreSQL database to support conducting an in-depth analysis. Because of the large amount of data being retrieved, a significant amount of manual effort was required to process the entire data set. For example, even though the data was downloaded in CSV file format, each individual file was too large to be opened in either a text editor or in Excel, so it was necessary to use a third-party piece of software, Delimit, in order to process it into manageable subsets that could then be opened individually. Macros written in VBA within Excel then were used to automate the data conversion and consolidation across the different data subsets. PostgreSQL was chosen as the database management system because of its native support for GIS integration; this will provide the opportunity to perform more in-depth geospatial analysis in the future.

Table 15.2 lists the top ten agencies that received service calls, along with each one's top complaint types, in terms of the number of calls made in 2012. We also report, in Table 15.3, the top 20 complaints overall (based on a number of calls) for this same year.

Table 15.1 Selected 311 call attributes

Attribute name	Description
Unique key	Unique identifier
Created date	Date and time, the record was created
Closed date	Date and time, the record was closed
Agency	Overall agency abbreviation
Agency name	Specific agency name
Complaint type	Category of complaint type
Descriptor	Detailed description of complaint
Incident zip	Zip code of incident location
Incident address	Street address of incident location
City	City of incident location
Borough	Borough of incident location
Due date	Date and time, the request is due
Resolution description	Description of call resolution update
Resolution action updated date	Date of call resolution update
Latitude	Latitude of incident location
Longitude	Longitude of incident location

Table 15.2 Top ten agencies based on number of calls in 2012

Agency	Agency name	No. of calls 2012	Top complaint types
HPD	Department of Housing Preservation and Development	562,761	Heating, general construction, plumbing, paint—plaster, non-construction
NYPD	New York City Police Department	294,053	Noise—residential, blocked driveway, illegal parking, noise—commercial
DOT	Department of Transportation	256,972	Street light condition, street condition, traffic signal condition, broken meter
DEP	Department of Environmental Protection	147,084	Water system, sewer, noise, air quality, hazardous materials
DSNY	Department of Sanitation	112,008	Dirty conditions, sanitation condition, graffiti, missed collection
DPR	Department of Parks and Recreation	106,055	Damaged tree, maintenance, overgrown tree/branches, sidewalk condition
DOB	Department of Buildings	88,235	General construction/plumbing, elevator, special enforcement, construction
DOF	Department of Finance	83,040	DOF Literature request, SCRIE, DOF property issue, DOF payment issue
DOHMH	Department of Health and Mental Hygiene	47,563	Rodent, food establishment, indoor air quality, standing water, food poisoning
TLC	Correspondence—Taxi and Limousine Commission	22,918	Taxi complaint, for hire vehicle complaint, taxi compliment, found property

Table 15.3 Top 20 complaint types in 2012

Rank	Complaint type	Agency	No. of calls in 2012
1	Heating	HPD	182,974
2	Noise—residential	NYPD	127,524
3	General construction	HPD	112,436
4	Street light condition	DOT	93,866
5	Plumbing	DOB	91,192
6	Paint—plaster	HPD	77,287
7	Street condition	DOT	67,050
8	Non-construction	HPD	60,055
9	Water system	DEP	57,600
10	Blocked driveway	NYPD	50,645
11	Damaged tree	DPR	50,394
12	Traffic signal condition	DOT	47,484
13	Sewer	DEP	36,895
14	Electric	HPD	35,398
15	Noise	DEP	34,137
16	Dirty conditions	DSNY	33,605
17	Illegal parking	NYPD	31,934
18	Building/use	DOB	26,113
19	General construction/plumbing	DOB	25,286
20	Sanitation condition	DSNY	24,402

15.4 Data Analysis

As discussed above, our analysis of the collected 311 data focuses on characterizing the numbers of calls received by the system during and after incidents of natural disasters. Some of these disaster events were localized, like the tornadoes that hit Brooklyn and the Bronx in 2010, and some of them, like Hurricanes Irene and Sandy, impacted the entire New York City metropolitan area. We capture the overall call behavior by considering a time series representation for each of a number of significant call types, along with historical call volumes in each case, in order to determine if there were either more or fewer calls than normal during the impacted periods. Analyzing deviations across several such time series can provide us with an indication of the impact of the events on different aspects of the municipalities, and thus, it can help describe the impact on their corresponding service infrastructure networks.

Since it is infeasible to analyze all possible complaint types in this paper, we focus instead on five types of complaints that had significant changes (positive or negative) in the number of calls received by the city, as measured before, during, and after Hurricane Sandy struck New York City in 2012. These five complaint types include *damaged tree*, *traffic signal condition*, *general construction*, *street light condition*, and *blocked driveway*, all of which are among the top twenty complaint types in 2012. They were chosen specifically to represent a range of different agencies, services, and types of response. We then identified six additional natural disaster events that occurred in the New York City area between 2010 and 2012 and analyzed each type of complaint with respect to all seven events. The chosen set of events is presented in Table 15.4.

Figure 15.2 shows the daily number of calls related to the complaint type *damaged tree* from 2010 to 2012. It is easy to see that there is a large increase in the number of calls associated with every event except for event 3, the North American Blizzard of December 2010. In contrast to this, however, some of the other complaint types suffer a decrease in the number of calls received during a hazard event. For example, Fig. 15.3 illustrates that the number of *blocked driveway* calls decreased during both Hurricane Irene (event 4) and Hurricane Sandy (event 6).

Such variation in the numbers of calls received obviously can be due to factors other than a disaster event, such as the impact of different days of the week, the occurrence of holidays, and changes in temperature. In order to find statistically

Table 15.4 Seven disaster events from 2010 to 2012

Event ID	Event description	Date of event
Event 1	2010 Nor'Easter	13–14 Mar. 2010
Event 2	Brooklyn/Queens tornadoes	16 Sep. 2010
Event 3	N. American Blizzard	25–27 Dec. 2010
Event 4	Hurricane Irene	28 Aug. 2011
Event 5	Major snowstorm	31 Oct. 2011
Event 6	Hurricane Sandy	29 Oct. 2012
Event 7	2012 Nor'Easter	7 Nov. 2012

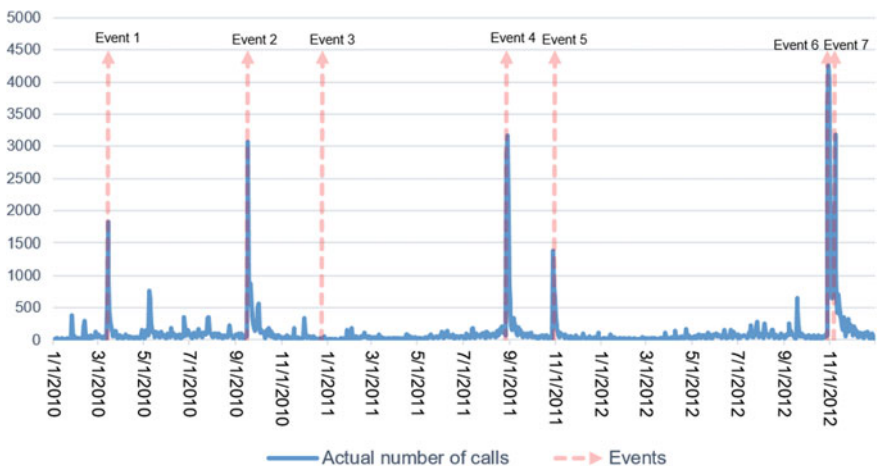

Fig. 15.2 Number of *damaged tree* calls

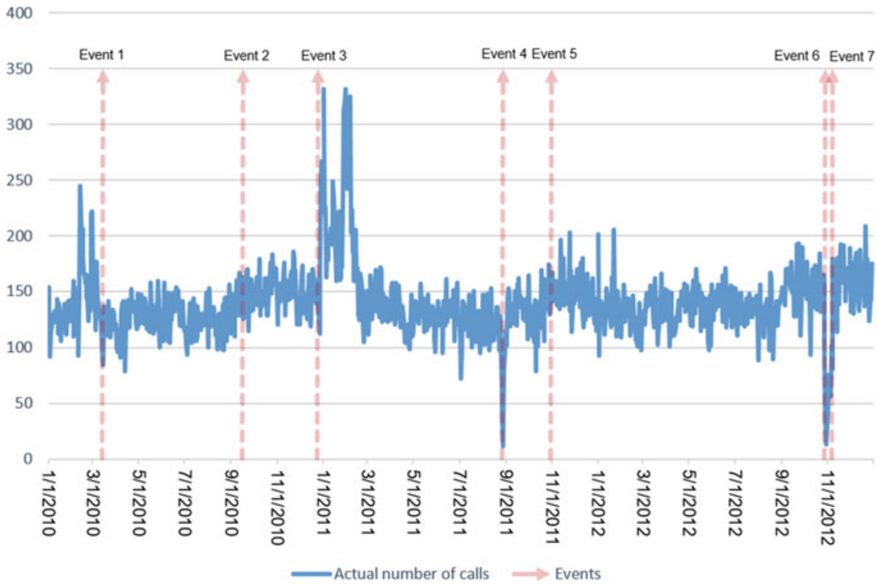

Fig. 15.3 Number of *blocked driveway* calls

significant changes in the number of calls, therefore, we need to control for these more systematic changes in the numbers of calls. To this end, we compare the observed number of calls of each complaint type, on a daily basis, to a predicted range based on the historical expected number of calls.

Following Zha and Veloso (2014), we apply the random forest method (Breiman 2001) to predict the number of calls. Our model uses five specific independent variables that have been identified by Zha and Veloso (2014) as having impacts on the number of calls: average temperature, temperature range, occurrence of snow, day of week, and holidays. We used the actual number of calls received during the past three years, for each complaint type, to build random forest models and we used these random forest models to predict number of calls in the following year. After predicting the average number of calls received during each day, we applied the quantile regression forest method developed by Meidhausen (2006) to find 95% prediction intervals for each prediction point. Figure 15.4 shows the actual number of calls, the predicted number of calls, and the upper and lower bounds for the prediction intervals for *blocked driveway* complaints between 2010 and 2012. When the actual number of calls are higher (lower) than the upper (lower) bound of the prediction interval, it indicates that the difference between the two values is statistically significant (p value < 0.05).

To evaluate the effect of disaster events on the number of calls received for each of the five complaint types, we calculated the difference between the actual number of calls received and the upper bound of the prediction interval (or the lower bound of the interval if the actual number of calls is lower than the lower bound),

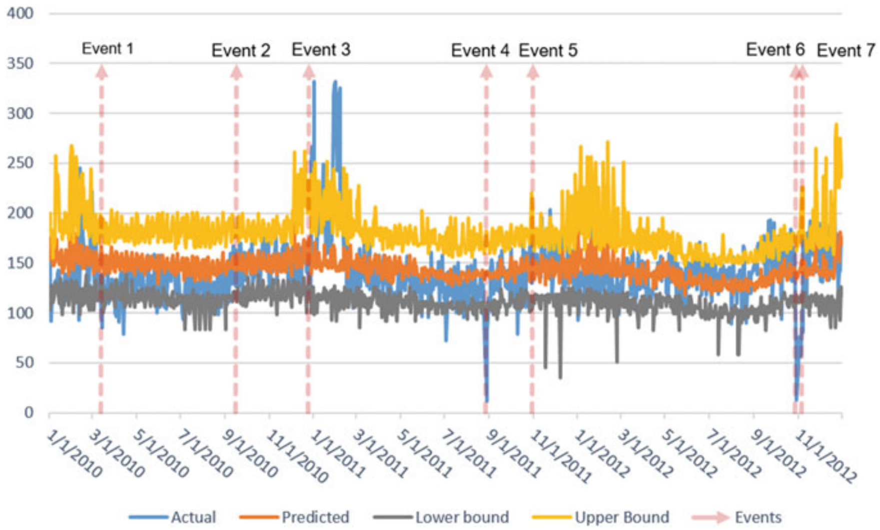

Fig. 15.4 Actual, predicted, and prediction intervals for *blocked driveway* calls during 2010–2012

ranging from the day of each event to 2 weeks after the day of the event (i.e., for a total of 14 days for each event and each complaint type). We then adapted the resilience measurement approach taken by Zobel and Khansa (2012) and calculated the average amount of absolute percent deviation per unit time over the 14 day period ($\overline{X}_{c,e}$) for each complaint type, $c \in \{1, \ldots, 5\}$, and each event $e \in \{1, \ldots, 7\}$, along with the corresponding total amount of time spent in a state of either exceedance or loss ($T_{c,e}$).

These average percent deviation and total time values then allow us to calculate a distinct resilience value for each combination of complaint type and event: $R_{c,e} = 1\text{-}(\overline{X}_{c,e\mathrm{Tc},e} / T^*)$ where the threshold $T^* = 14$ days. This, in turn, can be used to give us a multidimensional characterization of resilience across each of the complaint types and each of the selected disaster events.

15.5 Results

The result of calculating the resilience value for each of the seven events and each of the five complaint types is given in Table 15.5. The actual amount of deviation for each complaint type varies dramatically due to differences in call volumes, so each instance of $\bar{X}_{c,e}$ was normalized to a percentage value with respect to the largest observed deviation for that complaint type.

It is easy to see from these results that the resilience behavior associated with each type of call varies across the different events. Furthermore, it can be seen that

Table 15.5 Multidimensional disaster resilience by event for each complaint type

	Complaint					Mean (std dev)
	Damaged tree	Traffic signal	General construction	Street light	Blocked driveway	
Event 1	0.9070	0.8862	0.9552	0.9671	0.8066	0.9044 (0.0641)
Event 2	0.8298	0.8869	0.9664	0.9953	1.0000	0.9357 (0.0745)
Event 3	0.9987	0.9091	0.6917	0.6922	0.6245	0.7832 (0.1614)
Event 4	0.7775	0.9032	0.7972	0.9708	0.8325	0.8562 (0.0799)
Event 5	0.9831	0.9761	0.9701	0.8177	0.9930	0.9480 (0.0733)
Event 6	0.4180	0.7204	0.7858	0.9021	0.5397	0.6732 (0.1938)
Event 7	0.8228	0.9252	1.0000	0.9892	0.8964	0.9267 (0.0724)
Mean (std dev)	0.8196 (0.1956)	0.8867 (0.0795)	0.8809 (0.1203)	0.9049 (0.1128)	0.8132 (0.1756)	

for each specific event, the different types of calls exhibit very different resilience behavior. Overall, Hurricane Sandy generally appears to have caused the largest disruption across all complaint types, while the major snowstorm in 2011 had the least overall impact over time, with respect to this particular set of indicators. The *damaged tree* complaint type had one of the lowest average resilience values and the largest amount of variance across events, primarily because of the huge impact of Hurricane Sandy, and calls about *traffic signal* issues were among those exhibiting the most resilience and they varied the least from one event to the next.

It is important to keep in mind that although a set of such resilience values can provide a good overall indication of the different types of behavior being exhibited by the system as a whole, the individual values themselves do not capture the important tradeoffs between the amount of deviation and the length of time for which that deviation persists. The ability to reflect both of these characteristics in a single value is one of the distinguishing strengths of resilience as a performance measure, but the additional ability to consider both the amount of deviation and the length of time as separate sub-measures is an even more powerful advantage of the concept as formulated above. We characterize this ability first by focusing on the changes in deviation and recovery time across different events, and then by focusing on the changes in deviation and recovery time across the different complaint type indicator variables.

15.6 Characterizing Resilient Behavior for Each Resilience Dimension

We can qualitatively characterize the tradeoffs between the amounts of deviation and the amount of time spent recovering by examining the response curves for the positive and negative deviations in a specific type of call across the different events, as in Fig. 15.5. For example, from these response curves, one can see that even though the impacts of the 2010 Tornadoes on call volumes were significant and they persisted for quite a few days, the much larger initial impact of Hurricane Irene actually led to a lesser amount of exhibited resilience even though the call volumes stabilized much more quickly. The extremely low resilience associated with Hurricane Sandy, in comparison to the other two events, was the result of a combination of both larger average call volumes and a longer recovery time. We thus need to look at both average deviation and recovery time in order to be able to differentiate the ways in which different systems may be resilient.

Following the previous work of Zobel (2010, 2011a) and Zobel and Khansa (2012), therefore, we may compare the resilience associated with the different events by plotting the sub-measure of average percent deviation against that of the recovery time on the corresponding set of recovery curves. As shown in Fig. 15.6, this allows us to see not just the relative resilience of the different processes (each curved line represents the same resilience value, with values to the lower left being

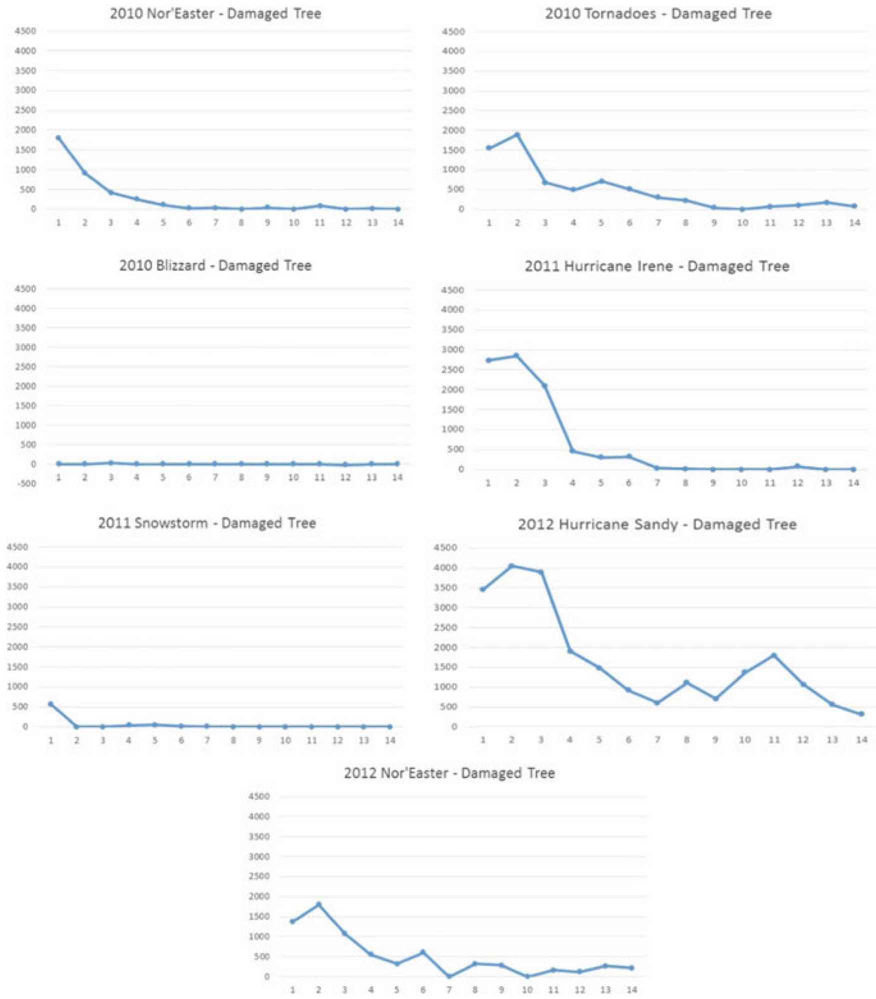

Fig. 15.5 Deviations in call volumes overtime for damaged tree calls during 2010–2012

closer to 100% resilient) but also the relative values of the two sub-measures for each event and each type of complaint calls. This, in turn, allows us to better understand the relative behavior of the different call types across all events.

For example, calls about *damaged trees* generally persist for much longer after an event than do calls for other types of complaints, even though the actual amount of deviation observed tends to be a little less and the time to recovery can still vary significantly across the different events. On the other hand, calls about *traffic signal* issues tend to change volume consistently across events, but the effect persists for different amounts of time depending on the context. In contrast, calls about *street light* issues have a wide range in volume after events but they generally subside

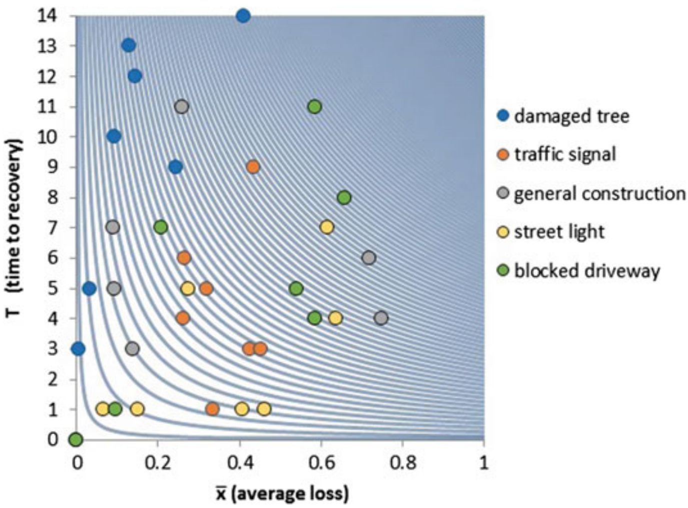

Fig. 15.6 Loss versus recovery time for each call type and event during 2010–2012

somewhat quickly. Except for two instances, calls about *general construction* issues tend to deviate only a little bit from their normal volumes and they are relatively widely distributed in terms of the length of time that the deviation persists. One can also clearly see that three of the events led to very similar levels of resilience in the general construction dimension because they are very nearly collinear, even though their associated recovery times were relatively different. Finally, calls about issues with a *blocked driveway* vary significantly across both time and loss, depending on the event. This suggests that the type of disaster event has a significant impact on the number of calls for this dimension.

15.7 Characterizing Resilient Behavior for Each Event

We may also explore the relative impacts of the different disaster events more directly by instead focusing on the time series response curves for each given event across the different resilience dimensions. For example, Fig. 15.7 provides the set of response curves associated with Hurricane Sandy in particular. Each of these graphs is scaled so that the largest value on the y-axis corresponds to the maximum deviation for the given dimension across all events.

These response curves easily allow us to see that Hurricane Sandy is associated with an increase in some types of calls and a decrease in other types of calls. Such differences can clearly help to describe the specific types of impacts that a given event has on the municipality. In this case, for example, the increased numbers of calls about *damaged trees* echoes the reports of downed trees as well as the reported

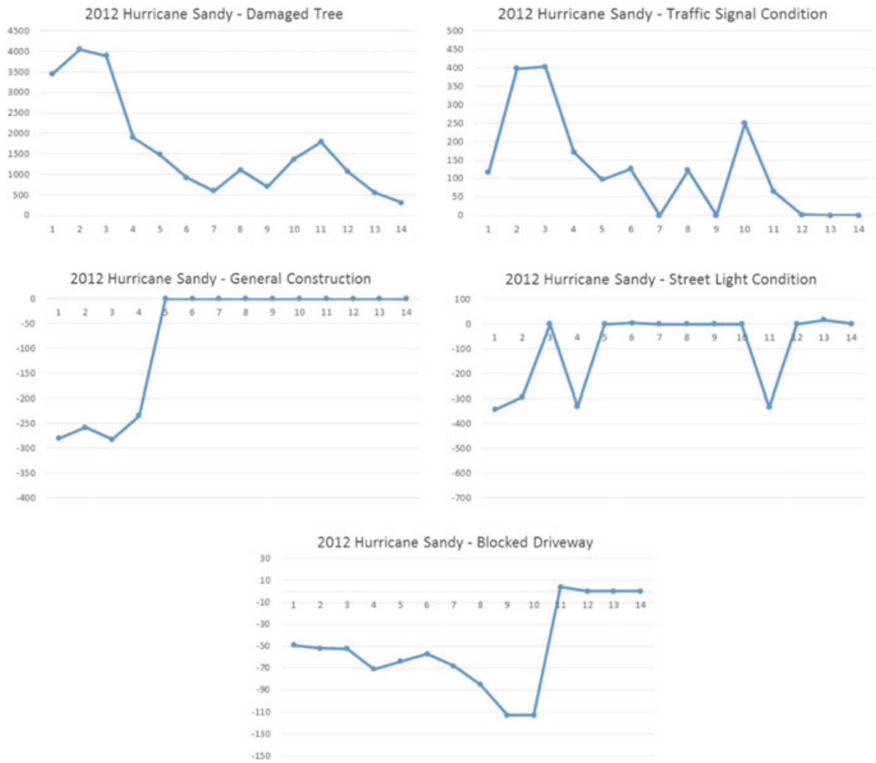

Fig. 15.7 Deviations in call volumes overtime for each dimension for Hurricane Sandy

wind speeds during the storm (NWS 2012). At the same time, however, the reduction in the number of calls about *blocked driveways* also reflects the fact that there were fewer vehicles on the road, and thus, fewer instances of vehicles being parked in such a way as to block a driveway. The drop in calls about *general construction* issues also reflects the fact that during a major storm, people will tend to actively complain less (at least temporarily) about problems with their cabinets or about stuck windows or doors.

Following the example of Fig. 15.6, it is also interesting to look at the different events in the context of the resilience curves and to assess the tradeoffs between call volumes and the persistence of deviations in volume from normal. Figure 15.8 thus displays the same set of observations as Fig. 15.6 but groups them by event instead of by resilience dimension. It quickly becomes apparent from Fig. 15.8 that Hurricane Sandy and the 2010 North American Blizzard had instances of the lowest levels of resilience (closest to the top right portion of the graph), and that on most measures, Hurricane Sandy led to higher average deviations and longer recovery

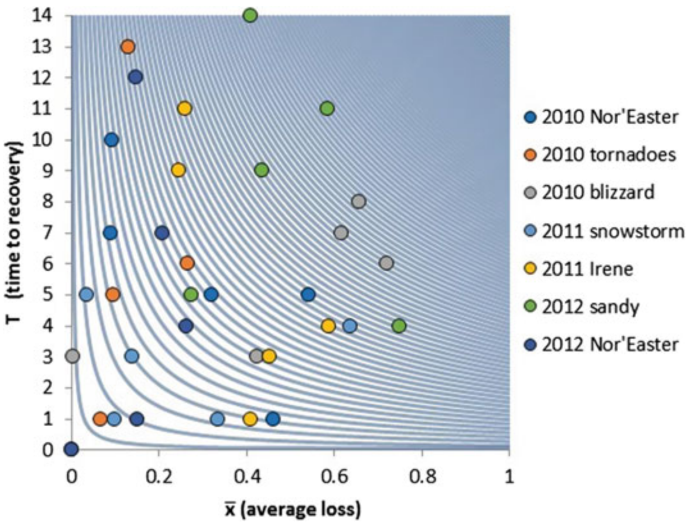

Fig. 15.8 Loss versus recovery time for each event and call type during 2010–2012

times than Hurricane Irene in 2011. One also can see that the 2010 Tornadoes had a wide range of recovery times but a smaller deviation in the number of calls than many of the other events and that the same was true for the 2012 Nor'Easter. In turn, the 2011 Snowstorm generally had less of an impact on either factor across most of the selected dimensions.

15.8 Summarizing the Behavior

If we take these results and create an equally weighted average of both the deviations and the recovery times, we can generate an overall average percent absolute deviation and an average time spent in a state of deviation for each of our five types of complaint calls. This generates a set of single observations that each correspond to the centroid of one of the subsets of points in Fig. 15.6, and it provides a more concise description of the relative resilience for each of the five dimensions (see Fig. 15.9). This makes it much easier to see the relative tradeoffs between loss and recovery time for each of our output measures, and thus to identify the relative extent to which each characteristic contributes to the overall measure of system resilience. Figure 15.10 provides similar information, but for each of the disaster events overall. By viewing the data in this way, it is straightforward to see which events caused the most deviations (Sandy, the 2010 Blizzard, and Irene), and the extent to which these deviations persisted overtime.

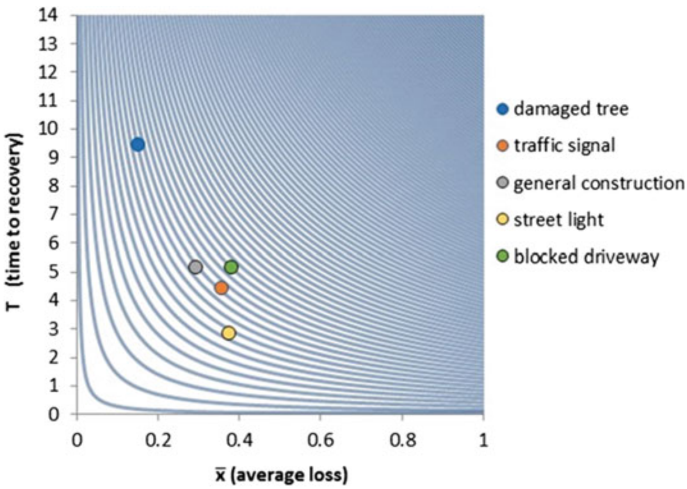

Fig. 15.9 Loss versus recovery time for each call type overall during 2010–2012

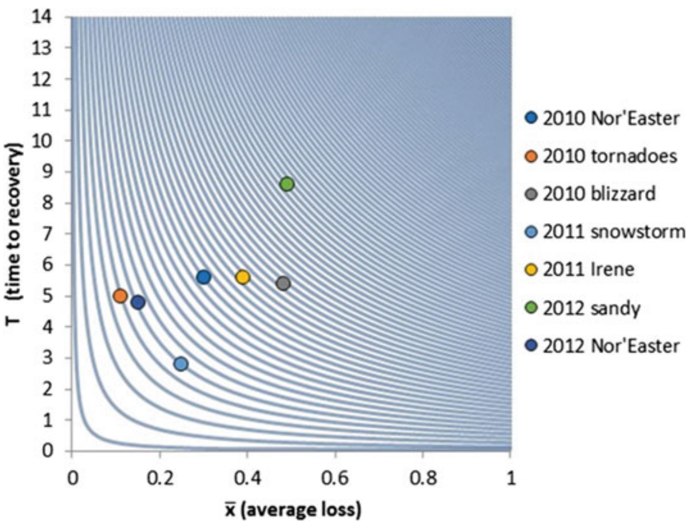

Fig. 15.10 Loss versus recovery time for each event overall during 2010–2012

15.9 Implications

The resilience of an urban community, with respect to a specific disaster event, is dependent on how well its component systems and processes can both resist and recover from that disaster, and thus there is significant value in being able to examine how those component elements behave and respond under disaster conditions. As we have seen above, we can gain a much better understanding of the ways in which the community is impacted by calculating and comparing the tradeoffs in the different types of behaviors that are exhibited in these interactions. This then allows us to better characterize the strength and persistence of an urban community's response within and across different disaster events.

The approach discussed above can be used as the basis for helping to identify which municipal services are likely to experience more (or less) demand after different types of disaster events. It can also help with assessing the degree to which that demand increases (or decreases) and the length of time for which it persists. This can be beneficial for crisis management planning and could inform decisions such as staffing changes or resource prepositioning.

From a political and public policy perspective, being able to identify how the community is being impacted by different kinds of disaster events can help the government to gain a better understanding of the population's needs, and how those needs change during crisis situations. Because the needs are being measured directly and the requests for services are unsolicited, the city can gain a much more accurate picture about the relative perceived importance of the different services that they provide than would otherwise be possible. From a strategic perspective, this can help with long-range planning and with improving policy to support the community in a more sustainable manner.

Such information can be leveraged, in particular, to help identify specific neighborhoods or geographic areas within the community that are more vulnerable, in different ways, to specific types of disasters. Analyzing the differences between neighborhoods or communities on these different dimensions can help to ensure that any fixed resource allocations are made appropriately and equitably, according to more localized needs. This can help to remove any unintended disparities in service levels during non-crisis situations, and it can lead to an improved capacity for resisting the impacts of crises when they do occur.

More generally, the approach above could help the municipality identify which aspects of municipal services are candidates for mitigation investments to reduce the initial impacts of a disaster (tree trimming to reduce the number of downed branches), or investments into quicker or more effective recovery operations to reduce the length of time that citizens are impacted (additional tow trucks to clear blocked driveways and roadways), in order, ultimately, to reduce the need for citizens to ask for help. It also could help to identify which aspects of municipal services may need *less* attention during and after a disaster event. This would allow resources to be allocated elsewhere, where there is more demand, and thus to improve the overall effectiveness of any disaster response.

15.10 Conclusions and Future Work

The approach discussed here provides the foundation for developing a more holistic, quantifiable characterization of the disaster resilience of an urban community. It specifically focuses on resilience as exhibited by the interactions between the community and the municipal service providers, and it concentrates on capturing the communication from the community to the municipality within a number of different categories of service requests. There are both quantitative and qualitative aspects of the approach, and it is easily extensible to other measures and other types of disaster events so that it is able to fit the unique characteristics of different urban environments.

The ability to simultaneously consider multiple dimensions of resilient behavior provides a powerful tool for better understanding how a community responds to a disaster. The different dimensions that are chosen as part of the analysis could easily vary depending not only on the municipality but also on the decision-maker (community leader, local official, business owner, emergency manager, etc.) and their motivation for better understanding the community's response to a disruptive event. The data to support characterizing the different characteristics of this response could also be drawn from a variety of different sources. The 311 data has a number of beneficial characteristics, such as a fixed structure for categorization and the open availability of past data, but one could also use Twitter data or data from other social media platforms to collect and analyze the community's behavior, both in crisis and non-crisis situations.

There are also a number of possible extensions to our approach for quantifying resilience that provide opportunities for further research. For example, although one can characterize the amount of significant positive or negative deviation in the number of calls overtime by analyzing the individual dimensions' response curves, as in Figs. 15.5 and 15.7, the resilience calculation is based on the absolute deviations. It, therefore, does not differentiate between positive and negative reactions to an event, either in its calculation or in its representation of the tradeoffs captured by the resilience curves in Figs. 15.8, 15.9, and 15.10. Since positive and negative deviations represent very different situations in this context, refining the approach to more clearly identify these different outcomes could improve the richness of the resilience visualization and the corresponding support for differentiating between different behaviors.

Another possible extension could be to incorporate a weighting scheme for the response to each type of disaster events, based on the total losses (i.e., physical or economic damage) suffered by the community in each instance. The extent to which the community's measured response correlates with the "actual" impacts of a given disaster could provide another interesting level of analysis. This could then be used to improve the potential predictive ability of the multidimensional resilience quantification approach, in support of more effective resource allocations and thus better service provision and support for the citizens in the community.

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Chapter 16
A Future-Oriented Agent-Based Simulation to Improve Urban Critical Infrastructure Resilience

Thomas Münzberg, Tim Müller and Wolfgang Raskob

Abstract The conversion to smart grids opens up a wide amount of possibilities to better control power distributions. The benefit is not only limited to a more secured and economical power distribution. It may also enable to bridge the gap between grid reliability management and disaster response. In particular under critical circumstances like grid instabilities, electricity may be missing or shortening. While distributing limited resources, the consideration of costumer's performances, their criticalities and vulnerabilities regarding lack of electricity and other vital services, and the focus on a sufficient continued supply of critical services in an urban area may have a significant leverage effect on urban resilience. To benefit from this effect, we introduce and discuss the foundation of an agent-based system for the purpose of building urban resilience through a decentralized and agent-autonomous coordination of CI services in a city during an emergency situation. Therefore, we introduce the specification of decision-making in the context of critical infrastructures and disaster management in this chapter. Furthermore, we discuss the basic ideas of modelling critical infrastructures as agents and we demonstrate how their functionality is implemented in the model. A key topic of this chapter is a discussion about the design of the agent's negotiation and its beneficial advantages in responding to critical infrastructure disruptions and in building more resilient cities.

Keywords Critical infrastructure protection · Urban resilience · Agent-based simulation · Decision support · Protection target levels

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16.1 Introduction

With the "Energiewende", the German electricity system is currently experiencing a fundamental transition. The transition is characterized by enhanced feeding-in of renewable energies, integration of new smart technologies, and continuing (digital) integration of infrastructures that were nearly totally separated in former times. This trend fosters innovations that are not just limited to the design of daily life procedures, the operations of networks, and the building of groundbreaking market structures. The fundamental transition also has high potentials to enhance urban resilience by a better management of service disruptions of so-called Critical Infrastructures (CIs). CIs provide vital services and thereby have high influence on the well-being of a population. It is of great public interest to keep CI services continuous or to fast recover them after a disruption in particular during and directly after disasters.

The organizational and technical transformation may allow novel coping strategy options, tactical respond advantages, and measures to manage emergency situations in more effective ways. However, it is still difficult to bring these potentials into practice. Therefore, we are developing a multi-agent-based model in which CI entities are described as autonomous agents that interact with each other and represent the CI services of a city or county under consideration. The multi-agent-based modelling approach should provide grid providers, CI utilities, and disaster management authorities with a decision support in how to beneficially use smart metre technologies for building urban resilience. At the same time, the approach should allow an enhanced understanding of the functional capabilities of interlaced CI services and of the onset of cascading effects. Therefore, simulating different kinds of disruptive events should allow comparisons of measure and strategy benefits that aim at a solid preservation of CI services.

To the best of our knowledge, there is still no sustainable design in the literature of how the agents interact and solve the problems caused by CI service shortages.

In this chapter, we introduce and discuss the foundation of an agent-based system for the purpose of building urban resilience through a decentralized and agent-autonomous coordination of CI services in a city during an emergency situation. The chapter consists of two sections. The first section is an introduction to the specification of decision-making. It comprises the definition of (urban) local CIs and urbanity and an accompanied discussion about the management to respond to CI disruptions. The second section addresses the development of the multi-agent-based simulation. This includes a discussion of the embedding of the agent-based simulation in the management procedures and the determining of agents in the context of CI protection and urban resilience. Furthermore, the agent-based distributed decision-making is discussed. The decision-making is based on the internal state of a CI entity which enables to determine the necessary resources to sustain a certain performance or to realize a sensible distribution of limited resources. To provide insights in the functionality and the implementation of the simulation, we discuss the modelling of the internal states of CI entities, the determining of necessary CI services, and the sensible distribution of remaining CI services. The section is concluded by a discussion of the advantages of multi-agent-based approach. The chapter is closed by a summary.

16.2 Urban Resilience and Critical Infrastructure Protection

In this section, we provide the underlying understanding about urban resilience and local CI entities which is the fundamental basis for the development of a multi-agent-based simulation for decision support. In the following, a brief discussion is conducted addressing the definition of CIs and urban resilience and the responds to CI disruptions.

16.2.1 Definition of (Urban) Local Critical Infrastructures

CI functions such as the supply of electricity, drinking water, and health care are essential basic structures and provide vital services to the population. Disruptions or failures of these services are hazardous and can lead to injuries or even losses of life, damage of property, social and economic disruptions, or environmental degradations (United Nations International Strategy for Disaster Risk Reduction 2015).

In accordance with the EU Council Directive 2008/114/EC on a common approach for the identification and designation of European Critical Infrastructures (ECI), there is a commonly used but not legally defined list of CI sectors and branches in Germany (Bundesministerium des Innern 2011b). It is reflected in many CI protection policies and mainly represents large-scale/wide-area CIs and supra-regional networks that are of national relevance (e.g. electricity transmission grids, cargo traffic, medical supply, etc.). However, this list is too coarse and not suited for the application in urban resilience. The urban resilience perspective requires a CI understanding of typical and concrete facilities that can be found in the majority of cities. Only a few large-scale/wide-area CIs or some components of them can be found in some cities. They are not representing the average local CIs of cities like hospitals, dialysis clinics, or pharmacies.

Usually, local CIs can be found in varying number and size in every city. However, a comprehensive and prevailing list of concrete facilities of local CIs is still missing in Germany. Many local disaster management authorities have compiled so-called local CI Cadasters or Land Registers (“KRITIS-Kataster”) about the local CI entities that are situated in their area of responsibility with relevant information (e.g. contact person, contact details, location, size, hazardous properties, emergency backup power capability, storage capacity (e.g. for food, consumables, drinking water, drugs), fuel tank capacity, emergency power infeed capability). These are often the only available documents about the individual characteristics of a city's local CI entities.

CI Cadasters are regularly kept as "living" documents which require periodic, cooperative, and interactive information exchange between the local disaster management authorities and the local CI entities. In Germany, this is often ensured by the establishment of CI protection partnerships which are promoted and led by the local authorities. The purpose of these kinds of cooperation is inter alia the creation of a common understanding and comprehensive treatment of risks and hence an improvement of urban resilience.

16.2.2 Urbanity and Local Critical Infrastructures

In the literature, many definitions can be found for the term urban resilience, e.g. (Meerow et al. 2016; Leichenko 2011; Chelleri 2012; Bhamra et al. 2011). An inclusive and flexible definition of urban resilience is exemplarily provided by (Meerow et al. 2016) who define urban resilience as "the ability of an urban system [...] 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". In the context of this chapter, we particularly focus on the ability of a system of local CIs to cope with the consequences of basic service disruptions. This initially addresses short-term resilience including a continued supply or fast restoration of disrupted services.

The "urban" understanding in this chapter addresses the public administrative responsibilities for crisis management according to the German crisis management system. In Germany, the independent cities and counties [the third administrative divisions according to the Classification of Territorial Units for Statistics (NUTS 3 level)] are operatively responsible to cope with any kind of crisis and disaster situation. For this purpose, they have appointed so-called crisis management teams which are in charge to coordinate all preparation and respond activities. Although some counties may also have urban character, we primary understand independent cities as "urban". This is also in accordance to the German regional planning policy which is following the central place theory. In this context, administrative divisions are distinguished regarding their infrastructural range of basic services. They are distinguished as centres of lower-order, middle-order, and higher-order. Historically based, an independent city had outstanding regional roles which mostly fostered the organic growth to a hub of local CIs. Hence, independent cities are almost exclusively determined as centres of higher-order which accurately captures our understanding of "urban".

16.2.3 Responding to Critical Infrastructure Disruptions

The response to a CI disruption comprises multiple challenges for disaster management authorities and CI providers. First, there is the nature of a city that is often understood as network of complex systems (Cruz et al. 2013; da Silva et al. 2012; Lhomme et al. 2012; Desouza and Flanery 2013). The functions of an individual local CI are complex themselves and can only be vaguely estimated by disaster management authorities. Furthermore, to conduct a CI service, the function of other basis structures is required. These interdependencies between different types of CI services are difficult to evaluate. Due to the interdependencies, it is possible that CI disruptions propagate through a CI system and escalate as cascading effects. This corresponds to the toppling domino theory that assumes an initiating CI disruption starts a sequence of additional disruptions on other CIs (Luiijf et al. 2009; van Eeten et al. 2011; Kadri et al. 2014; Pescaroli and Alexander 2016). From an empirical perspective, there is an overwhelming majority of cascading effects that are caused by disruptions in the energy and telecom sectors (Luiijf et al. 2009; van Eeten et al. 2011). This is not surprising as many analyses have shown that most of the CIs depend on electricity as well as on the information and communication infrastructures (Laugé et al. 2015; Stergiopoulos et al. 2016; Setola et al. 2009; Buldyrev et al. 2010; Kunz et al. 2013; Luiijf et al. 2009; van Eeten et al. 2011; Blake et al. 2013).

To obtain a clearer understanding of the role of interdependencies in network (large-scale) CI systems, dozens of interdependency models and simulations were developed in the last decades, e.g. (Ouyang 2014; Pederson et al. 2006; Yusta et al. 2011; Theoharidou et al. 2011; Eusgeld et al. 2008; Giannopoulos et al. 2012). In general, these tools provide useful insights in the functionality of large-scale CIs, but many of them do not adequately consider the need for decision support of local disaster management authorities. Usually, the application of the prevailing interdependency modelling methods (like system dynamics, Bayesian, and input–output modelling) request huge detailed information about the considered networks. In practice, this information—if available at all—is distributed through the CI entities but not held by a central or single party. The collection is time-consuming, repeatedly accompanied by compliance reservations and therefore often not in proportion to the added value. As mentioned before, the only available documents about the local CI entities of a particular city are in general the CI Cadasters or Land Registers which are supervised by the disaster management authorities.

Finally, the transition of the energy supply system provides new and powerful possibilities to manage crisis situations. Such crisis situations can be caused by grid instabilities or infrastructural destructions. There are multiple reasons for grid instabilities such as imbalanced load and generation or malicious cyber attacks. Destructions of infrastructures can be caused by sudden component failures, terror attacks, human error, or natural disasters.

The application of new mechanisms due to the Energiewende transition is still not sufficiently considered by the interdependency models yet. There is still a need for appropriate simulation and analysis tools for the purposes of local disaster management (Pescaroli and Alexander 2016).

Another important challenge in coping with CI disruptions is the question on how to appropriately respond to such events. The well-ordered service reduction at night times or at bank holidays clearly shows that it is possible to close some facilities for a limited time without causing additional risks. Likewise not every magnitude of service disruption automatically leads to a life-threatening situation. One reason for this is the fact that there are mechanisms like the determination of on-call medical units and emergency pharmacies which allow to maintain a minimum CI service at certain times. Another reason is redundancies, in particular in those cases in which CI entities are in a certain degree of competition. During a disruption of some CI entities, other still operational CI entities of the same type can step in and replace the missing service by providing an additional supply to a certain extent. Such local CI entities are for instance General Practitioners and pharmacies. In other cases such as hospitals and dialysis clinics, this only applies to some extent.

Furthermore, CI entities have coping capabilities to manage the effects of a services disruption for a limited amount of demand and time. Some processes are flexible, and it is possible to reschedule, extend, or delay their performance while keeping the key business of the CI service running. Also some CI entities have implemented coping capacities such as enhanced storage, larger than necessary tanks, and emergency backup generators that enable them to continue business without external supplies for a limited amount of time. Today, such coping capabilities are only used in the case of an emergency. However, the system transition may also motivate to reflect their use to reduce demands to keep a system of CIs in a city stabilized.

The reflections about admissible reduction of CI services imply that a system of local CI entities in a city can stay—even though for only a limited duration—in multiple states of stable equilibrium in which no (additional) risks occur. From an engineering point of view, however, there is only one single state of desired equilibrium that expresses the normal or initial state before the CI disruption occurred and to which a system has to be reverted to. For a detailed discussion of equilibrium and system resilience; see, e.g. (Holling 1996) and for a review in the context of urban resilience; see (Meerow et al. 2016).

Since years the determination of levels of CI supply that reasonably have to be ensured during a disruption of basic services to avoid (further) risks is of great interest in science, CI protection policy building and regional planning in Germany (Bundesministerium des Innern 2009, 2011a, 2012; Fekete 2012; Münzberg et al. 2014). The discussions revolve mainly around the so-called "protection target level" and the "minimum level of supply". Protection target levels ("Schutzziele") determine desired objectives for the implementation of coping measures. They define the reasonable lowest acceptable service level of a system that should be allowed or ensured as long as a CI disruption lasts. In this way, protection target levels also imply the tipping point between a safe and an unsafe system state. Hence, these levels can be understood as a maximal risk acceptance criterion that should be determined by political and societal debates. Depending on the type of CIs, the protection target levels are related to concrete facilities or a set of CIs of the same type. Furthermore, it is also imaginable to vary the target levels according to the type of considered regional centres or the spatial and temporal character of the CI disruptions. The concept of the "minimum societally accepted level of necessary CI service supply" ("Mindestversorgung" or "Mindestversorgungskonzept") is related to the discussion about protection target levels. It can be understood as the conceptual summary of all measures to achieve protection target levels in order to ensure the lowest reasonable level and safe stable equilibrium state of CI supply in which no (further) risks occur. In this sense, one seeks to obtain a safe shutdown state following a reactive failing-safe principle through maintaining an emergency supply. As there is still an ongoing debate about these levels, there are no common and standardized definitions, nor viable concepts for determining the levels, or solutions for the large number of legal reservations available.

Besides the minimum level of supply, it can be assumed that there are other safe equilibrium states in which a sufficient supply of basic services is ensured. To reach these desired states, a coordination between the CI providers is necessary that aims at optimal distribution solutions to satisfy CI service demands. Therefore, the effects of the CI system have to be understood and forecasted. In addition, a fast and adequate respond to system changes in a cooperative and altruistic way has to be ensured. However, the nowadays established CI protection partnerships do not fulfil these requirements. The single CI providers have only an isolated perspective on their own facilities, their facility-specific demands, and—if known at all—their safe state(s). There is only a restricted holistic systemic view referring to a sufficient supply of CI services in the city. The issues which CI facility to assist and how to upkeep business during a CI disruption are still difficult questions for CI providers and disaster management authorities.

16.3 Development of a Multi-agent-based Simulation

In this section, we discuss the development of a multi-agent-based simulation in accordance to the previously mentioned framework. Therefore, we first discuss how the multi-agent-based simulation could be embedded in the current and future management procedures. Secondly, we introduce the general approach of modelling agents which consists of the definition of agents, the modelling of the internal state of a CI entity, and a discussion of the advantages of this concept.

16.3.1 Embedding the Agent-Based Simulation in Management Procedures

At present, agent-based decision-making support has to be considered from two different views, as the agent-based model of a city's local CI entities and the real world city infrastructures are still strictly separated. Regarding this separation, the model currently can only be applied to simulate scenarios and evaluate the outcome of measures.

Nowadays, a crisis management group would be activated in a city in an event of a severe CI disruption like a long-term power outage or a cut-off of the water supply. As mentioned before the purpose of this group is to organize measures according to the nature of the occurring event. This procedure requires the gathering of all relevant information, especially from the CI entities of the city, to define the specific needs of the structures and to determine and commit appropriate measures such as distribution of remaining resources to achieve the highest benefit for the city.

This centralized view on decision-making in case of an emergency is straightforwardly established as the decision makers are human beings. However centralized decision-making inherently contains some disadvantages like a time delay during gathering the required information from the CIs until it can be processed and until certain measures can be committed. Additionally not all required information might be available in time, or recently changed or added information that may be useful is locally available but cannot globally be considered as it is not yet part of the process plan of the centralized working decision makers.

However, the strict separation exists for historic reasons as the required smart technologies were not yet available for integration at that time. Nowadays a crisis management group may use the results of the agent-based simulation to improve their decision. With the introduction of smart grid technologies it is not unlikely in the near future for the software agents of the discussed model to become part of the CIs as an intelligent embedded system and to actively contribute to a distributed decision process in a physical world. In this case the CIs should communicate and negotiate directly with each other avoiding the error-prone communication detour via the human crisis managers. Once the agents have concluded appropriate measures, they can be communicated to and used by the human deciders for the final decision-making.

The information exchange between the agents requires a functional communication. In crisis situations this can be limited or unfeasible (for instance during cyber attacks or destructed communication lines). However, agents may also identify available and missing communication links and integrate such findings in their decision-making process. Apparently, the manipulation of smart metres and agents may have severe impacts. Therefore mechanisms have to be developed to prevent the manipulation of smart CI components and to orchestrate an appropriate reaction to such adverse states respectively malicious intrusions.

16.3.2 Agents in the Context of CI Protection and Urban Resilience

The use of software agents is a generic programming paradigm that can be applied to solve various problems. Many different definitions of the term software agent exist. According to (Weiss 2000) a general and widespread accepted definition of an agent is the following:

"An agent is a computer system that is situated in some environment and that is capable of autonomous action in this environment in order to achieve its delegated objectives".

The key term in this definition is the autonomous acting of agents, thus providing a rather local and distributed approach of modelling in contrast to a monolithic and centralized view. The use of agent-based modelling is motivated by the direct transformation of city components to the software agent paradigm. The local CIs of a city are basically autonomous entities within the city environment. Different types of CIs result in different types of agents. The objectives of these entities are to provide services to the city like hospitals or to sustain themselves like households. Beginning with smart grid technology these entities start to sensor their environment and to communicate with each other to improve the distribution of resources or to establish the exchange of different services. Therefore the transfer of the city structures and their interdependencies into an agent-based model is reasonable and straightforward. Generally speaking all agents provide one or more services of specified quality at a specific price to the community.

In the following, we will synonymously refer to agents as representatives for specific CIs and vice versa as we pretend that agents will be fully integrated into most of the CIs respectively consumer and producer entities of a city in the future even if this is not done yet. Fortunately the implementation and evaluation of the required methods are independently possible on existing computer systems.

16.3.3 Agent-Based Distributed Decision Making

In contrast to centralized decision-making, an agent-based model of a network of intelligent entities encourages a distributed decision-making process. In principle and regarding real-life processes, the decisions are made by human beings in crisis management groups who make the finaldecision . Though distributed decision-making comes not naturally to humans and is at first difficult to understand, it provides some notable advantages: the agents representing the CIs possess all the necessary information on the state and requirements of the CI they model. No information transfer from structure to human being is required. Information transfer between agents is much faster and less error prone. Agents can consider every bit of currently available information even recently added or specific to their instance. Last but not least the upcoming smart grid technologies will install such intelligent entities and thus implicitly encourage a distributed decision-making process in the physical world. Still it is important to stress that even in the case that intelligent agents will autonomously suggest high-quality measures the final decision has to be made by human beings.

The very nature of agents lies in their autonomy. In a distributed decision-making process agents should autonomously react to changes in their environment, i.e. the city state and plan their future acting accordingly. In addition to the knowledge of their individual demands like, e.g. a pharmacy agent knows the average amount of cooled medicaments it has to provide under certain circumstances, the general following requirements must be fulfilled:

- The needs of an agent are not automatically identical to the needs of the city. Therefore the current needs of the city must be available to the agents in a way for them to understand it. This information is basically the request the crisis management group would face. Though the desired process of decision-making is distributed, the global needs of a city are rather centralized defined (beforehand) and have to be accessible. For simplification and without loss of generality it is possible to introduce a "city agent" who provides the necessary information like, e.g. "city district X should never be shutdown" in a data storage. For convenience other global information like, e.g. "42 people require permanent dialysis treatment" can be stored also, even if most of this information originates in the agents themselves and could be generated on demand. This kind of knowledge must be available to all agents. However its technical realization, e.g. if this information is really only centralized available or replicated to some or even all agents has no influence on the decision-making process.
- Agents should behave rational and altruistic. In practice this can differ because, for instance, some CI provider may be in competition with other providers and may try to misuse an emergency situation for their individual benefit. At the current stage, we assume similar behaviours of CI entities if they are from the same type without considering a wide range of variations. In future, the agents behaviour settings may vary based on a customized adaption. That should also include the provider's preferences probably characterized by non-altruistic interests. As in decentralized decision making, the individual CI providers preserve the sovereignty of information in particular about their internal state and its development during the duration of an outage situation. A non-altruistic agent respectively provider may misuse this asymmetry of information. This corresponds to the principal-agent problem in which CI providers use their information advantage to reach a better market outcome without considering the overall risk potential for the population.
- Agents react and interact on their environment and with other agents as they are permanently negotiating about services and planning their joint actions. Even though it may be technically challenging, we assume that measuring and communication are not interrupted even during a general power blackout. On a side note a disruption of communication would also hinder a centralized

decision approach. If the direct, automated or digitalized communication is broken no up-to-date information is available to a centralized crisis management group either. In this case centralized decision-making by the crisis management group is always the valid fallback solution, yet information has to be physically transferred to them by, e.g. motorbike messengers. An additional ad hoc deployable interface between cut-off analogue infrastructures and the digital smart grid would also be a worthwhile idea in such cases.

- Most notable for the agents to negotiate with other agents is that they require a frame of options to negotiate with. Some agents show a binary behaviour, i.e. if not all input requirements are fulfilled they cannot provide any service. On the other hand, for some agents, the quality of the provided service is debatable due to multiple internal equilibrium states that can be reached without causing additional risks. In addition, an entity is also allowed to increase the performance or quality by increasing higher input values, or loosely speaking, an agent provides better services for a higher price. "Quality" in this context may be defined as combination of attributes like duration of a service, number of people affected. The more options agents have for negotiations the higher the degree of freedom and the higher the dynamics and the flexibility they have to determine better solutions.

On a more general approach, an agent proactively aims for a specific task to fulfil, which is to keep itself alive and acting in the given environment. As a result it aims to achieve a desired internal equilibrium between the offered resources and the realized production respectively quality of service. It does so by tracking its internal state, by measuring changes of the environment, by communicating and interacting with other agents, and by more or less intelligently adapting its behaviour based on its state and environment. To provide an agent with this capability, a model of the internal state is required. Such a model is discussed in the next section.

16.3.4 Modelling the Internal State of a Critical Infrastructure Entities

The goal of the internal state modelling of CI entities is to provide agents with the capability to simulate and track their performances under the condition of insufficient supply respectively input services. A CI entity relies on a sufficient supply. In case of limited resources, the entity is usually not able to fulfil its contract respectively provide the negotiated quality of service. This may lead to a reduced or missing availability of CI services which can cause further severe impacts to the population.

The modelling of the internal state of a CI entity should enable an agent to autonomously simulate the consequences of a reduced or a lack of supply to evaluate its resulting overall performance. Usually, an entity can upkeep its business only for a limited time in the case of missing supply. By means of the modelling, it should be possible to calculate the internal equilibrium state of a CI entity in which it can provide a specific amount of service under restricted condition. The results enable agents to draw conclusions about their performance development in the near future which can be communicated to other CI entities respectively other agents and used for distributed decision making.

The consumption and production of a CI varies depending on the CI type, season, weekday, and time of day. It can be assumed that the CI entities from the same type behave similar. This fact allows an admissible simplification of using sub-models for specific CI types. The same underlying sub-model is used for all considered CIs of the same type. Although the CI entities of the same type have similar behaviour, their consumption and production varies with their size, service capacity, or utilization potential. In addition, the underlying core processes in a CI entity have differently implemented coping capacities which allow either shorter or longer continuation of business during a situation of lacking supply. The variations of size and coping capacity are considered by developing scalable sub-models for each CI type.

The use of scalable sub-models ensures a flexible integration of CI entities to a multi-agent-based simulation taking into account the concrete CI system environment of the considered city. This allows fast adjustments corresponding to the city's CI entities, their types and sizes. The requested information of the CI entities is usually comprised in the CI Cadasters. This reduces the expense for data collection and simplifies the implementation process.

The first maturity stage of the development of a multi-agent-based simulation includes the supply of electricity, drinking water, and medical products for households and for selected CI entities that provide health services in a city. The CI entities that are considered in this stage are drinking water supply, hospitals, dialysis clinics, general practitioner's (GPs), and pharmacies. Yet this is just a small subset of local CIs that could be considered. Nevertheless, these CI types allow a first test bed for the development and demonstration of the agent-based simulation. The physical interdependencies between the considered CI types are visualized in Fig. 16.1.

Figure 16.1 displays the interconnections of the CIs. This is also used for the determination of input and output goods for each CI entity. Input goods are defined as those services on which a CI entity relies on (consumption perspective). Output goods describe the service offered by a CI entity (production perspective). Input and output goods have a key role in the sub-models whose development will be described in detail in the following.

A sub-model is developed for each CI type. Each sub-model can be understood as a micro-simulation of a CI entity that consists of all key process elements to conduct the core service of the entity. A sub-model usually consists of multiple key process elements which rely on the input goods. In some cases, the key process elements themselves are also interconnected and provide input goods for other key process elements.

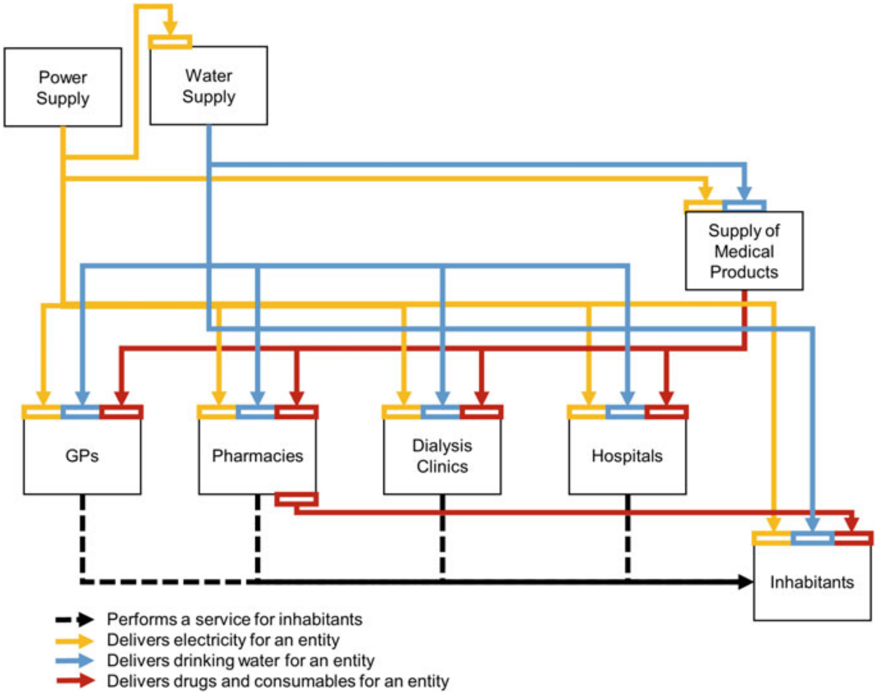

Fig. 16.1 Visualization of physical interdependencies between selected CIs

To ensure a structured and consistent proceeding, a comprehensive approach is defined for the development of CI type specific sub-models. This is based on following steps:

- Step one: identifying the internal core services of an entity and defining the corresponding key process elements,
- Step two: identifying the input goods for each key process elements,
- Step three: mathematical determination of general key process element's functionality by at least a daytime specific consumption function, a criticality function, and a continuity function for each of the input goods,
- Step four: aggregating a key process element's performance,
- Step five: aggregating the overall CI entity performance,
- Step six: checking plausibility.

