

Enhancing urban and infrastructure resilience

An institutional perspective

**De stedelijke en infrastructurele veerkracht vergroten
Een institutioneel perspectief**
(met een samenvatting in het Nederlands)

Proefschrift

ter verkrijging van de graad van doctor aan de
Universiteit Utrecht
op gezag van de
rector magnificus, prof.dr. H.R.B.M. Kummeling,
ingevolge het besluit van het college voor promoties
in het openbaar te verdedigen op

vrijdag 30 oktober 2020 des ochtends te 9.15 uur

door

Andreas Huck

geboren op 8 september 1985
te Freiburg i. Br., Duitsland

Promotoren:

Prof. dr. J. Monstadt

Prof. dr. P.P.J. Driessen

Prof. dr. A. Rudolph-Cleff

The degree is awarded as part of a Joint Doctorate with Technische Universität Darmstadt.

Dit proefschrift werd mogelijk gemaakt met financiële steun van de Deutsche Forschungsgemeinschaft (DFG) binnen de Onderzoeksopleidingsgroep KRITIS aan de Technische Universität Darmstadt [subsidienummer GRK 2222].

ACKNOWLEDGEMENTS

I owe a debt of gratitude to the many people who have supported me in various ways in writing this thesis. First and foremost I would like to thank my supervisors Jochen Monstadt, Peter Driessen and Annette Rudolph-Cleff for the time and energy they have dedicated to my work. I have enjoyed the freedom you gave me and have always appreciated your advice. Jochen, special thanks to you for your meticulousness and detailed comments on my texts and for your identification with my research project. Peter, I would especially like to thank you for your structured work style and for always keeping the overall context of my thesis in mind. Annette, special thanks to you for your constructive and acute way of giving feedback and for the encouraging discussions we had.

Next, I would like to thank my colleagues in the graduate school KRITIS at TU Darmstadt. In particular, I would like to thank Ivonne Elsner and Manas Marathe for their input and constructive criticism of early versions of my papers, Marcel Müller and Marcus Dombois for the many inspiring discussions on my research project, and Stefanie Eifert and Nadja Thiessen for the emotional support and the many conversations in the coffee kitchen. I am also grateful to all other colleagues and associated professors who have provided me with feedback and inspiration during our regular seminars. Many thanks also to the executives and the administration team, particularly Jens Ivo Engels, Tina Enders, Mälika Fetzer and Elena Dingersen for their support with my many conference and field trips. I also owe a thank you to the administrative staff at the department of Human Geography and Spatial Planning at Utrecht University for their support and hospitality during my research stays in Utrecht.

This research would not have been possible without the 46 anonymous interviewees in Rotterdam, Christchurch and from 100 Resilient Cities. Thank you so much for your time, trust and support. Many thanks also to Joy Burrough for her great editing work for large parts of this thesis.

In my private life, I want to express my gratitude to my partner Nora for being such a great support during ups and downs and to my family Barbara, Herbert, Claudia and Aimée for their interest and empathy.

TABLE OF CONTENTS

Acknowledgements 3
List of figures 6
List of tables 6
List of abbreviations 6

1 INTRODUCTION 7

1.1 Introduction 8
1.2 Urban and infrastructure resilience in theory and policy practice 9
1.3 An institutional perspective on the governance of urban and infrastructure resilience 19
1.4 Research aim, research questions and thesis outline 20
1.5 Research design and methodology 23

2 URBAN AND INFRASTRUCTURE RESILIENCE: DIVERGING CONCEPTS AND THE NEED FOR CROSS-BOUNDARY LEARNING 27

2.1 Introduction 28
2.2 Knowledge communities and cross-boundary learning 29
2.3 Methodology 31
2.4 Knowledge communities with regard to urban and infrastructure resilience 33
2.5 Discussion 39
2.6 Conclusion 42

3 TOWARDS RESILIENT ROTTERDAM? KEY CONDITIONS FOR A NETWORKED APPROACH TO MANAGING URBAN INFRASTRUCTURE RISKS 45

3.1 Introduction 46
3.2 Institutionalising urban resilience as a governance challenge 48
3.3 Rotterdam's governance challenges in institutionalising urban resilience: an infrastructural perspective 51
3.4 Key conditions for effective network management of mutually dependent actors responsible for operating critical infrastructures 56
3.5 Conclusion: on the potential role of municipalities in institutionalising urban resilience 59

4	BUILDING URBAN AND INFRASTRUCTURE RESILIENCE THROUGH CONNECTIVITY: AN INSTITUTIONAL PERSPECTIVE ON DISASTER RISK MANAGEMENT IN CHRISTCHURCH, NEW ZEALAND	61
4.1	Introduction	62
4.2	The need for institutional connectivity in order to achieve urban and infrastructure resilience	63
4.3	Methodology	66
4.4	Risk management in Greater Christchurch: Institutional reforms before and after the 2010–2011 Canterbury Earthquake Sequence	67
4.5	Discussion: Institutions, connectivity and resilience	75
4.6	Conclusion	77
5	MAINSTREAMING URBAN RESILIENCE IN CHRISTCHURCH AND ROTTERDAM?	79
5.1	Introduction	80
5.2	Mainstreaming urban resilience: Political commitment, governance networks and active engagement of decision-makers and citizens	82
5.3	Rotterdam and Christchurch as participants in 100RC: Problems of mainstreaming urban resilience	85
5.4	Discussion: Mainstreaming urban resilience requires more than participation in 100RC	92
5.5	Conclusion	94
6	CONCLUSIONS AND REFLECTIONS	97
6.1	Introduction	98
6.2	Summary of results	99
6.3	Institutional arrangements and the governance of urban and infrastructure resilience	103
6.4	Reflections and outlook	109
	References	113
	Appendices	133
	<i>Appendix 1: Overview of interviews – Chapter 3 (Rotterdam)</i>	<i>133</i>
	<i>Appendix 2: Overview of interviews – Chapter 4 (Christchurch)</i>	<i>135</i>
	<i>Appendix 3: Overview of interviews – Chapter 5 (Rotterdam & Christchurch)</i>	<i>137</i>
	Summary	139
	Samenvatting	145
	About the author	151

List of figures

- Fig. 1.1** Key capacities for urban and infrastructure resilience (Source: own overview) [12](#)
- Fig. 1.2** Governance strategies to enhance urban and infrastructure resilience (Source: own overview) [18](#)
- Fig. 1.3** The institutional perspective on the governance of urban and infrastructure resilience adopted in this thesis (Source: own overview) [20](#)
- Fig. 2.1** An analytical framework to compare communities of practice in urban and infrastructure resilience (Own figure based on Wenger, 2006, 2008) [31](#)
- Fig. 4.1** Analytical framework used in this study (Source: own overview) [66](#)
- Fig. 4.2** Timeline with main institutional reforms in Greater Christchurch (Source: own overview) [69](#)

List of tables

- Tab. 2.1** Comparing prevalent knowledge communities in urban and infrastructure resilience (Source: own figure) [40](#)

List of abbreviations

100RC	100 Resilient Cities
CCC	Christchurch City Council
CER Act	Canterbury Earthquake Recovery Act
CERA	Canterbury Earthquake Recovery Authority
CERR Act	Canterbury Earthquake Response and Recovery Act
CRO	Chief Resilience Officer
ECan	Environmental Canterbury (regional authority)
EU	European Union
EY	Ernst & Young
GDP	Gross Domestic Product
GMU	George Mason University
IPCC	Intergovernmental Panel on Climate Change
MCDEM	Ministry of Civil Defence & Emergency Management in New Zealand
Mw	Moment magnitude (characterising the relative size of an earthquake)
NCTV	National Coordinator for Security and Counterterrorism (Dutch abbreviation)
RF	Rockefeller Foundation
SCIRT	Stronger Christchurch Infrastructure Rebuild Team
SDG	Sustainable Development Goals
UK	United Kingdom
UN	United Nations
US	United States
USD	United States dollar

1

INTRODUCTION

1.1 Introduction

With more people living in urban areas than ever before and increasing global interdependence of cities, urbanists have declared the 21st century the century of cities (Carrillo et al., 2014; Kourtit et al., 2014; Tavernor, 2010). Urbanisation refers not only to the steady rise in the numbers of city dwellers and to the growing economic importance of cities, but – as more and more urban scholars recognise – also concentrates risks in cities (Filion et al., 2015; Jabareen, 2015; Joffe et al., 2013). The common assumption is that cities are particularly vulnerable to extreme weather events, natural hazards, terrorist or cyber-attacks and other potential shocks and stresses. This is due to their high population densities, architectural structures, economic importance and to their geographic location, for instance on deltas (Francesch-Huidobro et al., 2017; Godschalk, 2003). In addition, cities' interconnected infrastructure systems and their function as infrastructure hubs makes them more vulnerable to indigenous as well as exogenous threats because of the risk of cascading failures crossing sectoral and territorial boundaries (Graham, 2010a; Little, 2010b; Rinaldi et al., 2001). At the same time, disaster risk scholars recognise that extreme events and disasters are becoming more frequent and expect this trend to continue besides others due to climate change and increasing geopolitical conflicts (Smith and Petley, 2009). Under such circumstances, city managers, urban planners and infrastructure providers increasingly have to plan for risk, crisis and uncertainty (Coaffee and Lee, 2016).

In response to a rising sense of urgency to adapt cities and their infrastructure networks to climate change and to cope with extreme weather events or other type of threats, scholarship on disaster risk management, climate adaptation, urban planning and infrastructure management has taken up the concept of urban resilience as a normative framework. Resilience has been described as a governance concept (Chandler, 2014b) or as a policy narrative (Béné et al., 2017) promising to provide guidance on how to deal with the great challenges in the wake of rising risk and uncertainty. However, scholars report an 'implementation gap' between resilience as a policy objective and resilience as manifested in the implementation of risk management and urban planning practices (Coaffee and Clarke, 2015; Coaffee and Lee, 2016; Coaffee et al., 2018; Wagenaar and Wilkinson, 2015; Wilkinson, 2012)¹. In addition, Birkmann et al. (2016) argue that the nexus between urban resilience and infrastructures has so far been largely neglected by academic literature. The research described in this thesis takes an institutional perspective on the implementation gap, contributing to the emerging literature on the challenges of enhancing urban resilience and with a particular focus on infrastructure systems. For this, I apply a research

¹ In political science, the implementation gap is often defined more narrowly, referring to a gap between policy design and policy implementation (for a discussion see Hudson et al. (2019)). In accordance with mainstream resilience literature, in this thesis, the term is used in a broader sense, pointing to a gap between the normative vision (or guiding principle) of resilience as discussed in academic and policy debates and resilience as manifested in policy making and planning practice.

strategy making use of theories on urban governance as well as empirical evidence from two cases: Christchurch in New Zealand and Rotterdam in the Netherlands.

In the remainder of this chapter, I elucidate the research topic and research strategy and I position this research in existing strands of literature. Firstly, I provide a literature review on urban and infrastructure resilience, resulting in a problem statement. Secondly, I provide an institutional perspective on the governance of urban and infrastructure resilience as a conceptual basis for this thesis. Thirdly, based on some identified academic voids, I explain the research aim and develop the main research question as well as subsidiary questions, which guide the following chapters of this thesis. Thirdly, I explain the research design used for this study.

1.2 Urban and infrastructure resilience in theory and policy practice

Throughout the history of humankind, there have always been hazards and disruptive events that threatened people and their settlements. However, the beginning of this millennium is marked by four megatrends that are significantly changing hazards' frequency, magnitude and potential impact on communities: climate change, technologisation, urbanisation and globalisation. Firstly, with rising global temperatures and sea levels, climate change is expected not only to threaten communities at the coast but to also cause frequent extreme weather events such as heavy rain, drought periods and hurricanes (IPCC, 2014). Secondly, technologisation and the growing dependency of societies on technological systems potentially increase and accelerate the impacts of hazards (Hokstad et al., 2012) and invoke new threats, such as new forms of (cyber) terrorism. The increasing complexity of tightly coupled infrastructure systems such as modern information and communication systems, transport and logistic systems, and power generation and distribution systems enhances the risk of technical infrastructure failure cascading across sectoral and territorial boundaries (Little, 2010b; Rinaldi et al., 2001). Thirdly, cities around the world are growing continuously, with more than half of the world's population now living in urban areas (United Nations, 2019). High population densities, the concentration of economic activity in cities, dense built-up environments as well as the high concentration of infrastructure networks make cities more vulnerable to natural hazards and other types of threat (Godschalk, 2003; Monstadt and Schmidt, 2019). Fourthly, our world is becoming more and more globalised and our cities are becoming more and more connected through economic relations and infrastructurally mediated flows of production material, knowledge and people (Lechner and Boli, 2019). Therefore, risks, hazards and potential threats might easily cascade and migrate.

In light of these megatrends, some scholars see cities as being at the forefront of developing new approaches for mitigating or adapting to different kind of risks deriving for example from climate change and international terrorism (Coaffee, 2009; Evans, 2011; Hodson and Marvin, 2010a, 2010b). As a guiding principle for urban

development, the notion of *sustainable urban development* has for several decades been receiving much attention. Often referring to the triple bottom line of sustainable development, this notion covers planning and development approaches in addition to urban visions including the low carbon city, the smart city, the renewable city and the green city (for an overview of influential contributions on sustainable urban development see Wheeler and Beatley, 2014). Another prominent – and sometimes competing – perspective relates to the concept of *urban resilience* (for a comparison of sustainability and resilience see Redman, 2014). Not only the fact that Coaffee and Lee (2016) have declared resilience to be one of the most important guiding principles for urban development nowadays but also the concept's focus on risk, crisis and uncertainty justifies its utilisation for this research. Indeed, some of the most popular approaches to modern risk management in cities refer to resilience (Bach et al., 2014; Etinay et al., 2018; Matyas and Pelling, 2014).

1.2.1 The rising popularity of urban and infrastructure resilience in academia and practice

— That the sub-field of urban risk management is receiving increasing academic attention is exemplified in book titles such as *Cities at Risk* (Filion et al., 2015; Joffe et al., 2013), *The Risk City* (Jabareen, 2015) and *Disrupted Cities* (Graham, 2010a). In particular, research on urban resilience is burgeoning (Caldarice et al., 2019) and has expanded to cover various bodies of literature, including urban sociology, infrastructure studies, development studies, security studies, risk management, public administration, urban planning and climate change adaptation. Accordingly, there are plenty of academic definitions of urban resilience (Meerow et al., 2016), many of which are applicable across disciplinary boundaries. This has led some scholars to think of resilience as a 'boundary concept' connecting and bringing together different epistemic communities (Baggio et al., 2015). The core idea of urban resilience is to enhance a city's capacity to deal with a diverse range of potential shocks and stresses. Based on an extensive review of academic and grey literature provided by Arup, Rockefeller Foundation's 100 Resilient Cities programme (hereafter 100RC) has defined urban resilience as: 'the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience' (100RC, 2017a, p. 10). Referring to 'systems within a city', the definition draws an explicit link to – among others – urban infrastructure systems. This is in line with current scholarship pointing out the crucial role of technical infrastructures both for causing or accelerating the great challenges of the 21st century and for dealing with them (Labaka et al., 2015; Monstadt and Schmidt, 2019).

Some critical scholars point out that in the absence of a uniform definition, resilience risks becoming just another political 'buzzword' (Brown, 2016; Walsh, 2013), which would make it 'an empty signifier which can be filled with multiple meanings and which can serve conflicting political, economic, and social interests' (Davoudi et al., 2017). Other authors criticise the concept and its application in policy practice (Béné et al., 2017; Brunetta and Caldarice, 2019; Mikulewicz, 2019). They emphasise

the normative positive interpretation of the concept (e.g. Olazabal et al., 2012), point to potential negative trade-offs in implementing urban resilience (e.g. Chelleri et al., 2015) or to the inherently conservative application of the concept resulting in preservation of the status quo rather than in the transformation required for addressing the great challenges of our time (Derickson, 2017; Evans and Reid, 2013; Lang, 2011). Others argue that applying the concept of urban resilience risks neglecting issues of politics, power and equity because the questions of ‘resilience for whom, what, when, where and why?’ are not sufficiently addressed (Cote and Nightingale, 2012; Evans, 2011; Meerow and Newell, 2019; Weichselgartner and Kelman, 2015).

Against this background, Coaffee and Lee (2016, p. 262) argue that it has now become more important to ask what resilience *does* instead of what it *is*. As a first response to this question, it can be stated that resilience undoubtedly and increasingly influences urban policy planning debates in cities around the world, as exemplified by international initiatives such as ICLEI’s Resilient Cities Programme (www.resilient-cities2019.iclei.org) and the UN-HABITAT Urban Resilience Hub (www.urbanresilience-hub.org). Urban resilience plays a key role in international governance documents such as the Sustainable Development Goals (SDG 11), the Paris Agreement and the New Urban Agenda and it represents the core of the Sendai Framework for Disaster Risk Reduction. In addition, the philanthropic sector is engaging in urban resilience building (UN-Habitat, 2017): for example, the Rockefeller Foundation assigned USD 100 million funding to its 100 Resilient Cities Programme between 2013 and 2019. Although that programme ended in 2019 it will continue to shape the global resilience movement for some time, as most member cities have developed their own resilience strategies and have appointed a Chief Resilience Officer under the programme’s guidance. Leitner et al. (2018) describe the foundation’s approach as ‘globalising urban resilience’, emphasising its profound influence on local policy and decision-making in cities around the world.

1.2.2 Towards an operational understanding of urban resilience

Resilience stems from the Latin word *resilire*, which means ‘to leap back’. Although it is by no means a new concept (Alexander, 2013), its widespread use in academic and political discourses is relatively new (Coaffee, 2008; Baggio et al., 2015; Walker and Cooper, 2011). While early debates have often focused on contrasting different understandings of resilience, i.e. ‘engineering resilience’ vs ‘ecological resilience’ (Holling, 1996), recent interpretations from urban studies literature employ an evolutionary understanding of the concept (Davoudi, 2012). In contrast to traditional equilibrist understandings of resilience, this interpretation challenges the idea of an equilibrium and instead assumes that systems may constantly change over time (with or without external pressure). Considering a range of different definitions stemming from various bodies of literature, Meerow et al. (2016) come up with an encompassing definition of urban resilience which marks the starting point for this thesis:

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. 39)

In order to operationalise this definition, I follow Matyas and Pelling (2014), who argue that resilience can be imbued with greater analytical depth through the elaboration of particular resilience capacities as distinct – although not discrete – options for decision-making and risk management policy. Therefore, urban and infrastructure resilience is understood in this thesis to mean a bundle of capacities within a city to enable that city to better cope with shocks and stresses. In particular, according to a review of literature and in line with the general definition provided by Meerow et al. above, three main strains of thought highlight distinct resilience capacities that are relevant for cities and their infrastructure systems (cf. Hegger et al., 2016): Firstly, *resistance* describes the capacity of a city and its citizens to resist shocks and stresses. For instance, this capacity can be raised by establishing protection measures such as dikes or by strengthening structural aspects of the built environment. Secondly, *recovery* accounts for the capacity to absorb and recover from shocks and stresses. This capacity is determined, for example, by the efficiency and efficacy of crisis management, urban and regional planning or repair activities. Thirdly, *adaptability* refers to the capacity to adapt to changing circumstances and to transform by stimulating learning processes in system design and management. Examples include adaptive flood management or disaster-conscious designation of at-risk settlement areas in light of new knowledge on the spatial distribution of risks and vulnerabilities.

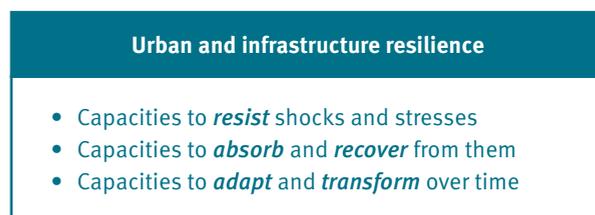


Fig. 1.1 KEY CAPACITIES FOR URBAN AND INFRASTRUCTURE RESILIENCE
(SOURCE: OWN OVERVIEW)

Enhancing urban and infrastructure resilience: insights from four perspectives
Debates on how to enhance urban and infrastructure resilience can be found in a number of different bodies of literature. This PhD thesis mainly concentrates on the perspectives of urban planning, infrastructure management, disaster risk management and climate change adaptation. This represents a strategic selection, partly neglecting other discourses such as those on regional economic resilience (e.g. Hassink, 2010), the infrastructure resilience of energy systems (e.g. Hodbod and Adger, 2014), transportation systems (e.g. Donovan and Work, 2017), and information and communication systems (e.g. Baig et al., 2017), psychological resilience (e.g.

Fletcher and Sarkar, 2013) as well as community resilience (e.g. Magis, 2010). These discourses are clearly relevant for urban development and sometimes overlap broader urban and infrastructure resilience debates. However, since this thesis does not focus on a specific infrastructure domain but rather considers the governance of multiple, interdependent infrastructures, there is no need for an in-depth examination of such specific discourses that often employ a technical rather than a governance perspective. The following debates and fields of application – urban planning, infrastructure management, disaster risk management and climate change adaptation – that, by definition, adopt a cross-sectoral and cross-policy perspective seem more appropriate for this purpose.

An urban planning perspective

Urban planning literature often frames cities as complex adaptive systems (Meerow et al., 2016), highlighting their networked and self-organising character. Whilst early attempts to conceptualise urban resilience describe cities as socio-ecological systems (Lebel et al., 2006), scholars have recently made use of a socio-technical system understanding (Amir, 2018) or have combined both perspectives into social-ecological-technical systems (Markolf et al., 2018). In fact, the resilience of cities and the resilience of their infrastructure networks and services are inherently intertwined (Marana et al., 2018b; Monstadt and Schmidt, 2019) and awareness of urban vulnerabilities to technical infrastructure failures has grown steadily during recent years (Graham, 2010a; Little, 2010a). However, Hommels (2018) shows that linking social and technical aspects of resilience poses major challenges in policy making and planning practice because different groups of actors dealing with each dimension seldom integrate their work. Similarly, Stumpp (2013) points to difficulties in transferring the academic concept of resilience across disciplinary boundaries.

From the perspective of urban and regional planning practice, [...] attaining urban resilience requires an enhancement of planning and designing techniques and the development of new repertoires of 'doing' planning in order to make cities and their associated critical infrastructures and communities more resistant and adaptable to a complex combination of endogenous and exogenous shocks and stresses. (Coaffee and Lee, 2016, pp. 5–6)

This statement by Coaffee and Lee is exemplary for a discourse in urban planning literature on the need to modify planning procedures and design techniques in order to enhance resilience. In this vein, Porter and Davoudi (2012, p. 329) argue that there is great potential for resilience 'to reframe planning in ways that break open sterile analyses and rigidly conservative interventions, so that we can see them afresh.' A major focus of this strand of literature lies either on the inclusion of different sectoral perspectives in the formulation of policy objectives (e.g. Hommels, 2018) or on the compatibility of policy objectives across different policy fields (e.g. Chmutina et al., 2016). In addition, urban planning literature points to the need for active engagement of diverse actor groups in planning processes. This does not automatically mean less governmental involvement in planning and decision-making. On the contrary, municipal governments often take a leading role when institutionalising urban

resilience. However, it does mean that governments – local or otherwise – cannot govern for urban resilience alone, independently from other actors and solely by introducing top–down regulation. In this vein, Boshier (2008) points to gaps between the actions of planners and those tasked with disaster risk reduction. Similarly, Coaffee and Clarke (2015) call for better cooperation between planners and climate scientists, disaster risk managers, the police and other relevant actors, such as infrastructure providers and network owners.

An infrastructure management perspective

Critical infrastructures, as the backbones for modern societies, have become a focus for risk management literature and practice (Fekete and Fiedrich, 2018). Largely invisible and taken for granted (Star, 1999), and often perceived as boring and culturally banal (Graham, 2010b), critical infrastructures provide those services that enable modern living in the first place. In the event of infrastructure failure or breakdown, however, they become visible (‘unblackboxing’) and can put the social order of a city, region, or country at risk (Graham, 2010b, p. 18). Hence, critical infrastructures are often defined with regard to their potential impacts in the case of failure: ‘if disrupted or destroyed, [they] would have a serious impact on the health, safety, security or economic well-being of citizens or the effective functioning of governments’ (Bouchon, 2006, p. 38). So far, there is no agreement on which infrastructures are considered critical, and definitions differ from country to country. Whilst some definitions include social infrastructures like health care and food supply, there are four technical and networked infrastructure realms that are mentioned almost consistently in academic and practice-oriented literature: energy, water, transport and telecommunication. Due to the dependence of human life on these services, they are aptly described as ‘lifelines’ in some places (Coaffee and Clarke, 2016)².

The risk of failures of critical infrastructures cascading across sectoral and spatial boundaries, and the identification of cross-sectoral interdependencies has received particular attention in scholarly literature on infrastructure management (Hokstad et al., 2012; Perrow, 1994; Rinaldi et al., 2001). A power blackout, for instance, might have secondary effects on other infrastructure systems such as water provision, transportation and telecommunication because these infrastructure systems are functionally coupled and their operation is mutually dependent (Kröger and Zio, 2011). In addition, exogenous risks (for instance, related to extreme weather events or natural hazards) may be amplified by the increased complexity and interdependency of infrastructure systems (Bollinger et al., 2013). While the material and technical connectivity between infrastructure sectors is increasing, the scholarly literature has revealed that the organisations managing them are becoming more fragmented (Almklov et al., 2012; Boin and McConnell, 2007). Two of the reasons for this phenomenon are privatisation and deregulation (Monstadt, 2009; Offner, 2000). In addition, various scholars (Boin and McConnell, 2007; de Bruijne and van Eeten, 2007) have observed that interdependencies across infrastructure sectors pose

² When ‘infrastructures’ are referred to in this thesis, they are always critical infrastructures.

major coordination problems. As interdependent infrastructure systems allow risks to migrate across time and space (Münzberg et al., 2017), these authors advocate considering infrastructural interdependencies in risk management practices to enhance resilience (de Bruijne and van Eeten, 2007; Monstadt and Schmidt, 2019). In this vein, the literature often calls for a shift from protectionist towards adaptive risk management approaches in the design of infrastructure resilience policies (GMU, 2007; Medd and Marvin, 2005) and points to the need to create public-private partnerships covering different infrastructure domains (Bach et al., 2014; Dunn-Cavelty and Suter, 2009).

A disaster risk management perspective

Empirical research on disaster risk management has confirmed the assumption of fragmented and siloed management structures that hamper resilience (Coaffee et al., 2018; de Bruijne and van Eeten, 2007; Mamula-Seadon and McLean, 2015). With respect to proactive and reactive management of disasters, scholars point to fragmented and poorly coordinated decision-making which does not fit the complex and cross-sectoral demands of disaster risk management (Godschalk, 2003; McFarlane and Rutherford, 2008; Pearce, 2003). Accordingly, Sapountzaki et al. (2011) call for policies and actors with joint responsibility for risk management to be better coordinated. Similarly, it has been argued that the efficacy and efficiency of disaster risk management increasingly depends on the ability of the relevant actors to break up existing policy silos and implement cross-boundary working relationships (Almklov et al., 2012; Matyas and Pelling, 2014). This recognition stems partly from empirical research that indicates that large-scale disasters often unveil dissonance between institutions involved in risk management (Birkmann et al., 2010a; Mamula-Seadon and McLean, 2015). The basic assumption in this body of literature is that risk management arrangements should better mirror the interconnectedness of the external world (Duit et al., 2010, p. 365) and that policy reforms are required to enhance the coordination of and cooperation between relevant agencies and actors, which will ultimately enhance the resilience of cities, their infrastructure systems and their communities.

In addition, disaster risk management literature contributes to the resilience debate by portraying disasters as providing an opportunity for learning and subsequent changes in policy design and risk management practices. For instance, Birkmann et al. (2010a) argue that disasters regularly raise risk awareness and that 'dominant ways of thinking and acting are subject to critical review and revision' (p. 638). This may consequently lead to the (re)design of policies and to the (re)adjustment of actor constellations in the respective risk management arrangements (Birkland, 2001; Smith and Birkland, 2012). Seeing disasters as 'windows of opportunity' reflects a general trend from protectionist to adaptive forms of risk management, which has also been described as moving from a 'fail-safe' to a 'safe-to-fail' paradigm which is in line with resilience thinking (Ahern, 2011). As such, disasters potentially generate learning processes, which can benefit the resilience of cities and their infrastructure systems in the sense that they are better prepared to deal with future events.

A climate change adaptation perspective

Climate change adaptation is framed differently in literature, with concepts such as ‘climate-proof cities’ (Albers et al., 2015), ‘climate resilience’ (Gilissen et al., 2017), ‘future proofing’ (Boston et al., 2014) and ‘climate adaptation’ (Dewulf et al., 2015) being used interchangeably. Cities are at the centre of this debate due to their explicit vulnerabilities to climate change impacts such as sea level rise, heavy rainfall, droughts or storms (Boyd and Juhola, 2015; Hodson and Marvin, 2010b). Essentially, cities are already facing hazard induced by climate change and will continuously and increasingly do so, irrespective of mitigation efforts they make (IPCC, 2014). The fact that the majority of large cities in the world are located in coastal regions (Boyd and Juhola, 2015) alone justifies the urgency with which climate scientists advocate adapting cities to the consequences of climate change rather than solely contributing to its mitigation.

Early debates on urban resilience in mainland Europe were predominantly associated with climate change adaptation (Coaffee and Clarke, 2015). Because of its cross-cutting character referring equally to ecological, social and technological systems (Boyd and Juhola, 2015), it is argued that climate change adaptation – rather than constituting a policy field of its own – should be *mainstreamed* into existing sectoral policies and decision-making practices, including urban planning and design, infrastructure planning, risk management and so forth (Friend et al., 2014). The idea of ‘intra- and inter-organisational mainstreaming’ particularly aims at generating ‘shared understandings and knowledge, develop[ing] competence and steer[ing] collective issues of adaptation’ across departmental and sectoral boundaries (Wamsler and Pauleit, 2016, p. 73). In this sense, mainstreaming can lead to synergy effects being created between different policy fields and to resource savings. However, it might also raise the risk of issues becoming less visible and receiving less attention due to a lack of dedication (Runhaar et al., 2018). Although this concept is predominantly used in literature on climate change adaptation, it reflects current debates on the governance of urban and infrastructure resilience in other bodies of literature very well because it precisely points to a new cross-cutting policy field which regularly lacks substantive authority, institutional order and substantive expertise (cf. Massey and Huitema, 2013). In addition, the literature regularly highlights that planning for climate change adaptation requires multi-level, multi-sector and multi-actor efforts as well as effective and efficient coordination and cooperation across territorial and temporal boundaries (Bauer and Steurer, 2014; Dewulf et al., 2015) and the involvement of diverse actors from the public and the private sector as well as citizens (Friend et al., 2014; Uittenbroek et al., 2014).

Governance strategies for enhancing urban and infrastructure resilience

As the insights into the different bodies of literature show, scholars from different disciplines and backgrounds seem to agree on the need for adaptive and networked governance to enhance urban and infrastructure resilience. In fact, the notion of ‘adaptive governance’ is prominently represented in resilience literature, stressing the need for governance systems to adapt to changing circumstances in a flexible manner and to learn from past experiences (Djalante et al., 2011; Gunderson and Light, 2007; Pahl-Wostl, 2009). For instance, Folke et al. (2005, p. 441) argue that ‘[a]daptive

governance systems often self-organize as social networks with teams and actor groups that draw on various knowledge systems and experiences for the development of a common understanding and policies.’ Closely related, the idea of ‘governance networks’ or ‘actor networks’ is receiving much attention in resilience literature and hence has led to a call for effective coordination and collaboration between relevant actors at different levels of governance, such as planners, risk managers and infrastructure providers (Duit et al., 2010; Ernstson et al., 2010; Goldstein, 2012; Janssen et al., 2006). In summary, and as revealed by my review of the literature, four governance strategies for enhancing urban and infrastructure resilience can be derived. Each of these forms the core of the chapters 2 to 5 and will be introduced in-depth in each chapter.

The first strategy is *knowledge co-production*, advocated by a range of scholars (Berkes, 2009; Goldstein and Butler, 2012; Muñoz-Erickson et al., 2017; Wyborn, 2015) to enhance cross-boundary learning for urban and infrastructure resilience. Jointly producing knowledge across disciplinary and administrative boundaries is said to be important for bridging policy silos, for agreeing on common objectives, and for collaboratively working towards enhancing resilience (Comfort, 1994; Pahl-Wostl, 2006; Stumpff, 2013; Toubin et al., 2015). The second strategy advocated in the literature is *strategic network management* to gather the relevant actors in decision-making processes, to moderate potential and actual conflicts of interest, to coordinate the action of single actors and to provide strategic direction to resilience measures (Duit et al., 2010; Ernstson et al., 2010; Goldstein, 2012; Janssen et al., 2006). According to Klijn and Koppenjan (2016, p. 11), network management entails the establishment of ‘more or less stable patterns of social relations between mutually dependent actors, which cluster around a policy problem, a policy programme and/or a set of resources and which emerge, are sustained, and are changed through a series of interactions’. The third strategy, demanded by resilience scholars in view of fragmented decision-making and policy silos, is *enhancing connectivity* (Ernstson et al., 2010; Ingold et al., 2018; Wuijts et al., 2018) between relevant actors and organisations in order to enhance vertical, horizontal or cross-territorial cooperation and coordination (Almklov et al., 2012; Dewulf et al., 2015; McPhearson et al., 2015). These three dimensions are particularly important regarding infrastructures, because infrastructure systems usually extend beyond local jurisdictions, their management is executed across different policy levels and various policy fields, and the effects of their failure might easily cascade and travel over sectoral and administrative boundaries (Coaffee and Clarke, 2016; de Bruijne and van Eeten, 2007; Monstadt and Schmidt, 2019). Finally, the fourth strategy, proclaimed by a range of scholars, is the need to integrate resilience objectives into existing sectoral policies and decision-making practices: it is referred to as *mainstreaming* (Chelleri, 2018; Friend et al., 2014; Kernaghan and da Silva, 2014; Pathak and Mahadevia, 2018). Whilst enhancing connectivity concerns improving interaction between different actors and organisations, mainstreaming refers to considering resilience as a key objective for policy making across different domains and sectors. In contrast to a ‘dedicated approach’ to policy making, in which specialised, stand-alone policies and programmes are developed (Uittenbroek et al., 2014), mainstreaming is referred to as contributing to create synergy effects between different domains as well, as it represents a potentially

resource-efficient and effective policy strategy because budgets can be combined (Runhaar et al., 2018; Uittenbroek et al., 2013).