The approach is generic and has to be adapted to the individual structure and the functionality of a CI type. Step one to three are conducted accompanied by the literature reviews, extensive data collection, and interviews with CI providers, operators, and experts. As a first result, there is a visualization for each CI type specific sub-model displaying the considered key process elements and their

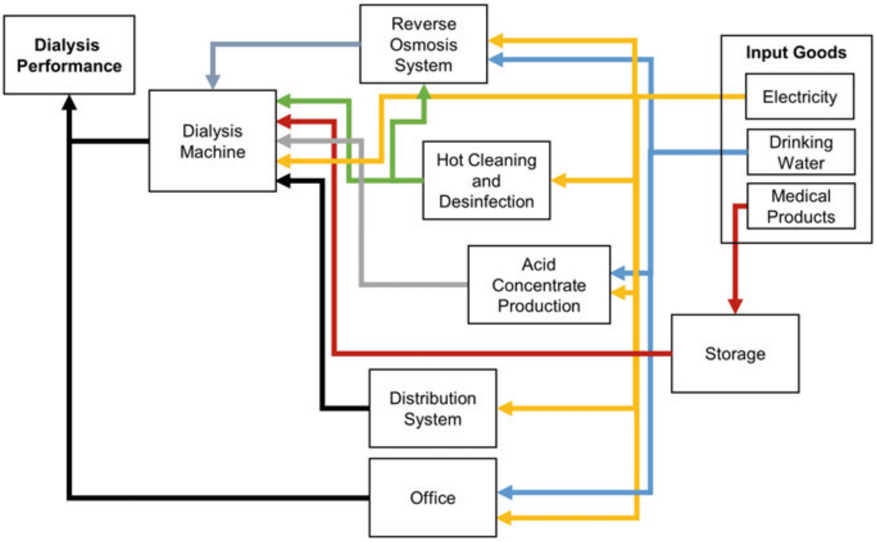

Fig. 16.2 Visualization of considered key process elements of a dialysis clinic (such as Reverse Osmosis System, Dialysis Machine, Acid Concentrate Production, Office) and their interconnections in the corresponding sub-model

interconnections. An example of such a visualization for the CI type of dialysis clinics is displayed in Fig. 16.2.

Figure 16.2 shows the identified key process elements and their interdependencies for the sub-model of a dialysis clinic as a result of the steps one and two. The determining of mathematical functions in step three aims at the function of the key process elements and their modelling. In this step, at least a day-time specific consumption function, a criticality function of input goods, and a continuity function are determined for each of the input goods of a key process element. The day-time specific consumption function represents the variations depending on season, daytime, and type of day. It takes into account different capacity or potentials of a CI entity, hereby enabling scalability. Although the function represents the consumption of input goods under normal conditions, it is also possible to calculate the consumption for an emergency-triggered increase or decrease of demand. This also includes capabilities to reschedule, extend, or delay some processes if possible. The criticality function describes the consequences on the performance of a key process element if the input goods are missing. It determines the behaviour of the key process element during a lack of input goods. Furthermore, some key process elements are able to keep up a continuous business even in the situation of missing supply. This is caused due to the use of coping capacity and reflected in the determination of a continuity function. The continuity function is scalable according to the amount of implemented coping capabilities in the key process elements. In step four, the functions are aggregated to calculate the performance of the key process elements. In step six, this allows a simulation of the

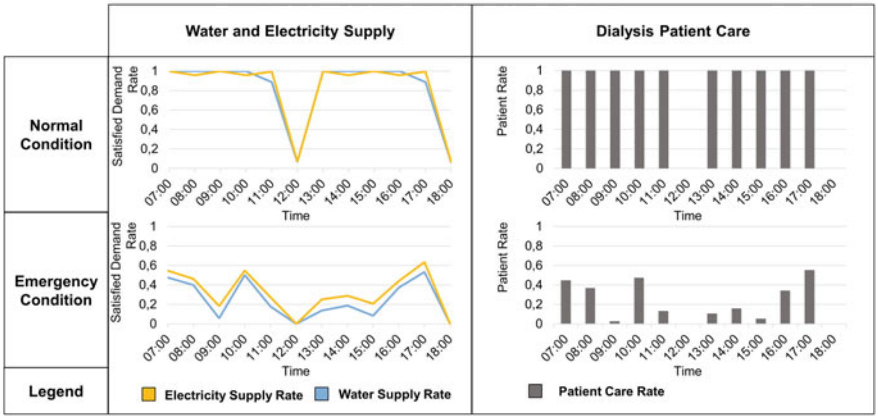

Fig. 16.3 The results of fictive simulation runs calculating performances of a dialysis clinic under normal and emergency conditions in which the supply of electricity and drinking water is reduced

consequences for the whole CI entity and a forecast of the internal state for the time during an event of missing CI services.

In case of a concrete dialysis clinic, the sub-model can be applied according to the size of the clinic and the coping capacity of its key process elements.

Models established this way can be tested by a fictional emergency condition that simulates changes of the supply for a couple of hours (see Fig. 16.3). The simulation results of this example show the development of the quality of service during a day and hence the internal state of the whole CI entity for the considered outage scenario. The varying supply of the input goods electricity and drinking water has severe impact on the performance of the clinic. The adjusted sub-model enables to forecast the internal state of clinic taking into account the reduced amount of input goods. The comparison between the normal and emergency condition demonstrates that the dialysis clinic can only ensure a continuous business for a limited amount of patients. A permanent supply is no more possible under the emergency conditions.

This finding provides detailed insights about the still available CI services of the analysed entity. The consequences of an outage scenario can then be analszed by taking into account the performance results of all CI entities in the considered area. The results of different scenarios assist the decision on how to distribute available resources (like electricity, emergency power units, or fuels). Ideally, a smart distribution achieves the highest possible beneficial equilibrium in a city, and, at best, outage of CI services is prevented.

In practice, the CI providers and the disaster management authorities have to negotiate the distribution. In future, this negotiation may be automatically realized by the use of smart metres and their communicative connection in a smart (grid) environment. However, there is still no knowledge available about how the negotiation process has to be implemented to reach the highest beneficial outcome. It can be assumed that different negotiation approaches lead to different results. Hence, the selection of a specific method is significantly levering the resilience of a region. To shed light on this issue, we are aiming at simulating and comparing different agent negotiation methods in our upcoming research.

In the next sections, we discuss the aspects to be considered when negotiating the determination of required resources to sustain a certain performance and the sensible distribution of limited resources to achieve the highest possible beneficial equilibrium in a city.

16.3.5 Determining Resources to Sustain a Certain Performance

During a power blackout or a training exercise, the question is of interest what resources are required to provide a specifically given performance, especially a minimum supply of services, by the CIs of a city. In general, this question is not triggered by changes in the environment but is explicitly requested by the crisis management group, and thus the agents have to be explicitly instructed to solve this request.

As presented in the previous section, all agents define state transfer functions to predict their internal state depending on their environment, mainly the available supply of power and water. The internal state is then simplified to a single performance value. However, the request to determine the input parameters that are required to achieve a specified performance value requires the inverse of the state functions. In general, these functions cannot easily be inverted, and sometimes it may not even be possible. Nevertheless, a straightforward method to estimate the parameters to achieve a certain performance is to iteratively vary the input parameters until the estimated performance is satisfyingly close to the desired one. This brute force approach can become computing time intensive depending on the parameter space and state transfer functions, yet it is simple and yields to the desired results for a single, local agent. The overall performance of a group of agents can be defined as sum respectively aggregation of the single performances of the agents.

To determine the requirements for all agents of a city, each single agent has to be questioned with a specific local goal. While this is possible, it requires human coordination by splitting the global request to local ones. Also on a global scope better solutions requiring less resources to achieve the same performance may exist, especially if different qualities of service are available and the agents are able to provide them according to the input they are granted. To voluntarily provide a service with lower quality for less resources assumes an altruistic behaviour of the agents where agents may relinquish resources for the good of the society. To benefit from this behaviour, it is therefore preferable to define a city-wide performance like a performance value for dialysis clinic (or in absolute values an amount of patients to be treated) and let the agents determine the required resources for the global request.

Striving for the globally optimal solution of this request is not trivial because of the complexity of the combinatorial possibilities. It is still an ongoing research how to improve the approach yet confine the computation time to an acceptable limit.

16.3.6 Sensible Distribution of Limited Resources

In case of a power supply disruption, there may be still some resources left to be distributed between the agents in a way to maximize the benefit for the city. Such an optimisation problem where packages (service for resource) are packed to maximize the outcome are generally known as knapsack problems as described in, e.g. (Zäpfel et al. 2010). Sophisticated algorithms like (Polyakovsky and M'Hallah 2007) are known to address these combinatory problems in multi-behaviour agent environments. In the following section, we want to address the potential framework of input parameters that can be considered for sensible distribution respectively negotiation. Several stages of complexity can be distinguished:

- The least complex request is the assumption of equal types of agents with no flexibility. They require certain resources as input and provide their service in return. The quality of service of such agents, respectively their performance, is either 1 (available) or 0 (not available). The distribution request can be straightforwardly solved by algorithms like the knapsack method.
- A more complex request is the assumption of equal types of agents with flexibility in quality of service. They achieve different performances depending on the provided resources. In case the performance of the agents is discretely depending on a small number of input possibilities, the distribution request may still be addressed by knapsack algorithms and by varying the discrete input possibilities. Non-discrete performance dependency of resources can be addressed by introducing discrete classes. However depending on the variation of input possibilities, the computing complexity may increase quickly.
- The most complex request is the assumption of different types of agents with flexibility in quality of service. The different types of agents follow some global conditional restrictions like hospitals are more important respectively critical than households therefore they have to be supplied first [for more insights about the criticality of CI types see (Münzberg et al. 2017)]. Basically this request adds another degree of freedom to the problem increasing the complexity an additional time. Determining the optimal distribution for a city in a reasonable amount of time is currently impossible and one has to settle for a "satisfying" distribution in an acceptable amount of time, e.g. by limiting the computation time and using the best solution so far.

In case of a CI service disruption, the agents will sense it by the sensors in their environment and autonomously begin to investigate coping methods and the distribution of remaining resources. In the following, we present some considerations how agents could react in that case.

- Initially, the agents should organize themselves in groups with a distinguished leader according to their types as this will help to coordinate and to communicate with external partners like the human beings from the crisis management group.
- The group leaders then will investigate the available resources. Such resources can be provided externally by, e.g. emergency power generators or from within the city by, e.g. solar panels of local households.
- Next, the leaders agree on different tasks in descending order of importance to perform. The highest mandatory tasks are directly endangered human lives. The secondary tasks may be highly valuable facilities or institutions. The tertiary tasks may be the prevention of minor injuries, and so on. This requires global knowledge (which may already be implemented in the agents behaviour) and has to be fixed by the accident management group beforehand. The agents will try to address the tasks in the order of importance.
- For each task, the agents know if they have to contribute to fulfil it. As an example, a hospital may have patients in need of intensive care. As consequence, the hospital will join in the negotiations of resources in the first round as human lives have highest priority.
- The distribution of resources itself can be determined in many different ways. Besides straightforward approaches like the knapsack algorithm agents provide other methods of coordination and interaction like negotiation and bargaining, auctions, goal programming, multi-objective optimizations, arguments, game theory, and many more (Weiss 2000). As an example of negotiation, the hospitals of the city may offer their service in turn for resources. To do so they need a protocol, i.e. a common understanding of expressions and statements used in the negotiation process. Expressed in human language a hospital may offer in terms like "I can provide intensive care for 4 people for 10 kWh, or for 10 people for 20 kWh". Another option could address the targeted achievement of a desired set of objectives like it is given by protection target levels or equilibrium states such as the minimum level of supply ("Mindestversorgung") or other safe states in which a sufficient supply of basic services is ensured. In all cases, it is up to the leader to organize the negotiations. Many options and parameters are possible to be taken into account, like performance indicators, vulnerability values, stakeholder preferences, time dependencies, absolute and relative attribute values, location, available coping capabilities, to only name a few.
- As the agent behaviour and the negotiation process is organized in time steps, one has to be aware of looping logic problems. Contradictions may occur between different time steps due to the negotiation process in one time step is based on forecast of the internal state. This state may be changed according to

the negotiation made in former time steps. The problem can be addressed by using longer intervals for the negotiations such as concrete block bids that consider a supply of a CI service in a specific amount for a specific time period of, e.g. multiple hours. In this way, the agent may periodically negotiate at different points in time during the whole outage time.

- Finally, the leaders distribute the fixed agreements to their group members and external partners like the crisis management group. In case of no contact to external partners, the agents could either perform the measures autonomously or do nothing, depending on the pre-adjustment of the crisis management group.

The presented process is highly complex and a field of ongoing research as we are constantly refining and improving the suggested procedures.

16.3.7 Advantages of Multi-agent-Based Approach

In comparison to other decision support approaches like optimization algorithms carried out by a single instance, the distributed agent-based approach provides inherent advantages like most notably scalability, extensibility, focus on local resilience, up-to-dateness, and transparency.

Scalability: Agent-based modelling provides a great flexibility in scaling as agents are in general service providers. For example, to model the power consumption of households, a coarse agent model aggregating each city district may be initially sufficient. Such an agent can simulate the consumption depending on the number of inhabitants in a district and a characteristic function. However, at some point, a more accurate simulation of household consumption per street may be required. In this case, the district agent will not use its characteristic function anymore, but will delegate the request to sub-service providers, e.g. newly introduced street agents in his district. Thus, a more accurate simulation of household consumption is possible, yet the general structure of the overall model has not to be changed.

Extensibility: At some point in time new types of CIs or more general, additional types of consumers and producers of resources are added to the city model. Centralized decision-making would require a reconfiguration of the whole decision process, a revision of the information flow between CIsand decision makers, and further technical actions like re-compiling and deployment. The distributed decision-making shifts the “knowledge of how to decide” into the software agents. This of course requires rather intelligent agents that are able to organize themselves, to acquire necessary data, and to appropriately react on the changing states of a city. As a benefit of this approach, new light-weight agent types like solar panel agents as power producer can simply be added to the network as they contribute to the decision process in a generic way by their very design. Nevertheless, the introduction of new heavy-weight CIs that interact and affect all existing agents in a specific way like some infrastructure comparable to the water supply will require a modification of all concerned agents.

Local resilience: With increasing smartness of the local components (smart grids) more and more small, local providers of resources are available like households feeding solar panel power into the power grid. While in default operation mode, these small providers may be mainly helpful to contribute green decentralized generated power to the network, in case of a serious network disruption they can significantly decrease the vulnerability in their neighbourhood. Assuming the producers and consumers of this neighbourhood are smart agents, they are capable to detect the cut-off from their main supply. They will start to distribute the locally available resources as an isolated (island) operation without the need for a centralized management, thus fast reacting to the situation and forming resilient islands.

Up-to-dateness: A very important problem in a decision situation is the correctness or up-to-dateness of the underlying data like the number of actual patients in a hospital, currently closed streets, or local maintenance downtimes. Depending on the type of CI, the relevant data describing the state of the structure can be more or less outdated at the time when the decision is to be made. This can be caused by lazy updates of the state, especially if updates are done manually by human beings, or by delays in the transport from the structure to the deciders. In both cases, smart agents can reduce this inherent problem. On the one hand, agents can measure their environment state and, depending on the available sensors, are therefore always up-to-date. On the other hand, in case of a distributed decision-making, there will be no delays caused by requesting and transferring the necessary data to a centralized location.

Transparency: As smart grids are introduced, the concept of more or less autonomous and intelligent entities maps directly to an agent-based software approach. Therefore, the modelling and comprehension of agents is much more straightforward and comes naturally to human beings in contrast to a centralized model even if the applied methods are basically the same. Such transparency can be very helpful to better understand the processes of an urban area

16.4 Summary

The introduction of smart grids into urban areas opens up a wide amount of possibilities to better understand critical infrastructure processes of a city and as consequence provides insights to improve the resilience of a city against disruptions of basic service supply. The realization of the entities of a smart grid as software agents in a multi-behaviour agent system not only allows to simulate and analyse supply disruptions today but also motivates a direct embedding of software agents in real devices in the near future.

The presented approach was preliminary implemented using the Repast Simphony framework (Argonne National Laboratory 2015) for evaluation of the concept. This framework is a Java-based, cross-platform development environment for agent modelling. The models for this CIs were derived by the above noted procedures and implemented in Repast Simphony as Java classes with Java

Fig. 16.4 An agent-based realization of some critical infrastructures of the city of Karlsruhe. The different icons indicate water supply, hospitals, pharmacies, and dialysis clinic. The green and blue bars indicate the state of the power respectively water supply of the according structure for the considered point in time of the simulation

annotations (Collier and North 2016). Annotations are compiler meta-directives, which in case of Repast Simphony are used to mark the interface points between main frame and model implementation. Additional information on agents is derived by implementing agents as JavaBeans and by the framework using Java introspection techniques, thus simplifying the implementation of agents. Figure 16.4 shows the visualization of some CI entity agents (water supply, hospitals, pharmacies, and dialysis clinic) of the city of Karlsruhe. To achieve this, the implemented CI types were instantiated with real-life CI entities using parts of the original information of the CI Cadaster of Karlsruhe and publicly available information from e.g. OpenStreetMaps.

On the one hand, these agents can autonomously determine appropriate measures to cope with supply disruptions if they are cut from their supervisors. In the near future also, other CI types will be modelled and implemented to consider as many relevant local CI services in an urban area as possible. On the other hand, their localized and comprehensive analysis is a valuable contribution to the decision support process of the human deciders of a crisis management group. The findings can be used in the disaster preparation phase to provide valuable information of how to implement an agent-linked smart grid transition process and to enhance the resilience by using simulations to identify capability weaknesses and strengths of a city's CI services.

Taking into account future developments of city systems over decades, agent-based simulation will potentially enable to identify pathways for enhancing urban resilience. We therefore shed light on the basic modelling approach, and in particular on the strategical negotiation of agents, to prevent undesired states of vital service provisions. It is an essential foundation of our research activities on simulation-based decision support for Critical Infrastructure Protection (for more details, see also Ottenburger and Münzberg 2017; Raskob et al. 2015a, b).

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Chapter 17
An Indicator-Based Approach to Assessing Resilience of Smart Critical Infrastructures

A. Jovanović, K. Øien and A. Choudhary

Abstract The overall resilience of modern societies is largely determined by and dependent on resilience of their critical infrastructures (CI). These infrastructures are becoming increasingly smarter and more efficient by means of smart technologies such as sensors, gateways, processors. The use of smart technologies also makes the CIs increasingly interdependent and vulnerable to various hazards. CI resilience against threats, such as cyber-attacks, terrorist attacks, natural hazards, is pivotal to ensure continued operations and well-being of the society. To achieve this goal, understanding and measuring the resilience of the CI is of key importance. The main objective of the current research agenda is to improve existing approaches by providing an innovative "holistic" methodology for assessing resilience of smart critical infrastructures. The methodology proposed here, as part of the SmartResilience project, is based on resilience indicators (RIs), and it is structured in six levels (RIs, issues, phases, threats, CIs, and area/city) to obtain a measurement of the CI resilience within an area such as a city. The methodology helps understand "how resilient the CIs are against particular threats" and "what measures could help improve their resilience." Furthermore, the chapter also provides first results of the implementation in sample case studies. This methodology is expected to be useful to visualize, trend, and benchmark the resilience at regular intervals, contributing to resilience management of smart critical infrastructures.

Keyword Critical infrastructures · Smart technologies · Resilience indicators Resilience assessment

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17.1 Introduction

17.1.1 Resilience of Critical Infrastructures

The overall resilience of modern societies is largely determined by and dependent on resilience of their critical infrastructures such as energy grids, transportation systems, governmental bodies, and water supply. This is clearly recognized by the European Union in its policies and research agenda, such as the DRS (Disaster-Resilience) actions and projects safeguarding and securing society, including adapting to climate change (European Commission 2013). In this context, the issue of "measuring resilience" has an important place and it is tackled primarily by means of indicators, within the DRS-14 line of calls (European Commission 2013) emphasizing the need for "… a better understanding of critical infrastructure (and)… for defining measures to achieve a better resilience against threats in an integrated manner including natural and human threats/events (e.g. due to human errors or terrorist/criminal attacks)…" The overall goal of the current research agenda is, hence, to improve current approaches by providing an innovative "holistic" methodology for assessing resilience of critical infrastructure. The methodology proposed here, as part of the SmartResilience project (SmartResilience 2016) is based on resilience indicators. The EU does not provide a clear definition or framework for tackling the concept of resilience—single projects and activities currently follow a number of often quite different paths. Thus, one main goal of the recent research agenda is to establish common frameworks, approaches, definitions, and guidelines.

Resilience concepts have been developed by, e.g., the Federal Agency of Emergency Management (FEMA), which is a part of the United States Department of Homeland Security (USDHS) (FEMA 2014), by the OECD (OECD 2014) and the United Nations Office for Disaster Risk Reduction (UNISDR) (UNISDR 2015). New research, initiated by the EU Horizon 2020 projects such as RESILENS (2016), RESOLUTE (2016), DARWIN (2016), and SmartResilience (2016) also addresses the issue of developing resilience approaches. The need for guidelines and frameworks for resilience is particularly important in the areas of ICT security and related critical infrastructures, which may be considered as "smart infrastructures." While the information technology provides more and more possibilities to make critical infrastructures "smarter," it also creates more risks and vulnerabilities (The future of smart cities: Cyber-physical infrastructure risks 2015). The EU research project SmartResilience makes an attempt of combining a common framework for resilience with the need to adapt this framework to new technology related risks and opportunities.

The basic idea of the project is that modern critical infrastructures are becoming increasingly "smarter" (e.g., "smart cities"), providing an increasing amount of data and thereby the possibility to measure resilience by using big and open data indicators. Following this idea and the objectives of the project, SmartResilience defines resilience of an infrastructure as "*the ability to anticipate possible adverse* *scenarios/events (including the new/emerging ones) representing threats and leading to possible disruptions in operation/functionality of the infrastructure, prepare for them, withstand/absorb their impacts, recover from disruptions caused by them and adapt to the changing conditions*" (Jovanović et al. 2016).

Making an infrastructure "smarter" usually means making it smarter in normal operations and use. Further, these "smarter" systems may be characterized by the following features (Jovanović et al. 2016):

1. Integrative and interconnected
2. Intelligent by the use of ICT, Web technology, and smart computing
3. Smart governance-oriented, inclusive of end-users
4. Sustainable/progressive/future-oriented
5. Efficient and maximize service.

However, it has to be checked if such a smart critical infrastructure (SCI) will behave equally "smartly" and be "smartly resilient" when exposed to extreme threats, such as extreme weather disasters or, e.g., terrorist attacks. Similarly, the question is, if making existing infrastructure "smarter" is achieved by making it more complex, would it also make it more vulnerable? Would this affect resilience of an SCI in its ability to anticipate, prepare for, adapt and withstand, respond to, and recover? These questions are of increasing interest for the research community. In this chapter, the SmartResilience project is presented as it is developing a new, advanced, resilience assessment methodology, which takes the vulnerability of SCIs into account in a holistic manner. This methodology is based on the identification of existing and new, smart indicators of resilience (SmartResilience 2016). The project provides a broad basis to develop both the new methodology and the indicators, as well as addressing a series of issues still open. Among them are, e.g., the definition of "smartness," use of "big data," and interconnectedness, interdependencies, and ripple effects in the case of complex scenarios including different types of threats (e.g., terrorist attacks, cyber-attacks, extreme weather).

17.1.2 Challenges of Smart Critical Infrastructures

The approach proposed here assumes that an event challenging the resilience of modern infrastructure will potentially be an emerging risk (Jovanović 2015), e.g., malicious use of smart meters for regulating power supply. Emerging risk is understood as a risk not necessarily well known and spreading increasingly in its infrastructural context over time, leading to cascading and ripple effects. One example of such an emerging risk is a man-caused release of toxic aromatic liquids with cascading effects on several other critical infrastructures. Policy priorities in such a situation can, and often will, evolve over time. Thus, emerging risks, especially if combined with SCIs, represent a challenge for both infrastructure owners and the policy-makers.

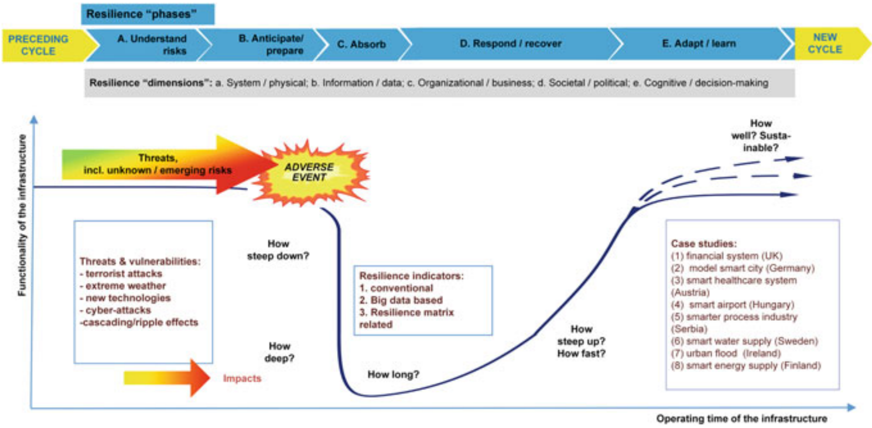

Fig. 17.1 Resilience UV curve in the SmartResilience project

The SmartResilience project (SmartResilience 2016) proposes a new approach to tackle the specific emerging challenges to the resilience of SCIs. The approach includes a shift from the common V-model established in the resilience literature (Albert et al. 2000; Linkov et al. 2014) to an adapted UV model (Jovanović 2016) as shown in Fig. 17.1.

Further, with the indicator-based approach, one of the pressing challenges to find trends and patterns in the large and high-dimensional datasets can be captured in intuitive indicators of high practical use. Many infrastructures lend themselves exceptionally well to be analyzed from a complex network perspective (Albert et al. 2000). Many real-world networks (such as communication or social networks) have a surprisingly high degree of robustness with respect to random errors or perturbation. However, this robustness comes at the high price of extreme vulnerability to targeted attacks. Network science methods have resulted in actionable information on network vulnerabilities in response to disruptive events in the context of transportation (Guimerá et al. 2005), power (Solé et al. 2008), and communications (Doyle et al. 2005). An additional challenge in the design of resilient infrastructures is that multiple interdependencies between mutually dependent networks induce an additional component of fragility (Doyle et al. 2005).

The challenges for applying the approach are, obviously, greater when dealing with more complex infrastructures, and, generally, the "smart infrastructures" are more complex than the conventional infrastructures.

17.2 Basic Idea of the Approach

As mentioned in the introduction, in order to keep pace with new emerging risks and increasingly smarter infrastructures, it is crucial to develop new methodologies and tools; hence, the introduction of the UV model. When it comes to resilience of critical infrastructures, the "UV"-model (or –curve) is more suitable, because "tipping points" are not of main interest, whereas the response phase is highly relevant. Since the response necessarily takes some time, a flat bottom curve is more representative, than a "V"-curve (Jovanović et al. 2016). Moreover, the "UV"-model (or –curve) is more of a conceptual model. In reality, it will hardly be a smooth curve. It is more likely to fluctuate, making it difficult to model. Moreover, if there are interdependencies and cascading effects, several curves are needed to represent resilience graphically.

In addition, new smart resilience indicators can potentially be built upon (SmartResilience 2015):

1. Indicators not specifically envisaged as resilience indicators, possibly already accepted and applied in related areas, such as risk, safety, business continuity, sustainability, those proposed by OECD, GRI, API, HSE, IAEA, and other organizations;
2. New resilience specific indicators proposed by experts (the "conventional way" of creating and using indicators), including those proposed in standards;
3. New resilience indicators derivable out of Big Data and Open Data (in an explorative or "unsupervised" manner).

The indicators can be, e.g., "supervised" or "unsupervised," leading or lagging, basic or more sophisticated, and more or less dynamic. In principle, unconventional indicators, i.e., the ones derived from Big and Open Data (such as information flow in a communication network) can be considered as "smarter" and, thus, may be more appropriate as "smart resilience indicators." Each of the above sources might provide useful indicators for the single phases of the resilience cycle (cf. Fig. 17.1).

Phase A, *understand risks*, is applicable prior to an adverse event. It emphasizes the emerging risks (ERs) and includes their early identification and monitoring; For example, what could the "adverse event" be? This is followed by phase B, *anticipate/prepare*, also applicable before the occurrence of an adverse event. It includes planning and proactive adaptation strategies, possibly also "smartness in preparation" (Jovanović et al. 2016). Phase C, *absorb/withstand*, comes into action during the initial phase of the event and shall include the vulnerability analysis and the possible cascading or ripple effects; For example, "how steep" is the absorption curve, and "how deep" down will it go? Phase D, *respond/recover*, is related to getting the adverse event under control as soon as possible, influencing the "how long" will it last question. Further, it includes the post event recovery; For example, "how steep up" is the recovery curve for normalization of the functionality? It is followed by phase E, *adapt/learn*, which encompass all kinds of improvements made on the infrastructure and its environment; For example, affecting "how well" the infrastructure has adapted after the event, and whether it is more resilient and "sustainable." The activities in this phase also lead to preparation for the future events, and hence, this resilience curve exhibits a reoccurring cycle (Jovanović et al. 2016).

These five phases along with five resilience dimensions form the 5×5 SmartResilience resilience matrix (RM) as shown in Table 17.1. The dimensions help in categorizing the indicators. Dimension a, *system/physical*, includes technological aspects of the given infrastructure, as well as the physical/technical networks being part of a given infrastructure, and interconnectedness with other infrastructures and systems. Dimension b, *information/data*, is also related to the technical systems but is dealing specifically with information and data. Dimension c, *organizational/ business*, covers business-related aspects, financial aspects, and HR aspects as well as different types of organizational networks. Dimension d, *societal/political*, encompass the broader societal and social context, also stakeholders not directly involved in the operation and/or use of the infrastructure (e.g., social networks). Lastly, dimension e, *cognitive/decision-making*, accounts for perception aspects (e.g., perceptions of threats and vulnerabilities) (Jovanović et al. 2016).

Depending on a given situation (infrastructure, scenario), all the sources may yield, often a large number of, indicators for all the phases of the resilience cycle. However, for practical purposes too many indicators may become a burden, especially in the case when the resilience of different infrastructures should be compared. In practice, the indicators cannot be considered neither independent, nor standardized. Theoretically, in such a case, one would prefer dealing with one resilience indicator only. One indicator might be good for comparison, but it can hardly represent the complexity of practical situations (e.g., complex scenarios, unknown responses, uncertainties). The methodology being proposed in the SmartResilience project (Jovanović 2015; SmartResilience 2016), explained in Sect. 17.4, tries to combine the advantages of "one resilience indicator" (convenient for use, but not transparent) with the advantages of many indicators (transparent, but cumbersome), e.g., through several levels of aggregation.

For collecting the indicators and applying the approach, the theoretical framework for indicator selection, scoring, weighting, and aggregation must be defined (Cutter 2010). Once when the set of indicators is considered and accepted as representative, the dynamic "smart" resilience assessment "checklists" can be created and used for the assessment of the respective SCI (e.g., water, energy, smart city) as described in Sect. 17.7.

Table 17.1 Resilience matrix: resilience indicators in different phases of the resilience cycle and resilience dimensions (Jovanović et al. 2016)

Phases →→→ versus. Dimensions ↓↓↓	A. Understand risks	B. Anticipate/prepare	C. Absorb/withstand	D. Respond/recover	E. Adapt/learn
a. System/physical					
b. Information/data			5×5		
c. Organizational/business					
d. Societal/political					
e. Cognitive/decision-making					

17.3 Scenarios: Threats and Infrastructures

The project covers eight scenarios with a mix of infrastructures and related threats in order to assess the resilience of the SCIs, and in addition, one hypothetical case to simulate cascading effects. The cases are ordered as per the phonetics (Radiotelephony phonetic alphabet 2016) from ALPHA to INDIA as shown in Table 17.2.

Case 1 (ALPHA) of smart finances in the city of London emphasize consideration of any disruptions to business continuity, whether it is a terrorist attack, cyber-attack or a natural threat such as a hurricane (Buhr et al. 2016).

Case 2 (BRAVO), i.e., Heidelberg in Germany, considers terrorist attacks and cyber-attacks as major threats to their infrastructures (Buhr et al. 2016), whereas natural threats such as urban floods are considered partly applicable.

Case 3 (CHARLIE) of smart health care system infrastructure (in Austria) considers cyber-attacks leading to massive breach of privacy as the prime threat to their SCI. Increasingly, terrorist attacks are seen as relevant to include. Further, different scenarios are considered important such as disasters and man-made crises that may lead to challenges in normal mode of operations or events leading to exceeding the capacity of emergency departments and failures in other critical infrastructures such as power supply for hospitals (Buhr et al. 2016).

Case 4 (DELTA), i.e., a smart transportation system represented by an airport in Hungary, considers terrorist attacks as the most important threat. Besides this, property crimes endangering or disrupting operations, malevolent use of airport systems or airplanes, attacks or incidents from outside the airport (UAV fly-in, firing lasers at approaching airplanes), accidents and disruptions caused by human negligence as well as strikes, are considered as specific threats. Natural disasters are second in importance for this case (Buhr et al. 2016).

Case 5 (ECHO), i.e., a smart industrial system case in Serbia, identifies terrorist attacks, cyber-attacks, and extreme weather conditions as most important threats and these could possibly lead to interruptions in the critical supply chains.

Case 6 (FOXTROT), i.e., smart water supply in Sweden, evaluated climate change related events as crucial to the drinking water supply, e.g., drought leading to shortage of water supply or a heavy rainfall leading to contamination (Buhr et al. 2016). In addition, cyber-attacks are considered important in relation to security, ICT, and human error.

Case 7 (GOLF), i.e., City of Cork, has been vulnerable to extreme weather and flooding events in urban areas leading to disruption of several other critical infrastructures (Buhr et al. 2016).

Case 8 (HOTEL) of smart energy supply system in Finland recognizes cyber-attacks and extreme weather conditions as major threats. In addition, interruption in critical supply chains such as coal supply and district heating are of considerable importance (Buhr et al. 2016).

Case 9 (INDIA) is a hypothetically integrated case considering multiple infrastructures and multiple threats leading to cascading and ripple effects.

Table 17.2 Critical infrastructures and threat scenarios

Smart critical infrastructure (SCI)/ Scenarios	Terrorist attack	Cyber-attack	Natural threats	SCI-specific events
Case 1 (ALPHA): Smart finances (UK)	✓	✓	✓	Disruptions leading to business continuity, e.g., cyber risks, climate risks
Case 2 (BRAVO): Smart cities (Germany)	✓	✓	(✓)	Social unrest, urban floods
Case 3 (CHARLIE): Smart health care (Austria)	✓	✓	(✓)	Massive breach of privacy, disruption in power supply, scenarios of disasters and man-made crises, interconnected events
Case 4 (DELTA): Smart transportation (airports, Hungary)	✓	✓	(✓)	Disruption of airport services
Case 5 (ECHO): Smart industrial/production plants (Serbia)	(✓)	✓	(✓)	Industrial accidents
Case 6 (FOXTROT): Smart water supply (Sweden)		✓	✓	Climate change leading to water shortage, heavy rainfall leading to heavy water contamination
Case 7 (GOLF): Smart city (Ireland)			✓	Flash floods in urban areas leading to disruption of several CIs
Case 8 (HOTEL): Smart energy supply systems (Finland)		✓	✓	Interruption of coal supply & district heating
Case 9 (INDIA): Integrated Virtual case Study (Combined scenarios in all SCIs)	✓	✓	✓	Cascading effects

Applicability: ✓—yes, (✓)—partly

In this chapter, only some of the single cases have been considered, i.e., BRAVO, DELTA, and ECHO. The INDIA integrated case scenario will form the final goal where dependencies and interdependencies will be considered in the future work.

17.4 Assessment Methodology

17.4.1 Reference Approaches

The methodology developed in the SmartResilience project (SmartResilience 2016) is based on several previous methods, notably the ANL method (Fisher et al. 2010), the Leading Indicators of Organizational Health (LIOH) method (EPRI 2000, 2001; Øien et al. 2010), and the Resilience-based Early Warning Indicator (REWI) method Øien 2010, 2013; Øien et al. 2011; Øien and Nielsen 2012; Øien et al. 2012).

The ANL method for assessing a resilience index (RI), or resilience measurement index (RMI), is structured in five levels, providing indicators on the lowest level. A similar hierarchy is used in the SmartResilience project for assessing resilience levels, entering the indicators on level 6. The structure is somewhat similar in the two approaches, and many of the resilience attributes are the same; however, the level at which the various resilience attributes are found differs between these two methods.

The LIOH method focused on developing indicators for a set of seven themes important for the "health" of a nuclear power plant, some of which have their roots from the research on high reliability organizations (HRO) (Wreathall 2006). They also formed part of the basis for factors considered important in resilience engineering. The LIOH method uses three distinct terms for the levels in their structure of the method. These are *themes*, *issues,* and *indicators*. The issues are in principle divided into general issues and specific issues (for nuclear power plants); however, in some of the applications it was regarded as sufficient to use only one common level for the issues.

This idea was brought further to the REWI method, using three levels to identify early warning indicators for resilience, i.e., starting with resilience attributes, followed by issues important for these resilience attributes, and finally develop indicators to measure the issues. In REWI, the level of resilience attributes is not termed themes as in LIOH, but rather *contributing success factors* (CSFs). Thus, the structure consists of *CSFs*, *issues* and *indicators*. The CSFs are determined based on identification of factors contributing to successful operations including recovery of potential incidents, prior to causing any accident with consequences; thus, the term contributing success factors (Størseth et al. 2009). They are structured in two levels, of which the lowest level consists of eight factors, or resilience attributes. The CSFs are partly, but not entirely sequential.

17.4.2 Basic Idea and Assumptions

In SmartResilience, the resilience attributes are based on the definition of resilience used in the project (SmartResilience 2016), as described in the introduction. From the definition, the five phases of the resilience cycle, presented in Fig. 17.1 and Table 17.1, are obtained.

For each of these phases, the issues that are important for them are identified, and indicators to measure those issues are developed. Thus, the three lowest levels in the SmartResilience structure are *phases*, *issues,* and *indicators*. In addition, the issues (and corresponding indicators) are structured according to five dimensions (Jovanović et al. 2016) included as rows in Table 17.1. These phases and dimensions form the Resilience Matrix illustrated in Table 17.1. Variations of such resilience matrices exist in the literature (e.g., Linkov et al. 2014; IMPROVER project 2016; READ project 2016).

One difference between the 5 × 5 matrix in SmartResilience, and some other matrices proposed (4 × 4, 7 × 3, etc.), is that the dimensions are only used for structuring the issues and indicators, and to support the identification of issues. The phases are of prime importance, meaning that it is not necessary to fill every cell in the matrix with issues and indicators, i.e., the dimensions are not equally important. The cells themselves have no part in the calculations of the resilience levels.

17.4.3 Levels of Assessment

In addition to the three lower levels of the structure, i.e., phases, issues, and indicators, the overall structure consists of three more levels. Starting from the top, the first level is the area level, e.g., a city or smart city, for which the degree of "smartness" will differ, but the assessment methodology applies for all cases. The second level consists of the critical infrastructures (CIs), and the third level deals with the threats. The overall structure of the SmartResilience methodology is illustrated in Fig. 17.2.

Since the users performing resilience assessments of their area/city, critical infrastructures, and/or specific threats are not assumed to be resilience or risk experts, the SmartResilience methodology is deliberately kept as simple, transparent, and easily understandable as possible. Thus, there is reluctance to add additional levels or crosscutting topics, which will increase the complexity of the model. All models are simplifications of reality, and it will always be a balance between having a model that is simple and transparent on one hand, and being sufficiently realistic on the other hand.

Three specific features are treated within the six level structure. These features are related to how to deal with the Information & Communication Technology (ICT) infrastructure as an overarching infrastructure, how to deal with cascading effects, interdependencies and interactions, and finally, how to deal with the potential vulnerability and opportunities of smart features being increasingly introduced in critical infrastructures. These are challenging topics for which detailed solutions are still under development.

The ICT infrastructure may affect several of the other critical infrastructures, and this needs to be explicitly considered when issues are defined in the resilience

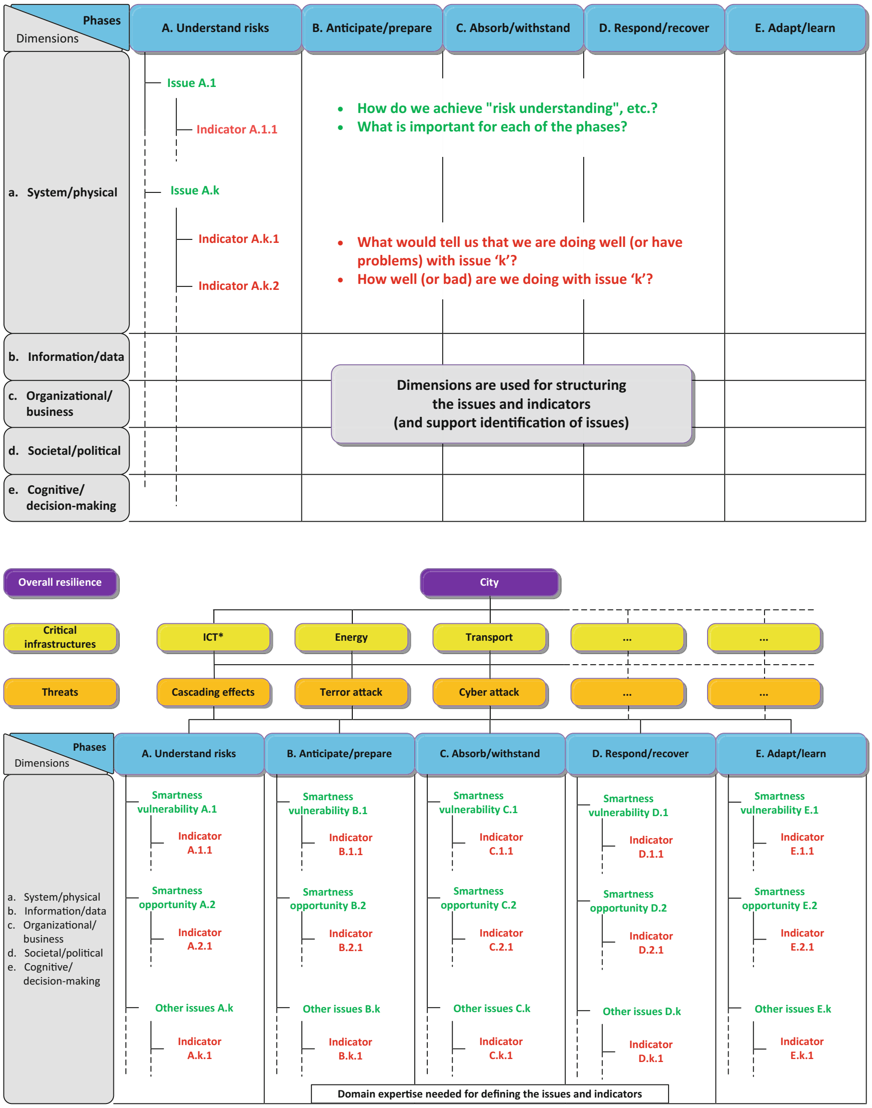

Fig. 17.2 Basic outline of the methodology

matrix for the ICT infrastructure. This is indicated in Fig. 17.2 adding an asterisk, i.e., ICT*. Depending on the responsibilities and service agreements for the ICT infrastructure, they must ensure sufficient backup systems or alternative solutions to provide the agreed service level to other CIs. The other CIs must include, explicitly as issues, backup systems for all systems they depend on. This includes ICT, but typically also energy (power supply). Each CI should review all relevant CIs and other systems to determine to what degree they depend on these systems, and whether backup systems or other redundancy measures are required. This includes consideration of the resilience of the other systems, i.e., if a given CI depends on a low resilience infrastructure, then redundancy or alternative solutions are required in order to be highly resilient. The resilience level of the other systems are not taken directly into account in the calculations. Instead, redundancy, backup systems, alternative solutions, etc., are considered in the calculations (through scores).

Cascading effects are treated as a specific type of threat, also shown in Fig. 17.2. One example of this, included as a scenario in the SmartResilience project, is a cloud of toxic fume from a fire in a chemical plant, which is drifting toward an airport. Each CI needs to consider which accidents that may cause a cascading effect that affects them.

Other types of interdependencies or interactions may also be treated as specific threats, and added as indicated by "others/specify" in Fig. 17.2. Smart features ("smartness") of critical infrastructures are included explicitly as smartness vulnerability and smartness opportunity on issue level. These are default issues (candidate issues), for which the relevance should be considered for all phases in all types of assessments.

Another specific issue, which could be treated on issue level, is related to one of the distinctions between resilience assessment and risk assessment, which is the focus on the unexpected, and how well a city/area or critical infrastructure, is prepared for the unexpected. This can be explicitly accounted for by, e.g., measuring the number of incidents/accidents not included in the response plans, and the degree of learning from incidents/accidents experience by others, which may occur in the specific case, but not being included in the response plans. This could be included as issues in the adapt/learn resilience phase.

Two important general features of the methodology are its flexibility and its demand for domain expertise in "configuring" the resilience model for a specific area/city or critical infrastructure. A fixed list of critical infrastructures for cities in Europe does not exist, and it must be up to each city or area using the methodology to decide which infrastructures that are critical for them. Similarly, no fixed list of threats exists, neither on area level nor for the single critical infrastructures. Thus, it will be up to the users to define which threats they consider as relevant. This is shown in Fig. 17.2 with "others/specify" both for critical infrastructures and threats.

Domain experts are needed in order to define the important issues, and how to measure these issues, i.e., identifying the indicators. They are in a way "configuring" the resilience model, which largely is a one-time effort prior to using the model for calculating the resilience levels, although some adjustments, tuning, and reconsiderations are expected. Thus, in the implementation phase, it is important to have a close collaboration between the users, the method developers, and the IT developers (of calculation and presentation tools).

17.4.4 Resilience Index

The SmartResilience method steps are as follows:

Step 1. Select the area, e.g., a smart city—*Level 1*
Step 2. Select the relevant critical infrastructures (CIs) for the area—*Level 2*
Step 3. Select relevant threats for each critical infrastructure—*Level 3*
Step 4. Consider each phase for each threat—Level *4*
Step 5. Define the issues within each phase—*Level 5*
Step 6. Search for the appropriate indicators for each issue—*Level 6*
Step 7. Determine the range of values (best and worst) for each indicator
Step 8. Assign values to the indicators
Step 9. Perform the assessment (e.g., by calculating/aggregating the score(s))
Step 10. Use results, e.g., comparison, benchmarking, and "stress testing."

The assessment of resilience can be performed at different levels, e.g., for an entire city or some other area, for one or more critical infrastructures, and for one or more threats. It may also be an assessment of a particular threat within an area, affecting certain critical infrastructures, e.g., flooding in a city affecting water supply, energy, and transport. The term "scenario" is used here, for a specific selection of critical infrastructures and threats for a given area/city, i.e., the selected area, critical infrastructures, and threats.

Steps 1–6 are selections and considerations related to the six levels of the methodology as explained previously, whereas steps 7–10 are related to the calculations and the use of the results.

Any type or form of indicators are considered appropriate in the SmartResilience methodology, meaning that they can be yes/no questions, numbers, percentages, portions, or some other type. Their real values, of whatever type, are collected and transformed to a *score* (or rating) on a scale from 1 (worst) to 5 (best). This requires the determination of best and the worst values for each indicator, i.e., Step 7. The score is obtained by interpolation between the best and worst values.

At every level, there is a possibility to give *weights*; however, it is recommended to be restrictive with the use of different weights, as this will lead to less transparent calculations and results. Thus, equal weights are the default values at all levels.

When performing the resilience assessment, the indicators' real values are entered into the calculation (Step 8), and the issue scores are obtained as average weighted scores of the indicator scores. Thus, also issues (level 5) are measured using scores on a scale from 1 to 5, similar as the indicators (level 6). It is also possible to let a specific indicator overrule the effect of the other indicators, i.e., having "knock out indicators" where, in the case of a low value, the effect is not "averaged away" through an average weighted score of all the indicators.

On the next higher level (level 4—phases), the scores are calculated and then transformed to a scale from 0 to 10, providing *resilience levels (RILs)*. This resilience level scale (0–10) is kept from phases and upwards, i.e., for threats (level 3), critical infrastructures (level 2), and areas (level 1).

The reasoning behind the selected scales is that a scale from 1 to 5 for indicators (and issues) are sufficiently broad, especially if there are needs to perform expert judgments to provide scores for the indicators (or directly for the issues) in case of lack of data (Øien 2001). A main goal of the SmartResilience project has been to develop a method for assessing level of resilience using a scale approach of resilience level (RIL), which was included in the call text for the project (SmartResilience 2015). This has similarities to the use of safety integrity levels (SIL) for safety-instrumented systems (IEC 61508 (2010)), only using integer values from 0 to 4. However, in SmartResilience, the resilience levels are increased to a scale from 0 to 10, since it is a linear scale (not logarithmic as the SIL scale). This is considered to provide sufficient differentiation, and at the same time, it does not create the illusion that the assessment is more accurate than it can really be.

The calculation is performed in a database, and the assessment for the given case/scenario is saved (Step 9). The structure of an example case in the database is illustrated in Fig. 17.3. Only the selections made at each level are shown, since the "complete" structure for the most complex case may consist of thousands of nodes.

The results of the resilience assessment, which in the case of a full scope assessment for a smart city covers all the relevant critical infrastructures, all relevant threats for each critical infrastructure, all five phases of the resilience cycle, all relevant issues for each phase, and all indicators for measuring the issues, can be used in various ways (Step 10). One is to compare with previous assessment, i.e., providing a trend showing how the level of resilience is progressing. Since the calculation is performed on all levels, it is also possible to "drill down" and identify the reason for an increase or decrease in resilience compared to the previous assessment. Another use is to compare with other cities, areas, or critical infrastructures, i.e., to benchmark against others, which provides the opportunity to learn from others. The resilience of a city/area or a critical infrastructure can also be assessed by imposing a set of threats (including defined challenges such as interactions and cascading effects), i.e., stress testing the resilience ability of the city/area/critical infrastructure, and compare the results with predefined criteria. This is further described in Sect. 17.7.

17.4.5 Sample Cases

Selected use cases have been employed during the development of the structure of the model, the mathematical equations, and the overall calculations. The development and testing of the equations and calculations have been performed independently using the SmartResilience database, in a progressive manner starting from simple and transparent examples, such as a case dealing with one threat and one infrastructure to, eventually, cases dealing with multiple threats, multiple smart critical infrastructure, and ripple effects.

The three sample cases have been selected from the eight case studies in the SmartResilience project. The three sample cases are:

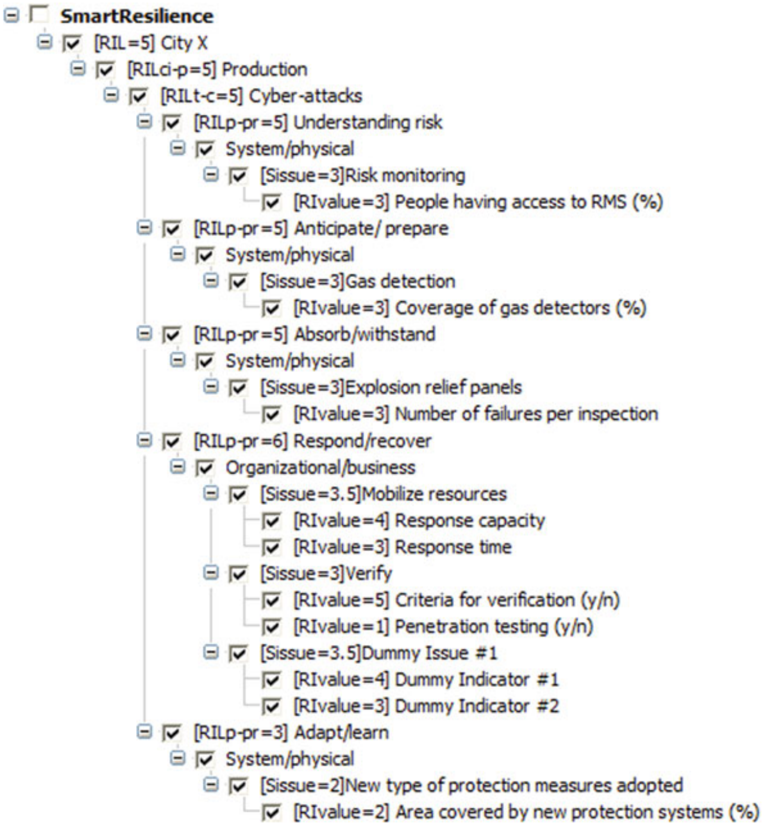

Fig. 17.3 Calculation performed in the database

- Refinery in the city of Pančevo in Serbia, representing production/supply as a critical infrastructure
- Heidelberg Bahnstadt in Germany, representing a smart city/area
- Budapest Airport in Hungary, representing a critical transport infrastructure.

Sample cases #2 and #3 have only been used to develop the structure, not for any calculations, whereas sample case #1 has been used for the development of the equations and calculations. The sample cases are further described in Sect. 17.6; however, it should be noted that the sample application cases so far have been used as part of the development of the methodology. Full scope applications of the methodology on selected cases still remains to be accomplished.

17.5 Implementation of the Methodology

17.5.1 Resilience Indicator Identification and Collection

The indicator identification and collection are performed in several stages throughout the project, and the indicators are refined through an iterative process. The collection consists of relevant issues and corresponding indicators that are used in each case (presented in Sect. 17.4) to measure the resilience of the respective infrastructure, including general issues and indicators relevant for all cases.

In the initial phase, a preliminary collection of over 450 resilience indicators was compiled (Jovanović et al. 2016). The main portion of these is conventional indicators, and only a small portion represents the big data indicators. This collection of indicators will be further refined after domain experts' search for specific issues in every scenario and a final list of indicators will be devised. Then, these indicators are structured according to the methodology into phases of the resilience cycle as explained in Sect. 17.4.

The preliminary collection of indicators are categorized and distributed according to, e.g., phases, dimensions, and sectors/areas (Jovanović 2016), e.g., there are 177 indicators for the anticipate/prepare phase and only 13 for the adapt/learn phase.

Generally, indicators come from a variety of sources including existing standards, public documents, company practices, literature, and similar, but are also largely defined within the project (Jovanović et al. 2016). This is especially true for the "big data," which obviously depends largely on the availability of data in each project case study.

17.5.2 Tools—Visualization

The number of indicators to assess the resilience and the data related to each of these indicators—big data in particular—can be overwhelming and create problems in understanding the impact of any disruptive event and the corresponding cascading effects on the critical infrastructure. Hence, it is crucial to use data visualization to ease the process. In order to do so, D3 (Data-Driven Documents), a JavaScript library is used. It brings data to life through its interactive visualization tools (Data-Driven Documents 2016) and will support the indicator-based methodology to measure resilience of SCI and inform decision-making.

As shown in Fig. 17.4, the data in the CSV (Comma Separated Values) or JSON (JavaScript Object Notation) format is transformed into canonical form to fit in D3 and provides insights through user-friendly visualization and easy interaction by the users.

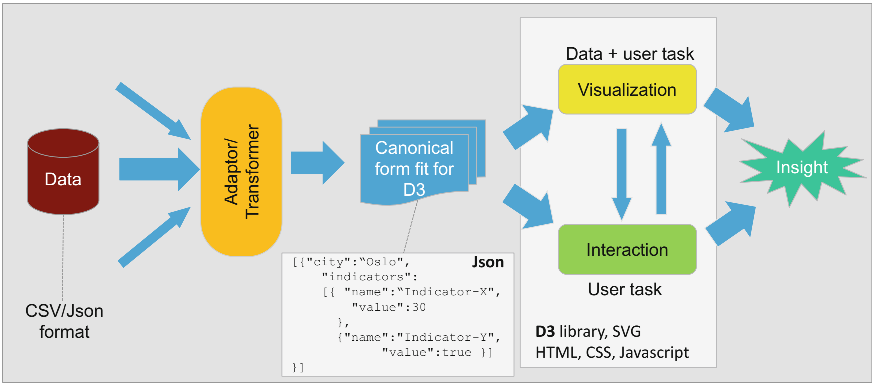

Fig. 17.4 Design and application of interactive visualization for RIs (Barzelay 2016)

17.6 Sample Application Cases

17.6.1 A Smart City

One of the sample cases introduced in Sect. 17.4.5, sample case #2, is Bahnstadt in Heidelberg, Germany (Heidelberg-Bahnstadt 2016). It constitutes an example of a smart city, or smart community within the city of Heidelberg.

Bahnstadt in Heidelberg is one of Germany's largest urban development projects. It is designed to be Heidelberg's first smart neighborhood. Bahnstadt is located in the southwestern part of Heidelberg's city center, and it shares a border with the main station. The energy concept consists of passive house standards as a universal construction method, district heating supply to be covered in the medium term by renewable energies, and intelligent control of power consumption using smart metering. Bahnstadt being the first smart neighborhood is dependent on the critical infrastructure: Stadtwerke Heidelberg (SWH) (Stadtwerke Heidelberg 2016; Buhr et al. 2016).

SWH provides its customers in Heidelberg and the region with reliable electricity, gas, and heat, and offers many services related to energy saving and climate protection. On behalf of the city of Heidelberg and other communities, they are also responsible for water supply. In addition, SWH operates the swimming pools, the cable cars, garages, and also controls the city coordination tasks and are a part of the funding for public transportation. With a turnover of over 200 million euros and more than 1000 employees, of which around 350 are on loan to the regional transport company, it is a major employer in Heidelberg. As one of the largest public energy suppliers, SWH along with the City of Heidelberg and other partners is leading the way into providing electricity without any nuclear power. The energy concept 2020 shows the way to this goal: with a clear plan of action along the entire value chain of an energy supplier—this includes measures for greater energy efficiency and expanding renewable energies—from generation and storage through offering products (Stadtwerke Heidelberg 2016). According to Bundesministerium des Innern (Bundesministerium des Innern 2009) "Definition of Critical Infrastructures," SWH belongs to the Critical Infrastructure Sectors "Energy" and "Water" and the subsectors "Electricity" and "Public Water Supply" (Buhr et al. 2016).

In general, the Heidelberg case study covers multiple critical infrastructures, which are exposed to multiple threats requiring resilience in all phases through multiple issues measured by multiple indicators; however, in the simplified use case referred to in Sect. 17.4.5, only one critical infrastructure, one threat and one phase are included. The threat selected—terrorist attack—is one of the three main threats identified by SWH, the other two being flash floods and cyber security breach (Buhr et al. 2016). Some of the important issues identified for resilience against terrorist attacks are surveillance, communication, and training (Buhr et al. 2016). This is illustrated in Fig. 17.5, including examples of potential indicators to measure the issues. It is not distinguished between the different dimensions.

17.6.2 Smart Production (Refinery)

Sample case #1, introduced in Sect. 17.4.5, is a refinery in an industrial zone of the city of Pančevo in Serbia, representing (smart) production/supply as a critical infrastructure.

City of Pančevo with its Southern Industrial Zone is chosen to represent a case study for the resilience of critical infrastructures as a representative of the industry sector, with many recognized threats in the neighborhood. In order to perceive and understand the influence of industry with respect to resilience, it is necessary to cover the impact of each individual risk factor in this industrial zone as well as the impact of this zone on other critical infrastructures or systems (Buhr et al. 2016).