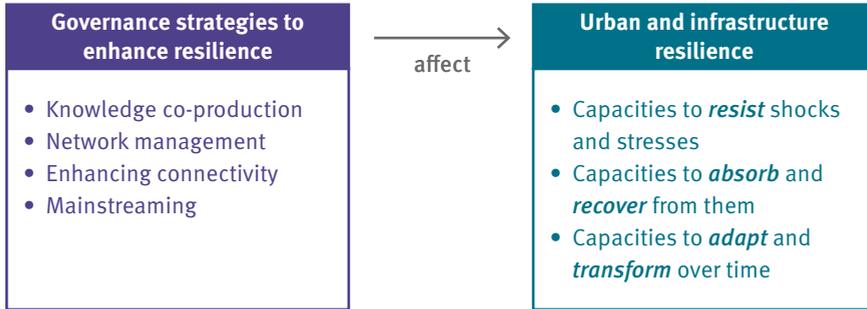


Fig. 1.2 GOVERNANCE STRATEGIES TO ENHANCE URBAN AND INFRASTRUCTURE RESILIENCE (SOURCE: OWN OVERVIEW)

1.2.4 Implementation gaps and institutional voids

Despite its popularity in academic and policy discourses, empirical studies suggest that policymakers and planners struggle to institutionalise resilience and that their attempts tend to be incremental, ad hoc and reactive (Coaffee and Lee, 2016; Fünfgeld and McEvoy, 2012). They face challenges with respect to breaking up existing policy silos and sectoral decision-making (Bulkeley and Tuts, 2013), public-private cooperation (Dunn-Cavelty and Suter, 2009), citizen participation (Vallance, 2015) and fragmented risk management arrangements (Sapountzaki et al., 2011). Accordingly, scholars report an ‘implementation gap’ between resilience as a policy objective and resilience as manifested in the implementation of risk management and urban planning practices (Coaffee and Clarke, 2015). In this regard, Cathy Wilkinson argues:

...what resilience means in practice for urban governance is yet to be thoroughly examined. Indeed, there is an apparent gap between the advocacy of social-ecological resilience in the scientific literature and its take-up as a policy discourse on the one hand, and the demonstrated capacity to govern for resilience in practice on the other. (Wilkinson, 2012, p. 319)

This practical problem is reflected in a lack of academic knowledge on how to institutionalise urban and infrastructure resilience (Coaffee et al., 2018; Normandin et al., 2019). As described above, in academia, resilience is often used as a normative concept to justify proposals for cross-boundary cooperation and coordination amongst actors and organisations. However, the existing literature mainly focuses on policy design and calls for stronger collaboration between stakeholders for policymaking. Yet only a few approaches systematically take an institutional perspective on the governance of urban and infrastructure resilience, even though an institutional perspective is crucial for understanding adaptive and networked governance strategies

because institutions provide formal guidelines and informal behavioural norms that affect the interaction of different actors (North, 1990; Ostrom, 2015). Hence, the institutionalisation of resilience objectives may help to bridge implementation gaps by strengthening the legitimacy, coordination, and support for resilience policies across sectors and departments (cf. Anguelovski and Carmin, 2011). This thesis aims to address this academic void by refining the knowledge on the challenges of institutionalising urban and infrastructure resilience and by taking an institutional perspective on governance strategies to enhance urban and infrastructure resilience.

1.3 An institutional perspective on the governance of urban and infrastructure resilience

— Nowadays, cities are seldom understood as static and place-bounded entities, but more often as dynamic webs of relationships between multiple human and non-human agents. Therefore, urban planning and development has to be understood within frameworks of multi-actor and multi-level governance (Hughes et al., 2018; Salet, 2018). In light of the literature review above, the key assumption adopted for this thesis is that the governance of urban and infrastructure resilience involves far more actors than the municipality and that new networked relationships between actors that have previously worked separately have to be institutionalised in such a way that they generate shared understandings and knowledge and collectively manage the development of resilience capacities (Béné et al., 2017; Biermann et al., 2007; Godschalk, 2003; Groot et al., 2015; Wamsler and Pauleit, 2016). Against this background, *institutionalising urban resilience* refers to the consolidation of adaptive and networked governance strategies – such as knowledge co-production, network management, enhancing connectivity and mainstreaming – to enhance resilience capacities to resist, recover and adapt (cf. Folke et al., 2005; Jordan and Schout, 2006).

This thesis thus follows the institutionalist approach to understanding urban region dynamics adopted by Healey and others, who concentrate on webs of social relations to analyse and explain planning processes and collective action. For instance, Healey’s approach of collaborative planning (Healey, 1997) adopts an institutionalist perspective to explain how different networks of people may meet and collectively solve local environmental problems. Her approach focuses on ‘the task of building up links across disparate networks, to forge new relational capacity across the diversity of relations which co-exist these days in places’ (Healey, 1997, p. 61). In this understanding, planning and place-making are significantly shaped by how different actors interact and, therefore, by the institutional patterns of social norms that guide, legitimate or impede their interaction.

Institutions, here, are understood as ‘systems of rights, rules, and decision-making procedures... [that] give rise to social practices, assign roles to the participants in these practices and govern the occupants of the various roles’ (Young et al., 2008, xiii). As such, institutions enable or constrain the action and interaction of different actors (Ostrom, 2015). Institutions can be formal or informal (North, 1990). Helmke

and Levitsky (2004, p. 727) differentiate between these two types of institutions by referring to ‘rules and procedures that are created, communicated, and enforced through channels widely accepted as official’ (i.e. formal institutions) and ‘socially shared rules, usually unwritten, that are created, communicated, and enforced outside of officially sanctioned channels’ (i.e. informal institutions). Examples of formal institutions include written laws, regulations and standards. Informal institutions include work routines, traditions or established epistemologies.

The literature review above also clearly reveals that institutional arrangements for urban and infrastructure resilience are shaped by a complex web of public and private actors spanning different policy and infrastructure domains, levels of governance and administrative territories. Hence, from an institutional perspective on governance, the implementation gap of urban and infrastructure resilience can be described as a discrepancy between the generally accepted notion that governance systems should mirror the interconnectedness of the external world on the one hand (Duit et al., 2010, p. 365) and, on the other hand, the current fragmentation of risk governance that leads to policy silos and limits the collective action of relevant actors (de Bruijne and van Eeten, 2007; Ingold et al., 2018; Sapountzaki et al., 2011). In accordance with this understanding, Fig. 1.3 provides a conceptual framework for this thesis.



Fig. 1.3 THE INSTITUTIONAL PERSPECTIVE ON THE GOVERNANCE OF URBAN AND INFRASTRUCTURE RESILIENCE ADOPTED IN THIS THESIS (SOURCE: OWN OVERVIEW)

1.4 Research aim, research questions and thesis outline

The main aim of my research was to gain a more detailed understanding of the implementation gap of urban and infrastructure resilience by analysing related policy making and planning in two cities – Christchurch and Rotterdam – using an institutional perspective. This understanding can then be used to derive suggestions for institutional reform to enhance urban and infrastructure resilience. Instead of contributing to the debate about the definition of resilience by asking what urban resilience *is* or should be, the research primarily aims to contribute to a clearer picture of what resilience *does* or could do when tackling future threats and hazards (cf. Coaffee and Lee, 2016). Against the background of the identified academic voids, a range of authors have pointed to the need for a better social science understanding

of building resilience and for empirical research on the concept's application in governance practice (Coaffee et al., 2018; Labaka et al., 2014; Medd and Marvin, 2005). This thesis responds to these calls. It addresses the implementation gap of urban and infrastructure resilience by empirically investigating the challenges of enhancing and institutionalising resilience. The main research question examined in this thesis is:

How do current institutional arrangements shape the governance of urban and infrastructure resilience and how should they be restructured to address existing implementation gaps?

This research question goes beyond identifying key actors who should cooperate or whose actions demand coordination. Rather, it aims at understanding the underlying structures that guide their interaction and thereby hamper or enable the enhancing of resilience. Chapters 2 to 5 each focus on one governance strategy to enhance resilience (see Fig. 1.3). Each chapter addresses one or more subsidiary research questions.

Chapter 2: Knowledge co-production

How does knowledge production take place in two different knowledge communities dealing with urban and infrastructure resilience? How does this shape the respective governance and policymaking practices?

As already noted, urban and infrastructure resilience are inherently intertwined (Monstadt and Schmidt, 2019). At the same time, there is an academic void regarding the nexus of urban resilience and infrastructures (Birkmann et al., 2016). Chapter 2 analyses and confronts the literatures on urban resilience and infrastructure resilience. The chapter provides an institutional perspective on knowledge production, exploring how different communities of practice develop and conserve distinct epistemologies and priorities in discussing resilience. It shows how these disparities may influence governance outcomes, doing so by reflecting on the importance of knowledge co-production for adaptive and networked governance and discussing the potential of resilience to serve as a boundary concept (cf. Baggio et al., 2015).

Chapter 3: Network management

Which institutional key conditions are required for effective network management for enhancing urban and infrastructure resilience?

Municipal administrations often take a leading role with regard to urban and infrastructure resilience measures. Yet, city administrations' role for the integrated management of infrastructure failures and the conditions required for effective network management remain largely unaddressed in the current literatures. Chapter 3 is a case study of Rotterdam. It helps to better understand the potential role of municipal administrations as key actors in the governance of urban and infrastructure resilience and explores institutional key conditions for effective network management. The results reveal particular institutional voids and constraints that hamper policymakers and planners in their approaches to enhance urban and infrastructure resilience and provides some suggestions on how to address these voids and constraints.

Chapter 4: Enhancing connectivity

*How does institutional connectivity affect urban and infrastructure resilience?
How can institutional connectivity be achieved in the first place?*

The literature calls for enhancing connectivity to cope with the complex demands on risks management and climate change adaptation and to contribute to adaptive and networked governance (Duit et al., 2010; Fink, 2011; Raju and van Niekerk, 2013; Sapountzaki et al., 2011). However, despite the emerging call for more connectivity, there is no approach that thinks through how connectivity can help to enhance specific resilience capacities of a city and it remains largely unclear how connectivity can be achieved in the first place. Chapter 4 provides an institutional perspective on connectivity and analyses how institutional connectivity affects a city's particular resilience capacities. Using a case study of Christchurch in New Zealand, this chapter also reflects on how the complexities and uncertainties induced by disaster situations affect connectivity building and how urban governance can cope with them.

Chapter 5: Mainstreaming

What are the institutional prerequisites for mainstreaming urban and infrastructure resilience in policy and decision-making?

Chapter 5 focuses on the strategy to mainstream urban and infrastructure resilience in policy making and decision-making in the two case study areas of Rotterdam and Christchurch. It provides an analysis of institutional constraints for mainstreaming that are apparent in both cities despite their contextual differences. With both cities participating in Rockefeller Foundation's 100 Resilient Cities Programme, this chapter reflects on the role of international organisations for policy integration and mainstreaming. The chapter concludes with some suggestions for institutional reform to address the identified constraints.

Chapter 6: Conclusions

The concluding chapter summarises the results gained from the empirical analyses and addresses the main research question of how current institutional arrangements shape the governance of urban and infrastructure resilience. From an institutional perspective, it provides a nuanced understanding of the implementation gap by identifying institutional voids and constraints that hamper enhancing resilience. At the same time, it elaborates how institutional arrangements should be restructured to address existing implementation gaps. As such, the results of this study not only address the identified academic voids but can also be of use for policy makers and planners at different levels of government in terms of identifying particular voids and constraints in existing institutional arrangements that hamper resilience and in terms of suggestions for institutional reform to enhance resilience.

1.5 Research design and methodology

Because chapters 2 to 5 are published papers, each of them can be read separately and independently. However, to answer the main research question raised above, they need to be considered jointly. This section therefore gives an overview of the research design and methodology used and justifies the case study selection.

1.5.1 Qualitative research design

The approach used in this research project was qualitative, combining deductive and inductive analysis. This approach allows theory to inform and guide the empirical analysis, whilst at the same time providing the flexibility to ‘discover’ new issues during the research process, to refine existing theory and to generate new knowledge (cf. Ali and Birley, 1999). This is in line with Hennink et al.’s (2011, 4 ff.) ‘qualitative research cycle’ approach, in which research design, data collection and data analysis constitute interconnected stages of research, thereby acknowledging the inductive nature of qualitative research but at the same time continuously alternating with deductive reasoning. Qualitative research is suitable for answering the research questions mentioned above because it helps to understand processes and social interactions, it allows complex issues to be studied that are too complex or hidden to be disentangled by quantitative research and it provides depth, detail, nuance and context to the research issues (Hennink et al., 2011, p. 10).

Case studies were chosen as the main research method for this research project. Yin (2018, p. 15) defines case studies as ‘an empirical method that investigates a contemporary phenomenon (the “case”) in-depth and within its real-world context’. As Yin (2018, p. 16) further explains, in case studies, often the phenomenon analysed cannot be separated from the context. This is important to acknowledge because urban and infrastructure resilience is rarely a phenomenon that can be researched under laboratory conditions. Rather it is highly context specific, which is why each city sees different aspects as important for enhancing resilience (Johnson and Blackburn, 2014). Whilst chapters 3 and 4 each examine a single case study, chapter 5 makes use of a multiple-case study design, including and combining information from both cases. In order to provide a thorough overview of current debates in the fields of urban and infrastructure resilience and to address the first subsidiary question, chapter 2 makes use of a qualitative comparative literature analysis, without including empirical evidence from the two cases. As already mentioned, chapters 2 to 5 each contain a detailed explanation of the case study design and the analytical dimensions used.

1.5.2 Case selection

The two case studies were selected partly using pre-defined criteria and partly for pragmatic reasons. The research design required cities that are participating in or using international resilience initiatives to reflect on the role of international

organisations in resilience building. Therefore, the starting point used was the biggest urban resilience initiative: the database of cities participating in the 100 Resilient Cities Programme. Another criterion was the accessibility of data in terms of existing urban resilience policies. This led to the number of candidates for case study being reduced to those that had already developed a resilience strategy and appointed a Chief Resilience Officer to coordinate its implementation. Another criterion that further reduced the candidates for case study was that I had to be able to read and understand accessible policy documents and news articles and conduct in-depth interviews and could do so only in English or German. Also considered when selecting the cases were the two policy areas of climate change adaptation and disaster risk management. After a preliminary analysis of the resilience approaches taken by these cities, two cities were selected: Rotterdam in the Netherlands (with the main focus on climate change adaptation) and Christchurch in New Zealand (with the main focus on disaster risk management). This case selection was to some extent based on the premise that different experiences of disasters in recent decades profoundly shape the policy discourse and also the public debate on urban risk management and may lead to different perceptions of resilience.

Whereas Christchurch experienced a devastating series of earthquakes in 2010/2011, Rotterdam has not experienced a major disaster in recent decades. However, because 80% of the city of Rotterdam is below sea level, the threat of flooding is omnipresent. Rotterdam has been the subject of a considerable amount of research in the fields of climate change adaptation and adaptive water management (e.g. Dunn et al., 2017; Restemeyer et al., 2016) and there is a range of studies on disaster risk and emergency management in Christchurch (e.g. Mamula-Seadon and McLean, 2015; Vallance, 2015). In addition, for both cities there is already some literature on urban resilience and infrastructure resilience in more general terms (Hayward, 2013; Lu and Stead, 2013; Spaans and Waterhout, 2017). That type of research has identified considerable challenges to upscaling the cities' successful experimental resilience projects (Frantzeskaki et al., 2014), integrating technical and social aspects of resilience in policy making (Hommels, 2018), providing effective recovery and repair (Saunders and Becker, 2015) and incorporating resilience principles into the repair of infrastructure networks (MacAskill and Guthrie, 2015). However, the cities' approaches to institutionalising urban and infrastructure resilience have so far not been researched in a structured way. Therefore, the case selection allows for the research questions of this thesis to be addressed, thereby providing new empirical insight to enrich academic literature.

1.5.3 Data collection and analysis

— The qualitative literature analysis in chapter 2 provides a systematic analysis of similarities and differences between two bodies of literature, i.e. literature on urban and infrastructure resilience (cf. Leech and Onwuegbuzie, 2008). Data was collected from international journal publications, books, edited volumes and research reports, using library databases and Google Scholar. In addition, grey literature available from

various sources (e.g. websites, key publications, and conference programmes and proceedings of international action networks for urban and infrastructure resilience) was collected for analysis. Next to literature reviews, data collection for chapters 3 to 5 also involved the use of in-depth expert interviews. Finally, much effort was expended in triangulating interview data with other information sources such as policy documents, plans and strategies, audits, cabinet papers, project reports, newspaper articles and the plethora of academic research available on the cases of Rotterdam and Christchurch.

Interviews were conducted with the help of semi-structured interview guidelines containing open-ended questions. Interviewee selection was based on conceptual considerations such as the coverage of different infrastructure sectors, different governmental levels and different policy fields (see chapters 3 to 5 for more detail). In addition, to identify key informants in the respective cities, preliminary meetings were held with other researchers who had conducted empirical research on the cases and use was made of the snowball technique. In total, 55 interviews were conducted, including nine follow-up interviews to collect more detailed information on issues discussed previously or to verify preliminary conclusions and to avoid misinterpretations. Although the benefits of personal contact are obvious (Hennink et al., 2011), for logistic and financial reasons, six of the 55 interviews (three original and three follow-up) had to be conducted online via Skype.

All interviews were audio-recorded and transcribed. The interview transcripts were then coded and analysed with MAXQDA analysis software. Because risk management and climate adaptation are shaped by the separation of roles across policy fields and governance scales and the interpretation of those responsibilities, the data gathering and assessment were value-laden with respect to the participants' perceptions and the choices made by the researcher (cf. MacAskill and Guthrie, 2017, p. 866). The method of Qualitative Content Analysis (Gläser and Laudel, 2013) helped to clearly differentiate between information provided by participants and the researcher's interpretation thereof. To further validate the results, preliminary conclusions were presented and discussed on a regular basis within the KRITIS interdisciplinary research training group at Technische Universität Darmstadt. In addition, the findings were presented to audiences of professionals in a range of international academic conferences and political symposia. Finally, preliminary versions of the paper publications were sent to all interviewees for feedback before submission.

2

URBAN AND INFRASTRUCTURE RESILIENCE: DIVERGING CONCEPTS AND THE NEED FOR CROSS-BOUNDARY LEARNING

Abstract

The concept of resilience has attracted considerable attention in policy and research communities in the fields of both urban and infrastructure development and governance. Resilience has been framed as a boundary concept bridging different communities of knowledge production and practice. However, a closer look at the joint enterprise, the shared repertoire, and the mutual engagement of respective knowledge communities in urban and infrastructure research and planning practice reveals that resilience is understood and dealt with in rather diverging ways. This paper explores some of these divides, then argues that differences in knowledge production can induce somewhat disconnected policy outcomes and governance approaches which consequently weaken cities' ability to address current and future challenges. Therefore, we call for more interaction and cross-boundary learning between respective knowledge communities.

Published as

Huck, A. and Monstadt, J. (2019) Urban and infrastructure resilience: Diverging concepts and the need for cross-boundary learning, *Environmental Science & Policy*, 100, pp. 211–220.
<https://doi.org/10.1016/j.envsci.2019.05.008>

2.1 Introduction

Global environmental change poses huge challenges to both cities and technical infrastructures. Researchers and practitioners in both realms are seeking ways to prepare for and deal with rising sea levels and extreme weather events, like hurricanes, droughts and heavy rainfall. Numerous extreme weather events have vividly exposed some of these challenges as well as the intricate relationship between urban and infrastructural vulnerability. As was the case of New Orleans, which was hit by Hurricane Katrina in 2005, the city was not only exposed to the immediate destructive impacts of storms and floods on its residents and built environments, but also to immense secondary impacts caused by cascading failures of energy, water, sanitation and transportation infrastructures (cf. Little, 2010b). These secondary impacts significantly damaged the social fabric of the city, as the hardest-hit communities were also among the poorest (Campanella, 2006). Moreover, infrastructure failure had enormous consequences on the city's and the region's environment by triggering the emission of hazardous materials from industrial facilities, storage terminals and pipelines (Cruz and Krausmann, 2009).

As cities are geographical nodes in infrastructurally mediated flows and as they accommodate high densities of people, they are particularly vulnerable to infrastructure failures (Monstadt and Schmidt, 2019). A power blackout can, for instance, pose far-reaching risks to the safety of urban populations and damage economies, natural and built environments and other technical infrastructures. Therefore, a city's ability to prevent and to prepare for infrastructural failures is a major component of a resilient urban system. Urban and infrastructure resilience are inherently intertwined.

However, during empirical research on resilience in Germany, the Netherlands, and New Zealand, we discovered in numerous expert interviews an epistemic divide between stakeholders of urban and infrastructural resilience. The experts indicated that this divide between communities can result in incoherent policy and managerial responses in risk mitigation and preparedness consequently reducing the effectiveness of crisis management. Several interviewees reported instances where infrastructure managers and urban planners make use of similar vocabulary whilst referring to fundamentally different aspects of their work. For instance, a community manager in Christchurch, New Zealand states: *'The problem is we all use the same words. We all say "resilience" [...]. But to me it means something different compared to infrastructure or engineering people. [...] There are lots of people who are talking about resilience, but there is only a small group of people who are able to talk about resilience across disciplines or sectors.'* These indications from expert interviews raised questions about how the knowledge on resilience is being produced and how the challenge of building resilience is dealt with in different expert communities.

The objective of this paper is thus to disclose and compare how knowledge production takes place in two different knowledge communities dealing with urban and infrastructure resilience, then to critically reflect on the widespread conjecture

of resilience as a boundary concept – a concept that is malleable enough to adapt to the epistemological approaches, methods and knowledge interests of epistemic communities but which is, at the same time, precise enough to bridge epistemic divides, to create identity and to structure common practices across communities of knowledge production (Baggio et al., 2015). We ask how boundaries between knowledge communities are created and reinforced, and how in turn this shapes respectively disparate policy making and governance practices. Therefore, our paper assesses ongoing academic debates on urban and infrastructure resilience through a set of variables derived from established theories and concepts of knowledge production. Based on a qualitative assessment of academic literature and grey literature published by selected multipliers, we argue that a better understanding of the particular and often disparate patterns of knowledge production on resilience is crucial to comprehend the opportunities and challenges of integrated approaches to urban and infrastructural resilience. The aim of our study is not to systematically test existing hypotheses in a representative way but to explore and describe different ways of knowledge production and dissemination.

In the following section, we provide a brief introduction into the debate on epistemic cultures, epistemic communities and communities of practice, then operationalise our analysis along three dimensions, namely common enterprise, shared repertoire and mutual engagement (Section 2.2). We then outline the applied methodology and scope of this study (Section 2.3). In Section 2.4 we compare the knowledge production in communities of practice in the fields of urban and infrastructure resilience. Hereafter, we discuss the identified epistemic and cultural divides and their consequences for policy making and the governance of urban and infrastructure resilience (Section 2.5). Finally, we challenge the common framing of resilience as a boundary concept. We conclude by arguing that cross-boundary learning and the co-production of new knowledge may benefit both realms in dealing with the multi-layered complexities of urban and infrastructure resilience (Section 2.6).

2.2 Knowledge communities and cross-boundary learning

Whilst urban and infrastructure resilience might practically be difficult to separate, resilience is understood and dealt with in diverging ways depending on the discipline of a researcher or the institutional affiliation of a decision maker. As knowledge production and governance outcomes are mutually constitutive (Frantzeskaki and Kabisch, 2016; Muñoz-Erickson et al., 2017), it is not surprising that current governance practices seem to struggle to combine different knowledge elements that are required to deal with complex realities of urban and infrastructure resilience (cf. Hommels, 2018). Therefore, in our analysis, we focus on different ‘knowledge systems’ as ‘the organizational practices and routines that make, validate, communicate, and apply knowledge’ (Muñoz-Erickson et al., 2017, p. 1). In order to draw conclusions on how knowledge systems shape policy making and governance practices in urban and infrastructure resilience, we make use of the notions of epistemic communities, epistemic cultures and communities of practice.

Firstly, *epistemic communities* influence policymaking and governance practices because these groups have ‘recognised expertise and competence in a particular domain and an authoritative claim to policy-relevant knowledge’ (Haas, 1992, p. 3). Knowledge production shapes, and is shaped by, the social practices in urban and infrastructure management and governance. Hence, an epistemic community in the field of urban resilience does not comprise urban resilience scholars alone, but also practitioners like city planners, agencies like UN-Habitat, consultancies, and non-governmental actors such as the Rockefeller Foundation. Similarly, epistemic communities in the field of infrastructure resilience comprise infrastructure scholars as well as service and network providers, asset managers and respective regulators, agencies and companies active in the field. This understanding frames knowledge as a cultural phenomenon rather than a set of abstract propositions (Knorr-Cetina, 1981).

Secondly, the notion of *epistemic cultures* brings into view ‘a nexus of life worlds and the machineries of knowing that develop within a specialty’ (Knorr-Cetina and Reichmann, 2015, p. 874). Epistemic cultures guide and constrain both knowledge and practice by establishing available ways of thinking, knowing and acting. This allows us to question the idea of resilience as a boundary concept, as it may be dealt with in fundamentally different ways within the fields of urban and infrastructure resilience. Because knowledge and practice are mutually constitutive (Orlikowski, 2002) as well as socially, culturally and historically situated (Handley et al., 2006), different ‘machineries’ of knowledge production (Knorr-Cetina, 2003) in their respective fields might actually hamper the required co-production of knowledge between urban and infrastructure scholars and practitioners. Resilience can only serve as a boundary concept if it helps to meaningfully link different machineries of knowledge production.

Thirdly, focusing on the epistemic subjects themselves, namely *communities of practice* (Lave and Wenger, 1991), allows us to compare different knowledge communities and their different means of knowledge production. Fundamentally, the notion of communities of practice tells us that ‘different knowledge communities will have, not just different methods, but different epistemic machineries and understandings’ (van House, 2002, p. 235). Wenger (2008) describes three ways in which practice contributes to building knowledge communities, namely through mutual engagement, joint enterprise and shared repertoire. In our analysis, we focus on these three constitutive elements of knowledge communities to get to the bottom of knowledge production and epistemic divergence.

Fig. 2.1 illustrates our analytical framework. First, we focus on the joint enterprise of respective communities of practice; that is, an identity defined by a shared domain of interest. We ask: *How is resilience understood, and how was this understanding established over time? How are cities and infrastructures conceptualised? How are research problems framed?* Second, we compare the shared repertoire of the respective communities of practice, namely the development of resources like experiences, stories, tools and ways of addressing recurring problems. We ask: *What kinds of solutions are envisioned to solve identified problems, and what kinds of methods, techniques and instruments are used for knowledge production?* Third, we analyse the mutual engagement within respective communities of practice, viz.

the engagement in joint discussions and the sharing of information. We ask: *Who represents the respective knowledge communities, and how do they organise social and professional interaction and knowledge exchange?* The concepts of epistemic communities and epistemic cultures help us to place knowledge production in the context of governance and policy making and to discuss critically the notion of resilience as a boundary concept.

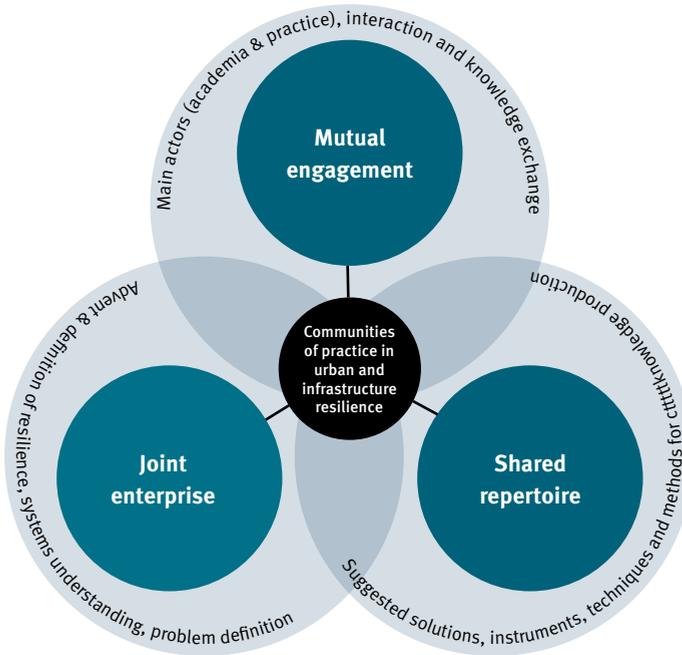


Fig. 2.1 AN ANALYTICAL FRAMEWORK TO COMPARE COMMUNITIES OF PRACTICE IN URBAN AND INFRASTRUCTURE RESILIENCE (OWN FIGURE BASED ON WENGER, 2006, 2008)

2.3 Methodology

To assess the two bodies of literature on urban and infrastructure resilience, we draw on elements of qualitative comparative analysis, which are referred to by Leech and Onwuegbuzie (2008, p. 593), as presenting ‘a systematic analysis of similarities and differences across cases’. More specifically, we analyse and compare existing literature on urban and infrastructure resilience based on the analytical categories developed in Section 2.2. As opposed to quantitative bibliometric surveys, the aim of this qualitative analysis is to generate and refine hypotheses to be tested by future quantitative analyses or empirical case studies.

Throughout the research projects on resilience mentioned in the introduction, we first established a database of international journal publications, books, edited volumes, and research reports using library databases and Google Scholar. Google Scholar was used because it contains no restrictions with regard to the time of publication. The databases were searched for publications containing the key words [urban OR city OR cities AND resilience OR resilient] and [infrastructure OR infrastructures AND resilience OR resilient] and were sorted by relevance. Our inductive approach took the form of a structured snowball process – checking reference lists and indicated key words of the most relevant publications – so consequently we extended and updated our database. Out of approximately 400 references, we identified 122 discrete publications that referred directly to ‘urban resilience’ and 86 references that referred directly to ‘infrastructure resilience’. These cover the period from 1973 to 2017, and more current publications have been added selectively to the analysis in cases where they provided additional evidence.

In order to generate our hypotheses, the literature has been analysed according to the analytical questions developed in Section 2.2. Existing literature reviews (e.g. Bach et al., 2014; Meerow et al., 2016), critical conceptual debates (e.g. GMU, 2007; Pizzo, 2015), and the review sections of empirical papers were especially helpful in answering some of the questions, because they often contain informed judgements about general developments in each respective field. In cases where our questions could not be completely answered by the academic literature, we include grey literature published by select multipliers in our analysis. To wit, we analysed the websites, key publications, and conference programmes and proceedings of international action networks that play a major role in practical application of both concepts. For urban resilience, arguably one of the main players is the Rockefeller Foundation which pioneers the 100 Resilient Cities Programme (100RC) (www.100resilientcities.org). Moreover, the city network ICLEI (www.iclei.org) has established itself as major organisation for knowledge production and dissemination in the field, for instance through their yearly Resilient Cities series (<http://resilient-cities.iclei.org/>). For an overview of players in the field of urban resilience see UN-Habitat (2017). With regard to infrastructure resilience, comparable international organisations have yet not been formed. The International Association of Critical Infrastructure Protection Professionals might come closest as an association aiming at ‘leadership in the domain of critical infrastructure security and resilience’ (www.cip-association.org). Moreover, infrastructure providers are often active in organisations that provide best practice guidelines, link to international standards, and offer opportunities to exchange knowledge in the field of business continuity. Therefore, we selected the Business Continuity Institute (www.thebci.org) as another major source of information.

Working hypotheses based on the comparison were then presented and discussed in regular group discussions within an interdisciplinary group of researchers working on cities and critical infrastructures, including urban sociologists, engineers, political scientists, historians, and philosophers. This gave space to consider diverse ways of interpretation and to include current developments in the respective academic debates. Whilst we acknowledge the limitations that come along with qualitative

literature reviews and the selection of exemplary sources of information (see Haddaway and Macura, 2018 for potential limitations and biases), we are confident that our review covers the main arguments and most prevalent epistemologies in the respective fields. With our results, we want to contribute to the emerging dialogue on knowledge production for urban resilience and to lay groundwork for further representative bibliometric analysis, in-depth case studies and representative surveys of the respective communities of practice.

2.4 Knowledge communities with regard to urban and infrastructure resilience

While resilience was originally used by engineers and physical scientists, ecological scientists have taken up the concept along with systems thinking since the 1960s (Elsner et al., 2018; Lindseth, 2011), prominently advocated by Holling's seminal article (Holling, 1973). Within the plethora of debates that gather under the umbrella of urban and infrastructure resilience, there is significant overlap in both fields of research and practice. Subsequently, the boundaries between urban resilience, infrastructure resilience, climate change adaptation, disaster risk reduction and sustainable development are blurred. However, as we will show in the following sections, both concepts contain specific knowledge elements from their respective communities that rarely address the intricate interlinkage of resilient cities and infrastructures.

2.4.1 Joint enterprise in knowledge communities of urban and infrastructure resilience

Advent of the concepts

It is only since the 1990s that academic debates on urban resilience and their inherent social, institutional and material frameworks have attracted significant attention – mostly as a response to global environmental change (Lu and Stead, 2013, p. 200). In the US, the UK and Japan, manmade and naturally induced disasters – such as 9/11, Hurricane Katrina, and the Japanese earthquakes and tsunami in 2011 – quickly pushed the resilience concept to the top of urban planning agendas, along with a concern that urban systems are ill-equipped for similar future events (Coaffee and Clarke, 2015, p. 250). In mainland Europe, the integration of resilience as a concept in urban planning and policy discourses emerged more slowly and mainly focused on climate adaptation, with a focus on flood risks (Coaffee and Clarke, 2015). The number of fields in which the concept of urban resilience is used has rapidly increased, covering the domains of urban ecology, urban sociology, climate change adaptation and disaster research, as well as development studies (Meerow et al., 2016). The latter developed as a mainstream of urban resilience research focusing on cities in the global South and linking debates on resilience with those on good governance (e.g. Allen et al., 2017). The movement has recently been taken up by international networks such as ICLEI and the Rockefeller Foundation, who are forming networks of knowledge exchange and action programmes.

In the US, critical infrastructure protection evolved as a matter of national security during the Cold War in response to the recognition of societal dependence on critical infrastructures (Collier and Lakoff, 2015). Increasingly, resilience has gained prominence as a concept that stresses the notion of preparedness for infrastructure failures and that acknowledges the character of infrastructures as complex, adaptive systems (GMU, 2007). Coaffee and Clarke (2016, p. 1) argue that the increased acknowledgement of system interdependencies and the risk of cascading failures (Rinaldi et al., 2001) has, over time, resulted in a ‘resilience turn’: a ‘paradigm shift from protective-based risk management towards adaptive-based resilience’ (see also Coaffee, 2013). Coaffee and Clarke (2016) depict a stepwise shift from the protection of technical assets prioritizing robustness and effective response in the aftermath of a crisis to an increased awareness of the socio-technical character of infrastructures, the social impacts of their failure and the role of governance for preparedness and adaptability (see also Bach et al., 2014; Dunn-Cavelty and Suter, 2009). Consequently, the concept was taken up by organisations such as the Business Continuity Institute and the International Association of Critical Infrastructure Protection Professionals in their mission statements and working programmes. Whilst there is a branch of literature on urban resilience of vulnerable urban communities in the global South (e.g. Allen et al., 2017), literature on infrastructure resilience mostly addresses infrastructures in Europe and North America.

Definition of resilience

Olazabal et al. (2012, p. 11), state that urban resilience has been often used as an analytical tool for assessing physical structures, functions, and services in the context of climate change. Moreover, Pizzo (2015, p. 134) argues that urban resilience has often been presented as a politically neutral. Lately, however, the concept has increasingly been exploited in a normative sense by stating that ‘enhancing adaptive capacity should be the overall goal of resilience’ (Klein et al., 2003, p. 43). Existing reviews of academic literature on urban resilience point to the concept’s interpretive flexibility and its increasingly expansive use (Chelleri, 2012; Elsner et al., 2018; Meerow et al., 2016). The concept has been used to address various issues, e.g., social dynamics, metabolic flows, governance networks or the built environment (Chelleri, 2012, p. 300). Moreover, Chelleri (2012) identifies a shift from engineering resilience to socio-ecological resilience, acknowledging the existence of multiple possible equilibria and highlighting the ability of a system to learn, adapt and transform over time (see also Davoudi, 2012). Authors that make use of this understanding often assume that conventional engineering understandings of resilience – emphasising the characteristics of safety, stability and robustness – involve trade-offs with flexibility and hence weaken the resilience of urban environments and communities (e.g. Welsh, 2014, p. 20).

Conventionally, engineering debates in the field of infrastructure resilience have understood resilience as ‘the ability of a system to return to an equilibrium or steady-state after a disturbance’ (Davoudi, 2012, p. 300; Holling, 1973), reflecting a ‘bounce-back’ mentality (Gay and Sinha, 2013; Rogers et al., 2012). Akin to the concept of urban resilience, infrastructure resilience has broadened its meaning. Over time, its initial focus on ideas of robustness, stability, protection and prevention of

failures as well as on quick recovery from crisis has shifted to notions of pro-activity, adaptability and flexibility (Bach et al., 2014), echoing a shift of mentality from *fail-safe* to *safe-to-fail* (Ahern, 2011). This shift stems – at least partly – from work in the social studies of technology, implying a socio-technical understanding of infrastructures (Amir and Kant, 2018; Hommels, 2018) and acknowledging organisational (Hollnagel et al., 2006) and institutional components of infrastructure resilience (Boin and McConnell, 2007; Labaka et al., 2016). However, Yumagulova (2012, p. 22) argues that out of the three dimensions of infrastructure resilience – technological, organisational and institutional – the one that is most exploited in the field is still the technological one.

Systems understanding

Traditionally, urban resilience literature has often conceptualised cities as complex socioecological systems (e.g. Gleeson, 2008; Wagenaar and Wilkinson, 2015). However, the sociotechnical dimension of cityscapes has regularly been neglected. Even as an increasing number of researchers refer to critical infrastructures in their urban resilience frameworks (e.g. Chen et al., 2013; Marana et al., 2018a), they barely acknowledge the material politics inherent in their creation, maintenance and transformation as well as the canalising effects of technologies on urban governance and decision making (Bijker, 2006; Winner, 1980). Only recently, sociotechnical system understandings enter urban resilience debates (e.g. Hommels, 2018) and scholars have combined socioecological and sociotechnical systems (Krumme, 2016). What remains is that urban resilience is often bound to municipal jurisdictions. Whilst some scholars particularly highlight the relationships of cities with other cities (e.g. Harman et al., 2015), or embed cities in a multilevel governance perspective (e.g. Dewulf et al., 2015), Meerow (2016, p. 43) argues that many of them neglect such relational dimensions of urbanity.

In contrast, resilience as portrayed in the reviewed infrastructure debates was traditionally often considered to be mediated by complex technical systems (e.g. Kröger, 2008; Rinaldi et al., 2001). This understanding has been broadened by debates in social studies of technology, which introduce a sociotechnical perspective (Guy et al., 2012). Recently, researchers have even made use of the notion of social-ecological-technical systems to define interdependent infrastructures (Markolf et al., 2018). Whilst users are often still rendered as passive recipients of infrastructure provision rather than as active agents in a sociotechnical system (Bach et al., 2014, p. 7), the criticality of infrastructures is often defined with terms related to the severity in the case of their failure: ‘if disrupted or destroyed, [they] would have a serious impact on the health, safety, security or economic well-being of citizens or the effective functioning of governments’ (Bouchon, 2006, p. 38). With regard to spatial dimensions, the reviewed debates often overlook the particular spatialities of urban centres and their respective social fabrics (e.g. Labaka et al., 2016). However, as the infrastructural crisis in the aftermath of Hurricane Katrina showed, knowledge about place-based vulnerabilities of infrastructure systems as well as of the spatially uneven vulnerabilities of different social groups is of utmost importance in case of technical failure.

Problem definition

The majority of reviewed literature in the field of urban resilience refers to the exposure of cities to climate change, extreme weather events and rising sea levels. Worldwide urbanisation trends and the vulnerability of specific urban places to coastal or river flooding, droughts, and fire hazards is often used as a rationale for urban resilience initiatives (e.g. Johnson and Blackburn, 2014; Klein et al., 2003). Many studies point to the tremendous practical difficulties in implementing resilience ideas in urban planning practices and decision-making (e.g. Coaffee and Lee, 2016). This implementation gap is regularly presented as an urban governance problem, typically characterised by uncertainty and ambiguity (Coaffee and Lee, 2016) as well as a lack of collaboration or citizen and wider stakeholder participation (Goldstein, 2012). Initiatives of ICLEI and the Rockefeller Foundation clearly follow this argumentation and aim at closing this implementation gap.

Research in the field of infrastructure resilience regularly points to threats posed by natural hazards, terrorism, ageing infrastructures and technical failures (Bach et al., 2014; Graham and Thrift, 2007). The rationale for focusing on technical infrastructures is often based on the assumption that modern societies strongly rely on complex and increasingly interdependent infrastructure systems (see e.g. Almklov et al., 2012; Brassett and Vaughan-Williams, 2015). Interdependency, again, increases the risk of cascading effects and the vulnerability of these systems in case of failure (Rinaldi et al., 2001). Increasingly, scholarship on infrastructure resilience frames the challenge of resilience not as a technical issue, but as a governance challenge pointing to fragmented policies and actors in the field (Almklov et al., 2012) or to the exclusion of a wide range of relevant stakeholders in infrastructure decision making (Labaka et al., 2014).

2.4.2 Shared repertoire in knowledge communities of urban and infrastructure resilience

Suggested solutions

The way urban resilience is approached clearly differs across cities and nation states and is shaped by different institutional contexts and planning cultures (Johnson and Blackburn, 2014; Spaans and Waterhout, 2017). However, a significant part of these approaches go together with governmental encouragement of active citizenship, stakeholder engagement, decentralised responsibility and self-organisation (see e.g. Chandler, 2014a). Many are based on multi-stakeholder collaboration and lead in strategy development or master planning (e.g. 100RC). Literature in the field proposes different governance modes as suggested solutions, such as ‘networked governance’ (Jordan and Schout, 2006), ‘governance of complexity’ (Chandler, 2014b) and ‘adaptive urban governance’ (Birkmann et al., 2010b) and often focuses on climate change adaptation as response to climate change impacts (e.g. Birkmann et al., 2010b; Harman et al., 2015).

Whilst urban resilience debates often centre on climate change adaptation, the reviewed literature on infrastructure resilience regularly promulgates an all-hazards

approach that no longer allows assumptions to be based exclusively on knowledge gained from experience (see e.g. GMU, 2007). This viewpoint induces a strong focus on the mitigation of risk and on risk preparedness in engineering systems (e.g. Hollnagel et al., 2006). In addition to this, other solutions have been proposed such as the re-arrangement of institutional settings (de Bruijne and van Eeten, 2007), close linkages to crisis management (Boin and McConnell, 2007), collaborative governance (Labaka et al., 2016), public-private partnerships (Chen et al., 2013) and networked governance (Dunn-Cavelty and Suter, 2009). Moreover, vulnerability mapping is frequently used in national infrastructure resilience strategies – e.g. in the US, the UK and Australia (Collier and Lakoff, 2015). Next to this, national governments often require infrastructure providers and utilities to establish business continuity management – a management approach that identifies potential threats and their impacts on business operations as well as plans and prepares for disturbances and crises (Herbane, 2010). In contrast to vulnerability mapping, business continuity management uses a process-oriented approach that is embedded in business plans and operational strategies. Whilst business continuity management supports the notion of self-reliance, its use in the context of resilience also supports Joseph's (2013) claim that it delegates responsibility from the state to individual infrastructure providers.

Instruments and techniques for knowledge production

In the reviewed debates on urban resilience, knowledge production for climate change adaptation regularly makes use of modelling and simulations of droughts, floods or heat islands to inform planning and development decisions (e.g. Chapman et al., 2013; Gersonius et al., 2016). Moreover, we found numerous examples that made use of site visits, interviews and workshops – often building on local community engagement (e.g. Birkmann et al., 2010b; Lu and Stead, 2013). The programmes and projects in the field frequently develop new tools to analyse, measure or increase resilience, as for example the City Resilience Index of 100RC (Arup and RF, 2015). However, an examination of ICLEI's resilient cities conference programmes and reports since 2010 (available at <http://resilient-cities.iclei.org/>) shows that the need for partnerships with the private sector is only gradually receiving more attention. Moreover, the technological vulnerability of cities is often neglected.

Because the proposed solutions for infrastructure vulnerability often centre on protecting physical systems from external threats, different instruments and techniques of risk assessment are used in the reviewed literature and in practice. They range from risk analyses, threat assessments, vulnerability assessments, and impact assessments (de Bruijne and van Eeten, 2007, p. 22) to interdependency assessments (Rinaldi et al., 2001), probabilistic modelling of cascading failures (Kröger and Zio, 2011) and other modelling and simulation techniques (Huang et al., 2014; Kröger and Zio, 2011). This indicates engineers' and infrastructure managers' ambition to make the future more predictable and to reduce complexity of resilience management. However, as described above, the resilience shift also comes along with a greater acknowledgement of uncertainty and gradually includes strategies of *safe-to-fail* (Bach et al., 2014).

2.4.3 Mutual engagement in knowledge communities of urban and infrastructure resilience

Main actors

Our literature review reveals that urban resilience debates are largely shaped by international organisations (e.g. United Nations), consultancies (e.g. Arup), foundations (e.g. Rockefeller Foundation), city networks (e.g. ICLEI) and the philanthropic sector (see also UN-Habitat, 2017). ICLEI's resilient cities conference series shows that urban stakeholders at the city level predominantly stem from the fields of planning, landscape architecture and environmental policy, and focus on climate mitigation and adaptation, drought and flood risks, storm water, urban heat islands and green infrastructures. Infrastructure providers, network owners and asset managers, however, rarely take part in these urban resilience initiatives.

The reviewed debates in infrastructure resilience are mainly framed by engineers, regulatory governmental agencies, standardisation institutes and consultancies from the fields of engineering (e.g. Siemens Management Consulting). Moreover, infrastructure resilience plays an important role in local and national crisis management (see e.g. Boin and McConnell, 2007). Although a range of public-private partnerships emerged in the field of infrastructure resilience (Dunn-Cavelty and Suter, 2009), close contact and information sharing with infrastructure providers and network owners across sectors seems to be the exception rather than the rule (de Bruijne and van Eeten, 2007). Non-governmental, philanthropic and environmental organisations as well as representatives from city administrations, urban planners and landscape architects are largely absent from respective conferences (see section below).

Interaction and knowledge exchange

Over the last decade, urban resilience has become a buzzword in urban planning and policymaking (Davoudi, 2012, p. 329). The concept has been taken up by urban sustainability networks such as ICLEI, providing links between researchers, activists and local governments. Knowledge production and information sharing on urban resilience takes place internationally at academic, semi-academic and practitioner-oriented conferences and workshops (e.g. ICLEI's annual Resilient Cities series), through the publication of reports (e.g. World Bank Group), or through international programmes such as 100RC. These initiatives regularly promulgate the sharing of best practices and are often linked to academic work in fields such as urban studies (e.g. Spaans and Waterhout, 2017), and sustainability sciences (e.g. Birkmann et al., 2010b), while engineering studies have a rather marginal role.

Communities in the realm of infrastructure resilience meet, for example, at annual conferences such as Critical Infrastructure Protection and Resilience Europe (www.cipre-expo.com) or its counterpart Critical Infrastructure Protection and Resilience Americas (www.ciprna-expo.com). These conferences are strongly shaped by debates on civil protection and homeland security, and the main groups of participants stem from government agencies as well as private companies in the security sector and some security-related researchers. Informal networking and

partnering approaches are not as popular in the field of infrastructure resilience compared to that of urban resilience. An exception can be found in Lloyd's Register Foundation's 'The Resilience Shift' (www.resilienceshift.org). However, up to today, formal policymaking at the national level (strategic) and corporate decision making of infrastructure providers (operational) seem to play a more prominent role.

2.5 Discussion

Our analysis discloses that knowledge elements of both communities of practice intermingle, and mutually shape each other. For instance, the field of infrastructure resilience increasingly makes use of collaborative governance approaches. However, it became apparent that there are a range of prevalent understandings and beliefs that dominate debates in the respective fields. These dominant viewpoints are condensed in the following Tab. 1. The table shows first that the concepts of urban and infrastructure resilience are rooted in different histories, use the term resilience in different ways and have discrete systems understandings. This leads to diverging problem definitions, which can create knowledge boundaries between the respective communities. Second, urban and infrastructure resilience debates centre on distinct ideas to solve problems and make use of distinct sets of instruments and techniques to produce knowledge. Consequently, dissimilar understandings and visions of the future emerge, which further amplify epistemic divides. Third, concepts of urban and infrastructure resilience develop within largely separated knowledge communities composed of particular experts who interact and share their knowledge within specific venues and with limited overlap. This fosters intrinsic views confined to specific objects of resilience and constrains cross-boundary learning by inducing certain path-dependent learning practices. As Wenger argues, 'shared practice by its very nature creates boundaries' (2000, p. 232). When separated, different knowledge communities are likely to devalue each other, particularly if there is no direct contact between them (Albert et al., 2008).

Variable	Operationalisation	Urban resilience	Critical infrastructure resilience
Common enterprise	<i>Advent of the concepts</i>	<ul style="list-style-type: none"> - US/UK: originally disaster focused - Europe: focus on climate change adaptation and flood risks - Amplification of use due to natural disasters (Katrina, Sandy) 	<ul style="list-style-type: none"> - Homeland security focused - From protection to resilience of critical infrastructures - Widened understanding of critical infrastructures by highlighting their sociotechnical character
	<i>Definition of resilience</i>	<ul style="list-style-type: none"> - Socio-ecological/evolutionary understanding of resilience - Focus on adaptability and transformation 	<ul style="list-style-type: none"> - Engineering/sociotechnical understanding of resilience - Focus on stability, protection, prevention, and recovery
	<i>Systems understanding</i>	<ul style="list-style-type: none"> - Cities as complex socio-ecological systems - Starting use of a social-ecological-technical system understanding - Focus on spatial scope of municipal jurisdictions 	<ul style="list-style-type: none"> - Critical infrastructures as complex sociotechnical systems - Starting use of a social-ecological-technical system understanding - Focus on spatial scope of (interconnected) technical networks
	<i>Problem definition</i>	<ul style="list-style-type: none"> - Global environmental change, anthropogenic and natural hazards - Urbanisation - Focus on socio-ecological issues in the cityscape - Social inequality and/or lack of democracy/participation - Urban governance issues 	<ul style="list-style-type: none"> - Natural hazards, terrorism, ageing infrastructure, vulnerability of complex, interdependent systems - Increasing reliance on complex, interdependent systems - Focus on material and technical issues and on interdependences - National regulation; emphasis on public-private partnerships
Shared repertoire	<i>Suggested solutions</i>	<ul style="list-style-type: none"> - Climate change adaptation - Participatory planning, community engagement, informal cooperation - Strategy development - Master planning 	<ul style="list-style-type: none"> - All-hazard approach - Focus on risks - Mitigation, preparedness - Regulation - Business continuity management - Public-private partnerships
	<i>Instruments, techniques and methods for knowledge production</i>	<ul style="list-style-type: none"> - Drought/flood/heat island simulations - Resilience analysis tools (quantitative and qualitative) - Empirical research making use of case studies, site visits and workshops 	<ul style="list-style-type: none"> - Risk assessments (risk analysis, threat assessment, vulnerability assessment, impact assessment, interdependence assessment) - Empirical research making use of modelling and simulation techniques
Mutual engagement	<i>Main actors (practice)</i>	<ul style="list-style-type: none"> - Local governments (urban planning, landscape architecture, environmental policy) - International organisations - Philanthropic sector - Consultancies 	<ul style="list-style-type: none"> - National governments (civil defence, infrastructure policies) - Infrastructure providers/network owners - Consultancies, security service providers
	<i>Main actors (academia)</i>	<ul style="list-style-type: none"> - Urban studies - Planning and geography - Environmental studies 	<ul style="list-style-type: none"> - Engineering sciences - Science and technology studies - Increasingly planning and geography
	<i>Interaction and knowledge exchange</i>	<ul style="list-style-type: none"> - Ample informal interaction - City networks - Reports/rankings - Academic/semi-academic conferences - Sharing of best practices 	<ul style="list-style-type: none"> - Little informal interaction - Special purpose conferences (e.g. security) - Special purpose projects (e.g. interdependence modelling)

Tab. 2.1 COMPARING PREVALENT KNOWLEDGE COMMUNITIES IN URBAN AND INFRASTRUCTURE RESILIENCE (SOURCE: OWN FIGURE)

The above table may depict differences between urban and infrastructure research and practice in a highly condensed and schematic manner without acknowledging the full scope of existing interfaces and in-between conditions. Moreover, the qualitative review based on selective sources is by far not representative. However, our study indicates that divides in major elements of knowledge production do not solely entail particular implications for distinct conceptual perspectives but also for distinct governance approaches of cities and infrastructures. Following Haas (1992), policy-relevant knowledge produced in expert communities has a considerable influence on policymaking. Accordingly, it can be assumed that a range of infrastructure resilience strategies, business continuity plans, and national regulations are rooted in the idea of protecting physical assets and downplay their entanglement with social and natural systems or other key characteristics of resilience described in urban resilience debates, such as adaptability and transformative capacity. Although local crisis management may be inherently responsible for some infrastructural aspects, it is often restricted to reactive measures and lacks authority in preventive approaches (cf. Monstadt and Schmidt, 2019). What remains, then, are infrastructure resilience strategies at national levels and business continuity plans of individual infrastructure providers. This seems problematic, as they reinforce the dichotomy between nation-states being held responsible for providing protection strategies and cities being directly affected by potential infrastructure failure due to their geographic location as physical nodes in infrastructural flows. At the same time, as Hommels (2018) describes, governance attempts to approach urban resilience might recognise the importance of technical infrastructures for the functioning of the city but still substantially lack the authority and technical knowledge to address the interdependencies of different infrastructure domains and the risks of cascading failures beyond municipal territories.

A range of researchers have picked up on these kind of discrepancies and argue that urban resilience requires a ‘multidisciplinary theory that integrates and coordinates a variety of city dimensions such as critical infrastructures, society, economy and environment into a unified conceptual framework’ (Marana et al., 2018a, p. 40). The recent use of notions like social-ecological-technological systems for defining cities and infrastructures (e.g. Krumme, 2016; Markolf et al., 2018) might point to first interfaces between both fields of research. Moreover, there is a range of academic work at the intersection of urban and infrastructure resilience. For example, Jon Coaffee and colleagues (Coaffee and Clarke, 2016; Coaffee and Lee, 2016) understand resilience as applying to cities and infrastructures at the same time; Hommels (2018), Graham (2010a) and Medd and Marvin (2005) approach infrastructure resilience particularly at the urban level; and Monstadt and Schmidt (2019) approach particular urban governance challenges of infrastructure resilience. In addition, initial attempts to combine urban and infrastructure resilience initiatives in practice have been made. For instance, the Rockefeller Foundation’s ‘100 Resilient Cities’ programme integrates infrastructures in their urban resilience framework (Arup and RF, 2015), and partners with Ernst & Young to examine why urban governments neglect resilience thinking in their infrastructure strategies (100RC and EY, 2017).

Nevertheless, it seems that such approaches are still rare and often lack sufficient conceptual foundations in academic debates. Whilst both communities refer to the concept of resilience, there are considerable epistemic differences that manifest in social practices and the governance of cities and infrastructures and ultimately undermine the effectiveness of the respective resilience strategies. Following the notion of epistemic cultures, it can be argued that resilience has not yet kept its promise to serve as a boundary concept in the sense of linking different machineries of knowledge production and allowing ‘groups to coalesce and form stable, if transitory, working relationships’ (Kimble et al., 2010, p. 440). Here, the ambition cannot be to realign the boundaries between, or even to merge, different epistemic communities with genuinely different and partially incommensurable perspectives. Rather, our analysis points to the need for more interaction and mutual learning of both epistemic communities’ enterprise and repertoire to enable coordinated action despite remaining differences.

2.6 Conclusion

— This paper shows that the notions of epistemic cultures, epistemic communities and communities of practice can provide means to critically reflect on the character of resilience as a boundary concept. They can broaden our understanding of the relationship between knowledge and practice, and they can help us to analyse specific sub-discourses and how they each shape practical divides in social practices and in the governance of cities and infrastructures. Kastenhofer (2007, p. 363) argues that cultural change can result in strengthened cooperation patterns between different knowledge communities. Along the lines of our three comparative dimensions, we now provide some food for thought concerning how this could be approached.

First, urban and infrastructure resilience debates may benefit from a broader understanding of the term ‘resilience’ that equally applies to socio-technical as well as to socio-ecological dimensions. This understanding should also focus on potential trade-offs that might exist between certain resilience capacities such as flexibility and robustness and find ways where such capacities can complement or replace each other. In this sense, infrastructure resilience debates might benefit from the insights of place-based social vulnerabilities and locally specific discretions, as much as urban resilience debates might benefit from acknowledging the role of networked infrastructures for urban flows and societal resilience. This does not require any stakeholder to abandon a previously held position or understanding of resilience but rather to widen perspectives by actively seeking positive trade-offs and synergies. 100RC displays a proactive step in this direction by combining social and infrastructural resilience principles in their framework (Arup and RF, 2015). However, as Hommels (2018) shows, linking social and technical resilience faces enormous challenges in today’s institutionally fragmented governance frameworks.

Second, the repertoire of urban resilience research and practice could benefit greatly from modelling, simulation and calculation of destructive scenarios of infrastructure

failures and from a stronger collaboration with the private sector. Place-based infrastructure resilience strategies and business continuity management plans may well inform community resilience programmes regarding where and when certain measures are needed in a crisis situation. Vice versa, the infrastructure resilience repertoire could benefit from collaborative governance approaches and stakeholder participation mechanisms, from including the users' view in infrastructure resilience action and from improving cross-sector cooperation and the co-production of knowledge. Meaningful links between multi-stakeholder collaboration and business continuity management approaches could further contribute to better coordinate urban and infrastructure resilience strategies. This does not mean that knowledge elements of both communities should merge into a single repertoire. On the contrary, conflicting interests and world views of actors may be very important as a source of inspiration and innovation. However, it requires institutional frameworks that stimulate and enable multilateral learning and interaction.

Third, in order to engage in cross-boundary learning and knowledge sharing, members of both knowledge communities may benefit from cross-boundary resilience research and practice in the sense of mutual engagement across rather than within communities of practice. For instance, in Europe, some action-research projects, funded by the EU³, include actors from both knowledge communities and provide opportunities for experiential learning, experimentation and the co-production of new knowledge. They might provide means to allow both epistemologies to bring in their strengths and develop new ways of defining problems and understanding reality. However, their success needs to be measured not only at an incremental project-based level. Equally important are changes in design guidelines, regulations, policies and laws to shape broader urban development and infrastructure management practices beyond individual projects.

The establishment of a common playing field of epistemic communities in urban and infrastructure resilience depends significantly, however, on further empirical research to test and elaborate the initial findings presented in this paper. Future research in the form of comprehensive bibliometric literature reviews, representative and quantitative surveys of communities of practices in both fields or in-depth case studies should be used to validate these results.

3 These include projects like SMR RESIN (<http://smr-project.eu/home/>), and RAMSES (<http://www.ramses-cities.eu/home/>).

3

TOWARDS RESILIENT ROTTERDAM? KEY CONDITIONS FOR A NETWORKED APPROACH TO MANAGING URBAN INFRASTRUCTURE RISKS

Abstract

Critical infrastructures are increasingly recognised to be playing important roles in urban resilience theory and practice. However, little is known about which governance challenges result from making them an integral part of urban resilience policies and what role city administrations play or could play in the resulting governance arrangements. We address these shortcomings in the scholarly literature by analysing the case of the Dutch city of Rotterdam, which has positioned itself as a frontrunner with regard to urban resilience. We find that the city administration is limited in its authority and depends on decisions made by other public and private actors, particularly those relating to the integrated management of interconnected infrastructure networks such as those for water and energy provision. We therefore argue that institutionalising resilience will strongly depend on city administrations' institutional capacity to manage networks more effectively. For this, we derive key conditions for institutional adjustments in current governance arrangements. Necessary adjustments include redefining roles and responsibilities for cross-territorial risk management, cross-sectoral and cross-departmental budgeting of resilience measures, and integrating local actions and measures with those at regional and national levels of government. Our conclusions call for national and supranational legal reforms to establish uniform procedural rules for urban risk management and contingency planning to provide guidance for municipalities on how to enhance the resilience of their cities and infrastructures.

Published as

Huck, A., Monstadt, J., Driessen, P. and Rudolph-Cleff, A.: Towards resilient Rotterdam? Key conditions for a networked approach to managing urban infrastructure risks, *Journal of Contingencies and Crisis Management* (Early View)⁴.

<http://doi.org/10.1111/1468-5973.12295>

3.1 Introduction

During recent decades, awareness of urban vulnerabilities to technical infrastructure failures has steadily increased (Graham, 2010a; Linkov and Palma-Oliveira, 2017). In this context, critical infrastructures are often conceptualised as interdependent socio-technical systems where physical artefacts such as sewers and power generators interact with organisational and institutional arrangements (Guy et al., 2012). Critical infrastructures are usually defined as assets or systems that are essential for the maintenance of vital societal functions and whose disruption or destruction would have a significant negative impact on a society's health, safety, security and economic or social well-being (EU, 2008). In this study, we focus on urban infrastructures at the interface of water and energy provision. These systems are of particular importance because they mediate flows of goods and services that shape the character of today's networked cities (Chen and Chen, 2016). Because cities are geographical nodes of these flows and have dense populations, they are explicitly vulnerable to infrastructure failures (Monstadt and Schmidt, 2019). At the same time, urban crisis management highly depends on their seamless functioning (Fekete and Fiedrich, 2018). Hence, the ability to prevent and to prepare for infrastructural failures is undeniably a major component of a resilient urban system.

Resilience, as a new 'policy narrative' for urban development (Béné et al., 2017), creates a new understanding of risk that highlights the need to break up existing policy silos, combat fragmentation and to establish multi-level, multi-sector and cross-territorial working relationships (Matyas and Pelling, 2014). However, urban scholars have noted that there is no consensus about how urban resilience should be institutionalised in current governance systems (Chandler and Coaffee, 2017b; Coaffee et al., 2018). In addition, the scholarly literature on urban resilience tends to address cities as a bounded 'container space' and to neglect the multi-scalar dimensions of infrastructurally mediated flows connecting cities closely to their rural hinterlands, neighbouring municipalities and other cities worldwide (Huck and Monstadt, 2019; Monstadt and Schmidt, 2019). Whilst municipalities and their administrations are often held responsible for developing and implementing resilience strategies and plans, they play different roles with respect to critical infrastructures. They regulate and partially own infrastructure systems such as those for wastewater management. At the same time, they are responsible for crisis and risk management to ensure their citizens' protection and safety. This latter role implies negotiation and coordination with other private and semi-private infrastructure providers, network owners and other actors with responsibilities for crisis and risk management. Yet city administrations' role for the integrated management of critical infrastructures and the required conditions for effective network management remain largely unaddressed in the current literature. To address this void, we ask the following main research question: *Which key conditions are required for effective network management for enhancing urban infrastructure resilience?*

To answer the research question, we analyse existing and missing links between actors in the interface between urban development and infrastructure management in

the city of Rotterdam: a city that has positioned itself as a frontrunner and innovative test bed for climate change adaptation by promoting demonstration projects such as floating pavilions and water retention basins (Gemeente Rotterdam, 2014). Accordingly, the city has received widespread scholarly recognition for its experimental approach to water-sensitive urban design and for its pioneering role in urban resilience (Dunn et al., 2017; Lu and Stead, 2013). Rotterdam's active role in various networks such as 100 Resilient Cities, ICLEI and C40, testifies to its great awareness of issues of resilience and climate adaptation.

For exploring certain governance challenges in Rotterdam, data gathering was primarily based on 26 semi-structured expert interviews. The interviews were conducted between October 2017 and May 2019, which allowed us to track relevant projects and actions of key actors over a longer period of time, rather than to obtain a snapshot of a situation. Interviewees included civil servants, senior advisors and consultants, strategic decision-makers from public and private sectors and senior academics with in-depth knowledge of Rotterdam's resilience policies. We selected interviewees from the planning, maintenance and water departments within the city administration as well as from governmental bodies at the regional and national level such as the safety region, the Rijkswaterstaat or the Ministry of Infrastructure and Water Management. In addition, we selected senior managers working on security-related issues and business continuity employed by private or public-private infrastructure providers or by owners of networks for water and energy provision such as Stedin and Evides. Appendix 1 lists interviewees, their affiliation and the main topics of discussion. We used Qualitative Content Analysis (Gläser and Laudel, 2013) to categorise and distil relevant information from the coded interview transcripts. The codes we allocated referred to governance challenges we identified in multi-level, multi-sector and cross-territorial risk management of critical infrastructures and to what we considered to be the city administration's possibilities and limitations to respond to these governance challenges. Our preliminary findings were discussed with selected interviewees to collect further evidence and to confirm our conclusions. For the same reason, a draft of this paper was sent to all interviewees for comments before submission. For deriving key conditions for a networked approach to managing infrastructure risks, we triangulated our interpretation of the experts' perspective with research on scholarly and grey literature, including policy documents, plans and strategies.

In the following section we lay the basis for our analysis by engaging with the literature on the governance of urban resilience and critical infrastructures. Here we develop an understanding of governance challenges as specific mechanisms and institutional constraints that impede actors' collective action to contribute to realising certain policy objectives. In Section 3.3, we analyse ongoing project work and policy making in Rotterdam, focusing on the city's resilience strategy as well as on risk management for critical infrastructure systems. From the statements of the interviewed experts', we identify specific governance challenges that arise when critical infrastructures become an integral part of urban resilience policies. In addition, we analyse how civil servants in Rotterdam address these challenges. Based on the results of our analysis, in Section 3.4 we derive some key conditions for effective network management of

mutually dependent actors responsible for operating critical infrastructures. In Section 3.5, we conclude that municipal administrations such as Rotterdam find themselves in a position of having ‘responsibility without power’ (Peck and Tickell, 2002, p. 386) because effective network management requires institutional reform that extends beyond their administrative jurisdiction.

3.2 Institutionalising urban resilience as a governance challenge

— Whilst definitions of urban resilience may differ from city to city (Spaans and Waterhout, 2017) and across academic debates (Huck and Monstadt, 2019), the following definition provides a general and encompassing elucidation:

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. 39)

As Matyas and Pelling (2014) argue, resilience can be imbued with greater analytical depth by elaborating on particular resilience capacities as distinct – although not discrete – options for decision-making and risk management. A literature review reveals three main strains of thought highlighting distinct resilience capacities that are relevant for cities and their infrastructure systems (cf. Hegger et al., 2016): *Resistance* describes the capacity of a city and its citizens to resist shocks and stresses. *Recovery* accounts for the capacity to absorb and recover from shocks and stresses. *Adaptability* refers to the capacity to adapt, learn and transform. By making public its resilience strategy (Gemeente Rotterdam, 2016), the city administration of Rotterdam has assigned itself an active role in enhancing such capacities. However, issues such as the risk management of interdependent infrastructure systems constitute new ground for urban policy making in the city (Hommels, 2018).

Originating from the realm of homeland security in the US, critical infrastructure protection gained recognition in security-related policy discourses in Europe and in other parts of the world at the beginning of this century (Bach et al., 2014; Collier and Lakoff, 2015). Scholars have highlighted infrastructural interdependencies and potential cascading failures that cross sectoral and spatial boundaries (Rinaldi et al., 2001). The assumption is that modern infrastructures are composed of tightly coupled systems in which the failure of a single system component, or failures at a limited geographical scale, can cause the failure of an entire system as well as of a functionally interdependent system of systems (Kröger and Zio, 2011). Moreover, exogenous risks (for instance, related to climate change), may be amplified by the increased complexity and interconnectivity of different infrastructure systems (Bollinger et al., 2013). Seager et al. (2017) argue that the amplification becomes even more severe when failures cross ownership, operational and regulatory boundaries.

If relevant actors and organisations have never established working relationships, insufficient interorganisational communication and coordination in the time-sensitive management of acute crises can considerably amplify cascading infrastructure failures. Consequently, some authors (Hokstad et al., 2012; Linkov and Palma-Oliveira, 2017; Perrow, 1994) have advocated taking account of infrastructural interdependencies in risk management practices which require there to be working relationships among the multiplicity of stakeholders involved in infrastructure governance (Bach et al., 2014), including public, private and semi-public actors (Dunn-Cavelty and Suter, 2009).

Only recently have scholars of urban resilience taken up these debates (Huck and Monstadt, 2019). For instance, Chang et al. (2014) outline the vital importance of a shared understanding of regional infrastructure disruption for disaster-resilient cities. In addition, Monstadt and Schmidt (2019) point to the importance of considering functional interdependencies of critical infrastructure systems when institutionalising urban resilience. Because urban threats and stresses are triggered by – or accelerated through – the growing complexity and interconnectedness of technical, social and ecological systems, urban scholars call for adaptive and networked forms of urban governance (Crowe et al., 2016; Ernstson et al., 2010). It is very unlikely that any one actor or actor group can design and implement resilience policies alone. Rather, scholars in the field of urban and infrastructure resilience seem to agree on the need for actors to work together across administrative, sectoral and territorial boundaries in a more strategic way (Almklov et al., 2012; Boin and McConnell, 2007; Coaffee and Clarke, 2016; Godschalk, 2003; Padt et al., 2014). Hence, it is necessary to establish new working relationships between actors that have previously worked separately, or to rearrange working relationships of incumbent stakeholders whose interests, goals and strategies might be at odds with each other (cf. Scharpf, 1978). This is in line with Klijn and Koppenjan's (2016, p. 11) concept of *network management*, which entails establishing 'more or less stable patterns of social relations between mutually dependent actors'. Against this background, institutionalising urban resilience refers to the consolidation of adaptive and networked governance arrangements to enhance resilience capacities (cf. Folke et al., 2005; Jordan and Schout, 2006).