City of Pančevo has the so-called Southern Industrial Zone located at the southeast edge of the town, right next to the residential area of the city, approximately 4 km from the city center. In addition to the compound of the HIP-Petrohemija a.d. Pančevo, this zone includes the HIP Azotara Pančevo a.d. and NIS Oil Refinery Pančevo. The area is connected to road, rail, and river circulation by means of the port on the Danube River. In this industrial zone, there is a production of petroleum products, basic chemical products, poly-ethylenes, mineral fertilizers, calcium ammonium nitrate, carbamide, and NPK fertilizers (Buhr et al. 2016).

In general, the industrial zone is an area covering one type of critical infrastructure (although multiple plants), is exposed to multiple threats, and needs to be resilient in all phases through multiple issues measured by multiple indicators. In the simplified use case referred to in Sect. 17.4.5, only one single plant and one threat are included; however, all phases are covered, but only for the calculations. The threat selected is cyber-attack. The main emphasis of this use case was the development of the calculations. The scenario is illustrated in Fig. 17.5, with some examples of issues and indicators. Only the phase respond/recover is shown.

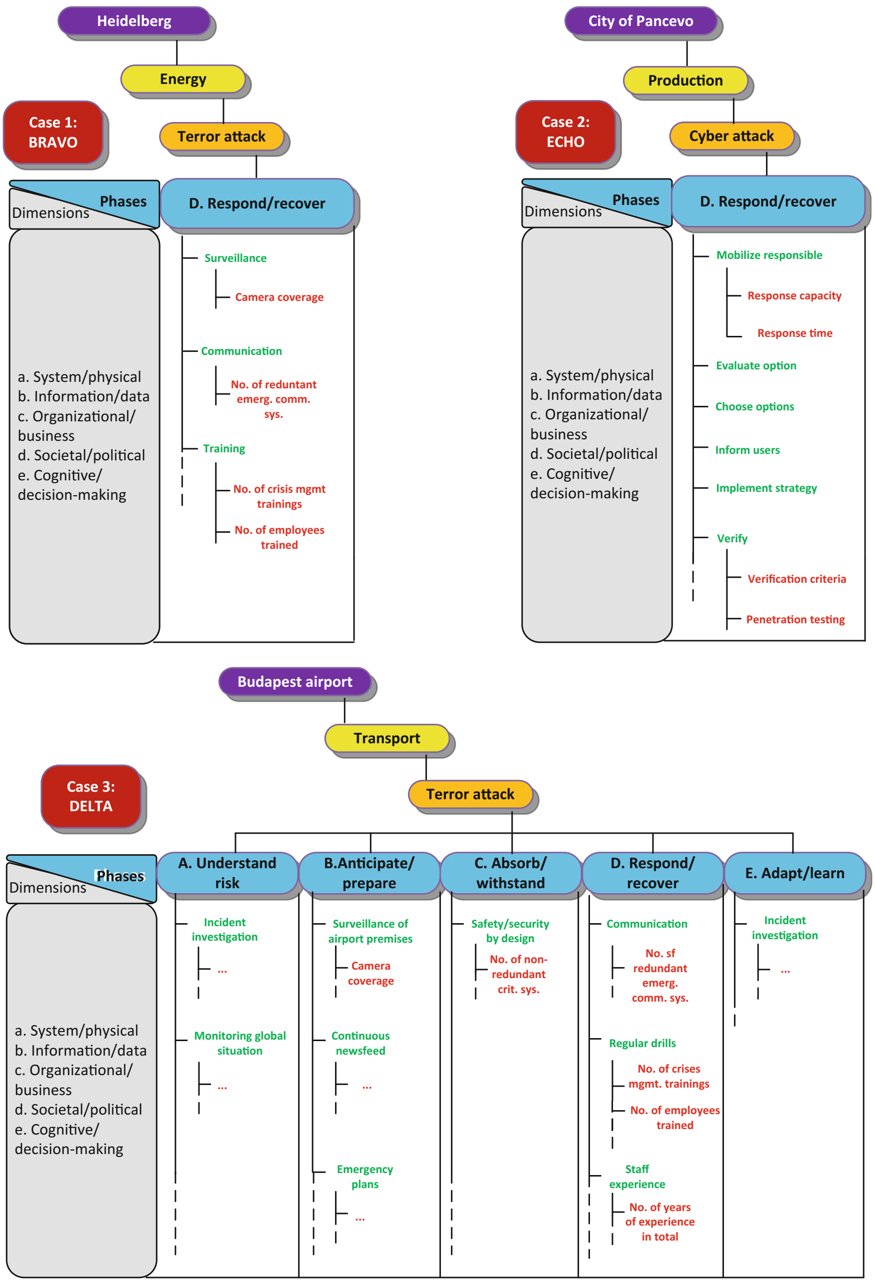

Fig. 17.5 Examples of different scenarios for the sample cases BRAVO, ECHO & DELTA

17.6.3 Smart Transportation

Sample case #3, introduced in Sect. 17.4.5, is the Budapest Airport in Hungary, representing a smart transportation critical infrastructure.

The Budapest Liszt Ferenc International Airport (BLFNR) is the largest international airport in Hungary and is built at the easternmost limits of the Hungarian capital city, Budapest. The total land area of the facility is 15,050,000 square meters, 25% larger than London Heathrow International Airport (Allet 2004). The facility has both commercial (passenger, cargo) and general aviation traffic, but is also occasionally serving military airplanes (e.g., KC-130s airplanes in the Balkan wars). In 2015, the commercial aviation served 10,298,963 passengers, 92,214 airplanes, and 91,421 tons of cargo with coordinated work of approximately 12,000 people (Airports Council International Europe 2016; Buhr et al. 2016).

Currently, BLFNR is the second most protected critical infrastructure in Hungary. The level of security is provided by a well-coordinated cooperation of authorities (including first responders) and private companies, with the airport operator company in the first place. With 52 flight companies, 8 authorities, 3 ground handling companies, 27 shops and so on, there are more than one hundred of actors, all obliged to take its part in protection of the airport as a critical infrastructure (Buhr et al. 2016).

In general, an airport is a specific type of critical transportation infrastructure, exposed to multiple threats requiring resilience in all phases through multiple issues measured by multiple indicators. In the simplified use case referred to in Sect. 17.4.5, only one threat is considered; however, all phases, and multiple issues and indicators are included. Terrorism is considered one of the main threats and is selected in this use case. Issues identified as important are drills, staff experience, communication, and incident investigation (Buhr et al. 2016). This is illustrated in Fig. 17.5, including examples of potential indicators to measure the issues. All phases are covered, but it is not distinguished between the different dimensions.

The sample application cases are illustrated using only specific limited scenarios. The threats are selected from those considered as important by the sample application cases themselves (Jovanović et al. 2016) and the same is true for the issues (except for sample case #1, where the issues were identified in a separate workshop by the method developers). When the method is tested in the case studies in the SmartResilience project, including the three use cases, it is important that domain experts identify all relevant issues and indicators for all phases, all relevant threats, and all relevant critical infrastructures. This will provide a full scope testing of the calculations of the scores and resilience levels (RILs) on all relevant assessment levels.

As an alternative to define issues first and then indicators, it is possible to start with existing indicators in use and ask what issue they actually measure, and then consider if these issues are of sufficient importance to be included in the overall resilience model. Further, the database of collected (resilience) indicators in the SmartResilience project can be reviewed in order to (i) determine if some of these are relevant as supplementary indicators for measuring the already identified important issues, or (ii) determine whether some of the indicators are relevant measures of new issues.

17.7 Conclusions: Comparison, Benchmarking, and Stress Testing of Resilience in Different CIs

The examples presented in Sect. 17.6 integrate smoothly into a "smart city" integrative example (see Fig. 17.6). In other words, the "smart city example" is the integration platform for different critical infrastructures including the examples considered in Sect. 17.6.

The approach presented in this contribution is a snapshot of the development efforts in the SmartResilience project (end of 2016). The approach is at this point in time still under development, and it is expected to be extended in the direction of its applicability for other features (models and tools) within the project (Jovanović et al. 2016a, b; SmartResilience 2016):

- the "resilience cube"
- the "dynamic checklists" and
- the resilience indicators based on and derived from the "big data."

Comparing this approach to some of those applied elsewhere (Cutter 2010; FEMA 2014; Linkov et al. 2014a, b; OECD 2014), one can see that with its orientation toward critical infrastructures and use of indicators, it is probably more adapted for the quantitative resilience assessment. This also enables an improved qualitative assessment, which was one of the main goals of the resilience model development in the SmartResilience project.

When the approach is developed and implemented in terms of the IT tools, it will enable improved assessment, comparison, benchmarking, and stress testing of resilience in different critical infrastructures, in particular the "smart" critical infrastructures. These applications are illustrated in Fig. 17.7, showing, e.g., that the comparison of resilience in different phases in the resilience cycle can be done in a very intuitive and transparent way. The stress test of resilience for all infrastructures is, on the other hand, still an open issue, which has to be explored in due course.

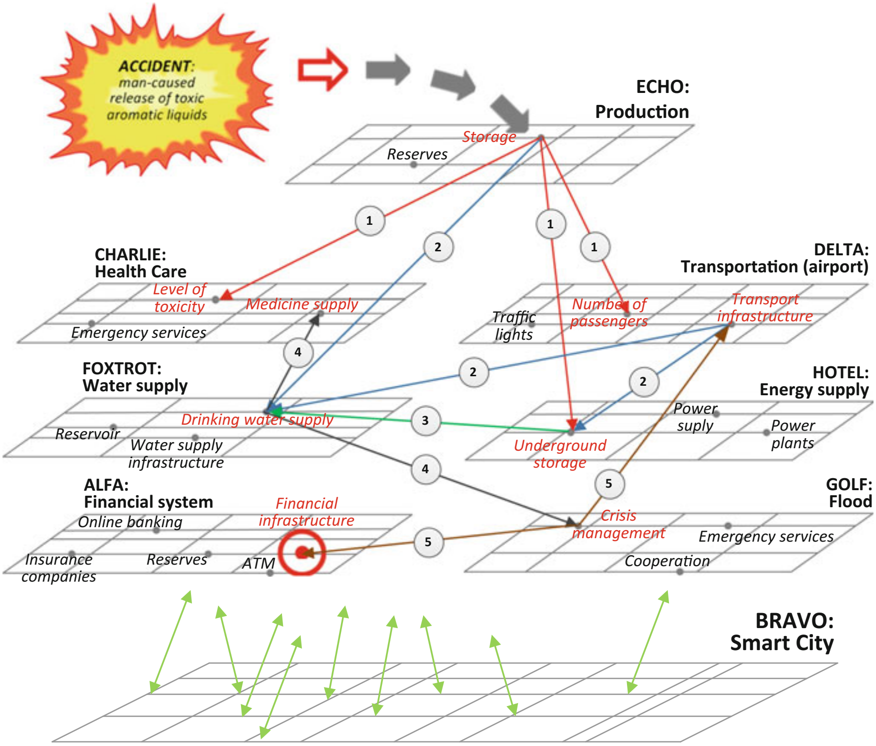

Fig. 17.6 Interaction between the SCIs in a hypothetical case within a "Smart City" (the smartresilience "integrative" hypothetical case (SmartResilience 2015; SmartResilience 2016)

Particular challenges to be addressed are those related to cascading or ripple effects in multi-infrastructure systems (cf. Fig. 17.6) and consistent consideration of time in the analysis.

The emphasis of the future work, in the short-term, are:

- finalizing the resilience assessment methodology
- further completing the indicator database
- developing a tool based on the methodology and the indicator database
- apply both the tool and the methodology in the project case studies.

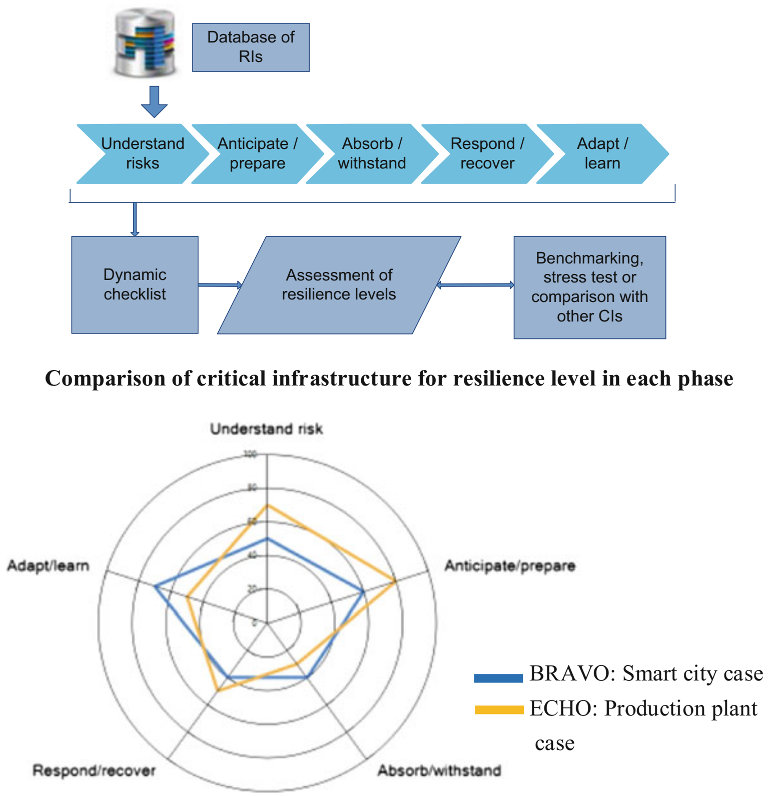

Fig. 17.7 Application of the approach for benchmarking, stress test, and comparison of resilience of different CIs

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Chapter 18
Certified Video Surveillance Systems for More Resilient Urban Societies

Simone Wurster, Irene Kamara, Thordis Sveinsdottir and Erik Krempel

Abstract Resilience and security are prominent elements of twenty-first century European and international political agenda. The focus on resilient systems that are able to respond to threats, as well as to anticipate and recover, plays an important role in this regard. Increasingly sophisticated video surveillance systems form a part of security and disaster response mechanisms. In addition to technological advancement of surveillance systems, there are also concerns about the potential trade-off with human rights and freedoms of citizens. Thus, there is a need for means that allow for the protection of freedoms and human rights, while also ensuring security. One such solution, which deals with the potential of a new pan-European certification scheme for video surveillance systems, is presented in this chapter. This scheme focuses on evaluation according to the social dimensions of Security, Trust, Efficiency and Freedom infringement (S-T-E-Fi). Based on a description of the evaluation methodology and its criteria, two scenarios and how the methodology would be used for the purposes of evaluation of installed video surveillance systems operating within these scenarios are presented. The article finishes by outlining the future development of this scheme as well as further research needs.

Keywords Public security · Conformity assessment · Standards
Certification scheme · Privacy

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18.1 The Need for Secure and Resilient Urban Societies

Secure and resilient societies are an overall policy and development goal worldwide. Both the UN and the EU have a firm focus on addressing increasingly complex security challenges, while also guaranteeing the rights and freedoms of the individual (see for example United Nations Trust Fund for Human Security 2009 and European Union 2016). Furthermore, the sustainable development goals of the United Nations include the aim to “make cities and human settlements inclusive, safe, resilient and sustainable” (United Nations 2015), goal 11. In addition, the European Union describes one of its main objectives as “to preserve and develop the European values of justice, freedom, and security whilst addressing the increasingly complex security challenges” (European Commission 2009, p. 2).

A focus on resilient systems that are able to respond to threats, as well as to anticipate and recover, is also a major driver in the political sphere. Increasingly, sophisticated video surveillance systems[1] form a part of security and disaster response mechanisms. Smart video surveillance systems have the capacity to analyse the data that they collect and thereby assisting their operators by evaluating events such as violence or accidents. For this purpose, image processing algorithms are used to process captured live data in search of critical events.

In the face of increasing surveillance, in addition to technological advancement of surveillance systems, there are also concerns about the potential trade-off with human rights and freedoms of citizens. Thus, there is a need for means that allow for the protection of freedoms and human rights, while also ensuring security.

One such solution, which deals with the potential of a new pan-European certification scheme for video surveillance systems, is introduced and presented in this chapter. This scheme focuses on evaluation according to the social dimensions of Security, Trust, Efficiency and Freedom infringement (S-T-E-Fi) (see Hempel et al. 2015). The assessment methodology has roots in the three-year European-funded project CRISP (Evaluation and Certification Schemes for Security Products).[2] CRISP developed the building blocks of a CRISP certification scheme, which can be used for evaluating and certifying video surveillance systems based on their societal impact.

Based on the need for appropriate video surveillance systems to build more resilient urban societies, this chapter refers in particular to the potential improvement of the framework conditions for their implementation by the new certification instrument. This contribution will firstly outline the need for resilient urban societies, which increasingly require security measures that do not infringe on citizen’s fundamental rights. Second, we introduce the CRISP evaluation methodology and

[1]In accordance with ISO 22311:2012, surveillance systems are defined as comprising “of cameras, recorders, interconnections and displays that are used to monitor activities in a store, a company or more generally a specific infrastructure and/or a public place” (definition for CCTV system).

[2]The CRISP Project was funded by the European Commission 7th Framework Programme from April 2014—March 2017. More information on the project can be found at: http://crispproject.eu/.

third, outline two scenarios and how the methodology would be used for the purposes of evaluation of installed video surveillance systems operating within these scenarios. Lastly, we outline the future development of the CRISP scheme in the resilience and detection context as well as further research needed within this field.

18.2 The Concepts of Resilience and Security and the Role of Urban Monitoring and Surveillance Solutions

Resilience and security are prominent elements of twenty-first century European and international political agenda, see European Commission (2009) (whole document) and also Engelbach et al. (2015), p. 18.

Resilience describes "(t)he ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions" (United Nations 2009, p. 24).

"Security" is defined by (DhS 2007) as

> reducing risks to critical infrastructure or the effects of natural or manmade *disasters* by appropriate measures.

Differentiating between security and resilience, (DhS 2007) regards resilience as

> the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions.

As an example of resilience measures, the development of business continuity plans is mentioned. Combining both concepts, (Hollnagel 2011) refers to *disaster* resilience, defined as:

> the capability to prepare for, prevent, protect against, respond to or mitigate any anticipated or unexpected significant threat or event, including natural disasters or *terrorist attacks*, to adapt to changing conditions and rapidly bounce back to a normal or a 'new normal', and reconstitute critical assets, operations and services with minimum damage and disruption to public health and safety, the economy, environment and national security.

Specifying the relation between resilience and security, Lovell et al. summarise key research topics from a resilience point of view. Their overview shows these resilience-security links, for example by topics such as "food security, agriculture and resilience", "conflict, fragile states, security and resilience" as well as "urban, urbanisation, infrastructure and resilience", which is relevant in the context of this chapter. They also highlight the importance of appropriate planning in the security and resilience context.

Extending the list of disaster resilience tasks in Hollnagel (2011)'s definition, (Wright and Rodrigues 2012) identified six fundamental qualities and elements of resilience: 1. Anticipation of vulnerabilities, threats, attacks, crises, 2. Preparedness,

3. Prevention, detection and response, 4. Mitigation, 5. Recovery and 6. Sharing of responsibility and cooperation between stakeholders. In this context, (Labaka 2013) focuses on prevention, absorption and recovery and found that the first stage can be further specified by the tasks signal detection and preparation/prevention (see Labaka 2013, pp. 18 and 33). In each stage, the importance of monitoring systems, such as video surveillance is high (see Labaka 2013, p. 99).

Video surveillance implies specific resilience and security tasks. An example in the field of urban transportation infrastructure is the identification of problematic luggage by appropriate *protective technical solutions*, which leads to the avoidance of a disaster. Relevant *responsive behavioural* questions in this context are, for example: Which reaction measures were specified in advance? How is the situation handled? How is communication managed? How is the evacuation of endangered persons organised from a logistical point of view? and How is panic avoided? In any case, the identification of potential threats by appropriate surveillance solutions is the first element in this context. Since these solutions aim to *avoid* disasters and not to *overcome* them only, emphasis is put on them in this chapter.

The relation between resilience and *efficiency* is an additional issue in this context, which led to an intensive dialogue among the members of the Disaster Resilience Network http://www.jiscmail.ac.uk/disaster-resilience.

Ensuring an appropriate security level in the EU also requires that it strengthens the legal and ethical dimensions of all security solutions to guarantee the rights and freedoms of individuals, particularly as they relate to privacy (see European Commission 2009). This also means that it must reinforce the social dimension of security technologies to ensure that they allow societies to effectively respond to risks and losses ("societal resilience", European Commission 2009, p. 3). In summary, "new technologies and solutions need not only be validated; they should also be certified and where appropriate standardised, so they can become part of an effective response to security threats" (see European Commission 2009, p. 4).

18.3 Societal Needs in the Urban Security and Video Surveillance Context

Technological emergence offers ever growing capabilities to security technologies used to enhance security. However, they can also raise societal concerns as the early debates on body scanners have shown. Video surveillance systems provide another example for such risks.

Video surveillance systems nowadays detect and recognise individuals, relate the images to other databases and uniquely identify persons. Video surveillance systems are established in most of public spaces in the EU countries, public means of transportation, critical infrastructures, hospitals, private homes, but also on aerial vehicles such as drones. The collection and processing of all this data has significant impact on privacy and personal data protection, but also other rights. Footage from video surveillance systems can be used for predictive policing and stigmatising the residents of neighbourhoods categorised as areas of high risk for criminality.

Raab et al. (2015) explain that such surveillance may itself erode social freedoms and public goods such as privacy, either precautionary or in mitigation of the harms caused to the public goods of free societies. The proliferation of surveillance security technologies is to be attributed to some extent to the fear of crime and antisocial behaviour (Webster et al. 2013). Campbell and Van Brakel (2015) argue that even though many individuals will not easily challenge such surveillance power structures (presumably also due to the aforementioned fear), privacy should fall like a blanket across all citizens. The same goes for other rights and fundamental values, as for instance equal treatment and non-discrimination. Furthermore, researchers identified trust-building, transparency of information, a culture of responsibility, education and regulation among the societal needs in security (Dönitz et al. 2014). Such framework conditions need to be facilitated alongside the need for secure and resilient societies. There is a common fallacy that security and privacy are mutually exclusive, meaning that if individuals want to be more secure, they have to give away some of their rights, in that police or security service providers may watch and record activities of individuals, without being hindered by rights of "under surveillance" individuals such as the right to privacy.[3] Hildebrandt (2013) has explained that there is no issue of trade-off, but rather balancing of the security and privacy. Both security and privacy—as well as other fundamental rights—can be protected.

In fact, there are several means and practical tools to help protect rights and freedoms, while ensuring security. Solutions to address both security needs and societal needs as described above will be presented in the following sections. Requirements based on the new European General Data Protection Regulation (GDPR) 679/2016 play an important role in this regard.

18.4 The Importance of Certified Security Solutions for Urban Societies and the CRISP Project

Certification is an important instrument to address security-related and societal needs. Besides the regulatory environment, the framework conditions for certification and conformity assessment in general are a critical factor for Europe's security and potentially needed EU-level actions (see ECORYS 2011). Certification is

> a procedure by which a third party gives written assurance that a product, process or service conforms to specified requirements, also known as conformity assessment (IEC 2010), see also (ISO/IEC 1996).

It is also

[3]Read discussion about 'trade-off' between security and privacy in (Solove 2011).

> a procedure used by the certification body to confirm that the qualification requirements for a method, level and sector have been fulfilled, leading to the issuing of a certificate (ISO 2012).

According to (Teichler et al. 2013), the main value of conformity assessment in general is its contribution to overcome market imperfections, for example information asymmetry and adverse selection. Advantages derived from conformity assessment include, for example preservation of quality, high product safety, avoidance of damage and injuries, reduction of risks and higher specialisation effect. The practical economic benefit of conformity assessments is shown in numerous studies, (see Guasch et al. 2007) for an overview. According to a survey of the International Accreditation Forum (IAF), certification (as part of the conformity assessment) adds value and increases trust (Frenz and Lambert 2013). Nevertheless, the development of conformity assessment solutions for security systems is characterised by numerous challenges. ECORYS (ECORYS 2011) identified the following issues: highly fragmented European market, no common (single) framework that applies to security products and the market for security products as a whole; absence of common certification systems for security products and no mechanism of mutual recognition across countries of products certified at a national level. Actions are needed because

> effective civil security must embrace interoperability, standardisation, certification (and) validation (…) that cut across public and private spheres (European Commission 2009), p. 14.

But there are also boundaries. As (Lookabaugh et al. 2006), pp. 12–13 observed:

> an organization may find it infeasible to maintain adequate criteria to certify products that change rapidly in function and capability. In such cases, certification may be practical only if it is restricted to aspects of the system that undergo fewer changes and that can be reasonably isolated.

Certification is also an instrument to protect, alongside with the law, fundamental rights. This was recently formalised in the new EU data protection framework. The 679/2016 General Data Protection Regulation (GDPR) modernised the data protection legal framework in the EU, introducing several novelties in relation to the previous regime of the Data Protection Directive 95/46/EC, including data protection by design, standardisation and certification. The Regulation establishes data protection certification mechanisms in its art. 42 and 43.[4] The role of such certifications is to demonstrate compliance with the legal obligations, promote transparency and accountability of natural or legal persons processing personal data.

The CRISP consortium addressed the need for a pan-European certificate for security systems. CRISP was a three-year security research project (April 2014–

[4]The General Data Protection Regulation will be applicable in 2018.

March 2017), funded by the European Union.[5] It aimed to contribute to measures that increase citizen trust and confidence in security technologies and to facilitate a more harmonised playing field for the European security industry by providing pan-European certification for security systems, which also considers societal and legal issues. Furthermore, it aimed to support the goal to provide protection in an efficient manner (Wurster et al. 2016). Key outcomes of the project, which consisted of nine work packages, were a EU Security Certification Manual, a roadmap for the implementation of the CRISP scheme and a CEN Workshop Agreement.

18.5 The CRISP Methodology and its Pilot Area "Video Surveillance"

The CRISP project objective was to develop an innovative evaluation and certification methodology for the CRISP certification scheme for security systems. In principle, CRISP-based conformity assessment consists of two stages: evaluation (configuration and assessment) and certification (audit, attestation and surveillance), see Fig. 18.1. The CRISP methodology integrates the Security, Trust, Efficiency and Freedom infringement (S-T-E-Fi) dimensions in its evaluation stage. The CRISP methodology is an innovative approach, as certification has, to date, primarily focused on the assessment of technical requirements for security systems and does not consider the new requirements based on the GDPR. Examples for the CRISP assessment criteria and their application will be given in Sect. 18.7.

CRISP's assessment process involves three primary parties: (1) the client, which is, for example an organisation with urban security tasks that wants to operate a video surveillance system and is applying for CRISP certification; (2) the evaluation body, comprised of external, independent S-T-E-Fi experts, which assesses the installed surveillance systems and (3) the certification body, which will grant certification in accordance with CRISP standards and requirements.

A series of scenario workshops on the CRISP methodology was conducted, which included the areas of video surveillance systems, border control systems, civil drones and specific security solutions to protect houses. In a roadmap, created in June 2016, the CRISP consortium specified the next step after the project's completion (see Wurster et al. 2016). According to this roadmap, the novel CRISP concept will first be piloted for video surveillance systems. Key assessment topics are according to (CEN-CENELEC 2017):

Security dimension

1. Are there measures in place for assessing possible threats (prior as well as after the installation of the system) and in further consequence to adequately address situations involving possible threats?

[5]More information on the consortium can be found at http://crispproject.eu/.

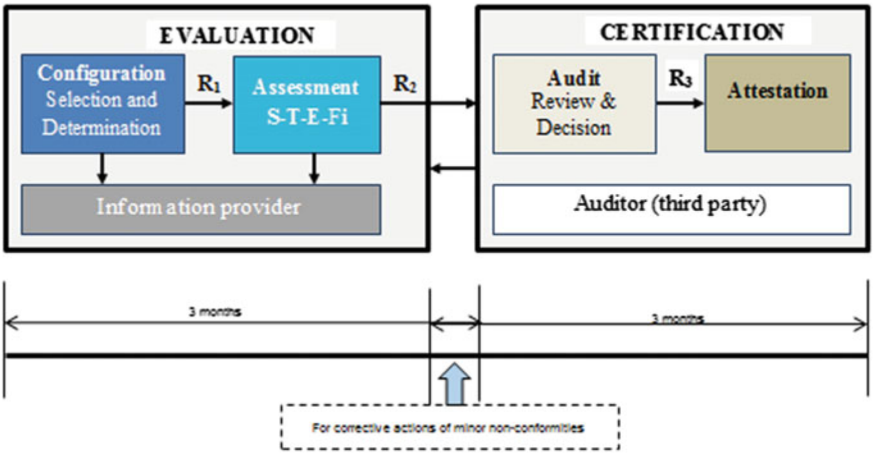

Fig. 18.1 The overall frame for the CRISP certification of installed systems (*Source* CRISP consortium)

2. Are there measures in place to ensure that the video surveillance system and the operator accurately react to actual security threats?
3. Are there measures in place to ensure that the video surveillance system performs as intended in actual situations of an occurring threat and/or security incident?
4. Does the video surveillance system pose a risk to users/scrutinised and who is accountable for the security actions in relation to the device?

Trust dimension

1. Is the system respectful for users and scrutinised?
2. Is transparency of the system ensured?
3. Is the system reliable for users and scrutinised?
4. Is the system user-friendly?
5. Does the system offer trust tools?

Efficiency dimension

1. Is appropriate information on the system provided?
2. Are appropriate measures implemented to avoid unintended negative economic effects?
3. Does the system allow for appropriate utilisation?
4. Is interoperability ensured?
5. Are appropriate life cycle costs ensured?

Freedom infringement dimension

1. Does the system respect (in terms of installation/design/operation/use) the dignity and customs of the scrutinised?
2. Are due process rights of the individuals affected by the surveillance system guaranteed?
3. Are the basic principles of data protection respected by having measures in place to ensure:

   - that personal data processing is lawful, transparent and fair,
   - that personal data are only processed for a specified purpose,
   - that only the data strictly necessary for a specific purpose are being processed/stored,
   - that personal data processed are accurate,
   - the integrity and confidentiality of personal data being processed,
   - the accountability of the operator of the system.

The CRISP methodology will serve as the foundation of the CRISP certification scheme. According to the CRISP roadmap, this scheme will be further developed by an interested organisation upon the completion of the CRISP project. The CRISP scheme will not redefine the technical requirements that are already in place (e.g. in European standards). Instead, the S-T-E-Fi dimensions offer the inclusion of social assessment criteria in the certification of security systems. Therefore, the scheme will contribute to the protection of fundamental rights and promote compliance with relevant EU laws, with a particular focus on the GDPR.

Certification by the CRISP scheme will assure that a security system has been assessed on the basis of the S-T-E-Fi dimensions and has been found to comply with applicable assessment criteria. CRISP certification can be sought initially by both those who procure and those who run video surveillance security systems on their premises (Hempel et al. 2015).

As Fig. 18.1 shows, a maximum time of 3 months is expected for system evaluation and an additional 3 months will be granted for certification. Certification will be granted for 3 years, during which the certification body will conduct regular surveillance assessments, and it is expected that the certificate holder will provide all necessary documentation of compliance, as well as provide notice as to any expected changes.

18.6 Application Case: Privacy-Aware Smart Video Surveillance Systems

Video surveillance systems were invented in 1942, and from the beginning, the technology had been used for security and safety purposes. While in a conventional closed-circuit television (CCTV) system an operator has to evaluate all captured data for critical events like violence, so-called smart video surveillance systems support the operator in the evaluating step. Image processing algorithms are used to process captured live data in search of critical events.

While smart CCTV systems can help increase security and safety, they come with high-potential privacy infringement. Biometric identification can be used to recognise an offender days after an incident. Tracking algorithms can be used to track an offender over large areas. Provided with enough resources and misused by a malicious operator such a system could have a huge impact on the privacy of all people in the supervised area. While nowadays, the architecture is used for smart video surveillance systems, the concept can easily be transferred to smart city applications. In dense crowds of people, a multitude of sensors will be used to monitor and regulate everyday life. This will require new concepts to balance security, trust, efficiency and freedom infringements.

To cope with the privacy risk while still increasing security, (Roßnagel et al. 2011) propose that a systems' functionality should be coupled to the current situation. This architecture was refined by Fraunhofer IOSB (Birnstill and Pretschner 2013) to a generic privacy-aware video surveillance architecture that operates in three distinct modes.

"Default Mode" is used in most of the time. Here, no critical event was detected and therefore impact on privacy must be limited. The operator has only limited access to information, functionality, e.g. all video data is artificially pixelated, and he cannot use automatic tracking. "Assessment Mode" is activated once an algorithm, i.e. violence detection, or the operator has detected a potential critical event. In this mode, first clues for a critical incident exist. The operator is granted access to extended information, e.g. high quality video streams, to assess the situation. "Investigation Mode" is activated once a suspected incident is confirmed. In this mode, it is known that a critical event is present. Therefore, the operator is allowed to use the highest level of functionality to prevent further damage. Algorithms with a high privacy impact, e.g. automatic person tracking and biometric identification, become available. Once the incident is cleared, the systems change back to "Default Mode". Fraunhofer IOSB used this architecture to design and develop multiple security- and safety-related scenarios. Two of them are described here:

Safety scenario NurseEye: NurseEye is designed for hospitals and nursing homes. It utilises the privacy-aware smart video surveillance architecture as shown in Fig. 18.2.

In "Default Mode" all video data is processed by an algorithm designed to detect people falling to the floor. When no fall is detected, the data is deleted. If a fall is detected, the system changes into "Assessment Mode". Here a member of the nursing staff gets access to an anonymized video of the fall to evaluate it. If the alarm is confirmed, the systems go into "Investigation Mode". Here the nurse has full access to the live video data to assess the current situation. Once the incident is handled, i.e. the fallen person has received help, the system goes back to Default Mode and all collected data is deleted.

Security scenario Unattended Luggage (Fischer et al. 2014): The second scenario focuses on security and can be deployed in areas such as airports, train stations, shopping centres or public events. In "Default Mode" data is captured and

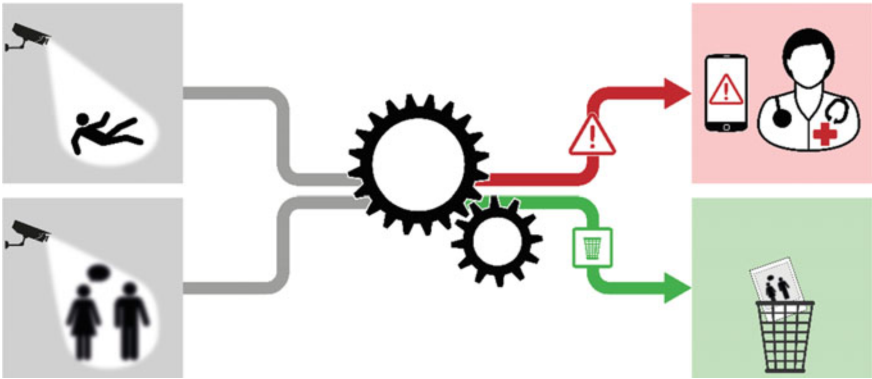

Fig. 18.2 NurseEye data processing

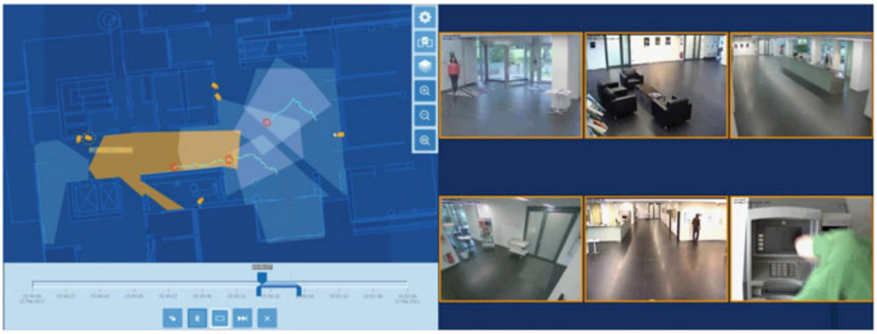

Fig. 18.3 Security scenario unattended luggage: an operator uses the video archive to find the owner of a piece of luggage. (*Source* Fraunhofer IOSB)

stored in a 24 h archive that is not available for the operator. Additionally, an algorithm searches for unattended pieces of luggage. If one is detected, "Assessment Mode" is activated and the operator is alarmed. If the operator confirms the alarm, "Investigation Mode" is unlocked. Here the operator has access to the video archive (Fig. 18.3) to find the owner of the luggage.

Once this person is found, the operator can activate a tracking algorithm to let the system process where the owner went after abandoning their luggage. This information is used by the operator to decide if the area must be evacuated, e.g. if the owner left the area in a hurry, or if a security officer should inform the owner about their forgotten luggage, e.g. if the owner just went to a nearby kiosk. Once the incident is handled, the system goes back into "Default Mode". The next section outlines a CRISP assessment of both systems.

18.7 CRISP Assessment of the Privacy-Aware Smart Video Surveillance Systems

The two video surveillance systems can be evaluated, using the CRISP methodology, by applying a number of social and legal assessment criteria consisting of assessment questions, which fall within the S-T-E-Fi dimensions. The following figure gives an example (Annex A of CEN-CENELEC 2017 provides an overview of all criteria in detail):

The **security dimension** includes assessment criteria and questions relating to the functionality of a security system in countering security threats and reducing risks. Specific questions relate to false positives and negatives, non-recognition of threats, and resistance to external and internal manipulation. In the second scenario, the issue of false positives and negatives is central to the analysis and evaluation. If applicable, compliance with relevant standards is assessed. Training of staff (for instance of a nurse with access to the live video data in the NurseEye scenario), risk analysis (see Fig. 18.4) and health and safety procedures surrounding the use of the surveillance system will also be assessed within this dimension. With respect to assessment relating to users of the system, assessment criteria focus on clarity of instruction and appropriateness of training (e.g. in privacy and data protection rules and regulations) as well as clear lines of communication, roles and responsibilities with the aim of invoking trust of the staff operating the system. In short, for the systems described in Sect. 18.6, the assessment within the security dimension would first and foremost focus on the functionality of the system, while the trust dimensions assess the experiences and perceptions of both the users of the system as well as the persons subject to surveillance.

Assessment criteria within the **trust dimension** are designed to ensure that good practice, standards, regulation and law are followed in surveillance practices. With regard to evoking trust from persons within an area covered by surveillance systems, the assessment criteria include questions regarding transparency and stipulate that areas covered by CCTV must declare this with signage that clearly state the organisation responsible for the scheme, the purpose of the scheme and a contact telephone number. This would be especially important to the NurseEye system, as it operates within a private setting and with vulnerable people. Information about the operation of the system would thus be necessary to instil trust in people living in the home and those who visit the facility. In practice, for the systems described in Sect. 18.6, in semi-public areas, that may reveal sensitive information for individuals, such as the existence of a health issue or travelling destinations, time, location and accompanying individuals, the trust dimension evaluation would focus on how trustworthy the system is and is perceived to be.

The assessment of the surveillance system's **efficiency** focuses on both general efficiency indicators and efficacy. In terms of general efficiency indicators, the questions in the above scenarios would revolve around measures to avoid malfunction and misuse and the related costs. The assessment of the system's efficacy would look at issues of interoperability (for instance in the unattended luggage

<table>
<tr><th colspan="3">SECURITY DIMENSION</th></tr>
<tr><td colspan="3">S.1 Are there measures in place for assessing possible threats (prior as well as after the installation of the system) and in further consequence to adequately address situations involving possible threats?</td></tr>
<tr><td colspan="3">S 1.1 RISK, Threats</td></tr>
<tr><td>Assessment question</td><td>Assessment requirement</td><td rowspan="2">Relation with standards or regulation (…)</td></tr>
<tr><td>1. Has a risk assessment been performed prior to the design and installation of the video surveillance system, assessing the probability and the impact of threats and hazards on the operational site? [yes/no]
2. Which issues have been addressed in the risk assessment and have the results of the assessment been included in the design and installation of the system? [qualitative]</td><td>Prior to video surveillance system design, a risk assessment shall be performed, which will identify threats and hazards to the premises and assess their likelihood.
The required security functions for the mitigation of the threats shall be identified and the video surveillance system will be designed in a way to mitigate the assessed risks at the specified location and in regard to the identified threats.</td></tr>
<tr><td colspan="3">S 1.2 RISK, Risk grade & operational requirements</td></tr>
<tr><td>Assessment question</td><td>Assessment requirement</td><td rowspan="2">Relation with standards or regulation (…)</td></tr>
<tr><td>1. Has the video surveillance system been assigned to a security grade? [yes/no]
2. Have specific operational requirements been defined for the video surveillance system and do they explain what it implies for the system to perform as intended? [qualitative]</td><td>The results of the risk assessment shall be used to assign a security grade to the components, sub-systems and functions of the video surveillance system. These shall define the specific operational requirements – the need, justification and purpose – of the system when in operation.</td></tr>
<tr><td>(…)</td><td></td><td></td></tr>
</table>

Fig. 18.4 Example of CRISP assessment requirements

scenario, how the smart surveillance system functions in relation to the other installed systems to which it transmits information). Questions of life cycle costs concerning the operation, maintenance and disposal of the system in relation to the added value to the security targets of the organisation using the system should also be considered under the efficiency dimension. Looking at the unattended luggage scenario, the retention of the captured data for 24 h would be evaluated for its efficiency and cost-effectiveness.

The **freedom infringements dimension** of the S-T-E-Fi assessment in the above scenarios is significant to assess whether the smart surveillance system in both cases interferes with fundamental rights and freedoms of the individuals. In the case of NurseEye, personal data and privacy assessment questions and criteria are very relevant, as images and data recorded in a hospital are likely to include data concerning health, which are a special category of personal data, subject to strict protection regime (art. 9 GDPR). Questions would therefore assess several issues, such as the information provided to the persons that are subjected to the surveillance measure, the possibility of the individuals (data subjects) to access, rectify and delete personal data relating to them. Other issues are how and for how long the data are stored, who has access from the side of the personnel, what are the data security measures to protect the data from unauthorised access and malicious attacks are also part of the S-T-E-Fi assessment criteria, which are applicable to the above scenarios. In addition, relevant criteria are the measures against discrimination, persistent tracking and profiling, for instance in the unattended luggage scenario. Such measures could include proper training of the operator of the system to prevent personal biases from affecting his or her judgement. In the same line, the existence of mechanisms for due process rights (e.g. complaint mechanisms) in the organisation responsible for operating the surveillance system would also be examined. As a result, the assessment under freedom infringements would identify and assess whether and how the system impacts fundamental rights, since as mentioned in Sect. 18.3, security and fundamental rights should be balanced.

This brief presentation of possible S-T-E-Fi criteria for the assessment of the two surveillance systems scenarios shows that the multidimensional methodology of CRISP guarantees to a large extend that apart from security issues, socio-legal and economic issues related to surveillance systems are assessed and resolved, before a CRISP certification is awarded. In this way, such issues are incorporated early in the assessment of the system and thus better integrated and addressed.

18.8 Challenges Related to the Implementation of the CRISP Approach and Solutions

Although CRISP provides various benefits, outlined in detail in CRISP's briefing papers, which are available on its website, the implementation of the CRISP scheme presents a variety of potential challenges. Reasons are, for example the novelty of its structure and the sensitive nature of its content matter. To address these issues, the CRISP consortium started various activities to engage its numerous stakeholder groups and specified a number of additional measures in the roadmap for the CRISP scheme (Wurster et al. 2016). Further action items of CRISP's roadmap include, for example:

- Collaboration with certification bodies, end users, the security industry, regulators, policy makers, insurance companies and other interested or affected groups starting in the initial phases of implementation. This will ensure that all steps are adequately informed and validated to drive acceptance and trust in the CRISP scheme.
- Collaboration with the European Commission to encourage that it publicly advocates for the CRISP scheme. This is important in demonstrating the value of certification which is imperative to drive uptake of the scheme, both by certification bodies as well as those who seek certification of their systems.

- Collaboration with the Member States that they work to educate and inform the public about the positive aspects of CRISP certification.

The fragmented nature of the security industry may also prove challenging for the implementation of the CRISP certification scheme. A specific solution, on which the CRISP consortium focuses, is that the European Commission develops legislation for security systems containing minimum requirements for security systems. Furthermore, this challenge can be overcome via the establishment of standards to encourage unification across the sector. CRISP's CEN Workshop Agreement (CWA) builds the foundation for further actions in this regard. The CWA is a technical agreement developed and adopted through consensus in a workshop setting by participants that are responsible for its content. It is valid for 3 years, after which it can either be re-submitted for a further 3 years, withdrawn or be further developed into a full standard.[6] This process was started by the CRISP consortium in 2016. The CRISP CWA was published by CEN on 10 May 2017 and is now available for uptake from the CEN-CENELEC website (CEN-CENELEC 2017).

18.9 Conclusions and Outlook

This chapter has addressed a specific topic in the relation between security and resilience. It has outlined the potential benefits of certification of surveillance systems, which involves assessment of socio-legal dimensions to meet the demand for security systems in smart cities that do not breach the fundamental rights of citizens. We have presented the CRISP methodology and its potential use for assessing smart surveillance systems operating within two security scenarios and how the assessment allows for security issues, socio-legal and economic issues to be assessed and resolved, before certification.

Certification is an important process that can provide assurance that a product or system conforms to specific requirements and has qualified for a certificate issued to that effect. Considering the drive for security in smart cities and the concern over the impact of increased surveillance on citizens, certification, which aims to mitigate trade-off between security and fundamental rights, provides a solution that addresses both security needs and societal needs in the same instance. The CRISP methodology has the potential to be the foundation on which a certification scheme such as this can be built.

The CRISP methodology was elaborated by a panel of interested parties at a CEN workshop which issued a CEN Workshop Agreement (CWA), which sets the course for further standardisation efforts and provides input for the development of a future certification scheme (CEN-CENELEC 2017). The development of a certification scheme is outside the remit of the CRISP project, which ended in March

[6]CEN Boss, CEN Deliverables (2017) [Online] https://boss.cen.eu/reference%20material/guidancedoc/pages/del.aspx.

2017. The CRISP consortium has on completion of the project been seeking interested parties for developing the CRISP methodology and CWA into a fully fledged certification scheme.

With respect to future research in this field, the application of the CRISP methodology to different security systems and in different security contexts remains an interesting topic. Secure and resilient societies will require multifaceted solutions to respond to ever changing risks, relying on innovations such as big data, Internet of Things and smart safety and security technologies. It is imperative that socio-legal impact of these entities be fully understood and assessed, and for this purpose certification schemes such as the proposed CRISP scheme should provide appropriate tools and processes.

Besides these aspects, the resilience concept shows that an appropriate detection of the societal threats described in this chapter and an adequate response not only require suitable, certified technical solutions but also appropriate behaviour and response concepts—two other areas, in which certification provides benefits. In summary, an appropriate realisation of the prevention and protection issues of disaster resilience require integrated socio-technical measures, which cannot be divided from each other.

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Chapter 19
Situational Resilience—A Network-Perspective on Resilience to Crime

Herbert Schubert and Tim Lukas

Abstract Based on a reflection of resilience in the criminological context the article combines the logic of network theory with Bruno Latour's Actor Network-Theory in order to provide a concept of situational resilience that allows overcoming the dichotomous interpretation of resilience as independent characteristics of individuals and objects. From this perspective, resilience develops as a result of everyday situations comprising the actions of people who are associated with each other and with specific non-human beings, and material artefacts. Resilience arises in the operational process of networking between these different entities. Situational resilience means that specific associations of human, non-human beings and artefacts produce qualities of resilience in concrete situationally embedded action processes. This conceptualization has consequences for the empirical research of situational resilience: social actors and material factors should be considered in their association in order to recognize resilience patterns and their respective conditions of embedding. The article recommends to analyse these characteristics in empirical research that is focused on resilience patterns of human-artefact-constellations in (urban) settlement spaces.

Keywords Situational resilience · Crime prevention · Network theory
Environmental criminology · Collective efficacy

19.1 Initial Situation

In order to explain crime and its prevention, rational choice theory is often used to illuminate the underlying causes of criminal behaviour (see Clarke 1980; Cohen and Felson 1979). It places a rationally weighing person in relation to opportunities

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for crime. Aiming at systematically reducing the opportunities to commit crime rational choice theory fuelled the development of an architectural deterministic school based on the behaviouristic assumption that the behaviour of the individual could be positively influenced by the design of the physical environment. In this respect, the approach of "Crime Prevention Through Environmental Design" (CPTED) emphasizes the construction of resistant, robust spatial designs as well as space and place management as crime prevention strategies in urban residential and industrial estates, and shopping areas (see Atlas et al. 2008; Crowe 2013).

Strategies of urban resilience are deeply rooted in this research tradition which follows the assumption of resilience as a result of certain inherent characteristics of individual people on the one hand and particular features of the built environment on the other hand (Coaffee et al. 2009 p. 70 ff; Lukas 2015, 2016). The concept of urban resilience thus utilizes different perspectives, merely bridging the gap between social and technological science. From a psychological point of view, resilience results from the inner attitudes of the individual whose predispositions are generated within the framework of socialization processes or from substantial social cohesion. The engineering perspective is focussed on risk analysis methods as well as on the flexibility and robustness of materials and technical constructions. The understanding of social sciences emphasizes the substantial characteristics of social institutions and communities that enable resilience. In natural sciences, the interdependence of nature and anthropogenic structures is presented within the framework of ecological system models, whereby resilience is the result of specific system relations. Overall, an essentialist understanding prevails, grasping resilience as a quality that is intrinsic. In this paper, a counter-perspective will be developed on this understanding of a reified concept of resilience.

Based on a reflection of resilience in the criminological context, we combine the logic of network theory with Bruno Latour's Actor Network Theory to provide a concept of situational resilience that allows overcoming the dichotomous interpretation of resilience as independent characteristics of individuals and objects. From this perspective, resilience develops as a result of everyday situations comprising the actions of people who are associated with each other and with specific non-human beings, and material artefacts.

19.2 Resilience in Criminological Context

So far, the concept of resilience has received only little attention in the criminological context. While the academic literature on resilience is extensively growing in disaster risk research and psychology (Fekete et al. 2014; Fletcher and Sarkar 2013; Lorenz and Dittmer 2016), resilience is a relatively new concept in criminology, essentially comprising two distinct lines of study. On the one hand, criminological resilience research is devoted to developmental and life course criminology, searching for factors that distinguish non-offenders from offenders in high-risk environments (see, e.g. Lösel and Bender 2003; Lösel and Bliesener 1992). Comparing the life courses of delinquent and non-delinquent individuals, emphasis is on exploring protective rather than risk factors and pathways out instead of into crime. Thus, developmental and life course criminology take into consideration all factors that promote positive adaptation in the face of adversity, with most of such factors involving social control and self-control (Agnew 2016). Thus, the thrust of this research line is "a systematic search for protective factors" (Luthar and Cicchetti 2000, p. 544) that differentiate how people cope following exposure to factors that place them at risk of crime and victimization (Homel et al. 1999). Crime prevention, therefore, involves the manipulation of multiple risk and protective factors early in developmental pathways that lead to offending, often at "turning points" (Sampson and Laub 1993) between different life phases.

On the other hand, substantial consideration has been given to identifying the supraindividual capacities that make communities resilient to disorder and crime-related behaviours. In this direction of research, a connection between the two concepts of resilience and "collective efficacy" (Sampson 2012) is made. Innes and Jones (2006, p. VI; see also Innes 2014) found out that a "neighbourhood's resilience to crime reflects the distribution of economic and social capital and is connected to the presence or absence of collective efficacy". Sampson (2013) himself, who initially developed the collective efficacy approach as an explanation for varying crime rates in urban neighbourhoods, examines the relationship of both concepts, when promoting collective efficacy as a social remedy for disaster and crisis situations. That is, adapted from the idea of collective efficacy, a neighbourhood appears resilient to both crime and catastrophes, if its residents are willing to intervene on behalf of a common good, and there are mutual trust and shared norms among the neighbours. Drawing on this model and theories from environmental criminology, Breetzke and Pearson (2015) identified social and physical neighbourhood-level characteristics that promote resilience to crime in neighbourhoods with disadvantageous socioeconomic settings. Based on New Zealand census and crime data, they found that crime-resilient neighbourhoods had decreased access to a range of healthcare, education and living infrastructures. Previous research by Thompson and Gartner (2014) identified a number of resilient neighbourhoods in the city of Toronto which were characterized by higher than average levels of poverty, families headed by lone parents, black residents, residents who were recent immigrants and residents aged 15–24. In this sense, these neighbourhoods were comparable to bordering neighbourhoods with high homicide rates. However, homicide rates in the resilient neighbourhoods were below—and in some cases, well below—the citywide average of Toronto. The authors suggest that this resilience could be due to certain interactional mechanisms present in these neighbourhoods such as social cohesion or collective efficacy.[1]

As a summary, it can be stated that criminological resilience research has mainly focused on what makes individuals and neighbourhoods resilient to crime and disorder despite their disadvantageous settings. While a wide range of individual and neighbourhood-level characteristics have been identified, that have been shown to protect from becoming an offender or a victim of criminal conduct, an analytical perspective on the interplay of individual and physical factors in concrete situations of resilience is still lacking.

In the following section, we derive a conceptual model of resilience that will allow for the detailed analysis and subsequent prevention of criminal offences. In drawing on network theories, we propose a theoretical concept for the analysis of resilience which has been successfully proven in the criminological context, e.g. for the explanation of situational crime prevention in nightlife places (Demant and Dilkes-Frayne 2015), the connected segregation of new enclaves of privileged and underprivileged in global cities (Wissink 2013) and the aetiology of knife crime (Holligan 2015).

19.3 Theoretical Approach: Resilience Through Connected Elements in Situations

The starting point of our analysis is the critique of an essentialist concept of resilience, as if resilience would be an identity and quality that is inherent in a particular phenomenon. Alternatively, we propose a processualistic concept of resilience: accordingly, resilience occurs situatively in actu (during action). This approach is capable of overcoming the dualistic theory architecture of resilience on the one hand and vulnerability on the other, and replacing it by a thinking that classifies resilience on a continuum of hybridizations. We follow Harrison White, who formulated the relational turnaround in sociology at the beginning of the 1960s, based on the anti-categorical imperative of network theory (see White 2008).

In the logic of network theory, the individual does not decide in isolation how it acts—instead, action is conceived as a function of the social environment and thus determined by the embedding. Therefore, network theory uses models of social structure that are based on patterns on relations instead of the attributes and attitudes

[1]Against this background, some criminologists believe the concept of resilience to be an empowering model that can benefit and strengthen marginalized people in disadvantaged urban neighbourhoods (Walklate 2011). In contrast, Foucauldian governmentality approaches consider the “resilient subject” as an expression of neoliberalism and stress that governments are promoting self-discipline and legitimizing the expansion of their own power in criminal justice (Ball 2011; de Lint and Chazal 2013). As Hardy (2015, p. 78) has observed, these contrasting views within criminology mimic divisions in the wider literature on resilience (Chandler and Coaffee 2017).

of individuals. According to the idea and conception of man in network theory, both thinking and action are strongly influenced by the surrounding relationships and reference persons, not by social categories. Embedding in social networks explains cultural orientations and practices more reliably than the category of socioeconomic status. Traditionally attributed features such as gender, social status of parents, migration background or intelligence do not adequately explain these differences. The actual positions in social networks and thus the access (or lack thereof) to social resources are expected to be more reliable indicators (ibid., p. 139).

Christakis and Fowler (2008, p. 285), therefore, reject the traditional rational choice-model of a "homo oeconomicus", who is rational, selfish and autonomous. According to the logic of network theory, they develop the construct of a network man—the "homo dictyos" (from the Latin homo for man and the Greek diktyon for network)—whose behaviour cannot be reduced to his own interest. All decisions are made depending on the structure of relations, i.e. the social embeddedness influences the behaviour.

The core of Harrison White's network theory is that the orientation of people is fundamentally generated by their positions in social networks. By continuously linking social transactions, different cultures emerge from these heterogeneous contexts. Against this background, the following core elements play a major role (see White 2008): (1) Ties represent not only the formal links—such as over ordination or subordination in organizations or the simultaneous presence in an event—but also informal links in everyday life. They can be specified as the relationship type. The connections between nodes rather than nodes themselves are in the focus of interest. (2) Set of Nodes—Analytically, the focus is on the question how a network can be defined to make it analysable or designable. (3) Situations—The credo of network theory emphasizes relationships as the basic entities of the network. But they develop continuously; this ongoing renewal process by negotiation takes place in social situations in which the relationships are embedded. (4) Bimodal Networks—In bimodal networks, there are two types of nodes: actors and event situations in which the actors meet and their relations negotiate. (5) Negotiation—In the situations of events, the actors observe and influence each other. In the sequence of the behaviour, which is shown in the situations, a reliability between the actors arises. In the process of negotiation, each network develops its culture, and these stylistic elements are continuously developed. (6) Culture—The negotiation refers not only to the structure of relations and the behavioural expectations of the participants; as a result, shared interpretations and evaluations also play a role. Thus, a network is not just a relationship system, it also represents a common culture. This is reflected in preferences for consumption and for traditions, norms and institutions that are relevant for resilience. (7) Positions—The actors in the sense of nodes are involved in a network in different ways. They adopt different typical positions associated with specific behavioural expectations. The network roles convey what the actors do and how they have to behave. (8) Story—The relationships and the structure of the network is transmitted not only through the behaviour and direct experience in the situations and events, but also through communication. In communicative brokerage—for example, by a third party—interpretative and narrative meanings are attributed to the relations. This is part of the transported culture of the network itself and its structure. The circulating story about it, which will be modified from situation to situation, becomes the medium of the negotiation process.

What kind of insight do we draw from this? Resilient reactions to an event cannot be traced back to individual competencies or characteristics. We have to view them in the context of their social and situational embedding. The interconnected nodes are, on the one hand, persons and, on the other hand, the events that connect persons. Within the framework of these situations, negotiations are taking place, which are condensed into a culture during the process. A good example is neighbourhood networks of social and non-social elements, which lead to effective community control and prevent crime. In this regard, Bursik and Grasmick (1993) highlight the relevance of networks of association between community residents, schools, churches and other community institutions and agencies in their analysis of reasons why residents of some communities commit more crimes than residents of other communities and why residents of particular neighbourhoods are victimized at higher rates than residents of other areas.

Against this background, we deduce the following thesis: resilience is a function of social actors and event elements (two-mode logic) that are related to each other in situ. And it is the expression of a culture that emerges during the process of connecting practice. To this extent, we can distinguish between network links that create a resilience culture and crosslinks that do not have resilience capacities.

Overcoming the focus on human relationships is the goal of Bruno Latour's Actor Network Theory. He extended the network-shaped braid of people and social institutions to other involved non-human elements (Latour 2007). The nodes of a network will not only be formed by social actors and the events that connect them —nodes are also material things such as technical artefacts or even immaterial phenomena such as programs and discourses. None of these elements has the single control over what happens—the action is translated and transformed only in the interaction between human and non-human entities (Laux 2014, p. 49). The conceptually equal treatment of both human and non-human beings as material and immaterial elements has been described as an extended principle of symmetry.

In the sense of Bruno Latour, resilience can be understood as a conglomerate of many associated sources of action. Resilience arises in the operative process of networking different entities. The traditional natural/cultural difference is abandoned by the fact that actions are no longer limited to human figurations, but are described as a symmetrical association of human and non-human entities whose linked activities form a comprehensive program of action. Every non-human entity that changes a given situation by making a difference is also recognized as an actor (Latour 2007, p. 123). According to Actor Network Theory not only social actors but also non-social actors such as technology and knowledge are brought into action in a heterogeneous intertwining. For this reason, the notion of the actor is replaced by that of an "actant", in order to point out that not only social actors or human beings are given capacity for action or agency. The process leading to the construction of an actor network is described as a transformation in which the activities and characteristics of all involved actors will be changed after connecting.

In order to develop the first steps and elements for a counter-perspective on resilience, we choose a situational approach. In situations of everyday life, the different perspectives are linked: people, non-human entities and material artefacts are interconnected. Artefacts range from spatial design to spatial equipment, from technical apparatuses to personal objects. According to this logic, "situational resilience" means that specific associations of humans, non-human beings and artefacts produce resilience in concrete situationally embedded action processes. We do not interpret resilience as independent characteristics of individuals and involved objects. So, the action programs of people who are not associated with specific non-human beings and artefacts are less resilient in specific situations.