To operationalise our analysis, below we explain some key terms.

Firstly, *institutions* can be understood as the 'rules of the game named governance' which structure the roles and guide the interactions of different actors (Hohn and Neuer, 2006, p. 294). In this context, *actors* are those that have the power and resources to contribute to realising certain policy objectives or, conversely, to prevent others from doing so. They compose a sub-group of the wider group of stakeholders who have a stake or interest in the decision-making process (Hegger et al., 2014, p. 4131). Importantly, institutions can be either formal (e.g. written laws, regulations or standards) or informal (e.g. working routines, traditions or established epistemologies) (North, 1990). As such, institutions in socio-technical infrastructure systems can range from laws and regulations on water provision to standards on disaster risk management, and from established working routines of infrastructure providers to traditional epistemologies of certain professionals like risk contingency managers or

planners. A number of scholars argue that some sort of institutional reform is required to cope with and adapt to the increasing digitalisation, privatisation and globalisation of critical infrastructure networks and services and to emerging risks such as those imposed by climate change (e.g. LaPorte, 2007; Zaidi and Pelling, 2015).

Secondly, *governance arrangements* can be defined as institutional constellations resulting from the interplay between state and non-state actors involved in relevant policy domains (definition adapted from Hegger et al., 2014, p. 4131). Governance arrangements for interdependent critical infrastructure systems are characterised by a complex web of public and private actors such as different municipal departments, regional planning authorities and national or international regulators, private and semi-private network owners and service providers and consumers, and producers of infrastructure services. Consequently, public–private partnerships receive considerable attention in governance debates on critical infrastructures (Dunn-Cavelty and Suter, 2009). Often, these governance arrangements are described as being fragmented and thus limit the collective action of the various relevant actors that would be required to manage the cascading effects of failing infrastructure networks (de Bruijne and van Eeten, 2007). Interestingly, the urban level of infrastructure management and the particularity of urban vulnerabilities to infrastructure failure has received only minor attention in the literature on critical infrastructures (Huck and Monstadt, 2019). Moreover, the particular role of municipal administrations in these risk governance arrangements has so far seldom been discussed.

Thirdly, if critical infrastructures are an integral part of urban resilience policies, their fragmented management can be seen as a major governance challenge for institutionalising urban resilience (Monstadt and Schmidt, 2019). From this it follows that *governance challenges* can be defined as those mechanisms and institutional constraints that impede actors' collective action to contribute to realising certain policy objectives. When enquiring about the potential role of a city administration for institutionalising urban resilience, we therefore have to enquire about the capacity they have to perpetually overcome particular governance challenges and to initiate institutional reform. In this sense, institutionalising urban resilience requires strategic action and long-term thinking (Godschalk, 2003). Whilst explicit governance challenges have already been defined for certain fields such as flood risk management (Dieperink et al., 2016) and the nexus of spatial planning and disaster risk management (Sapountzaki et al., 2011), to our knowledge this is not the case for the integrated management of critical infrastructure systems at the urban level. In order to identify certain governance challenges in Rotterdam, we reveal three analytical dimensions of institutional fragmentation gleaned from the literature:

- *Horizontal fragmentation* refers to the multi-sectoral character of infrastructure management. It is argued that disconnects between relevant policy domains (e.g. emergency management, environmental management, urban planning, and infrastructure management) or between relevant infrastructure sectors and their relevant private-public and private stakeholders impede collective action to achieve urban and infrastructure resilience (e.g. Almklov et al., 2012; McPhearson et al., 2015; Medd and Marvin, 2005).

- *Vertical fragmentation* concerns issues of multi-level governance where local, regional, national, and international policy making is not sufficiently synchronised (e.g. Adger et al., 2005; Dewulf et al., 2015; Vedeld et al., 2016). Equally important are mismatches between the policy level where the problem arises and the level where policies to tackle it are formulated (Padt et al., 2014).
- *Territorial fragmentation* relates to the misalignment of neighbouring or otherwise connected territories which might become an issue because infrastructure networks cover dissimilar territories and threats or failures might easily cascade between them, requiring action to be taken far away from the places where the initial problem arose (Chelleri et al., 2015; Coaffee and Clarke, 2016; Ernstson et al., 2010).

3.3 Rotterdam's governance challenges in institutionalising urban resilience: an infrastructural perspective

With over 600,000 residents, Rotterdam is the second largest city in the Netherlands. The city is part of the densely populated Randstad metropolitan region and is close to The Hague, which is the seat of the Dutch government. Its location in the Rhine–Meuse–Scheldt river delta accounts for the city's fundamental role in the Dutch economy, as it hosts Europe's largest cargo port, accounting for 6.6% of the national GDP (Port of Rotterdam Authority, n. d.). However, it also explains the city's vulnerabilities to risks induced by climate change, such as rising sea levels and heavy rain events. Since approximately 80% of the city is below sea level, urban life in Rotterdam heavily depends on protection mechanisms such as dikes and storm surge barriers, as well as on a system of drainage ditches, canals and pumping stations to keep the city dry. In turn, this system depends on electricity and communication (including internet), which makes it vulnerable to power outages and cyber attacks.

In 2016, Rotterdam released the Resilient Rotterdam Strategy (hereafter: resilience strategy), which developed from the idea to position climate adaptation challenges in a resilience framework (Hommels, 2018, p. 274) and at the same time to better connect existing initiatives on social cohesion, climate adaptation, infrastructure management and cyber protection (Interview 4). Rotterdam is the first Dutch city to have developed such a comprehensive resilience strategy and to have financed specific resilience personnel such as the Chief Resilience Officer. Some authors therefore describe Rotterdam as being at an advanced stage with respect to institutionalising urban resilience (Lu and Stead, 2013; Spaans and Waterhout, 2017). However, this also means that the city can hardly fall back on role models elsewhere, for example for exploring new policy areas such as the integrated risk management of interdependent infrastructures in urban areas.

Clearly, infrastructure resilience involves not only sectoral planning and regulation (e.g. for water and electricity) but also issues of spatial planning, asset management, civil protection and physical safety. Moreover, incumbent actors at other governmental levels as well as private and semi-private infrastructure providers and network owners play important roles in the governance of critical infrastructures and hence in institutionalising urban resilience. For instance, the Province of South Holland's core tasks refer not only to spatial planning but also to environmental management and regional public transport. Regional electricity provider Stedin closely depends on national network provider Tennet but is also regulated by the Ministry of Economic Affairs. Regional water provision is organised by the semi-private company Evides and regulated by the Ministry of Infrastructure and Water Management. Wastewater management and regional flood defence are planned by regional water authorities (*waterschappen*). The port of Rotterdam as a major transportation and logistics hub is managed by the port authority (*Havenbedrijf Rotterdam*). Cross-cutting risk and crisis management is regulated by the Ministry of Justice and Security, which also has under its aegis the national counterterrorism agency (National Coordinator for Security and Counterterrorism, known by its Dutch abbreviation NCTV) responsible for the overall resilience of Dutch critical infrastructure (NCTV, n.d.). Whereas emergency and crisis management in the Netherlands are a local responsibility, municipal executives are grouped into so-called safety regions (*veiligheidsregios*). The Rotterdam–Rijnmond safety region covers Rotterdam and 14 neighbouring municipalities, the harbour of Rotterdam and Rotterdam The Hague Airport. Some of the tasks of the safety region are to prepare an integrated risk profile for the region and to coordinate different stakeholders – including infrastructure providers and emergency services – in times of emergency (for more details on the role of the safety region see Prins et al., 2012).

3.3.1 Coordinating policy and infrastructure domains in Rotterdam

— With regard to institutionalising resilience, our analyses reveal that Rotterdam is characterised by some degree of horizontal fragmentation which becomes visible in issues of cross-departmental cooperation within the municipality as well as in problems of cross-sector cooperation and coordination across different infrastructure sectors.

Anchoring resilience thinking in the municipality

As a member of 100 Resilient Cities, Rotterdam has made use of a standardised process to develop a resilience strategy, including broad stakeholder involvement. Interviewees from the municipality perceived this process as highly beneficial because through it they made new contacts and discovered unknown interdependencies with other departments of the city administration (Interviews 4, 8). However, shortly after the strategy was released, cross-departmental collaboration declined, because most of the defined projects were allocated to different departments in the city (Interview 22). 'Anchoring resilience thinking' at the strategic decision-making level in the municipal administration remains a challenge for the resilience team consisting of the Chief Resilience Officer and two civil servants, (Interviews 4, 22).

Our analyses reveal three main governance challenges that hamper greater cross-departmental cooperation and collective resilience action. Firstly, an external observer identified relatively rigid epistemic traditions within the individual municipal departments (Interview 15). This respondent argued that the same people who were responsible for climate adaptation planning are now responsible for the resilience strategy, which may lead to climate change issues being given preferential treatment compared with other resilience matters and that friction might arise if the resilience team starts to interfere in issues that were previously managed by other people. Secondly, an interviewee argued that cross-departmental cooperation remains challenging as long as the municipal budget is allocated in a departmental way (Interview 22). Thirdly, a lack of political support for urban resilience as opposed to other municipal programmes such as those promoting the energy transition or circular economy was identified (Interviews 22, 24). An interviewee from 100 Resilient Cities even argued that the resilience strategy competes directly with these programmes with respect to which future vision will gain political support (Interview 18).

To respond to these challenges, the resilience team opted to exploit the possibilities of linking resilience goals to the existing goals of other municipal programmes and to concentrate efforts on selected pilot and demonstrator projects (Interview 22). This strategy caused other interviewees (Interviews 2, 15) to criticise the rather informal and non-binding character of the resilience strategy. Moreover, one interviewee argued that Rotterdam runs the risk of cross-departmental cooperation lasting only as long as project funding and therefore having to be re-established when the next project starts (Interview 1).

Issues of cooperation and coordination across different infrastructure sectors

Although interviewees report there are well-established governance arrangements to coordinate and cooperate within single infrastructure sectors, they identify an institutional void with regard to infrastructure providers' joint responsibility for risk management (Interviews 6, 7, 13, 14). Infrastructure providers focus most of their attention on internal contingency management and use internal preparedness strategies that are insufficiently communicated to or coordinated with other providers or municipal planning and crisis management. In fact, at municipal level, there is no coordinating body that aligns different sectoral approaches, detects infrastructure interdependencies or defines critical infrastructures at city level. Consequently, infrastructure providers like Stedin or Evides take little part in discussions on urban resilience in Rotterdam (Interviews 8, 9, 11), neither are municipal actors involved in internal risk and contingency management of infrastructure providers (Interviews 7, 13).

Again, interviewees highlighted the challenges that accompany diverging and relatively rigid epistemic traditions of different actors. For instance, it was mentioned that public and private organisations still lack a shared understanding relating to risk and contingency management (Interviews 8, 9, 11, 19, 21). Whereas for infrastructure providers like Stedin or Evides the paramount concern is to protect the physical system from damage, the municipality focuses on the safety of its citizens. Moreover, public flood risk management can be described as moving from a purely protectionist approach to a more adaptive one (Francesch-Huidobro et al., 2017), thereby

considerably increasing cooperation between the municipality of Rotterdam, the water authorities and the regional environmental protection agency (Spaans and Waterhout, 2017). However, several interviewees noted that infrastructure providers did not necessarily undergo the same cultural change process and were still focusing their attention on protection measures rather than on adaptation potential (Interview 15), with each provider *'focusing on their core business'* (Interview 13). In addition, representatives from network providers argued that interdependencies are very hard to manage because cross-sector cooperation is very time and resource intensive as it involves understanding the other's culture, strategic logic and rationale. As such, the absence of an obligation to invest in cross-sector initiatives and the lack of dedicated budget to promote them is hampering cooperation and coordination across different infrastructure sectors (Interviews 7, 13, 15).

Interestingly, Stedin, Evides and the municipality of Rotterdam maintain very close relationships, as evidenced by the agreement they have entered into to coordinate their maintenance of the city's underground infrastructure (Interview 9). Not only is it more cost-efficient to bundle operations in the underground, it also reduces the risk of damaging other infrastructure networks while digging and it reduces traffic disruption and the need to cut off services to residents. Having a common goal (i.e. cost efficiency in replacement and repair) has made it possible to build stable working relationships between public and private partners. However, the cooperation is restricted to asset management and it is not planned to include continuity management or strategic risk management in the near future (Interview 23).

3.3.2 Multi-level governance for infrastructure resilience

— Although the NCTV is making slow progress in identifying cross-sector interdependencies at the national level (Interview 19), interviewees mention missing an information flow to the regional and local levels (Interviews 19, 26). There seem to be very limited possibilities for Rotterdam to contribute to national projects in this policy domain; neither are national ministries part of resilience discussions in the city. Even more surprisingly, we found limited cooperation between the safety region and the municipality of Rotterdam in urban resilience and infrastructure management, although their expertise in risk management would be beneficial for future-oriented planning (Interviews 8, 11, 26).

The main challenge to increasing the information flow from the NCTV to lower levels of government is apparent from the regulatory frameworks and existing contracts with infrastructure providers that prohibit data sharing (Interview 19). Although safety regions struggle to obtain information from private infrastructure providers (Interviews 11, 26), the NCTV is often not allowed to provide them with specific information – e.g. on the location of specific vulnerable assets (Interview 19). In addition, there is still uncertainty about who is actually responsible for issues of cross-sector infrastructure resilience and at what level of government (Interviews 11, 19, 26). From the perspective of the safety region, interviewees particularly regret the lack of a formal mechanism that would make them part of planning processes in the municipalities (Interview 11).

Also mentioned in this context was the difficulty of broadening the scope of the safety region from purely reactive disaster management to proactive risk management (Interviews 3, 11, 26). Interviewees do not expect this to change unless a major disaster forces a political re-think and the reallocation of budgets for risk management (Interviews 25, 26).

Because both sides are starting to recognise their co-dependencies, cooperation between the safety region and the municipality has slowly increased in recent years (Interviews 3, 11, 16). One way this is taking place is through scenario workshops conducted by the municipality to improve evacuation planning (Interview 3). In addition, a leading manager from the safety region (Interview 26) hopes to formally establish an advisory role for the safety region in planning processes for the municipal structural plan (*gemeentelijke omgevingsvisie*) that is currently being prepared. To our knowledge, there is as yet no ambition to include municipalities in NCTV projects or to involve the NCTV in the local resilience debate.

3.3.3 Cooperation and coordination across different territorial jurisdictions

Whereas emergency management was originally organised at a municipal level, the Rotterdam–Rijnmond security region covers the territory of 15 municipalities. Regional flood risk management operates largely in the administrative jurisdictions of water authorities. Three of them intersect with the municipal boundaries of Rotterdam, which considerably increases the coordination effort because each water authority has its own democratically elected committee (Interview 24). Neither the safety regions nor the regional water authorities are aligned with the territorial jurisdictions of the provinces. Network operators and service suppliers often operate beyond the geographical boundaries of the municipality, safety region or water authority. For instance, Evides' water supply area extends from the Rotterdam area to the coast in the West and to the border with Belgium in the South, whilst Stedin's electricity network covers the areas of Rotterdam and The Hague and extends inland towards Utrecht. The particular geographies of infrastructure operation are at odds with the existing territorial jurisdictions of traditional risk management and public administration. In addition to that, the Ministry of Infrastructure and Water Management defined so-called 'spatial adaptation regions' that did not coincide with provincial jurisdictions or the jurisdictions of water authorities or safety regions. Here, municipalities and water authorities were supposed to work together to identify potential consequences of floods on critical infrastructures in so-called 'stress tests'. However, it is fair to state that this experiment failed (Interview 21).

Adding an extra layer to the existing complex geographies of risk management in the form of 'adaptation regions' complicated cooperation between relevant actors, leading to uncertainty about who was responsible for what and where (Interviews 5, 21). Two major issues were the lack of a dedicated budget for conducting the stress tests and the failure to define a governance structure for allocating roles and responsibilities among the actors (Interview 21). Another issue was that municipalities were unable

to obtain information from private and semi-private infrastructure providers on their vulnerabilities and location of assets because there was no established working relationship between most of them (Interview 21). It was mentioned that infrastructure providers and network owners do not have the capacities and resources to participate in every single municipal initiative or to take part in exercises organised by different safety regions whose jurisdictions happen to intersect their supply area (Interviews 14, 19). Finally, we found that the municipality of Rotterdam had difficulty in maintaining cooperation on cyber resilience with the three water authorities because the board members changed during the political election cycle (Interview 24).

The Ministry of Infrastructure and Water Management recently discarded the ‘spatial adaptation regions’ and is now working with two provinces as pilots to see whether this scale is more suitable. In these pilot regions, the project leader cooperates with a representative of the province and a representative of a local safety region. An important goal of this cooperation is to establish contact with critical infrastructure providers for conducting the ‘stress tests’. Moreover, it is an attempt to concentrate forces, because safety regions face similar problems in receiving information from critical infrastructure providers so as to be able to conduct risk assessments (Interview 21). City administrations, however, are not part of the resulting consortia.

3.4 Key conditions for effective network management of mutually dependent actors responsible for operating critical infrastructures

— In response to the identified governance challenges, Rotterdam’s city administration is slowly starting to act as a network manager within the governance network associated with urban and infrastructure resilience. According to Klijn and Koppenjan (2016, p. 11), governance networks are ‘more or less stable patterns of social relations between mutually dependent actors, which cluster around a policy problem, a policy programme, and/or a set of resources and which emerge, are sustained, and are changed through a series of interactions’. Developing a resilience strategy in cooperation with a broad range of stakeholders clearly exposes the potential to serve as strategic anchor point, laying out common values and providing a clear methodology. Defining common goals and co-creating policies are substantial prerequisites for what Goldstein (2012) calls collaborative resilience. Moreover, aligning resilience goals with those of other municipal programmes in Rotterdam contributes to sustaining resilience thinking across different municipal departments as proposed, for example, by Sapountzaki et al. (2011). Initiating scenario workshops with the safety regions on evacuation planning or conducting workshops with the three water authorities to evaluate cyber-related vulnerabilities further establishes social relationships that cross jurisdictional boundaries and cluster around urban and infrastructure resilience. These efforts by the municipality clearly contribute to establishing new cross-boundary working relationships as advocated by urban and

infrastructure resilience scholars (e.g. Coaffee and Clarke, 2016; Crowe et al., 2016). In other instances, the initiative comes from other actors, such as the safety region (which is trying to be assigned a formal role in strategic municipal planning processes) or the Ministry of Infrastructure and Waterworks (which is starting to collaborate with provinces and safety regions to assess infrastructure vulnerabilities). A particularly promising way of more effectively coordinating infrastructure policies and management across individual infrastructure domains and their territorial scopes is to increase involvement of the Rotterdam–Rijnmond safety region, as it already maintains the necessary contacts with infrastructure operators and network owners in the region. Whilst the safety region is already important in coordinating the different emergency services (Prins et al., 2012), its role for proactive infrastructure management and planning in Rotterdam could be strengthened.

Despite the many positive outcomes of the resilience strategy in Rotterdam with regard to public awareness and the implementation of boundary-crossing initiatives and projects, it is becoming clear that to establish ‘more or less stable patterns of social relations between mutually dependent actors’ (Klijn and Koppenjan, 2016, p. 11), project-based work as currently advocated by the resilience strategy might not be sufficient. Rather, the short-term character of many projects brings the risk that actors will relapse into siloed working habits after a particular project ends and that relationships will have to be re-established time and again. This stands in contrast to the notion of institutionalisation as a consolidation of adaptive and networked governance arrangements, as defined in Section 3.2 (cf. Folke et al., 2005; Jordan and Schout, 2006). Apparently, there is a lack of procedural rules providing guidance on how to enhance and maintain cross-boundary working relationships between the large numbers of relevant actors in order to stabilise networked governance arrangements. The case of Rotterdam offers some indications of the key conditions for effective network management of the mutually dependent actors responsible for operating critical infrastructures, which can lay the basis for the development of such rules. These are elaborated below.

Firstly, cross-sectoral budgeting of infrastructure resilience measures and cross-departmental budgeting of municipal projects would contribute to establishing lasting working relations at a strategic level both in the municipality and amongst public and private infrastructure providers. The resulting collective action across departmental and sectoral borders could help to dilute rigid epistemic traditions by creating co-designing processes and shared goal definitions (cf. Huck and Monstadt, 2019). As such, it could contribute to further broadening the focus of climate adaptation in Rotterdam to include other potential risks such as power failures or cyber attacks. It could also contribute to establishing a shared understanding of risk between public administration and private infrastructure providers that are accountable for both the protection of physical systems and the safety of the citizen (cf. Dunn-Cavelty and Suter, 2009).

Secondly, better integration of actions and measures at the local level with those at regional and national levels of government would contribute to more effective risk management practices (cf. Vedeld et al., 2016). This includes rules for sharing

information on infrastructure vulnerabilities between different levels of governance, as well as multi-level negotiations on the allocation of budget and responsibility. In this sense, it would prevent actors at lower governance levels being made responsible for particular measures such as defining infrastructure vulnerabilities without having sufficient jurisdiction, institutional capacity or budget. Hence, it could contribute to solving the current problems that have arisen as a result of the minor role played by safety regions in proactive cross-sector infrastructure resilience and by the inability of the NCTV to provide them with information. From an urban resilience perspective, defining critical infrastructures at a municipal level and discussing and agreeing on acceptable levels of risk in the city or in certain parts of the city seem to be promising exercises. They would address the current mismatch in which the effects of infrastructure failures are mainly felt at local level, but policies to deal with such disruptions are designed at national level (cf. Padt et al., 2014).

Thirdly, our analysis calls for the roles and responsibilities for cross-territorial risk management to be redefined. Defining *who* is responsible for *what* and *where* across historically grown and separated entities such as safety regions, water authorities, provinces and municipalities clearly requires considerable investments in time, money and personnel (cf. Dewulf et al., 2015). However, such negotiation processes are necessary to prevent inefficient and uncoordinated action by individual actors and to do justice to the cross-boundary character of infrastructure systems (Seager et al., 2017). The case of Rotterdam shows that not only is it necessary to give infrastructure providers clear duties and responsibilities, but also to give them a clear picture of whom they should provide with what kind of information and when.

In summary, our analysis contributes to practical and scholarly debates on institutionalising urban resilience in four ways. Firstly, by combining approaches of urban resilience and critical infrastructure research, it helps to better understand the urban level of infrastructure risk management and the particularity of urban vulnerabilities to infrastructure failure. Secondly, it reveals particular governance challenges associated with the management of critical infrastructures in urban areas and it discloses the need for institutional reform. Thirdly, it provides key conditions for such an institutional reform. We argue that procedural rules for approaching different dimensions of institutional fragmentation (horizontal, vertical and territorial) must be (re)designed. Uniform procedural rules could guide municipalities and regions in contingency planning, vulnerability and risk assessment and in crisis management, harmonise risk management and define which relevant actors should participate and how they should do so. Fourthly, our analysis provides insights into the particular role of municipal administrations in institutionalising adaptive and networked governance arrangements, which will be presented in the remaining section of this paper.

3.5 Conclusion: on the potential role of municipalities in institutionalising urban resilience

By participating in the 100 Resilient Cities programme, Rotterdam's city administration has assigned itself an active role in institutionalising urban resilience and has positioned itself as an international frontrunner. Some governance challenges nevertheless remain to be overcome, particularly with respect to the integrated management of interconnected infrastructure networks such as those for water and energy provision. Although municipalities are often formally responsible for developing and implementing urban resilience strategies and plans, their responsibility for institutionalising favourable conditions for effective network management is limited. To some extent, municipalities like Rotterdam face a condition which Peck and Tickel (2002, p. 386) refer to as 'responsibility without power'.

The results of our study show the need for national and supranational levels of government to design and implement legal reforms that institutionalise uniform procedural rules for urban risk management and contingency planning, providing guidance for municipalities on how to enhance the resilience of their cities and infrastructures. As our analysis revealed, key conditions for such an institutional reform may include the clarification of roles and responsibilities for cross-territorial risk management, cross-sectoral and cross-departmental budgeting of resilience measures, and a better alignment of local activities with activities at regional and national levels of government. In contrast to defining universal resilience and safety standards, procedural rules may, for example, guide municipal governments in how to assess place-based vulnerabilities, how to prepare integrated contingency plans in a more standardised manner and whom to engage in such assessments, planning procedures and other risk management practices. As such, procedural rules could help not only to operationalise national infrastructure resilience strategies and their unsubstantiated claim of achieving voluntary cooperation among governments, businesses, and civil society but also to establish uniform institutional frameworks for urban resilience policies (Monstadt and Schmidt, 2019, p. 17). In this sense, our study shows that academic and policy debates on urban resilience should focus more on how local levels of governance are embedded in complex territorialities of infrastructure systems and the different governance levels involved in managing these systems.

100RC addressed supranational levels of government by releasing 'prospectuses' for the United States, the European Union and other world regions (100RC, n.d.). For instance it aimed at 'pushing EU policy to support urban resilience' (100RC, 2017b). However, international city networks such as 100RC can hardly be held responsible for inducing legal reform at national or supranational levels of government. Rather, they can serve as a test bed for urban resilience measures, promote the exchange of experiences among municipalities and put resilience on the urban policy agenda. As the role of international networks has so far often been neglected in scholarly literature (for an exception see: Leitner et al., 2018), their influence on policy making

at different levels and how they can contribute to institutionalise urban resilience deserve further examination. 100RC could serve as an interesting case study as it was unexpectedly dissolved in summer 2019 and, therefore, there is an opportunity for an ex post analysis of its activities. In addition, future research would potentially benefit from focusing more on political decision-making at different levels of government (and how they interact), which was beyond the scope of this study. Gaining these kinds of insights from cities approaching the challenge of institutionalising urban resilience will be important for future research and for tackling the question raised by Coaffee and Lee (2016) of what resilience *does* instead of solely asking what it *is*.

4

BUILDING URBAN AND INFRASTRUCTURE RESILIENCE THROUGH CONNECTIVITY: AN INSTITUTIONAL PERSPECTIVE ON DISASTER RISK MANAGEMENT IN CHRISTCHURCH, NEW ZEALAND

Abstract

The management of large-scale disasters in urban agglomerations often reveals fragmented governance structures. Accordingly, recent debates in the field of disaster risk management call for better coordination of agencies and actors across organisational and territorial boundaries, arguing that this would ultimately improve the resilience of urban areas. However, our analysis of the metropolitan area of Greater Christchurch, which experienced a series of devastating earthquakes in 2010/2011, shows that this conclusion inadequately acknowledges the uncertainties and institutional complexities in the governance of resilience. We show that debates on urban resilience can benefit from the concept of institutional connectivity – defined as institutionalised forms of vertical, horizontal or cross-territorial interaction – to systematically address these complexities. Our empirical results suggest that the efficacy of different forms of institutional connectivity depends on prevailing circumstances. Therefore, particular forms of connectivity should be prioritised on a case-by-case basis. Our empirical study reveals that enhancing institutional connectivity is a resource-intensive and contested process that might induce negative trade-offs. We contend that because institutions shape how different agencies and organisations interact, scholarly debates on urban resilience should put more emphasis on processes of institutional reform and stress the political dimension of institution building for urban resilience.

Published as

Huck, A., Monstadt, J. and Driessen, P. (2020) Building urban and infrastructure resilience through connectivity: An institutional perspective on disaster risk management in Christchurch, New Zealand, *Cities*, 98, 102573.
<https://doi.org/10.1016/j.cities.2019.102573>

4.1 Introduction

In 2010 and 2011, the metropolitan area of Greater Christchurch, New Zealand's second largest city region, was struck by a sequence of earthquakes that had severe and ongoing impacts on its social, built, economic and natural environments. The most devastating shock in February 2011 caused 185 fatalities, widespread damage to infrastructure systems, and destroyed or damaged many inner-city buildings. The central business district was cordoned off to the public for up to two years and only slowly became revitalised as businesses and residents returned. Infrastructure repairs and the reconstruction of the city's built environment are still ongoing and are expected to continue for the next two decades. Moreover, a range of long-term mental health impacts such as post-traumatic stress disorders will be felt for decades. In response, Greater Christchurch has carried out institutional reforms in risk management to better prepare for potential future events. Urban resilience has become a visible policy objective, as expressed in the city region's participation in the Rockefeller Foundation's 100 Resilient Cities programme (100RC, 2019). This reflects the growing popularity for urban resilience to be deployed as a prescriptive tool for urban decision-makers (Coaffee and Lee, 2016). However, in common with the findings of other studies (Chandler and Coaffee, 2017a; Coaffee et al., 2018), operationalising and institutionalising the concept in existing governance systems proved a major challenge. This paper takes an institutional perspective on urban resilience and aims to contribute to defining the institutional prerequisites for the concept's implementation.

Although the series of earthquakes in Christchurch did not trigger wide-ranging cascading effects of failing infrastructure networks that exacerbated the direct threats of the earthquakes, the city council has acknowledged that the ability to prevent and to prepare for infrastructural failures is a major component of urban resilience (CCC, 2018). It thus recognises that intact or quickly recovering infrastructure was crucial for efficient response and recovery after the earthquakes. A range of basic services such as communication, electricity, and key transportation nodes (e.g. the airport) experienced relatively minor disruption and were restored relatively quickly, which allowed national and international search and rescue teams to access the city, hospitals to continue services, and police and fire-fighting personnel to communicate with each other. Consequently, if we conceive of infrastructures as being an integral component of urban systems, urban risk management needs to acknowledge their specific materialities, spatialities, functionalities and their specific – often fragmented – governance structures.

Various authors in the field of risk management have argued that fragmented institutional settings within and beyond urban boundaries pose some of the most severe challenges to implementing urban and infrastructure resilience in existing governance practices (Coaffee et al., 2018; de Bruijne and van Eeten, 2007). Others have pointed out that large-scale disasters often unveil dissonant institutions to do with risk management (Mamula-Seadon and McLean, 2015; Sapountzaki et al., 2011) and that they can be seen as providing an opportunity for institutional reform because they raise risk awareness, may lead to improvements in codes and building

standards and because ‘dominant ways of thinking and acting are subject to critical review and revision’ (Birkmann et al., 2010a, p. 638). Resilience benefits from these developments because they generate learning processes that result in institutional frameworks being adjusted in order to improve the capacity for dealing with future disasters. Hence, it should be possible to learn from processes of institutional reform in the aftermath of a disaster and to draw conclusions about institutional prerequisites for implementing urban and infrastructure resilience. This study particularly addresses the questions of how institutional connectivity – defined as institutionalised forms of vertical, horizontal or cross-territorial interaction – affects urban and infrastructure resilience and how institutional connectivity can be achieved in the first place. Moreover, the case allows conclusions to be drawn on how the complexities and uncertainties induced by disaster situations affect connectivity building and how urban governance can cope with them.

In order to address these questions, we empirically analyse the case of Greater Christchurch. We deliberately chose this case study because the city region responded to the experience of the earthquakes in 2010/2011 with wide-ranging institutional reforms to disaster risk management, urban planning and infrastructure management. To systematise our analysis, in Section 4.2, we develop a theoretical framework, linking the concept of institutional connectivity to current debates on the governance of urban and infrastructure resilience. We distinguish three dimensions of institutional connectivity (vertical, horizontal and territorial) and three resilience capacities (resistance, recovery and adaptability), as this differentiation permits detailed analysis of how specific dimensions and forms of institutional connectivity change over time and impact the city’s resilience. Section 4.3 introduces our methodology. A qualitative case study approach using in-depth expert interviews as well as scholarly and grey literature allows us to discover the political dimension of institutionalised interaction across policy domains, policy levels and territorial jurisdictions. Moreover, such an approach helps when considering some aspects of the increasing complexity and uncertainty induced by disaster situations. In Section 4.4, using our analytical dimensions, we describe institutional reforms in Greater Christchurch before and after the earthquakes. In Section 4.5, we discuss these institutional reforms and elaborate on the influence of connectivity on urban and infrastructure resilience in order to answer the research questions posed above. In Section 4.6 we conclude by calling for a nuanced view on issues of collaboration and we outline the value of using the concept of connectivity in debates on urban resilience.

4.2 The need for institutional connectivity in order to achieve urban and infrastructure resilience

— Although the concept of resilience has undergone a surge in popularity as an analytical and management-oriented concept for urban studies scholars and urban decision-makers as well for those involved in infrastructure management, there is no consensus on how it should be operationalised and institutionalised in urban governance systems (Chandler and Coaffee, 2017a; Coaffee et al., 2018).

Consequently, it has been argued there is a disparity between resilience as a policy objective and resilience as manifested in the implementation of risk management (Wagenaar and Wilkinson, 2015). However, scholars seem to agree on the need for policies and actors with joint responsibility for risk management to be better coordinated (Sapountzaki et al., 2011) and for the interdependencies of infrastructure networks to be taken into account (Hokstad et al., 2012). Many of them perceive human decision-making and institution building as being too fragmented and poorly coordinated to deal with the increasing interconnectedness of social, environmental and technical systems and with the complex demands of disaster risk management (McFarlane and Rutherford, 2008; Pearce, 2003). Therefore, it is generally accepted that in order to deal with complex change processes, governance systems should mirror the interconnectedness of the external world (Duit et al., 2010, p. 365). Moreover, it is argued that safety increasingly depends on the ability of the actors involved to break up existing policy silos and implement cross-boundary working relationships (Almklov et al., 2012; Matyas and Pelling, 2014).

Breaking up silos and enhancing connectivity has been described as one of the main challenges to implementing urban resilience (Coaffee et al., 2018, p. 403) and infrastructure resilience (de Bruijne and van Eeten, 2007). However, it seems that resilience debates tend to overlook typical governance challenges of conflicting interests, politics and discordance about the allocation of costs and benefits; furthermore, they rarely address particular urban contexts and the uncertainties and institutional complexities entrenched in the governance of resilience. Moreover, although critical assessments of partnerships and networked governance approaches prevail in political science and sustainability studies (e.g. Forsyth, 2010; Khan, 2013), some scholars (Harman et al., 2015; Surminski and Leck, 2016) argue that the literature on urban and infrastructure resilience contains very few attempts to assess if institutional connectivity is always the best solution. In particular, the literature does not propose specific forms of connectivity for pursuing the goal of urban and infrastructure resilience. To explore this shortcoming, we differentiate between three dimensions of institutional connectivity that are referred to in case studies on urban and infrastructure resilience around the world – horizontal, vertical and territorial – and three capacities of resilient urban systems – resistance, recovery and adaptability. Below, we first distinguish between the three main dimensions of connectivity.

- a *Horizontal connectivity*: Various authors (e.g. Almklov et al., 2012; McPhearson et al., 2015) call for institutional connectivity between different policy domains and infrastructure sectors. From a risk management point of view, it makes sense to focus on policy domains of emergency management, urban and regional planning, and infrastructure management, which can be subdivided into sectoral infrastructure management, as different ministries and governmental departments are responsible for managing or regulating different sectors. Per sector, ownership of the assets varies between public, semi-public and private. Actors across these policy domains potentially shape governance arrangements and outcomes.
- b *Vertical connectivity*: Several scholars working on disaster risk and urban resilience (e.g. Dewulf et al., 2015; Vedeld et al., 2016) have set out to identify new architect-

tures in multi-level governance because the policy domains and infrastructure sectors involved are governed at different policy levels. For example, in New Zealand, highways and ‘roads of national significance’ fall under the aegis of the national New Zealand Transport Agency, whilst municipalities are responsible for local roads. Electricity supply networks can be divided into national and regional/local distribution networks. Although primarily regionally based, Emergency Management uses an upscaling disaster management approach: from local to national states of emergency. Moreover, recovery funding for large-scale disasters is shared between national and local government at specific ratios.

- c *Territorial connectivity*: Cross-jurisdictional and territorial connectivity has been highlighted by, among others, Coaffee and Clarke, 2016; Monstadt and Schmidt, 2019. Infrastructures comprise a complex web and regularly expand beyond administrative jurisdictions (local or otherwise). In Christchurch, water supply and wastewater management are organised within the territorial jurisdictions of Christchurch City Council. Other infrastructure networks extend beyond the city’s boundaries: for example, the electricity network extends north and includes parts of Waimakariri District. Similarly, various roads and other transport systems connect Christchurch to its neighbouring districts as well as to national and international destinations.

Despite the lack of a single definition of the concept of resilience with respect to cities and infrastructures (Elsner et al., 2018; Meerow et al., 2016) and although in each city, different aspects are seen as being important for resilience (Johnson and Blackburn, 2014), three main strains of thought in resilience literature can be distinguished that highlight distinct resilience capacities (cf. Hegger et al., 2016).

- a *Resistance*: the capacity to resist shocks and stresses, e.g. by protection measures.
- b *Recovery*: the capacity to absorb and recover from shocks and stresses, e.g. by crisis management or urban and regional planning.
- c *Adaptability*: the capacity to adapt and transform, e.g. by including learning processes in system design and management.

These differentiations allow a nuanced analysis of how institutional connectivity affects urban and infrastructure resilience. Moreover, taking an institutional perspective helps us to examine how connectivity is established or dismantled and to elaborate on the role of politics and actors’ conflicting interests, and the particularities of disaster situations in this. It has been argued (Lowndes, 2001) that an institutional perspective helps when seeking to understand change in urban policy development, which confirms the appropriateness of our approach to the analysis of institutional reforms in Greater Christchurch.

For this study, we used the definition of institutions proposed by Young et al. (2008, xiii): ‘systems of rights, rules, and decision-making procedures...[that] give rise to social practices, assign roles to the participants in these practices and govern the

occupants of the various roles'. As such, institutions both enable and constrain cooperation and coordination between different actors in a governance regime. They can be formal or informal (North, 1990). Formal institutions are 'rules and procedures that are created, communicated, and enforced through channels widely accepted as official' (Helmke and Levitsky, 2004, p. 727). Examples include written laws, regulations or standards. In contrast, informal institutions are 'socially shared rules, usually unwritten, that are created, communicated, and enforced outside of officially sanctioned channels' (Helmke and Levitsky, 2004, p. 727) such as work routines, traditions and knowledge systems. As such, institutional connectivity might be shaped predominantly by formal or informal institutions, or its foundation can change from the one to the other. Fig. 4.1 illustrates the analytical framework for this study.

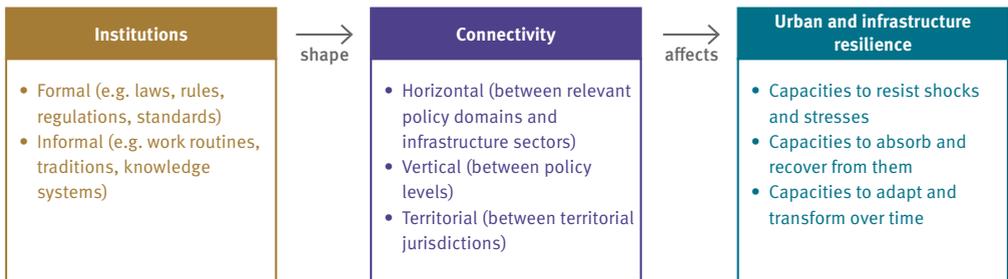


Fig. 4.1 ANALYTICAL FRAMEWORK USED IN THIS STUDY (SOURCE: OWN OVERVIEW)

4.3 Methodology

Our qualitative research involved conducting 29 semi-structured expert interviews between February 2018 and December 2018 covering the range of policy domains and policy levels outlined above. The interviewees were drawn from different infrastructure sectors and different territorial jurisdictions. They included civil servants as well as elected politicians, senior advisors and consultants, strategic decision-makers from public and private sectors and senior academics with in-depth knowledge of the case. All interviews were audio-recorded, transcribed and anonymised. The interviewees' roles and organisations are listed in Appendix 2. Evidence was also obtained from a range of other sources, such as policy documents, plans and strategies, audits, cabinet papers, project reports, newspaper articles and the plethora of academic work available on the earthquakes and their aftermath. Moreover, the first author of this paper attended workshops and conferences on infrastructure resilience in the region.

We used Qualitative Content Analysis (Gläser and Laudel, 2013) to code, categorise and distil relevant information from the data in accordance with the analytical framework. In the first step, several processes of institutional reform relating to risk management, spatial planning and infrastructure management were defined. We did not stipulate the period investigated, thereby allowing interviewees to refer

to institutional reform processes further back in the past if they considered them important for the city region's response to the earthquakes. The second step was to analyse the institutional reform processes in relation to the dimensions of institutional connectivity that they affected: horizontal, vertical and territorial. In addition, we focused on identifying conflicts of interest and on discovering uncertainties and complexities induced specifically by the disaster situation. This step allowed us to draw conclusions on how processes of connectivity building take place and how institutions shape connectivity. In the third step, we drew on these insights when assessing information on the city's capacities to resist, recover and adapt. Expert judgement was essential for drawing conclusions on how institutional connectivity affects urban and infrastructure resilience. Because expert interviews inevitably contain bias (Bogner et al., 2009), we used several techniques to reduce it. For instance, during the interviews, the experts were confronted with the opinions of other experts; we also conducted follow-up discussions with selected interviewees in order to collect specific evidence and to avoid misinterpretations. Interview data was triangulated with existing academic literature as well with public media reports, governmental reports, plans, strategies and assessments. Preliminary results were presented and discussed at the Canterbury Earthquake Symposium in Christchurch on 29/30 November 2018 and a draft version of this paper was sent to all interviewees for their comments.

4.4 Risk management in Greater Christchurch: Institutional reforms before and after the 2010–2011 Canterbury Earthquake Sequence

— New Zealand is a high-income country with a constitutional monarchy. There are two main tiers of government: central and local. Local government is split into 11 regional councils and 66 territorial authorities (12 city councils and 54 district councils). Among regional councils' responsibilities are environmental management, regional transport planning and regional civil defence – the latter includes the provision of natural hazard information. The territorial authorities are responsible for the well-being of their local communities and the provision of civil infrastructure services, environmental health and safety, building control, district civil defence and land-use control (Government of New Zealand, 2015). With its 624,000 inhabitants, Canterbury Regional Council, also known as Environment Canterbury, is the second most populous regional council in New Zealand and the most populous on the South Island. It comprises ten territorial authorities, including the Christchurch City Council (388,500 inhabitants) and the neighbouring district councils of Waimakariri (60,700) and Selwyn (62,200), which together comprise the Greater Christchurch Area (511,400) (ECan, 2018).

New Zealand has a relatively well-established disaster risk management framework that pre-dates the Hyogo Framework for Action 2005–2015 (cf. MacAskill and Guthrie, 2016). The Civil Defence and Emergency Management Act 2002 sets generic objectives

and assigns significant responsibility for decision-making to the local governments. Regional Civil Defence Groups are typically led by mayors or their representatives and essentially represent a consortium of local authorities, emergency services and critical infrastructure providers that in New Zealand are called lifeline utilities (Glavovic et al., 2010). The Act requires lifeline utilities to ‘ensure that [they are] able to function to the fullest possible extent, even though this may be at a reduced level, during and after an emergency’ (MCDEM, 2002). Despite this obligation, there are barely any mechanisms in place to assess or enforce emergency planning of lifeline utilities (Interviews 2, 11).

Although earthquakes are common in New Zealand, the Canterbury Earthquake Sequence was unexpected and revealed the presence of previously unknown geological faults. Tremors were first felt in and around Christchurch at 4.35 a.m. on 4 September 2010. The Mw 7.1 earthquake – commonly referred to as the ‘Darfield Earthquake’ – had its epicentre approximately 40 km west of Christchurch but was felt widely across the South Island. It caused widespread damage and several power outages but no directly related fatalities. However, the earthquake was followed by a series of aftershocks. The most devastating Mw 6.3 aftershock occurred on 22 February at 12.51 p.m. very close to Christchurch city centre, and at shallow depth. In addition to causing 185 deaths, the ‘Christchurch Earthquake’ destroyed or damaged most of central Christchurch’s built environment and large parts of the metropolitan infrastructure networks (Cubrinovski et al., 2014; 2015). The second most important cause of infrastructure damage after seismic movements was liquefaction. As described in the introduction, Christchurch did not suffer an infrastructure crisis with cascading effects of failing services, but service provision varied significantly between different parts of the city, with the central business district cordoned off for up to two years.

Because of their aftermath of thousands of aftershocks, the earthquakes do not represent a single point in time from where the city had to recover, but rather a period of constant uncertainty and fear. Although different phases of disaster risk management overlap, for reasons of readability, we follow a chronological order and subdivide our case analysis into the different phases they were referred to in interviews and grey literature: 1) Pre-earthquake developments, often referred to as ‘peace-time’; 2) Response (times of local, regional, or national states of emergency); 3) Recovery (short- and medium-term recovery after humanitarian needs have been met), 4) Regeneration (long-term recovery and regeneration activities); 5) Back to normal? (Establishment of new business-as-usual practices). Fig. 4.2 represents an overview.

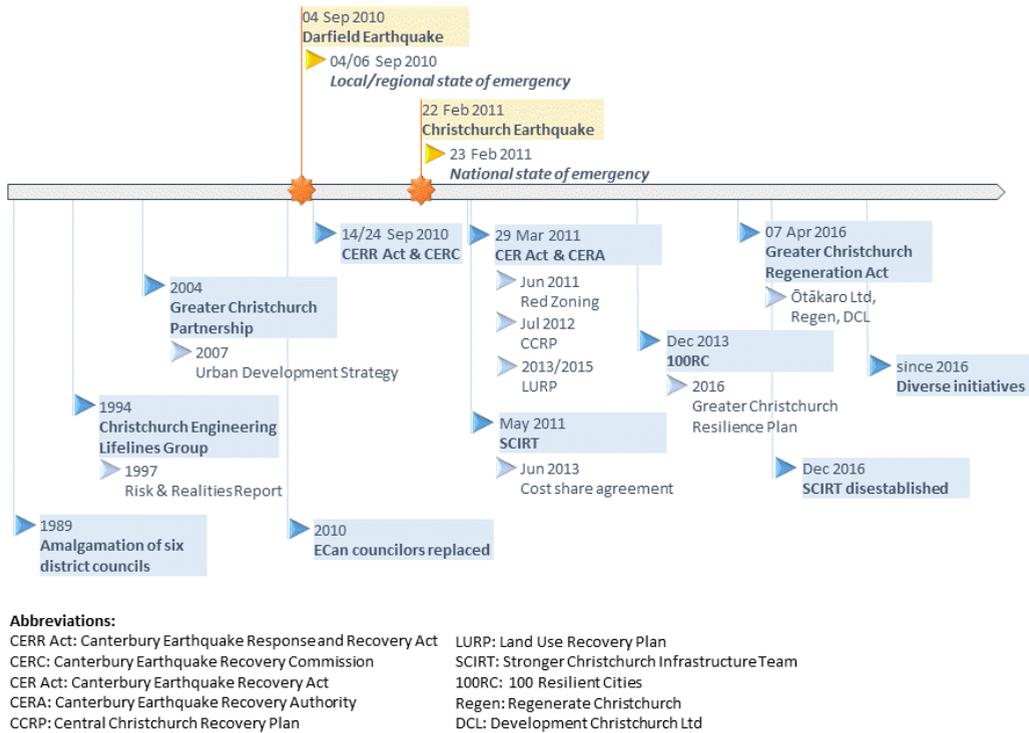


Fig. 4.2 TIMELINE WITH MAIN INSTITUTIONAL REFORMS IN GREATER CHRISTCHURCH (SOURCE: OWN OVERVIEW)

4.4.1 Pre-earthquake developments in Christchurch

In Christchurch, future-oriented asset management began by being complicated by the amalgamation of six boroughs into the Christchurch City Council in 1989. An interviewee recalls that asset managers had difficulty understanding each other's management practices at the time that digitisation was becoming commonplace and *'paper drawings in the bottom drawer haven't been pulled out and shared and understood'* (Interview 4). In this sense, creating connectivity between territorial jurisdictions without building institutional capacity to manage previously separated infrastructure systems led to rather reactive asset management procedures, which were overwhelmed by the task of emergency response to the earthquakes (Interview 4).

Stakeholders from different infrastructure sectors nevertheless started to collaborate in an informal project setting within the Centre for Advanced Engineering at the University of Canterbury. As a result of this collaboration, the Risks and Realities Report (Centre for Advanced Engineering, 1997) provided sector-specific and cross-sector risk assessments and proposed protection and mitigation measures. Meanwhile, the ad-hoc collaboration of the parties involved (including infrastructure

providers) transformed into the Canterbury Lifelines Group. From the interviews we infer that lifelines that successfully resisted the earthquakes benefitted from this cross-sectoral work and from building relationships and signing mutual aid agreements within and beyond their sector (Interviews 1, 7, 27). For example, interviewees employed by the regional electricity provider Orion noted that the report was one of the main reasons for Orion to invest in resilience (Interviews 8, 25). However, the report failed to have impact beyond the boundaries of the project team (Interview 22). A major issue was that risk information rarely penetrated as far as to spatial planning decisions in the city council, with the result that some land-use decisions were unjustifiable from a risk management perspective, such as developments on liquefiable ground (Interviews 3, 6) (cf. MacAskill and Guthrie, 2016). These examples show that though institutional connectivity between infrastructure sectors helps build a city's capacity to resist, this capacity can be stultified by a lack of connectivity between policy domains.

In 2004, the city council and its neighbouring districts Selwyn and Waimakariri entered into partnership with the Environment Canterbury regional council and the New Zealand Transport Agency to manage growth in the city region. The resulting Greater Christchurch Partnership devised the Greater Christchurch Urban Development Strategy (CCC et al., 2007). As described in Section 4.4.4, this cross-jurisdictional Partnership proved to be particularly helpful for post-earthquake regeneration. In March 2010, shortly before the Darfield Earthquake, regional water management issues resulted in 14 elected regional councillors in Environment Canterbury being replaced by commissioners appointed by central government. This action took place at a time of relative political uncertainty and dispute about the future of Greater Christchurch and provoked political dissent between the city council and its neighbouring districts as well as between local, regional and national policy makers. Interviewees described the relationship between the city council, Environment Canterbury and central government as troublesome, non-trusting and tremendously uncooperative (Interviews 1, 3, 4, 7). These cross-jurisdictional and cross-level discrepancies subsequently significantly hampered response and recovery work in Christchurch, as outlined in the following sections.

4.4.2 Response: local, regional and national states of emergency

— Responding to the Darfield Earthquake, the three affected local authorities – Christchurch City Council, Waimakariri and Selwyn – announced the local state of emergency; the regional state of emergency was announced two days later. Our analysis reveals that during the following weeks there was a major disconnect between the city council, Environment Canterbury and central government due to political disagreement and personal disagreement between key decision-makers (cf. Parker and Farrington, 2012). Many interviewees accused the city council of being extremely uncooperative and unwilling to work in the foreseen emergency structures that would place response coordination in the hands of the regional coordinator (Interviews 7, 11, 24). One day before the local state of emergency ended, the government introduced the Canterbury Earthquake Response and Recovery (CERR) Act and established

the Canterbury Earthquake Recovery Commission consisting of the mayors of the three affected territorial authorities plus one representative each from Environment Canterbury and central government. However, this did not change matters but instead created confusion about who was in charge of the overall recovery (Brookie, 2014, p. 260). An official review concluded that local civil defence and emergency structures were dysfunctional and that recovery from the Darfield Earthquake had stalled by the time of the Christchurch Earthquake (McLean et al., 2012). In this sense, vertical and territorial connectivity that was institutionalised during a crisis situation did not bring the expected outcome of better cooperation but was outweighed by existing political discrepancies. This was one of the reasons why central government stepped in directly after the Christchurch Earthquake and declared a national state of emergency: an action that put the Director of the Civil Defence Ministry in charge of the response, implementing a clear command and control structure.

Two interviews (11, 24) confirm that political disputes played hardly any role in the acute response phase. Hence, the concentration of decision-making power for emergency response in a national authority contributed greatly to the city's capacity to resist. In terms of immediate infrastructure recovery at a technical level; however, our interviews suggest that the shift of responsibility caused some delay in early response work, as the staff responsible (i.e. national lifeline controllers) were not familiar with the regional specifics and had not been actively involved in existing regional networks (Interview 25). This indicates a trade-off, in the sense that vertical connectivity enforced by the national state of emergency did help to temporarily sidestep political dissent, but also contributed to negative consequences on infrastructure networks' capacities to resist and recover. Moreover, in the next section we show that the concentration of decision-making power in hierarchical structures was transmitted to the recovery phase, where it gave rise to major disputes and negatively affected the city's capacity to recover.

4.4.3 Recovery: rebuilding a city

— The Canterbury Earthquake Recovery (CER) Act 2011 came into force on 19 April of that year, repealing the Canterbury Earthquake Response and Recovery (CERR) Act. It established the Canterbury Earthquake Recovery Authority (CERA), a government department with former energy minister Gerry Brownlee functioning as Minister of Earthquake Recovery to lead the recovery process and to create and maintain working relationships with the local authorities. CERA had powers under the Act to decide reconstruction priorities, compulsorily acquire land, enter premises, undertake works and demolish and dispose of dangerous buildings (Brookie, 2014, p. 262). Moreover, the Act allowed a recovery plan approved by the Minister to override the requirements of New Zealand planning legislation frameworks embodied in the Resource Management Act, the Conservation and Reserves Acts and large parts of the Local Government Act and the Land Transport Act (Brand and Nicholson, 2016). Therefore, CERA can be described as an organisation encompassing all three connectivity dimensions whilst simultaneously concentrating extraordinary decision-making power in the person of Gerry Brownlee, a representative of the national government. An early

report on roles and responsibilities in recovering from the earthquakes (Office of the Auditor-General, 2012) stresses the need for collaboration between CERA and other public sector agencies, communities, non-governmental organisations and the private sector.

CERA's status as a national department strengthened horizontal connectivity between different policy fields at the national level (Parker and Farrington, 2012, p. 172). However, a former CERA staff member recalled that it became increasingly difficult to coordinate vertically across policy levels due to the existing political discord (Interview 21). Disagreement between the city council and central government peaked in 2013, *'when the real costs of recovery became visible'* (Interview 22). Dissent grew on a number of occasions: for example, during the development of a Central City Recovery Plan which CERA took over from the city council. Whilst the Auditor-General's Report stresses the need for closely involving the city council as well as Christchurch's citizens (Office of the Auditor-General, 2012, p. 61) the council felt 'stripped of their authority' (Parker and Farrington, 2012, p. 161) and citizens felt left out of the discussion. Moreover, CERA developed a zoning plan in which red-zoned land was deemed unsuitable for redevelopment due to the extent of damage and expected future risk and so homeowners were offered the opportunity to be bought out. However, some decided to stay and others in more rural areas out of CERA's zoning exercise's scope were never given a buyout option (Interview 22). Under the provisions of the Local Government Act, the city council had to continue providing services to single premises in areas where most residents had left, which was immensely costly. Several interviews (18, 20, 29) suggest that such negative side-effects could have been avoided if the environment had been more conducive to collaboration. It seems that the existing conflicts and different interests of local and central government clashed with the hierarchical approach to recovery. This complicated the recovery process by undermining well-intended vertical and horizontal connectivity.

The recovery of publicly owned networked infrastructure was organised in an unprecedented institutional setting by establishing the alliance-based Stronger Christchurch Infrastructure Rebuild Team (SCIRT), which was funded by CERA, the city council and New Zealand Transport Agency and included five of New Zealand's largest contracting companies as non-owner participants. The unique alliance structure bypassed competition between the construction companies and created a climate of cooperation (see Walker et al., 2017 for detailed discussion). However, a review by the Auditor-General (Office of the Auditor-General, 2013) revealed that despite collaborative intentions, CERA failed to actively engage in SCIRT operations, resulting in a lack of direction. In addition, a contretemps between CERA and the city council culminated in disagreement about financing infrastructure recovery. Because central government contributes 60% to the cost of repairing infrastructure after a disaster, CERA feared overspending and that the government would effectively finance the council's regular infrastructure renewal costs. This led to new cost-sharing negotiations and to subsequent changes to the design guidelines applied within SCIRT. The new design guidelines slowed down the recovery process by putting projects on hold, changing project outlines and erasing projects from SCIRT's portfolio. Moreover, recovery funding and insurance barely paid for improving infrastructure systems beyond the

pre-earthquake state (see MacAskill, 2016, p. 162 for a detailed discussion). The inability to agree on financing resilience improvements (MacAskill and Guthrie, 2018) and the protracted decision-making caused by the misalignment of SCIRT's rapid operational pace with the slower progress of strategic planning by CERA (Office of the Auditor-General, 2013, p. 7) considerably reduced the city's capacity to adapt and exploit the opportunities arising from the vertical connectivity formalised in response to the disaster.

4.4.4 Regeneration: long-term recovery in Christchurch

— In 2013, the Land Use Recovery Plan, an important strategic planning document for regeneration, was developed to supplement the existing Greater Christchurch Recovery Strategy. Interestingly, the Greater Christchurch Partnership proved to be particularly helpful because it could provide 1) a pre-agreed common understanding across territorial jurisdictions of how the region should be developed and 2) a range of existing analyses which accelerated the process of developing the plan. It was a lucky coincidence that the scope of the partnership exactly matched the spatial scope of direct earthquake effects. The partnership itself has since adapted a more recovery-related approach and in 2016 updated the Urban Development Strategy and expanded its partner base. The portfolio of common planning goals has been enriched by a transport statement, a freight strategy and a Greater Christchurch Resilience Plan (see below). Previously established cross-jurisdictional and cross-level connectivity in the form of the Greater Christchurch Partnership arguably supported the city region's capacity to recover and has proved to be contributing importantly to its ability to adapt in the future.

In 2016, the Canterbury Earthquake Recovery Act expired and with it, CERA. The Greater Christchurch Regeneration Act 2016 marked a transition period from recovery to regeneration. Ōtākaro Ltd., a government-led agency, now manages some of the crown-led anchor projects in the central city. Development Christchurch Ltd., the city's new urban development agency, leads development projects in Christchurch's eastern suburbs. Regenerate Christchurch, co-led by the central government and the city council, is overseeing the regeneration of Christchurch, with a focus on the central business district, the coastal suburb of New Brighton and the Red Zones. One interviewee (10) sees these changes positively in that responsibilities are now more clearly allocated and the city is slowly becoming the master of its own destiny again. However, there are still major uncertainties with regard to how long-term recovery is managed. For example, at the time of data gathering, it was still unclear who would own, govern and fund land development in the Red Zones (McDonald, 2018). In addition, another interview (4) suggests that the different organisations, specifically local and national government, still lack a cooperative attitude, which is slowing down the regeneration process. Moreover, changes in national government – in 2017 the Labour Party took over from the National Party – have led to much uncertainty about future arrangements (Interview 1). In this sense, Greater Christchurch is still struggling to find its optimum in terms of institutionalising connectivity, particularly across policy levels and policy domains.

4.4.5 Back to normal? New developments and lessons learned from the earthquakes

— A range of ongoing initiatives across all policy levels can be ascribed to learning processes from the earthquakes; several are specifically aimed at increasing institutional connectivity. For instance, the new Justice and Emergency Services Precinct in Christchurch hosts city, regional and national civil defence offices in one open-plan floor of a building, to increase the vertical connectivity of emergency services. Moreover, the Canterbury Lifelines Group is currently updating the 1997 Risks and Realities report. The new report – ‘Risk and Resilience’ – widens the scope to regional level and aims to increase working relationships between different infrastructure sectors (Interviews 9, 16). In addition, the apparent gap between local and regional decision-makers is being approached both formally and informally. For instance, the Mayoral Forum has been revitalised as a virtual unitary mechanism to serve as a coordinating body between local authorities. This formal cross-jurisdictional collaboration is considered beneficial for knowledge exchange and coordination (Interviews 9, 14). In addition, the council is collaborating with the Canterbury Civil Defence Group on a project called ‘regional approach to natural hazards’ that aims to define responsibilities and links across different organisations more clearly and to better involve civil defence officers and asset managers in spatial planning processes. Moreover, the council is striving to involve emergency services in engineering codes of practice to ensure infrastructure is designed to meet risk management requirements. However, this cross-domain initiative is struggling to receive support from higher political levels and thus lacks formative impact at this stage (Interviews 23, 26). Nevertheless, interviewees find that the relationship between the city council and Environment Canterbury has greatly improved since pre-quake times (Interviews 2, 4, 23).

Another example of institutional reform is Christchurch’s participation in the Rockefeller Foundation’s 100 Resilient Cities programme (100RC, 2019) and the development of a resilience plan for Greater Christchurch in close collaboration with the Greater Christchurch Partnership (CCC, 2016). Whilst interviewees described the development process, which involved a vast number of stakeholders in and around Christchurch, as extremely valuable to encourage conversations across policy domains, the momentum seems to be tailing off as responsibility across different projects is distributed among participating organisations with little need for cooperation. Regular large-scale cross-domain consultation comparable to the development phase of the plan is considered desirable by interviewees (Interviews 3, 12) but is not foreseen in the near future. Moreover, the timing of the development of a resilience strategy was described as unfortunate because the respective actors were busy with recovery and were already operating under enormous time pressure and resource constraints (Interview 12). Finally, the voluntary and informal character of the resilience plan raises doubts about how successfully it can be integrated into existing plans and strategies in the future (Interviews 10, 12, 29).

The learning processes and institutional adaptation appear to vary tremendously. After SCIRT was disestablished in 2016, the city council incorporated the remaining

repairs in their business-as-usual asset management programme. The changes in design guidelines described in Section 4.4.3 are adding to the city's bill for regular maintenance work. For instance, the costs of wastewater asset management in the city are expected to rocket in the next couple of years due to postponed recovery work (CCC, 2018). The postponement might be partly attributable to institutional disconnect between the city council and SCIRT, as business-as-usual maintenance remained the city council's responsibility whereas repairing earthquake damage was SCIRT's responsibility (MacAskill and Guthrie, 2017). In addition, although the city council was one of three owner organisations of SCIRT, interviewees from SCIRT and from the city council regret that the council has made only very limited use of lessons learned from SCIRT for taking over earthquake repairs and for delivering effective asset management (Interviews 4, 17). It seems that the city council is sticking to traditional working habits and that SCIRT's contribution to institutional adaptation in the long term has been negligible: the institutional connectivity SCIRT provided during the recovery phase was temporary and as it affected earthquake repairs only and was not incorporated into business-as-usual practices, it was limited in scope.

4.5 Discussion: Institutions, connectivity and resilience

Our empirical analysis of Greater Christchurch reveals that enhancing connectivity is a highly political and contested process and that it is a fluid construct. The cooperation of different actors waxes and wanes, the connectivity between all three dimensions analysed becomes institutionalised and de-institutionalised, and conflicts between different parties intensify and decline. Our results confirm that large-scale disasters potentially foster changes in institutional arrangements and organisational structures. More explicitly, actors across the analysed policy levels, policy domains and territorial jurisdictions identified specific gaps in connectivity, and various initiatives are attempting to close them (see e.g. Section 4.4.5). However, the case study also shows that enhancing the institutional connectivity for risk management is not a smooth process, as it often encounters entrenched and conflicting interests of key players and requires the reallocation of resources. As such, the insights yielded by this study reveal four interesting points that are worth discussing in respect to the research questions introduced in Section 4.1.

Firstly, we found that institutional connectivity may appear in various forms and is shaped by, but not limited to, the cooperation between different organisations and actors in a specific field. It may entail a) the integration or amalgamation of policy domains, policy levels or territorial jurisdictions into one coherent arrangement, b) institutionalised forms of cross-boundary collaboration and coordination or c) ad hoc, temporary or informal cooperation of actors across boundaries. Moreover, institutional connectivity can comprise hierarchical decision-making structures, as exemplified in CERA or more partnership-oriented liaisons like SCIRT. It became apparent that institutional connectivity can be derived bottom-up, with several actors recognising the benefits of enhanced cooperation and coordination, as the case of the Canterbury

Lifelines Group shows. However, it can also be enforced top–down, as was the case when the national government established CERA. The case of Greater Christchurch shows that adopting a particular form of institutional connectivity is neither right nor wrong. Rather, what determines which form of connectivity is preferable depends on the circumstances. For instance, whilst a hierarchical form of connectivity induced top–down might bring benefits for direct response to disasters, long-term recovery might require more networked forms of governance prompted in a bottom–up manner.

Secondly, our analysis shows that different connectivity dimensions had very specific impacts on the three resilience capacities of resistance, recovery and adaptability. For instance, links between policy levels proved to be especially important for the capacity to recover from disasters when local authorities lack the capabilities and resources to adequately respond. The institutionalised connection between the city council and the national government within CERA drastically impacted recovery work both positively and negatively (see Section 4.4.3). Apart from that, coordination between different policy domains is an essential prerequisite for building the capacity to adapt and transform over time. This becomes visible in the lack of connectivity between civil defence, spatial planning and infrastructure management prior to the earthquakes (Section 4.4.1). Then again, connectivity between territorial jurisdictions proved to be important for long-term recovery goals in the regeneration phase, as the example of the Greater Christchurch Partnership (Section 4.4.4) shows. Therefore, and in critique of the main body of literature, we argue that approaches to enhance connectivity require critical review and prioritisation in terms of what particular forms and dimensions of connectivity should be enhanced according to the prevailing circumstances.

Thirdly, the case reveals that recovery, regeneration and adaptation are contested processes where entrenched political and financial interests of individual actors or involved political parties are at stake, institutional or financial resources are reallocated and power imbalances and disputes over autonomy become visible. It also became clear that cross-boundary decision-making processes in response and recovery are highly influenced by the personal relationships and economic and political interests of the actors involved. Along with uncertainty about roles and responsibilities, diverging interests of the actors involved or poor personal relationships might cancel out the positive effects of formally institutionalised connectivity. For example, in the response phase to the Darfield Earthquakes institutionalised connectivity for disaster response between the city council and Environment Canterbury was essentially ineffective due to personal and political conflicts between key actors. Moreover, a lack of clarity about roles and responsibilities, no common understanding about recovery targets and misaligned paces of decision-making were among the main reasons for the difficulties CERA and SCIRT experienced in aligning local and national stakes. These insights stand in contrast to the often unpoliticised call for institutional connectivity in academic debates on risk management and urban resilience. Because institutions shape the way different agencies and organisations interact, we believe that processes of institutional reform and the politics involved should receive more attention in these strands of literature.

Fourthly, during response to and recovery of a large-scale disaster, limitations in time and financial resources as well as public pressure might complicate approaches to enhance connectivity and constitute some of the complexities and uncertainties of resilience governance. After all, coordination and cooperation cost time and money which cannot be invested elsewhere. Often, scarce resources are used to quickly reinstall services for the community rather than to introduce new innovative ways to adapt and transform (cf. MacAskill and Guthrie, 2015). This contributes to preserving the status quo and shows that emergency situations might provoke trade-offs between different resilient capacities (i.e. resistance, recovery, adaptation). The case of the Greater Christchurch Partnership demonstrates the positive effects of pre-agreed arrangements, plans and processes for response and recovery. At the same time, the difficulties of reaching cross-boundary agreements in CERA and the challenges in developing the Greater Christchurch Resilience Plan in the midst of recovery exemplify the difficulty of enhancing connectivity shortly after a disaster. Moreover, our results show that disaster situations can provoke temporary institutional reforms. Whilst institutions are usually designed for longer time periods, the case of the Canterbury Earthquake Recovery Act and of SCIRT's design guidelines show that institutional connectivity that has been established in the aftermath of a disaster might be only temporary. Conversely, connectivity institutionalised before the disaster, as was the case for the Greater Christchurch Partnership or the Canterbury Lifelines Group, tends to remain in place and become more important for shaping the city region's future. This finding supports existing work on Christchurch's recovery demonstrating the need for clearer terms of engagement between central and local government (MacAskill and Guthrie, 2018). Consequently, the point in time at which connectivity is enhanced matters hugely. These insights can contribute to a better understanding of how the uncertainties and complexities induced in disaster situations affect connectivity building and make clear that institutional connectivity should ideally be in place prior to a disaster.

4.6 Conclusion

— Enhancing institutional connectivity is often described as the main way of achieving resilient cities and infrastructures. However, calls for more cooperation in risk management often remain vague and do not fully take account of the politics involved in institutional reform or of the uncertainties and complexities associated with disaster situations. The results of our analysis of the institutional reforms in the city region of Greater Christchurch eight years after the devastating Canterbury Earthquake Sequence suggest that different forms of institutional connectivity are unequally important for enhancing urban resilience; they depend on prevailing circumstances. Moreover, we found that enhancing institutional connectivity is a resource-intensive and contested process that might induce negative trade-offs.

The concept of connectivity provided us with a lens for analysing the effects of practised and missing coordination and cooperation on the resilience of a city region. Specifically, it proved to be useful for identifying and analysing different forms and

dimensions of connectivity and their effects on particular resilience capacities such as resistance, recovery and adaptability. Our conclusion that these effects differ depending on the circumstances enriches existing literature on urban resilience, which so far has paid little attention to such nuances. Moreover, the results of our analysis highlight the importance of politics for processes of institutional reform. Because the interaction of agencies and actors is shaped by institutions, contested processes of institution building deserve more attention in the literature on urban and infrastructure resilience. We argue that scholars of risk management should not see institutional connectivity as a goal in itself but rather as contested processes that can either support or impede specific resilience capacities. This might make it possible to define more accurate and appropriate institutional prerequisites for implementing resilience in existing urban governance arrangements on a case-by-case basis. Accordingly, risk management and urban resilience practice can benefit from a more nuanced and contextualised view of institutional connectivity by prioritising and defining bespoke connectivity needs for the given situation (e.g. acute response vs. long-term recovery) that lend themselves to be fostered by particular resilience capacities (e.g. resistance vs. adaptability). We thus encourage other researchers to critically apply the concept of institutional connectivity in resilience research so as to enrich conceptual discussions and to further explore the implementation gap of urban resilience.