The central assumptions are as follows: In individual and collective action programs, social actors and material factors (non-human beings and artefacts) "assemble" and form effective resilience structures in combination. This linking in actu contributes to the extent to which threatening crime situations are critical/failing or successful/resilient. Spatial and material factors weaken or strengthen the action programs of social collectives and enable the activation and maintenance of social control (see Schubert 2016).

19.4 The Concept of Situational Resilience

Resilience is regarded as an effect resulting from the effort to prevent, i.e. we examine prevention measures as input, the design of the situation as output, and resilience as outcome. Thus, the resilience cycle (see, e.g. Leismann 2012) reads as follows in our perspective:

For the transfer of the concept of resilience, we refer to six characteristics of resilience (see Pfeffer 2014):

(1) The first characteristic is marked by "diversity". We derive the assumption that differently structured spatial and operating models are more crisis-proof than standard patterns (see Page 2008).

(2) In a second perspective, "redundancy" plays a key role. In general, this means that important components of a concrete system are present more than only once. Instead of building the system on a single, central component, there is a strong network of various small components. Similarly, this quality is associated with the concept of the "Meme": Meme is a cultural communicative sensory unit, which—like a biological gene—is distributed redundantly by simple copying and varying. In the transfer to spatial design and organizational concepts, it could be concluded that originality and uniqueness should be no longer in the focus. Instead, the concepts should be easy to copy and to spread (see Blackmore 2000).
(3) The third characteristic is the "modularity" and independence of system components. Independent modules increase resistance, because in the case of an event negative influences are not transmitted from module to module and thus to the entire system. As a planning and design paradigm, all nodes of a system should be equally interrelated with each other in a hierarchy-free manner in order to be able to integrate as many independent resources as needed (see Johnson 2013).
(4) The fourth characteristic of resilience is "feedback-sensitivity". This follows the logic of preventive early detection: the faster a system is able to detect and react to disturbances, the less damage will occur. Feedback loops can be created by spatial proximity, media connections or appropriately designed information systems. They follow the SLOC logic—i.e. small—local—open—connected (see Manzini 2013).
(5) The fifth feature concerns "adaptability". From this point of view it is emphasized that adaptive, soft and pragmatic systems can react more easily to changes than rigid and heavy systems. The latter threatens to break if stressed, rather than yield, in order to return to the original basic state.
(6) The sixth characteristic is "environmental sensitivity". The environmental embedding is particularly important here: The better a system is embedded in its direct environment, the less vulnerable it is to negative influences and shocks. Environmental sensitivity is achieved by involving the addressees—from residents to professionals and to other stakeholders—in design and organizational solutions (see Pfeffer 2014). Both participation and governance issues are affected.

We transmit these six characteristics to our approach of "situational resilience". The focus is on resilience patterns of human-artefact-constellations in (urban) settlement spaces. The resilience of the situation is the result of a successful interaction (association) of spatial factors, social actors and artefacts. In accordance with the characteristics of resilience, the components of situational resilience can be assigned as Table 19.1.

Table 19.1 Resilience patterns of human-artefact-constellations in (urban) settlement spaces

	Spatial factors	Social actors	Artefacts
Diversity	Mix of uses (homogeneity increases vulnerability)	Different space users with different knowledge (inhabitants, working population), coupling	Different artefacts are available in the case of an event and can be used (e.g. bike, subway, smartphone)
Redundancy	Openness of the space for alternative options (e.g. subway: one output blocked, two further outputs)	Rapid emergence of aid through communication and action: social cohesion enables redundancy	Alternative ways for a function (if the mobile phone would have no reception, an emergency call column could be used)
Modularity	Independence of individual spatial components (shopping mall vs. shop line)	Different resources are quickly linked to one another in the case of an event (e.g. violence in the subway station: present people combine their knowledge)	Interaction of different technical modules: shutter, light, window, alarm system
Feedback-sensitivity	Zoning, visibility in space for the early detection of dangers	Social interdependence of actors generates early perception of threat and rapid feedback (civil courage), cooperation of professional actors (police, housing company, etc.)	Early warning by, e.g. pattern recognition, "smart surveillance"
Adaptability	Formability (designability) of urban spaces	Flexible adaptation and willingness to learn with regard to changing general conditions (e.g. burglar series: increased protection measures, establishment of a security guard)	Adaptation of technical equipment (e.g. target hardening)
Environmental sensitivity	Connections of the area with the whole city, region, etc.: Disadvantaged neighbourhoods are often only insufficiently connected.	Participation of stakeholders, governance, embedding of the addressees in the planning and design process	Integration of artefacts into the spatial context

19.5 Conclusion

In this paper, we drafted a sketch showing how resilience could be represented as part of everyday life. For this step, it is necessary to dissociate oneself from the research tradition of resilience as the result of certain inherent characteristics of human beings on the one hand and the material environment on the other hand. Thus, the growing literature in disaster risk research and psychology can be interpreted in that way. We conceptualize a counter-design to the notion that resilience is a component of intrinsic qualities of people, materials and technical constructions.

Also in criminological context, the concept of resilience has received little attention. Criminological resilience research is focused on developmental and life course criminology, searching for factors that distinguish non-offenders from offenders in high-risk environments. The question which situational elements are linked in the empirically analysed reality has not been considered in criminology so far. The systematic search for protection factors does not take into account any environmental features of social–material embedding. The perspective is focused on influencing the individual and its actions. Therefore, criminological approaches to resilience are merely based on the traditional model of a rational, selfish and autonomous homo oeconomicus.

For our alternative approach, we refer to the model of homo dictyos—the network man—who cannot be reduced to individual interests, because decisions depend on the social and material embedding. This shows similarities to the concept of collective efficacy, whereby resilience in the neighbourhood presupposes the supraindividual distribution of economic and social capital (see Sampson 2012; Innes 2014). In the case of crime and disaster, a neighbourhood proves to be resilient, if the residents are connected by mutual trust and shared norms. The significance of connectedness is clearly highlighted in this criminological concept. We draw on this basic figure of connectedness with our theoretical consideration of resilience as created through connected elements in situations. In order to show this in a differentiated way, we refer to the anti-categorical imperative of network theory.

In the logic of network theory, the individual does not act in isolation but in the context of its social embedding. Therefore, patterns of relationships—i.e. connectedness—play a central role in network theory, while the intrinsic characteristics of the individual individuals are not considered. Against this background, resilience responses in action chains cannot be attributed to individual competences or characteristics. These personal characteristics themselves are also the result of social as well as situational embedding. The interconnected nodes are on the one hand persons and on the other the events that connect them. Within this framework of connected elements, negotiations are taking place, which are condensed during the course of the process into a specific style or a culture. We deduce that resilience is a function of social actors and event elements (two-mode logic) that are related to each other in situ. With this theoretical concept, resilience can be understood as an expression and part of a culture that is continuously developing in the process of connecting practice.

We added Bruno Latour's Actor Network Theory to our approach. In this concept, the nodes of a network are represented not only by social actors and their events of networking, but also by material things such as technical artefacts and by immaterial phenomena. The circle of elements, which are connected to each other under a perspective of resilience, grows as a result. None of the elements has the single control over what is happening, because actions are translated and transformed only in the interaction between human and non-human entities. Our counter-perspective of a situational approach towards resilience assumes that in situations of everyday life, the different perspectives are linked: people, non-human entities and material artefacts are interconnected. The artefacts range from spatial design to spatial devices to technical devices and personal objects. Resilience arises in the operational process of networking between these different entities. Situational resilience means that specific associations of human, non-human beings and artefacts produce qualities of resilience in concrete situationally embedded action processes. Therefore, we do not interpret resilience as independent characteristics of the involved individuals and objects, but as a result of situations comprising the actions of people who are associated with each other and with specific non-human beings and artefacts.

On this note, our conceptualization has consequences for the empirical research of situational resilience: social actors and material factors (non-human beings and artefacts) must be considered in their association in order to recognize resilience patterns and conditions of embedding. In further research, the characteristics of these patterns have to be analysed, such as crisis-proof diversity, redundancy of connected components, equally interrelated modularity of the elements, feedback-sensitivity by the logic of preventive early detection, environmental sensitive embedding of the connected elements in the direct environment and their soft and pragmatic adaptability. With our approach of situational resilience, we recommend to analyse these characteristics in empirical research that is focused on resilience patterns of human-artefact-constellations in (urban) settlement spaces.

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Part V
Resilience Trends, Paradigms and Reflections

Chapter 20
Urban Riskscapes—Social and Spatial Dimensions of Risk in Urban Infrastructure Settings

Florian Neisser and Detlef Müller-Mahn

Abstract A central challenge of urban risk governance lies in the complexity of the overlapping of multiple risks. This problem is particularly relevant and obvious in urban infrastructure settings. The concept of riskscapes addresses and integrates various aspects of risks: the overlapping of different risks, the multiplicity of perspectives on the same spatial area and spatially different meanings and consequences. An important aspect of the riskscapes concept lies in the range of perspectives regarding the risks. This article takes a closer look at aspects of multiplicity and overlaps of different riskscapes as well as the spatial and temporal dynamics of risks and riskscapes while turning to empirical findings on the transportation of hazardous goods. This is discussed with a specific focus on stationary and mobile forms of risk in the context of urban infrastructures. Based on a comparison of risk management in the Netherlands and in Germany, an aligned risk management strategy in regard to spatial planning and hazardous incidents regulation is recommendable. A context-sensitive, practice-oriented, and socio-spatial understanding of risks is necessary to grasp the context of specific urban situations and to get an in-depth understanding of risk situations—including the aspects stationary and mobile risks.

Keywords Riskscapes · Urban infrastructure · Technological risks
Mobile risk · Risk management

20.1 Introduction

Living in a city may be risky: traffic accidents, crime, and security-related problems, potential failures of supply networks, technological hazards, or sudden disruptions of infrastructures are situations any city dweller may have to face. Some of these risks are encountered only individually due to specific lifestyles, consumption

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patterns, and habitual practices, such as the risk of riding a bicycle through the city center, while others affect particular neighborhoods, social groups, or communities, for example, the inhabitants of an area with high crime rates or the people living in the vicinity of an industrial plant that is processing toxic substances.

Urban risks are complex because of two reasons: Firstly, because of the density of urban populations, structures and people´s movements through space which make city life particularly vulnerable to the multitude of overlapping physical threats embedded in the urban fabric; And secondly, because the interaction between these diverse dimensions of physical threats may eventually create surprises and paradoxical reactions that are difficult to anticipate and manage. After the terrorist attacks in central London in 2005, many people took to their bicycles in fear of further violent incidents on the subway, although cycling in London did also require some kind of risk-taking.

One of the methodological challenges of risk governance lies in the complexity of the overlapping of multiple risks. This problem is particularly relevant and obvious in urban infrastructure settings. Describing flood risk and defining specific action plans is an established approach of risk governance. But what about more complex settings of, say, flood, critical infrastructures, and the disruption of public services? The question arises as to how the complexity of urban risks and their interaction can be addressed in a holistic approach that takes into account the materiality of singled-out factors, spatial overlaps, human perception, and risk-related behavior.

It is this complexity of overlapping and interrelated risk that is addressed by the concept of riskscapes. Proceeding from this general layout of the concept of riskscapes as proposed by Müller-Mahn and Everts (2013), we will take a closer look at aspects of multiplicity and overlap of riskscapes as well as the spatial and temporal dynamics of risks and riskscapes while turning to empirical findings on the transportation of hazardous goods.

20.2 Riskscapes—An Emerging Concept to Address the Social and Spatial Dimensions of Risk

The concept of riskscapes (Müller-Mahn and Everts 2013, p. 24) can be understood as a "tool" for a specific agenda of risk research: Starting from on the observation that risks "do not exist in isolation from one another" (ibid.) and that each risk "occupies, not just metaphorically, a specific territory" (ibid.) the concept calls for analyzing different risks within a common framework and foregrounds their spatial dimensions. Riskscapes constantly emerge from risk management practices (or, more generally speaking, all sorts of practices carried out to handle risks), which are at the same time based on and reproductive of assumptions on the spatial dimensions of the specific risks they are geared to. The neologism riskscape has already been used by others before (e.g., Bickerstaff and Simmons 2009); however, the theoretical backgrounds were further elaborated by Müller-Mahn and Everts (2013) with reference to the works of three authors: (1) anthropologist Appadurai's (1990, 1998) understanding of the concept of—*scape*, (2) social theorist Schatzki's (1996, 2002, 2010) work on practice theory, and (3) human geographer November's (2004, 2008) accounts of the "spatialities of risks."

(1) The term riskscape not only at surface level bears resemblance to Appadurai's (1990, 1998) use of the suffix—*scape*, "deliberately chosen to produce variations of the metaphorically understood term 'landscape'" (Müller-Mahn and Everts 2013, p. 25). Appadurai (1990) himself declares to "use the terms with the common suffix scape to indicate first of all that these are not objectively given relations which look the same from every angle of vision, but rather that they are deeply perspectival constructs, inflected very much by the historical, linguistic, and political situatedness of different sorts of actors […]" (p. 296). Müller-Mahn and Everts (2013) particularly refer to the subjectively constructed nature of multiple overlapping—*scapes*: Just as there "is never one landscape, which is the same to all observers, but multiple landscapes depending on the range of possible perspectives" (p. 25), there is not one riskscape but a set of different riskscapes. The inherently subjective nature of—*scape* borrowed from Appadurai, entails that "there are at least as many riskscapes as there are individual perspectives" (Müller-Mahn and Everts 2013, p. 25). The host of different riskscapes is not isolated, but "partially overlapping" and "intrinsically connected" (ibid., p. 26); hence, riskscapes can be a matter of controversy and conflict. Subjectivity to Müller-Mahn and Everts does, however, not imply a purely cognitive or metaphorical notion of riskscapes but they incorporate material elements rooted in physical space just as much as they incorporate representations and products of imagination.

(2) Secondly, the concept of riskscapes makes reference to Schatzki (1996, 2002), arguing that the analysis of riskscapes, just as the analysis of social phenomena in general, "has to foreground human activity" (Müller-Mahn and Everts 2013, p. 26) or, in Schatzki's (1996, p. 89) own words, the "temporally unfolding and spatially dispersed nexus of doings and sayings." The authors proceed on the assumption that "things, spaces, or societies are not just given or preexisting items, but […] are made and remade through an intricate set of practices" (Müller-Mahn and Everts 2013, p. 26). As practices are "bound up in time and space" (ibid., p. 26), Schatzki (2009, p. 40) suggests studying the "timespaces" of human activity and the "place-path arrays" of practices. In that line of reasoning, landscapes "are not given networks of material objects but they are experienced and made sense of through practice" (Müller-Mahn and Everts 2013, p. 26). To them, the same holds true for riskscapes which "are practiced and constituted in practice" (ibid., p. 26). As to the multiplicity of riskscapes referred to above, the authors draw another analogy to Schatzki's notion of landscape stressing that "since the practices carried out in relation to landscapes are plural, landscapes are plural, too" (ibid., p. 26)—even if they relate "to the same objective spatial expanse of the world" (Schatzki 2010, p. 106). Acting upon something as a risk inevitably brings about a specific riskscape. But as practices vary, riskscapes will vary as well.

(3) Finally, November's (2004, 2008) seminal work on "spatialities of risk" is the third strand of theoretical underpinning to the concept riskscapes. Quite similar to the above-mentioned practice theory approach, November (2004) argues that a variety for practices of identifying and managing risks leads to a variety of risks. Another important aspect of November's "spatialities of risk," which, again, goes in line with the practice theory research agenda, refers to the multiplicity of risks. November and others (most notably Bickerstaff and Simmons 2009) point out that various practices do not only result in various risks (co)existing in one place but also in a certain degree of instability. She observes that "some risks turn into risks of a different category, after the initial risk has been managed" and they not only tend "to build up in some places" but also "to transform overtime" (November 2004, p. 277). In other words, their (co)occurrence in a place might fluctuate overtime. These observations point to questions concerning the fluidity of risks and, subsequently, the continuously evolving nature of their riskscapes.

In summary, riskscapes are the product of spatially and temporally situated practices geared toward multiple risks. They bring together an assemblage of immaterial interpretations and assumptions about the spatiality of risks and material objects located in a (physical) landscape acted upon in attempts at risk management (in a very broad sense). Subsequently, there is rarely (if ever) one riskscape but multiple riskscapes which are likely to overlap and interact. Riskscapes are not static but change overtime when risks are being reinterpreted, handled differently or (physically or metaphorically) move in and out of the sight of "risk managers". These aspects, taken together, call for an idiographic understanding of riskscapes in order to grasp their contextuality and to account for the particularities of the relations they incorporate.

20.3 Urban Riskscapes—Aspects of Technological Risks in Cities and Urban Agglomerations

Many scholars have contributed to the topic of urban risks and to discussions about urban infrastructures, urban vulnerabilities, city planning, and disasters (e.g.: Davis 1998; Graham 2010; Hewitt 1997, pp. 266–320; Maida 2008; Matsuoka and Shaw 2014; Pelling 2003; Pelling and Wisner 2009a; Schwarz and Meyerhöfer 1995)—not to mention the plethora of works on specific hazards and case studies on particular cities. Out of the variety of aspects of urban life considered to be making it more (or less) risk prone, we will in the following concentrate on a number of issues which relate to the finding that urban spaces have particularly been subject to anthropogenic transformation. These insights more than ever question the concept of the "natural" hazard. Of course, cities have repeatedly been hit by "natural" hazards—the disasters which they caused were, however, far from natural. With ongoing urbanization, an ever-growing share of risks will have to be regarded as technological risks (or at least as hybrids). These technological hazards come in a variety of different guises; according to the United Nations Office for Disaster Reduction (UNISDR), the range encompasses "industrial pollution, nuclear radiation, toxic wastes, dam failures, transport accidents, factory explosions, fires, and chemical spills" (UNISDR 2007, n.p.). Just as the hazards are various so are the impacts they might have on cities—ranging from contaminations of their surroundings to the stoppage of the flows that continuously support urban life.

We will in the following take a closer look at technological risks which bear the peculiar characteristic of being at the same time static and mobile: the risks related to hazardous material transportation (hereafter referred to as "hazmat transports"). Cidell (2012) described this specific quality of risk as characterized by mobility of the risk source in the case of hazardous material transportation. A crucial aspect is the simultaneity of presence and absence of risk (Cidell 2012; cf. Bickerstaff and Simmons 2009) which characterizes these "risky mobilities" (Cidell 2012, p. 15). Hazmat transports are not fixed in time and space (Cidell 2012, p. 13), and the source of risk is moving in space with a potential incident along the whole track (Hecht 2003, p. 19). Within the differentiation between "'focused risks' (concentrated on one site) and 'diffuse risks' (dispersion of risk within a territory)" (November 2004, p. 276) railbound hazmat transports are a hybrid of this binary. The risk is focused on the track and marks a specific spot in case of an incident but it is also diffuse along the specific line of route and along all the lines of the railroad network. The latter is especially true when there are no regulations having regard to the routing of hazmat transports. The regional focus of the chapter at hand lies on Germany and the Netherlands. Different aspects of the transportation of hazardous goods and their relevance for forming different riskscapes are based upon examination of the legal situation and practices with regard to emergency management in these countries.

20.4 Of Stationary and Mobile Risk in Urban Riskscapes —Research on Hazmat Transport Risk Management in Germany and the Netherlands

While hazardous facilities are stationary but nevertheless linked with 'absencing' and 'presencing' of risk (Bickerstaff and Simmons 2009), hazmat transports are characterized by their mobility. This mobile quality shapes the subjective appraisals of the risk. Furthermore, it determines the management strategies specific to it. Hazmat transports are characterized by uncertainties about what is transported and at what time the transport is at a certain spot along the route. This latent presence of hazardous material and the perceived risk shape the specific riskscape accompanying hazmat transport through urban areas: "[…] [G]oods might be passing through, but the infrastructure will stay fixed on the landscape, along with the hopes and fears it engenders in travelers and neighbors by its physical presence as well as the absent presences […]" (Cidell 2012, p. 16). The risk of hazmat transports is latently always there, it is a continuous risk event ('*riskantes Dauerevent*') in the terminology of Böschen (2003, p. 141) on chemical risks in general.

Generally, transport infrastructures are a prerequisite for today's society with its global linkages and the general division of labor as a basis for intensive exchange of goods. The urban centers are linked via transport infrastructures with other urban areas as well as with the periphery. In a way, the urban agglomerations are not just characterized by their population density or the density of the built-up environment in general but by the network density of channels of supply among which transport lines such as highways or railroads are important urban structures. This holds especially true in the context of expanding transnational economic activity and rising freight transport volumes. Therefore, transport infrastructures count among the "critical infrastructures," a term which pursuant to the German National Strategy for Critical Infrastructure Protection (BMI 2009) denotes "organizational and physical structures and facilities of such vital importance to a nation's society and economy that their failure or degradation would result in sustained supply shortages, significant disruption of public safety and security, or other dramatic consequences" (p. 4). It is, according to Aradau (2013), "through their capacity for being disrupted and their effects upon the smooth functioning of society" that "infrastructure becomes materialized" (p. 184) in the context of critical infrastructure protection. The outages relate to the risk of deceleration or interruption of the desired or normatively set circulation.

Transport infrastructures shape boundaries of concern ('*Betroffenheitsgrenzen*'; cf. Lübbe 2006, p. 80) by virtue of the side effects of the infrastructures themselves. The inherent tension is brought about by the widespread availability of goods and services on the one hand and by risks and pollution on the other hand.[1] Urban areas are the hubs of transport and by their network function are exposed to large volumes of transport. Thus, urban risks also contain risks of transportation—for example, hazardous material transportation through cities. Just as described above in the context of outages of critical infrastructures, hazmat transports imply the risk of a breakdown of normality—both with respect to their "critical" nature and to the hazardousness of the transported goods[2]—making the infrastructure itself a risk for residents and abutters. But another quality of this risk is the mobility of the hazard. The risk is latently existent along the route. "For transport, where the position is unpredictable and initially the chemicals involved are unknown, the emergency

[1]The tension between chances and risks is different with regard to urban areas and rural areas. Rural areas might not have the same advantages from transport lines as urban areas do, where the goods are shipped to and away from. Rural areas might just be passed through and are only spaces to be overcome, while the side effects are observable nevertheless. Since this chapter (and the main part of the book) focuses on urban risks, this cannot be elaborated any further although it is an important issue.

[2]Primary effects are characterized by direct impacts by hazardous materials themselves. In the case of an accident, subjects of protection (*Schutzgüter*; humans, real assets, and the environment) may be affected directly, by explosions, chemical burns or contamination, for example. Secondary effects may be additional consequences such as temporally delayed explosions and fires (Söder 1996, 7; Wiesmann 1995).

response becomes the responsibility of the local fire brigade and perhaps the local civil defense in case of large accidents" (Haastrup 1994, p. 496). Or as Lindell et al. (2007) note: "Small-to-moderate releases of hazardous materials at facilities are occupational hazards. These often pose little risk to public safety because the risk area lies within the facility. However, releases of this size during hazmat transportation are a public hazard because passersby can easily enter the risk area and become exposed" (p. 133). Both quotations underline specific problems in regard to mobile risks such as hazmat transports.

The problems mentioned are also noteworthy since they have a direct impact on the practices of emergency management. In urban environments, the units of disaster response (essentially fire brigades) are confronted with specific problems. Due to the circumstances as railroad tracks are not always accessible due to high densities of urban housing, it might be difficult to see and/or access the actual incident site and plan the response operation accordingly. Furthermore, it can be difficult to gain access to the tracks and/or to extinguish a fire since the length of the fire hose is limited or the water supply is far off. In combination with possible problems in assessing the situation properly because of limited visibility, railbound hazmat incidents pose a central issue for firefighters in urban areas.

These aspects are mainly framed by the urban environment and urban development which limit the opportunities for emergency preparedness and disaster response in general. But this also indicates problems regarding the legal situation and the consideration of spatial planning. The *Basisschutzkonzept* (Baseline Protection Concept) of the German Federal Ministry of the Interior (BMI 2005) does not explicitly focus on external[3] hazmat transports but it suggests applying similar safety and security considerations as in the case of stationary facilities (BMI 2005, p. 11). Generally, the consideration and regulation of hazardous material transportation, on external (outside of facilities) railroad tracks, for example, by legislation and spatial planning is not as thorough as in the case of stationary facilities. Dinkloh (2004, p. 186) notes that article 12 of the EC Seveso-II directive (EC directive 96/82/EC)[4] on the control of major-accident hazards involving dangerous substances as well as the German law concerning the protection from harmful environmental impacts due to immissions (*Bundes-Immissionschutzgesetz BImSchG*) constitute an obligation on spatial planning authorities to take precautionary measures regarding hazardous incidents. However, neither the relevant spatial planning laws (*Raumordnungsgesetz* ROG) nor the federal building code (*Baugesetzbuch* BauGB) nor associated ordinances define parameters such as distances or any measures as such. Even ordinances such as the land use ordinance (*Baunutzungs-Verordnung* BauNVO) do not cover hazardous incidents (cf. Dinkloh 2004, p. 186). The German Hazardous Incidents Ordinance (*12. BImSchV*) does only cover stationary hazardous facilities and not the transport routes of any mode

[3]Meaning external to hazardous (stationary) facilities.

[4]It has to be noted that the implementation of the Seveso directive varies greatly among different countries (Haastrup 1994, p. 495).

of transport. This failure to incorporate such risks is hardly comprehensible (Jochum 2009, pp. 26–27).

Thus, there is a need for a smart coordination between the technically oriented safety measures of infrastructure operators and the preventative measures of spatial planning. Comprehensive risk management should incorporate all aspects of risk regulation and emergency response (Dinkloh 2004, p. 192). The increased transport of goods, and with it of hazardous materials, demands an intensified attention to transportation risks (Haastrup 1994, p. 497) and their management—especially in urban areas. Thus, potential conflicts may be avoidable but this calls for long-term planning since there are architectural conservation regulations or "grandfathering" (*Bestandsschutz*) issues (Dinkloh 2004, p. 189). This is especially true for urban areas where "grandfathering" is common due to the long-standing historical development of cities. It is striking that it is especially in urban agglomerations that this is an issue since the Seveso directive does not take account of "grandfathering" in connection with hazardous objects (Rumberg 2011, p. 131). Furthermore, the directive(s) do not apply to transportation risks. This proves to be an issue within the triangle of aspects discussed here: hazardous material transportation through urban areas, the lack of adequate coordination between spatial planning aspects and hazardous incidents ordinance in regards to hazmat transport, and last but not least the specific urban conditions and issues such as "grandfathering" rights.

In the Netherlands, the demand for a coordination of hazardous incident prevention and spatial planning as a tool of disaster risk management has been addressed (Staatsblad van het Koninkrijk der Nederlanden 2015). Seemingly this has to do with different cultures of risk management or even different "risk cultures" in general. Central to these different approaches is, in the Netherlands, a tendency to work with probabilistic approaches in risk assessments, such as those regarding hazmat transports, versus deterministic directives and ordinances in Germany (Ale 2005, p. 203). In the Netherlands, the logic of preparedness (cf. Anderson 2010) in combination with the logic of precaution are dominant when it comes to hazmat transport risk management whereas in Germany mainly the precautionary principle seems to be dominant in this specific case of railbound hazmat transport risks. The Netherlands are, together with Switzerland, countries which consequently use quantitative measures to assess risks in regards to hazmat transports—and not just hazardous facilities. These assessments are being used as a basis for spatial planning decisions.

In the Netherlands, the external safety policy operates on basis of quantified risk assessments of individual risk (IR) and group risk (GR). The IR describes the localized probability that an unprotected person dies by an accident with hazardous materials per year on a certain spot when the individual resides there a full year. The GR describes the probability of a certain incident in which an amount of *n* persons die (Bottelberghs 2000, pp. 64–65). Figure 20.1 shows a schematic visualization of individual risk (IR) near a hazardous facility and near a railroad (cf. Jonkman et al. 2003, p. 4; van der Vlies and Suddle 2008, p. 121). These cartographic risk contours are guidelines for decision-makers and planners (van der Vlies and Suddle 2008, p. 122) by which distances between residential houses and

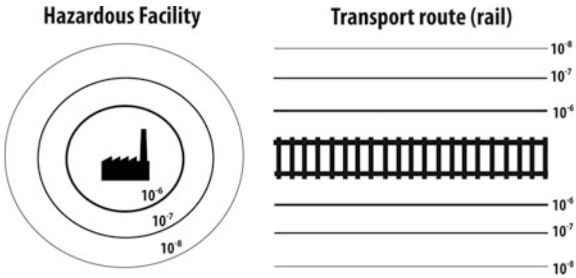

Fig. 20.1 Schematic visualization of the risk assessment in the Netherlands: Individual risk (IR) contours hazardous installation (point source) and a transport route (line source) (authors design based on Jonkman et al. 2003, p. 4; van der Vlies and Suddle 2008, p. 121)

transport routes are decided. "The government uses a 'risk contour' for the distance between residential buildings and transport routes. In principle, no building work may be carried out within this risk contour. This contour indicates the possible death rate following an accident at a company or during the transport of hazardous substances. The more transport vehicles using a certain route, the greater the likelihood of an accident. In cases where the standard used by the government is exceeded, residential buildings must be at a safe distance from the route. These areas along the route are indicated by the description 'risk distance required'" (Interprovincial Overleg et al. n.d., n.p.).

As indicated above, the approach taken by the Netherlands, namely coordinating spatial planning and hazardous incidents regulation, is an example of how to cope with the issues and tensions arising between the interests of transport, spatial development and safety. In contrast to the Seveso directives (I, II, and III), hazmat transports are included in the external safety policy of the Netherlands (Versteeg 1988, p. 220; Bottelberghs 2000, p. 63). The external safety policy on railroad transport for urban areas lays the foundation for assessing and regulating risk associated with transportation. Furthermore, in 2015 the Netherlands introduced a law concerning spatial planning measures in regard to hazmat transports. This so-called base transport network law (*Wet basisnet*) addresses the problem associated with being a densely populated country with large urban agglomerations and at the same time being a major transit country for freight transport of all kinds (cf. OTIF 2012; Staatsblad van het Koninkrijk der Nederlanden 2015). This law integrates the identification of hazmat transport routes, with zoned building restrictions alongside such routes including additional building codes and distance requirements for certain buildings. Thus, routing has been seen as an option: "Routing can be a measure that may only apply for a certain period of time (e.g., a day, a year). Routing can also be restricted to the transport of specific dangerous goods that contribute substantially to the amount of risk" (OTIF 2012, p. 3). In sum, the base transport network law (*Wet basisnet*) makes a strong argument for and a progressive step toward linking spatial planning, risk management of hazmat transports, and urban development.

20.5 Concluding Remarks

The mobile quality of hazmat transport risks does not only influence the risk perception but, based on overlapping risks and different *riskscapes* also highlights the need for aligned risk management strategies. More generally, the implications of this mobile quality of risk include the importance of studying spatial practices (Bickerstaff and Simmons 2009, p. 869) and the spatial constitution and performance of risk subjectivities (ibid., 2009, p. 870).

The concept of riskscapes addresses and integrates various aspects of risks: the overlapping of different risks, the multiplicity of perspectives on the same spatial area, and spatially different meanings and consequences. An important aspect of the riskscapes concept lies in the range of perspectives regarding the risks. The riskscapes of experts of transportation or urban planning differ from those in emergency management and disaster response. The riskscape of residents is another one which should ideally be taken seriously as well.

As outlined in this chapter of the book, riskscapes are characterized by a multiplicity of risks. Moreover, as Beck (1995, pp. 35–36) has noted, there are three major aspects to the relation of risk and the city: dependence on decision-making processes, manufactured incalculability, and heterogeneity. As a consequence, a lot depends on location, proximity, situation, times, groups, and individuals. This is, as described above, also fundamental to the concept of riskscapes. It is about the different ways in which people make sense of the contexts of risks and elements constituting them. For example "[e]ngineering and public health professionals recognize different aspects of risk and use different kinds of tools. People at risk also use different logics to recognize and evaluate competing risks" (Pelling and Wisner 2009b, p. 5) and "different practices and perspectives result in different riskscapes. These are, however, not isolated from one another" (Müller-Mahn and Everts 2013, p. 33). A context-sensitive, practice-oriented, and socio-spatial understanding of risks is necessary to grasp the context of specific urban situations and to get an in-depth understanding of risk situations—including the aspects stationary and mobile risks. The concept of riskscapes accounts for that since it recognizes the interrelations between risk concerns, risky places, and practices constituting risks. This was discussed here with a specific focus on stationary and mobile forms of risk in the context of urban infrastructures and associated riskscapes and different practices of risk management in Germany and the Netherlands. Yet, we strongly argue to consider the multiplicity of risks, the multiplicity of perspectives and practices accompanied with it and to think in a multiplicity of futures.

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Chapter 21
Researching Milieu-Specific Perceptions of Risk, (in)Security, and Vulnerability—A Conceptual Approach for Understanding the Inequality and Segregation Nexus in Urban Spaces

Kristina Seidelsohn, Martin Voss and Daniela Krüger

Abstract European cities are characterized by a growing social inequality, residential segregation as well as socio-cultural differentiation. Consequently, the capability of urban residents to protect themselves or to resume normality after a large-scale disaster is unequally distributed. In this chapter, we develop and exemplify a conceptual approach to assess milieu-specific perceptions of risk, (in) security, and vulnerability and further this research within the conceptual framework of sociological disaster research. We argue that approaches to communicate risk prevention, to implement sustainable adaptation strategies, or to reduce unequally distributed vulnerabilities cannot be successful without the engagement of the inhabitant's subjective perception patterns. A milieu-oriented research approach allows for the linking of the subjective dimension of risk, vulnerability, and (in)security with the social and spatial distribution of resources and capital (Bourdieu in Die feinen Unterschiede. Kritik der gesellschaftlichen Urteilskraft. Suhrkamp, Frankfurt am Main, 1987), which both form and reproduce social and spatial segregation (Scheffer and Voss in Erfolg durch Schlüsselqualifikationen? „Heimliche Lehrpläne" und Basiskompetenzen im Zeichen der Globalisierung. Pabst Science Publishers, Berlin, Bremen, Miami et al., pp 102–115, 2008). Using a case study in a mid-sized German city as a basis, we will sketch the theoretical approach first, then exemplify it with empirical results, and close by drawing some conclusions on milieu-specific perceptions of risks, (in)security, and vulnerability in urban spaces.

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21.1 Introduction

European cities are characterized by a growing social polarization and socio-cultural differentiation. Social inequality is spatially mirrored and visible within the residential segregation of socially marginalized groups, inhabiting neglected and often ethnically diverse neighborhoods. Hence, the capability of urban residents to protect themselves against various hazards or to resume normality after a large-scale disaster is unequally distributed. The current state of research on social vulnerability predominantly analyzes the spatial exposure to risks in relation to the social distribution of resources and, accordingly, the potential for disaster protection and response. These approaches focus on "objective" or technical criteria for vulnerability to identify the susceptibility of individuals or communities (Bankoff et al. 2004). In this chapter, we develop and exemplify a conceptual approach to assess milieu-specific perceptions of risk, (in) security, and vulnerability. We argue that unless their *subjective* dimensions are generally understood and addressed as—perhaps *the most*—relevant dimensions in the distribution of inhabitants in urban spaces and for the reproduction of social inequalities, approaches to communicate risk prevention, to implement sustainable adaptation strategies, or to reduce unequally distributed vulnerabilities cannot be successful. A milieu-oriented research approach allows for the linking of the subjective dimension of risk, vulnerability, and (in)security with the social and spatial distribution of resources and capital (Bourdieu 1987). Bourdieu's concept of "social spaces" (ibid.) represents a core contribution to the sub-disciplinary fields of the sociology of space and urban sociology for explaining the demarcations between social actors through the concept of habitus (see Löw 2001). Here, competencies acquired during socialization become relevant in ways similar to those of physical construction restrictions and, likewise, feature subjective perception patterns, which both form and reproduce social and spatial segregation (Scheffer and Voss 2008).

In order to make these thoughts accessible to research on risk, (in)security, and vulnerability, this paper furthers this research within the conceptual framework of sociological disaster research. Using a case study in a mid-sized German city as a basis, we will sketch the theoretical approach first, then exemplify it with empirical results, and close by drawing some conclusions on milieu-specific perceptions of risks, (in)security, and vulnerability in urban spaces.

21.2 Current State of Research

In the following, we will focus on "objectivistic" versus "subjectivistic" approaches as well as place-based versus generic approaches for dealing with social vulnerability in the context of sociological disaster research in urban spaces. From an "objectivistic" perspective, social inequality is spatially mirrored and evidenced in the unequal distribution of living space in a city. In addition to questions that focus on segregation as an expression of the spatial exposure of certain urban districts to risks, dangers, and insecurities, the residents' capacity to deal with threats and damaging events plays a similarly decisive role in their potential ability to regain a certain degree of normality after disasters. Social scientific vulnerability research (Felgentreff and Glade 2008; Voss 2008, 2009) has shown that the availability of capital and resources significantly determines the probability of becoming a victim of an accident or a disaster or not, as well as one's ability to expediently resume—insofar as possible—everyday life in the aftermath of the incident. The probability and extent of being affected vary beyond simple factors such as one's place of residence; they also vary with regard to social characteristics such as one's career, age, sex, etc. (Blaikie et al. 1994; Bankoff et al. 2004), and a minimal endowment of resources is accompanied by a higher susceptibility to certain risks. But this materialist, or rather essentialist approach cannot explain the reasons for these spatially expressed inequalities, nor does it tell us anything about the experienced meanings. Firstly, people develop differing subjective perceptions of risks in relation to their actual personal norms, values, capabilities, and expectations about their own futures. Consequently, the willingness and ability to evaluate, adapt, and deal with perceived risks, (in)security, and vulnerability vary as does the evaluation of the destruction during a disaster. Therefore, statistically observed data concerning "objectified" (in)security does not necessarily tell us anything about the current living conditions—the realities of the people— their motivations to stay or to leave, their communication and information needs, their expected behavior during a disaster or in its aftermath, and so forth. On the contrary, it construes a reality on its own that is then misunderstood as the "real reality," forming the basis of infinite false consequences.

Vulnerability studies in urban spaces have thus far focused on three main aspects in regards to safety and security, namely, research on criminality and terrorism, the question of dealing with natural hazards, and the safeguarding of infrastructural resources (Bürkner 2010). As a result, to date little, if any, attention has been given to the subjective perception of vulnerability. Existing quantitative studies tend to omit contextual factors such as the living environment in a city and empirical results vary, as they are dependent on, and influenced by topical political occurrences and media reporting. One can thus conclude that conceptions of risk, (in) security, and vulnerability are constructs of social perceptions that are subject to cultural interpretive patterns, developed through historical experiences. Exploratory qualitative studies primarily focus on the middle class or define the "poor" or disadvantaged solely in terms of their economic circumstances and thereby fail to touch upon the differentiations within these groups (e.g., study on the perception of climate change by Weller et al. 2010). This topic is highly relevant in the face of increasing pluralization and increasingly heterogeneous "modern" urban societies. In addition, the increasing ethnic diversity in urban spaces also receives little attention although the categories of "ethnicity" or "race" may have a decisive influence on other socio-economic characteristics. Following this idea, Donner and Rodríguez (2008) elaborate that "despite overwhelming support regarding the relationship between gender and risk perception, this evidence becomes less clear when considered in the context of race. A poor black woman will face different—and arguably more severe challenges—than a middle class non-Hispanic white woman during periods of disaster" (pp. 1106–1107). On the other hand, based upon these experiences, people develop a complex architecture of adapted perceptions and coping capacities to arrange themselves within their marginalized position and their normative frames, which will make a difference not only in terms of behavior or communication in extreme situations, but will also strongly influence their willingness to adapt to risks identified by experts (who represent the part of the society from which they feel largely excluded). While the interrelation between race, class, and inequality has already been investigated in a few studies in the USA (see Bolin 2007 for a discussion of five decades of hazard and disaster research on race, class, and ethnic inequalities), the interrelation in Europe is less clear. There is a distinct lack of qualitative and quantitative studies that can explain the differences between "natives" and "emigres" in the perception of risks, (in)security, and vulnerability (see study on immigrants (Bustamante 2002), refugees and other "objectively" vulnerable groups (Hugman et al. 2011).

Possible links can be found in studies that investigate the perceptions and fears of criminality: a realm of study that has been exploring the divergences between "objective" crime rates and subjective insecurity perceptions for quite sometime. These studies often discover that when better-advantaged groups feel unsettled by certain population groups, they "criminalize" those groups. Factors that are highly influential in the creation of fears of criminality in such cases include the media, local measures, the prevailing image of the living environment, as well as individual characteristics such as entitlements to safety and security, or tolerance levels. Furthermore, risk consciousness is dependent on topical political occurrences and the mediation of such events through the media, which accordingly causes stark variations between every survey (Henn and Vowe 2015). Heijmans (2001), for example, reveals that feelings of security and risk can already differ between two households, which external observers would otherwise identify as equally vulnerable due to their presumably similar conditions.

> [T]he two households might still perceive risk differently and, as a consequence, prefer different risk reduction measures. The degree of perceived risk varies greatly among households and depends on class, gender, location, and other particular conditions shaped by economic, social and political processes. (Heijmans 2001, p. 1).

Nevertheless, an overarching theory is missing that could potentially substantiate the subjective similarities of specific groups in addition to their differences while providing an understanding of the interplay between various social groups in urban districts. Given that disastrous events may affect the entire structural fabric of a city, it seems especially important to support "alliance building among communities at risk" (Heijmans 2001, p. 15) in complex urban societies. Hence, space and the spatial integration of these perceptions and sources must be granted greater consideration in future research on hazards and disasters. Recent investigations that compare the residents of both poorer and affluent districts in terms of their trust in disaster management systems and their coping capacities have shown that trust in disaster management authorities is more pronounced in poorer city districts than in affluent ones, while people appraise their own self-help capabilities similarly highly in both instances.[1] Beyond this, the question remains unanswered as to which social, cultural, and economic resources and capital are deployed, and how these are subjectively evaluated. Place-based situational approaches are needed to obtain a whole picture, yet analysis on vulnerability is often conducted for relatively large administrative units (for example, on the county/district level), which glance over extreme domestic differentiation that exists in cities. In order to understand the inner dynamics of "communities of place" (Pelling and High 2005, p. 308), we also have to differentiate and identify who the residents are in these "poor" and "affluent" communities.

Considering this state of research, the next section of the paper will critically discuss the milieu concept based on Bourdieu's milieu-theoretical approach. The studies into vulnerability which deal with Bourdieu's habitus concept and the respective capital in urban spaces either focus primarily on developing countries (Aguilar and Riviera 2015; Deffner 2007; Sakdapolrak 2007; Van Voorst 2014) or base their investigation on "affectedness" which can be explained through difference in one's capital endowment (Saalmann 2013). They point out that the concept of a "risk habitus" (Aguilar and Riviera 2015, p. 8) is useful in understanding how individuals judge, decide, and act against the background of a specific set of resources and within a specific set of actions (ibid.). Additionally, they show "that individuals' judgements of their own vulnerability are based on their perceptions of preparedness to face a risk situation; it does not matter the actual hazard level to which they are exposed" (ibid., p. 7). Regarding the subjective vulnerability in Germany, especially in the urban context, there are indeed only a few findings available (Birkmann 2011) and existing ones are lacking an integrative synopsis (see Heesen et al. 2014; Lorenz et al. 2015) and they do not make use of the far more complex space and field theory behind habitus and capital. Making use of this approach, Bourdieu has shown homologies between occupationally determined milieus in France (Bourdieu 1987). His basic approach on social spaces was further

[1]Here, we refer to the results from a survey that the Disaster Research Unit (DRU) conducted in Berlin, see also Lorenz et al. (2015). The survey is part of the research project Enablement of Urban Citizen Support for Crisis Response (ENSURE) of the Disaster Research Unit, Funded by Federal Ministry of Education and Research (time frame: August 2013–July 2016). It is a representative study (N = 1006) in Berlin intending to create an in-depth understanding of human behavior and self-evaluation during the isolation-phase of a disaster.

developed in a pioneering way by Michael Vester and his colleagues. Vester et al. (2001) replace social occupationally determined class fractions with social milieus and developed these further into a typology forming analysis of mentalities (see Vester 1976). The approach was then used to produce numerous significant works centering on the social structure of both East and West Germany (see Lange-Vester 2007; Vester et al. 1995). The milieu approach allows the integration of qualitative and quantitative methods as done by Bourdieu. This approach has thus become prevalent in both the scientific analysis of social structures (Otte 2004; Otte and Baur 2008; Vester et al. 2001) and in the field of market research (Sinus Sociovision). Milieu and lifestyle research accommodates the sophistication and differentiation of ways of life in modern societies.

The research expands upon the class and social strata models by adding a horizontal differentiation. A more sophisticated application or development of the milieu approach, however, in the context of disaster research has yet to be undertaken.[2] This research would involve answering questions regarding the extent to which milieu-specific differences can be found in the habitual construction of risk, (in)security, and vulnerability perceptions: how do feelings of risk, (in)security, and vulnerability influence processes of socio-spatial segregation, shape coping capacities, and thus (re)produce not only vulnerabilities, but also resilience?

21.3 Theoretical Outline

In urban sociological research and especially in research on segregation in terms of the spatially uneven distribution of various sections of the population (especially the Chicago School's "Community Studies"), the milieu concept is often applied when dealing with marginalized groups, which are thereby reduced to a specific combination of lifestyle and resource patterns. However, following the influential work of Pierre Bourdieu, the milieu idea can be applied in a more encompassing way. Following Bourdieu, the term can explain how people perceive and integrate themselves into various living circumstances. Bourdieu's (2009) empirical investigation shows that one can attribute a similar "perception of the social world" (p. 189) to actors with similar social position configurations (age, job, gender, etc.), lifestyles, and capital (economic, social, cultural, symbolic, and others) due to a field-specific formed habitus. The habitus positions actors within social space while simultaneously forming the field(s) in which the actor moves around and which again form/modify the respective habitus. The previously set available or gained resources and their respective value within the social space thereby influence the probability of endowing a certain preconscious framing of perception, taste,

[2]The milieu approach and the concept of habitus by Bourdieu and others also influenced the (sustainable) livelihoods approach (for example Scoones 1998; De Haan and Zoomers 2005; Sakdapolrak 2014).

thinking, and action, as Bourdieu indicates. The habitus is formed and altered during different lifestyles throughout the life cycle, yet people tend to seek out and value the particular environment for which their "incorporated" pattern is best equipped. On the other hand, people exhibit illogical behavior in the environments that are most alien to their incorporated pattern (see Bourdieu 1987). The habitus can be described as a kind of immanent but flexible law; a disposition stabilized through a multitude of factors, and thereby responsible for the regularity and situational pertinence of human action and therefore the statistical likelihood of said actions. The acquisition of these habits occurs primarily through practical and pragmatic everyday dealings with the world and is produced with and by participating in interaction nets. In accordance with this statement, Bourdieu assumes that the habitus provides a structured and structuring framework for thinking, perception, and action.

Bourdieu's habitus concept is closely related to the idea of a multidimensional space of social fields and social positions, which are ordered relative to one another and are to be viewed in a relational manner. These social positions (re)produce themselves through field-specific actions governed by field-specific rules and asymmetric power relations in which actors struggle, compete, and fight for their personal values and in which they themselves are grounded in the relationship between various kinds of capital. According to Bourdieu (1983), in addition to economic capital, cultural capital (educational degrees, incorporated capital), social capital (relationships or social ties), symbolic capital, and other forms of capital become valuable resources within certain fields, while in other fields the same amount and structure of certain capital can be less or more valuable.

In the sphere of disaster research, the milieu-theoretical view and Bourdieu's idea of the social field often remains unconsidered. As exceptions, Saalmann (2013) and Sakdapolrak (2007) argue that the approach would allow for an understanding of social vulnerability as a field, structured by capital and power relations, "(…) governed by a specific set of rules, and characterized by competition and struggle (…)" (p. 56). The position of an actor within this field indicates likely coping and adaptation capacities, strategies, and so on to the researcher, based on the subjective perspective of one's own vulnerability.

Thus, Bourdieu's work is also well-suited for connecting milieu-theoretical approaches systematically with urban social spaces as well as going beyond an understanding of hazards as being just an "objective risk" of exposed living conditions; instead, these risks are socially produced as well. Modern urban societies are distinguished by their socio-cultural heterogeneity as well as by the pluralization of life styles (Heitmeyer and Anhut 2000), in which spaces for similar social circumstances as well as networks of isolated island-like spaces have arisen and produce various milieu-specific perceptions and realities of risks, (in)security, and vulnerability. Each milieu has its specific perceived as well as "objectively" manifest risks, but they all develop situational capacities to adapt and become resilient within these risk patterns. On the other hand, actors may also choose risky places in relation to their personal subjectively perceived coping capacities. In light of this, a milieu-specific connection between residential locations and urban spaces becomes all the more relevant (Löw 2001, p. 259, compare with Schulze 1996); so-called "milieus of choice", which may not only avoid but also choose "objective" risky areas voluntarily, stand in stark contrast to involuntary milieus of the so-called left-behinds (see Gebhardt 2008). Thus far, segregation has been essentially understood as primarily determined by "objective" positional attributes rather than by various lifestyles (for example Otte 2004). Mutual lifestyles and collective experiences develop by means of the "typical bundling of 'objective' living conditions and 'subjective' attitudes" (Hradil 1987, p. 163). The strategies that social milieus develop regarding risks, (in)security, and vulnerability in order to position and move in (physical and social) space in addition to how milieus judge, evaluate, and perceive such spaces become increasingly relevant.

21.4 Method

The project "Vulnerability, Safety, and Security in a Just City," financed by the Federal Ministry of Education and Research in Germany, studies the subjective dimension of risk, (in)security, and vulnerability. To do so, we look at social processes of (re)producing social inequality or, more specifically for the urban realm, social segregation and how this process shapes and is being shaped by perceptions of risk, (in)security, and vulnerability. The empirical vignettes presented here are based on data from interviews conducted in 2015 in the German city of Wuppertal. It consists of 25 interviews with residents and 12 with experts. Wuppertal is a mid-sized city with over 350,000 residents in the federal state of North Rhine-Westphalia. In order to capture a range of urban living conditions, we chose a design in which an intra-urban comparison between a relatively affluent and a relatively poor district was possible. Our aim is not to compare the districts as such, but to look at practices (coping and participative capacities), social segregation, and group specific perceptions (for a methodological discussion on comparisons see Blokland et al. 2016).

Based on the milieu concept, resource-based vulnerability and subjective vulnerability will be analytically separated, but interpreted theoretically as being interconnected. The indicators for the measurement of resource-based vulnerability identified here are the social position of the interviewed persons (volume and structure of economic, cultural, and social resources, and capital), their participative capacity, the spatial proximity (physical quality of space) and the social cohesion within the neighborhood (voter participation). In the context of the subjective vulnerability, we assume that the sense of self, perceptions of space and spatial practices, risk perception, perceived vulnerability, contact with as well as trust in agencies tasked with security are relevant indicators for investigation. Following

Resource-based Vulnerability	• Social position (volume and structure of resources and capitals) • Spatial proximity (physical quality of space) • Social cohesion within the neighborhood (e.g. voter participation)
Subjective Vulnerability	• Sense of self • Perceptions of space and land use • Risk, safety and security perceptions and perceived vulnerability • Perceived participative capacities • Contact with / trust in agencies tasked with security

Fig. 21.1 Indicators of the measurement of social vulnerability

Voss (2008), we further measured the participative capacity of residents by assessing their perceived possibilities for taking measures against perceived risks, uncertainty, and vulnerability as well as the perceived accountabilities for actions. Participative capacity is hereby understood as the capacity to influence processes, which shape the individually experienced constructed, as well as social environment, hence to influence the development of the constructed neighborhood and the larger city context as well as discourses that render a specific group of persons into marginalized positions and so on (Fig. 21.1).

The entire sample comprises groups that have been conceptualized as "objectively" vulnerable in previous research: e.g., the homeless, people that consume alcohol regularly in public places, the unemployed, the elderly, and people with a migration background; the last of which takes center stage in the proceeding vignette. People with Greek, Turkish, and Arabic backgrounds (numerically, the first two groups are the largest migrant groups in the research presented here) from both socially well-off (high formal education, income above average) and less well-off dispositions (basic formal education, income below average) are compared, differentiated, and examined for possible relations. In the study, we focus on "objectively" socially vulnerable people, meaning those marginalized in cities in accordance with their precarious social positions on the one hand; on the other hand, we include elderly people as an example of the impact of physical vulnerability during the life cycle. We methodically contrast these groups in terms of affluent and physically able interviewees. Within the affluent districts all interviewees had a German background because few "non-Germans" live in that part of the city. Furthermore, these people were of similar social circumstances, yet represented different age groups, genders, and therefore, a variety of perspectives informed by different milieus and lifestyles. The aim of this design was to identify deviations between the subjective perspectives and the objectivized data on risk, (in)security, and vulnerability and to thus understand the social physics of segregation and the unequal distribution of residents to statistically safe/unsafe places in more detail and from a "real-life perspective." The following section's analyzes represent excerpts from a theory-based content analysis (Mayring 2010).

21.5 Empirical Vignette

21.5.1 Who Are the "Vulnerable" in "Vulnerable" Districts?

The "objective" positional attributes among the interviewees with Greek origins taken from the interviews we analyzed and present here are characterized by their occupational independence or their status as an employee in a small business. These businesses are in service sectors such as food products, cafes, or bars, which serve Greek specialties. The businesses of the interviewees are located spatially close to one another and people and car traffic densely frequent the accompanying street. Further, the interviewees both work and live in the same relatively poor district in Wuppertal but represent different ages and genders.[3] The interviewees of the older generation, which immigrated decades earlier, still has poor language skills, though those of the subsequent second generation improved in Germany and they now possess a native speaker level of language proficiency. Despite these differences of age and life experiences, those interviewees comparably mention the "others" (those on the "other side of the street")—those who are socially more disadvantaged in the city district—as being a significant factor for insecurity. These "others" are for example supposedly responsible for drug dealing, fights, carjacking, and other (petty) criminal activity. Those interviewed distinguish themselves as being separate from said "others" and this sentiment is similarly found and shared across the generations (parents who immigrated as well as their children of the second generation). The socio-spatial segregation mentioned above occurs in this case through a combination of social cohesion and the image the migrants have of themselves as "simple" yet "orderly" tradespersons. They focus on and seek "gainful" employment and explicitly separate themselves from the illegal businesses that are practically at their front doors: they avoid these places and maintain their social cohesiveness by conversing primarily in their mother tongue. Although they inevitably and necessarily share public spaces with people of similar or worse social positions, they separate themselves socially from those who fall underneath the social "threshold of respectability" (Vester 2010, p. 112). This means there is physical proximity at the same time as contact segregation and discrimination internally within groups of the same social circumstance or strata (see Eyles 2016 [1990]; Krüger 2016).

Furthermore, there is next to no sensibility for other topics on security matters beyond criminality: for example, the high burden on the local environment due to car traffic, noise levels, or the consequences of climate change. This idea is likewise

[3]Café/Bar owner, male, living in the poorer district for more than 30 years; Bistro employee, female, 10 years living in the poorer district, from Crete, single mother; Grocer, male, 28 years, son and employee in the family business, grew up in Germany.

supported by an interviewed expert from the program “Social City” in the poor district.[4] This expert highlighted the poor living conditions of the area in question in comparison to his original place of residence in the affluent district. In addition, he mentioned the intergenerational transfer of “risky everyday behavior”—“risky behaviors” that have come to be seen as “normal”—such as children who play on a street with heavy car traffic. Following this, people’s perception and evaluation of their living environment build up and come to form their habitual interaction with everyday dangers and risks that are no longer seen as such. At the same time, residential segregation often “sorts” people into places that show fewer residential qualities due to the density of buildings or proximity to large streets and highways (see Böhme and Preuß 2017). Still, a great amount of trust in the public agencies and offices responsible for safety and security can be found among all age groups (in our case, in both generational groups across the sexes) which seem to be rooted in former negative experiences from the country of origin. Of those interviewed who had immigration backgrounds—and especially those interviewees with Greek origins— many consistently drew comparisons between emergency services from their home country and those here in Germany. These comparisons—often stemming from personal experience—would then emphasize the reliability of the safety and rescue services in Germany (as one Greek woman implied: 3 days versus 10 min until rescue teams would arrive at the scene, as well as the police escorting her son to school after he had been threatened). This sentiment was not just limited to those Greek speaking interviewees, as nearly all those surveyed with migration backgrounds share the personal experience that the police and fire brigade have been reliable and quick to arrive on scene. Furthermore, the aforementioned interviewees feel there is an unambiguous understanding regarding legal status und a reliable application of law that is then further combined with a heightened sense of security (this is in direct contrast to the situation in more affluent districts where people conversely complain of an increasing negligence, especially concerning the police. This sentiment is discussed further below, as it helps to provide evidence for eroding and weaker trust placed in the institutions and organizations tasked with safety and security). At the same time, there is a level of cohesion that has been described as “very high” that exists within ethnically determined relationships, which in the case of an emergency, can secure one’s survival.[5] While the experts interviewed point out the social isolation of individuals—particularly regarding the

[4]In the project, we interviewed numerous experts that we will systematically relate to the population at large. In the following vignette, we draw them into the discussion in a cursory manner.

[5]The whole aspect of “level of cohesion” and social network settings could gain thoughtful insights from Granovetter’s work regarding the “Strength of weak ties” (1973). Granovetter distinguishes between “strong ties” and “weak ties”—while weak ties “are here seen as indispensable to individuals' opportunities and to their integration into communities; strong ties, breeding local cohesion, lead to overall fragmentation” (p. 1378). Therefore, strong ties may have ambivalent impacts on the level of cohesion—one the one hand, they lead to societal fragmentation; on the other hand, they may represent necessities of life in the local context and especially in the case of emergency.

'Traditional working milieu' with migration background	
'Objective' occupational status	Employee in small businesses in service sectors
Sense of self	"simple" yet "orderly" tradesperson
Significant factor in perceived vulnerability	'illegal business' on the 'other side of the street'
Strategies regarding vulnerability	Social separation from those who fall underneath the social "threshold of respectability" (Vester 2010, p. 112)
Level of cohesion	"very high", ethnically determined relationships and strong networks
Socio-spatial segregation	Physical proximity at the same time as contact segregation

Fig. 21.2 'Traditional working milieu' with migration background

elderly, single parents, and unemployed persons—in poor neighborhoods, when coupled with the high requirements on safety mentioned above, many ethnic and/or religious groups show high densities and frequencies within their respective communities. This is sometimes attributed to a lack of adequate language skills and experiences of discrimination. "News" is disseminated quickly and this information strategy seems to provide a very efficient avenue of aid in the case of an emergency. That which is often viewed in nationwide debates as a lack of integration or assimilation, functions within these groups as a sheltering of sorts that ensure daily livelihood. However, the interviews indicate that the selected vulnerable interviewees pay less attention to "invisible" natural hazards such as climate change-related processes as well as practical preparedness for disastrous events. Adaptive planning —should it wish to follow an ideal plan for a heterogeneous populace—has to take these differentiations within "poor" neighborhoods into account and furthermore, must take on the challenge of establishing new strategies for participation in safety-related discourses (Fig. 21.2).

In contrast, we interviewed residents who had moved out of the relatively poor district, but who nonetheless still regularly visited the district. Those respondents who were of a Turkish migratory background as well as those of an Arabic migratory background were on the council of a mosque and cultural center, all had a university degree[6] or they were part of the second generation and students,[7] or had higher level jobs that require formal training.[8] As a result, all interviewees had very high levels of German language proficiency. In comparison to the "traditional working milieu" (Vester 2010, p. 112) above, the religious, and in this case, Islamic identification played a larger role in comparison to ethnic or national origin within the "achievement-oriented employee-milieu" and the "upper service-provider

[6]Male, 52 years old, in Germany for 20 years, Turkish citizenship; male, 43 years of age, immigrated to Germany as a child, German citizenship.

[7]Male, 22 years of age, born in Germany, German citizenship, would like to apply for dual Turkish citizenship, parents are of Turkish decent, studies commercial IT.

[8]Male, 26 years of age, born in Germany, of German citizenship, parents come from Turkey, installs gas-lines and water plumbing.

milieu" (ibid.). This was especially poignant regarding perceptions of risks and (in) securities. One interviewed expert with an Islamic-Arabic background who had a leading position as a volunteer at a Muslim association explicitly touched on the perception that many religious community members share. Namely, that "they" (those of the Muslim/Arabic community) are often implicated as having terrorist connections, that they see themselves confronted with hostility regarding religious symbolism, and that they consequently fear attacks from Islamists and distance themselves greatly from violent confrontations. They avoid places where Salafists congregate as well as those parts of the city in which they presume German residents of the extreme right might live. Therefore, they segregate the city in their mental maps in terms of criteria that are of religious relevance. The milieu-specific connection between place of residence and urban space is characterized by greater distances than by that of the Greek community touched on above; people's place of residence is often not located in those presumably economically disadvantaged city spaces, yet they often volunteer in those areas and maintain contact with the people considered to be left behind who share the same ethnic background. In such cases, the evidenced residential segregation is not to be equated with contact segregation: the budding middle class and the upwardly mobile second generation both function as a bridge between the different social situations and strata. Due to their orientation toward the German middle class, they define and distance themselves distinctly from right-wing extremists or radical Islamist groups on the right of the political spectrum. They seek out and maintain contact with members of institutions and organizations tasked with safety and security, especially with the police, as they are considered necessary for certain religious events. As a result, this group expresses a high level of trust in the police's support and their reliability. Their strategies regarding risk, (in)security, and vulnerability express themselves beyond ethnically determined networks and instead are found in their socio-spatial separation from their original place of residence in the "disadvantaged" part of the city and their subsequent departure from the district. This strategy is often explained in terms of bettering one's economic situation and is also the means by which residential segregation physically and spatially reproduces itself through "objective" positional attributes. Cultural capital in the form of educational degrees and cultural knowledge and skills enables their social advancement from the original milieu up to echelons of the German middle class. This means that people retain the cultural knowledge from the milieu of their origin along with the existing social connections of that milieu: this then enables a mediation between different milieus and living environments.

The perceptions of risk, (in)security, and vulnerability presented in the milieus of Turkish and Arabic origin are, however, less founded in the problematic situation within "disadvantaged" city districts. Rather—and as mentioned above—they are grounded in the fear of terrorist reprisals from so-called Islamists. In the opinion of those interviewed, such attacks also harbor the added danger of follow-up reprisals from right-wing German extremists against Muslim communities. This represents a shift of ideological and religiously founded conflicts and cuts into the center of the everyday subjective perception of one's vulnerability. This risk perception takes

'Achievement oriented employee milieu' with migration background	
'Objective' occupational status	Higher level jobs that require formal training
Sense of self	German middle class oriented + religious and in this case, Islamic identification
Significant factor in perceived vulnerability	Salafists and right-wing German extremists
Strategies regarding vulnerability	Move out of poor districts, avoidance of specific places
Level of cohesion	Mediation between different social milieus, mosque community as a 'family'
Socio-spatial segregation	Residential segregation but no contact segregation; segregation through religion-related criteria

Fig. 21.3 'Achievement oriented employee milieu' with migration background

significant precedence in their life over other perceptions, such as those concerning environmental hazards of urban life or the possibility of a major damaging event. Presumably, the religious notions also inform their notions about (un)certainty, death, and danger perception: an aspect which needs to be explored in a future investigation that considers the pluralization of religious membership and world views. The respondents to the survey place a great amount of trust in the mosque's community as a "family" that always has its doors open and can be of great value as a point of reference during emergency situations; even for those that are not part of their ethnic community (Fig. 21.3).

21.5.2 Who Are the 'Non-vulnerable' in Relatively Affluent Districts?

The respondents in the relatively affluent district uniformly have the same place of residence, same place of origin, and same social situation, yet they differ in age and gender.[9] Although all three respondents from the affluent district differ in terms of age-based lifestyle-specific characteristics, they all expressed entirely similar perceptions of risk, (in)security, and vulnerability: the largest security problem they all mentioned was the "migrants" and "foreigners" which they all labeled as being responsible for taking advantage of the welfare system in Germany. While experts report that, contrary to this belief, integration has been rather successful in Wuppertal and that most migrants have already "assimilated" and "no longer stand out", all three respondents from the affluent district named

[9]70-year-old man who is in retirement; two young adults: one male, 22 years of age that has completed vocational education and one female, 21 years of age in the process of finishing her professional education.

immigration as being a problem. They did this in spite of the fact that there were scarcely any migrants in their area, if any at all. Nonetheless, they ranked the areas of the city as being safe and unsafe according to their personal estimations regarding the proportion of foreigners. The milieu-specific connection between place of residence and urban space occurs here via their avoidance of the space imagined as "unsafe" named "Talachse"[10] and through their active attempts to spend time outside of the inner city. Touching on this, the older interviewee stressed that he would rather go with his wife to a larger city nearby to go shopping than frequent the "inner city" of his city. His justification of this lies in his conviction that people in the larger city are better dressed and are more respectful to one another. His notions of the "poor" parts of the city do not draw upon his own daily experiences; rather they draw on his perception of what a safe and calm place is. This means that the interviewee and his wife look precisely for public spaces that are set in a similar social situation, even if those lie beyond their area of residence. When viewed with habitus hermeneutics (Lange-Vester and Teiwes-Kügler 2013) one can say there is evidence of hierarchical notions in the form of a positive appraisal of order, subordination, resentments, and concerns of social status. If one were to explain this need to distinguish oneself from those of lower social strata and circumstance as Bourdieu might, the answer would be that perhaps the interviewee's social situation is located below that of the average found in the affluent district under investigation, especially concerning economic capital. In this sense, he and his wife do not possess any property that distinguishes them from the majority of their neighbors in the district. The majority of the interviewed experts in the sub-project themselves live in the investigated affluent district, own houses, and are active in higher public offices or in other occupations that are located in modern labor milieus or in elevated service sector milieus. They speak positively about "successful" cases of immigrants integrating and distance them from those "less well integrated" people who live in the "disadvantaged" areas of the city, such as in the poorer district investigated here. The elderly interviewee living in the affluent district appears to rely upon the demarcations of the lower social classes in fear of their own social downgrade, as Bourdieu (1987) can show through his investigations.

In the case of the two younger respondents, it was expressly evident that they had a "politically correct" awareness that forbids racism, discrimination, as well as expressing resentments and prejudices. As an example, the young man expressed at the beginning of the conversation that he does not want to be seen as racist and that he has nothing against "foreigners." The responses from both younger interviewees contain statements that differentiate between "good" and "bad foreigners," and the sentiment that certain disadvantaged areas of the city are

[10]Refers to the surrounding area of a river that runs through the city of Wuppertal where comparably poor residents live.

correlated to the number of foreigners living there. As such, the interviewees name "foreign" adolescents as being the greatest source of vulnerability for "German" adolescents and furthermore that the respondents segregate the urban space in terms of this hazard perception in order to deal with risk, (in)security, and vulnerability.[11] According to the respondents, the causes of these problems are due to the "exploitation of social systems" and in saying so, the respondents exhibit an ascetic pattern of perception regarding employment—a perception pattern in which duty, discipline, and self-control play a role alongside a hedonistic orientation during periods of leisure. In comparison, natural hazards and environmental dangers are scarcely feared because the respondents rely on the emergency services in such an event and have likewise next to no personal experience with emergencies that they can draw upon. They clearly demonstrate the knowledge (the cultural capital) as to where information can be found in the case of an emergency (on the internet for example—or as in the case of the older interviewee—over the radio) and they trust in the high solidarity in their city district. All the respondents commented critically on the perceived dwindling reliability of emergency services. This was especially evident in the statement of the younger male respondent who gave an account of the increasing corruption as he had heard from his father who worked as a police officer. The respondent could not name the exact reasons behind this corruption. All three interviewees differ regarding their age and stage of life, but they show strong similarities in their milieu of origin as can be characterized by Vester (2010) as "modern or traditional petty bourgeois employee-milieu," as well as in their metropolitan interaction in the city. At this point, a study that focuses only on older people in certain city districts would most likely overlook the intergenerational lines or the passing on of specific perceptions and behavioral patterns regarding risk, (in)security, and vulnerability sensibilities. In this case, the age or the specific exigencies of age are not the deciding factors. Rather, the city district as a common living environment as well as the milieu (of origin) is relevant. The number of interviews conducted, however, is not sufficient to be able to start making representative statements. To check the validity of this thesis as to where milieu-specific patterns are found, we will have to conduct a follow-up quantitative investigation, which should further enlighten this question and prove their representability (Fig. 21.4).

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[11]The aspect of prejudices against foreigners despite contact with them reminds of the work of Gill Valentine (2010) regarding the social topography of prejudices and the discussion about the relation of contact and prejudice. "Decades of research show that intergroup contact can promote reductions in intergroup prejudice (…)" (Tropp and Pettigrew 2005, p. 951), but this could just be the case under certain conditions. Otherwise, specific conditions of contact can reinforce prejudices and intergroup enmity (Heitmeyer and Anhut 2000, p. 42f.).

"Modern or traditional petty bourgeois employee-milieu" – German natives	
'Objective' occupational status	Higher level jobs that require formal training
Sense of self	German middle class oriented
Significant factor in perceived vulnerability	Foreigners and illegal immigrants
Strategies regarding vulnerability	Social and spatial avoidance of places with a high rate of migrants
Level of cohesion	Milieu-oriented
Socio-spatial segregation	Residential and contact segregation with poor districts

Fig. 21.4 'Modern or traditional petty bourgeois employee-milieu'—German natives

21.6 Conclusion: How to Reduce Inequality and Social Vulnerability?

This paper sketched a milieu-oriented research approach for the linking of the subjective dimensions of risk, (in)security, and vulnerability with the social/spatial distribution of resources and capital (Bourdieu 1987; Vester et al. 2001) within the conceptual framework of the sociology of disasters. We argued that the subjective dimensions of risk, (in)security, and vulnerability in their general understanding should be conceptualized as highly relevant dimensions not only for segregation, the (re)production of inequalities and (adjunctive) vulnerabilities, but also for communication efforts in the context of disaster prevention or the implementation of sustainable adaptation strategies, among others. Using a case study in a mid-sized German city as a basis, we focused on qualitative interviews with groups that have been conceptualized as "objectively" vulnerable with a specific focus on people with and without migration backgrounds in relatively socio-economically poor as well as in affluent districts. The milieu-based theoretical concept facilitates comparisons between different societal groups from the same social stratum and allows for their internal differentiation.

The main results show that the subjective dimension of risk, (in)security, and vulnerability leads to milieu-specific strategies in spatial practices and social distinction. Thus, contact segregation cannot be equated with residential segregation and vice versa. The "traditional working milieu" with a migration background in poor districts shows a physical proximity with inhabitants of the same social stratum and contact segregation at the same time; the main strategy to avoid the perceived vulnerability and (in)security is social separation from those who fall underneath the social "threshold of respectability" (Vester 2010, p. 112). The "achievement-oriented employee-milieu" with a migration background moved out of poor districts and therefore shows residential segregation but no contact segregation with inhabitants in the poor district of origin. Based on an Islamic religious identity, the respondents segregate the city in their minds in terms of criteria that are of religious relevance. Presumably, the religious notions also inform their notions about (un)certainty, death, and danger perception: an aspect which needs to be explored in a future investigation that considers the pluralization of religious membership and world views. The “modern or traditional petty bourgeois employee-milieu” (Vester 2010) of native Germans in affluent districts ranked the areas of the city as being safe and unsafe according to their personal estimations regarding the proportion of foreigners. Their notions of the “poor” parts of the city do not draw upon their own daily experiences; rather they draw on their perception of what a “safe and calm place” is. This means that the respondents look precisely for public spaces that are set in a similar social situation, even if those lie beyond the area of residence.

The results of analyzing the subjective dimension of risk, (in)security, and vulnerability, show the additional benefit of going beyond collecting “objective” data of exposed individuals, communities, or city districts. In connecting relevancy structures of different social milieus, it is possible to get closer to the topic at hand and bring about a sensibility for the concerns of specific groups within milieus. A milieu-oriented and culturally sensitive approach is also useful in linking the necessities of different groups within communities with the institutions and organizations tasked with their safety (Seidelsohn et al. 2016). Furthermore, discourses and planning processes regarding safety and security should also pay attention to different hierarchies and conflicts within communities (Seidelsohn (Kraft) and Freiheit 2011) such as those relations that consequently cause one migrant group to view another ethnic group negatively, holding them responsible for societal ills (for example “Eastern Europeans” being blamed for petty crimes in the example provided in the empirical vignette). As with various other approaches, our first empirical results show that strong prejudices can be found between “native Germans” and “poorly integrated migrants,” as well as between different ethnic groups which may have the potential to undermine networks in disasters where the whole neighborhood might be affected. In order to show the gaps in justice that occur, further research must view the subjective vulnerability as it is linked with the “objective” perception that the institutions and organizations tasked with safety and security put forward.

As a forecast, the theoretical model and the results based on the milieu-oriented concept are helpful in regarding the question of how various sections of the population and their perceived exposure, (in)security, and vulnerability can be involved in future planning processes for more resilient cities. In certain safety-related discourses, it seems rational to address specific (occupationally determined) milieus separately. As such, the inquiry into a more just distribution of safety and security not only touches upon the distribution of “objective” resources and capital, or the distribution of residential space, but also draws upon the distribution of the potential to partake in safety-related discourses and planning processes of those particularly “vulnerable” milieus, which have less impact on such discourses. Safety and Security can be presumed to be resources, which are mediated and negotiated between various social circumstances. This is contextualized against a background of political and ideological conflicts, social demarcations, and milieu formations that harbor contestations, struggles, and discriminations within and between social dispositions or strata. In the analysis of our hitherto collected data, it appears necessary to interpret the mentality patterns surrounding subjective (in)security in light of the drawn conflict lines, cleavages, and social relations (see Vester 2010; Gebhardt 2008, p. 103).

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Chapter 22
Resilience and Thriving in Spite of Disasters: A Stages of Change Approach

Norbert Mundorf, Colleen A. Redding, James O. Prochaska, Andrea L. Paiva and Pamela Rubinoff

Abstract This chapter discusses individual, social, and organizational readiness for change in the context of resilience and sustainability; research focuses on measuring and improving population preparedness for catastrophic events, especially events exacerbated by extreme weather and sea-level rise. Resilience needs to be addressed directly through physical and financial measures, redistribution of control mechanisms, stress and conflict management pre- and post-disaster. Also, populations will benefit from adapting their attitudes and everyday habits that will be affected by projected disruptions in resource availability, infrastructure, and environmental conditions. This chapter demonstrates the potential of the *Transtheoretical Model* (TTM) to improve preparedness to respond to extreme weather and sea-level rise. One key strength of this model is its ability to reach even those who are not yet ready to take action and perhaps even unaware. TTM interventions have proven effective in changing numerous health behaviors—not only for individuals, but also at the organizational and policy level. TTM shows promise to promote sustainability and resilience behavior changes on a large scale. Current work has produced promising results at the local level, and a federally funded collaborative of multiple agencies is currently preparing to evaluate this model nationally.

Keywords Behavior change · TTM · Extreme weather · Sea-level rise Disaster preparedness

22.1 Resilience and Behavior Change

This chapter focuses on individual, social, and organizational readiness for change. Given the context of the book, we will address readiness for change in the broader context of resilience and sustainability, and preliminary research findings geared

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toward measuring and improving preparedness for catastrophic events, in particular, those related to extreme weather and sea-level rise.

It has been documented throughout this book that resilience needs to be addressed directly through physical and financial measures, such as reallocation of resources, redistribution of control mechanisms, and stress and conflict management pre- and post-disaster. In addition, however, populations will also benefit from adapting their attitudes and everyday habits that will be affected by projected disruptions in resource availability, infrastructure, and environmental conditions (Doppelt, 2008, 2015, 2016; Pacala and Socolow, 2004).

Our research demonstrates the potential of the TTM to improve readiness for change. Specifically, we will detail our behavior change approach, and its results for preparedness to respond to extreme weather and sea-level rise. One key strength of this model is its ability to reach even those who are not ready to take action and maybe not even aware of it yet. TTM interventions have proven effective in changing numerous health behaviors—not only for individuals but also at the organizational and policy level. We believe TTM shows promise to promote sustainability and resilience behavior changes on a large scale, as well. Our current work, applying the TTM to preparedness for extreme weather and sea-level rise (see Sect. 5.1), has produced promising results at the local level, and a federally funded collaborative of multiple agencies is currently preparing to evaluate this model nationally.

22.2 Theoretical Foundation

Sustainable change is the underlying theme driving the necessary environmental and social momentum required for lasting progress. In our work, we have adapted the *transtheoretical* (TTM) or *stages of change* model, which has proven highly successful in promoting health behavior change–to sustainability and resilience in the face of impending threats facing our physical environment, natural resources, and social fabric.

Research based on the transtheoretical model of behavior change (TTM) has shown with more than 50 risk behaviors that change unfolds over time and involves progress through a series of five stages. (1) Precontemplation (not ready): people do not intend to take action in the foreseeable future, usually measured as the next six months. (2) Contemplation (getting ready): the stage in which people intend to change in the next six months. (3) Preparation (ready): people intend to take action in the immediate future, usually measured as the next month. Typically, they have also taken some significant step toward action in the past year. (4) Action: people have made specific overt observable modifications in their lifestyles within the past six months. (5) Maintenance: the stage in which people have made specific modifications in their lifestyles more than 6 months ago. At each stage, different principles and processes of change need to be applied if populations are to make progress toward effective action and maintenance. Our work is based on the TTM which is measurement and data-driven with strong empirical support across a range of health, financial, organizational, and environmental behaviors (Levesque et al. 2001; Prochaska et al. 2015).

As behavior scientists, we realize the need to go beyond academic analyses. Hence, our goal is not only to document interdisciplinary research conducted at the intersection of environment, communication, behavior change, culture, and policy but also to contribute to a roadmap for proactive change.

The approach is based on the premise that at a fundamental level, communication and behavior changes are vital to creating the connectivity required to maintaining a vibrant culture of sustainability and resilient change. Readiness for change implies both preparedness for the practical challenges resulting from disruptions and disasters and the efficacy to rebuild and maintain personal, familial, and community coherence, which makes it possible to "bounce back better."

Research using the transtheoretical model of change (TTM) has documented in numerous studies that key segments of the population are either not aware of the problem at hand or not intending to attempt change (*Precontemplation*); others are aware of the problem but are not yet willing or ready to implement changes (*Contemplation*); another segment, in *Preparation* is ready to act on messages about changing behavior. Some have already changed their behaviors or have arrived at long-term change (*Action* and *Maintenance* stages).

Different messages and strategies need to be targeted to population segments that are in different stages of change. For example, early-stage individuals need to become aware of a problem and the multiple benefits that can come with changing, while later stage individuals need assistance and support to strengthen or maintain changes they have already made.

22.3 Sustainability and Resilience

In one randomized trial examining the impact of TTM-tailored interventions on various categories of well-being (suffering, struggling, and thriving), efficacy was demonstrated for both a TTM exercise intervention and a stress management intervention (Prochaska et al. 2012). Moving people from suffering and struggling to thriving is an important foundation of resilience. Thriving is the highest category of well-being in this framework.

Working with 4000 adults from 39 states in this randomized population trial, TTM-tailored communications had significant impacts on physical, emotional, and overall well-being, all of which were strongly related to resilience (Prochaska et al. 2012; Prochaska and Prochaska, 2016). A striking result of this work was that these TTM communications helped more than 40% of the population, who were suffering or struggling at baseline, progress to thriving within six months. Communication messages based on TTM that can enhance thriving and resilience resulting from disasters would be very important to develop and evaluate.

While it has many other connotations, the concept of resilience is also related to sustainability. This perspective implies embracing readiness for the environmental, social, economic, and cultural challenges related to climate change and its consequences, resource depletion, overpopulation, and environmental pollution (Doppelt, 2008; 2015, 2016). Human readiness is pivotal in combination with tangible activities, such as conservation measures, food security, and measures to manage the impact of flooding (www.resalliance.org). It encompasses a wide array of issues, from social–ecological systems, agriculture and food systems (FAO/OECD), climate change adaptation, and psychology (http://www.apa.org/helpcenter/road-resilience.aspx).

Another focus especially relevant for sustainability and resilience is multiple behavior change. For instance, research has shown that targeted behavior change feedback can encourage physical activity and healthy lifestyle choices while promoting a combination of multiple sustainable behaviors. Velicer et al. (2013) demonstrated that a TTM intervention was not only successful in encouraging physical activity, healthy diet, and reducing TV viewing in a large group of middle school students, and it even had a beneficial impact on reducing alcohol use and smoking uptake. This work underscores the need to identify and target multiple synergistic behaviors simultaneously. Resilient behavior transcends immediate disaster preparedness and encompasses social, political, financial, and cultural changes at the individual, community, and policy levels (Salzarulo et al. 2016).

22.3.1 Changing Sustainability Behaviors

While the primary focus of this chapter is readiness in the face of an acute disaster, lasting lifestyle changes are also critical for the ability to thrive during and after a crisis and to minimize negative long-term impacts. Public health challenges such as obesity and sedentary lifestyles are connected; their prevalence in poorer population segments underscores the urgency of concerted efforts; these groups are also often most vulnerable to environmental challenges. Targeted interventions can provide an effective and low-cost, individualized way to reach specific audiences and to encourage healthy behaviors. Promoting physical activity (Sallis et al. 2016) and access to community resources are critical in the face of rising health care costs, obesity rates, population aging, and numerous threats to public health resulting from insufficient physical activity levels. Enhancing health and well-being is an important part of promoting a culture of resilience.

Our earlier work has focused on promoting sustainable transportation choices. The built environment, transit, walkability, and food access have important connections with both quality of life and overall population health. Sustainable transportation alternatives can improve quality of life and provide economic opportunities for disadvantaged population segments, minorities, the disabled, elderly, and youth. Scheepers et al. (2014) reviewed various incentives designed to promote active transportation, as a way to encourage physical activity and reduce the dependence on single occupancy vehicle (SOV) transportation. Almost all studies in their analysis of published research found positive effects on (sustainable) mode shift from car use to active transportation. Typically, more than one intervention tool was used, such as social marketing, individualized transportation plans, improved facilities, or financial incentives.

We successfully adapted TTM measures for sustainable transportation stages of change, decisional balance, and self-efficacy in a RI campus community (Redding et al. 2015) and compared our results to a NH campus community (Fu et al. 2016). TTM measures were also adapted for green eating (Weller et al. 2014). These measures provided an empirical foundation for the development of TTM-tailored behavior change interventions, which have been shown to increase awareness and support, as well as moving people forward in the stages (Monroe et al. 2015; Mundorf et al. 2015). These results demonstrate that the TTM applies to sustainable behavior changes and can inform effective intervention and communication strategies to promote sustainable behavior changes, including those needed to enhance disaster preparedness.

22.4 The TTM Four Effects for Preparedness

Previous research across a range of risk behaviors (Blissmer et al. 2010; Prochaska et al. 2015) has identified four effects or drivers that predict successful behavior change at long-term follow-up. Here are the four effects adapted to preparedness behaviors:

(1) The stage effect states that at-risk individuals who are in the preparation stage at baseline will have greater success in adapting preparedness behaviors than those in the contemplation stage who will have greater success than those in the precontemplation stage.
(2) The effort effect reflects that at-risk individuals making the best efforts at baseline (e.g., endorsing that they have more pros and fewer cons of changing) will have higher percentages adopting preparedness behaviors than those with poorer efforts (endorsing a high number of cons changing and few pros of changing).
(3) The severity effect generates the prediction that those who would experience more severe effects from storms (e.g., injuries, cost, and disruption) would also be most likely to take action and maintain a higher level of preparedness over time.
(4) The treatment effect predicts that populations receiving a TTM intervention will show greater behavior change.

22.5 Application to Disaster Preparedness

We have in the past few years begun to apply the TTM to preparedness for extreme weather and sea-level rise (Rubin et al. 2014). In light of climate change impacts, our focus has been on sea-level rise and extreme weather in coastal regions, especially in the eastern US. During the past several years this region has been exposed to flooding and major storms, including Hurricanes Katrina (2005), Irene (2011), Sandy (2012), and recently Matthew (2016). Looking into the future, sea-level rise is a key concern, especially when combined with a growing number of extreme weather events (hurricanes, winter storms, inland flooding). A variety of threats emerge, which are primarily physical (water and wind damage), and also economic (immediate costs; long-term revenue loss in real estate, tourism, etc.) and social (disruption of families, communities and social structures).

Typically, government officials, politicians, and the general public are most concerned with these issues during and after a crisis. However, after the crisis has been "dealt with" many of those who may be affected in the future shift their focus to other, seemingly more pressing issues, until the next crisis emerges. Even gradual, population-wide increases in problem awareness may help facilitate changes at individual, community, and policy levels.

22.6 Communicating Risk and Disaster Preparedness

Efforts to communicate disaster preparedness and risk messages have led to increased public awareness. However, US Federal Emergency Management Agency (FEMA) surveys indicate that the public today is little more prepared to respond to a disaster than it was several years ago. This conundrum reflects the axiom in the science of behavior change that increasing awareness is necessary to start the change process, but is insufficient to change behavior by itself, reflecting the disconnect between theory and practice. Technology innovations (smartphone apps, texting urgent messages in real time, etc.) can improve risk and disaster preparedness communications (Bopp et al. 2016; Shklovski et al. 2010). Improving such communications by integrating TTM health behavior change research insights is also promising. Behavior change research indicates that: (1) the behavior targeted for change must be clearly defined and include specific achievable actions; and that (2) behavior change is a long process where each stage defines a small step forward on the way to permanent behavior change. While efforts at linking behavior change and preparedness have been shown to be successful (Mileti and Darlington 1995), it remains uncommon for most emergency managers, communicators, and planners to incorporate behavior change research insights when communicating with the public.

This project addresses key questions about what motivates individuals and groups to prepare for disasters before threats exist, when threats exist, and when a crisis is occurring. FEMA's report, *Preparedness in America,* reflects key concepts that parallel those in the TTM.

Our initial work was designed to determine readiness for change and to develop targeted messages to move people toward greater readiness. One critical difficulty was to determine a "focal behavior," which is the primary goal of our behavior change strategies. This proved to be challenging because of the scope of adaptation and mitigation issues to be addressed. Factors to be considered were location, distance from the shore, exposure to natural risks, community characteristics, and economic circumstances.

Early on in our project, key actions focused on individual (household level), rather than community level or policy change. Based on preliminary research, three components were chosen as representing disaster preparedness: being informed, getting a kit, and making a plan. While these actions are primarily suitable for preparedness in an acute emergency situation, they also help individuals and households adapt to longer-term climate change impacts.

The secondary focus was on mitigation behaviors designed to reduce damage from wind and flooding. These behaviors were tailored only on the individual's stage of change. Previous multiple health risk behavior research demonstrated that applying CTIs that are fully tailored on each relevant TTM construct for the primary behavior (e.g., medication adherence) and tailored to stage only for secondary behaviors (diet and exercise) was effective for each of the three behaviors (Johnson et al. 2006). In our study, the primary behavior was disaster preparedness and secondary behaviors were wind and flood.

To evaluate the efficacy of communication interventions, longitudinal studies are necessary over a period of time that reassesses participants after one- and two-year periods to determine how behaviors change and to adjust the individualized feedback accordingly. This is not common practice. Our program promotes such an effort and will be scalable to large populations to effectively communicate disaster preparedness and risk messages. The direct end users of this project are coastal residents in Rhode Island, Massachusetts, Florida, and Alabama—with a starting sample of 3000. However, to ensure the continued use of this research in practice, it will also target local, state, and Federal emergency managers, and coastal planners, who can help us to identify ways to incorporate and/or adapt the research findings to strengthen their communication programs.

The major outcome metric will be comparable to that used in more than 25 population trials—the percentage who progress from "not prepared" to "prepared" for disasters. A revised Internet-based CTI together with ongoing coaching through individualized text messages to 1000 participants is expected to increase the efficacy of storm preparedness—the key behavior targeted. The project will assess participants every 12 months, so the team can dynamically tailor the messages to their stage.

22.7 Measurement Development and Preliminary Assessment

22.7.1 Stage of Change

Knowing an individual's stage of change is necessary in order to understand his or her progress through the stages. Participants' stages of change were assessed across three primary behaviors and seven secondary behaviors. Participants chose one statement that best reflected their current situation from a list of five staging statements. For example, for disaster preparation, the staging question was "Have you prepared for a potential disaster by making an action plan and preparing disaster supplies such as food, water, and other essentials that allow you to be self-sufficient for at least five days?" The five response options were: (1) "No, and I do not intend to prepare in the next year" (*Precontemplation*); (2) "No, but I intend to prepare in the next year" (*Contemplation*); (3) "No, but I intend to prepare in the next 6 months" (*Preparation*); (4) "Yes, I have been prepared for the last year" (*Action*); or (5) "Yes, I have been prepared for more than a year" (*Maintenance*).

The results from the stages of change survey across the three primary behaviors and seven secondary behaviors showed that the distribution of stages differed noticeably across the ten primary behaviors. The staging distribution for disaster preparedness showed the broadest distribution, with a good distribution of individuals in each of the five stages. Of the 277 participants, 14.8% were in Precontemplation, 15.2% in Contemplation, 10.8% in Preparation, 22% in Action, and 37.2% in Maintenance for disaster preparedness. This means that about 59% were already engaged in sufficient disaster preparedness to be self-sufficient for five days if a disaster were to strike (the Action criterion), while the remaining participants were not. Of those who were not yet ready for disaster, good proportions of individuals were either thinking about (Contemplation) or getting ready (Preparation) to start being prepared to be self-sufficient for five days in case of disaster. These stage distributions were strikingly similar to what has been found for some major health risk behaviors, such as smoking. This supports the use of TTM and CTI for behaviors such as climate change adaptations and disaster preparedness.

22.7.2 Decisional Balance

This component of TTM, which evaluates perceived pros and cons of behavior change, helps move the individual through the stages of change. For the decisional balance measure, twenty items were included in the initial survey, with ten pros and ten cons of taking adaptive actions. Respondents were asked: "How important to you are the following statements in your decisions concerning risk reduction strategies?" Respondents then ranked the importance of each statement to their decision-making regarding specified adaptive actions on a five-point Likert scale with one corresponding to “not important” and five corresponding to “extremely important”.

Confirmatory factor analysis was performed on the twenty original decisional balance items to test the measurement model. In the iterative series of analyses, the initial twenty items were reduced to eight final decisional balance items with good measurement properties: four pros and four cons. Now that the measure was developed, responses could be summed for each scale and evaluated next in relationship to the stages of change.

A large increase in pros was observed between the Precontemplation and Contemplation stages and the Preparation and Action/Maintenance stages. This between group differences in this cross-sectional study would correspond to an approximately one standard deviation increase in pros from Contemplation to Preparation if it had been a longitudinal study. A decrease in cons was also observed between stage groups. Importantly, the cross-sectional patterns observed for disaster preparedness were consistent with the cross-sectional and longitudinal patterns found across many health-related behaviors (Prochaska, 1994; Prochaska et al. 1994; Hall and Rossi 2008). This finding supports the application of the TTM to preparedness behaviors.

22.7.3 Self-efficacy

In addition to decisional balance, self-efficacy (also called “confidence”) contributes to moving individuals through the processes of change. The self-efficacy metric measures individual’s levels of confidence in his or her ability to take and maintain behavior change actions. For the confidence scale, thirteen items were included in the initial survey and each respondent rated his or her degree of confidence on a five-point Likert scale (1 = not at all confident to 5 = completely confident). Confirmatory factor analyses were performed on the thirteen original confidence items, reducing the list to the best six items. Confidence scores were then calculated for each participant by summing the responses for the final six items. As expected, confidence increased across stages of change, with the largest difference observed between preparation and action stages.

22.7.4 Computer-Tailored Intervention

The disaster preparedness computer-tailored intervention (CTI) was a pilot study designed to promote increased preparedness for natural disasters such as tropical storms and hurricanes, inland and coastal flooding, and blizzards through a Web-based interactive survey. Participants were recruited through email announcements, listservs, postcards, and personal contacts. The pilot disaster preparedness CTI consisted of one session lasting approximately 20 min that began with an overview of the pilot study, informed consent, and questions to determine eligibility followed by a series of interactive questions. This study examined three behaviors: increasing disaster preparedness, reducing the risks of wind damage, and reducing the risks of flood damage. The primary focus of the CTI was increasing individuals' preparedness for disasters that will become more frequent with climate change. Being prepared was defined as a three-part process including the actions of "getting a kit, making an evacuation plan, and being informed."

22.8 Conclusion

Communication strategies are critical for this work and its future applications. Our pilot study that combined individualized online communication and community meetings was successful in encouraging different segments of the target audience to move toward greater readiness to prepare for extreme weather and sea-level rise. It also created a framework for creating effective communication strategies to prepare different population segments for coastal hazards and other disruptions.

22.8.1 Mitigation, Adaptation, and Policy

As we look toward a sustainable future, we need to preserve our environment, conserve resources, promote social justice, and minimize violent conflict. We also need to prepare for coming hazards, given current climate, and population trends. Governments, NGOs, and citizens' groups have begun to chisel away at seemingly insurmountable challenges. As with many public health problems (e.g., smoking, diet), policy typically reflects existing awareness and attitude change in the population, being reactive instead of proactive. Leading by being proactive would support greater readiness to take the necessary steps. For example, a study in six countries of smokers and quitters showed strong relationships between stages of readiness to quit smoking and support for 5 different smoking-related policies ranging from least restrictive (education) to most restrictive (smoking bans in public places). Smokers in Precontemplation were least supportive of any type of policy, and former smokers in Maintenance were most supportive (LaForge et al. 1998). These results suggest that helping populations progress out of Precontemplation will increase support for policies related to preparedness and adaptation, as they have for smoking-related policies. Helping individuals to continue to progress is likely to continue to increase their support for disaster and adaptation-related public policies as well. We have the tools to communicate change, but it takes a network of change agents and readiness at all levels to design and disseminate effective messages.

We have seen significant progress in individual and community health behaviors resulting from attitude and behavior change. For instance, there has been considerable progress in multiple health behavior changes. We believe that TTM can be effective in changing multiple adaptation and sustainability behaviors, as it has with multiple health behaviors. Gathering this evidence would advance the field by producing an integrative communications platform for research and intervention. Not only can this behavior change informed approach integrate across multiple behaviors but also across multiple levels, such as individuals, families, communities, and populations.

The work discussed in this chapter highlights the importance of behavior change and communication in this emerging field of resilience. Social, physical, financial, and psychological resilience is integral to giving us the strength to pursue sustainable options. Our TTM behavior change approach is scalable and applicable across different cultural contexts. We hope that it will become a key ingredient in future efforts to develop resilience.

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Norbert Mundorf Ph.D. is a Professor at the University of Rhode Island (URI), where he has taught since 1987. With his background in communication, he is involved in various interdisciplinary research, teaching, and outreach initiatives to promote sustainable transportation, resilience, and health. Research interests include media, global, and online communication, as well as sustainability and behavior change. He has worked with the URI Transportation Center, Cancer Prevention Research Center, and the Coastal Institute. With the University of Göttingen and Fraunhofer ISI, he has collaborated on issues related to virtual mobility and sustainable transportation, including the impact of transportation choices on health and active living. He has been involved in projects related to health promotion (smoking, alcohol, DUI), sustainability and behavior, acceptance of innovative renewable materials, and preparedness for the impacts of climate change. At URI, he is the coordinator of the Sustainability Minor, and he has actively promoted a global online debate network with universities in Germany, Russia, China, and other countries.

Colleen A. Redding, Ph.D. is a Research Professor at the Cancer Prevention Research Center and Psychology Department at the University of Rhode Island. She has published more than 120 peer-reviewed papers and chapters on diverse topics in Health Psychology and Behavioral Medicine. Her contributions include developing and evaluating TTM-tailored computer-delivered interventions to single and multiple health behaviors in a range of diverse populations. She is one of the leading researchers using the transtheoretical model (TTM) of behavior change to improve multiple health risk behaviors, sexual health promotion, sun protection, energy balance, sustainability, stress management, medication adherence, and advance care planning. She has been PI on a series of large and small grants examining optimal TTM tailoring of smoking cessation feedback and mediators of health behavior change. She is an editor and reviewer for many high-quality health-related journals. She has been a principal or co-investigator on at least 25 successful NIH and CDC research grants summing to more than $80 million dollars.

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Pam Rubinoff is a Coastal Resilience Extension Specialist at the Coastal Resources Center and RI Sea Grant, at URI's Graduate School of Oceanography. Over the past two decades at URI, Rubinoff has combined her skills in engineering and coastal drop policy to advance an interdisciplinary coastal resilience portfolio in Rhode Island and developing nations throughout the world, including Latin America, Southeast Asia, and West Africa. In collaboration with a diverse group of partners, Pam facilitates the use of climate science for effective policy, planning and action by coastal communities, state governments, and private sector stakeholders. Rubinoff's leadership has contributed to efforts including Rhode Island's state policy on sea-level rise, coastal green infrastructure, FORTIFIED Home program, development of National Coastal Smart Growth principles, USAID's Coastal Adaptation Framework, and URI's partnership with the National Coastal Resilience Center of Excellence of the US Department of Homeland Security. Ms. Rubinoff has a master's degree in marine policy from the University of Rhode Island and a bachelor's of civil engineering from the University of Delaware. Her career spans from the US Army Corps of Engineers and the US Peace Corps in Thailand, to the shores of Cape Cod where she was the Regional Coordinator for the Massachusetts Coastal Zone Management Program.

Chapter 23
Foresight in Sight: How to Improve Urban Resilience with Collaboration Among Public Authorities?

Riitta Molarius, Nina Wessberg, Jaana Keränen and Mervi Murtonen

Abstract Creating a resilient built environment for citizens is one of the main issues public authorities face when planning urban areas, such as new residential areas, suburbs, shopping centres, or traffic stations. Today, in particular, the safety and security of the built environment focuses on city planning. New technologies, including digitalisation, as well as citizens with differing feelings about and experiences of safety and security challenge city planners, and this requires attention. Utilising foresight methods, such as the participatory scenario-building method, is one way to adapt to future changes in urban settlements and help decision-makers in creating a better tomorrow for citizens. This paper presents one foresight method, termed scenario-building process, as a tool for city planners to create a safer and more secure built environment for citizens with different needs and backgrounds. The paper discusses how to use participatory scenario building together with city authorities and other stakeholders for planning urban areas. By presenting a case study from Finland, where the method was used to develop the area around a railway junction station, the paper brings out four scenarios developed to visualise possible future paths of the studied railway station area. The case study was part of the HARMONISE—A Holistic Approach to Resilience and Systematic Actions to Make Large-Scale Built Infrastructure Secure—project that was funded by the European Union within the Framework Programme 7.

Keywords Foresight · Scenario · City planning · Safety · Resilience

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23.1 Background

There are many reasons why a safe and secure built environment, including a high level of safety and security, is not always well received. Ratcliffe and Krawczyk (2011) have presented eight challenges that explain why yesteryears' planning methods are no longer adequate for today's city planners. These include large populations, lack of resources, new technologies, the diversity of risk, complex economies, and redefined enemies. Schumacher (2003) has written, "Security is always implemented by humans on request of humans". Thus, even securely built systems may run into situations in which there is a risk of human error and of malicious human behaviour. When the security of systems fails, it is vital that the whole living environment is built in a resilient way. A resilient city has the ability to overcome different kinds of failures, unexpected changes in demographic circumstances, extreme natural hazards, the collapse of operating business environments, and terrorist attacks among other things (Molarius et al. 2016).

The ability to recover from a failure is one main issue in question for urban resilience. This ability includes a number of individuals with disaster management skills who are able to take a key role in a recovery situation. Important in recovery is the availability of economic resources, including insurance contributions or claim payments. The availability of mental support is also important, especially in cases in which recovery may take a long time. Ahern (2011) states that cities with a sufficient level of economic and social diversity have a complex variety of responses to adapt to changes in society. City planners and political decision-makers need to understand more deeply the society for which they are working. They should learn how to build an environment that at the same time improves communal awareness and cooperation, both inside and outside the community, and improves the feeling of safety and security by tackling serious threats beforehand.

Speight (2011) highlights that security often fails because macroenvironmental sociopolitical threats are not sufficiently taken into account. All these kinds of threats against a resilient city can be identified and designed in a foresight process that can be designed to identify and analyse forthcoming technological, sociopolitical, and other kinds of challenges. The aim of the foresight process is to make city planners aware of possible future scenarios and help them to outline and create the desired future. Within a foresight process, major potential changes are systematically identified, mapped and analysed in the operational environment and in the city composition within a chosen timescale.

This article focuses on the above-mentioned shortcomings and presents a method for including macroenvironmental sociopolitical threats in the planning process early on. The objective is to integrate resilience theme, which focuses on a city's capacity to continue its existence in all situations, with the foresight approach. In general, the city planning process includes many uncertainties due to lack of knowledge or faulty knowledge about the future. With the help of foresight methods, it is possible to fill this gap in knowledge and design shock-resistant, healthy, adaptable and regenerative urban areas that are self-organising and organisational learning. For this reason, city planning that includes a foresight approach can be seen as one key element of building resilient new areas.

The main terms of this article are resilience and foresight. In general, "resilience" means the ability of a system to adjust in the face of changing conditions (Pickett et al. 2004). In the context of the HARMONISE project, "urban resilience" has a more specific focus on safety and security, and it refers to a city's capacity "to continue its existence, or to remain more or less stable, in the face of surprise, either a deprivation of resources or a physical threat" (Longstaff 2005; Hynes et al. 2013). Resilience consists of different key pillars including requirements for foresight and preparedness, for a holistic fashion of multiple risks and hazards and for the integrated governance of response (Hynes et al. 2013).

"Foresight" can be seen as a systematic, participatory, holistic and future intelligence-gathering process that supports decision-making. It is also seen as the "ART" of exploring systemic changes in order to better anticipate, recommend, and transform possible futures. It attempts to look into the future systematically, and with a long-term view. In this sense, the foresight approach distinguishes from everyday future planning we all are doing in our lives (UNIDO 2005). Chia (2004) states that foresight can be seen as a "unique and highly valued human capacity that is widely recognised as a major source of wisdom, competitive advantage and cultural renewal within nations and corporations". In the context of urban resilience, foresight can be seen as a way to develop a range of views of possible paths describing how the future might develop, or, how we would like it to develop. The concept incorporates the understanding of these paths sufficiently well to enable proposing which decisions should be made today in order to create the best possible tomorrow (Horton 1999).

This study was part of the HARMONISE—A Holistic Approach to Resilience and Systematic Actions to Make Large-Scale Built Infrastructure Secure—project that was founded by the European Union in the Framework Programme 7. One key objective of the HARMONISE project was to engage end-users in urban resilience planning and development. The project consisted of five case studies throughout Europe.[1] The Finnish case study presented here aimed at discerning possible futures of the districts around a new railway station area in the centre of Vantaa city.

23.2 Foresight as a Part of Planning Resilient Cities

Rohrbeck (2011) has stated that foresight processes would strengthen strategy-building processes in organisations. He describes these foresight processes as corporate foresight processes and introduces some actions where foresight could

[1]The other four case studies are located in Bilbao (Spain), in Dublin (Ireland), in Genoa (Italy) and in London (Great Britain).

be especially helpful in contributing to strategy-building processes (Rohrbeck 2011). In the urban context, at least two of these actions are particularly relevant:

- To support the management of discontinuous change by detecting changes in the operating environment and by channelling information into and through the organisation,
- To support gaining and retaining a competitive advantage in turbulent times by identifying needed strategic resources.

In other words, the foresight process considers and tries to tackle the continuous information flow in cities and their surroundings. It embeds people in designing their future and prepares cities for the future and for resource efficiency.

Foresight processes consider the main mega trends, such as ageing, climate change, resource and energy efficiency, digitalisation and robotisation, that effect city planning. These tendencies can be recognised, for example, by using the PESTE method (Meristö and Laitinen 2009). PESTE refers to political, economic, societal, technological and ecological trends and variables that are explored to collect driving forces, signs of change and weak signals to an illustrative map (Meristö and Laitinen 2009). Changes in these trends, as well as the sociotechnical changes in a society as a whole, should be taken into account when creating resilient future scenarios.

Jabareen (2013) suggests a resilience-based city planning framework that considers a city's vulnerabilities, uncertainty-oriented planning, urban governance and prevention actions. Changes in natural hazards, immigration and security circumstances should be accounted by creating maps and scenarios of the anticipated changes. Lister (2007) points out that all innovations should be piloted by using "safe-to-fail" design experiments, which means that a failure event poses no significant risk to society. Especially in the cases of complex societal changes, such as demographic changes and major natural hazards, in which anticipated events cannot be tested or piloted, scenario work might be useful and might provide valuable views to possible courses of actions and long-term developments.

Scenarios are one option from a palette of foresight methods (see e.g. UNIDO 2005; Popper 2008). They provide alternative views of the future. They identify significant events, main actors and their motivations, and they convey how the world is thought to function in the specified circumstances. Scenario-building processes help city planners understand how things interact and what their dependencies are. Using built scenarios enables an exploration of what the future might look like and what changes are needed or likely to boost the scenario realisation (Ratcliffe 2000). A well-crafted scenario allows organisations and society as a whole to become more proactive and helps them to work specifically for their desired future.

In general, the scenario-building process consists of the following phases (Ratcliffe 2000):

1. Task identification and analysis,
2. Key decision factor appraisal,
3. Analysing driving forces,
4. Ranking driving forces and selecting alternative projections,
5. Generating a scheme for the future, e.g. scenarios,
6. Future scheme evaluation and transfer (output).

The identification of the key factors is the core task in the scenario-building process since those factors specify the futures people need to adapt to or tackle. For instance, according to Jabareen (2013) important factors in the city context may include vulnerability, prevention, urban governance, recovery and societal behaviour. Vulnerability, in this context, refers to the capacity of a society to resist harmful changes that take place in the environment (Jabareen 2013). These changes can include, for example, changes in critical infrastructures or in the working environment (e.g. economic crisis, wars).

In the background of all these key factors is the technological change that occurs at a rapid pace. Changes in technology can be predictable, faster than expected, or perhaps they will not occur at all, or they are totally unexpected or even revolutionary in that they change an entire existing system. Dolata (2009) has pointed out that the speed of the progression of technology depends on its adaptability to be a part of other technologies, routines or strategies. The regulations and norms of society may enhance or prevent this development. In addition, new grand inventions that require new infrastructure will not progress without support from society (e.g. wind power). However, technological development takes place parallel to social development (Geels 2002; Schot and Geels 2008; Geels and Schot 2007), and for this reason, it is important to take technological development into account.

Ensuring an effective urban foresight process entails the use of participatory planning processes to embed stakeholders in common visions and targets. City planning can be seen as a way to operate within a complex adaptive system (Desouza and Flanery 2013). Leathard (2003) points out that by working together in a multidisciplinary group, it is possible to achieve better and more acceptable results than by working alone. He calls this process "collaborative training". Innes and Booher (2010) highlight that the conventional way of planning cities by trusting only expert knowledge and reasoning based on argumentation is insufficient today. They assert that networked participation can broaden the planning process with much wider areas of information including social, ecological and technological knowledge. This kind of robust network can create new and progressive outcomes and strategies that consider future unknown conditions and demands (Desouza and Flanery 2013).

Innes and Booher (2010, p. 35) argue that a new form of planning and policy has emerged called "collaborative rational", which is based on participatory cooperation. They present conditions which are necessary for collaboratively rational planning processes. Firstly, participants should represent a broad diversity of different interests of the discussed topic. Secondly, participants should be independent, and thirdly, the meetings must boost open, authentic and face-to-face dialogue. Glenn (2003) has noted that the degree to which different stakeholders are involved in making a decision is the degree to which the decision will be accepted by the public.

Participatory processes have several benefits, including

- Decision-makers are more prepared to make long-term plans and difficult decisions when they can have a broader view of the problem discussed (Giere and Moffat 2003).
- The results that are achieved by using collaborative work are better than the results achieved by individuals and stakeholder groups working separately and alone (Leathard 2003).
- The participatory process accelerates the implementation of the strategy because decision-makers are already embedded into the decisions during the foresight process (Glenn 2003).
- The participatory process utilises distributed cognition as well as explicit and tacit knowledge to improve results (Nonaka 1994; Shu-Chen and Cheng-Kiang 2009).

However, there are some disadvantages to participatory processes, including

- Participants may represent parallel opinions or scholarships where only one side of a topic is taken into account (Heikkilä et al. 2007).
- The process may lack a facilitating agent whose role is to ensure that all participants are heard (Heikkilä et al. 2007).
- Participants are not always ready to accept the opinions of other professions, which can hinder cooperation (Abbott 1995).
- Participants may become too keen on the plans they develop and thus become slaves to them (Ramos 2002).

Multidisciplinary groups can be seen as one of the best approaches to combining knowledge and creating valuable new ideas by using distributed cognition as well as an individual's tacit and explicit knowledge (Nonaka 1994). Participatory group processes encourage knowledge exchange and develop a deeper understanding of central issues important to the future.

23.3 Case Study: The City of Vantaa

The main goal of the Vantaa case study was to support the strategy-building process of the city. The participatory scenario-building process was utilised to tackle the potential safety and security risks pertaining to the surroundings and the area of the railway station in the city.

Vantaa is a rapidly growing city, alongside the capital of Finland, Helsinki, and has a forecast annual growth of 1.6% for the period 2017–2020 (City of Vantaa 2016). It is the fourth biggest city in Finland with around 215,000 inhabitants (statistical data from the year 2015). It is a home to a growing railway station and the Helsinki-Vantaa airport. The area has been undergoing extensive construction work. A new railway station building and rail traffic connections to the airport, the local bus station area and the first part of a large office and new shopping centre have been built. The number of rail and bus passengers is expected to rise notably, and there is a clear need for paying attention to safety and security issues in the area. The main challenge for the city planners is how to ensure that all passengers and people living in the area enjoy their stay in the station area and feel safe. Ensuring safety and security seems to be a common interest for all city decision-makers although their prioritisation of potential means alters.

Plausible future scenarios were generated by using participatory foresight methods to improve interaction between city planners and other safety- or security-related stakeholders. The aim of the scenario-building work was to reveal different paths to desired, probable or unwanted futures.

The whole scenario-building process[2] is described in Fig. 23.1. The case study in Vantaa started with a scoping process, including a meeting with the security manager and the project director of the city. In the meeting, the main target of the scenario-building process was decided, and the preparation of a participatory workshop was outlined. In addition, the discussions in the first meeting consisted of the identification and selection of relevant stakeholders and participants to be invited to participate in the foresight process, including interviews and workshop.

The background information utilised in the scoping meeting consisted of:

- The results from a project completed in 2013 dealing with the security of the inhabitants of Vantaa;
- The results of earlier development projects carried out in the area, such as building the system of recording surveillance cameras, a "safety walk" study (a method that examines the safety and security of a studied area), and an open conversation session on local development issues, including safety and security issues, for citizens, local authorities and elected officials;
- Statistical data from the police and Vantaa city; and
- The Vantaa city safety and security plan.

The current state of security in Vantaa city was analysed by using established statistical data. This consisted of spatial data on police tasks in the area, information dealing with the features of the current population and summaries. Forecasts for population growth in the near future provided by Statistics Finland[3] were also used (City of Vantaa 2016). The safety and security plan for Vantaa city included the

[2]Participatory scenario building work book available: http://www.vtt.fi/inf/pdf/technology/2016/T259.pdf.

[3]http://tilastokeskus.fi/til/index_en.html.

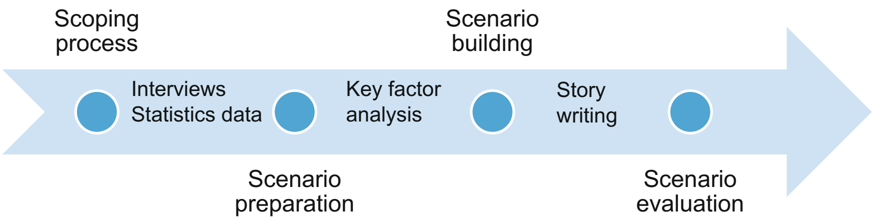

Fig. 23.1 Process of scenario building in the Finnish case study

main targets of and actions for safety- and security-related issues in the near future. In addition, statistics from public transport providers and the results of safety surveys for consumers of public transport were analysed. These statistics consisted of customer satisfaction surveys and Benchmarking in European Service of Public Transport (BEST[4]) surveys. A customer satisfaction survey is implemented twice a year and consists of order and security issues.

Safety and security data were also collected from expert interviews in which representatives of the police, city planning, social services and youth services, the public transport sector, and a local accommodation and restaurant service provider were interviewed. Discussions with a local department at the University of Applied Sciences were also conducted in order to make possible for students to participate in the workshop. Interviews were carried out to find out the opinions and viewpoints of:

- the desirable future of the railway station and its immediate surroundings,
- readiness to face disturbances,
- potential success factors and/or barriers to achieving the desirable future,
- common trends in city planning and development, and
- possible stakeholders related to safety and security issues in city development work.

The gathered information identified two main safety and security factors (key factors): disorder in behaviour and citizens' fear due to this disorder. Citizens revealed that they were mostly afraid of different kinds of troublemaking, vandalism, crimes and the disruptive alcohol drinking of small groups in public places. These factors were the starting point for the scenario work.

The identified key factors were more closely analysed to identify the main drivers and barriers for scenario work. As a result, two forces were highlighted:

- The extent of cooperation in society: the development of society in terms of individual- or community-centred development.
- The quality of safety and security actions (S&S): the development of safety and security in terms of hard S&S (technology such as surveillance cameras, gates,

[4]The BEST survey is part of a European public transport survey that is implemented yearly and includes security issues.

police forces) and soft S&S (guiding, built environment, positive civil activities, etc.).

On the base of the identified key factors, four scenarios were defined and a fourfold table was formulated to describe them. The contents of the scenarios were created in a participatory workshop with the stakeholders of Vantaa city and its partners related to safety and security issues.

The workshop was conducted in April 2015 on the premises of Vantaa City, and it lasted for four hours. As the workshop was one part of the real city planning process in Vantaa, plenty of different stakeholders were invited to participate in the process by the security manager of the city. The 20 participants of the workshop represented several city planning sectors, other city represents and other safety- and security-related stakeholders, including:

- city risk management and preparedness,
- city planning, including traffic planning and building design,
- public transport actors,
- social services and youth services,
- public cultural services, including library services,
- rescue services,
- police,
- security services of the railway station and shopping centre premises,
- local private service producers,
- security business training, including a few students from the University of Applied Sciences,
- local parish and
- property management services.

The target of the participatory workshop was to brainstorm city planning for the railway station and its immediate surroundings 10 years in the future. The main question was: What kind of place will the railway station area be in the year 2025?

For the workshop, the participants were divided into four groups. Each group studied a possible future from one specific point of view of the scenario framework, which is shown in Fig. 23.2: Community-Soft, Community-Hard, Individual-Soft and Individual-Hard. Firstly, in the groups the participants identified political, economic, social, technological and environmental trends (PESTE) that might have an influence on the city development. These trends and their impacts to the city development were discussed together. Based on this discussion and trends, each group discussed and identified examples of potential urban culture and housing circumstances, safety, and resiliency in the case area. All the ideas were written down into post-it tags and pasted into the A3-size table in the wall which formed the first version of the scenario story.

The role of the researchers (4 of them) was to keep the discussions going and on focus, and write down the ideas, opportunities, risks and threats emerging during the workshop.

In the workshop, different opinions and views of future impacts were committed to post-it labels, and they were assembled in a timeline on wall tables. After the brainstorming session, these opinions and views were categorised according to their main content from soft to hard security and from lower to higher degree of cooperation. The scenario ideas were presented and further improved with all workshop participants. After the workshop, the scenarios were explained more deeply to decision-makers to clarify thoroughly their content.

Finally, project participants independently evaluated four developed scenarios. Researchers sent an evaluation template to all workshop participants who then provided feedback on the following areas:

- What does the future look like in the light of these scenarios?
- What are the main actions required to direct current safety and security circumstances towards the desired vision?
- What should be done to avoid worsening the situation?
- How would you like to complete or change the developed scenarios?

In addition to these questions, feedback was also requested in order to improve the participatory scenario development process.

23.4 Results

Four different scenarios were developed in a participatory scenario-building process (Fig. 23.2):

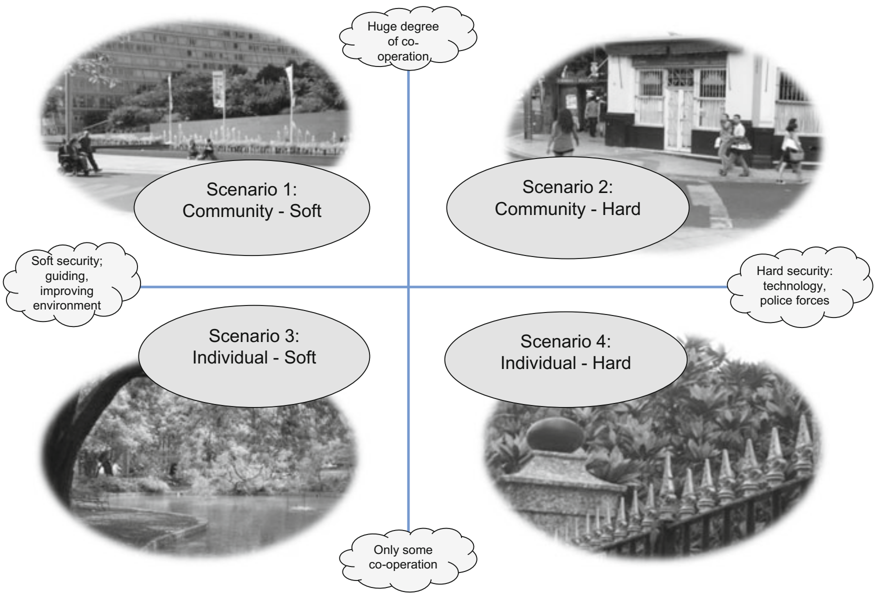

Fig. 23.2 Four scenarios generated in the case study foresight process

(1) A community spirit-based scenario with soft security technologies (Community-Soft),
(2) A community spirit-based scenario with hard security technologies (Community-Hard),
(3) An individual-based scenario with soft security technologies (Individual-Soft), and
(4) An individual-based scenario with hard security technologies (Individual-Hard).

For all scenarios, a rich and detailed story was written. To understand more deeply the character of each scenario and differences between them, certain characters were highlighted. These characters were the focus of the scenario creating process: focus on security, character of typical citizens, type of resilience and a possible motto (Table 23.1). The developed scenarios all differed from each other, as they should in order to outline different future options. Three of the scenarios were quite neutral and gave quite a positive future illustration, but the fourth scenario (Individual-Hard) was considered a frightening and totally unwanted possible future illustration. The main characteristics of the four scenarios and the main differences among them are described in Table 23.1.

The results of the scenario process were delivered to all stakeholders for further discussion and decision-making. The safety and security board of the city discussed these.

The feedback from all 20 participants of the scenario workshop varied, and both positive and negative comments were received. Some of the participants thought that the method presented an opportunity to converse with people from different positions and different backgrounds without tight restrictions, and this was seen as very good. In particular, the participants in the workshop found it very valuable to bring together diverse knowledge and competencies to evaluate society and make possible proposing new ideas and thoughts for further consideration. The opposite opinions highlighted that the results of the process were just people's own opinions and viewpoints. They pointed out that the understanding of the development history of the area and reliable statistics must be taken more thoroughly into account in urban development. They also found the results too general and hoped that the ideas would be further developed.

However, almost all feedback suppliers thought that the participatory scenario-building method was easy to follow and addressed important topics. The majority also experienced that they had got new information on urban resilience during the process. Feedback that was more critical was given about implementation and reliability. Some of the participants thought that the outputs were difficult to implement, at least in their own work, and the results were not credible enough.