5

MAINSTREAMING URBAN RESILIENCE IN CHRISTCHURCH AND ROTTERDAM?

Abstract

Despite the burgeoning popularity of resilience as an urban policy narrative, we know little about how policymakers and planners approach the challenge of operationalising urban resilience or what problems they face. Although their ultimate goal is presumably to integrate resilience goals into sectoral policy and decision-making as well as to dissolve policy silos, the concept of mainstreaming has received relatively little attention in urban resilience literature so far. To address this void, we use the concept of mainstreaming to analyse the two cities of Christchurch and Rotterdam, both participants in the Rockefeller Foundation's 100 Resilient Cities Programme. We identify three main problems that are apparent in both cities despite their contextual differences. The first is to make resilience a top priority for policymaking and planning because it competes with other urban development agendas for political commitment. Secondly, institutionalising cross-sector governance constitutes a problem because participation in 100 Resilient Cities brings few incentives for institutional reforms. The third problem – to achieve active engagement of decision-makers from public and private sectors – arises because urban policymakers and planners are not sufficiently equipped to convince them to invest additional resources in terms of personnel, time and money. In light of these problems, we argue that participating in 100 Resilient Cities is a relevant but not sufficient first step to mainstream urban resilience in Christchurch and Rotterdam. In addition to developing a resilience strategy and appointing a Chief Resilience Officer, formal changes (for instance in procedural law and national policymaking) are required, to address the problems identified.

Submitted as

Huck, A., Monstadt, J. and Driessen, P.: Mainstreaming urban resilience in Christchurch and Rotterdam?, *Geoforum*. (Accepted pending minor revisions)

5.1 Introduction

The concept of resilience is increasingly influencing urban policymaking and planning in cities around the world. Hundreds of city administrations have developed strategies and programmes striving to enhance the resilience of their cities and citizens. Two cities that have recently gained prominence in the urban resilience community are Rotterdam (Netherlands) and Christchurch (New Zealand). Whilst Rotterdam has received considerable appreciation for pursuing adaptive urban water and flood management (e.g. Dunn et al., 2017), Christchurch has been recognised for its response to and recovery from a devastating series of earthquakes in 2010 and 2011 (e.g. Bennett et al., 2014). Although both cities are situated in considerably different socio-political and environmental contexts and have had dissimilar experiences with disasters in recent decades, they share common approaches to operationalise urban resilience, as both cities participate in the Rockefeller Foundation’s 100 Resilient Cities Programme (hereafter: 100RC). Participation includes the development of a resilience strategy and the appointment of a so-called Chief Resilience Officer, who ‘acts as the city’s point person for resilience building, helping to coordinate all of the city’s resilience efforts’ (Berkowitz, 2015). 100RC defines urban resilience as ‘the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience’ (100RC, 2019). Chronic stresses are day-to-day or cyclical negative impacts on the city’s fabric, such as drier summers or recurrent heavy rainfall, but also growing social inequality or high unemployment. Acute shocks are sudden events, such as earthquakes, floods or terrorist attacks (100RC, 2019). Similar interpretations of urban resilience exist in academic debates in the domain of urban studies. For instance, Meerow et al. (2016, p. 39) define urban resilience 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’.

The concept of urban resilience has stimulated lively debates in different bodies of academic literature, such as infrastructure studies, disaster risk management, urban sociology, climate adaptation, development studies and urban planning. Importantly, urban resilience is associated not only with modifying the built environment of a city but increasingly with changing the structures and practices in risk management and governance arrangements (Coaffee and Lee, 2016). As such, urban resilience represents a prime example of a newly emerging cross-cutting policy narrative (Béné et al., 2017) concerning areas of urban planning, infrastructure management, environmental management, risk management and social policy alike. Accordingly, to enhance urban resilience, scholars advocate establishing new governance networks across different policy sectors (Bourgon, 2009), dissolving governance silos (Coaffee et al., 2018) and enhancing cooperation between different public and private actors as well as between these and society (Marana et al., 2018a). It follows that the most common approach to operationalise urban resilience can be described as

mainstreaming: the integration of resilience goals into policy and decision-making in the city (cf. Massey and Huitema, 2013). Although the concept of mainstreaming is regularly applied in the subareas of (urban) climate resilience (Friend et al., 2014; Saito, 2013) and climate adaptation (Runhaar et al., 2018; Uittenbroek, 2015), it is not yet part of the standard repertoire of the broader debate on urban resilience (see Johnson and Blackburn, 2014 for an exception). Likewise, 100RC does not use this concept in its 'City Resilience Index' (Arup and RF, 2015) or in its mid-term evaluation report (Urban Institute, 2018). A report on early insights into how participating cities operationalise resilience does use the concept of mainstreaming, but without specifically defining it (100RC, 2016).

In this study, we make use of the concept of mainstreaming to contribute to existing literature dealing with challenges to operationalise urban resilience (Chandler and Coaffee, 2017a; Coaffee et al., 2018). Indeed, little is known about how policymakers and planners approach these challenges and what problems they face. Because mainstreaming resilience goals in policymaking and decision-making in the city can be described as the ultimate goal of operationalising urban resilience, we analyse two cities that use similar approaches in this regard as both of them participate in 100RC. Christchurch and Rotterdam were among the first cities accepted to participate in 100RC and both published their resilience strategies and appointed a Chief Resilience Officer in 2016 (CCC, 2016; Gemeente Rotterdam, 2016). Almost three years of experience with the strategy and with the role of the Chief Resilience Officer provide a sufficient knowledge base to address the following research question:

In how far does participation in 100RC contribute to mainstreaming urban resilience in policy and decision-making in Christchurch and Rotterdam?

Our main source of information is 55 expert interviews with municipal representatives, participants in the strategy development process, Chief Resilience Officers and their resilience teams, as well as with other relevant stakeholders, such as emergency managers at regional and national levels, providers and network owners of critical infrastructure services, civil servants, politicians and 100RC staff. Interviews took place between October 2017 and May 2019. They lasted between 45 and 120 minutes and were audio-recorded, transcribed and coded. Appendix 3 provides an overview. Other primary data, such as newspaper articles or policies and plans at municipal, regional and national level – particularly the cities' resilience strategies – were also an essential object of analysis. We used Qualitative Content Analysis (Gläser and Laudel, 2013) to identify and distil particular problems that policymakers and planners face in mainstreaming urban resilience and to categorise them. To develop the categories, we drew on the literature review presented in Section 5.2 and then further refined them in light of the empirical analysis. The categories include 1) problems related to making resilience a top priority for policymaking and planning, 2) problems related to establishing and maintaining cross-boundary governance networks, and 3) problems related to achieving active engagement and support from decision-makers from public and private sectors as well as citizens.

In the next section, we give an overview on how current risk management and governance literature discusses problems of operationalising urban resilience. We introduce the concept of mainstreaming and develop analytical sub-sections for the empirical analysis. In Section 5.3, we analyse how urban resilience has been operationalised in Christchurch and Rotterdam, focusing on the cities' participation in 100RC. In particular, we identify and analyse problems that policymakers and planners face with regard to mainstreaming urban resilience. It is important to mention that we are not seeking to evaluate the success of implementing the resilience strategies. Rather, we seek to enrich academic and practical debates on operationalising urban resilience by defining and analysing requirements for mainstreaming. In the remaining two sections, we discuss the identified problems in light of the existing literature and come up with some suggestions to stimulate mainstreaming, supplementing the measures taken in the context of 100RC.

5.2 Mainstreaming urban resilience: Political commitment, governance networks and active engagement of decision-makers and citizens

— The introduction of the concept of resilience in the social sciences, including in urban and regional studies, was justified by the need to respond to global threats such as climate change and international terrorism (Walker and Cooper, 2011). With the same rationale, the concept has pervaded public policy fields of national security, critical infrastructure protection, financial risk management and urban planning (Walker and Cooper, 2011). The increasing attention paid to resilience as an urban policy narrative (Béné et al., 2017) is demonstrated by international initiatives such as ICLEI's Resilient Cities Programme (www.resilientcities2019.iclei.org) and the UN-HABITAT Urban Resilience Hub (www.urbanresiliencehub.org). Resilience is mentioned explicitly in the Sustainable Development Goals, in the Paris Agreement and the New Urban Agenda, and it represents the core of the Sendai Framework for Disaster Risk Reduction. There is no doubt that 100RC not only joined this trend but has also been a major driving force behind it. The Rockefeller Foundation has dedicated USD 100 million funding to the programme, supporting no less than 100 cities around the globe to develop resilience strategies and appoint a Chief Resilience Officer. 100RC has collaborated with other international NGOs as well as with private tech firms and consultancies to create a global resilience market (Leitner et al., 2018) and participating cities striving to implement their strategies are increasingly the subject of urban resilience research (e.g. Fastenrath et al., 2019; Spaans and Waterhout, 2017).

The aspirations that accompany the concept of urban resilience could hardly be more ambitious. Scholarly and grey literature both highlight the potential to adapt to and/or mitigate various problems, including the negative consequences of climate change (Boyd and Juhola, 2015), an increased risk of terrorist attacks (Coaffee, 2009), natural hazards (Hutter et al., 2013), failing infrastructure systems (Amin, 2002) and economic decline (Hassink, 2010). In short, urban resilience promises to provide guidance on how to deal with an increasingly complex and interconnected world where the failure of one

sub-system can easily cascade to other sub-systems of the city. Consequently, urban resilience literature often frames cities as complex adaptive systems, acknowledging the interdependent character of social, ecological, technical, economic and other systems in a city and highlighting their self-organisation (Meerow et al., 2016). The success story in the rise of this concept can be ascribed to the concept's interpretative flexibility (Amir and Kant, 2018), allowing it to be applied to various policy and action fields. Accordingly, some authors, such as Baggio et al. (2015), argue that resilience can serve as a boundary concept bridging different epistemic divides and creating identity to structure common practices across different communities of knowledge production.

However, the concept's inflationary use and interpretive flexibility also have a potential downside. Davoudi et al. (2017) argue that resilience risks becoming 'an empty signifier which can be filled with multiple meanings and which can serve conflicting political, economic, and social interests'. This assumption raises criticism about the concept's applicability and usefulness (Béné et al., 2017; Brunetta and Caldarice, 2019; Mikulewicz, 2019). For instance, some scholars criticise the concept of urban resilience for not capturing adequately the political dimension of this resilience. Critical scholars rightfully pose the question of 'resilience for whom?' (Lebel et al., 2006; White and O'Hare, 2014), highlighting the fact that resilience measures regularly privilege certain social groups over others. Meerow and Newell (2019) have recently broadened the focus and provide an analytical framework for urban resilience, raising questions of 'resilience for whom, what, where, when, and why?'. This differentiation not only allows questions to be asked about who benefits from certain resilience measures but also indicates that it matters what kind of system or sub-system is intended to become resilient. Moreover, it points to potential spatial and temporal trade-offs of resilience policies and asks who has the power to define what resilience is and how the concept is used. Ultimately, the win-win paradigm that is often promulgated with the introduction of the concept into political practice (Leitner et al., 2018) seems difficult to sustain.

Cities participating in 100RC have assigned themselves an active role in operationalising urban resilience and fostering institutional transformation (Urban Institute, 2018). However, urban resilience is usually not yet a distinct policy field in the sense of comprising substantive authority, institutional order and substantive expertise (cf. Massey and Huitema, 2013). Therefore, policymakers and planners now face the task of mainstreaming urban resilience in policy and decision-making. *Mainstreaming*, here, means that resilience objectives are integrated into existing sectoral policies and decision-making practices. As Runhaar et al. (2018) show, mainstreaming can contribute to create synergy effects between different sectors as well, as it represents a potentially resource-efficient and effective policy strategy because budgets can be combined. However, in contrast to a 'dedicated approach', where specialised, stand-alone policies and programmes are developed (Uittenbroek et al., 2014), mainstreaming might also run the risk of diminishing issue visibility and attention (Runhaar et al., 2018). Interestingly both the literature on mainstreaming – particularly climate adaptation mainstreaming – as well as the literature on challenges to operationalise urban resilience cluster around three mutually related but distinct issues.

Firstly, in response to an overly rationalist way of risk management that relies on monitoring and prediction, introducing urban resilience as a new policy goal is often associated with a paradigm shift highlighting the need for adaptation, flexibility and contingency planning (Perelman, 2007). This shift is accompanied by a change in focus – from managing risk to managing vulnerability and contingency (Oels, 2013). The literature suggests that such a paradigm shift is very hard to achieve because relevant actors, such as risk managers, have been trained to work in a predict-and-control environment and epistemic traditions are hard to change (Huck and Monstadt, 2019). In addition, Normandin et al. (2019, p. 21) argue that it requires cultural change, including a transformation of interests and powers, incentives, and knowledge dissemination. Very similar challenges are described in the literature on mainstreaming climate adaptation. There it is argued that for any policy integration to be effective, there must be a minimum of political commitment (Massey and Huitema, 2013). Uittenbroek et al. (2014) distinguish between direct and indirect political commitment. Whilst direct political commitment refers to setting a political agenda, allocating resources and endorsing specific policies, indirect political commitment is mainly organised through finding synergies by policy coupling and combining resources (Uittenbroek et al., 2014, p. 1044). As resilience applies to and connects different policy fields, such as urban planning, natural resource management and crisis management, we contend that mainstreaming urban resilience equally requires political commitment in the sense of anchoring resilience as a new overarching policy paradigm and allocating resources, as well as in the sense of finding synergies by policy coupling.

Secondly, the governance-related literature on urban resilience calls for new governance models that highlight the need for governance networks across sectoral, administrative and territorial boundaries. Organisational fragmentation and institutional silos are perceived as vulnerabilities because they prevent efficient and effective collaboration of relevant stakeholders, including private and public actors. For instance, Almklov et al. (2012) point to the fragmented management of interdependent infrastructure systems and Vedeld et al. (2016) call for strengthening multi-level governance arrangements for urban resilience. This closely corresponds to climate adaptation literature stressing the need for multi-level (Bauer and Steurer, 2014) and multi-sector (Dewulf et al., 2015) governance networks. In particular, the notion of ‘intra- and inter-organisational mainstreaming’ promotes the idea of collaboration and networking across departmental and sectoral boundaries ‘to generate shared understandings and knowledge, develop competence and steer collective issues of adaptation’ (Wamsler and Pauleit, 2016, p. 73). Some authors, such as Frazier et al. (2010), stress the challenges that accompany networked governance arrangements for urban resilience, in that different stakeholder groups might have diverging perceptions and interests. As Sanchez et al. (2018, p. 2) argue, this might result in ‘organisations cherry picking specific aspects and leaving other aspects unaddressed, polemic turf-wars that will not result in action and, most challenging, a lack of cohesion in attempts to achieve meaningful urban resilience’. Hence, mainstreaming urban resilience requires the establishment and maintenance of cross-boundary governance networks to identify synergies and resolve conflicts of interest.

Thirdly urban resilience literature highlights the fact that enhancing resilience is not merely an issue of public policy but requires active engagement and support from the private sector as well as from citizens (Marana et al., 2018a). For instance, decision-making and planning of private infrastructure and health providers have great influence on a city's resilience (Monstadt and Schmidt, 2019; Zaidi and Pelling, 2015). Moreover, it is argued that effective disaster prevention and recovery requires the involvement of citizens and calls for extensive public participation (Vallance, 2015). Accordingly, approaches of public–private partnerships (Dunn-Cavelty and Suter, 2009) and citizen engagement (Pearce, 2003) become prominent not only in the literature on operationalising urban resilience but also in the literature on mainstreaming climate adaptation (Friend et al., 2014; Uittenbroek et al., 2014). However, engaging these different stakeholder groups is challenging because they regularly have diverging interests (McConnell and Drennan, 2006). The challenge for policymakers and planners becomes an issue of developing and applying appropriate methods and techniques to convince these different stakeholder groups alike to engage actively in resilience-building measures (Uittenbroek et al., 2014). Therefore, mainstreaming urban resilience requires the commitment and active engagement of decision-makers from public and private sectors as well as citizens.

In light of this literature review, we structure our analysis of the cities of Christchurch and Rotterdam along these three issues. In particular, we concentrate our analysis on the process of developing the resilience strategy, on the set-up of the official policy document and on the role of the Chief Resilience Officer in each city, delineating specific problems that policymakers and planners face in mainstreaming urban resilience.

5.3 Rotterdam and Christchurch as participants in 100RC: Problems of mainstreaming urban resilience

By singling out Rotterdam and Christchurch, we study two cities in different parts of the world that have had dissimilar experiences with disasters over recent decades. Whilst Christchurch experienced a series of devastating earthquakes in 2010 and 2011 that caused 185 deaths and destroyed much of the city's built environment, Rotterdam has not suffered any similarly destructive catastrophe since the Second World War. This difference not only has implications on how resilience is perceived in the two cities but also profoundly shapes the policy discourse as well as the public debate on urban risk management.

New Zealand is located in the western part of the Ring of Fire; an area of the Pacific Ocean characterised by frequent tectonic plate collisions and frequently experiencing severe earthquakes, volcanic eruptions and tsunamis. Due to the uncontrollability of such natural hazards and due to their regular occurrence, disaster risk management in New Zealand is characterised by a focus on response and recovery. New Zealand was one of the first countries making use of the concept of resilience for national

policymaking (Britton and Clark, 2000), and a new National Resilience Strategy was recently published (New Zealand Government, 2019). This policy documents a paradigm shift from a purely protectionist to a more adaptive approach in risk management. In the Netherlands, there are similar signs of approaching a paradigm shift in risk management, particularly in flood management (Restemeyer et al., 2016), as exemplified by the National Adaptation Strategy (Ministry of Infrastructure and the Environment, 2016) or the new Delta Programme (Ministry of Infrastructure and Water Management, 2018). However, resilience as a concept is only slowly entering policy discourses. This does not mean that the Netherlands has tended not to attach as much importance to resilience issues. However, resilience as a term for policymaking is relatively new.

Despite their differences, the cases have much in common. Historically, both Christchurch and Rotterdam were built on land that was not geologically unsuitable for settlement. Settlement was only possible due to progressive use of engineering works, such as dams and drainage systems (Borger and Ligtdag, 1998; Watts, 2011). Without these works, Christchurch would sink into a swamp and most of Rotterdam would be under seawater. In this sense, since their establishment, both cities have dealt with urban resilience issues by managing the risks posed by water. Nowadays, the cities share another feature with respect to urban resilience: both have been accepted to participate in 100RC pioneered by the Rockefeller Foundation. Both cities, particularly the mayors, saw the opportunity to link different policy fields and were attracted by the idea of entering a city network for knowledge sharing (Interviews 1, 4, 31, 48).

Participation in 100RC usually starts with the development of a resilience strategy according to a standardised procedure. An agenda-setting workshop including the opportunity for broad stakeholder participation is followed by a preliminary resilience assessment to identify ‘discovery areas’. Working groups for each ‘discovery area’ are tasked with identifying potential actions for improvement. Finally, cross-cutting issues are identified in workshops. With the help of an external partner – in both cases AECOM – the resilience strategy is written up based on these assessments; it includes a vertical hierarchy covering a vision, goals and proposed projects. In addition, 100RC covers the costs of appointing a so-called Chief Resilience Officer for two years, who reports directly to the Chief Executive in the municipal administration and/or to the mayor. Both cities opted to retain this position after the 100RC funding period (see 100RC, 2016; Arup and RF, 2015; Urban Institute, 2018 for further details).

5.3.1 Problems of gaining political commitment

— Despite the initial support of the mayors, the resilience strategies did not receive unreserved support in the two cities. In Christchurch, the prescriptive timeframe imposed by 100RC to develop the resilience strategy did not align with the particularities of recovering from an earthquake (Interviews 31, 46, 47). In the midst of the recovery process, it was not a key priority of many stakeholders to develop a new strategy – especially as it relates to the more distant future (Interviews 46, 47,

48). Scarce resources in terms of time and money seemed to be better invested in restoring urban life as quickly as possible. Public pressure and media attention were enormously high and put a great strain on many actors (Interviews 23, 26, 27), most of whom had to deal with private losses and psychological stress themselves (Interviews 22, 44). In addition, the time was marked by a constant fear of the next earthquake. A civil servant from the city council describes the situation as follows:

In a city like this, with this scale of reconstruction as a result of the biggest natural disasters in our history going on... it was a really crowded place to try and have a conversation about resilience. [...] It was a struggle to find out exactly where you fit in and what your entry level was in this wider conversation around recovery. [...] So, in hindsight, is resilience the right conversation for Christchurch? Absolutely. Was the timing perfect? Probably not. [...] ...you're struggling for air time and there is so many other things going on. (Interview 31)

In Rotterdam, it became clear that the resilience strategy is in competition with other existing initiatives and visions of the city (Interviews 18, 51). Not only has the municipal government agreed to transform Rotterdam into a resilient city, but the city also has strategies and visions for sustainability, circular economy and energy transition, to name just a few. Interviewees describe the resilience strategy in Rotterdam as lacking political commitment compared to other visions such as sustainability or circular economy, in that there is no dedicated political target and no programme office with associated funding (Interviews 1, 4, 51). Hence, the challenges for advocates of the resilience strategy in Rotterdam are similar to those in Christchurch. They have to seek opportunities to link resilience with other urban policy goals in a way to create positive spin-offs and they have to look for ways to combine existing sectoral funding for cross-sectoral resilience work (Interviews 4, 8, 31, 46, 51) – key essentials of the indirect approach to gain political commitment to mainstreaming.

In our analysis, we also found that the set-up of resilience strategies hinders their anchoring as an overarching policy goal. The strategies were developed along the guidelines of 100RC and in cooperation with international consultancy AECOM. Experiences gained throughout this process could be shared within a global network of cities and assistance for implementation could be acquired from international tech and engineering companies, such as Cisco and Siemens. In a way, 100RC created a small world of its own that Leitner et al. (2018) call the 'resilience complex'. Consequently, the resilience strategy risks becoming a rather siloed policy document without any formal legitimation from higher levels of government. To give a contrasting example, the Rotterdam Adaptation Strategy (Rotterdam Climate Initiative, 2013) is based on knowledge developed through the nationally funded programme *Knowledge for Climate* (www.knowledgefoclorclimate.nl) and is closely related to the National Adaptation Strategy (Ministry of Infrastructure and the Environment, 2016). This kind of multi-level policymaking is a core factor for policy success (Dewulf et al., 2015).

Christchurch took an interesting approach to counteract the risk of developing the resilience strategy as an alienated policy document: the municipality closely linked the strategy to the existing Urban Development Strategy (CCC et al., 2007), a strategy developed for the metropolitan region of Greater Christchurch in a partnership between the city government of Christchurch, its neighbouring districts of Waimakariri and Selwyn, the National Transportation Agency and the Regional Environmental Agency. An interviewee describes the resilience strategy as *'putting a resilience lens on the Urban Development Strategy'* (Interview 29). Although the resilience strategy is not based on any legal status, it is thus closely connected to an existing network of actors in a formal setting, which might give it greater influence (Interviews 29, 46, 48). However, this might also deprive the resilience strategy from greater visibility, as actors might perceive it as a by-product of the Urban Development Strategy (Interview 30) and not as an overarching leitmotif of the city: such misperception is one of the main disadvantages of mainstreaming as described by Runhaar et al. (2018).

In summary, introducing a resilience strategy and appointing a Chief Resilience Officer have not yet led to resilience being anchored as an overarching and generally accepted policy goal in the two cities. Urban resilience rather represents one out of many urban agendas with which it competes for political commitment and the allocation of resources. The fact that the resilience strategies are embedded only marginally in multi-level policymaking processes further challenges their viability. In both cases, the result is that actors have to seek actively for synergies and potential links between resilience and other policy goals and hence to deploy ways for raising indirect political commitment.

5.3.2 Problems of institutionalising governance networks

Although the resilience strategies might not be legally binding documents and are perceived by some stakeholders as a rather informal guideline for action (Interviews 2, 24, 29), they still represent the most holistic attempts of policymaking in both cities. Informants in both cities report that the strategy development process contributed to drawing new links between previously separated policy fields and to making new contacts within and beyond the city administrations' boundaries (Interviews 1, 4, 15, 21, 22, 28, 29, 31, 45, 52). The benefits of defining a common vision and of gaining a similar understanding of resilience have been stressed (Interviews 8, 45, 46). Informants from both cities further highlight the benefits of mutual learning in the global network of participating cities (Interviews 4, 8, 18, 20, 47, 48) as well as the fact that participation in 100RC contributed to the municipal administrations seeing themselves in a leadership position (Interview 21). In addition, in both cities the Chief Resilience Officers play increasingly important roles in formal decision-making, as they are key informants when new city plans and city visions are being developed (Interviews 47, 51).

Nevertheless, whilst the mid-term report of 100RC reaffirms the goal of supporting institutional transformation (Urban Institute, 2018, p. 10), both cities face considerable challenges to institutionalise cross-boundary governance networks and

to maintain the relationships built up during the development phase of the strategy. In Rotterdam, for example, it is proving to be difficult to involve external stakeholders, such as private infrastructure managers and network owners (Interviews 3, 14, 52). In addition, overlapping territorial jurisdictions (for instance, of water authorities, safety regions, provinces, municipalities and infrastructure providers) complicate cooperation (Interviews 49, 50). In Christchurch, the network of actors is characterised by the experience acquired during the response and the recovery after the series of earthquakes in 2010 and 2011. Recovery and repair was accompanied by significant disputes about who should bear the costs of recovery (Interviews 21, 33, 36, 39, 48) and who has the power to define what the future city of Christchurch should look like (for a detailed discussion, see Bennett et al., 2014). For example, at the time of data collection, national and local governments were still arguing about how to share the costs of reconstruction and increased demands for maintenance (Interviews 39, 46, 48). Any kind of network management has to take these strained relations into account, which makes any cross-boundary collaboration a highly political issue.

With respect to the set-up of the strategies, Christchurch took the aspect of cross-territorial connectivity into account at an early stage in the development of its strategy. From the outset, the neighbouring districts of Waimakariri and Selwyn were included: they were co-signatories of the application to join 100RC. Thus, the strategy was extended from Christchurch's administrative boundaries to the Greater Christchurch Metropolitan Region. Interviewees retrospectively commended this approach for better fitting the spatial scope of the experienced disaster and for creating the option of addressing issues that reach beyond the city's boundaries, such as transportation, regional development and regional risk management (Interviews 22, 25, 29, 31, 46, 48). However, as is the case for Rotterdam, the strategy itself entails only small incentives for actors to institutionalise new cross-boundary relationships: cooperation is mostly restricted to the scope and timespan of the projects defined in the strategy, which brings the risk that established relationships could disintegrate over time after a particular project is completed (Interviews 1, 8). Furthermore, the voluntary character of the strategies does indeed encourage cross-boundary collaboration whenever different actors share common interests and potentially benefit from one another. However, we could identify only small incentives to connect actors with diverging interests or to foster negotiations for the redistribution of resources.

The main issue is that connections between different initiatives listed in the resilience strategies and between different actors are mainly maintained by the Chief Resilience Officer as 'the city's point person for resilience building' (Berkowitz, 2015). Limited resources in terms of time, money and personnel were mentioned by a range of interviewees (23, 31, 47, 51, 52) as a major impediment impeding the connections between different actors that were built during the strategy development process. For example, one informant stated: *'It is simply too much to manage it all'* (Interview 51) and another one argued: *'...just putting one CRO in ain't gonna make a city resilient'* (Interview 32). The Chief Resilience Officers of both cities have to set priorities and decide which projects they want to support (Interviews 47, 51). However, prioritisation also means that other projects and initiatives are not taken into account, even though they could benefit from being viewed through a resilience lens (Interviews 47, 51). One

informant points to a weakness related to the role of the Chief Resilience Officer as a single point person for building up the actor network: *'If [the Chief Resilience Officer] was hit by a truck tomorrow – God forbid – then everything would be gone. There would be almost no one left to continue the resilience work in the city.'* (Interview 33) In summary, the endeavours associated with participating in 100RC have not yet led to considerable changes in urban governance structures in Christchurch and Rotterdam. Although the development phases of the resilience strategies have contributed to drawing new cross-boundary relations between some actors, the strategies seem to provide small incentives for actors to maintain and further consolidate these networks. Rather, they function at a voluntary and project-centred basis, which constrains cross-boundary cooperation both in time and in relation to the participating actors. In the absence of such incentives, the role of the Chief Resilience Officer as a network manager seems to be daunting.

5.3.3 Problems of gaining active engagement of public and private decision-makers and citizens

Whilst it was relatively easy to convince political decision-makers to participate in 100RC because it brings financial benefits (Interview 46), in both cities, informants report difficulties with regard to securing the active engagement of these decision-makers (Interviews 4, 47). In particular, informants referred to the challenge of getting decision-makers from different departments of the municipality to be equally enthusiastic about the concept of resilience (Interviews 46, 51). Although all initiatives listed in the strategy refer to one or several aspects of resilience as defined by 100RC, the added value of the strategy is that it provides links and develops synergies between these single initiatives (Interviews 4, 8, 20, 31). As such, what stakeholders perceive as one of the most important benefits of participating in 100RC is indeed an opportunity to mainstream resilience in policy and decision-making. However, it also represents one of the biggest challenges (Interviews 31, 47, 51, 52).

'Adopting the resilience lens' (Interview 4) often requires project managers and policymakers to consider issues that were previously beyond their remit. This entails the investment of additional resources in terms of personnel, time and money. One of the main challenges with regard to convincing political decision-makers to invest these additional resources is that the added value of resilience measures is hard to demonstrate, let alone to quantify (Interviews 1, 46). Whilst other urban agendas are backed up by concrete and measurable goals, such as to become CO₂ neutral by 2050, resilience as a goal seems to be too complex to be expressed in such concrete terms:

We are also living in a political climate... we have a city council that needs to approve budget, etc. Therefore, on the one hand you want to show results. [...] But if you can't measure it, how can you show the results? (Interview 1)

With regard to decision-makers from the private sector, the City Resilience Framework (Arup and RF, 2015) used by the cities to develop the strategy seems to be well suited to attract a range of different actors to engage in the process (see Section

5.3.2). However, it does not seem to be fully suited to convince them to buy into the idea and to agree to long-term investments. Although one of the main tasks of the resilience teams in Rotterdam and Christchurch lies in advocating resilience, in explaining the concept and in demonstrating its usefulness within and beyond the municipal administration (Interviews, 4, 8, 31, 47), they seem to lack customised tools or mechanisms to demonstrate the added value of their initiative. Decision-makers from the private sector are difficult to access because they participate in other forums (Interviews 5, 7, 13, 30), speak a different language (Interviews 6, 15, 50) and are often unfamiliar with the way municipalities work (Interviews 15, 53). In this vein, one interviewee (46) regrets that the support of 100RC *'pretty much stops after the planning stage'*. Another interviewee (29) refers to the risk of the resilience strategy remaining *'a shiny new document with the flavour of the month'* that might be substituted by *'the next thing that comes along'*.

Attracting public support for and actively engaging citizens in the strategy is similarly challenging in both cities. In Christchurch, a major public participation process took place around the time that the city started its resilience initiative. The development of the Christchurch Recovery Plan included an unprecedented dimension of public participation under the guidance of the city council (Bennett et al., 2014). Unfortunately, the enthusiasm of the population was considerably reduced when the national government took over the planning process in a non-transparent manner under the state of national emergency (Vallance, 2015). Setting up another large-scale participation procedure for the resilience strategy did not seem to be appropriate at that time. Nevertheless, the 100RC process improved the relationship between the municipality and native Māori communities and gave Māori a stronger role in urban development planning (Interviews 29, 32, 48). Māori worldviews and knowledge proved to be in line with resilience thinking and hence contributed to developing a mutual vision for the city. Moreover, the strategy includes a range of bottom-up initiatives, such as the development of a 'time bank' to strengthen community cohesion and the resilience team cooperates with grassroot initiatives such as the *Gap Fillers* to promote public participation in urban development issues (Interviews 46, 47, 48).

Rotterdam, too, decided to put a strong focus on social cohesion in their resilience projects concentrating on some of the most deprived areas of the city (Interviews 51, 52). However, the process of developing the strategy also served as a mechanism to pre-select who has the power to articulate needs and interests (Hommels, 2018). Indeed, compared to other municipal programmes, such as the Rotterdam Water Sensitive Initiative, public participation in the resilience strategy is limited. Nevertheless, similar to Christchurch, Rotterdam is increasingly investing in public education, as can be seen in events such as the Rotterdam Venture Café (www.venturecaferotterdam.org), which regularly hosts themed evenings on urban resilience and how to achieve it. The city also cooperates with the Rotterdam University of Applied Sciences, which offers courses and exchange programmes on urban resilience. In addition, the city is increasingly collaborating with the local arts scene to promote urban resilience thinking among Rotterdam's citizens and to initiate a wider public debate on urban resilience (Interviews 8, 51).

In summary, developing a resilience strategy and appointing a Chief Resilience Officer has only partly succeeded in actively engaging decision-makers from the public and private sector as well as citizens. For instance, the resilience teams in Christchurch and Rotterdam had problems achieving public support during the development phases of their strategies because they made only limited use of public participation processes at this stage. However, they now show great creativity to inspire the public in their initiative, linking it to the local arts scene, grassroots movement and educational system. Comparable mechanisms seem to be lacking with respect to convincing decision-makers, particularly those from the private sector. One of the main reasons for that from the perspective of the interviewees is that the resilience teams lack sufficient techniques, mechanisms and meeting places to demonstrate the added value of resilience.

5.4 Discussion: Mainstreaming urban resilience requires more than participation in 100RC

Our analysis provides some interesting insights for the academic debate on operationalising urban resilience. In light of the results, we argue that developing a resilience strategy and appointing a Chief Resilience Officer are relevant but not sufficient first steps to mainstream urban resilience in Christchurch and Rotterdam. If these endeavours are not backed up by institutional changes, for instance in procedural law and national policymaking, we see a risk that they will lead only to incremental changes tied to specific project scopes and timeframes. In the following, we discuss the identified problems that policymakers and planners face with regard to mainstreaming urban resilience and, in order to address them, make some suggestions for supplementing the measures taken in the context of 100RC.