Table 23.1 Characteristics of the four scenarios created to outline the future of Vantaa railway station surroundings

Scenario	Focus on security	Citizens	Resilience	Motto
Community-Soft	A large amount of people (travellers, students) Movement (light traffic: pedestrians, cyclists)	Multiculturalism and different needs Families with children Government is interested in citizens' well-being	Community culture and its enhancement by creating assembly areas and common events People are interested in each others' well-being	Enjoy being and working together
Community-Hard	Foresight, Preparedness Industrial risks Communication	More resources to the well-being of young people	Disturbance and accident contingency plans Good cooperation between safety experts Improving the physical safety of the environment	Hard security creates a reliable basis on which to build a comfortable existence
Individual-Soft	Individual responsibility and resources Connection between well-being and security Municipal, public authorities and experts supporting individual people Outreaching security	Malign and self-reliant Tolerance and encouragement Support available for the needs of individuals	Individual abilities and skills to use The smooth operation of small units Decentralised responsibility for safety	New way to be a citizen
Individual-Hard	Technical control of premises, rooms, areas and people The role of society in creating a community emphasis	Individuality Physical solitude but also virtual community Small group resurgence	Based on a strong role in society, but also on responsibility of businesses providing personalised services	Buying human relationships

They wanted to see more fact-based knowledge in the process. This feedback told us that the participants did not sufficiently understand the spirit of foresight, which is a systematically organised brainstorming session with minimum scientific emphasis.

23.5 Conclusions

The resulting scenarios combine the ideas, opportunities, risks and threats emerging from city stakeholders who are involved in sustaining the safety and security of the society, such as police, youth work, health care, city planners. These experts review the society from their own point of view, and therefore, they are able to bring valuable points into the discussions. This kind of multi-visionary scene can be achieved only by participatory approaches.

The methodological choices were done by the researchers and the city representative (security manager) together to find a most suitable way to act in the case. In Finland, the participatory methods are today largely used because they are seen as a part of transparent city politics. An open and transparent planning process that engages all stakeholders will typically encounter less opposition.

The work of researchers and their role in the workshops was mainly targeted to combing information and arranging it according to the participants' opinions. None of the researchers live even near the planning area (distance at least 150 km), and thus no one had any personal interest into the case. The researchers didn't even steer the discussions towards the new focus areas as it was done through the used PESTE methodology: each participant was in turn asked to point out important PESTE trend.

One interesting observation in the Vantaa case study was that participants wanted to reject the negative, unwanted future, such as the Individual-Hard scenario. This is, however, the power of the scenario-building method, to show the possibilities and potential of different kinds of futures, not just the desired one. It seemed that participants did not want to discuss negative scenarios. In fact, they wanted to deny that this kind of development could happen in their city. Consequently, they could not see the role of the scenario process as highlighting possible negative courses of events that they could potentially prevent themselves by active interference.

However, this is also a warning sign to a facilitator of a foresight process. In order to guide successful participatory scenario building inside any society, sufficient time for opening the scenario-building process is required. It must be clear to everyone that both desired and undesired futures, utopias and dystopias, are needed for a successful scenario process.

Despite this, the participatory scenario-building process was an interesting approach that gave new insights into city planning and strategy-building processes. Stakeholders in the Vantaa case study found the approach a useful way to change viewpoints and create discussion between various actors who are relevant to city development processes. Thus, one of the most valuable features of the approach was to gather different actors and stakeholders together, permit them to become acquainted with each other, and give them the opportunity and sufficient time to discuss a topic, in this case the future of safety and security in the city. This wholeness is an advantage that cannot be achieved by using desk research or expert judgement.

In general, the results of the scenario-building process can be seen as a starting point to be further developed with more detailed analyses and expert work. The participatory scenario-building process with various stakeholders is, therefore, a preliminary study, the results of which open up new viewpoints to decision-makers and city planners, and in this way guides planning actions to make the city more resilient and ready for future challenges. The process will create the future of and influence city development. City decision-makers can create a vision of their future city in a participatory scenario-building process, and at the same time, embed themselves in the paths and actions that lead to the vision.

To better engage workshop participants in all of the scenarios and possible futures, they should participate in the scenario generation process. This, however, takes more time than was available in the present study. One way to ease the role and work of participants in discussing and understanding all the scenarios, including negative ones as possible future options, is to organise the workshop in a way that all participants create all the scenarios. In that way, each participant will contribute to each scenario framework. In the Vantaa case, this would have meant taking part in four different groups: Community-soft, Community-hard, Individual-soft, and Individual-hard. This would enrich the outcome of the scenario-building process and engage participants in many kinds of scenarios. In the future, worst-case scenarios might be tackled and best-case scenarios boosted because city stakeholders will have been made aware of signals of unwanted development.

The case study in Vantaa encourages further development of an approach in which resilience themes and city planning are integrated into foresight and strategy planning processes with the participatory scenario-building perspective. The main benefit of the approach is the increase in communication between various stakeholders and decision-makers and, therefore, an increase in the diversity of viewpoints that can be taken into account in making cities more resilient in the future. The scenario-building process structures these viewpoints into stories, which, in the best situation, are clear and differing and outline nicely possible future options. These possible future stories give a framework for decision-makers to plan the future of a city and make it as detailed as desired since the scenarios allow for detailed planning. In addition, scenarios, with various and rich viewpoints, may reveal issues that would not be covered without a participatory storytelling process.

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Chapter 24
How to Demarcate Resilience? A Reflection on Reviews in Disaster Resilience Research

Maike Vollmer and Gerald Walther

Abstract Resilience has emerged as one of the major buzzwords for political and academic discussions that pertain to a constant well-being and functioning of societies and infrastructures. While the term has led to the emergence of various initiatives and funding schemes, the diversity of different concepts of resilience and its utility is quite large. The chapter reflects on several reviews that have recently been conducted to analyze the different ways of defining and conceptualizing resilience. Most of these reviews have been performed within current projects on disaster resilience that are funded by the European Commission. The discussion of these reviews serves to highlight overlapping but also potentially conflicting elements within the resilience discussions. Particularly, four questions are addressed within the discussion: (1) Does being resilient mean to be able to "bounce back", or to adapt? (2) Who or what is resilient? (3) Does resilience target protection against unknown or known threats? And (4) what are boundaries of resilience to related concepts? The chapter then identifies overlap with similar terms such as risk management to provide possible ways forward and strengths and weaknesses of various approaches. It is thus a starting guide for scientists, policymakers, and other relevant stakeholders on how to ensure that resilience can be transformed into a concept that is open yet consistent enough to enable its operationalization.

Keywords Resilience · Definition · Concept · Review · Disaster resilience

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24.1 Introduction

Discussions of the term “resilience” have a long-standing history in academia. For example, Luthar (2006) reviews the history of resilience in developmental psychology where the term already emerged in the 1960s. Other origins can be found in the fields of engineering, mathematics, complex systems theory, and ecology (Brown 2014). Eventually, the concept was adopted by so many scientific fields that it emerged within the general public discourse, which prompted *Time* magazine to declare “resilience” the “environmental buzzword” of 2013 (Walsh 2013). As can be expected, the proliferation of the term within a vast number of research fields has yielded an even bigger number of definitions, concepts, and understandings of the term.

Within the EU project SmartResilience,[1] but presumably also within many other research activities, several questions have therefore arisen: How should the term be defined? What are its most relevant attributes? To what object does it refer? How should it be measured? How is it related to vulnerability and risk? And how do different contexts and disciplines result in differences in definitions and applications? Many review articles have been published that engage with these questions.

Instead of adding one further review to the literature of review articles on the subject, and thus replicating already existing work, this chapter will take a birds-eye view and reflect on recent reviews. The goal is to identify congruencies among reviews as well as to elucidate differences. In other words: Is there any common ground on definitions, and what are contentious elements within literature on resilience? The goal of this chapter is not to declare any specific definition of resilience or to prematurely shut down any sort of debate. The goal is rather to outline what types of definitions have been used to identify competing elements within definitions.

Starting point for this discussion of review articles is work conducted within current projects on disaster resilience that are funded by the EU. These (at the time of writing) ongoing projects all had to grapple with the concept of resilience in order to operationalize it for their specific project goals. These large-scale reviews are supplemented with reviews that have emerged within 2016 and which were therefore not included in discussions within the EU projects. The focus on recent reviews ensures that most recent developments in addition to more historical discussions of resilience are both equally present. It implicates the assumption that all relevant research results are sufficiently represented—even if one is ignored in one review, it is assumed to be covered in another review.

[1]SmartResilience—Smart Indicators for Smart Critical Infrastructures (May 2016–April 2019), http://www.smartresilience.eu-vri.eu/.

24.2 Methods

Comprehensive reviews of resilience, its concepts, and different usages have recently been conducted by projects that answer to the call topic "Crisis and disaster resilience—operationalizing resilience concepts" (DRS-07-2014) within the EU Research and Innovation programme H2020.

A review on the term resilience was part of the basic working steps within all these projects. It included comprehensive quantitative and qualitative literature reviews as well as expert interviews on the term resilience in general and partly in the context of critical infrastructure.

In addition to these five projects, a system that searches different databases such as Web of Science, Science Direct, SpringerLink, and others simultaneously (available within the Fraunhofer-Gesellschaft) was used to identify articles on reviews of the definition and concept of resilience. The keywords "review," "disaster," and "resilience" were used, and the results were filtered by date of publication between 2013 and 2016. Review articles that targeted a domain other than disaster risk reduction, or that did not directly target the definition or concept of resilience, were excluded. This process provided the reviews conducted by Meerow et al. (2016) and Hosseini et al. (2016). Under "results," the methods and main results of the reviews conducted within the five EU projects and of the two additional reviews that are relevant for this chapter are summarized. Analyzing these review documents resulted in an identification of major issues that should be considered for conceptualising resilience. These issues are further elaborated in the discussion section.

24.3 Results

This section will provide a short description of the reviews of each of the EU projects as well as briefly summarize their key findings. Similar information is also given for the two review articles by Meerow et al. (2016) and Hosseini et al. (2016).

The **project IMPROVER**[2] aims to develop a European Resilience Management Guideline and demonstrates the Guideline through pilot implementation. As an initial step, an overview of the existing scientific literature regarding the concept of resilience has been prepared with a specific focus on critical infrastructure resilience. In addition, information on the definitions and implementation of a concept of resilience in different countries and continents is provided. In order to gain the envisaged information, an extensive literature review was conducted, a workshop was held, and personal interviews with critical infrastructure operators and resilience experts in Europe were held. The resulting report elaborates on different

[2]IMPROVER—Improved risk evaluation and implementation of resilience concepts to critical infrastructure (June 2015–May 2018), http://improverproject.eu.

aspects of resilience in general, of community resilience, of critical infrastructure resilience, and describes results of the case studies in different continents (Melkunaite 2016).

IMPROVER concludes that resilience in most cases is either understood as the ability to *bounce back*, or to *adapt*. While bouncing back means to return quickly after a shock to the pre-defined state, adaptation means a change of the entity or system, while providing the same service or filling the same operational niche as before.

Regarding the *relation of resilience to vulnerability*, there are different understandings, mainly as a result of different definitions of the two terms. Key parameters of vulnerability are seen in the exposure, susceptibility, and coping/adaptive capacity of elements. Often discussed is the question if resilience and vulnerability should be treated as a positive and negative end of a spectrum or as two completely different concepts. Some authors follow the first approach, arguing that vulnerability of a system results from reduced resilience (e.g., Resilience Alliance 2017, Manyena 2006). However, other authors (e.g., Cutter et al. 2008) see an overlap between the two concepts, thus proposing that many characteristics influence only the vulnerability or only the resilience of a system, while other characteristics influence both.

With regard to the *relation of resilience to risk management*, three different perspectives in policies on critical infrastructure protection, identified by Suter (2011) have emerged: Resilience as *the new goal of risk management*, resilience as *an alternative to risk management*, and resilience as *part of risk management* (Suter 2011).

Relevant *domains* that have been identified, with their specific developments and applications of resilience, are the societal, economic, ecological, organisational, and critical infrastructure domains (Melkunaite 2016).

The **SMR project**[3] aims to develop a resilience management guideline specifically for urban resilience. As part of this work, SMR conducted a review of literature on resilience with a thematic focus on the urban environment (Radianti 2016; Rankin and Bång 2016; Bång and Rankin 2016). This review includes an analysis of definitions and related concepts, methods and approaches, and operationalization. Their literature review consisted of searching for the phrases *urban resilien** and *disaster resilien** in the Scopus database. This approach yielded nearly 3000 articles that were then further reduced to a more manageable number in four steps, which involved a narrowing of the scope, an initial review, a quality check and finally a review of the full papers. They ended up with a final total of 119 articles.

SMR summarizes that resilience definitions incorporate the following three elements:

- *absorb shock,*
- *ability to adapt,*
- *ability to recover or 'bounce back'*.

[3]Smart Mature Resilience (June 2015–May 2018), http://smr-project.eu/home/.

In addition, SMR also identified 22 *frameworks of resilience* with their respective key features. While all frameworks refer to urban resilience, this field could be broken down into further subtopics. Predominant among these was the area of natural hazards/climate change, followed by community resilience and economic resilience. In terms of specific indicators that are used within these frameworks, there was hardly any consensus, which, according to the authors, highlights the various ways to increase resilience.

The variety of frameworks prompts SMR to conclude that "there is a huge variety of policy suggestions across the numerous EU projects targeting resilience. Lacking empirical evaluations of the long-term impact of those policies it is currently not possible to highlight particular policies as "best practice," i.e., being superior to others" (Radianti 2016, p. 73). Yet, SMR attempted to at least provide *definitions for resilience* in several dimensions of resilience:

- Critical infrastructure resilience,
- Community and social resilience,
- Urban or city resilience,
- Organisational/local government resilience,
- Individual resilience,
- Economic resilience,
- CBRNE resilience,
- Communication resilience.

Eventually though, SMR also comes up with the following overall definition for city resilience: It "is the ability of an urban system or community to resist and absorb, or to adapt to and recover from shocks and long-term stresses with the goal to keep the city functioning, and to learn from ongoing processes of city and cross-regional collaboration to anticipate future demands and strengthen the general preparedness" (Bång and Rankin 2016).

The **project RESILENS**[4] aims to operationalize the concept of resilience by integrating risk management and vulnerability assessment. As a basis for this work, RESILENS has conducted a review of the state of the art in risk management and resilience and their relationship with critical infrastructure (Clarke et al. 2015). This review comprises a qualitative analysis of key literature.

RESILENS then comes up with the following *definition of resilience*: "Resilience is the ability of a system or systems to survive and thrive in the face of a complex, uncertain, and ever-changing future. It is a way of thinking about both short-term cycles and long-term trends: minimizing disruptions in the face of shocks and stresses, recovering rapidly when they do occur, and adapting steadily to become better able to thrive as conditions continue to change. Within the context of CI [Critical Infrastructure], the resilience process offers a cyclical, proactive and holistic extension of risk management practices" (Clarke et al. 2015, p. 3).

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[4]Realising European ReSILiencE for Critical INfraStructure, (May 2015–April 2018), http://resilens.eu/.

Given the specific focus on the interaction between *risk management and resilience*, RESILENS describes four perspectives on how this relationship could look like, based on Suter (2011):

(1) Resilience as a goal of risk management: Many documents describe resilience as the overarching goal of protection policies and risk management as the method to achieve this goal. Resilience replaces or complements the concept of protection, which was previously defined as the goal of risk management activities.
(2) Resilience as a part of risk management: Resilience is understood as a part of risk management. Activities to strengthen resilience are needed in order to deal with the so-called "remaining risks", i.e., risks that have not been identified or underestimated and are thus not covered by appropriate protection (preventive) measures.
(3) Resilience as an extension of risk management: This transitionary perspective recognizes the importance of risk management to critical infrastructure operation, but proposes that these practices need to be extended to encompass resilience practice that integrates social and organisational factors, as well as building capacity to change.
(4) Resilience as an alternative to risk management: This perspective challenges the traditional methods of risk management and promotes resilience as a new way of dealing with risks in a complex environment. It is argued that a probabilistic risk analysis is not an adequate approach for socio-technical systems that are confronted with nonlinear and dynamic risks and are themselves characterized by a high degree of complexity. Instead of preventing risks and protecting the status quo, such systems should enhance their resilience by increasing their adaptive capacities (Clarke et al. 2015, p. 36).

The **DARWIN project**[5] aims to improve responses to expected and unexpected crises that affect critical societal systems. A specific goal necessary for this advancement is the development of resilience guidelines and innovative training modules on crisis management for managers and operators. The first step in this effort was to conduct a systematic review of the concept of resilience, which comprised of an initial literature review, which was then supplemented with in-depth interviews with actors in health care and emergency and crisis management as well as with air navigation service providers (Woltjer 2015).

The survey resulted in a list of over 300 definitions of resilience, which highlights the diverse nature of the term. Yet, despite this diversity, it was possible to derive several results from this survey. First, most articles discussed *community resilience* and *ecological resilience*, although some other domains also started to emerge (infrastructure resilience). Second, the predominant objects of resilience were either a *system* or a *community*. Resilience is generally exemplified by actions

[5]DARWIN—Expecting the unexpected and know how to respond, (June 2015–May 2018), http://www.h2020darwin.eu/.

designed to help to *adapt* or to be able to *bounce back*. Actions that intend to improve prevention were mostly absent. Yet, both planning and responding are important elements when discussing solutions and practices. These solutions and practices especially pertain to *information and communication*, *involvement and engagement of stakeholders*, as well as to *measuring or assessing resilience*. A few solutions address *education and training* of personnel. Most of these solutions are still on a rather low maturity level (mostly concept or early demonstration phases).

It is the goal of **RESOLUTE**[6] to improve the resilience of the urban transportation environment by producing a Resilience Guideline. The initial work involved a qualitative analysis of key literature: a review of resilience literature; review of risk analysis and management guidelines at national and EU level; review of applied tools and methods; and a review of training programs. These four steps provide the basis for the conceptual framework of RESOLUTE (Ferreira and Simões 2015).

Based on Jackson (2009) and Westrum (2006), RESOLUTE argues that three conditions are fundamental to resilience:

- "*Avoidance* relates to the ability to foresee potential threats and prevent something bad from happening.
- *Survival* implies that the system, while experiencing disturbance, maintains operation, even if partially incapacitated. This means that the system is able to cope with ongoing trouble and therefore prevent something bad from becoming worse.
- *Recovery* refers to the ability of the system to repair itself and regain desired performance after something bad has happened" (Ferreira and Simões 2015, p. 38).

The literature review also resulted in the identification of several keywords associated with resilience: *sustainability, absorb change and disturbance, regenerate*, or *react and recover*. According to RESOLUTE, all of these definitions can be clearly separated into two camps. *Engineering resilience* refers to a system's ability to return to a state of equilibrium after a disruption. It thus stresses the ability to *maintain a condition of stability. Ecological resilience* describes a system that allows for reorganization to take place in order to preserve the relations among parts of the system. This entails the creation of a new equilibrium. In terms of resilience, this approach aims to create the capacity to *cope with variability*.

In the following, main results of the two reviews conducted by Meerow et al. (2016) and Hosseini et al. (2016) are summarized.

Meerow et al. (2016) conducted a review on definitions of urban resilience by searching in Web of Science and Scopus, analyzing the period of 1973 until 2013. Using co-citation, which measures how often two or more studies are cited together, influential publications and researchers were identified. Strongest influence,

[6]RESilience management guidelines and Operationalization appLied to Urban Transport Environment, (May 2015–April 2018), http://www.resolute-eu.org/.

following this method, had the well-known article by Holling (1973). In the further analysis, only those publications were included that offer an own definition of resilience.

The authors derive six *conceptual* "*tensions*" apparent in the resilience literature. While one of them is related to the definition of "urban" (not explained here), the other five tensions are seen evident also in the broader resilience literature: (1) *"understanding of system equilibrium";* (2) *"positive versus neutral (or negative) conceptualizations of resilience";* (3) *"mechanisms for system change";* (4) *"adaptation versus general adaptability"; and* (5) *"timescale of action."*

To elaborate: (1) refers to the question, if the state prior to disturbance is the targeted state after disturbance ("single-state"), or if several stable states exist that are acceptable ("multiple-state"), or if a "dynamic non-equilibrium" is assumed, following an understanding that systems undergo constant changes; (2) takes note of the problem that the desired state needs to be defined and is not always clear, and that not all stakeholders benefit equally from resilience-based actions; (3) refers to pathways to a resilient state, and can focus on "persistence," "transition," or "transformation"; (4) targets the understanding of adaptations, especially distinguishing between specific adaptations to known threats, and more generic adaptability; (5) acknowledges the relevance of time needed for recovery after disturbance.

The authors also formulate their own *definition of urban resilience*, which is supposed to take a position on each of the six tensions, while at the same time remaining flexible enough to be adopted by a range of disciplines: *"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 et al. 2016, p. 38).

The authors conclude that the concept of resilience can work as useful boundary object, and that applying resilience in different contexts requires answering questions such as resilience for whom, to what, when, where, and why—based on work from different authors who had posed similar, or part of these questions (amongst others Brown 2014, Carpenter et al. 2001, Chelleri et al. 2015).

Hosseini et al. (2016) conducted a review of recent research articles related to defining and quantifying resilience in various disciplines, with a focus on engineering systems. The result is a classification of several aspects of identified approaches.

The review involved literature from various disciplines, published from 2000 to April 2015. It was conducted using Web of Science and key words in the search included resilience modeling, resilience quantification, disaster resilience, and others.

In order to identify trends in the resilience literature, the *distribution by domain* was analyzed. Most of the papers identified in the review belong to the Psychology domain, followed by the Environmental, Social, and Ecology domain. The Engineering domain presents only a smaller proportion. However, an analysis of the distribution by journal showed that most of the articles were published by the "Reliability Engineering and Systems Safety" journal.

The key element of the paper is a classification and description of resilience assessment approaches. While the two main categories are *qualitative and quantitative assessment approaches*, both categories comprise subcategories: qualitative assessment can comprise (a) "conceptual frameworks that offer best practices," or (b) "semi-quantitative indices that offer expert assessment of different qualitative aspects of resilience." The conceptual frameworks provide insights about the definition and understanding of resilience, without quantitative values. The semi-quantitative methods involve expert opinions, which are aggregated in an index. The quantitative methods can be (a) "general resilience approaches that offer domain-agnostic measures to quantify resilience across applications," or (b) "structural-based modeling approaches that model domain-specific representations of the components of resilience." By applying general resilience approaches, resilience is assessed by comparing the performance of a system before and after disruption. In structural-based approaches, resilience is measured by emphasizing the structure of a particular system.

The review concludes that while the term resilience is increasingly used, work is still needed to make resilience assessment more usable. This includes resilience planning, a better understanding of resource allocations, trade-offs between different dimensions of resilience, and standards for ensuring resilience.

24.4 Discussion

Upon first, and even second glance of the reviews as presented in the results section, an alternative version of the adage that "a theory that explains everything, explains in fact nothing" is quick to manifest: Resilience is defined in such a varied abundance that at present one could argue that it is lacking the ability to meaningfully conceptualize developments and characteristics and to become a rallying point for a specific field of research. The DARWIN project alone identified over 300 definitions of resilience, and SMR has identified 22 different frameworks where it is used. The question looms large on how one can make sense of all of these data. One approach is to embark on a journey to identify consensus and discrepancies between these accounts of resilience. However, the road soon gets muddled because different starting points or foci sometimes make it hard to judge on consensus versus discrepancies. Furthermore, not only is resilience defined differently, the concepts and terms that are used to define resilience are themselves multi-definitional and are used in quite varied and inconsistent ways. Or similar concepts, categories, and aspects are described with different terms. Or similar aspects, the "components" of resilience, are defined on different levels—for example, some resilience definitions comprise only three components that define resilience, while others comprise a rather long list of components.

It has been argued that this definitional indeterminacy is actually advantageous as it opens up the possibility to develop knowledge in a more contextual, bottom-up fashion that takes into account geographical differences and cultural heterogeneity (Weichselgartner and Kelman 2015). However, the challenge of definitional indeterminacy of resilience does not necessarily imply that a specific top-down approach to resilience is demanded or preferred. What is at stake is the ability to effectively communicate though. If there is not even a common understanding on what is intended to be achieved, then it becomes literally impossible to talk about different approaches, solutions, or knowledge.

The following discussion is not to be understood as a commanding demarcation of resilience but is supposed to provide guidance to untangle an own perception of resilience and thus to contribute to the development of a research field of resilience that is not fraught with inherent definitional inconsistencies. Of course, the following account is necessarily tainted by the authors' own history of working with resilience and thus does not aspire to be exhaustive.

Four main questions have been identified in this regard:

(1) Does being resilient mean to be able to "bounce back," or to adapt?
(2) Who or what is resilient?
(3) Does resilience target protection against unknown or known threats?
(4) What are boundaries of resilience to related concepts?

24.4.1 To "Bounce Back" or to Adapt?

Presumably, the most direct road ahead is to first engage with the various definitions of resilience.

The SMR project concludes after a comprehensive review of resilience articles that *"absorb shocks," "ability to adapt," and "ability to recover or bounce back"* are components of most common definitions. While these definitions seem innocuous, a closer look at these four concepts reveals some problems that may arise when resilience is indeed understood in this manner.

Regarding *"adapt"* and *"bounce back,"* several definitions only aim at one of these directions, targeting either to return quickly after a shock to the pre-defined state ("bounce back"), or targeting a change of the entity or system, while providing the same service or filling the same operational niche as before ("adapt") (e.g., results of the DARWIN and IMPROVER projects). Also the two types of resilience as described by the RESOLUTE project, "engineering resilience" and "ecological resilience," can be understood as representing these two points of view—bouncing back versus adapting. The problem is that if a system is supposed to "bounce back," it will get back into its starting shape. Yet, this apparently clashes with the idea to "adapt," which implies that a transformation has to take place.

This is also in line with one of the "tensions" that Meerow et al. (2016) identified as "Notion of equilibrium" while adding a third dimension: Depending on the understanding of resilience, the targeted state after disturbance is the same as prior to disturbance (*"single-state"*), or a choice of several stable states (*"multiple-state"*), or a *"dynamic non-equilibrium,"* following an understanding that systems undergo constant changes. While the authors see the "dynamic non-equilibrium" closely related to the understanding of resilience as being adaptive, Meerow et al. (2016) understand the "multiple-state" alternative being equal to "ecological resilience," while the "single-state" alternative equals the understanding of "engineering resilience."

Possibly, a solution to the apparent discrepancy between bouncing back and adapting could be found by exploring who or what exactly is supposed to display resilience. At least, the answer to the "who or what" in a concrete case shall provide guidance for answering the question if "bouncing back" or "adapting" is more desirable.

24.4.2 Who or What is Resilient?

The apparent discrepancy between bounce back and adapt has emerged quite succinctly in the discussion of engineering resilience and ecological resilience within RESOLUTE. In engineering resilience, a system is resilient if it reverts back to its original setup after stress has been applied and the system was disrupted. In contrast, in ecological resilience, a system is resilient if it maintains the relations between the parts of the system during stress. It thus allows for new types of setups and new equilibriums.

While these analogies from ecology and engineering are useful as theoretical constructs, they fail to take into account the nature of the system itself. For example, it may be less beneficial to discuss the ability of a physical object such as a bridge to be resilient in the ecological sense. After all, any reorganisation of part of the system would be disastrous to the function of it. Conversely, it may prove less beneficial to discuss the engineering equilibrium of a local community. After all, communities hardly exhibit a single equilibrium in best of times but are rather fluid in general.

As a result, DARWIN identifies "two major entities, system and community […] as dominant concerning the element that is resilient" (Woltjer 2015). Both IMPROVER as well as SMR have extended this analysis and looked at various dimensions or domains of resilience. For example, IMPROVER proposes that one has to discuss resilience for society, economy, ecology, organisations, and critical infrastructure. SMR has gone even further in their analysis. They provide tentative definitions for resilience for different environments and with regard to different systems, e.g., for critical infrastructure resilience, community and social resilience, urban or city resilience, or organizational/local government resilience. In a similar vein, Hosseini et al. (2016) refer to disciplines where the term resilience is most commonly used—the Psychology domain, followed by the Environmental, Social, and Ecology domain. They also note an underrepresentation within the engineering domain.

Regarding interdependencies between different systems, an approach is cited by IMPROVER, which distinguishes between *"internal" and "external" resilience*: While the internal resilience refers to the system where the initial failure occurs, the external resilience captures all other affected systems (e.g., critical infrastructure; society) (Labaka et al. 2015; Melkunaite 2016).

The separation of resilience into several subcategories based on specific actors, domains, or dimensions may prove useful in getting around the problem of bouncing-back versus adapting. However, this solution still retains the problem that "resilience" as a stand-alone term will have conflicting definitions. Any discussion of "resilience" will have to be accompanied by a plethora of additional terms, which runs the risk of further confusing the issue. Any umbrella term needs to be cohesive. Additional signifiers that further reign in the term are certainly useful and quite common, yet the key term has to retain the same definition for it to be effective. Retaining bouncing-back and adapting as definitional elements undermines this concept.

24.4.3 Protection Against Unknown or Known Threats?

Another "tension" identified by Meerow et al. (2016) is "Understanding of adaptation," mainly distinguishing between specific adaptations to known threats, and more generic adaptability. In this context, several authors are cited that use different terms in this regard: "specified" versus "general" resilience (while the specified resilience is often related to known risks, and the general resilience to unforeseen threats), "inherent" versus "adaptive," "short-term adaptation" (which means becoming highly specialized) and "longer-term adaptation" (Meerow et al. 2016). Both the IMPROVER and the RESILENS project engage with this question within their discussion on the relationship between resilience and risk management. Both agree that resilience as a goal of risk management will focus on dealing with risks that are foreseeable and ensuring that the object that is resilient will be able to deal with these threats. At the other end of the spectrum, resilience is seen as not only being an alternative to risk management but also challenging the concept that a probabilistic assessment of risk is still adequate in modern complex environments. While risk management tries to maintain the status quo by trying to prepare for foreseeable threats, resilience tries to create adaptive capacity without directly discussing specific threats. Beyond these two views, RESILENS argues that there are two additional intermediate relationships between resilience and risk management: resilience as (a) a part of risk management or (b) as an extension of risk management. In the former concept, resilience activities support risk management by addressing the unknown threats. In the latter, risk management needs to integrate resilience activities that pertain to social and organizational factors and include the capacity to change. The discussion on protection being targeted against unknown or known threats is thus closely related to the question on boundaries to related concepts (vulnerability, risk).

24.4.4 Boundaries to Related Concepts?

Several terms, theories or concepts are closely related to *resilience*. Often discussed is the relation to *vulnerability* as well as to *risk management*.

As amongst others described by the IMPROVER project, there are different understandings regarding the relation of resilience to *vulnerability*. Key parameters of vulnerability are seen in the exposure, susceptibility, and coping/adaptive capacity of elements. However, differences in concrete definitions of vulnerability and resilience lead to different understandings of the relation between both. Some authors follow the approach that resilience and vulnerability should be treated as positive and negative poles on the same continuum, amongst others concluding that vulnerability of a system results from reduced resilience. However, other authors see an overlap between the two concepts, assuming that many characteristics influence both, while some are only relevant for either the vulnerability or the resilience of a system (Melkunaite 2016).

Also the relation between resilience and *risk management* is often discussed as explained above, resulting in the different point of views that are mainly closely related to the question if also unknown, or only known threats should be addressed.

24.5 Conclusion

The intention behind this chapter was to provide an overview of the term of resilience and how it is situated within the academic landscape. However, even a cursory engagement with the topic revealed that resilience is abundantly defined. In fact, it has created such traction in so many fields that to demarcate any academic field of resilience seems practically not feasible.

A possible conclusion would be that resilience is used in so many fields that it is inopportune and detrimental to the debate to use any sort of overall definition of resilience. Yet, any definition is of course incapable of pinpointing what something is, but rather to demarcate against what it is not within the corpus of our shared language. The problem is therefore not that a term has different meanings within different discourses. This is also the case for other terms or theories, where any comparison between definitions of a term in different fields of academia hardly yields any congruence and shared understanding (e.g., "realism" within international relations literature versus "realism" within epistemology). Nevertheless, using the term within the specific fields will be understood by other actors within these fields. However, a problem arises if resilience within a discourse is so “permeable” as to accommodate any kind of concept—even mutually exclusive ones.

It has thus become the goal of the chapter to provide guidance for those who are interested in pushing forward resilience by possibly decreasing its scope. Several contentious elements within resilience definitions have been identified. It is the hope of the authors that future work will focus on these different ways to understand resilience, while not ignoring possible additional developments and discussions.

But of course, given the vast amount of effort put into understanding and defining resilience, it would be disingenuous to claim that this chapter has given an all-encompassing account of all of the literature. The results also depend on what the reflected reviews have captured, and what was possibly ignored. Yet though, the chapter has provided what the authors consider to be the gist of the major contentious arguments within many of the debates, based on what different reviews have already concluded.

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Chapter 25
Challenges in Establishing Cross-Border Resilience

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Abstract This chapter focuses on resilience stakes that characterize urbanizing cross-border regions. While cross-border regions are characterized by multiple sources of vulnerabilities that are inherent to their development and history, knowledge remains partial in relation to how these regions address disasters that could affect both sides of the frontier. For decades, most cross-border regions have been expanding both from economical and institutional perspectives. In the meantime, urban density has been increasing, as well as the complexity of critical infrastructures—for instance, transportation or electricity distribution—that support essential services such as health care. Due to such complexity, these infrastructures

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represent major vulnerabilities for cross-border regions nowadays. In addition, borderland citizens' behaviours remain uncertain, due to history and co-existing diverse cultural backgrounds. The chapter introduces the concept of resilience as a valuable lens to investigate disaster management of cross-border regions. More specifically, this chapter proposes to draw on resilience methodologies to address risks related to infrastructure, organization and behaviours in cross-border regions. By doing so, the chapter contributes to a holistic perspective on these vulnerabilities and their management when a disaster strikes. While a large spectrum of European projects has taken into consideration some of cross-border regions' specificities, a comprehensive approach to cross-border resilience is still missing. We illustrate the relevance of this approach with the example of the French–German cross-border region. Going further, the chapter presents the INCA project that relies on multidisciplinary investigation of cross-border resilience and will deliver an agent-based model to support decision-making in cross-border regions facing disasters.

Keywords Urban resilience · Cross-border regions · Crisis management
Risk management · Multidisciplinary approach · Agent-based modeling
German–French frontier · Critical infrastructure · Social vulnerability

25.1 Introduction

Urbanizing areas face an increasing likelihood of being struck by critical incidents due to their dependency on critical infrastructures (CIs) and a growing risk of natural disasters (Coleman 2006). Cross-border regions make no exception as they are going through intense urbanization, characterized by growing volumes of social and commercial exchanges and increasing institutional, economic and social integration (Shen 2014). However, in comparison with inland areas, cross-border regions' specificities can generate additional complexity in managing critical incidents. This chapter aims to explore factors for cross-border urban resilience complexity, their implications as well as present and future solutions. This chapter will focus on *inter*national boundaries and does not cover *intra*national borders.

All over the world, many territories' delimitation has been fading and cross-border regions have significantly developed economically, gaining momentum from an institutional perspective (Anderson and O'Dowd 1999), in Asia and Europe particularly. Socio-economic networks have risen around frontiers, including the most contentious borders, such as the Gaza Strip (Parizot 2006). Characterized by increasing density, cross-border regions' populations have demonstrated a strong impulse towards economic and social integration. However, some inner vulnerabilities remain. Tensions and divergences of interests became latent as commercial exchanges expanded, but they appear to aggravate when the region faces challenges. For instance, the Tajik–Afghan frontier in Central Asia has experienced intense commercial exchanges for the last decade—including drug trafficking—in addition to migration due to civil wars in Tajikistan, which has led to increasing insecurity and violence as well as constrained mobility (Kraudzun 2012). The sustainability of these regions in case of a disaster represents a major stake.

Facing intense urbanization and increasing risks of critical incidents, cross-border regions are facing the necessity to improve their resilience. In Europe, where the end of the Second World War resulted in institutional support for borderland integration, this effort is of particular relevance given the existence of small European states—such as Luxembourg, Switzerland, Slovenia and the Balkans—and many major cities located in a cross-border area, such as Strasbourg and Basle (Reitel 2006) or even Nice-Torino.

But how to support cross-border urban areas' resilience to disasters? Intrinsic issues of cross-border resilience to unexpected large-scale incidents remain an open scientific question as well as a burning but unaddressed concern for practitioners. From a practical perspective, if a city in a cross-border area is affected by a natural or man-made disaster, a joint effort from civil protection authorities is crucial. However, the existence of a border between the affected cities increases complexity for crisis management operations: Successful intervention requires coordinated measures between the two countries involved, a profound knowledge of administrative and economic conditions on each side of the border as well as the ability to overcome intercultural barriers due to language, administrative procedures, habits and social standards.

The French–German border region represents a particularly insightful case to study cross-border resilience. Deducing its resilience simply based on its seemingly economic prosperity and integration would mislead practitioners and decision-makers. Invisible but deep vulnerabilities remain in the French–German cross-border, which makes full consideration of its specificities necessary to evaluate and improve its resilience. For this reason, this chapter focuses on the *Upper Rhine region* as a cross-national border.

The structure of the chapter is as follows: Section 25.2 outlines the specificities of cross-border regions that make resilience a valuable lens to investigate disaster management in such areas. It also details the implications of resilience as an approach to cross-border disaster management. Section 25.3 presents existing programmes that reflect Europe's efforts to deal with resilience in Europe. The section examines the contribution from these projects and highlights some unaddressed issues and emerging challenges which are crucial to cross-border resilience but were overlooked by these programmes. Section 25.4 details the case of the French–German cross-border region, the Upper Rhine. Section 25.4 also provides a short overview of the INCA project that aims at tackling some major challenges inherent to cross-border resilience. The last section of the chapter proposes avenues for further reflection in this challenging research area.

25.2 The Specificities of Cross-Border Regions and Resilience as a Valuable Lens

A border is defined as a "line on a map" (Agnew 2008: 175) or a frontier area separating political divisions, geographic areas, countries or states. While frontiers are not always tangible, natural structures (mountains, river, lake, sea, bay, strait, etc.), artificial structures (wall, meridian, etc.) or even culture can embody boundaries between neighbouring regions or countries (Guo 2015). While cross-border regions have been empowering, some vulnerabilities remain (Sect. 25.2.1) which calls for further consideration of resilience as a valuable lens to help these regions dealing with disasters (Sect. 25.2.2). In line with this view, a large spectrum of programmes has been settled and partly completed (Sect. 25.2.3).

25.2.1 Cross-Border Urban Regions: Empowerment Versus Inherent Ever-Lasting Vulnerabilities

Since the last decades, a multidisciplinary stream of research labelled "borderland studies" has emerged to tackle burning stakes related to territories across frontiers, from geographical, political, social or even organizational perspectives (Newman 2006). The rise of this stream of research reflects the increasing role of cross-border regions on the international political and economic stages.

The levels of cross-border regions' quick development and urbanization are multiple. First of all, cross-border regions have historically played the role of "*places of passages*" (Dahles and Van Hees 2004: 316) between border towns which dispose of increasingly integrated international economic networks, such as between Basle and Strasbourg (Reitel 2006). Secondly, these regions share CIs which were established by national authorities in order to promote international commercial exchanges and, as an indirect but surely even more important by-product, peace between countries. As a result, the European commission, since the 80s, has identified cross-border regions as promoters of economic cohesion within Europe. The European Regional Development Fund (ERFD) has been funding multiple borderland territories through specific programmes such as INTERREG,[1] INFOREGIO[2] or even URBACT[3] for urban regions that comprise a large panel of borderland cities such as Strasbourg, San Sebastian, Maastricht, Hengelo or Liberec. Thirdly, cross-border regions show a unique economic, institutional and cultural path of development. Cross-border regions are transforming into independent regions from an economic perspective (Reitel 2007) due to the eagerness of the population to promote their own identity and economic

[1]https://www.interregeurope.eu/.

[2]http://ec.europa.eu/regional_policy/en/.

[3]http://urbact.eu/.

development (Newman 2006; Parizot 2006). Finally, in the latest years, globalization has been influencing both public policies and human agencies that then fuels borderland regions empowerment. Globalization has intensified the rise of economic and social exchanges within numerous cross-border regions, thereby indirectly affecting the fate of the populations living in these territories. For example, Brazilian national decision-makers have aligned cross-border integration policies to international deregulation principles, which affected inter-urban relations (Kanai 2016).

Even though cross-border regions are seemingly empowering from economic, political and social stances, they also bear risks and can even collapse from multiple stances. Despite long-term pacification between two or more countries, cross-border populations' federation remains fragile. Even though national and cross-border institutions acknowledge the need for joint effort to address issues that extend from one side of the frontier, some borders used to embody separation and suspicion, in particular in the most critical times, such as war (Aron 1984). Reflecting this, the term "frontier" stems from the military vocabulary (Kraudzun 2012). Therefore, the remembrance of border as a source of threat can quickly re-emerge in a cross-border population during hard times. When cross-border populations are predominantly binational, they might feel torn between two distinct social identities (Wessendorf 2016). In Europe, for instance, the rise of cross-border regionalism can lead local populations to struggle to bridge two identities: on the one hand, a regional identity promoted by the development of local activities and infrastructures, and on the other hand, national cultural and institutional legacy (De Sousa 2012). Agglomeration that expands beyond frontiers leads to an economic and social network in a discontinuous topological and institutional context (Reitel 2002, 2007). Cross-border inner contradictions can thus negatively impact urban population in challenging settings.

In addition, investment in CIs in cross-border regions can expose one side of the frontier to higher risks. National authorities allocate resources in borderland regions to promote national interests that might diverge from neighbouring countries' objectives (Dahles and Van Hees 2004). If these infrastructures collapsed, one side of the frontier should account for its responsibility, which could aggravate latent tensions between countries. As a vivid illustration, the French–German–Switzerland and French–Belgium borderlands are characterized by risky infrastructures such as nuclear plants or chemical wastage that could impact the whole cross-border regions but remain under one side's responsibility.

Finally, the empowerment of cross-border regions and their increasing role on the economic stage have led to specific institutional experiments for decades (Hooper and Kramsch 2004). The rationale is that cross-border regions' governance is particularly complex. Intense cooperation has developed across frontiers from multiple standpoints, including economic development (Petrakos 1997), governance, transport, health or conflict prevention (Guo 2015) and social cohesion (Yoder 2003). However, defining rules for responsibilities over territories is complex as cross-border regions result from territorial (Newman 2006) and institutional (Pikner 2008) reconfigurations.

Cross-border regions and their populations are radiating economic, social and political perspectives but their inherent vulnerabilities can also aggravate tensions when a disaster strikes. States' accountability, governance and social cohesion can be easily endangered when large-scale incidents occur. For this reason, cross-border regions ought to approach disaster from a double perspective. First, they need to address the incident itself. Second, they need to address difficulties that can accompany the occurrence of an incident and question the regions' future. The concept of resilience appears as a valuable concept to investigate the way cross-border regions handle this double challenge.

25.2.2 Resilience

Resilience is an integrative concept that became prominent in twenty-first century scientific thinking as well as on the political agenda. It encompasses two main ideas: response to stressful incidents and sustainability of systems in coping with stressful incidents (Reich et al. 2010). Resilience to disaster generally refers to the four key functions of disaster risk management that we further explore in this chapter: (i) disaster risk mitigation and prevention, (ii) disaster preparedness, (iii) disaster response and (iv) disaster recovery (Boin et al. 2010).

The concept of resilience has been used in various scientific domains. In engineering, resilience qualifies the capacity of a metal to resist to an impact. In psychology, resilience refers to an outcome of successful adaptation to adversity (Reich et al. 2010) or various types of trauma (illness, death, disasters, dictatorship, etc.). From this perspective, resilience defines a framework of preventive and curative intervention (Ionescu 2011). In Ecology, it has been used to describe the nonlinear dynamics of complex adaptive ecosystems while considering their capacity to absorb shocks or to transform to a new equilibrium as a stable resting point of a system (Holling 1973, 1986).

The resilience concept was introduced in the field of crisis, emergency and disaster management to address methodological limitations of traditional approaches to risks (Douglas and Wildawsky 1983). The literature outlined the necessity to consider both strategies and risks to get prepared and respond to unforeseen situations (Wildavsky 1988). Following these initial works, initiatives have been introduced to characterize the specificities of resilient organizations and territories. Regarding organizations, a set of capacities has been enunciated for allowing organizations to respond to unexpected situations. For instance, avoiding incorrect and simplified representations of situations, managing expertise, responding to the diversity of situations that can possibly occur correspond to major capacities (Weick and Sutcliffe 2007; Hollnagel et al. 2006). With respect to territories, models of crisis and disaster management as adaptive processes were proposed (Cutter et al. 2008; Béne et al. 2012). From this perspective, resilience is an emergent process allowing the different systems of a territory to overcome a shock and associated consequences induced by a disaster.

Since the 1990s and the UN Resolution 44/236, the United Nations has developed four programmes: the international decade for natural disaster reduction, the Yokohama strategy for a safer world, the Hyogo framework for action and the Sendai framework for disaster risk reduction. The envisaged goals and developed measures evolved by progressively considering all types of potential disasters (natural, technological, etc.), crisis management functions—risk management, risk prevention and mitigation, preparation, alert, short- and long-term recovery—and all actors of the society (citizens, volunteers, first responders, communities, governments) at local, national and sub-national level. Resilience has been appraised as a renewed perspective to risks and in particular to disasters (Boin et al. 2010).

25.2.3 Resilience, a Promising Avenue for a Renewed Perspective on Disaster Management in Cross-Border Regions

Disasters result from either a natural or industrial incident that propagates and escalates in the territory, causing massive social and economic damage (Godschalk 1991; Perry and Quarantelli 2005). A large spectrum of international organizations' guidelines—such as the UNISDR Local Government Self-Assessment Tool (LG-SAT) (UNISDR 2012), the Rockefeller Foundation and ARUP city resilience framework (CRF 2014), TISP regional disaster resilience assessment and enhancement guideline (2011) or the HCFDC orange flag label—provide indicators and guidelines which aim to assess and improve territorial capacities to prevent, prepare for, respond to and recover from disasters.

More specifically, improving urban cross-border regions' resilience relies on assessment and enhancement methods with consideration of (i) the risks specific to disasters and (ii) particularities of cross-border resilience requirements. These methods cover the four phases of urban resilience to disasters (prevention, preparedness, response and recovery). They are hazard-independent and do not take into account cross-border or incident specificities. They provide mechanisms which enable initiating for the development of territorial resilience management systems. However, their application requires adjustments to specific areas, including threats that can potentially affect the territory, geographical profile, urbanities profile, economical profile, sociological profile, etc.

Risk assessment requires information about natural incidents that can occur on the territory, industrial infrastructures that can initiate a disaster and for the characteristics of the territory that can stop, propagate or escalate the incident. Physical laws that rule natural phenomena and associated risks do not recognize political borders. Consequently, considering borders during risk assessment implies collecting data related to the natural environment and to technological infrastructures —critical or not—situated on the other side of borders and also to identify how the border affects the evaluation of risks (increase or decrease impacts, propagation and escalation of the initial hazards, exposure, vulnerability and sensitivity of the population and the infrastructures of the territory). The potential differences between the culture of risks (perception of risks, memory of incident, lessons learned, etc.) of the different countries have to be considered when collecting and interpreting data.

While planning, designing and monitoring for the preventive mechanisms in cross-border regions require strong cooperation between countries, a large spectrum of differences from one side of the frontier to other remains unaddressed. Disaster risk prevention traditionally consists of actions aiming to decrease risks and potential consequences of disasters (Jha et al. 2013). In most cases, these actions are either location-based (land use planning, building in redundancy, etc.), structure-based (increase of the resistance of buildings and infrastructure, regulation and building codes, etc.) or budget-based (ex-ante financing mechanisms, transfer mechanisms, fund mobilization, etc.). The standardization of preventive measures from each side of the border requires the compatibility of the different rules, standards and cultural norms shaping land use management, building management and financial and assurance management, with equivalent political commitment and budget. Risk communication compels countries to consider the cultural differences between countries in order to produce messages that can be understood by the whole population of the cross-border region.

Disaster preparedness consists of supporting emergency response capabilities including warning systems, citizen education, evacuation routes, supply chains and communication procedures established prior to disasters and emergency incidents (Boin et al. 2010). The term *preparedness process* refers to "*pre-impact activities that establish a state of readiness to respond to an extreme incident that could affect the community*" (Lindel et al. 2007). The preparedness process aims to provide policies and organizational structures, trained responders and protected facilities which are in place before a disaster occurs (Masterson et al. 2000). Therefore, the preparedness phase focuses on preparing for the next disaster. Typical preparedness activities include disaster and evacuation planning, training and exercises as well as stockpiling of supplies (Jha et al. 2013). Planning, design and monitoring of training should be based on a cooperation process between the different countries and should consider the specificities of borderland. Differences and similarities between regulations and crisis management organizations from the different countries have to be considered during training design. Cross-border disaster scenarios have to be designed in order to shape infrastructure and response organizations and more specifically the tasks of leadership, communication and cooperation.

Disaster response consists of acting immediately before, during and after a disaster to save lives and minimize damage. Response activities start with detection of the incident and end with the situation stabilization (Boin et al. 2010). While the response stage aims to contain the threat, minimize the damage and prevent critical systems from breaking down, responders often face unexpected situations and deep uncertainty. Time pressure requires quick decisions and actions in a highly uncertain environment (Boin et al. 2010; Wearne and White-Hunt 2014; Weick and

Sutcliffe 2007). However, the inner complexity of a cross-border area can challenge crisis response, both from a technical (alert, protect, monitor, search and rescue, etc.) and non-technical (situation awareness, communication, coordination, decision-making, leadership, stress and fatigue management) perspective.

Disaster recovery includes restoration activities aiming at both the short-term activities as well as the long-term activities to rebuild social and economic functionalities (Masterson et al. 2000). Challenges for the short-term restoration activities in a cross-border area comprise the integration of volunteers coming from the other part of the border to help restoring the affected territory, synchronized restoration of interconnected infrastructures and services affected by the disasters with consideration for the different norms and regulations. Challenges for long-term restoration activities include the restoration and the creation of new social and economic potential while considering the specificities of the borderland and learning the lessons from the disaster.

25.3 New Methodologies, Programmes and Remaining Challenges to Face Disasters in Cross-Border Regions

25.3.1 New Methodologies

Various methodological frameworks have been developed for assessing and enhancing the resilience of individuals, organizations and territories such as the CD-RISC scale (Connor and Davidson 2003), the RASP framework (Hurtes and Allen 2001), the Resilience Organization framework (Seville 2009), the RAG framework (Hollnagel et al. 2011; Rigaud et al. 2013), the LG-SAT for Disaster Resilience (UNISDR 2012) or The Infrastructure Security Partnership (TISP 2011). Each framework is constituted of a set of indicators related to the topics considered (individual perception and capacity to act, leadership, situation awareness, communication, critical infrastructure capacities, etc.) and various assessment methods.

25.3.2 Implemented Programmes in Europe

In addition to the knowledge created by research, corresponding legal frameworks have evolved and funding programmes aiming at facilitating cross-border cooperation have been developed, such as INTERREG in 1989, INTERACT in 2008 and EURAC in 2009 (Russo 2012). However, difficulties still exist and cultural, technological, organizational and legal challenges have to be overcome. While some projects are particularly relevant for addressing some aspects of cross-border resilience, most of them do not cover all its aspects simultaneously. As a result, they

Table 25.1 European programmes devoted to resilience

Programme title	Focus/objective	Practical output	Unaddressed issues
UNISDR—LG-SAT ARUP TISP	Assess and improve territories' resilience	Indicators and guidelines	Specificities of the cross-border regions are not considered
C2-SENSE	Increase interoperability	Profile-based emergency interoperability framework	
DISASTER	Improve data exchange capability, possibly in neighbouring countries	Development of a common and modular ontology, SOA algorithms	
IDIRA	Support regionally available emergency management capacities	Conceptual framework	
BRIDGE	Increase interoperability	Technical and organizational solutions	
DRIVER	Evaluate emerging solutions to increase civil societies' resilience	Evaluation framework and training solutions	
CRISMA, SICMA, INKA	Enhance cooperation between multiple stakeholders in disasters	Decision-making models and simulation	Critical infrastructures disruption
INKA	Optimize volunteers' integration into crisis response	Guidelines and good practices	
ALERT4ALL	Support intra- and inter-agency collaboration	European shared alert system	Multicultural dimension of cross-border regions, volunteer's involvement
BESCU	Enhance emergency communication and evacuation procedures	Cross-culturally validated instruments and indices	Cross-border region specificities and context
EDUCEN	Improve evacuation procedures in a multicultural context	Multimedia handbook	

(continued)

Table 25.1 (continued)

Programme title	Focus/objective	Practical output	Unaddressed issues
IMPROVER	Measure the impacts of different concepts of countries for societal, organizational and technological resilience of CIs, including cross-border examples	Risk evaluation techniques, reviews, and test for the effects of dependencies	Volunteers' integration
SEMPOC, MIA, FACIES, RISKGIS, Failure Prediction, and MICIE	Identify general interdependencies between CIs and risk management	Simulations	Operational issues in disaster response
emBRACE	Assess resilience of multiple participants	Methodologies for evaluating, modelling and assessing resilience of different participants	Cross-border region specificities and context
COMRADES	Improve the quality of alerts and information provided by the population	Open-source, community resilience platform	
RESILENS	Identify resilience best practices	European resilience management guidelines and interactive Web-based decision support platform	
ICRED	Support decision-making for resilience	Conceptual framework, a scenario builder, and GIS	

represent insightful sources of methodologies but call for additional consideration of specific scenarios related to cross-border resilience.

Table 25.1 presents the large spectrum of European programmes devoted to resilience and details their contribution, outputs and limitations. They are detailed in the remainder of this section.

Cross-border aspects and multi-agency response

Multiple projects such as DISASTER, C2-SENSE, BRIDGE, SALUS, ALERT4ALL and IDIRA were aimed at enhancing the technical interoperability and the resource planning process among multiple participants involved in operational emergency management. These projects were almost exclusively focused on bridging the gap between technical communications in a multiple agencies environment. They hardly addressed cultural issues in managing disasters as well as stakeholder involvement. Apart from the DISASTER, BRIDGE and IDIRA projects, cross-border aspects were not considered.

DISASTER project targeted improvements in data exchange capabilities for stakeholders who would be located in neighbouring countries. IDIRA aimed at providing a conceptual framework that would allow supporting and augmenting regionally available emergency management capacities. This framework would also be used for resource planning in operations across national borders. The BRIDGE project aimed at developing technical and organizational solutions to ensure interoperability, harmonization and cooperation among stakeholders. Likewise, ALERT4ALL aimed at a shared alert system within Europe. Although these projects also did not fully take into account cultural issues, volunteer involvement and decision support tools were developed to support intra- or inter-agency collaboration. In the BRIDGE project, this also included the development of an agent-based dynamic workflow composition and communication support system. However, these projects provided no model-based forecast.

Models and simulations to enhance the cooperation between different stakeholders in crisis management were topics within the projects CRISMA and SICMA. The CRISMA project aimed at developing a simulation-based decision support system for modelling crisis management which allowed simulating potential impacts depending on the factors that are behind the crisis development. The SICMA project pursued similar objectives and aimed at providing decision-making modeling and analysis tools to improve insights about the collective behaviour of crisis response organizations. This also included human crowd behaviour in organizations. Both projects did not consider potential cascading effects from independent CIs, cross-border aspects or volunteer involvement.

DRIVER focused on evaluating emerging solutions for society resilience, responder coordination, training and learning. This project also involved the evaluation of the solutions regarding their improvement in coordinating the response efforts and their benefits for cross-border operations.

A more intensive focus on cultural aspects in a multi-agency environment in disaster situations was taken by the coordination and support action EDUCEN. The objective of the project was a multilevel, multimedia handbook to support the general interplay between all involved stakeholders. The specificities of cross-border aspects as well as the involvement of volunteers were not considered. Cultural aspects of the responses from affected people are specifically addressed in the BESCU project. The project aimed at enhancing emergency communication and evacuation procedures by better understanding the cultural response. Based on psychological tools and evaluations of past incidents, BESCU investigated cross-cultural and ethnic differences in human behaviour during crisis. The output of the project was cross-culturally validated instruments and indices, which supported the identification of differences and similarities in prevention, knowledge and safety culture habits.

Critical Infrastructures (CI) risks and dependencies

A large spectrum of projects contributed to a better understanding of intra-infrastructural issues in specific sectors or for insights into risks related to CIs' interdependencies, including SEMPOC, MIA, FACIES, RISKGIS, Failure Prediction and MICIE. Although these projects' results can be used in decision-making, they hardly addressed operational issues in disasters. The project CascEff focused on interdependencies and cascading issues in crisis management, in particular cross-border crisis situations in which collaboration between multiple responders became necessary. In addition, CascEff considered first responder tactics, human activities and interactions to develop an incident evolution tool. However, this tool was not a model-based one and did not address the integration of volunteers either.

Models for CI performances and stakeholders' actions were used in the projects IMPROVER and RESILENS. The IMPROVER project aimed at measuring the impacts of different concepts of countries for societal, organizational and technological resilience of CIs, including cross-border examples. This was realized by the development of risk evaluation techniques, reviews and a system-of-systems approach to test the effects of dependencies and interdependencies between individual CIs and sectors. The RESILENS project aimed at identifying best practices by turning the theoretical resilience framework into practice. Therefore, a European Resilience Management Guideline in combination with an interactive Web-based decision support platform was developed to enhance the resilience of CIs by measuring and benchmarking preparation levels against cascading effects. Both projects, however, neither considered cultural differences of (neighbouring) countries nor volunteer involvement.

Volunteer involvement

To date, there is no specific EU project that exclusively addresses volunteer aspects in the disaster response activities. DRIVER addressed this topic in one of its sub-projects titled "civil society resilience". On a national level, the German INKA project focused on optimal solutions regarding the integration of volunteers. The project provided insights and discussion about ways to increase the engagement of volunteers before and in crisis situations. However, CI disruptions and cross-border effects were not considered.

Community resilience building

Various projects shared the objective to measure community vulnerability and resilience to be better prepared for upcoming disasters. The emBRACE project provided advanced methodologies for evaluating, modelling and assessing resilience of a community's stakeholders. A technical support for community resilience was to be provided by the COMRADES project. It aimed at a collective platform for community resilience which could help communities reconnect, respond and recover from crisis situations in particular with the help of tools based on social media applications. However, the tool development was limited to the use of social media. The ICRED project provided a conceptual framework, a scenario builder and a GIS to enable the development of decision support tools by measuring performances and resiliencies of systems. The results could be applied to different hazards and provide insights into physical infrastructure and socio-economic dimensions as well as for different spatial and temporal scales. Interdependencies between network infrastructures were also considered by an integrated model. Although the models enhanced the community resilience building process, even though specific topics such as CI interdependency, cross-border issues and stakeholder involvement were not considered specifically.

25.3.3 Unaddressed Issues and Emerging Challenges of Cross-Border Urban Resilience in Disasters

As outlined, a large spectrum of programmes has tackled four major topics related to cross-border urban resilience, namely multi-agency coordination, volunteer involvement, CIs and community resilience building. These initiatives have provided or are currently providing insightful guidelines, methodologies and tools. However, an exhaustive review of these programmes also indicates that they have overlooked some inherent features of cross-border regions that can represent major vulnerabilities and sources of uncertainty. We detail here the unaddressed issues of cross-border regions that still require attention in future years (Sect. 25.3.3.1) and some of the emerging challenges that cross-border disaster responders will be confronted with (Sect. 25.3.3.2).

25.3.3.1 Unaddressed Issues

Crisis and emergency infrastructures and management

Despite harmonization efforts between national and regional crisis management systems, different structures in the civil protection systems prevail, which can aggravate cooperation difficulties when a disaster strikes. Overall consistency of procedures and operations is crucial to support collaborative awareness in crisis management (Treurniet et al. 2012). Cooperating forces across borders should mutually understand command chains and practices from the other side of the border to ensure an effective dealing with the incident. Mutual understanding is particularly important in urban regions because of the diversity of participants involved in disasters. This requires synchronized information flows and similar levels of information on both sides. DISASTER (Data Interoperability Solution At Stakeholders Emergencies Reaction) aimed at providing a means to improve information transmission. Based on end-user requirements, a methodical basis for connecting IT-based emergency management systems was developed (Pappert et al. 2015; Cepeda 2015). However, emergency response does not only depend on formal infrastructures. Power relationships, informal practices and rituals (Hart 1993), despite their seemingly invisibility, deeply impact information transmission (Comfort 2007). Harmonizing information systems therefore require awareness of informal differences between disaster management systems from the two sides of the frontier.

Acceptance of resilience capability building policies

As mentioned here, communities have specific cultural backgrounds that fundamentally influence the way their members interact and behave in facing disaster risks. These cultural backgrounds are reflected by diverging beliefs, feelings, behaviours, traditions, social practices and technological arrangements to manage disaster risks. Interestingly, diverging risk behaviours coexist in neighbouring countries that share many cultural similarities. For instance, Switzerland, Austria and Germany are neighbouring countries. Their citizens share German as a local language, similar economic and education standards and many other cultural characteristics. In 2016, a broad public debate was unleashed in German-speaking countries after the German federal government published the novel strategic policy for civil protection (Bundesministerium des Innern 2016). The updated policy aimed at increased resilience and self-help-capacity of citizens but encountered an unaware audience, which vehemently ignored the former recommendation with respect to water and food stockpiling. A public debate resulted from this reaction, which led print and online media in Switzerland and Austria to survey the stockpiling issue among their readers (Bluewin Portal 2016). This survey revealed significant contrast from one side of the frontier to another: The population in Austria and Switzerland endorsed the stockpiling recommendation as part of disaster prevention in contrast to German citizens who expressed aversion or strong reservation. Although Switzerland, Austria and Germany share many cultural similarities, their populations revealed unexpected and surprising differences when it comes to disasters. Divergences in resilience capacities and disasters' perception in neighbouring countries can have severe implications for cross-border disaster management. Cross-border authorities and organizations involved in disasters do not always understand and remain aware of these differences which can lead diverging levels of vulnerability among neighbouring communities. However, if a cross-border region faces a disaster, one community can need external assistance earlier than others. Better prepared communities may be able to assist the most suffering ones. Hence, authorities can approach divergent levels of acceptance and preparation among populations as an opportunity to stimulate the cross-border resilience capability through a better exchange of resources. However, cross-border organizations still retain the requirement for a better understanding of divergences between cross-border communities as well as a means to transform them into fruitful interactions.

Cooperation issues within cross-border emergency response participants

Initiatives in relation to cooperation between authorities and private participants in preparedness and crisis management hint at the problem of unpredictability in cross-border cooperation in prevention and responses due to heterogeneous levels of equipment, organizational autonomy (Boersma and Engelman 2012) and access to public services (Wismar et al. 2011) across the frontier. Beyond heterogeneity, the risk of language, intercultural and administrative barriers to a joint crisis resolution also pertains. In addition to this, there is also a significant lack of knowledge and information regarding the administrative structure and responsibilities of the corresponding institutions of the neighbouring country. If a prompt reaction to a major incident is needed, then the involved agency is urged to find out as fast as possible whom to contact as the relevant corresponding agency abroad. The lack of knowledge is a major issue as far as the compatibility of procedures and national frameworks are concerned, which may not only differ substantially between the two countries for legal, administrative but also for technical reasons (e.g. if technical norms and standards differ). From a temporal perspective, information sharing and communication are important for contingency planning during the pre-crisis phase as well as for ad hoc crisis management in the incident of a disaster. Conflicts of interests, in addition to governance complexity, can arise as barriers against effective cross-border resilience. For example, it is possible that both countries do not agree upon joint cross-border institutions which are to be established to facilitate coordinated crisis management. Furthermore, effective crisis management is a permanent and demanding task which comes at higher cost. Although these higher costs will certainly represent a good investment into higher resilience of the cross-border urban area, political and legal factors may inhibit cross-border cooperative solutions to burden-sharing. Thus, to some extent, cross-border crisis management must be backed by the political process and should be accepted by the wider public.

25.3.3.2 Emerging Challenges

Crisis management in modern times is a complex task which requires a high degree of coordination among many participants. For example, efforts have to be expended for aligned planning and action between a large spectrum of participants, as well as joint learning from past incidents. All this becomes even more important in the context of cross-border crisis management which confronts civil protection authorities with a variety of further challenges.

Increasing uncertainty related to collective and individual behaviours

Divergences among communities and cooperation strongly relate to the behavioural side of cross-border resilience. In this regard, some open questions and requirements for empirical knowledge about the behaviour of crisis management players in cross-border areas (authorities, citizens, critical infrastructure agents, volunteers, etc.) still remain. As far as the integration of volunteers is concerned (for more details on this topic, see Orloff 2011), authorities face the same challenges as in a nationwide context but again with increased complexity. For example, due to latent or past tensions between the two sides of the frontier, unexpected behaviours such as digital defamation can quickly arise (Mills 2015), generate violence and riots. Responsible bodies in charge of this task do not only need to dispose of cross-cultural resources and competencies. They must also be capable to support and provide resources to volunteers to integrate them in the most efficient way from both sides of the border.

New technological avenues to resilience

As mentioned here, authorities confront a significant extent of uncertainty when coping with a crisis at a cross-border level. However, in their attempt to overcome such uncertainty, authorities can rely on new tools to build and strengthen crisis management networks. Requirements for such crisis management networks are the share of common patterns of communication, established contacts to key people as well as mutual knowledge about the emergency procedures of the partner region. Both sides of the region therefore should inform each other about national crisis incidents, even when these incidents do not affect the neighbouring region. Maintaining information transmission is crucial to help participants understand how and why their counterparts and the authorities of the neighbouring country coped with the incident. Situational awareness that can result from information-based communication can serve as a basis to deal with upcoming threats in the cross-border region. In recent years, social media has contributed to widespread communication patterns and basic knowledge within crisis response networks by playing the role of boundary objects (Tim et al. 2017), in particular in cross-border contexts (Bharosa et al. 2012), thereby reducing the language barrier and promoting cooperation. However, occasionally social media has also proven to contribute to widespread confusion and hostility among participants. Therefore, organizations and citizens involved in cross-border disasters crucially need insights and training to improve their use of such technologies.

New tools also afford communication blueprints during a specific incident which can support a crisis management system's continuous improvement through long-term share and capitalization of experienced knowledge—from multiple sources like use cases, examples of national incidents and scenarios to be tested and implemented. Therefore, reflexivity—including testing—with regard to national plans is a prerequisite to cross-border cooperation. In addition, supranational supervision can help support extensive information and knowledge sharing. For example, the Financial Stability Forum promotes international stability through cross-border information exchange and cooperation between financial firms, banks and regulatory agencies.

Vulnerable citizens

Borders can be affected by massive migration flows related to climate change and political instability. After years of open policies in relation to borders—especially in

Europe—nations seem to be reinforcing controls, which increases the vulnerability of illegal immigrants (Pécoud and De Guchteneire 2006). Other vulnerable parts of the population comprise the eldest and the disabled. Consequently, how can one identify the most vulnerable part of a cross-border population and how can one communicate with it? Urban cross-border regions can be characterized by high density and difficulties when identifying this part of the population. Which factors complicate the strengthening of self-help capacities in a cross-cultural context and how (by which measures) can this strengthening be facilitated? In cross-border regions, coordination between emergency responders (including medical assitance services, physicians, hospitals, administration and authorities, etc.) represents a major source of support of self-help capacities. However, these responders can get overwhelmed by the complexity of cross-border coordination. The ideal scenario could be a full coordination which comprises the coordination of emergency interventions based on a joint planning of capacities (personnel and technical equipment).

25.4 Future Research on Cross-Border Resilience—What Next?

Cross-border region's specificities can challenge a generic approach to resilience, in particular when these regions are intensively urbanizing. More specifically, creating resilience in such regions implies the need to address inherent specificities—which can transform into emerging challenges. This final section presents our proposal to approach the issue of cross-border urban resilience by the French–German research project INCA. The French–German cross-border region appears as an insightful case (Sect. 25.4.1) due to its specificities and inner diversity. The INCA project aims at providing a thorough understanding of French–German cross-border resilience by considering one of its major issues: volunteer integration and flow of vulnerable population (Sect. 25.4.2). This project initiates deeper thinking on cross-border resilience and can be extended into additional avenues for research (Sect. 25.4.3).

25.4.1 The Specific Case of French–German Cross-Border Resilience

Europe represents a particularly insightful case to study cross-border urban resilience for two major reasons. Cross-border regions have been flourishing since the 1990s in Europe (Perkmann 2003), and they comprise growing metropolitan regions (Reitel 2007). European cross-border regions have grown thanks to important investments, strong entrepreneurship and mobility (Smallbone et al.

2007). While enlarging, Europe still perceives borders as an important sensitive topic, in particularly due to massive migration phenomena and criticism against the Schengen area (Berg and Piret 2006).

Given high past investments into cross-border regions—also commonly called *Euro-regions*—their resilience represents a major stake for Europe. Europe can therefore gain a great deal from successful preparation, response and recovery from disaster. Beyond the question of the European population's well-being, the development of cross-border social cohesion, economic sustainability and political legitimacy can strengthen European Union. On the other hand, failing response within cross-border area can fuel political and social tensions as well as prevent quick recovery from exogenous shocks. From this point, one might need to additionally explore the coming challenges that can further complicate borderland resilience, in particular in German–French cross-border regions.

25.4.1.1 French–German Cross-Border Areas as a Highly Active but Vulnerable Region

France and Germany borderland has experienced major conflicts and a contentious history. Nowadays, it comprises multiple agglomerations characterized by the presence of European institutions, intense economic activity and major transportation axes, specifically between Basle, Mulhouse, Freiburg, Offenburg and Strasbourg. At least two factors account for the ever-increasing density of the French–German cross-border. Due to the multiplicity of conflicts between the two countries in the last centuries, army representatives and reserves were settled on each side of the border, such as in Metz and Baden-Baden. In addition, the Rhine has naturally attracted population on its banks. This cross-border region has been defined as the "Upper Rhine" INTERREG region in 2007.[4]

Paradoxically, the French–German borderland is vulnerable to multiple risks, possibly from earthquakes, floods and industrial accidents due to the presence of chemical wastage, chemical and nuclear plants—such as the Fessenheim nuclear plant built in the 1960s and which will be closed by 2019. In such conditions, the region is vulnerable to the potential implications of these risks such as overcrowding and stress on hospitals, electrical blackout, water toxicity and radioactivity.

Given deep institutional, procedural and cultural differences, efficient disaster response and long-term resilience of the borderland territory remain seemingly challenging. Through the Lisbon treaty and the release of the Stockholm programme, the European commission has publicly outlined the need to settle foundations for European crisis management so as to foster Europe resilience. Because of the Lisbon treaty and the Stockholm programme, France and Germany belong to a larger set of countries likely to tend to a set of harmonized rules, procedures and

[4]http://www.transfrontier.eu/regions/upper-rhine-at-the-french–german-swiss-border/.

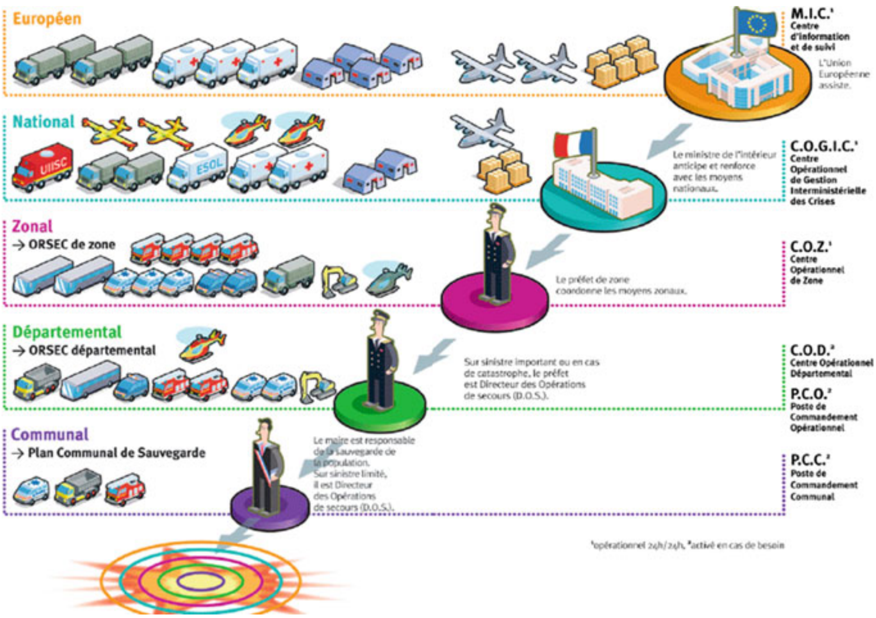

Fig. 25.1 Structure of the French civil protection system. (*Source* Institute for Major Incidents 2012)

operations. In addition, as neighbouring countries, French and Germany have developed common practices despite divergences in crisis management traditions. Even though social and economic integration is seemingly strong in the Upper Rhine region, each side of the frontier still refers to national systems. Between Germany and France, borderland regions are currently challenging the coexistence of two different socio-technical emergency systems. In addition, each side of the frontier needs to preserve coordination and institutional ties with other territories of their own country. This calls for the need to evaluate the potential and actual benefits from the development of a crisis management system that would be specific to the borderland region but different to national systems.

We propose in this section to focus on the divergences and commonalities between the French and German crisis management systems and deduce the major stakes related to the French–German borderland in the coming years.

25.4.1.2 Divergences and Commonalities Between French and German Disaster Management Systems

If a disaster strikes a French–German cross-border region, its population expects both German and French emergency systems to intervene and coordinate their activities while abiding by their national rules. However, as presented below, the two systems share a limited set of commonalities.

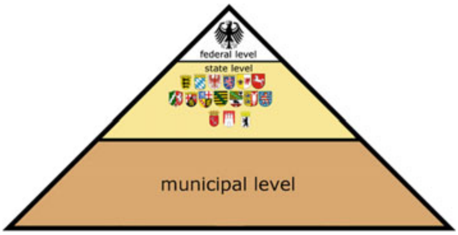

Fig. 25.2 Structure of the German civil protection system (*Source* adapted from InterKomm.eu 2017)

The French Republic is a unitary republic. Consequently, the responsibility for national civil protection is allocated to the French Ministry of Interior. The departmental fire and rescue services are responsible for regional civil protection. Contrary to Germany (see below), the French Prime Minister is directly responsible for civil protection in the entire country and can possibly intervene in every incident. Furthermore, civil protection and civil defence are not strictly separated. Rather they even share same structures. Some fire brigades (Paris and Marseille) are even military organizations.

The French Ministry of Interior specifies the structure of the civil protection system. Within this structure, local solutions are common. More precisely, there are local solutions not only in the different *départments* (counties) but even in the municipalities. But the disaster management depends on the scale of the incident. For example, during cross-communal incidents, the *departmental* level will be involved and assume control (and so on). Figure 25.1 shows the structure of the French disaster management with its different levels: local, regional, national and European.

After the Second World War, French authorities imposed the major principles for the French emergency and crisis management system. In 1952, ORSEC plans were thus created. In the first versions of the ORSEC plan, responsibilities and roles were clearly distributed between medical emergency services, firefighting, police services and local participants. The French crisis management system then significantly evolved when a law was passed in 2004 with regard to the modernization of the whole system. This law comprised sophistication of response plans and risks management for local and regional participants. Despite fund allocation from Europe, some organizations that can be involved in disasters are currently experiencing budget restrictions. Measures for volunteers' integration have significantly been integrated into risk preparation. However, the increase of volunteers involved in disaster stage has progressively become a coordination issue and has complicated decision-making. Finally, the French emergency management system has been experiencing digitization as a factor within the evolution of professional identities. Some emergency medical activities specific to crisis management, which used to be not strictly acknowledged, have gained additional recognition in the latest years. As another example, firefighting services have diversified their activities for information collection.

The Federal Republic of Germany has a federal political system. It is divided into 16 states, the so-called *Bundeslaender*. In this federal system, the responsibility for civil protection is delegated to the federal states. This leads to 16 different civil protection systems and every state has its own laws for regulating civil protection.

After the Second World War, the Technical Relief Organization (THW) was initially founded as a civil protection institution. Its main task was providing support in case of air raids. The Federal Ministry of Interior took responsibility for civil protection and the THW. Later on, when the Federal Ministry of the Defence was installed, the competences of civil protection were strictly divided into the two cases for war time (civil defence) and peace (civil protection). Because war affairs are always handled at federal level, the responsibility for civil defence was handed over to the Federal Ministry of Defence and the responsibility for civil protection was transferred to the states. Within the states, fire protection and emergency medical services are mostly delegated to the counties or big cities (which are independent from the counties). The single counties are also responsible for the handling of big incidents and disaster management. Only during serious incidents, which affect areas in more than one state, are the states involved in coordinating the disaster management, otherwise they are not directly involved in the civil protection, except in the definition of the laws. Figure 25.2 shows the structure of the civil protection system in Germany in a simplified form.

The federal level supports the states during cross-state incidents through the Federal Office of Civil Protection and Disaster Assistance (BBK), which was established in 2004 after two large occurrences, the great flooding in Germany and 9/11. The BBK comprises a coordination centre for cross-state incidents. Furthermore, the BBK provides common educational training for disaster management and supports the states with several guidelines (German Federal Office for Civil Protection and Disaster Assistance 2010).

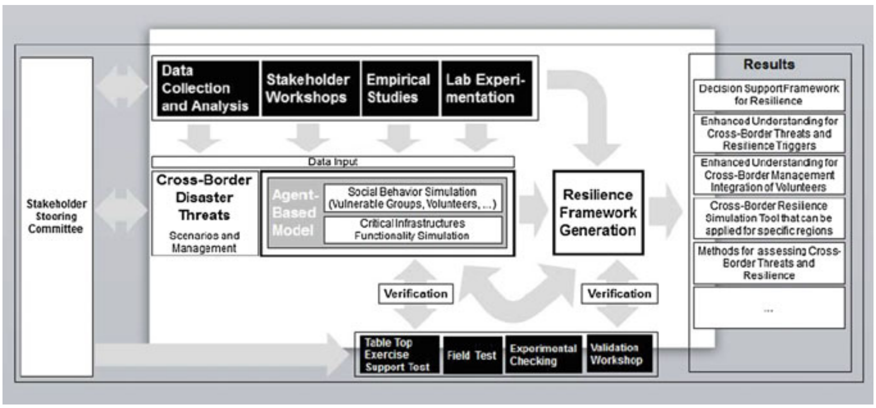

Fig. 25.3 Research framework of the project INCA

25.4.2 The INCA Project: A Short Overview of the Research Agenda

To improve cross-border resilience, further project-based research is necessary. Improving the methodological assessment of urban areas with respect to both disaster risks and particularities of cross-border resilience requires in particular:

- a profound understanding of the diversity and the complexity of disaster risks in cross-border regions, their consequences and potential resilience capacities available in an urban area. The existing programmes have considered some aspects of the inner complexity of cross-border regions and their implications on their resilience. However, they do not consider the combined effects of these aspects.
- the identification of the impact of disasters on cross-border areas and an understanding of the associated resilience processes.

In Spring 2017, the research project INCA (a decision support framework for Improving Cross-border Area Resilience to Disasters) with a French–German consortium started. The project will focus on resilience of cross-border areas by tackling some of the major challenges presented here, namely multicultural dimensions, organizational complexity, volunteers' integration and the management of the most vulnerable citizens. To do this, INCA approaches cross-border area resilience from an interdisciplinary perspective combining conceptual and empirical research which covers current trends with respect to three major dimensions: i) disaster management and urban resilience, ii) administrative and organizational aspects as well as with iii) a strong focus on people behaviour and interaction. In addition, INCA addresses the need to consider the combined effects of the aspects of the cross-border resilience, such as surprising behaviours, volunteers' integration and failing CIs. The project tackles these aspects on the basis of a cross-border blackout as a specific scenario. Within this scenario, the project aims at investigating cross-border structural and emerging issues that can challenge the resilience of the region. Based on this investigation, different options to increase resilience will be examined. To obtain these goals, INCA will develop a resilience framework, as shown in Fig. 25.3.

INCA's contribution comprises the establishment and improvement of information management in the case of cross-border incidents together with the involvement of volunteers during cross-border incidents. The information management will be evaluated from the perspective of connections between France and Germany. As detailed here, volunteer integration into the crisis management has been scarcely investigated but represents a burning issue that INCA fully takes into consideration.

25.4.3 Opening Questions for the Future of Cross-Border Resilience Research

This chapter contributes to the existing literature and research by putting into perspective cross-border urban region inner specificities on one side and methodologies and programmes on the other side. By doing so, it paves the way for a situated investigation of cross-border resilience challenges and levers. In the same vein, INCA aims to rely on a micro multidisciplinary investigation of cross-border resilience to produce actionable tools for disaster management. With the commencement of INCA, we identify two major challenges that research with regard to cross-border resilience is likely to confront.

First, existing programmes reflect the benefits and drawbacks from the establishment of specific crisis management practices in cross-border regions. However, specific methodologies drawn from research to harmonize procedures and strengthen cross-border resilience could paradoxically complicate its governance. In line with the existing dilemma between a cross-border's region autonomy and its requirement to abide by national rules, harmonizing resilience practices and rules across the frontier can also question the national authorities' prerogatives in administrating boundary territories. Given increasing complexity, how will borderland regions address the challenge of potential shifts in the distribution of responsibilities and prerogatives between resilience participants? Future research can address such mechanisms and may also consider other aspects of resilience capacity like trainings, education, investments and experiences.

Second, the most interesting avenues for further reflection concern the reuse of the knowledge created from investigation of a specific region. To what extent does general knowledge from urban resilience in disasters remain (or not remain) applicable in other cross-border regions? In the same vein, under which conditions can knowledge developed from an investigation of a specific cross-border region be generalized and be applied in other territories? This chapter focuses on the German–French cross-border region, and the INCA project fully investigates its cultural specificities. However, putting into perspective multiple cases—including non-European cases—is essential in the future to optimize knowledge exploitation for addressing the rise of major human, political and economic stakes in cross-border territories.

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Part VI
Perspectives from the Science-Policy Nexus

Chapter 26
Resilience—A Useful Approach for Climate Adaptation?

Thomas Abeling, Achim Daschkeit, Petra Mahrenholz and Inke Schauser

Abstract This chapter reflects on the parallels between resilience and adaptation and discusses whether a measurable resilience concept is useful for adaptation to climate change. It argues that a focus on measurability and operationalization risks to overemphasize conservative resilience concepts focused on maintaining the status quo (resilience as robustness) while marginalizing more intangible aspects such as learning (resilience as transformation). We suggest that those aspects of resilience that can be operationalized in a meaningful way should be integrated in existing concepts of climate change adaptation such as vulnerability and adaptive capacity. The most promising value of resilience for climate adaptation, we argue, actually lies in its ability to articulate a vision for a positive future ("Leitbild"). This meaning of resilience emphasizes the relevance of vision-building and the use of participatory instruments to foster learning and innovation. It is with this vision of development that resilience is able to expand the realms of climate adaptation.

Keywords Resilience · Adaptation · Measurement · Learning · Vision

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26.1 Introduction

Conceptualizations of resilience vary significantly in both academia and practice. Two different streams of thinking can broadly be identified: conservative framings of resilience emphasize robustness and maintenance of the status quo, while more progressive readings conceptualize resilience as learning, change and transformational change (cf. Carpenter et al. 2012; Fisher 2015; Schneiderbauer et al. 2016; Wink 2016).

The fifth assessment report of the Intergovernmental Panel on Climate Change acknowledges both perspectives in its definition of resilience: “Resilience: The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also *maintaining the capacity for adaptation, learning, and transformation*” (IPCC 2014: 40; italics by authors).

Both framings, resilience as robustness and resilience as transformation, have parallels in concepts related to adaptation to climate change. Resilience as robustness emphasizes the ability of a system (e.g. cities, regions) to withstand stresses or shocks such as climate change, particularly extreme events but also slow-onset changes. This meaning of resilience corresponds to the concept of “sensitivity” that is used in climate adaptation, for example, in the 2015 vulnerability analysis for the German government (adelphi/PRC/EURAC 2015). Resilience as transformation in the face of slow-going or rapid changes focuses on the capacity to learn and change. This understanding relates to the concept of “adaptive capacity”, which also emphasizes the ability of a system to change.

Against the background of these parallels between resilience and adaptation, this chapter reflects on whether a measurable resilience concept is useful for adaptation to climate change. It argues that a focus on measurability and operationalization risks to overemphasize conservative resilience concepts focused on maintaining the status quo. However, when considering likely severe and far-reaching impacts of future climate change, capacities for change and learning are crucial. Measuring these dynamic and often fuzzy aspects of social development would risk to significantly reduce the complexities of social systems such as informal networks and institutions that are at the heart of resilience.

Instead of attempting to develop a holistic, measurable resilience concept, we suggest that those aspects of resilience that can be operationalized in a meaningful way should be integrated in existing concepts of climate change adaptation such as vulnerability and adaptive capacity. Such a more narrowly defined agenda for operationalizing resilience frees capacity to focus on those aspects of the concept that can contribute to climate adaptation more substantially: the most promising value of resilience for climate adaptation, we argue, actually lies in its ability to articulate a vision for a positive future (“Leitbild”). This meaning of resilience carries a positive connotation and emphasizes the relevance of vision-building and the use of participatory instruments. It is in this ability to provide a hopeful and emotional guiding principle that the concept of resilience is most useful for climate adaptation.

In the remainder of this chapter, we substantiate our argument in four interrelated steps: first, we discuss conceptually the parallels between resilience, vulnerability and climate adaptation. We show that due to its close relation to the idea of "sensitivity", resilience as a measure for the robustness of a system is already captured in methods of vulnerability assessments. We argue that resilience relates to the concept of adaptive capacity if it is framed as a concept for social change. Second, we reflect on ways how such social dimensions of resilience could be integrated in existing tools for adaptation monitoring at the national level, but suggest that for national processes such as the implementation of the climate change adaptation strategy in Germany, appropriate monitoring or indicator systems are not available so far.

Third, empirical evidence from a case study on resilience to heatwaves in London, UK is used to demonstrate how such a focus on measurement and operationalization risks to undermine an acknowledgement of "soft factors" of resilience. In delivering heatwave risk management in London, informal institutions such as learning and social networks were integral. Fourth, we therefore suggest that the most promising value for adaptation might lie not in the operationalization of resilience, but in its ability to articulate a positive vision for development. Here, resilience goes beyond the somewhat technical idea of adaptive capacity and can have a substantial impact on development trajectories in climate adaptation.

26.2 Resilience and Vulnerability: Parallels to Sensitivity and Adaptive Capacity

Resilience and vulnerability are related concepts (Martin-Breen and Anderies 2011). In general, vulnerability and resilience are seen as opposites: a vulnerable system is not resilient; a resilient system is not vulnerable. Other authors argue that a resilient system is more than not vulnerable (c.f. Schneiderbauer et al. 2016; Welle and Birkmann 2016) and suggest that both are complementary concepts with different focuses: vulnerability—in the framework of climate change adaptation—focuses on potential damages due to sensitivity and adaptive capacity of an exposed system (IPCC 2007, 2014); resilience focuses on the capacities of a system to react to stresses or shocks (IPCC 2014; UNISDR 2007). Thus, both concepts seem to be synergistic: a reduction of the vulnerability of a system will likely—but not necessarily—increase its resilience.

Vulnerability assessments focus on the potential damages of (climate related) hazards and the structural weakness of a system with the aim of developing adaptation measures for improving the system. Resilience assessments, on the other hand, look at the strength and chances of a system, seeking to increase the motivation for change by offering a common vision, which may enable completely new solutions (Labaka and Sarriegi 2016; Sharifi and Yamagata 2016). To allow both (theoretical) concepts to influence policy, it is crucial that they are operable. Here, it is argued that the vulnerability concept in the context of climate change is already applicable, because it has been operationalized and extensively applied at different spatial scales in the past decade (see, e.g., adelphi/PRC/EURAC 2015; Harrison et al. 2015; Schuchard and Wittig 2012).

The concepts of resilience and vulnerability have in common their fuzzy definitions. There is no common methodological framework to operationalize them, which is partly due to the fact that their definitions are based on other vague and ambiguous terms such as adaptive capacity, sensitivity, flexibility or creativity. Both concepts depend on many variables which are themselves scale-dependent and changing over time and context. An assessment of both concepts will always include normative choices to decide which of the influencing factors need to be considered and are seen as critical.

Often the resilience of a system is analyzed with the aim of increasing its robustness by strengthening its coping capacity, mostly with the present conditions in focus. In a vulnerability assessment, these capabilities are seen as aspects of the sensitivity of a system. These capabilities can be operationalized by generic or context-specific information. However, because vulnerability assessments in the context of climate change are more interested in the future than in the present, the (present) coping capacity is often very much simplified or neglected. Still, it can be argued that due to this parallel to the concept of sensitivity, resilience as a measure for the robustness of a system to climate change is already included in vulnerability assessments.

Resilience—when understood as concept to deal with changes in a transformative way towards a new (future) status of the system—includes as core building stone its resourcefulness, including the capacity to learn and to progress. Vulnerability includes the capacity to adapt in the 2007 and the 2014 definition of the IPCC, and this also incorporates learning and development in the short and long term. Learning in technical systems may lead to a substitution of old systems and therefore to a neglect of old situations and solutions. Learning in social systems is based on balancing of different experiences with similar problems and on the creation of new solutions. This sheds light on the importance of memory.

Adaptive capacity and resilience are very similar concepts. Both incorporate similar capacities which enable a system to be robust up to a certain limit of stress and to adapt or to transform itself in the face of a stronger or continuing stress. The overarching goal is to maintain the operability and key functions of the system. Following this argument—resilience as similar to adaptive capacity—a resilience assessment as a measure for the capacity to adapt and to transform could be part of a vulnerability assessment. However, the capacity to learn is more prominent in resilience concepts than in most proposals for measuring adaptive capacity in vulnerability assessments.

26.3 Resilience in Adaptation Monitoring Approaches

A first step towards a systematic operationalization of social dimensions of resilience could be to explore ways of how learning can be incorporated in existing adaptation monitoring systems. As shown in our case study below, incremental adaptation and learning are crucial for building resilience. In the face of possibly severe climatic changes, supplemental transformative adaptation approaches may be required for the enhancement phase of the German Adaptation Strategy. These transformative approaches generally include creative and innovative solutions and behavioural changes (Mahrenholz et al. 2016) and require learning processes. Therefore, the feasibility of a robust monitoring of such aspects of resilience on a national level by indicators could support policy-making substantially.

Scientifically consistent as well as politically approved methods for monitoring of climate impacts and response measures (UBA 2015) on the one hand and an assessment of vulnerability including adaptive capacity (adelphi/PRC/EURAC 2015) on the other hand informed the establishment of the second German Adaptation Action Plan (Bundesregierung 2015). The method for the vulnerability assessment which has been successfully applied in this national context is published in a guideline to assist actors on the federal and regional level (Buth et al. 2017). The Adaptation Action Plan itself follows an incremental approach as it focuses on stepwise adaptation with short-term solutions, low- and no-regret measures (Vetter et al. 2016).

The German Environment Agency systematically gathers information on a household level regarding people's attitudes, behaviours and provisions pertaining to adaptation, especially to climate extremes. Data is gathered every two years and periodically published in the study "Environmental Consciousness in Germany" (UBA/BMUB 2017). Exemplified statements include "*I change my planning for spare time and holiday, e.g. I avoid especially exhausting activities during heat-waves or give up on hot holiday destinations.*", "*I change my winter sports activities*." or "*I ensure my property against risks of flooding, flash floods and landslides*". Resulting conclusions on learning processes have been drawn by the authors of the study, providing valuable additional information on resilience that should be used to further develop existing methods. We propose, for example, to interview adaptation actors or acting institutions (including municipalities, businesses, NGOs) not only about technical or financial capabilities but also about their potential to innovate and their diversity and flexibility in regard to structures and adaptation solutions. If this was surveyed regularly, such a monitoring itself would constitute a learning system, as respondents—in reflecting on the questionnaire—would be urged to identify innovative solutions of handling stress situations themselves.

However, such a potential for operationalization in a permanent impact-oriented policy process bears the risk of using inappropriate proxies for soft factors of resilience that are difficult to measure, such as learning, cultural traditions and their changes, existing values and their modification (for factors see Martinez et al. 2014;

Sharifi and Yamagata 2016). Operationalization therefore bears the risk of underestimating the social dimensions of resilience. Cultural traditions, for example, are difficult to measure because they depend on specific spatiotemporal conditions, and their changes vary on long timescales. Existing values differ individually so that it is a methodical challenge to derive constraints which allow valid conclusions for social groups or societies. Attempts to develop metrics and measurements for resilience should carefully bear this risk in mind. In practice, this could mean devoting sufficient resources and time to the development of "soft factor indicators", as budget constraints often force researchers into applying (quantitative) proxies that are readily available.

26.4 Intangible—Informal Networks and Resilience to Heatwaves in London, UK

Results from a case study on social learning in heatwave risk management in London, UK, demonstrate how a focus on measurable resilience concepts risks to undermine an acknowledgement of adaptation and learning as essential aspects of resilience (Abeling 2015a, b). The aim of the study was to understand how resilience to heatwaves is shaped by local-level behaviour and decision-making. Empirical evidence stemmed from 49 semi-structured expert interviews with risk planning officials from local authorities and National Health Service (NHS) organizations in London, conducted over the course of six months between 2013 and 2014. The study explored opportunities for learning and change within the networks of heatwave risk management institutions in London.

London is particularly vulnerable to the adverse effects of extreme temperatures. The city was adversely affected by several heatwaves in the last decade, including the 2003 heatwave which is estimated to have caused 2000 excess deaths, the 2006 heatwave (estimated: 680 excess deaths) and the 2009 heatwave (estimated: 300 excess deaths) (PHE 2014). London's urban area is subject to the urban heat island effect (GLA 2006). Heatwave risk management in London is delivered through local government organizations as well as organizations from the NHS and the voluntary sector. Local heatwave planning approaches are shaped by the National Heatwave Plan for England. The National Heatwave Plan was first developed by the Health Protection Agency in 2004, following the 2003 European heatwave. At the heart of the plan is the "Heat-Health Watch alert system", an early warning system for heatwaves in England. Heatwave alerts are disseminated to local authorities as well as to organizations from the NHS and from the voluntary sector. The London Resilience Forum, a multi-agency coordination platform for disaster risk management in London, provides the framework for heatwave planning in the city. It is here where resilience is articulated as a guiding principle for incremental changes to risk management in London.

Results show that informal networks were crucial for resilience because they supported formal risk management arrangements to function when the heatwave plan was activated. It was then when shortcomings of planning arrangements were revealed and where informal networks stepped in and compensated dysfunctional formal response arrangements. This was observed, for example, during the July 2013 heatwave in London, when trust relationships between risk managers allowed them to circumvent bureaucratic regulations that constrained an effective organizational response to the heat. A senior representative from a London Clinical Commissioning Group (CCG) reported that according to formal rules, they would not have been allowed to reach out to local General Practitioners (GPs) during the heatwave. To prevent overcrowding in the local hospital, the respondent aimed to advice local GPs to treat incoming patients with heat-related symptoms directly, rather than referring them to the hospital. The respondent suggested that they knew from past working relationships colleagues at the NHS England responsible for authorizing a direct communication between the CCG and GPs. The respondent was confident that these colleagues would trust in the appropriateness of local response measures, even if these were not authorized in advance and thus broke the formal rules and responsibilities of the risk planning regime. Here, trust relationships and informal networks helped to deliver disaster response at the local level in a way that would have not been possible if local planners would have followed the formal rules.

In local authorities, intangible aspects of resilience were of critical importance because learning in local government relied heavily on experiences with improvised responses to problems. Trial and error and reactive problem-solving were distinctive characteristics of learning processes in disaster risk management in London. A Resilience Officer from a pan-London emergency planning body suggested that risk planning arrangements in their organization were changed only after events revealed their inappropriateness. At the local level, a Director of Public Health from a London local authority reported that constraints in capacities and resources overburdened their organization, putting it constantly in a position to react, rather than to plan.

These "cultures of firefighting" suggest that incremental adaptation and learning through informal networks were crucial for heatwave resilience at the local level in London. The geographical proximity of London's 33 local authorities means that social networks, both formal and informal, cut across hierarchies and boundaries of the formal organizational system of risk management. Diversity of the network of social relationships that links together risk managers from across the city can facilitate the dissemination of knowledge, supports sharing of best practice examples and thus shapes capacity to learn in a way that is particular to the organizational architecture of disaster risk management in London. Tracing these aspects of resilience requires context-specific and in-depth engagement with the risk management community of practice. Attempts to measure and operationalize informal networks as part of a broader resilience assessment risk to elevate these networks from the hidden "shadow spaces" (Stacey 1996) in which they operate and into the spotlight of formality. This might undermine the very nature of informal networks and could threaten their functionality and their pivotal contribution to learning with the organization. The alternative of using as proxies available metrics, however, might fail to fully grasp the complexity of informal networks and their role for adaptation and learning as important aspects of resilience.

26.5 Resilience as a Vision and Guiding Principle

Against the background of increasing efforts in implementing adaptation strategies to reduce vulnerability and enhance climate resilience, there is a growing need for approaches to assess and monitor progress in decreasing vulnerability and to build adaptive capacity and resilience to climate change. Describing and assessing trends for impacts and adaptation responses aim at raising actors' awareness of challenges for climate policy. Moreover, monitoring informs strategy development by surveying the effectiveness as well as the efficiency of implemented adaptation measures and may legitimate the allocation of resources.

How can resilience be useful for this? We argue that resilience—in the context of climate change adaptation—is best used as a guiding principle ("Leitbild") and positive vision. It has the capacity to articulate a picture of a desirable future. As a target state or—by a transient process—permanent claim to strengthen a system's capabilities to deal with changes, resilience articulates a normative agenda. This claim could also include unknown future stresses, which would lead not only to an adaptation to known stresses but also to a complete transformation of a system. Such a transformation would need high flexibility, learning and innovative capacities, which can enable proactive changes. It is with this vision that resilience is able to expand the realms of climate adaptation. Vulnerability assessments have been used as tools to investigate and decrease system fragilities, whereas resilience assessments could be used as tools to investigate social development.

A few case studies so far have demonstrated that the use of resilience as a positive vision is useful as a normative foundation of learning and transformative processes. For example, Kegler (2014) describes strategies and perspectives of resilient and learning cities in Germany and emphasizes the participatory and experimental design of building a vision to transform regions under stress. Against the background of a well-grounded problem analysis, the first step was to develop positive goals or visions of resilient cities and regions. Other case studies, e.g. in the Greater Cairo region, depicted the necessity for participatory programmes for community-based engagement implementing the resilience vision for the region (ICLEI 2015). More generally, Lukesch et al. (2010) highlight the cyclical character of the resilience approach as well as the crucial first step: the region Voralberg in Austria developed a so-called Vision Rheintal to lay the foundation for a long-term socio-economic development.

Whether such approaches of framing of resilience to include learning and change and to serve as a guiding principle for future development are successfully transferable on a municipal, regional or national level remains unclear at this point. The described resilience approach might lead to challenging debates about competing visions or guiding principles of resilience. From our point of view, however, these debates are necessary to reveal, address and potentially mediate nested interests of key actors in resilience. Such dialogues, we argue, should best be organized as open and inclusive participatory processes at the local level. Further investigation is needed to assess how transformative capacities can be operationalized and integrated in adaptation monitoring. Hence, it remains a main challenge for science and practice to identify ways of consequently integrating social dimensions of resilience into the implementation of adaptation strategies.

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Chapter 27
Urban Resilience and Crisis Management: Perspectives from France and Germany

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Abstract The resilience concept and its application in the context of urban security encounter a series of grounded challenges for scientists, policy-makers, planning bodies, and the manifold authorities of jurisdiction and civil services. This chapter outlines a joint effort to explore structural and functional similarities and differences in France and Germany with regard to crisis management in urban systems, with the ultimate goal of identifying potential pathways of applying the resilience concept and exploring the potential for cross-national collaborative actions. Specific aspects of urban resilience and crisis management are portrayed: cross-border and international aspects, community resilience, psychosocial crisis management, and knowledge and information. In both countries, past and ongoing activities demonstrate the potential of connecting scientists and decision-makers in policy and

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practice to integrate multiple perspectives, bridging existing barriers between research, policy, and operational practice, and stimulating new technologies and innovative solutions. Furthermore, it became clear that enhancing urban resilience requires governance structures that promote cooperation among and between science, policy, and practice. Likewise, crisis management practices can be enriched through bi-national partnerships, collective activities, and shared co-management efforts. It is therefore suggested to further examine the various network strategies within hierarchical and horizontal collaboration structures and address the question of how the structural arrangements for collaboration within crisis management networks influence disaster resilience in urban areas.

Keywords Urban resilience · Crisis management · Disaster risk reduction
Cross-border collaboration · French-German partnership

27.1 Introduction

The context for the cross-country efforts outlined in this chapter is the resilience of urban areas with respect to crises and disasters in France and Germany. In Europe, more people live in urban areas than in rural areas, with 73% of its population residing in urban areas in 2014 (UN 2014: 1). In France, the urban population grew from 74% in 1950 to 79% in 2014. In Germany, the proportion of urban dwellers increased from 73% in 1950 to 75% in 2014. By 2050, 86% of the population of France and 83% of Germany are projected to be urban (UN 2014: 23). Continuing crises in both countries indicate that, in a rapidly changing world, risk assessments, warning systems, legislation, and technical capacities that focus on hazard processes and security issues, without addressing social vulnerability and resilience, are incomplete and insufficient. Any disaster also reminds us to further advance our scientific understanding and policy action on mitigation and response. In particular, the projected increase in frequency and/or intensity of natural disasters due to climate change, coupled with a growing population in urban areas, potentially increases vulnerability, risks, and losses with regard to urban systems.

Urban areas are disaster "hot spots" with critical infrastructure and significant drivers of risk: growing exposure to hazards; increasing populations and population density; interlaced infrastructure and energy systems; cascading risks and security aspects; and complexity of governance systems and responsibilities. Hence, there is an urgent need for comprehensive development planning and integrative risk governance. Since the administrative boundaries of cities no longer reflect the reality of urban development, smaller as well as larger, interconnected areas have to be considered. This requires, in turn, new forms of flexible governance. There is a need for enhancing both citizens' and infrastructure's resilience as a means of preparing urban areas in advance of disasters, as well as a counterbalance to social and individual vulnerabilities (The Kresge Foundation 2015; McDaniels et al. 2015).

Making urban areas more resilient to disasters and crises is a great challenge to the research, policy, and practice communities. In recent times, the resilience concept has been increasingly used with a diverse array of meanings in various scientific disciplines and different professional fields (Alexander 2013; McDaniels et al. 2015; Weichselgartner and Kelman 2015). One common thread among many contexts is the ability of materials, individuals, organizations, and entire social-ecological systems, from critical infrastructure to urban communities, to withstand severe conditions and to absorb shocks. Generally used to designate the capacity to cope with change and uncertainty, "resilience" became the currency in academic and policy discourses and a guiding principle in development planning.

Despite the wide range of application, resilience is not a universally accepted term, nor does it have a universally accepted definition for single fields, such as crisis management, disaster risk reduction, climate change adaptation, or urban planning (Alexander 2013; Meerow et al. 2016). In France and Germany, like in most countries, the view of governments and organizations on resilience is diverse: resilience as a process, a state and a quality, ranging from a global focus on food security and a national view on critical infrastructure to a sectoral view on business continuity and a local approach of operational response (Fekete et al. 2014; Weichselgartner and Kelman 2015). In comprehensive discourses, the interrelationship between resilience, sustainability, and culture is a central topic of planning (Zaumseil et al. 2014; The Kresge Foundation 2015).

The resilience concept and its application encounter a series of grounded challenges for scientists, policy-makers, planning bodies, and the manifold authorities of jurisdiction and civil services (O'Hare and White 2013; Herwig and Simoncini 2017). For instance, research has not yet examined various network strategies within hierarchical and horizontal collaboration structures and, thus, the question of how the structural arrangements for collaboration within crisis management networks influence disaster resilience remains unanswered (Jung and Song 2015). Moreover, critics point out that resilience might appear to be somehow "equal" or "democratic" in the sense that it encourages us to think that any person or community can learn how to "bounce back" from crisis, but it simultaneously masks the fact that resources are far from equally shared (Gillard 2016). By using the resilience concept to prepare for crises, one needs to be careful not to neglect the changeable underlying conditions causing vulnerability. From a cultural-psychological perspective, the western view on total preparedness and manageability of strokes of fate should be scrutinized (Zaumseil 2012).

While both in France and Germany much progress has been made in defining components of resilience, many questions remain about identification of appropriate strategies for building urban resilience, barriers to implementation of these strategies, and limits to the potential effectiveness of these efforts (Cerema 2015; Gross and Weichselgartner 2015; Leichenko et al. 2015). White and O'Hare (2014) point to the lack of clarity in policy, where conceptual differences are not acknowledged. Resilience is mainly discussed as a singular, vague, but optimistic aim. This imprecise political treatment of the term and the lack of guidance have affected practice by privileging an equilibrist interpretation over more transformative, evolutionary measures. As a result, “resilience within spatial planning is characterized by a simple return to normality that is more analogous with planning norms, engineered responses, dominant interests, and technomanagerial trends” (White and O’Hare 2014: 945).

This chapter outlines a joint effort to explore structural and functional similarities and differences in France and Germany with regard to crisis management in urban systems, with the ultimate goal of identifying potential pathways of applying the resilience concept and exploring the potential for cross-national collaborative actions. Section 2 depicts the intention behind the activity and describes the format and goals of the workshop. In Sect. 3, specific aspects of urban resilience and crisis management are portrayed: cross-border and international aspects, community resilience, psychosocial crisis management, and knowledge and information. Based on the discussions at the workshop, particularly these domains are suitable starting points to use synergies across administrative, sectoral, and national borders. The concluding Sect. 4 summarizes important findings and potential future activities.

27.2 A French-German Effort to Enhance Urban Resilience

Crises and disasters are often complex and unexpected when they occur (see Davies 2015). One small disturbance can trigger cascading effects, affecting multiple societal sectors. Hence singular, isolated approaches focusing on one field of expertise are of very limited use. Urban risks and crises should be approached from a multidisciplinary point of view, with very different academic disciplines and fields of practice getting involved. Closer collaboration and joint activities among scientific experts, urban planners, and crisis managers are posited as essential for reducing the negative impacts of disasters. Which societal actors are integrated and how they are involved are critical aspects for building resilience in practice. Nevertheless, there are few empirical studies available to inform theory or show how these issues are addressed (Aldunce et al. 2016), as well as to demonstrate how learning should be encouraged to enhance adaptive capacity for resilience (Yu et al. 2016). Consequently, the integration of various stakeholders and their expertise served as a starting point to tackle questions of transboundary risks and governance by a concerted integrative action. In a first scoping meeting at the Federal Office of Civil Protection and Disaster Assistance in Bonn, a small group of scientists and decision-makers from Germany and France explored suitable topics to enhance collaborative working across national contexts and across agencies. Subsequently, Juergen Weichselgartner and Bernard Guézo started with the organization of a Franco-German workshop on “Urban Resilience and Crisis Management: Perspectives, Barriers, and Innovative Pathways,” which was held in September 2016 in Lyon, France.

The organizers' intension was twofold: firstly, to bring relevant experts from France and Germany together to analyze contextual similarities/differences in crisis management in urban environments, identify barriers and bridges of applying the resilience concept, and to strengthen cross-national collaborative efforts; secondly, to better connect scientists and decision-makers in policy and practice to integrate multiple perspectives, bridge existing barriers between research, policy, and operational practice, and stimulate new technologies and innovative solutions. Through an exchange of scientific knowledge and real-world experiences, the workshop specifically aimed at: (1) systematically exploring the applicability of the resilience concept in urban environments; (2) analyzing the contextual surroundings of crisis management in France and Germany; (3) examining strengths, weaknesses, opportunities, and threats of current practices; and (4) stimulating French-German collaborative partnerships and joint projects.

In September 2016, about forty selected participants from France and Germany met in Lyon to illuminate important dimensions of urban resilience in greater detail (Fig. 27.1). A transdisciplinary approach was applied (see Weichselgartner and Truffer 2015; Le Feuvre et al. 2016), involving representatives from science, policy, NGOs, and operational practice with expertise in urban planning and/or crisis management, to stimulate stakeholder arrangements in urban partnerships. Selection of participants was based on criteria of what they *do*, rather than of what they *are* and where they *come from*. The scope and design of the workshop were structured around four dimensions of urban resilience that resulted from a three-year work program of the French Ministry of Environment and Cerema, involving national and international cases studies, bibliography analysis, and seminars open to scientific experts and practitioners (see Cerema 2015):

- Scales, e.g., temporal, spatial, and administrative scales
- Governance, e.g., decision making, stakeholders, hierarchies
- Response, e.g., anticipation, prevention, intervention
- Culture, e.g., risk perception, socioeconomic structures, coping capacities.

Fig. 27.1 Participants of the Franco-German workshop on "Urban Resilience and Crisis Management" in Lyon (photograph by B. Grün)

These aspects were highlighted by applying different mechanisms. On the first day, intensive time was spent for introducing participants, their motivation, and expertise. Two kick-off presentations illustrated cross-national aspects of resilience and crisis management. The second day and third day were structured around four working group sessions on "Identifying Changes in Status Quo," "Identifying Options for Future Collaboration," "Formulating a Vision Statement," and "Drafting Future Pathways." In total, twelve working groups (WGs) with plenary discussions were organized, which were always differently assembled with respect to sectoral and national expertise in order to efficiently use the multiplicity of diverse knowledge.

The workshop design allowed for intensive and stimulating discussions on the following three key themes and their interconnections: (1) Resilience: urban perspectives and dimensions; (2) Urban development: innovation and key technologies to enhance resilience; and (3) Crisis management: interdependencies, cascading effects, and cross-boundary cooperation. The workshop's premise was that highlighting prominent challenges by analyzing concrete social contexts and institutional settings can bring some light to the clouded interpretation of resilience and reduce existing gaps between academic works, operational missions, and the possibilities offered by new technologies. Therefore, an important feature of the expert meeting was cross-national and cross-sectoral learning from history, past work, and wider contexts in order to break out of the "trajectories leading to the normality of disasters" (see Kelman et al. 2016).

The workshop concept was the systems approach to understanding, seeking innovation as an emergent property of different kinds of knowledge. The overall goal of the meeting was not necessarily to reach a consensus on the resilience concept or the mode of crisis management, but rather to identify knowledge gaps, structural shortcomings, and innovative assets. Other objectives were to find new ways in approaching controversial issues and to define priorities for joint future research and collaborative activities. In addition, the SWOT framework was used as a guiding concept to help participants develop a full awareness of the factors, positive and negative, that may affect strategic planning and decision making (Fig. 27.2). Prior to the workshop, participants were invited to use the selected literature made available online and reflect on strengths, weaknesses, opportunities, and threats of current thinking and practices with regard to the four dimensions of resilience, i.e., scales, governance, response, and culture. By means of an online survey, participants were anonymously asked to express their views on aspects for improving urban resilience. This feedback helped the organizers to refine the WG sessions.

Fig. 27.2 SWOT framework with examples. Strengths and weaknesses refer to internal factors, which means the resources and experience readily available. Examples of factors typically considered include: financial resources (e.g., budget, funding sources, investment opportunities), physical resources (e.g., the organization's facilities and equipment), human resources (e.g., employees, target audiences), and current processes (e.g., department hierarchies, information systems). External forces influence and affect every organization and individual and are connected directly or indirectly to opportunities or threats. External factors typically reference things that an organization or individual do not control, such as: market trends (e.g., new products and technologies, shifts in audience needs), demographics (e.g., changes in population's age, race, and gender), partner relationships, and political, environmental, and economic regulations (graph by J. Weichselgartner)

27.3 Targeting Critical Aspects of Urban Resilience and Crisis Management

The history and root causes from which vulnerability and resilience emerge have always been of concern in disaster-related development work. Scientists and practitioners were motivated to understand why a system can or cannot "cope with a hazardous event or disturbance," the reasons of which are often due to "its essential function, identity, and structure" supporting vulnerability and hindering resilience (Kelman et al. 2016). In both Germany and France, collective expertise and experience in civil protection and crisis management exist, as well as national documents and strategies, taking into account the resilience of people and infrastructure (Ministère de la Défense 2013; Gross and Weichselgartner 2015). Crisis management—characterized as the processes by which an organization deals with a major event that threatens to harm the organization, its stakeholders, or the general public—requires specific skills and techniques to identify, assess, understand, and cope with a serious situation, from the moment it first occurs to the point that recovery procedures start. In particular, leadership competencies that facilitate the structuring, in general, of an efficient organization are of critical importance.

James and Wooten (2005) distinguish different competencies, including building an environment of trust, reforming the organization's mindset, identifying obvious and obscure vulnerabilities of the organization, making wise and rapid decisions, and taking courageous action, as well as learning from crisis to effect change.

However, decision-makers in crisis management are confronted with the need of constantly reviewing and adjusting their capabilities and capacities due to the changing landscape of risks and complexity of urban environments and, thus, policies. For instance, demographic changes such as the aging population heavily influence the structures of and processes in both crisis management organizations and the people at risk. Likewise, changing economic structures and financial arrangements, such as the privatization of services or budget constraints, have strong impacts on risk mitigation and response. In view of changing conditions and complexities, there is a need to strategically build alliances and use synergies across administrative, sectoral, and national borders. In the following sections, relevant aspects of urban resilience and crisis management that require further exploration in the French-German context are outlined.

27.3.1 Cross-Border and International Aspects

The importance of cross-border support in the face of large crises and disasters is illustrated by bilateral agreements aiming at facilitating quick cross-border relief assistance and regulating operational emergency support. Both France and Germany have entered into agreements with neighboring states about mutual assistance in case of disasters and severe accidents. Already signed on February 3, 1977, the German-French Agreement is the legal foundation of long-standing mutual solidarity and cross-national cooperation between communities and authorities. Numerous bilateral cooperation frameworks, regular information exchange, and formal, as well as informal, activities exist on regional and local levels to strengthen crisis management strategies and necessary coping capacities.

The importance of transnational collaboration in crisis management is underlined by impacts of incidents that cut across national borders. In France, the severe incidents at the Mont Blanc Tunnel in 1999 showed how lack of coordination could hamper the safety of the tunnel. As a result of the fire disaster with 39 fatalities, numerous studies and assessments have been undertaken, technical directives elaborated, and major changes introduced in the three years, the tunnel remained closed. Equally important, the incident fostered French–Italian cooperation to jointly improve security and maintenance. While the Mont Blanc Tunnel was originally managed by a French and an Italian public company, each managing half of the tunnel, all the operations are managed today by a single entity.

As in France, Germany has also experienced severe incidents, such as the Elbe River floods in 2002. These incidents underlined the need to rethink or improve alliances and networks to foster and broaden preparedness and crisis management, linking actors and capacities across administrative levels and sectors. In 2004, the

Federal Office of Civil Protection and Disaster Assistance (BBK) of the Federal Ministry of the Interior launched a crisis management training program, the so-called interministerial and interstate crisis management exercises LÜKEX (*Länderübergreifende Krisenmanagementübungen*), to improve communication and decision-making processes between governmental and nongovernmental actors at the highest strategic political levels. The main aim of the exercises is to review the overarching response capacity during unusual crisis situations using a sample practical test. Specifically, the training exercises are important to test established procedures, identify potential for improvement, determine the need for action, and improve crisis response abilities. The frequent training, therefore, improves the coordination and decision-making processes between federal and state authorities, commercial enterprises, research institutes, and other cooperation partners. In addition to their technical findings, the training exercises have another important effect—namely developing a network for crisis management. LÜKEX involves up to 3.000 participants and is held every two years using a specifically designed crisis scenario (Table 27.1).

There was broad agreement among the participants at the workshop that joint training programs and exercises would be a feasible and beneficial way to improve resilience and crisis management in both countries. In fact, joint networks and mutual knowledge are extremely useful in disaster situations when cooperative response is needed—exemplified by the Germanwings plane crash in France in March 2015—be it across borders or across various fields of expertise ranging from risk analysis to psychosocial crisis management (see Sect. 3.3). There is a clear need for organizing transnational activities with experts and policy-makers from different countries to explore the complex crisis management aspects in cross-border urban areas. One example that has been highlighted at the workshop is a current project on large-scale cross-border evacuation planning in Germany and Switzerland (*Grenzüberschreitende großräumige Evakuierungsplanung am Beispiel Deutschland—Schweiz*), led by the TH Köln—University of Applied Sciences and involving several supporting partners, such as the German Federal Office of Civil Protection and Disaster Assistance, the Swiss Federal Office for Civil Protection, the Ministry of the Interior, Digitization and Migration of Baden-Württemberg, as well as numerous counties and municipalities along the border. The overall aim of the bilateral project is the evaluation of existing plans and, consequently, the elaboration of a concept including a decision-supporting

Table 27.1 LÜKEX exercises and their scope (*source* BBK)

Year	Topic
2004	Extreme winter weather situation with power outages across large areas
2005	Terrorist attacks in connection with the 2006 FIFA World Cup
2007	Worldwide flu pandemic
2009/10	Terrorist threat with conventional explosives, chemical and radioactive devices
2011	Threat to IT security through massive cyber attacks
2013	Extraordinary biological threat situations
2015	Extreme storm surge

system to facilitate large-scale, cross-border evacuation planning. In an assumed scenario of a nuclear power plant incident at the German-Swiss border, the foci lie on three cross-border planning topics (i.e., warning, communication, and traffic management) and the applicability of the concept in different scenarios and regions.

Joint training and exercises provide fresh impetus to other areas of strategic crisis management, such as the further development of interdepartmental management structures, by providing them with a common platform that spans across different departments and areas of responsibility. Other identified fields where closer French-German collaboration could bring added value include critical infrastructures and technological development using social media and their relations with urban resilience. For instance, the modular warning system (MoWaS) has been deployed in Germany at the federal and state levels. At both levels, the system can issue georeferenced warnings that are transmitted via satellite to radio, TV, paging systems, the Internet, and the German railway's loudspeaker system within a matter of seconds and can be distributed to a wider network from there. In addition, there are smartphone apps to inform and advise people in case of a danger, for instance, NINA, developed by BBK, and KATWARN, developed by the Fraunhofer Institute for Open Communication Systems (FOKUS). In these fields, bilateral exchange takes place already, but it might be a challenging task to enhance such systems and applications in a transnational context of urban resilience.

Finally, there are internationally agreed regulations, at both the European and international levels, which provide a framework for joint cross-country efforts. In 2009, the European Commission (EC) adopted a community approach on the prevention of natural and man-made disasters. As a consequence, guidelines were set up to improve coherence and consistency among the risk assessments undertaken in the EU member states at the national level in the prevention, preparedness, and planning stages and to make these risk assessments more comparable between member states (EC 2010). While the guidelines are mainly addressed to national, regional, and local authorities involved in cross-border cooperation, the EU emphasizes that hazard and risk identification and analysis, impact analysis, risk assessments and matrices, scenario development, risk management measures, and regular reviews are major components of the EU disaster prevention framework and of prevention policies at all levels of government. At the European level, the EC has recently developed risk management capability assessment guidelines that countries can use to assess their own capabilities (EC 2015) and, at the international level, work on disaster risk management is drawn together under the Sendai Framework for Disaster Risk Reduction 2015–2030 (SFDRR), adopted by United Nations (UN) Member States in March 2015 and endorsed by the UN General Assembly. The SFDRR is the successor instrument to the Hyogo Framework for Action 2005–2015 (HFA). As the first of the post-2015 development agreements, the SFDRR is the basis for a disaster risk-informed and resilient sustainable development agenda (EC 2016).

In the SFDRR, the term "resilience" is explicitly included in the overall goal, in one of the seven global targets, and in one of the four priorities of action. More importantly, resilience of people and assets will be determined by the ongoing process of implementation: review of existing disaster risk reduction (DRR) policies; determination of key areas for coordinated policy initiatives; setting ambitious targets within the monitoring and reporting system; and fostering stakeholder participation by establishing national and sub-national platforms. The process is characterized by horizontal integration across different domains and vertical integration from the national to the sub-national level (see Peters et al. 2016):

- Implementing the SFDRR requires an approach ensuring synergies across the disaster risk reduction, sustainable development, and climate change agenda. It has to follow an all-hazard, transdisciplinary, and multi-sectoral approach that incorporates bottom-up as well as top-down actions (Aitsi-Selmi et al. 2015). This enables an improved mainstreaming and integration of DRR within different policy areas.
- The multi-stakeholder and all-of-society approach emphasizes that the state and its institutions cannot act alone in managing disaster risk. DRR is everybody's business and responsibility, and no one can be left out or behind. Such an approach is instrumental to ensure the full understanding of disaster risk at the local level and the adoption of measures that are tailored to the need of people at risk (UNISDR 2015).