Firstly, contrary to what the policy guidelines of 100RC suggest, anchoring resilience as a new overarching policy paradigm does not take place in an institutional vacuum. Rather, resilience competes with existing urban agendas and other policy goals for direct political commitment, such as the allocation of resources and visibility on the political agenda. Consequently, policymakers and planners in Christchurch and Rotterdam seek to enhance indirect political commitment by identifying cross-sectoral synergies, policy coupling and combining resources (cf. Uittenbroek et al., 2014). Essentially, their work is made difficult by a lack of political mandate from higher levels of government. In the absence of a national support programme on developing urban resilience strategies or other mechanisms of political legitimation, resilience strategies, such as those of Christchurch and Rotterdam, run the risk of being alienated and gaining little attention in the overall political discourse. Therefore, for mainstreaming urban resilience in policy and decision-making, endeavours have to go beyond developing a resilience strategy and appointing a Chief Resilience Officer. Rather, respective policies at national level are required to provide direct links to urban resilience strategies. For instance, policy reforms in national risk management arrangements making use of the concept of resilience could provide city administrations with guidance and a political mandate to mainstream urban

resilience. As the case of Melbourne, for example, demonstrates, national policies supporting an urban resilience strategy can considerably stimulate the implementation of ambitious urban resilience programmes (Fastenrath et al., 2019). Whilst Rotterdam might benefit from the city's positive experiences in multi-level governance for adaptive flood management (Dunn et al., 2017), Christchurch might be able to link the resilience strategy closely to the new National Disaster Resilience Strategy (New Zealand Government, 2019). It will be interesting to see if these opportunities will be seized.

Secondly, by participating in 100RC, cities enter a network of actors working jointly on issues of urban resilience and consisting mainly of other participating cities and their Chief Resilience Officers, private consultancies and tech firms. Leitner et al. (2018) call this the 'resilience complex'. However, this network of actors differs tremendously from what scholars of urban resilience would call governance networks that reach beyond sectoral, administrative and territorial boundaries (Almklov et al., 2012; Ernstson et al., 2010; Vedeld et al., 2016). Rather than assembling actors who are held together by a common commitment to or interest in a particular city and its citizens, actors in the 'resilience complex' are connected by a common interest in urban resilience in general or in the economic possibilities that the resilience market might entail (Leitner et al., 2018). This has been shown to have positive effects for participating cities in terms of learning, public awareness, knowledge dissemination and obtaining a leadership role and prominence in the urban resilience movement. However, it does not necessarily contribute to institutionalising governance networks that are required to define synergies, couple sectoral policies and combine budgets: some of the key essentials of mainstreaming (Uittenbroek et al., 2014). Actors who enter this sort of governance network mostly join voluntarily: for instance, by participating in the development of the resilience strategy or in some affiliated projects. Accordingly, cooperation is limited to those actors who benefit from specific projects and rarely goes beyond the scope or duration of a project. This reflects an incremental notion of operationalising resilience as urban experiments (Fastenrath et al., 2019; Wakefield, 2019) and an understanding of cities as experimental labs (Evans, 2011). Profound mainstreaming, however, would require all relevant actors – including those with diverging interests – to join. Moreover, it would require that these governance networks remain in place in the long term. Institutional incentives and amendments in procedural law should support endeavours such as the appointment of a Chief Resilience Officer to manage and maintain governance networks. Such incentives could include not only procedural guidelines or mandatory knowledge exchange, but also penalties for relevant organisations that have regularly behaved uncooperatively, or rewards for their particularly cooperative behaviour. They could also include the establishment of cross-sectoral budgeting for planning, development and assessment processes, particularly for those processes related to risk management.

Thirdly, attracting the support and active engagement of decision-makers from the public and private sectors as well as of citizens (Marana et al., 2018a) should not be taken for granted but instead seen as a resource-intensive and daunting process for those tasked with this assignment. This stands in contrast to the win-win paradigm underlying the policy guidelines of 100RC (Leitner et al., 2018), which suggests that

different actor groups are equally easy to convince of the added value of resilience because everybody can benefit from it. Accordingly, the guidelines do not provide guidance on how to engage with different groups of stakeholders, such as decision-makers from public and private sectors or citizens, particularly in the case of reluctant actors. However, our analysis shows that different stakeholder groups demand different ways of communication and that urban policymakers and planners are not equally equipped to attract their support and active engagement. Whilst the Chief Resilience Officers and their teams in Christchurch and Rotterdam show great creativity with respect to generating public support, they struggle to convince strategic decision-makers, particularly those from private sectors. This is no surprise, given that policymakers and planners are usually trained to involve citizens in planning processes and can make use of a broad repertoire of techniques that have been developed over recent decades to enhance public participation but are usually less familiar with attracting private businesses. Because citizen engagement (Pearce, 2003) and public-private cooperation (Dunn-Cavelty and Suter, 2009) are equally important to mainstream urban resilience, we suggest that policymakers and planners would particularly benefit from support in order to convince decision-makers from the private sector. This support could include the development of techniques and mechanisms to access appropriate forums and meeting places and to translate public policy jargon into the language of private companies. Bespoke training as well as the development of tools to demonstrate the added value of resilience to private decision-makers might be beneficial supplements to the support for strategy development and to the financial support for appointing a Chief Resilience Officer.

5.5 Conclusion

— The often-described triumphal rise of the concept of urban resilience at the international level becomes a much more difficult path when it comes to operationalising resilience in cities. A range of scholarly literature, including this paper, illustrates the enormous upswing of the concept by showing that resilience is prominently represented in international agreements such as the Sendai Framework for Disaster Risk Reduction or the Sustainable Development Goals. In this light, the impression could be gained that participation in programmes such as 100RC means resilience is already a top priority on urban policy agendas, that relevant stakeholders are politically committed and actively engaged and that self-organised cross-boundary governance networks evolve naturally. However, the examples of Christchurch and Rotterdam as participants in 100RC show how contested and resource-intensive mainstreaming urban resilience is and how problem-laden this task is for policymakers and planners.

It goes without saying that cities potentially benefit in many ways from participating in initiatives such as 100RC. In particular, cities that have not previously made use of the concept of resilience may benefit by starting a public debate about potential chronic stresses and acute shocks and by developing ways of preparing for and responding to them. Raising public and policy awareness is indeed a key prerequisite

for any resilience action to be effective (Molin Valdés et al., 2013). For Christchurch and Rotterdam, there is no doubt that without their participation in 100RC, the resilience debate in the cities would be a different one, if it existed at all. In addition, the municipal administrations have adopted a leadership role in the urban resilience movement, providing them with visibility within and beyond their administrative jurisdictions. The Chief Resilience Officers in both cities contribute to defining and implementing cross-sectoral resilience projects and thus to providing meeting places for relevant stakeholders who would otherwise not necessarily get together. Finally, the development of a resilience strategy that includes broad stakeholder participation, contributes to a common understanding of resilience and of the major urban governance challenges along the pathways to urban resilience. These are valuable requirements for mainstreaming urban resilience in policy and decision-making (cf. Runhaar et al., 2018; Uittenbroek et al., 2014; Wamsler and Pauleit, 2016). Our analysis, however, raises serious doubts as to whether these efforts will be sufficient to integrate resilience goals in sectoral policy and decision-making as well as to dissolve policy silos.

Policymakers and planners who approach the task of mainstreaming urban resilience walk a thin line between the desires to create synergy effects between different sectors and to provide a resource-efficient and effective policy strategy on the one hand, and the risk of diminishing issue visibility and attention on the other hand (cf. Runhaar et al., 2018). Nevertheless, mainstreaming urban resilience should stimulate structural rather than incremental innovations in policymaking, planning and decision-making procedures across different public and private domains. The added value of resilience initiatives is not only to provide a ‘resilience lens’ to different policy areas – as two of our interviewees (4, 29) put it – but ultimately to coordinate and combine different policies and decision-making processes so as to generate synergies and increase efficiency. Ideally, these coordination processes are not project-based but institutionalised in order to be effective in the long term. Relying solely on the 100RC blueprint of resilience policies to achieve this sort of change would be naïve to some extent, as it does not sufficiently address the main problems that policymakers and planners face. Rather, this blueprint needs to be supplemented by structural changes in (national) policymaking to enhance political commitment, by institutional incentives and amendments in procedural law supporting the establishment of governance networks and by support mechanisms and training for urban policy makers and planners to raise active engagement of different stakeholder groups, including decision-makers from the private sector.

Applying the concept of mainstreaming in research on operationalising urban resilience has helped us to delineate some specific problems of policymakers and planners and to provide suggestions for supporting them. However, it also raises some more questions. As such, we suggest future research should focus on how resilience is operationalised and by whom (cf. Meerow and Newell, 2019). A valuable strand of future research could be to analyse the role, interests and motives of different actors, such as international consultancies and tech firms, but also of city administrations that are taking part in resilience initiatives like 100RC. In addition, research on urban resilience should go beyond demonstrating the negative effects of siloed governance

arrangements (Almklov et al., 2012; de Bruijne and van Eeten, 2007; Vedeld et al., 2016). Instead, it should focus on why certain actors and actor groups in a city are more, or less, active and on finding out how to involve resistant actors and those with diverging interests. Finally, the literature on measuring and assessing urban resilience (Prior and Hagmann, 2013) should not merely be criticised for not accounting for the evolutionary character of cities (Davoudi, 2012). More constructively, its findings could be translated into mechanisms and techniques that help urban policymakers and planners to demonstrate the added value of resilience to decision-makers from public and private sectors. As more and more cities make use of the concept of resilience in policymaking and planning, we expect to find answers to these and similar questions step by step from empirical research on cities around the world.

6

CONCLUSIONS AND REFLECTIONS

6.1 Introduction

Due to their high population densities, their architectural structures, their economic importance and their geographical location (for instance, on deltas), cities are particularly vulnerable to various threats, such as those deriving from climate change (Boyd and Juhola, 2015), terrorist attacks (Coaffee, 2009) or natural hazards (Godschalk, 2003). The risk of cascading failures in coupled infrastructure systems intensifies these vulnerabilities (Graham, 2010a). The concept of urban and infrastructure resilience has been taken up in academic and policy debates as a normative framework to respond to such vulnerabilities (Baggio et al., 2015; Coaffee, 2008; Walker and Cooper, 2011). Resilience promises to provide guidance in times of risk, crisis and uncertainty and stresses the need for adaptive and multi-scale governance networks to manage cities' capacities to resist, recover and adapt (Birkmann et al., 2010b; Coaffee and Clarke, 2015; Coaffee and Lee, 2016; Duit et al., 2010; Folke et al., 2005; Goldstein, 2012). However, empirical research in the fields of urban planning, infrastructure management, climate change adaptation and disaster risk management reports a gap between the take-up of resilience in policy frameworks and its actual implementation and manifestation in risk management and urban planning practices (Coaffee and Lee, 2016; de Bruijne and van Eeten, 2007; Fünfgeld and McEvoy, 2012; Sapountzaki et al., 2011). Policymakers and planners struggle to institutionalise resilience and their attempts tend to be incremental, ad hoc and reactive (Coaffee and Lee, 2016; Fünfgeld and McEvoy, 2012).

Academic literatures on urban and infrastructure resilience display a void regarding this implementation gap in that they mainly focus on policy design and call for stronger collaboration between stakeholders for policymaking, neglecting the institutional complexities when it comes to the governance of urban and infrastructure resilience (Coaffee et al., 2018; Normandin et al., 2019). In addition, although the resilience of modern cities depends on the contingency of service delivery through critical infrastructure networks (Chang et al., 2014; Monstadt and Schmidt, 2019), the nexus of urban resilience and infrastructures has received only minor attention in academic research (Birkmann et al., 2016). The main aim of the research described in the foregoing chapters was therefore to gain a more detailed understanding of the implementation gap and to derive suggestions for institutional adjustments to enhance governance capacities for urban and infrastructure resilience. The chapters provide in-depth analysis and empirical evidence on how resilience is approached in policymaking and planning practice in the two cities of Rotterdam and Christchurch and on how their strategies are shaped by existing institutional arrangements. This allows the main research question to be addressed:

How do current institutional arrangements shape the governance of urban and infrastructure resilience and how should they be restructured to address existing implementation gaps?

The following section 6.2 summarises key results, addressing each of the subsidiary questions for this research as introduced in chapter 1. Section 6.3 discusses these

results in light of the main research question, highlighting my contribution to existing bodies of literature on urban and infrastructure resilience. In addition, it provides suggestions for institutional adjustments to bridge existing institutional voids and constraints with regard to enhancing resilience. Section 6.4 provides some critical reflections and indicates future research needs.

6.2 Summary of results

From a governance perspective, urban and infrastructure resilience stresses the need for collaboration and learning in multi-level, multi-sector, multi-actor and cross-territorial governance networks (Boyd and Juhola, 2015; Duit et al., 2010; Fastiggi et al., 2020; Goldstein, 2012; Goldstein and Butler, 2012; Ingold et al., 2018). This study provides an institutional perspective on the governance of urban and infrastructure resilience. According to this perspective, existing institutional arrangements can either support or hamper measures to enhance resilience. Institutions essentially influence what resilience *does* (cf. Coaffee and Lee, 2016). As such, resilience can very well function as a ‘boundary concept’ in the sense of connecting and bringing together different communities of practice (cf. Baggio et al., 2015). However, the efficacy of this function depends decisively on the design of institutional arrangements. Resilience can also contribute to establishing adaptive and networked governance systems, for instance, by fostering knowledge co-production, network management, connectivity and mainstreaming. However, the success of these governance strategies is enabled or restricted by institutional conditions and prerequisites in the given city or region. Finally, this study supports the thesis that disasters can function as a ‘window of opportunity’ to enhance resilience (cf. Birkmann et al., 2010a) because disasters rise awareness of specific vulnerabilities and reveal existing constraints and shortcomings in existing disaster risk management practices. However, it also demonstrates that the existing institutional arrangements and the complexities of disaster situations essentially determine the extent to which this ‘window of opportunity’ is used.

Chapter 1 distils four essential governance strategies to enhance urban and infrastructure resilience as promulgated in existing literature: knowledge co-production, network management, enhancing connectivity and mainstreaming. The following paragraphs answer the subsidiary research questions for this research, summarising the results from the individual chapters. The four governance strategies were addressed separately in chapters 2 to 5.

How does knowledge production take place in two different knowledge communities dealing with urban and infrastructure resilience? How does this shape the respective governance and policymaking practices?

The comparative literature analysis in chapter 2 shows that the concepts of urban resilience and infrastructure resilience are rooted in different histories characterised by different disciplinary traditions and operationalised in different communities of practice. Knowledge production in each community of practice is institutionalised by means of (1) an established repertoire of instruments, techniques and methods,

(2) entrenched ways of mutual engagement, and (3) routinised problem understandings. These institutional arrangements impose parallel knowledge production rather than supporting interlaced ways of knowledge exchange and cross-fertilisation. For instance, literature on urban resilience is often characterised by a socio-ecological system understanding that stresses adaptive capacities, whilst literature on infrastructure resilience adopts either an engineering or a socio-technical system understanding that focuses on capacities to resist and recover. The chapter further elaborates that this leads to disparate epistemologies and problem definitions, and dissimilar visions of the future, creating knowledge boundaries between the respective communities, which may result in somewhat disconnected policy outcomes and governance practices. The empirical results from the case studies in Christchurch and Rotterdam (chapters 3 to 5) support this conclusion. Several interviewees mentioned instances of urban planners and infrastructure managers making use of similar vocabulary whilst referring to different aspects of their work, which makes cross-boundary cooperation complicated. For instance, different epistemologies and priorities of action proved to be a main problem for aligning contingency planning of infrastructure providers with urban resilience initiatives in the city of Rotterdam (chapter 4).

To address these epistemic divides, Marana et al. (2018a, p. 40) call for a 'multidisciplinary theory that integrates and coordinates a variety of city dimensions such as critical infrastructures, society, economy and environment into a unified conceptual framework'. However, against the background of my study, it is questionable that a unified conceptual framework is desirable or even possible. Rather, the results of my research suggest that each epistemic tradition has its legitimacy and contributes important knowledge elements to the conceptualisation and operationalisation of urban and infrastructure resilience. Therefore, I suggest to better coordinate the knowledge production and to stimulate cross-boundary learning between different communities of practice: for instance, by adjusting institutional arrangements. Rather than unifying conceptual frameworks, it is promising to engage in collaborative processes, as exemplified by the development phase of Rotterdam's and Christchurch's resilience strategies, as such engagement may contribute to developing a common vision for the future that accommodates different epistemologies across disciplinary and sectoral boundaries. However, consolidating such cross-boundary interaction processes and making use of them to co-produce new knowledge remains a challenge for policymakers and planners in both cities as well as for academics from different disciplinary backgrounds.

Which institutional key conditions are required for effective network management for enhancing urban and infrastructure resilience?

The case study of Rotterdam confirms the assumption that municipalities play important roles in enhancing urban and infrastructure resilience as they often initiate and are in charge of resilience initiatives. However, it also shows that the city administration's institutional capacity to effectively manage the network of relevant actors is limited because the municipality depends on decisions made by other public and private actors, particularly those relating to the management of interconnected infrastructure networks. Klijn and Koppenjan (2016, p. 11) define governance

networks as ‘more or less stable patterns of social relations between mutually dependent actors, which cluster around a policy problem, a policy programme, and/or a set of resources and which emerge, are sustained, and are changed through a series of interactions’. Although a range of cross-boundary resilience projects has been started in Rotterdam, the current institutional arrangements hamper effective network management because they do not sufficiently account for consolidating vertical, horizontal and cross-territorial relationships between relevant actors and their collective action. The short-term character of many projects brings the risk that actors will relapse into siloed working habits after a particular project ends and that relationships will have to be re-established time and again.

The case of Rotterdam indicates an institutional void with regard to cross-boundary risk management and contingency planning. So far, institutional arrangements rarely relate different policy domains to one another, contribute little to harmonise relevant measures at different governance levels and barely accommodate risk management approaches across administrative and territorial jurisdictions. Therefore, the findings reported in chapter 3 call for uniform procedural rules for effective network management, providing guidance on how to enhance and maintain cross-boundary working relationships between the large numbers of relevant actors. These rules, established by national or supranational governments, could contribute to effective network management for enhancing urban and infrastructure resilience by (1) redefining roles and responsibilities for cross-territorial risk management, (2) institutionalising cross-sectoral and cross-departmental budgeting of resilience measures, and (3) better aligning local actions and measures with those at regional and national levels of government. This could contribute to establishing lasting working relations at a strategic level of decision-making both in the municipality and amongst public and private infrastructure providers, and to diluting rigid epistemic traditions by initiating co-designing processes and shared goal definitions (cf. chapter 2). In addition, it could prevent actors at lower governance levels being made responsible for particular measures such as defining infrastructure vulnerabilities despite not having sufficient jurisdiction, institutional capacity or budget.

How does institutional connectivity affect urban and infrastructure resilience? How can institutional connectivity be achieved in the first place?

The analysis of institutional reforms in Greater Christchurch during and after the devastating Canterbury earthquake series of 2010/2011 reveals that disasters can be seen as windows of opportunity for necessary institutional reforms. As such, the Canterbury earthquake series has fostered changes in institutional arrangements and organisational structures, as different actors across the analysed policy levels, policy domains and territorial jurisdictions identified specific gaps in connectivity, and various initiatives are attempting to address them. However, the case also shows that enhancing connectivity is a contested process that might induce negative trade-offs and conflicts between involved actors that arise from the reallocation of resources and the redistribution of authority. For example, transferring authority for decision-making in the field of urban development from city council to national government after the earthquakes caused substantial conflict and limited the efficiency and efficacy of long-term recovery work. In addition, the enhancing of connectivity is considerably

affected by the uncertainties induced by disaster situations and by institutional complexities of risk management arrangements. For instance, limitations in time and financial resources as well as public pressure after a disaster proved to complicate the enhancing of connectivity.

In Greater Christchurch, conflicts between different actors intensified and declined, their cooperation waxed and waned and their relationships became institutionalised and de-institutionalised over time. The case study revealed different forms and dimensions of connectivity. From an institutional perspective, connectivity may entail a) the integration or amalgamation of policy domains, policy levels or territorial jurisdictions into one coherent arrangement, b) institutionalised forms of cross-boundary collaboration and coordination or c) ad hoc, temporary or informal cooperation or information and knowledge sharing between actors across boundaries. In terms of governance, connectivity can comprise hierarchical as well as networked decision-making structures and it can be established top-down or bottom-up. In addition, the case study shows that different connectivity dimensions (vertical, horizontal, cross-territorial) had very specific impacts on the three resilience capacities of resistance, recovery and adaptability. Therefore, and in critique of the main bodies of literature, approaches to enhance connectivity require a critical reassessment and prioritisation in terms of which particular forms and dimensions of connectivity should be enhanced, given the prevailing circumstances.

What are the institutional prerequisites for mainstreaming urban and infrastructure resilience in policy and decision-making?

Despite the considerably different case circumstances in Rotterdam and Christchurch, both cities make use of common strategies to mainstreaming urban resilience, as they participate in the Rockefeller Foundation's 100 Resilient Cities Programme (100RC). The comparative analysis of both case studies in chapter 5 shows that the two cities share some common problems in this regard. Firstly, making resilience a top priority for policymaking and planning is restricted, since it competes with other urban development agendas for political commitment, the allocation of resources and visibility on the political agenda. Secondly, establishing and maintaining cross-boundary networks of actors dedicated to enhancing resilience is a problem because of a lack of incentives and rules to consolidate the commitment of single actors and to integrate all relevant actors, including those with diverging interests. Thirdly, achieving active engagement of decision-makers from private sectors remains a problem because urban planners and policymakers are not sufficiently equipped to convince them to invest additional resources in terms of personnel, time and money.

Chapter 5 concludes that relying solely on the 100RC blueprint of resilience policies would be naïve to some extent. Rather, mainstreaming resilience into policymaking and planning practice requires institutional adjustments in (1) procedural law and national policymaking to enhance political commitment, (2) the current system of incentives to support the establishment of governance networks that include reluctant actors and (3) support mechanisms and training for urban policymakers and planners to raise active engagement of decision-makers from the private sector. Clearly, participation in 100RC in both cities has positive effects in terms of learning, public

awareness, knowledge dissemination and obtaining a leadership role and prominence in the urban resilience movement – important prerequisites for mainstreaming activities. However, the analysis in chapter 5 shows that mainstreaming resilience has much more to do with the prevailing institutional arrangements than with participating in international networks of likeminded people.

6.3 Institutional arrangements and the governance of urban and infrastructure resilience

— The results of this study suggest that so far cities seem to be institutionally ill equipped to significantly enhance particular resilience capacities to resist, recover and adapt. Within the current institutional arrangements, cities will remain particularly vulnerable to extreme weather events, natural hazards, terrorist or cyber-attacks and other potential shocks and stresses. Therefore, to address urban vulnerabilities and to prepare for a future that is marked by megatrends of climate change, technologisation, urbanisation and globalisation, I argue that scholarly debates on urban and infrastructure resilience should put more emphasis on processes of institutional reform and that policy debates on risk and contingency management should focus on adjustments to existing institutional arrangements.

6.3.1 Insights for academic debates

— This study enriches academic debates from the fields of urban planning, infrastructure management, climate adaptation and disaster risk management by identifying institutional factors that support the persistence of the implementation gap of urban and infrastructure resilience. It reveals that current institutional arrangements often impede adaptive and networked governance strategies such as co-producing knowledge, network management, enhancing connectivity and mainstreaming. Rather, they support knowledge on urban and infrastructure resilience being developed in parallel and contingency and risk management being organised within sectoral and territorial silos, and they hamper the exchange of knowledge and information between different governance levels. Further, existing institutional arrangements do not provide municipalities with the required political mandate, legitimacy and authority to act as a network manager and to consolidate institutional connectivity. As chapters 2 to 5 illustrate, institutional factors that hamper adaptive and networked governance range from rigid disciplinary traditions and working routines in separate communities of practice to the allocation of resources for risk management along sectoral lines. In addition, they include formal regulations and law that are malformed in terms of – or even lack mention of – cross-sector, multi-level and cross-territorial risk and contingency management. In line with this main conclusion, this study provides four relevant insights for the academic debate on urban and infrastructure resilience:

Firstly, this study confirms existing literature in that there is indeed an implementation gap of urban and infrastructure resilience (Coaffee and Lee, 2016; de Bruijne and

van Eeten, 2007; Fünfgeld and McEvoy, 2012; Sapountzaki et al., 2011). In extension to mainstream literature, which has revealed policy silos or a lack of collaboration between different actor groups (Almklov et al., 2012; Matyas and Pelling, 2014; Sapountzaki et al., 2011), the institutional lens applied in this research reveals some of the reasons for these phenomena, thus providing a more nuanced understanding of existing implementation gaps. Institutions provide formal guidelines and informal behavioural norms (North, 1990; Ostrom, 2015) that either support or hamper the consolidation of adaptive and networked governance. For the governance of urban and infrastructure resilience, this study provides empirical evidence that the current institutional arrangements do not adequately enable – and may even hamper – governance strategies such as knowledge co-production (chapter 2), network management (chapter 3), enhancing connectivity (chapter 4) and mainstreaming (chapter 5). Hence, institutions are at least partly responsible for maintaining existing implementation gaps. At the same time, this study shows that if institutions are designed properly, they are a key lever for enhancing urban and infrastructure resilience.

Secondly, the results of this study call for a critical reassessment of governance strategies to enhance urban and infrastructure resilience, because it has revealed that existing institutional arrangements do not support particular resilience capacities to the same extent. The case of Christchurch (chapter 4) shows that different connectivity dimensions (vertical, horizontal and territorial) had very specific impacts on the three resilience capacities to resist, recover and adapt. Whilst connectivity between policy levels and territorial jurisdictions proved to be of paramount importance for recovering from the earthquakes because local authorities were overwhelmed by this task, connectivity between different policy domains proved to be essential for enhancing the capacity to adapt and transform over time. Capacities to resist, however, did not prove to depend on horizontal cooperation to the same extent, as they could often be enhanced with sectoral policy approaches or the action of key actors, such as an infrastructure providers or network owners. The example of Rotterdam (chapter 3) illustrates that existing institutional arrangements in the Netherlands have been built under the premise of ‘fighting against the water’ and thus predominantly enhance capacities to resist. The long period without severe flooding events or severe infrastructure breakdowns is evidence that high protection standards have made cities and their infrastructure systems relatively resistant to flooding despite significant degrees of institutional fragmentation. However, the analysis indicates that the existing institutional frameworks do not adequately support either the enhancing of adaptive capacities or the capacity to recover after a disaster, particularly given the interconnectedness of the infrastructure systems. Whilst mainstream resilience literature often makes use of resilience in a rather generic way, referring normatively to enhancing cooperation and collaboration across horizontal, vertical and territorial dimensions (Duit et al., 2010; Fink, 2011; Goldstein, 2012; Raju and van Niekerk, 2013; Sapountzaki et al., 2011), this study demonstrates that distinguishing between the three resilience capacities of resistance, recovery and adaptability contributes to a more nuanced understanding of how certain governance strategies may support enhancing urban and infrastructure resilience.

Thirdly, the insights provided in this study make clear that municipalities cannot be solely responsible for institutionalising urban and infrastructure resilience. Whilst some scholars contend that municipalities are becoming more and more important in their coordinating, networking, controlling and regulating functions (Dahlberg et al., 2015; Hohn and Neuer, 2006), this study suggests that they have to be viewed as being embedded in complex territorialities of infrastructure systems and the multi-layered institutional arrangements involved in managing these systems. Both case studies illustrate that municipalities' capacities to institutionalise knowledge co-production, different forms of connectivity, network management and mainstreaming are limited and that they depend on decisions made by other actors, particularly on the decisions of actors related to the integrated management of interconnected infrastructure networks. Whilst existing resilience literature is dominated by a normative claim for multi-level governance (for a discussion see Armitage, 2008), endeavours and approaches to enhance urban resilience at regional and national levels are significantly underrepresented. Empirical analyses focus almost exclusively on the city scale (Graham et al., 2016; King, 2008; Raju and van Niekerk, 2013) or take the international scale into account by referring to city networks (Johnson and Blackburn, 2014; Leitner et al., 2018). Without denying the importance of the existing literature on local and international developments, this study suggests there should be explicit emphasis on the roles of regional and national levels of governance in enhancing urban and infrastructure resilience. In addition, it calls for closely considering how responsibilities, authority and political legitimacy are distributed across different levels of governance for selectively determining which actors should take over regulating and coordinating functions to enhance urban and infrastructure resilience.

Fourthly, whilst the politics of resilience have not been the focus of this thesis, the empirical case studies have demonstrated that actors from across different policy domains, infrastructure sectors, levels of governance and territorial jurisdictions as well as public and private actors do not necessarily agree on whether and how to institutionalise urban and infrastructure resilience. Approaches to institutionalise urban and infrastructure resilience prove to be highly political and contested processes that might induce negative trade-offs, as they often encounter entrenched and conflicting interests of key players and require the reallocation of resources and the redistribution of authority. Ultimately, the governance of urban and infrastructure resilience not only requires effective coordination of individual interests but inevitably involves taking decisions that may benefit some actors more than others. Hence, although urban resilience has been framed as a post-political concept (Derickson, 2017), its effective implementation raises questions of politics, power and equity. These insights stand in contrast to the win-win paradigm underlying mainstream resilience literature (for a critical view on this see e.g. Derickson, 2017; Leitner et al., 2018), which suggests that different actor groups can benefit equally from resilience policies and measures. Therefore, next to a policy perspective (as presented by mainstream resilience literature), and next to an institutional perspective (as presented in this thesis), it is important to consider the politics of governance for urban and infrastructure resilience by considering conflicts of interest as well as the existing and changing power relationships between the actors involved.

6.3.2 Recommendations for institutional adjustments

— In light of the main conclusions and with respect to the second part of the overall research question, it is possible to derive some recommendations for institutional adjustments in order to address existing implementation gaps and to enhance urban and infrastructure resilience.

Formal legal reforms should complement informal approaches to stimulate adaptive and networked governance.

This research demonstrates that informal ways of approaching knowledge exchange and cooperation processes may result in promising projects and in important knowledge co-production processes, but reach their limits when governance networks including all relevant actors are to be consolidated in the long term. Restrictions to participation may occur either because some stakeholders or actor groups are actively or passively excluded from participation (as for instance described by Hommels, 2018) or because some of them lack sufficient interest and motivation to participate (as for instance described in chapter 3). Moreover, the cases show that project-based cooperation brings the risk that actors will relapse into siloed working habits after a project ends. Therefore, I argue that informal and project-based approaches to enhance adaptive and networked governance should be complemented by formal institutional reform.

As urban systems become increasingly interconnected through their infrastructures, the legal framework governing the management of these systems must evolve with them. Legal scholars have recognised the procedural logic of adaptive governance (for a discussion see e.g. Humby, 2014). Formal procedural rules should complement – not replace – informal ways to institutionalise adaptive and networked governance such as the development of a resilience strategy or the appointment of a Chief Resilience Officer and should provide a long-term perspective to establish and maintain functioning governance networks. Incorporating adaptive and networked governance strategies into legal frameworks would, for instance, require procedural rules on cross-boundary information sharing and on mutual participation in planning and management processes. In environmental law, permit requirements and procedures in which it is decided whether and under which conditions an activity should be permitted are often supplemented with environmental impact assessments (Ebbesson, 2010). Similarly, planning procedures could be supplemented by social and technical vulnerability or risk assessments, giving the respective risk management authorities a mandate to influence urban planning and development. In addition, compulsory interdependency assessments for infrastructure providers from different sectors and an obligation to conduct vulnerability assessments as well as to communicate their results across governance levels could enhance strategic and cross-boundary contingency management. Such endeavours could be supported by cross-departmental and cross-sectoral budgeting for contingency planning and risk assessment processes and by imposing shared accountability for their results. Even the mandatory design and adoption of regional and urban resilience strategies on a regular basis is conceivable. These should then provide explicit links to individual contingency plans, spatial plans and other development plans and policies such as

urban sustainability or smart city strategies, ideally calling attention to potentially required coordination processes between them, displaying potential synergy effects and demonstrating the added value of applying a resilience lens.

National and regional governments should take a more proactive role in institutionalising urban and infrastructure resilience.

Municipalities prove to be particularly successful in terms of experimenting with new forms of adaptive and networked governance, for instance by developing a resilience strategy or by implementing demonstration projects. This reflects an understanding of cities as experimental labs (Evans, 2011; Fastenrath et al., 2019; Wakefield, 2019). However, the results of both case studies raise doubts about whether municipalities are the most appropriate actors to establish and maintain governance networks for urban and infrastructure resilience. Municipalities such as Rotterdam and Christchurch lack sufficient jurisdiction and institutional capacity to manage potential and existing risks and threats, particularly when it comes to cascading infrastructure failures that extend far beyond the municipal boundaries. Therefore, I argue that actors at national and regional levels of governance should take a more proactive role in institutionalising urban and infrastructure resilience.

For instance, urban resilience initiatives and strategies should be embedded in a wider, national risk management framework. National resilience strategies could be developed that draw explicit links to the urban level of decision-making and thus providing actors at the local level with credibility and a mandate to act. Political mandate can be strengthened further by national resilience programmes dedicating budget and strategic direction to cross-boundary resilience initiatives at the urban level. Endeavours such as the new National Disaster Resilience Strategy (New Zealand Government, 2019) in New Zealand or the Dutch Delta Programme (Ministry of Infrastructure and Water Management, 2018) may inspire national policymaking in this regard. From an urban resilience perspective, one of main objectives of such endeavours should be to enhance credibility, legitimacy and authority at the local level to provide coordination between different policy domains and to establish and maintain new governance networks. In addition, national funding programmes for interdisciplinary research on resilience may contribute to co-producing new knowledge. New Zealand's National Science Challenge is an example of such a funding scheme and it includes a specific track on 'Resilience to Nature's Challenges' (<https://resiliencechallenge.nz/>). It remains to be seen in how far New Zealand's experiences with this programme can serve as a model for other countries to foster knowledge co-production.

Infrastructure networks extend across municipal boundaries, connecting cities to their hinterlands as well as to other municipalities, so next to the national level, the regional level deserves to receive more attention for institutionalisation processes of urban and infrastructure resilience. With the Canterbury Lifelines Group and the Rotterdam-Rijnmond safety region both case cities have institutionalised organisations at the regional level that seem to be suited for the task of providing coordination of decision-making between different infrastructure sectors. However, similarly to the municipality they lack official mandate and/or budget to act as a network manager.

Allocating more responsibility to these authorities requires adjustments of existing institutional arrangements in the form of providing them with budget and authority. In addition, the relationship of these authorities to city administrations on the one hand and to private or semi-private infrastructure providers on the other hand would require clarification and potentially formal regulation, as would their involvement in urban resilience initiatives at municipal level and the regulation of infrastructure contingency at the national level.

Institutional arrangements for adaptive and networked governance should be designed to be adaptive and flexible themselves.