It is important to note that the SFDRR is a non-binding agreement and, thus, has to be transformed into political commitments and actions. Transnational initiatives—such as the road map of the European Forum for Disaster Risk Reduction (EFDRR) aiming at providing guidance and highlighting a number of focal areas to strengthen the implementation of the SFDRR in Europe—can build on experience of the national platforms and promote the greater integration of disaster resilience considerations in decision making. In this context, a close Franco-German collaboration on sharing information, lessons learned, and best practices can contribute to supranational activities. Resilience might function as the conceptual link that connects the various actions and facilitates the required political coherence.

27.3.2 Community Resilience

There is no equivalent term and meaning that is uniformly used in German for the English term "community resilience." While the term "resilience" is debated at great length (see Sect. 27.1), this is not explicitly the case with "community." Different meanings range from spatial (communal) administrative boundaries (e.g., city, municipality) to shared values, interests, and actions in civil society communities (e.g., real-life social networks) (Carpenter et al. 2001). Sometimes community resilience means merely the resilience of the residents (e.g., resilient population/civil society) or the whole system of the "resilient city" as a local, spatial area that can be defined in administrative terms (e.g., municipality/community) with public administration, critical infrastructure, and civil society (Christmann et al. 2016; Meerow et al. 2016).

Following in this context the focus on "people" and the presumption that urban resilience needs and includes the resilience of local residents, the discussed forms of cooperation with the civil society to enhance preparedness and coping resources two dominant narratives can be carved in the German civil protection discourse:

(1) Civil society is the sum of individuals, which should be well informed and educated by flyers, mobile apps, and digital social media to evoke individual behavior change concerning preparatory action (self-protection), behavior following warning (self-help), and cooperation with the authorities during the response and recovery phases. Community resilience is constituted of the sum of individual resilience. It may result from biographic experiences and/or disaster-related education programs, mostly given by written information and/or in educational institutions education following fear induction models of behavior change (Carpenter 2010). Residents are called upon to support, complementarily, the governmental civil protection agencies and organizations in disaster situations. Those individuals who are willing should be integrated as "untied supporters" in specific platforms and networks to organize their assistance (Ohder and Sticher 2013).

(2) Civil society is the sum of social networks and initiatives which—more or less—influence the knowledge and behavior of their members. These subgroups are located in their households and living quarters, but also in educational institutions. Individuals should be reached by exploiting multiple social networks for rapid knowledge diffusion. The coordinating information agent should be in German research recommendations, a representative of a communal civil protection agency (Goersch and Werner 2011).

Both narratives assume a wide difference in expertise between the authorities and citizens, which ought to be reduced by the hierarchic one-way information "to" the individual residents of a quarter or in institutions. This approach could be characterized as an authority-centered top-down approach. Community resilience is considered as an "add-on" to institutional resilience. How groups are functioning naturally, negotiating, and prioritizing their risks and protection goals, as well as improving and sharing their wisdom and capacities, remain unclear.

Almost unnoticed by the German civil protection discourse, there are parallel initiatives in the field of health promotion to stimulate community resilience. On the European level for instance, WHO released "Health 2020: A European policy framework and strategy for the 21st century," which includes as one of four priority areas "Creating resilient communities and supportive environments," as well as specific approaches to educate the public in disaster literacy (WHO 2013a).

It is based on more than 50 years of experience in supporting social cohesiveness in natural social networks, in participatory policy, empowerment, and strengthening collective and individual (health) protection behavior. An inherent characteristic is the equitable communication with civil societal stakeholder. The main policy structures are implemented in the international and national "Health Targets" process (since 1970) and the worldwide "Healthy Cities Network" (since 1986) (WHO 2015). Both France and Germany have agreed to national health targets, and at present, 157 cities in Germany and 27 cities in France are active members in the Healthy Cities Network. One of the actual Healthy Cities targets comprises the development of adaptable strategies to climate change. Thus, in both countries, a broad expertise for creating resilient communities and cities exists, but it is regrettably not included in action groups and strategies in the field of civil protection. Critical is also the question of which strategic impulses in the domain of health promotion are valuable to transfer to the context of crisis management to build resilient cities. There are several aspects to consider, among others:

(1) The first strategy is the bottom-up "setting approach" (WHO 1986), i.e., institutions encourage their members with empowerment strategies to enhance the possibilities for people to control their own lives: "Empowerment implies that many competencies are already present or at least possible, gives niches and opportunities […] It implies that in those cases, where new competencies need to be learned, they are best learned in an context of living life rather than in artificial programs where everyone, including the person learning, knows that it is really the expert who is in charge" (Rappaport 1981: 16). Social communities should be strengthened where people interact with each other in everyday activities featuring binding relationships: in educational settings (day nurseries, schools, and universities) and in living environments, the workplace, in sports clubs, choirs, and other locations where shared activities take place and where community actions promote a sense of community.
(2) The second impulse is the "disaster literacy approach" (Brown et al. 2014), following the concept of health literacy (WHO 2013b), which builds literacy, not by expert-dominated hierarchical instructions, but in a process of self-guided and expert-supported social learning.
(3) As a third element, the widespread networks of settings (e.g., in preschool and school settings, hospitals, workplace, quarters), which are relevant stakeholders in the health target process, might be relevant for implementing civil protection objectives into the currently existing setting-related protective actions.
(4) Ultimately, there are sociological and community-psychological founded resilience models (see Norris et al. 2008; Bajayo 2010; Chandra et al. 2011), formulated in the context of health disasters. The social-ecological and social capacity models, respectively, broaden the understanding of dynamic and competent social systems, their knowledge, and capacities. Focusing on social interaction and integration as resources for preparedness, they emphasize the importance of (in)equality in power and skills, as well as the value of social boundaries for the coherence and local disaster coping capacities. They also assume a broad spectrum of strategies to expand autonomy, social empowerment, social capacities, and cohesiveness as predictors for community resilience (Beerlage 2017a).

Furthermore, participatory governance and the setting approach are implemented at the interface between health and urban development in the UN Principles for Healthy and Sustainable Places (UNU 2015). Two out of the ten targets focus on "engaging citizens dynamically" and "embrace diversity and complexity." Moreover, acknowledging and supporting participatory governance and local wisdom and capacities are not only issues in the domain of health, but also in disaster risk reduction (Weichselgartner and Pigeon 2015; Aldunce et al. 2016). However, concrete applications in the field of civil protection in Germany are still rare.

An interesting approach to foster local risk governance and awareness that is worth being explored is the link between environmental assets and the inhabitants of the territory in which they are placed, thus integrating DRR strategies at community level in wider policy fields. Coupling the resilient management of natural resources with sustainable urban development strategies requires approaches in DRR that empower the people and local communities. The geographical settings of rivers provide good opportunity to look at those links in concrete ongoing projects, for instance, by raising flood risk awareness, strengthening innovations in flood protection, and reassessing current practices in floodplain management. Individual examples are existing in both France and Germany, but joint discussions on these interlinked issues between decision-makers in civil protection and spatial planning would certainly be beneficial.

27.3.3 Psychosocial Crisis Management

Psychosocial crisis management is the understanding, handling, and/or controlled management of psychological and/or social influences on preparedness, prevention, response, and recovery. Main impulses derived from complex exercises—such as LÜKEX (see Sect. 27.3.1)—in the German crisis management system and the growing insight on the necessity to consider and apply psychological, sociological, pedagogical, cultural, and ethical knowledge. At the same time, it became evident that there are a lot of blind spots concerning the behavior of both "the general public" and diverse groups.

Psychosocial crisis management comprises the information retrieval and the systematic and strategic implementation of psychological and social predictors (knowledge, attitudes, and competencies). It deals with cognitive, emotional, and behavioral aspects of anticipation or coping with disaster of both crisis management and civil services personnel, as well as the civilian population. Subjects are for instance:

- Risk perception and adequate risk communication in diverse populations
- Preparatory behavior of public authorities, infrastructural services, and the civil society
- Information and support-seeking behavior
- Self-help activities, social support and cooperation in case of emergency or disaster

- Prevention of accidents and panic during evacuation
- Target group-oriented warning and crisis communication
- Interaction, collaboration, leadership, and faults in crisis management groups
- Coping with (traumatic) disaster experiences, fear, loss, and grief
- Health promotion and prevention for all emergency personnel
- Community action and capacity building for disaster prevention, preparedness, response, and recovery.

As a social science contribution to the cross-sectoral task to strengthen all involved persons before, during, and after emergencies, psychosocial crisis management is an important element of societal, community, and individual resilience. The scientific or practical knowledge about the interplay of all these elements is, to some extent, missing: While social science findings based on evaluations of (psychosocial and technical) assignments and coordinated response after a local mass emergency or after exercises exist, little is known about the interplay of these elements in the preparatory phases of crisis management. There is a lack of continuous documentation and evaluation of (coordinated) preparing procedures on the local level. Ultimately, the proportionate effects of different strategies to enhance response and recovery capacities cannot be elucidated.

The core component of psychosocial crisis management is the system of structures, strategies, methods, and protagonists to provide psychosocial prevention and post-disaster psychosocial care to be permanently implemented and managed within in the system of emergency management. German guidelines, based on scientific research, international guidelines, and intersectoral consensus conferences (Beerlage and Helmerichs 2010; BBK 2011), outline a system of multidisciplinary, stepped and well-coordinated interventions, which follow the diverse and dynamic needs and priorities—not only of survivors, relatives, bereaved, those who are missing their relatives, and witnesses, but also the emergency service personnel. The main goal for all people involved is to support their coping efforts and recovery—always considering and respecting personal, social, and cultural resources. Thus, psychosocial emergency support is complementary to a lack of resilience and—at the same time—contributes to individual and societal resilience, especially in the community of survivors, relatives, and bereaved or emergency service providers. However, there are no scientific studies about long-term effects of extensive post-disaster psychosocial care on the local social capital and cohesion in European urban areas. The 2010 Love Parade festival in Duisburg and the 2015 terrorist attacks in Paris, for example, provide fertile ground for studying long-term psychosocial effects.

Psychosocial crisis management includes general strategies of health promotion, psycho-education, and specific primary preventive health methods for members of civil protection services prior to critical incidents (Beerlage 2017b). The efficacy is scientifically well proven (Butollo et al. 2012). Learning from disaster response and recovery for the next disaster on the local community level is recently analyzed, especially in case studies (e.g., Zaumseil et al. 2014; Reifels et al. 2013). Nonetheless, research is missing concerning the primary preventive effects of psycho-education and public reporting of coping with disaster on experiencing trauma and recovery on persons or communities.

27.3.4 Knowledge and Information

Successful crisis management depends on a thorough concept of risk management put into practice. There are several models displaying the connection between risk and crisis management (see Krings and Glade 2017 for an overview), but they all share one critical feature: Crisis and emergency managers rely on data, information, and knowledge. What can happen; which version of the scenario is most likely to unfold; what are the consequences; and, hence, which priority decisions and actions must be taken? Considering the breadth of information and knowledge needed in order to manage urban risk and crisis, finding, understanding, evaluating, and applying information and knowledge is not an easy task, in particular when confronted with an overwhelming offer of non-validated data and information. It is not without reason that scholars increasingly request a more differentiated use of the term "knowledge" (Spiekermann et al. 2015; Weichselgartner and Pigeon 2015; Weichselgartner et al. 2016).

A topic that was recurrently discussed during the workshop, and therefore outlined in this section, was that the advancement of information technology is producing and delivering ever more facts and data, but much of that information remains unorganized, untapped, or unused. A practical example introduced at the workshop was the "Atlas of Vulnerability and Resilience (Atlas VR)," which was developed in the context of the research project "Feasibility study Atlas of Vulnerability and Resilience—Knowledge Management in Civil Protection" (Fekete and Hufschmidt 2016). Sponsored by the German Ministry of the Interior's Federal Office of Civil Protection and Disaster Assistance, the recently completed project provided the opportunity to discuss findings and experience gained.

Inspired by the idea of an atlas offering orientation in terra incognita, the Atlas VR aims to identify, share, understand, and preserve information and knowledge across the borders of expert fields and organizations. The philosophy behind the Atlas VR is not only to provide access to information and knowledge, but to look at a topic from different angles. This, in fact, is the key idea: offering perspectives from different disciplines and professions in a way that they can be understood by various users. In addition, accessing these perspectives quickly and providing links for ongoing search is a corner stone. Potential users of the Atlas VR are practitioners in the area of civil protection looking for content-specific knowledge and, thus, need a quality-tested and compact summary of different reports and studies. Moreover, scientists and students, perhaps also teachers and pupils, can make use of this format.

In order to fulfill the requirements, a special format was designed that is comprised of two parts: The first part gathers a set of expert articles written by scholars in the field of vulnerability and resilience—condensed on one double page and translating vulnerability and resilience from the viewpoint of psychology and public health, among others, into a language accessible to non-experts; the second part contains a quality assured collection of case studies dealing with issues of vulnerability and resilience in the context of civil protection, applying different methodologies and covering different spaces. Special icons allow for easy and quick identification of studies undertaken in a specific country (in the pilot version, Germany, Austria, Liechten-stein, and Switzerland are included) that cover a specific topic (vulnerability and/or resilience) or a specific spatial scale (nation, city, district, or household). Additionally, an index provides keywords for the categories "format" (e.g., expert report), "object" (e.g., community, building, business company), "triggers" (e.g., blackout), "discipline, profession" (e.g., seismology, spatial planning), and "data and methods used" (e.g., remote sensing, indicators, interview). Since the Atlas VR is available as an e-book, it contains interactive links and options to search for specific terms that are not indexed.

The majority of case studies can be thematically grouped into the following categories: vulnerability and/or resilience (1) of the population/specific social groups (with regard to infectious diseases, flooding, power blackout, and various natural hazards, partly in the context of climate change); (2) in rural areas; (3) in urban areas; and (4) of critical infrastructures (e.g., food logistics, drinking water, energy). With reference to the methodology, quantitative, semi-quantitative, and qualitative approaches are covered, and either existing data or data from one's own collection is used, e.g., measurements, observations, or (expert) interviews.

Atlas VR is a tool assisting to identify, evaluate, and understand quality-checked multi- and interdisciplinary information and knowledge on a range of topics within the field of vulnerability and resilience. Today, there is often a non-validated "flood" of information and knowledge—or, on the contrary, both are rare, particularly in case of emergency. Tools like the Atlas VR can help to access information and knowledge needed in risk and crisis management. Beyond that, it is important that the processes and outcomes of resilience reduction initiatives are thoroughly documented and reported, so that the approach is seen to be tested, assessed and, where necessary, modified and improved. Therefore, as a next step, it is planned to expand the Atlas VR in terms of case studies and areas covered.

27.4 Concluding Remarks

In a collaborative effort, distinct experts from France and Germany were brought together to analyze structural and functional similarities and differences in crisis management in urban systems, identify potential pathways of applying the resilience concept, and to strengthen cross-national collaborative efforts. Past and ongoing activities demonstrate the potential of connecting scientists and decision-makers in policy and practice to integrate multiple perspectives, bridging existing barriers between research, policy, and operational practice, and stimulating new technologies and innovative solutions. Furthermore, it became clear that enhancing urban resilience requires governance structures that promote cooperation among and between science, policy, and practice. Likewise, crisis management practices can be enriched through bi-national partnerships, collective activities, and shared co-management efforts.

The workshop resulted in a vision statement, i.e., the "Lyon Action Plan for improved cross-country Collaboration" (LAPCO), for the French-German partnership on urban resilience and crisis management, which summarizes findings and identified potential fields of bilateral activities. Moreover, there was broad consensus to further develop the idea of a bi-national committee and platform for dialogue and interaction. While joint activities such as the workshop are important, a suitably funded platform would be in the better position to build trust and credibility across national and sectoral borders, thus facilitating a more reciprocal relationship among the different societal actors and arenas. A road map was prepared to augment joint fields of consideration and activities. For example, how jurisdiction can effectively contribute to resilience-oriented crisis management policies and what legal instruments can support effective resilience building in urban environments are relevant aspects that need to be analyzed in the future.

The transition of resilience from a scientific concept to a policy agenda and an operational scheme in urban and crisis planning provides both opportunities and challenges for science, policy, and practice. One of the biggest challenges for managing urban risks lies in the probabilistic component of risk management, i.e., the basic assumption that once risks have been identified and quantified, they can be managed. Davies (2015) recently demonstrated that this assumption, and the processes that depend on it, is valid for frequently occurring risks, and therefore relatively minor events in a given locality, but intrinsically unreliable when applied to the risks associated with the larger, less frequent, and more damaging events that trigger disasters. The fact that probabilistically based risk management is only applicable reliably to DRR that considers large numbers of events leaves a methodology gap for mitigation and response at the local scale, which puts in question the validity of larger-scale strategies to reduce the impacts of crisis and disaster. In future meetings, attention will be paid to activities to tackle this gap in the French-German context.

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Chapter 28
Considerations About Urban Disaster Resilience and Security—Two Concepts in Tandem?

Alexander Fekete and Janos J. Bogardi

Abstract Urban areas and resilient cities are flagships of recent research to investigate not only worst-case impacts of hazards but also maximum effectivity of measures. Disaster-related security is a special form of security, when in special conditions under external and internal stressors foci shift towards demands on survival and stability but also reliance on resources rarely used in normal conditions for most of the people, both residents and visitors of a city or settlement. This chapter summarises the key aspects of the previous chapters. Different types of framing resilience are detected in the different case studies. Main components of resilience used in both quantitative as well as in qualitative assessments are analysed. Potential pitfalls in transferring concepts between countries are detected. Critique on 'measurability' attempts is made, while at the same time pragmatic and innovative ways of conceptualising and assessing resilience in urban contexts are on display. Types and subtypes of resilience used in this book are listed, ranging from 'climate resilience' to 'urban neighbourhood resilience'. Insights into how a resilient city can be constructed and planned are synthesised, as are aspects of smart cities and critical infrastructure that not only complement already existing measures and interests in sustainability but also set incentives for innovation.

Keywords Resilience concept · Security concept · Resilience components
Transfer limitations · Resilience framing

The book showcases different viewpoints on what resilience is in context to urbanity and ways how to conceptualise, analyse or put it into practice. However, no unique definition or comprehensive conceptual framework emerges directly from that. The following sub-chapter aims at summarising several considerations

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and components that might provide inspiration to develop a framework of urban disaster resilience and security. Even when promoting readers to wholeheartedly disagree, it could serve as stimulus.

28.1 Resilience—The Bigger Picture or Part of It?

In this book, two types of resilience can be differentiated, Type A resilience which is the umbrella term for everything to be addressed within a city related to aspects of DRR, CCA, sustainability. This integrative notion stresses the importance of interlocking those concepts and not falling for simplified solutions and perspectives. Resilience is both reactive, spontaneous, but also fostering transformation, flexibility, adaptation and long-term perspectives. Resilience Type A replaces risk management, risk governance, sustainability as overarching paradigms. Urban areas are melting pots of human development, and an integrative Type A resilience matches perfectly with a comprehensive notion of accepting complexity and interconnectedness of factors, actors and processes. As a major limitation, resilience becomes the synonym for everything and can be confusing for those wishing to coin definitions wherein resilience can be clearly differentiated from risk, vulnerability, adaptation, sustainability, etc. (see Bogardi and Fekete, forthcoming).

Resilience Type B can take different forms, but it mainly is a much more focused construct than Type A. Resilience can be the flip side of vulnerability, a sub-component or vice versa (Cutter et al. 2008). In the following, resilience Type B is conceptualised as a sub-component of risk and sub-component of a wide range of abilities, resting in a specific time phase of recovery. The advantage of such a reduced resilience Type B understanding is the possibility for differentiating it from vulnerability and other terms. This differentiation enables integration, interestingly. Since resilience can then be integrated with vulnerability and other components of abilities into a risk framework much easier than resilience Type A.

Table 28.1 shows that resilience is one ability amongst others within a risk assessment process. Resilience is nested in the recovery phase after a hazard impact. Resilience Type B is the process phase of 'bouncing back' or 'jumping back' which is the literal translation of the word resilience. Of course, resilience cannot only be realised when acting only during this phase; resilience, or rather, the ability for resilience must be prepared before, during and after the recovery phase in order to be ready, capable, resourceful and adaptive enough as an ability to enable recovery. This might help to solve the lingering confusion about resilience when many authors argue correctly that resilience cannot be reduced to bouncing back. However, it must be differentiated between the actual phase when resilience happens and the efforts taken to enable this. At the same time, overlaps with pre-existing terms such as adaptation or vulnerability should be avoided. Figure 28.1 provides another suggestion how to differentiate resilience more strictly from similar terms by placing resilience into a specific time phase (cf. Bogardi and Fekete forthcoming).

Table 28.1 Resilience as sub-component of abilities within a risk assessment

Risk assessment parts	Components/examples
Values at stake, objectives	Human life, health, environment, compliance, well-being, infrastructure, etc
Chances/opportunities	Benefits aspired by taking risk Unexpected positive side effects of risks
Hazards and threats	First- and second-order impact drivers upon a subject/object at risk Characteristics (frequency, magnitude, type, dosage, intentionality, etc.)
Exposure	Interrelation between chances, hazards and threats with vulnerabilities and abilities Spatial, temporal and quality characteristics
Criticality	Prioritised components of subject/object at risk
Vulnerability/susceptibility	Characteristics of subjects/objects that aggravate the impact effects
Abilities	Characteristics of subjects/objects that ameliorate the impact and improve the outcome of risk Examples according to time phases: Prevention Preparedness Coping Recovery/**resilience** Adaptation
Changes	Transformations triggered by the risk

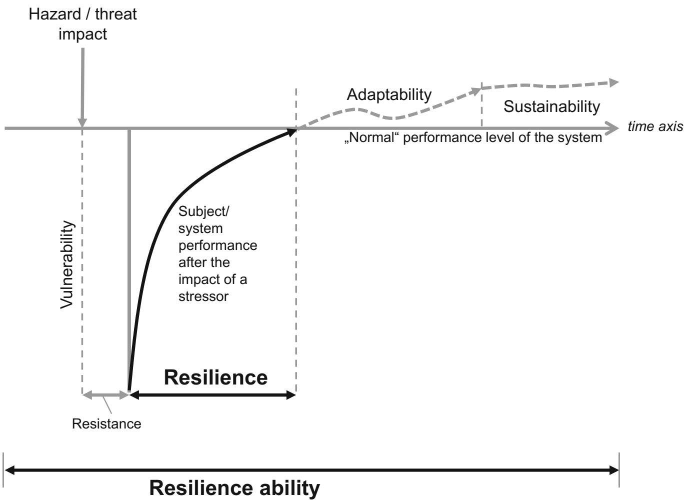

Fig. 28.1 Resilience as one-time phase within the process path of a subject/system at risk (modified after Bogardi and Fekete forthcoming)

While resilience Type A is encompassing, prompts thinking and acting in an integrative way at all time phases, resilience Type B is less global. Type B is more limited or specific by placing it as a sub-component with a risk assessment. This risk assessment is observing a process path of a subject (human being) or system (society, human–environment, technical system, etc.) where resilience can be differentiated into the state of resilience, which happens only after having experienced a reason to resile, and into the general resilience ability (Fig. 28.1) which should be cultivated before during and after hazard or threat impacts.

Figure 28.1 suggests also to differentiating resilience from the adaptation phase and the sustainability phase. In reality, there will be overlaps, but for a conceptualisation we argue that it is useful to separate it in order to be able to focus on its specific characteristics. Resilience covers the phase when the stress imposed by a hazard or threat decreases to such extent that the subject or system is not locked anymore in its development, but recovers. Adaptation can follow immediately or soon after and points at the option not just to return to the previous state but to adjust to novel conditions, learn and improve. Sustainability then indicates the phase when a system can evolve while considering resource consumption and continuity.

28.2 Urbanity, Resilience and Critical Infrastructure—A Special Affair?

Urbanity is more than thinking about risks and therefore more than being concerned about recovery after impacts only. However, urban areas are laboratories for observing and conceptualising resilience. Specific about resilience in an urban context is the concentration and overlay of human beings, values, ideas with structural and non-structural objects, nested in an environment. Hence, urban areas are an ideal example of socio-environmental or—ecological systems (SES). While SES is an established term already (Young et al. 2006), the specific interconnection between humans with environmental but also with man-made services (such as critical infrastructure) is not fully addressed at a conceptual level yet. Critical infrastructure not only offers methodological components such as protection levels and goals (Fekete et al. 2012; Fekete 2012) for prioritising risk management decisions that can help guide resilience operationalisation in a more explicit and focused way. Critical infrastructure can aggravate a disaster situation when failing, due to their importance for vital lifeline supply (termed criticality), but at the same time they are a key component for recovering from a disaster impact, hence they are a core part of resilience of an urban habitat. Table 28.2 shows an example of vulnerability and resilience aspects in an urban environment.

28.3 Security, Risk and Resilience—Common Denominators of Stability?

In this book and especially in the title, we have raised expectations about inter-linkages of disaster resilience and security. The book chapters have captured mainly resilience aspects and few security aspects such as video surveillance as a technical security measure. However, security is a much broader term, and in the understanding of human security (Ogata and Sen 2003), there exist multiple forms of security, covering food security, economic security, security from natural hazards and man-made risk impacts and so forth. Is security a part of resilience or, is security another umbrella term? In Fig. 28.2, we have advanced the political security understanding of the original source (Frei and Gaupp 1978) and illustrate how risk and resilience interact with such security conceptualisation. Frei and Gaupp (1978)

Table 28.2 Urban disaster resilience components and critical infrastructure

Urban components	Vulnerability aspects	Resilience aspects
Infrastructure: • Daily life services • Critical lifelines	• Cascading effects due to interdependencies • Exploitation • Service interruptions • Failure	• Lifelines • Backbones for recovery of human beings and technical support systems • Enabling accessibility, availability (Roads, Information) of/for other services (e.g. emergency aid, repair, etc.)

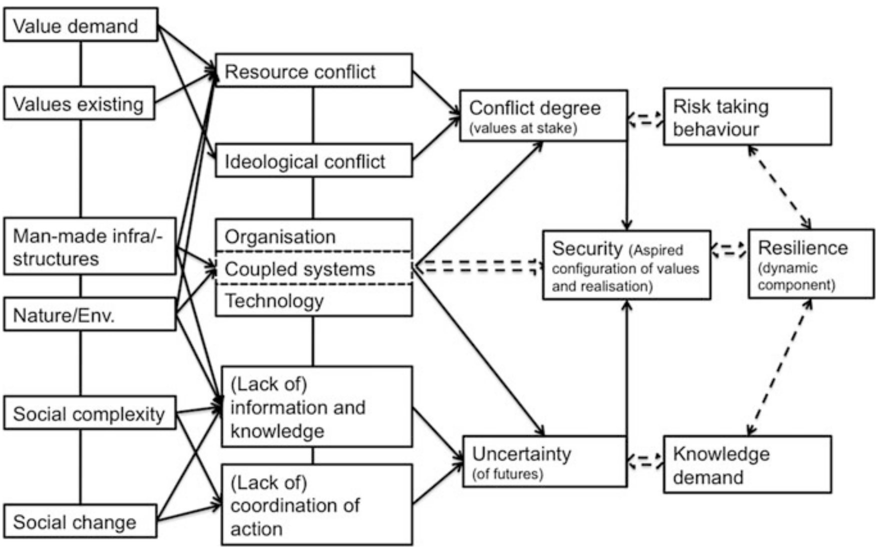

Fig. 28.2 Security, risk and resilience framework (modified after Frei and Gaupp 1978)

rightly split security not into safety and security, which are often rather interchangeably used terms (Jore 2016). Security is an aspired state that is liable to change, but resembles a stability situation. This is similar to equilibrium models and certain types of resilience used in complex systems research (Gunderson and Holling 2002). This aspired configuration is composed of two major process streams; one the conflict degree resulting from value demands and limitations. The other is uncertainty of knowledge, derived from social processes of coordination and knowledge production. The modification of this concept (Fig. 28.2) includes a third process line; natural and man-made structures and processes that are combined as coupled systems, for example in a city or village, a place bound to a combination of environmental and human factors and assets. Security is linked in this third stream to organisational as well as technical aspects and their combination. This matches many established concepts used in security research such as fire safety or risk management that often differentiate between organisational and technical safety and security.

Risk in this concept is a part that results due to the conflict degree over values at stake that are either real or still hypothetical. There also exists a knowledge demand due to the awareness of such risks that addresses the uncertainty process stream.

Resilience in this concept is the dynamic component that adds to security as an aspired stabilising state or configuration. Resilience can be the dynamic phase of reaction of the human being (subject) or system after a perturbation of security states due to conflicts. Resilience can also be a dynamic part by its ability to amplify (bouncing) reactions that can later on lead to adaptation (Resilience ability in Fig. 28.1).

28.4 Limitations

The presented considerations are liable to myopia in several respects. First of all, it is a (natural) hazard informed theoretical background. Second, stressing urban contexts neglects the importance of interaction between urban and rural and environment in general. The representation of resilience as a reduced and operationalisable form may provoke criticism especially in a field of urban research, which usually prefers the encompassing notion of resilience. Resilience, even in a reduced form, can take many more variants than the one presented in Fig. 28.1, for instance, resilience as a reaction to take place as a 'bouncing forward' motion or, before the impact hits, which could be termed 'presilience' (Bogardi and Fekete forthcoming). Besides ongoing struggles to define resilience in the scientific community, there also exist major overlaps between definitions of risk and security, for example. Risk is the 'effect of uncertainty on an expected result' (ISO—International Organization for Standardization 2015) or '…on objectives' (ISO—International Organization for Standardization 2009). This is the security process stream in reference to knowledge and coordination of action in Frei and Gaupp (1978) (see also Fig. 28.2).

28.5 Conclusion

Risk, security and resilience are often analysed separately or interchangeably. In this chapter, considerations for linkages between resilience, risk and security have been suggested, and components outlined in tables and framework figures. While many of the assumptions may be incomplete or even wrong, it may offer starting points for establishing a common understanding of how resilience, risk and security are connected.

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Chapter 29
Synthesis

Alexander Fekete and Frank Fiedrich

A ship in harbour is safe, but this is not what ships are made for.
William G.T. Shedd

Abstract Urban areas and resilient cities are flagships of recent research to investigate not only worst-case impacts of hazards but also maximum effectivity of measures. Disaster-related security is a special form of security; when in special conditions under external and internal stressors, foci shift not only towards demands on survival and stability but also towards reliance on resources rarely used in normal conditions for most of the people, both residents and visitors of a city or settlement. This chapter summarises the key aspects of the previous chapters. Different types of framing resilience are detected in the different case studies. Main components of resilience used in both quantitative as well as in qualitative assessments are analysed. Potential pitfalls in transferring concepts between countries are detected. Critique on 'measurability' attempts is made; while at the same time, pragmatic and innovative ways of conceptualising and assessing resilience in urban contexts are on display. Types and subtypes of resilience used in this book are listed, ranging from 'climate resilience' to 'urban neighbourhood resilience'. Insights into how a resilient city can be constructed and planned are synthesised, as are aspects of smart cities and critical infrastructure that not only complement already existing measures and interests in sustainability but also set incentives for innovation.

Keyword Resilience concept · Security concept · Resilience components
Transfer limitations · Resilience framing

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Urban areas and resilient cities are flagships of recent research to investigate not only worst-case impacts of hazards but also maximum effectivity of measures. But cities were not only built to offer “safe harbours”, alluding to the picture of the quote. Urban areas are not all about security, at least not in modern time. Mainly, urban areas are hubs for living and development. However, urban areas are selected for research and funding, since density of people and human values are concentrated here. This concentration is both an asset and risk factor.

Certainly, there are additional reasons why cities and urban areas are selected for funding research and development projects. It is often easier to start hallmark projects with major cities not only for reasons of visibility of such demonstration and pilot programs, but also for (institutional) resources existing already in cities in contrast to smaller villages. While the discussion has already started to also focus more on smaller and medium-sized cities, urban margins, urban-rural interlinkages and also the role of the environment within city areas (Birkmann et al. 2016), it seems appropriate to reflect on the current status of urban disaster-related resilience and security research with this book.

What can be observed as current trends in this line of research and what can possibly be transferred? This is a guiding thought to this book and to the following synthesis chapter, based on the chapters in this book. The following sections are arranged according to guiding questions inspired by the chapters, inserted as subheadings.

29.1 What Types of Security Is Dealt with in Context to Urban Disaster Resilience?

While ‘urban resilience’ is often framed as a holistic, overarching umbrella concept for the overall development of a city, this book critically reviews this ambition. Living in a city and planning cities is not only about security aspects and also is not only about urban resilience. It is about all the multiple pull-factors that cities offer but also about push factors that suggest or urge people to flock to a specific city as a destination.

So may we tweak the proverb to: “*A city holistically protected is safe, but this is not what cities are made for*”?

There are many security-related aspects, and of course, there have been many cities in former times especially being built as fortifications. But disasters such as river floods, earthquakes or even war are not the main drivers to start building the majority of cities, world-wide. However, dealing with such disaster exposures has become an almost natural theme for a wide range of cities and time periods.

The chapter by *Doyle and colleagues* illustrates how more and more security themes are added to resilience in an urban context. Starting from environmental aspects, impact of crime is added to urban insecurity and urban planning. This leads to agendas shaping a city, such as “cities of control” as in New York after 9-11.

Doyle *and colleagues* also describe recent transformations of European cities from 2015 under the impression of terror attacks, when the topics of urban "targets" emerge: both hard and soft targets. It remains to be seen how much soft and hard structures in cities in Europe transform mindsets and behaviour of people and structures such as concrete road barriers and if, for how long. But any security measure introduced carries advantages and disadvantages, and risks are often just shifted.

Neisser and Müller-Mahn underline this in their chapter, as risks "do not exist in isolation from one another". Concrete barriers might protect against terror attacks by trucks at one street corner, but what about the many other street corners and what about modified means of attack or targets? It seems important to consider the bigger picture of multiple security aspects, their unintended side effects (on freedom most prominently), persistence (in this sense, their sustainability) and their effectivity. Effectivity is often mainly understood in economic terms, but what is effectivity of security in relation to resilience? Maybe resilience offers insights into how to improve security in a way that it is considering the bigger picture, integrating social, environmental and economic aspects, integrating the return to normal demands with the longer-term perspectives of transformation and in such sense, offers a more integrative "effectivity". Doyle *and colleagues* say "The expansion of the concept has also inevitably led to problems of certainty and clarity". And later on they add "Crucially there still remains a lack of more holistic, integrated approaches to urban security—a gap which 'resilience' thinking is seen to address". Such holistic thinking could also be seen in flood risk management master plans. Doyle *and colleagues* emphasise the role of planners as integrators. "Thus, the planner plays a natural role in ensuring that urban growth, development and renewal does not jeopardise the safety and security of present or future citizens". However, we might add other stakeholders, including the residents and even visitors of a city to those needing to have a bigger picture of security and resilience—capabilities, side effects, immediate and long-term solutions and repercussions.

29.2 Is Security just Another Term for Resilience?

Security is a wider topic than disaster resilience, we hypothesise. While many notions of security and safety exist in context to hazard-, threat- or emergency fields, and while they are suggesting specific connotations and differentiations between safety and security, security in fact is a much wider term. For example, some fields regard security is related to national borders or for protection against terrorists and attacks, while safety is connected to individuals and their well-beings. However, there are also security needs of residents and visitors to a city that are much broader. People are also, and maybe mainly, interested in economic and social security. Daily income, interaction and feedback with other people and personal well-being are main concerns of people in many cities in most modern time periods. Certainly, in dire situations such as under political or ethnical conflicts and prosecution, security demands and types change.

Disaster-related security deals with special conditions when demands on survival and stability increase, as well as reliance on resources rarely used in normal conditions.

Wurster and colleagues extend the notion of resilience even beyond security: "The needs of individuals and society as a whole are not limited to the need for a resilient society safe from terrorism, criminality and other threats. Societal needs in a security context relate also to the respect of dignity, privacy, freedom of association and other fundamental rights".

29.3 Applying Resilience and Losing the Big Picture?

A critique on the scope of our book heard in several chapters is the danger of applications or operationalisations of resilience, especially when narrowing it down. *Anhorn* warns that such a scope "impairs the credibility of the multifaceted resilience concept". He especially emphasises not only the risk of oversimplification, but also the risk of missing the opportunity to let people participate by imposing a concept. In this sense, he argues that resilience is a kind of utopia, imposed by a Western view and transferred on cities in other areas and contexts such as Nepal. This is a strong argument and maybe apt to introduce into this book since it opens the agenda of a critical reflection on the stance and characteristics of resilience that we wish to consider in this book.

Is application and exemplification not always necessarily a simplification? Each case is specific and each methodology of applying resilience will be specific. But learning from the differences and from differences in case studies is important, too. Why is a credibility of a multifaceted concept 'at risk' when narrowed down to applications? This draws upon long-known debates between social and natural sciences, quantitative versus qualitative methods, theoretical versus empirical research and so on. The chapter by *Anhorn* rightly prompts to critically reflect on transferability.

Many of the book chapters seem to be in a status of consideration and conceptualising how to apply resilience, few have already done it. So it is a timely warning to consider the impacts of applying resilience in a narrow sense. It is also important to academically observe in which directions resilience is mainly applied; a predominance of certain quantitative indicators or certain participatory qualitative methods might tempt to let others think that operationalisations of resilience mainly have to follow these examples. Yet it is to be questioned whether resilience really is a decisive factor here or whether this scholarly debate would not continue with similar contexts such as sustainability, poverty or hazard research just as well. Impositions of Western views itself is also not a novel theme. But in the era of massive promotion by UN, INGOs, GOs and companies, it must be carefully reflected which aspects of a strong focus on urban resilience might sideline other important demands and needs of residents, visitors and all other stakeholder in an urban area.

29.4 Is Measurability the Only Bone of Contention?

The critique on quantitative approaches in applying resilience is articulated in more detail by the chapter of *Abeling and colleagues*. They argue that resilience measurability is too short sighted and that resilience is more than the conservative notion of “bouncing back”. Rather, they suggest, it should be more about an overall leitmotif, more emotional. The leitmotif argument falls in line with the chapter by Anhorn. The conceptual application of resilience of containing more that the word literally translates to is also applied by many other chapters in this book. While it could be debated as whether a broadening of resilience to an “all-encompassing” concept is useful or not (Fekete and Hufschmidt 2014), we focus here more on the argument by Abeling and colleagues against quantitative measurements and pro-social science approaches in that resilience measuring “would fail to capture the role of informal networks”. But, we may ask, what if metrics would simply be developed to track this? While social science approaches often criticise (rightly) the limitations of any metrical quantification and narrowed down exemplification of resilience (or vulnerability), it remains to be demonstrated that the same reflection is used upon the social science method. Abeling and Anhorn and their and other colleagues in this book certainly have an important warning to make for quantitative academics who too often neglect the complexity and contexts of phenomena. However, in the current time period, it must also be demonstrated what exactly is the complexity that cannot be covered by simply better quantitative data availability. At the same time, shortcomings of exemplary social science assessments must be addressed, too. Just as an example, we realised in our own work using participative social science methods such as workshops, focus group discussions and expert interviews that the same experts offer contradicting arguments in a repeated assessment only weeks after the first one. Reliability on individual quantitative results must be treated as cautiously as well as reliability upon individual qualitative results.

This call for reflection leads to the demands for scientific evaluation, which the chapter by *Brauner and colleagues* articulates. They suggest an approach to address how users evaluate and utilise resilience indicators, using also quantitative criteria next to qualitative. Such approaches are important to show up how to build bridges between the users, social and natural scientists, in a practicality oriented way. Such mixed methods and approaches are often balancing demands from different disciplines and end-user perspectives and almost necessarily must disappoint some in order to achieve a “bigger picture”.

29.5 How Can Resilience Be Characterised?

The chapter by *Vollmer and Walther* provides a good overview on different aspects and factors used to describe and assess resilience. They also show that in fact it is difficult to "demarcate" resilience from traditional risk or vulnerability approaches.

While some researchers might reject the very idea of simplifying resilience to a linear curve model, this is an important point for theoretical understanding and a basis for developing algorithms for other researchers. The chapter by *Jovanović and colleagues* provides an interesting observation about the characteristics of resilience as debated upon the widely used resilience curve or "bathtub model'. They observe that their flat "U-curve" model is more suitable, because "tipping points" are not of main interest, whereas the response phase is highly relevant. Since the response necessarily takes some time, a flat bottom curve is more representative, than a sharp "V-curve". As a caveat, they warn that, however, such a flat U-curve is more difficult to model. It is interesting to question whether the tipping point identification in a resilience quantification model is less important than in vulnerability and hazard assessments, for example. It is also interesting to consider the behaviours of an observed system more closely, and a U-curve in fact shows that linear recoveries are less realistic than undulating ups and downs and that this might also bear resemblance to gradual or creeping hazards such as droughts that are difficult to predict or model for their similar behaviour. In reference to the chapter by Abeling and colleagues and Anhorn, this is of course a very simplified vision of resilience by focusing on the recovery or bouncing back characteristics only. However, such simplification is a typical and necessary trait of any deductive and reductionist model. Rather than putting this aside as wrong, it must be known that also inductive and abductive approaches face limitations when simplifying to an example or individual case study. The U-curve here does not rule out modelling based on a transformative or complex understanding of resilience per se.

The chapter by *Mitchell* emphasises the amendment of resilience as a concept by going beyond the typically cited phases of the disaster cycle in UN definitions of resilience and adding the sustainability perspective: "Resilience is generally interpreted as the ability to absorb, recover from and adapt to external shocks without impairing long-term sustainability".Mitchell later on stresses the adoption of different perspectives and phases than usually covered in many critical infrastructure assessments that might be related to end-of-pipe conceptualisations: "problems at the consumption ends of infrastructure systems should not be judged less deserving of public attention".

Mitchell also differentiates two main theoretical approaches: "one emphasises the importance of physical infrastructure and privileges the role of experts in the decision-making process; the other focuses on creating social capital and elevates the role of laypersons".

Resilience, also in urban context it seems, is an inclusive concept that not only just tries to cover many time phases but also stakeholder perspectives. This integrative character however often puts certain disciplines and also end-users at unease; however, the downside of resilience as being so broad can also be regarded its strength and offering many incentives for learning and advancement of disciplinary and as well as practitioner horizons (Fekete and Hufschmidt 2016).

Another characteristic of resilience observed by urban and spatial planners is suggested in the chapter by *Schmitt and Greiving*. They find that "extreme weather events like summer storm Ela are of ubiquitous character, meaning they can occur anywhere with unknown probability and time of occurrence". Using such a hazard as context, they argue that while such a hazard behaviour involves great uncertainties, it is typical and in this respect useful characteristic of resilience that it assumes such uncertainties as treatable when adopting the UNISDR understanding of resilience. One strategy of coping with this uncertainty is the shift of focus from the hazard prediction to susceptibility assessments. "From a spatial planning perspective an adequate starting point for enhancing resilience are susceptibility analyses".

Regarding time phases, *Neisser and Müller-Mahn* indicate the importance of observing both static and dynamic hazards in the assessments of resilience. They provide an example that even combines both static and mobile aspects: the risks related to hazardous material transportation.

29.6 Which Are Components or Subtypes of Resilience?

There are many communalities among resilience terms as used in contexts in this book. *Weichselgartner and colleagues* express this in their chapter: "One common thread among many contexts is the ability of materials, individuals, organisations and entire social-ecological systems, from critical infrastructure to urban communities, to withstand severe conditions and to absorb shocks".

However, throughout the book, also differing perspectives and definitions of resilience are used.

Schubert and Lukas deduce from their theoretical background: "Resilience is a function of social actors and event elements (two-mode-logic) that are related to each other in situ. And it is the expression of a culture that emerges during the process of connecting practice". And as a specific resilience type, they describe situational resilience as: "According to this logic, 'situational resilience' means that specific associations of humans, nonhuman beings and artefacts produce resilience in concrete situationally embedded action processes". Using actor network theory, this is an intermediate type of resilience that tries to negotiate or link human and structural elements. This is close to what *Seidelsohn and colleagues* describe in their chapter as "'objectivistic' versus 'subjectivistic' approaches" even when Seidelsohn and colleagues mainly describe social vulnerability in their chapter and not resilience, explicitly. This however is quite interesting, since resilience does bear many traits similar to vulnerability.

Those researchers focusing on certain components of a city such as critical infrastructure regard certain characteristics of system behaviour in their definitions

Table 29.1 Types and subtypes of resilience used in this book

Type of resilience	Chapter
Climate resilience	Gencer and Rhodes
Communal resilience improved by public private partnerships	Wiens et al.
Community resilience	Hälterlein et al.; Weichselgartner et al.
Critical infrastructure resilience	Münzberg et al.
Critical infrastructure network resilience	Serre
Cross-border resilience	Adrot et al.
Flood resilience	Evers et al.
Predicted resilience	Zobel et al.
Resilience planning; spatial planning perspective;	Doyle et al.; Schmitt & Greiving
Situational resilience: associations of humans, nonhuman beings and artefacts	Schubert and Lukas
Smart (critical infrastructure) resilience	Jovanović et al.
Social vulnerability	Seidelsohn et al.
Urban infrastructure resilience	Brauner et al.
Urban neighbourhood resilience	Serre

of resilience. *Serre*, for example, sees that "the resilience definition can be transposed to the urban context as: "the ability of a city to operate in a degraded mode and recover its functions while some urban components remain disrupted".

The following table shows subtypes of resilience as used in this book (Table 29.1). "Urban resilience" is not taken into this table, since we assume that all chapters are written within the scope of this book on urban resilience or urban disaster resilience, respectively. The relatively large amount of variations of critical infrastructure subtypes may be due to the scope of the book, too.

29.7 Involving "The End-User" Better?

The chapter by *Evers and colleagues* takes a similar direction as the pragmatic and integrative approach by Brauner and colleagues as it includes user perspectives into a multicriteria decision approach. Their approach shows that "stakeholder participation is an important but complicated and delicate task". For instance, the chapter highlights challenges during participatory weighting processes such as they are time-consuming. They also find out that certain knowledge and decisions are restricted to researchers, and consensus seeking is resulting in averaging results.

While the chapter of Evers deals with examples of cities in Germany and UK, it is interesting to compare it to other international contexts such as the chapter on Nepal by Anhorn or the chapter on the USA by *Fisher and colleagues*.

The chapter by Fisher and colleagues is quite interesting as it touches upon aspects of pro-activeness that in a sense link to a lingering tension between ex-ante and ex-post phases in a disaster cycle. Fisher and colleagues observe that "an on-going challenge in the U.S. is the adoption of a proactive stance". This in an important observation for an international audience we wish to address in this book since in a number of fields, quite many approaches are adopted and transferred from the USA. And by having quite a number of concepts and methods available that emphasise proactive approaches that much it might give the impression that in countries of origin of such concepts, proactive is already state of the art and embedded everywhere. Fisher and colleagues provide some exemplary reasons that might be unique or transferrable to contexts in certain other countries. For example, "Today in the U.S., most citizens operate on the entitlement principle that since they pay taxes, the government should handle resilience/security". For a number of other countries, this could be similar. This points also to the tension between security, freedom and sovereignty of the citizens or local communities. It reminds also of the sensible construction of responsibilities and obligations in Germany, where authority and sovereignty of local bodies and Federal States versus the State is a hallmark (and bone of contention) not only of civil protection but also of internal security and many other aspects. For their context, Fisher and colleagues suggest "One way to increase resilience is to inspire a culture shift that strikes the proper balance among all stakeholders in working together to make the U.S. a more resilient Nation". Indeed, this approach is similar in Germany again, since in the field of critical infrastructure especially, around 80% of utilities and other infrastructure is privatised and the culture of conduct with the administrative authorities of districts and the state is a multiple stakeholder approach with only cautious regulation. However, such a "culture" as also the "resilience culture" is liable to political "climates" as much as to the tone of societal attention and cohesion and may undergo gradual transformations as well as sudden shifts punctuated for example, by sudden events such as crisis or disasters, but not limited to them.

One example is provided in the chapter by *Gencer and Rhodes*, where State and Mid-Region of Tennessee and the Cities of Nashville, Tennessee and Hoboken, New Jersey in the USA have seen shifts in policies due to environmental effects on cities such as storms and floods. Similarities to other countries exist, which started to adopt policies and actions to adapt to Climate Change effects partly due to obligations to better reduce emissions. But sometimes, such activities are also driven by extreme events such as singular or recurring floods or storms.

Gencer and Rhodes turn up the role of changes in regulation and incentives for a change of culture. "Until 2000, the concept of disaster risk management in the US relied primarily on federal funds being provided for relief after disasters struck". Evidently, behaviour and expectations of citizens on disaster relief has been formed by security and compensation schemes traditionally provided by the state or by authorities. Transformations in behaviour take time and efforts to improve acceptability, even in a country as the USA, where autonomy and freedom are major characteristics and attitudes of citizens. A conclusion of Gencer and Rhodes can be read as both achievement and warning: "The availability of multiple layers of government has been an effective safety guard against any individual layer's potential unwillingness to undertake protective risk management or climate resilience building".

A specific user and stakeholder group are volunteers, and there exist stark differences in the roles and numbers of volunteers between countries. With the advent of the so-called new or social media, major transformations and new emerging groups are organising themselves. This is a topic hotly debated among the traditional professional civil protection institutions as well as by the established organised volunteer organisations. The chapter of *Hälterlein and colleagues* looks into aspects of integrating volunteers into emergency response systems as part of operationalising resilience. They investigate scenarios of major crises where people have to seek emergency refuge and they inquire how to provide those refugees with minimum supply of water, food, information and housing. In order to make such civil defence planning more effective, they conduct and analyse exercises and evaluation of volunteer's actions.

Finally, the "end-user" is almost always also "the people", or more specifically, human individuals being the main actors or victims in scenarios urging to consider urban disaster resilience. While the people dimension is often still a black box in many assessment types, there especially exists a wide gap between knowledge and behaviour of "the people" in a crisis situation. The chapter by *Mundorf and colleagues* addresses this still unsolved problem that has stimulated hazard and risk research from the beginning. Psychology is a key factor but seldom integrated into quantitative assessments. Mundorf and colleagues offer an introduction into a theoretical background for ignorance and apathy, among other psychological factors that are long known and even perpetuated by recent UN frameworks such as the Sendai Framework for Disaster Risk Reduction, but it remains to be seen to which avail. However, it should in principle not be too difficult to include known angst and psychological factors into models using semi-quantitative indicators of many sorts. But also in traditional community resilience studies, the social and sociological aspects often dominate while individual perceptions are described but often lacking psychological explanations.

29.8 Which Urban Spaces Are Covered and Where Does Urbanity End?

In this book, the selected cities represent examples of what may be termed 'urban' (Table 29.2). We may define urban as all aspects that humankind perceive as structural and nonstructural cultural achievements to persist at certain locations. This vague working definition would include, in principle, rural villages as well. Built environment is a distinction and persistence sign of human achievements versus pure nature. Under a disaster and security perspective, these urban areas are parts or (sub-) types of riskscapes as presented in the chapter by *Neisser and*

Table 29.2 Cities and countries covered in this book

Cities	Countries	Cross-border regions
Budapest, Hungary	Finland	France–Germany
Hamburg (2), Germany	France	
Heidelberg, Germany	Germany	
Hoboken, New Jersey, USA	Hungary	
Golestan, Tehran, Iran	Iran	
London, UK (3)	Ireland	
Nashville, Tennessee, USA	Nepal	
New York City, USA	Serbia	
Vantaa, Finland	The Netherlands	
Wuppertal, Germany	UK	
	USA	

Müller-Mahn, based on earlier work by Müller-Mahn. Urban disaster resilience spaces are mainly known not only by exposure of human and assets, but also by the capabilities of cities to organise against detrimental impacts of stressors. But where does "urban" end here? It is often very difficult and rather artificial to delineate cities or urban spaces. In a small tiny village, is it the central business district that make people feel urban? Is it the bus station to the city with posters of cultural events, or the supermarket, or else? In a large city, do administrative boundaries really demarcate the ends of a city? Consequentially, we have included chapters to reconsider such limits and chapters on cross-border topics. *Androt and colleagues* show how urban networks are also reliant and constructed by connections between them such as transport routes.

A city could possibly also be defined by its risk factors. Neisser and Müller-Mahn write that "Urban risks are complex because of two reasons: Firstly, because of the density of urban populations, structures and people´s movements through space which make city life particularly vulnerable to the multitude of overlapping physical threats embedded in the urban fabric. And secondly, because the interaction between these diverse dimensions of physical threats may eventually create surprises". Density and overlap of multiple features in a city that might eventually create surprises are, after all, not just risk, but also factors of choice and chance, and cities and urbanity are basins of attractions (borrowing from the language of complexity research). The existence and abundance of push factors are both risky and attractive which is one reason why so many not only researchers but also policy makers might like a focus on cities.

We hypothesise that not just cities are areas of urbanity. Next to city networks and small and medium cities, also rural villages feature characteristics of cities: concentrations of values and culture, for example. We could also extend the field of urban spaces with similar characteristics as cities to concentrations of people and their values and assets that can be found in crowd events or, to refugee camps. The chapter by *Wiens and colleagues* analyses demands on logistics and differentiates quite pragmatically from an enterprise point of view, "hot spot regions" as

"A-regions" and "indirectly affected neighbour regions to a disaster hot spot" as "B-regions".

29.9 How Can a Resilient City Be Constructed and Planned?

The chapter by *Hosseinioon* illustrates the importance of urban planning. It is taking into account the structural layout of streets and buildings for a number of aspects beneficial in a crises, for example, accessibility by emergency teams.

"Regularisation leads to better structural quality of the buildings and hence less vulnerability in cities, because neighbourhoods have wider streets and more open spaces that allow more efficient behaviour when hazards strike and better access to emergency shelters and vehicles".

However, Hosseinioon warns also not to forget social demands and perceptions of the people even when the city of Golestan near Teheran in Iran has become less vulnerable from a structural point of view with better emergency access.

The chapter by *Schubert and Lukas* illustrates the importance of viewing both structural and behavioural as connected features in a city by analysing opportunities for crime. Utilising rational choice theory, they conclude that "that the behaviour of the individual could be positively influenced by the design of the physical environment". This is a finding that correlates to well-known public works on urban tipping points for crime and security management (Gladwell 2000).

Mitchell makes two interesting observations in his chapter on two factors of resilience that are often found in (spatial) risk assessments; about elevation and zonations. A typical behaviour of residents is the preference of remaining in place. But, on the other hand, higher = safer is a widely accepted rule of thumb. "Experts and locals perceive elevation as an open-ended variable, permitting continuous vertical adjustments by raising structures progressively higher as inundation risks increase. By comparison, risk zones on FIRMs (Flood Insurance Rate Maps) are viewed as imposing fixed (in/out, horizontal) limits on adjustment". This is quite a remarkable observation adding important user-information to analytical concepts and risk classes.

29.10 Smarter Cities Are More Resilient by Nature?

Next to resilient cities, other forms of trends have emerged how to plan or transform modern cities. Smart cities are certainly one proponent of transporting planners and industries' visions of how new technologies could be reshaping our living environment. Smart cities are by themselves focusing more on renewable energies, sustainable use of energy, e-mobility, the Internet of Things, industry 4.0 and all the attractive and positive aspects of transformations. There is less focus on limitations and negative aspects such as disasters or crisis. And yet, exactly for this reason, smart cities offer incentives, motivation, demands and windows of integratability with resilience which itself is often perceived as the big umbrella theme. There are many hazards coming with new technologies as is always the case next to the in most cases overwhelmingly dominating benefits. Cars and fridges linked to smart phones offer limited hazards such as espionage but could also be exploited by terrorists, for example. Smart grids are a concern for critical infrastructure experts when unguarded by smart security solutions. The chapter by *Jovanović and colleagues* observes: "However, it has to be checked if such a smart critical infrastructure (SCI) will behave equally 'smartly' and be 'smartly resilient' also when exposed to extreme threats, such as extreme weather disasters or, e.g. terrorist attacks". It appears that future research must also carefully investigate whether 'smarter' also means more complex and more vulnerable?

In some sense, the topic of smart cities is just like any trend topic related to novel technologies and technological impact assessment. *Molarius and colleagues* advise in their chapter that "all new innovations should be piloted by using 'safe-to-fail' design experiments".

29.11 How Can the Topic of Critical Infrastructures Be Better Integrated with Urban Disaster Resilience?

Serre identifies in his chapter: "the traditional risk analysis methods do not take into account the interdependence between the analytical system and the infrastructures, and in particular the critical infrastructures (CIs)". Furthermore, the chapter by *Mitchell* finds "that the term "infrastructure" is not widely understood by residents and the implicit definition of infrastructure refers to any collectively provided service. This is important to note for experts framing their research around conceptual paradigms such as critical infrastructure and shows they have to be aware about the perceptions of other experts or the people in their case studies on the same topic. This chapter by Mitchell also shows that awareness about CI like electricity is relatively low among lay persons. Other concerns come first such as caring about their home, regulations, etc.

The chapter by *Münzberg and colleagues* highlights the importance for cities to create cadastre of CIs in order to increase emergency and crises processes. Protection levels are a means of identifying critical thresholds of a city where even emergency supply might not be feasible anymore and preparations have to be planned. Protection levels are a possibility of generating research and action for more robust scientific investigation on what is the maximum level of disruption to a system, but it also offers incentives to consider the limits of coping and adaptation capabilities of a city, its inhabitants and visitors. Lately, in Germany some projects start to address this by developing minimum supply assessments and concepts (e.g.

CIRmin project). These concepts separate scenarios of short term and long-term crises where worst-case situations may occur when even emergency supply by the authorities cannot be guaranteed anymore and self-help of citizens and participation by private operators become a necessity as much as volunteer help and integrative cross-border cooperation. Minimum supply concepts of resilience are also looking into city planning of refugee shelters that still function in degraded mode and serving as 'lighthouses' or 'islands of last resort' for a certain time period (see also the chapter by *Hälterlein and colleagues* for this topic) until functionality of basic infrastructure is restored.

An aspect often overlooked in traditional critical infrastructure assessments is the role of the people affected or the customers. There is a gap merging social vulnerability perspectives, for example, or community resilience, with end-of-pipe conceptions of maximum failure durations and magnitudes of infrastructure services. The chapter by *Zobel and colleagues* nicely addresses this gap by analysing "the on-going interaction between a municipality and its citizens". In their case study in New York, they "get an indication of both the resilience of the infrastructure that supports the service provision, and the resilience of the families that rely on those services".

29.12 How Can Improvement of Existing Measures Brought in Line with Using Urban Disaster Resilience and Security?

The chapter by *Molarius and colleagues* illustrates the importance of advancing foresight and planning by "exploring systemic change in order to better Anticipate, Recommend and Transform possible futures". Such foresight assists strategic management mostly, within private or public organisations. However, planning in advance and gaining intelligence also relates to the field of knowledge management where existing information should be made available and shared better. Knowledge management as a finding of joint interest in several countries is also a topic within the chapter by Weichselgartner and colleagues.

Jovanović and colleagues show how existing indicators can be improved or novel indicators can principally be created: by adjusting old indicators, by involving experts or using novel data sources such as big data or open data.

Thieken and colleagues analyse the role of insurance as a measure in their chapter: "Using Germany as an example, this paper explores how flood insurance has contributed to resilience of residents in flood-prone urban areas since 2002". They find a preference of flood insurance to other adaptation options such as dykes among residents in one state in contrast to another group of residents in another state in Germany. They interpret this preference being a "low-cost response to system surprises". This is interesting since it relates to discussions about resilience as being an alternative to planning and preparedness relying on costly, rarely used structural measures and investing rather into flexible mechanisms such as reserve funds, useful as a reserve for any kind of situation. Or investing into no-regret measures similar to climate change adaptation or into fire brigades or resources useful everywhere and anytime, but not specifically for a specific hazard type or (flood) resilience type only.

The importance of more stakeholder involvement and incentives is described in the chapter by *Wiens and colleagues*: "all research results and practical insights which are available so far stress the importance of an incentive-based framework of public-private emergency collaboration which takes into consideration the conflicts of interest as well as the restrictions of the parties involved and which allows for an efficiency-analysis".

Wurster and colleagues provide an interesting example on video surveillance as a contested measure. They openly address the pitfalls and scepticism towards the usage of video surveillance and try to integrate the critique and also the ethical considerations into their concept. This way science should be conducted, rather than ruling out usage or analysis of certain measures per se, to address weaknesses and strengths and finding ways for integration of "security needs and societal needs simultaneously".

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