While the Rotterdam case study (chapter 3) displays relatively rigid institutional arrangements, the case of Christchurch (chapter 4) presents institutional arrangements as relatively fluid constructs which change over time and with regard to the different stages of disaster risk management. Although institutional reform in Greater Christchurch during and after the series of earthquakes was not always beneficial with regard to enhancing particular resilience capacities, the case shows that institutional arrangements have been adjusted constantly to adapt to new circumstances. The question for other cities is in how far institutional arrangements can be designed in a way to flexibly respond to changing circumstances, including in the absence of a devastating crisis, and how to ensure that they contribute to enhancing resilience capacities to resist, recover and adapt.

The baseline for adaptive institutional frameworks could be bottom-up initiatives and projects to bring together different actors, which helps to build trust, encourage exchange of ideas and develop a common vision of the desired future. The success of the Canterbury Lifelines Group in Christchurch and the municipality's successful cooperation with the local arts scene in Rotterdam demonstrate these positive effects. These sorts of bottom-up initiatives and informal actor networks can emerge quickly at a local scale and they provide a certain degree of flexibility in the sense that organisational structures and actor constellations can easily adapt to changing demands. However, they may remain largely ineffective if not linked to formal rules at regional and national levels of governance. In addition, whilst informal networks are often advocated as the main method to enhance resilience, there is no mandate for their formation and they are expected to emerge 'via the self-organization of the institutional milieu' (Garmestani and Benson, 2013, p. 13).

Nevertheless, the conclusion that only informal institutions are flexible is a fallacy. In accordance with the first recommendation for legal reform, formal institutions too should support adaptability, flexibility and reflexivity. Legal scholars came up with the notion of reflexive law, which establishes procedural rules and organisational norms but does not prescribe substantial outcomes of these processes (Garmestani and Benson, 2013; Scheuerman, 2001; Teubner, 1983). Reflexive law may foster the identification of potential synergies between different resilience capacities as well as the identification and elimination of potential trade-offs not by determining a specific policy outcome but by making sure that relevant actor groups are represented in decision-making processes. For instance, organisations such as the Canterbury Lifelines Group could be formally mandated to participate in major planning

procedures in the city of Christchurch and the organisation's composition could be arranged so as to include all infrastructure providers and network owners that have been identified as being of critical importance for the city.

6.4 Reflections and outlook

— This study illustrates how resilience is variously interpreted in two different cities and how this interpretation depends on their specific socio-economic environment and recent disaster experiences. At the same time, the results of this study revealed that both cities face very similar challenges in institutionalising resilience. The qualitative case study design that was chosen for this research provides in-depth empirical insights into the relatively new phenomenon of operationalising resilience in existing policy frameworks from an institutional perspective. It contributes to generating new knowledge which is relevant both for academia and policy practice by identifying institutional requirements for supporting adaptive and networked governance strategies. However, the case selection, the methods used for data collection and analysis and the chosen conceptual framework have some limitations. The following paragraphs summarise the five most important limitations of this study and suggest avenues for future research.

Firstly, whilst this study has engaged in detail with each of the four identified governance strategies for enhancing urban and infrastructure resilience (knowledge co-production, network management, enhancing connectivity and mainstreaming), it does not compare or explicitly link them. Differentiating between the single strategies helps to understand the different activities, processes and perspectives of institutionalising resilience in cities. However, the single strategies seem to be closely intertwined, policymakers and decision-makers often do not explicitly distinguish between them, and certain resilience measures or projects often serve some of them at the same time. Thus, knowledge co-production emphasises joint engagement across disciplinary or departmental boundaries with the aim of producing new resilience-relevant knowledge that is applicable in complex socio-ecological and socio-technical systems. Mainstreaming refers to considering this resilience-relevant knowledge in policies relating to different domains. Network management, again, mainly addresses the coordination between relevant actors and allows questions to be asked about the 'network manager' as the coordinating body, whereas enhancing connectivity is to do with improving the interaction and collaboration between previously separated actors more generally. In conclusion, adaptive and networked governance seem to require all four governance strategies presented in this study. However, the composition of individual strategies may differ from city to city and potentially include strategies other than those considered in this study, depending on their existing institutional arrangements or other contextual circumstances. Future research is needed to better understand how different governance strategies influence each other and how they could or should be effectively configured to enhance a city's capacities to resist, recover and adapt.

Secondly, whilst both case studies point to the importance of conflicts of interest between the actors involved in governance networks and their disputes over political attention, financial resources and autonomy, in this study the politics of resilience governance could only marginally be addressed. The roles, interests and motives of different actor groups such as international organisations, municipal administrations, politicians at different levels of government, infrastructure providers and network owners as well as the power relationships between them deserve further appreciation in empirical studies on urban and infrastructure resilience. As such, future research should focus on political processes of establishing and maintaining governance networks, and should consider the questions of resilience for whom? what? when? where? why? (Meerow and Newell, 2019). In addition, the empirical results of this study point to the importance of considering the redistributive dimension of resilience governance. Questions of responsibility and authority have to be reformulated. In addition, the (re-)allocation of institutional, financial and time resources for the benefit of effective crisis management and mitigation has to be negotiated afresh, in turn giving rise to questions of resilience at what costs and – even more importantly – questions of who is paying for resilience measures. The (re)allocation of resources and (re)distribution of authority in the context of resilience policies together form an important driving force for the action or inaction of actors and one of the main reasons behind emerging conflicts between individual actors in the respective governance networks. In order to find out what the governance of urban and infrastructure resilience could look like in practice, these kinds of questions will have to be addressed in future research.

Thirdly, in this study the materiality of infrastructure systems has only been considered to a limited extent. As scholars from the field of science and technology studies have shown, material artefacts and socio-political processes are co-constitutive (Hommels et al., 2014; Nowotny, 2006). On the one hand, material infrastructure systems and the built environment embed certain political ideas, cultural values and power relations of the past (Bijker et al., 1987). This is exemplified by the Dutch dikes system or large-scale infrastructures such as the Maesland Storm Surge Barrier, which can be seen as materialised artefacts of the political goal of ‘fighting against the water’ and as a prioritisation of enhancing the capacity to resist as opposed to the capacities to recover, adapt or transform. In Christchurch, political dispute more or less directly materialises in the spatial inequality of the reconstructed infrastructure systems. Here, areas rebuilt at early stages of the recovery benefit from higher building standards being followed than in the areas repaired at later stages after the cost-sharing agreements between local and national government and subsequent changes in the design guidelines. On the other hand, material infrastructures shape current governance processes and political goals by limiting the options of what is seen as being possible and desirable (Monstadt, 2009). Hence, enhancing urban and infrastructure resilience strongly depends on the materialities of existing technical infrastructure systems, which inevitably embody the political priorities of the times in which they were built. Future research would certainly benefit from analysing the governance of urban and infrastructure resilience under a socio-technical lens (highlighting the co-constitutive character of physical infrastructure systems and social systems) or techno-political lens (highlighting co-constitutive character of technology

and politics): cf. Foley et al., 2020; Hommels, 2020; Miller, 2019. This would allow for investigating how the materiality of existing infrastructure systems influences the establishment and maintenance of adaptive governance networks and the interaction of different actor groups in these networks, or for conclusions to be derived on the relationship between the materiality of infrastructure systems in a city and the political prioritisation of individual resilience capacities such as resistance, recovery and adaptability.

Fourthly, this study provided in-depth insights in decision-making processes for developing a contextualised and detailed understanding of institutionalisation processes in the two case study areas and for exploring new issues and challenges for involved actors. The qualitative research design chosen for this study enabled me to explore the relatively new phenomenon of institutionalising urban and infrastructure resilience. However, it did not allow the quantification of resilience or particular resilience capacities such as resistance, recovery and adaptability. At the same time, there is an emerging trend to produce quantitative tools, indicators and standards to measure urban and infrastructure resilience (for an overview and a discussion see Ilmola, 2016). In resilience research, as in large parts of the scientific world, the two groups of quantitative and qualitative researchers are rather sceptical about each other's findings. However, to better understand or even support the institutionalisation of adaptive and networked governance strategies, both seem necessary. On the one hand, there is an ongoing thirst for knowledge about how exactly and under what circumstances different cities address the challenge of institutionalising urban and infrastructure resilience, thereby demanding qualitative and explorative case study research such as that reported in this thesis (Fastiggi et al., 2020). On the other hand, this study confirms other research findings that there is the need to somehow measure resilience (e.g. Bozza et al., 2015; Ilmola, 2016) because those tasked with institutionalising resilience require quantitative tools to demonstrate the added value of resilience to decision-makers and politicians. Although the debate about whether urban and infrastructure resilience can be measured at all will probably not be resolved in the near future (cf. Prior and Hagmann, 2013), empirical research making use of different research designs and methodologies including quantitative research and mixed method approaches should complement and verify the findings of this study. For instance, quantitative analyses of academic literature and policy documents could be used to provide a better understanding of to what extent resilience as a concept is used across epistemic communities or policy domains. Quantifiable variables for the three capacities of resistance, recovery and adaptability could be developed to measure the extent to which they are enhanced, in how far they correlate with institutional changes and to gain more knowledge on potential trade-offs between them.

Fifthly, the case selection was focused on two mid-sized cities that are in relatively wealthy countries with democratic political systems and that participate in 100RC. Although the study goes beyond the analysis of particular resilience strategies and plans (such as Keenan, 2018; Woodruff et al., 2018) and analyses more than one city in terms of its ambition to enhance resilience (such as Spaans and Waterhout, 2017), it concentrates on two cities that apply similar approaches to institutionalise

resilience due to their participation in 100RC. As such, it focuses on a particular resilience programme, although the analysis is not limited to the implementation of that programme. Studies examining larger numbers of cities taking part in the same programme already exist. For instance, Johnson and Blackburn (2014) analysed data from 50 cities taking part in the UNISDR's Making Cities Resilient Campaign and the Urban Institute evaluated 22 participants in 100RC (Urban Institute, 2018). Fastiggi et al. (2020) fill a gap in academic literature by examining how 19 diverse cities in North America participating in different resilience programmes are approaching the challenge to institutional resilience. While their results largely coincide with the findings of this study, they also revealed some differences between the cities analysed: for instance, they found that larger cities tend to incorporate different policy fields and challenges into their resilience work, whilst smaller cities tend to concentrate on narrowly defined challenges. They also found that external funding organisations such as 100RC considerably influenced how the cities frame resilience. Similar research is required to reveal more commonalities and differences in approaches and challenges to institutionalise urban and infrastructure resilience between smaller and larger cities, between those participating in international city networks and those that do not, and between cities in different countries and world regions. Identifying such commonalities and differences could reveal a range of different challenges for the institutionalisation of resilience. In addition, they could result in a different appraisal of the significance of individual resilience capacities or indicate the need for further capacities beyond resistance, recovery and adaptability. One of the challenges for future conceptual research on the governance of urban and infrastructure resilience is to reveal common principles, features, processes and patterns despite case-specific circumstances and contexts.

REFERENCES

- 100RC (n.d.) *Publications – 100 Resilient Cities*. <http://www.100resilientcities.org/publications/>. Accessed 4 February 2020.
- 100RC (2016) *Resilience in action: Early insights into how cities are institutionalizing resilience*. <http://www.100resilientcities.org/wp-content/uploads/2016/10/Resilience20in20Action20100RC20Report20October202016.pdf>. Accessed 12 November 2019.
- 100RC (2017a) *Cities taking action: How the 100RC network is building urban resilience*. New York.
- 100RC (2017b) *The EU resilience prospectus*. <https://medium.com/the-eu-resilience-prospectus>. Accessed 4 February 2020.
- 100RC (2019) *Homepage – 100 Resilient Cities*. <http://www.100resilientcities.org/>. Accessed 14 January 2019.
- 100RC and EY (2017) *Getting real about resilience: How cities can build resilience thinking into infrastructure projects*. <https://www.ey.com/gl/en/industries/government---public-sector/ey-getting-real-about-resilience>. Accessed 23 July 2018.
- Adger, W. N., Hughes, T. P., Folke, C., Carpenter, S. R. and Rockstrom, J. (2005) Social-ecological resilience to coastal disasters, *Science (New York, N.Y.)*, 309(5737), pp. 1036–1039.
- Ahern, J. (2011) From fail-safe to safe-to-fail: Sustainability and resilience in the new urban world, *Landscape and Urban Planning*, 100(4), pp. 341–343.
- Albers, R.A.W., Bosch, P. R., Blocken, B., van den Dobbelsteen, A.A.J.F., van Hove, L.W.A., Spit, T.J.M., van de Ven, F., van Hooff, T. and Rovers, V. (2015) Overview of challenges and achievements in the climate adaptation of cities and in the Climate Proof Cities program, *Building and Environment*, 83, pp. 1–10.
- Albert, M., Laberge, S., Hodges, B. D., Regehr, G. and Lingard, L. (2008) Biomedical scientists' perception of the social sciences in health research, *Social Science & Medicine*, 66(12), pp. 2520–2531.
- Alexander, D. E. (2013) Resilience and disaster risk reduction: An etymological journey, *Natural Hazards and Earth System Science*, 13(11), pp. 2707–2716.
- Ali, H. and Birley, S. (1999) Integrating deductive and inductive approaches in a study of new ventures and customer perceived risk, *Qualitative Market Research: An International Journal*, 2(2), pp. 103–110.
- Allen, A., Griffin, L. and Johnson, C. (Eds.) (2017) *Environmental justice and urban resilience in the global south*. New York: Palgrave Macmillan US.

- Almklov, P., Antonsen, S. and Fenstad, J. (2012) Organizational challenges regarding risk management in critical infrastructures, in: P. Hokstad, I. B. Utne and J. Vatn (Eds.) *Risk and interdependencies in critical infrastructures: A guideline for analysis*, pp. 211–225. London: Springer London.
- Amin, M. (2002) Toward secure and resilient interdependent infrastructures, *Journal of Infrastructure Systems*, 8(3), pp. 67–75.
- Amir, S. (Ed.) (2018) *The sociotechnical constitution of resilience: A new perspective on governing risk and disaster*. Singapore: Springer Singapore.
- Amir, S. and Kant, V. (2018) Sociotechnical resilience: A preliminary concept, *Risk Analysis*, 38(1), pp. 8–16.
- Anguelovski, I. and Carmin, J. (2011) Something borrowed, everything new: Innovation and institutionalization in urban climate governance, *Current Opinion in Environmental Sustainability*, 3(3), pp. 169–175.
- Armitage, D. (2008) Governance and the commons in a multi-level world, *International Journal of the Commons*, 2(1), pp. 7–32.
- Arup and RF (2015) *City Resilience Index: Understanding and measuring city resilience*. <https://www.arup.com/publications/research/section/city-resilience-index>. Accessed 5 July 2018.
- Bach, C., Bouchon, S., Fekete, A., Birkmann, J. and Serre, D. (2014) Adding value to critical infrastructure research and disaster risk management: The resilience concept, *S.A.P.I.EN.S [Online]*, 6(1), pp. 1–12.
- Baggio, J. A., Brown, K. and Hellebrandt, D. (2015) Boundary object or bridging concept? A citation network analysis of resilience, *Ecology and Society*, 20(2), pp. 2–12.
- Baig, Z. A., Szewczyk, P., Valli, C., Rabadia, P., Hannay, P., Chernyshev, M., Johnstone, M., Kerai, P., Ibrahim, A., Sansurooah, K., Syed, N. and Peacock, M. (2017) Future challenges for smart cities: Cyber-security and digital forensics, *Digital Investigation*, 22, pp. 3–13.
- Bauer, A. and Steurer, R. (2014) Multi-level governance of climate change adaptation through regional partnerships in Canada and England, *Geoforum*, 51, pp. 121–129.
- Béné, C., Mehta, L., McGranahan, G., Cannon, T., Gupte, J. and Tanner, T. (2017) Resilience as a policy narrative: Potentials and limits in the context of urban planning, *Climate and Development*, 10(2), pp. 116–133.
- Bennett, B. W., Dann, J., Johnson, E. and Reynolds, R. (Eds.) (2014) *Once in a lifetime: City-building after disaster in Christchurch*. Christchurch, New Zealand: Freerange Press.
- Berkes, F. (2009) Evolution of co-management: Role of knowledge generation, bridging organizations and social learning, *Journal of environmental management*, 90(5), pp. 1692–1702.
- Berkowitz, M. (2015) *What a Chief Resilience Officer does*. <http://100resilientcities.org/what-a-chief-resilience-officer-does/>. Accessed 23 October 2019.
- Biermann, F., Chan, M.-s., Mert, A. and Pattberg, P. (2007) Multi-stakeholder partnerships for sustainable development: does the promise hold?, in: A. P. J. Mol, F. Biermann and P. Glasbergen (Eds.) *Partnerships, governance and sustainable development: Reflections on theory and practice*, pp. 239–260. Cheltenham, UK, Northampton, MA: Edward Elgar.

- Bijker, W. E. (2006) The vulnerability of technological culture, in: H. Nowotny (Ed.) *Cultures of technology and the quest for innovation*, pp. 52–72. New York: Berghahn Books.
- Bijker, W. E., Hughes, T. P. and Pinch, T. (Eds.) (1987) *The social construction of technological systems: New directions in the sociology and history of technology*. Cambridge, Mass., London: MIT Press.
- Birkland, T. A. (2001) Scientists and coastal hazards: Opportunities for participation and policy change, *Environmental Geosciences*, 8(1), pp. 61–67.
- Birkmann, J., Buckle, P., Jaeger, J., Pelling, M., Setiadi, N., Garschagen, M., Fernando, N. and Kropp, J. (2010a) Extreme events and disasters: A window of opportunity for change? Analysis of organizational, institutional and political changes, formal and informal responses after mega-disasters, *Natural Hazards*, 55(3), pp. 637–655.
- Birkmann, J., Garschagen, M., Kraas, F. and Quang, N. (2010b) Adaptive urban governance: New challenges for the second generation of urban adaptation strategies to climate change, *Sustainability Science*, 5(2), pp. 185–206.
- Birkmann, J., Wenzel, F., Greiving, S., Garschagen, M., Vallée, D., Nowak, W., Welle, T., Fina, S., Goris, A., Rilling, B., Fiedrich, F., Fekete, A., Cutter, S. L., Düzgün, S., Ley, A., Friedrich, M., Kuhlmann, U., Novák, B., Wieprecht, S., Riegel, C., Thieken, A., Rhyner, J., Ulbrich, U. and Mitchell, J. K. (2016) Extreme events, critical infrastructures, human vulnerability and strategic planning: Emerging research issues, *Journal of Extreme Events*, 03(04), 1–25.
- Bogner, A., Littig, B. and Menz, W. (Eds.) (2009) *Interviewing experts: Principles and practices*. Basingstoke: Palgrave Macmillan.
- Boin, A. and McConnell, A. (2007) Preparing for critical infrastructure breakdowns: The limits of crisis management and the need for resilience, *Journal of Contingencies and Crisis Management*, 15(1), pp. 50–59.
- Bollinger, L. A., Bogmans, C. W. J., Chappin, E. J. L., Dijkema, G. P. J., Huibregtse, J. N., Maas, N., Schenk, T., Snelder, M., van Thienen, P., Wit, S. de, Wols, B. and Tavasszy, L. A. (2013) Climate adaptation of interconnected infrastructures: A framework for supporting governance, *Regional Environmental Change*, 8(2), pp. 919–931.
- Borger, G. J. and Ligtenag, W. A. (1998) The role of water in the development of The Netherlands— a historical perspective, *Journal of Coastal Conservation*, 4(2), pp. 109–114.
- Bosher, L. (Ed.) (2008) *Hazards and the built environment: Attaining built-in resilience*. London, New York: Taylor & Francis.
- Boston, J., Wanna, J., Lipsky, V. and Pritchard, J. (Eds.) (2014) *Future-proofing the state: Managing risks, responding to crises and building resilience*. Sydney: Australian National University.
- Bouchon, S. (2006) *The vulnerability of interdependent critical infrastructures systems: Epistemological and conceptual state-of-the-art*. Luxembourg: Office for Official Publications of the European Communities.
- Bourgon, J. (2009) New directions in public administration, *Public Policy and Administration*, 24(3), pp. 309–330.
- Boyd, E. and Juhola, S. (2015) Adaptive climate change governance for urban resilience, *Urban Studies*, 52(7), pp. 1234–1264.

- Bozza, A., Asprone, D. and Manfredi, G. (2015) Developing an integrated framework to quantify resilience of urban systems against disasters, *Natural Hazards*, 78(3), pp. 1729–1748.
- Brand, D. and Nicholson, H. (2016) Public space and recovery: Learning from post-earthquake Christchurch, *Journal of Urban Design*, 21(2), pp. 159–176.
- Brassett, J. and Vaughan-Williams, N. (2015) Security and the performative politics of resilience: Critical infrastructure protection and humanitarian emergency preparedness, *Security Dialogue*, 46(1), pp. 32–50.
- Britton, N. R. and Clark, G. J. (2000) From response to resilience: Emergency management reform in New Zealand, *Natural Hazards Review*, 1(3), pp. 145–150.
- Brookie, R. (2014) Governing the Canterbury earthquake recovery 2010–2011: The debate over institutional design, in: J. Boston, J. Wanna, V. Lipsky and J. Pritchard (Eds.) *Future-proofing the state: Managing risks, responding to crises and building resilience*, pp. 251–275. Sydney: Australian National University.
- Brown, K. (2016) *Resilience, development and global change*. London, New York: Routledge Taylor & Francis Group.
- Brunetta, G. and Caldarice, O. (2019) Putting resilience into practice: The spatial planning response to urban risks, in: G. Brunetta, O. Caldarice, N. Tollin, M. Rosas-Casals and J. Morató (Eds.) *Urban resilience for risk and adaptation governance*, pp. 27–41. Cham: Springer International Publishing.
- Bulkeley, H. and Tuts, R. (2013) Understanding urban vulnerability, adaptation and resilience in the context of climate change, *Local Environment*, 18(6), pp. 646–662.
- Caldarice, O., Brunetta, G. and Tollin, N. (2019) The challenge of urban resilience: Operationalization, in: G. Brunetta, O. Caldarice, N. Tollin, M. Rosas-Casals and J. Morató (Eds.) *Urban resilience for risk and adaptation governance*, pp. 1–6. Cham: Springer International Publishing.
- Campanella, T. J. (2006) Urban resilience and the recovery of New Orleans, *Journal of the American Planning Association*, 72(2), pp. 141–146.
- Carrillo, F. J., Yigitcanlar, T., García, B. and Lönnqvist, A. (2014) *Knowledge and the city: Concepts, applications and trends of knowledge-based urban development*. Hoboken: Taylor and Francis.
- CCC (2016) *Resilient Greater Christchurch: Healthy land, healthy water, healthy communities*. Christchurch.
- CCC (2018) *30 year infrastructure strategy 2018–2048: Draft long term plan 2018–2048*. <https://www.ccc.govt.nz/assets/Documents/The-Council/Plans-Strategies-Policies-Bylaws/Plans/Long-Term-Plan/2018-2028/Infrastructure-Strategy.pdf>. Accessed 16 November 2018.
- CCC, ECan, Transit New Zealand, Selwyn District Council and Waimakariri District Council (2007) *Greater Christchurch urban development strategy and action plan*. <http://greaterchristchurch.org.nz/assets/Documents/greaterchristchurch/UDSActionPlan2007.pdf>. Accessed 25 September 2018.
- Centre for Advanced Engineering (1997) *Risks & realities: A multi-disciplinary approach to the vulnerability of lifelines to natural hazards*. Report of the Christchurch Engineering Lifelines Group. Christchurch, N.Z.: Centre for Advanced Engineering, University of Canterbury.
- Chandler, D. (2014a) Beyond neoliberalism: Resilience, the new art of governing complexity, *Resilience*, 2(1), pp. 47–63.

- Chandler, D. (2014b) *Resilience: The governance of complexity*. Abingdon: Routledge.
- Chandler, D. and Coaffee, J. (2017a) Introduction: Contested paradigms of international resilience, in: D. Chandler and J. Coaffee (Eds.) *Routledge handbook of international resilience*. New York: Routledge.
- Chandler, D. and Coaffee, J. (Eds.) (2017b) *Routledge handbook of international resilience*. New York: Routledge.
- Chang, S. E., McDaniels, T., Fox, J., Dhariwal, R. and Longstaff, H. (2014) Toward disaster-resilient cities: Characterizing resilience of infrastructure systems with expert judgments, *Risk Analysis*, 34(3), pp. 416–434.
- Chapman, L., Azevedo, J. A. and Prieto-Lopez, T. (2013) Urban heat & critical infrastructure networks: A viewpoint, *Urban Climate*, 3, pp. 7–12.
- Chelleri, L. (2012) From the «resilient city» to urban resilience: A review essay on understanding and integrating the resilience perspective for urban systems, *Documents d'Anàlisi Geogràfica*, 58(2), p. 287.
- Chelleri, L. (2018) Barcelona experience in resilience: An integrated governance model for operationalizing urban resilience, in: Y. Yamagata and A. Sharifi (Eds.) *Resilience-oriented urban planning*, pp. 111–128. Cham: Springer International Publishing.
- Chelleri, L., Waters, J. J., Olazabal, M. and Minucci, G. (2015) Resilience trade-offs: Addressing multiple scales and temporal aspects of urban resilience, *Environment and Urbanization*, 27(1), pp. 181–198.
- Chen, J., Chen, T. H. Y., Vertinsky, I., Yumagulova, L. and Park, C. (2013) Public-private partnerships for the development of disaster resilient communities, *Journal of Contingencies and Crisis Management*, 21(3), pp. 130–143.
- Chen, S. and Chen, B. (2016) Urban energy–water nexus: A network perspective, *Applied Energy*, 184, pp. 905–914.
- Chmutina, K., Lizarralde, G., Dainty, A. and Bosher, L. (2016) Unpacking resilience policy discourse, *Cities*, 58, pp. 70–79.
- Coaffee, J. (2008) Risk, resilience, and environmentally sustainable cities, *Energy Policy*, 36(12), pp. 4633–4638.
- Coaffee, J. (2009) *Terrorism, risk and the global city: Towards urban resilience*. Farnham: Ashgate.
- Coaffee, J. (2013) Rescaling and responsabilising the politics of urban resilience: From national security to local place-making, *Politics*, 33(4), pp. 240–252.
- Coaffee, J. and Clarke, J. (2015) On securing the generational challenge of urban resilience, *Town Planning Review*, 86(3), pp. 249–255.
- Coaffee, J. and Clarke, J. (2016) Critical infrastructure lifelines and the politics of anthropocentric resilience, *Resilience*, 5(3), pp. 161–181.
- Coaffee, J. and Lee, P. (2016) *Urban resilience: Planning for risk, crisis and uncertainty*. London: Palgrave Macmillan.
- Coaffee, J., Therrien, M.-C., Chelleri, L., Henstra, D., Aldrich, D. P., Mitchell, C. L., Tsenkova, S. and Rigaud, É. (2018) Urban resilience implementation: A policy challenge and research agenda for the 21st century, *Journal of Contingencies and Crisis Management*, 26(3), pp. 403–410.
- Collier, S. J. and Lakoff, A. (2015) Vital systems security: Reflexive biopolitics and the government of emergency, *Theory, Culture & Society*, 32(2), pp. 19–51.

- Comfort, L. K. (1994) Risk and resilience: Inter-organizational learning following the Northridge earthquake of 17 January 1994, *Journal of Contingencies and Crisis Management*, 2(3), pp. 157–170.
- Cote, M. and Nightingale, A. J. (2012) Resilience thinking meets social theory, *Progress in Human Geography*, 36(4), pp. 475–489.
- Crowe, P. R., Foley, K. and Collier, M. J. (2016) Operationalizing urban resilience through a framework for adaptive co-management and design: Five experiments in urban planning practice and policy, *Environmental Science & Policy*, 62, pp. 112–119.
- Cruz, A. M. and Krausmann, E. (2009) Hazardous-materials releases from offshore oil and gas facilities and emergency response following hurricanes Katrina and Rita, *Journal of Loss Prevention in the Process Industries*, 22(1), pp. 59–65.
- Cubrinovski, M., Hughes, M., Bradley, B., Noonan, J., McNeill, S., English, G. and Sampredo, I. G. (2015) *Horizontal infrastructure performance and application of the liquefaction resistance index methodology in Christchurch City through the 2010–2011 Canterbury earthquake sequence*. Christchurch.
- Cubrinovski, M., Hughes, M., Bradley, B., Noonan, J., Rex Hopkins, McNeill, S. and English, G. (2014) *Performance of horizontal infrastructure in Christchurch City through the 2010–2011 Canterbury earthquake sequence*. Christchurch.
- Dahlberg, R., Johannessen-Henry, C. T., Raju, E. and Tulsiani, S. (2015) Resilience in disaster research: Three versions, *Civil Engineering and Environmental Systems*, 32(1-2), pp. 44–54.
- Davoudi, S. (2012) Resilience: A bridging concept or a dead end?, *Planning Theory & Practice*, 13(2), pp. 299–307.
- Davoudi, S., Bohland, J., Knox, P. L. and Lawrence, J. L. (2017) *The resilience machine*. <http://www.urbanresilienceresearch.net/2017/02/09/the-resilience-machine/>. Accessed 13 March 2017.
- de Bruijne, M. and van Eeten, M. (2007) Systems that should have failed: Critical infrastructure protection in an institutionally fragmented environment, *Journal of Contingencies and Crisis Management*, 15(1), pp. 18–29.
- Derickson, K. D. (2017) Urban geography III, *Progress in Human Geography*, 42(3), pp. 425–435.
- Dewulf, A., Meijerink, S. and Runhaar, H. (2015) The governance of adaptation to climate change as a multi-level, multi-sector and multi-actor challenge: A European comparative perspective, *Journal of Water and Climate Change*, 6(1), pp. 1–8.
- Dieperink, C., Hegger, D. L. T., Bakker, M. H. N., Kundzewicz, Z. W., Green, C. and Driessen, P. P. J. (2016) Recurrent governance challenges in the implementation and alignment of flood risk management strategies: A review, *Water Resources Management*, 30(13), pp. 4467–4481.
- Djalante, R., Holley, C. and Thomalla, F. (2011) Adaptive governance and managing resilience to natural hazards, *International Journal of Disaster Risk Science*, 2(4), pp. 1–14.
- Donovan, B. and Work, D. B. (2017) Empirically quantifying city-scale transportation system resilience to extreme events, *Transportation Research Part C: Emerging Technologies*, 79, pp. 333–346.

- Duit, A., Galaz, V., Eckerberg, K. and Ebbesson, J. (2010) Governance, complexity, and resilience, *Global Environmental Change*, 20(3), pp. 363–368.
- Dunn, G., Brown, R. R., Bos, J. J. and Bakker, K. (2017) The role of science-policy interface in sustainable urban water transitions: Lessons from Rotterdam, *Environmental Science & Policy*, 73, pp. 71–79.
- Dunn-Cavelty, M. and Suter, M. (2009) Public–private partnerships are no silver bullet: An expanded governance model for critical infrastructure protection, *International Journal of Critical Infrastructure Protection*, 2(4), pp. 179–187.
- Ebbesson, J. (2010) The rule of law in governance of complex socio-ecological changes, *Global Environmental Change*, 20(3), pp. 414–422.
- ECan (2018) *How many people live in Canterbury?* <https://www.ecan.govt.nz/your-region/living-here/regional-leadership/population/census-estimates/>. Accessed 16 January 2019.
- Elsner, I., Huck, A. and Marathe, M. (2018) Resilience, in: J. I. Engels (Ed.) *Key concepts for critical infrastructure research*, pp. 31–38. Wiesbaden: Springer Fachmedien Wiesbaden.
- Ernstson, H., Barthel, S., Andersson, E. and Borgström, S. T. (2010) Scale-crossing brokers and network governance of urban ecosystem services: The case of Stockholm, *Ecology and Society*, 15(4).
- Etinay, N., Egbu, C. and Murray, V. (2018) Building urban resilience for disaster risk management and disaster risk reduction, *Procedia Engineering*, 212, pp. 575–582.
- EU (2008) Council directive 2008/114/EC: On the identification and designation of European critical infrastructures and the assessment of the need to improve their protection, *Official Journal of the European Union* (L 345), pp. 75–82.
- Evans, B. and Reid, J. (2013) Dangerously exposed: The life and death of the resilient subject, *Resilience*, 1(2), pp. 83–98.
- Evans, J. P. (2011) Resilience, ecology and adaptation in the experimental city, *Transactions of the Institute of British Geographers*, 36(2), pp. 223–237.
- Fastenrath, S., Coenen, L. and Davidson, K. (2019) Urban resilience in action: The resilient Melbourne strategy as transformative urban innovation policy?, *Sustainability*, 11(3), pp. 693–703.
- Fastiggi, M., Meerow, S. and Miller, T. R. (2020) Governing urban resilience: Organisational structures and coordination strategies in 20 North American city governments, *Urban Studies*, 1(3), 004209802090727.
- Fekete, A. and Fiedrich, F. (Eds.) (2018) *Urban disaster resilience and security: Addressing risks in societies*. Cham, Switzerland: Springer International Publishing.
- Filion, P., Sands, G. and Skidmore, M. (Eds.) (2015) *Cities at risk: Planning for and recovering from natural disasters*. Burlington, VT: Ashgate.
- Fink, J. H. (2011) Cross-sector integration of urban information to enhance sustainable decision making, *IBM Journal of Research and Development*, 55(1.2), 12:1-12:8.
- Fletcher, D. and Sarkar, M. (2013) Psychological resilience, *European Psychologist*, 18(1), pp. 12–23.
- Foley, R., Rushforth, R., Kalinowski, T. and Bennett, I. (2020) From public engagement to research intervention: Analyzing processes and exploring outcomes in urban techno-politics, *Science as Culture*, 109(1), pp. 1–26.

- Folke, C., Hahn, T., Olsson, P. and Norberg, J. (2005) Adaptive governance of social-ecological systems, *Annual Review of Environment and Resources*, 30(1), pp. 441–473.
- Forsyth, T. (2010) Panacea or paradox?: Cross-sector partnerships, climate change, and development, *Wiley Interdisciplinary Reviews: Climate Change*, 1(5), pp. 683–696.
- Francesch-Huidobro, M., Dabrowski, M., Tai, Y., Chan, F. and Stead, D. (2017) Governance challenges of flood-prone delta cities: Integrating flood risk management and climate change in spatial planning, *Progress in Planning*, 114, pp. 1–27.
- Frantzeskaki, N. and Kabisch, N. (2016) Designing a knowledge co-production operating space for urban environmental governance—Lessons from Rotterdam, Netherlands and Berlin, Germany, *Environmental Science & Policy*, 62, pp. 90–98.
- Frantzeskaki, N., Wittmayer, J. and Loorbach, D. (2014) The role of partnerships in ‘realising’ urban sustainability in Rotterdam’s City Ports Area, The Netherlands, *Journal of Cleaner Production*, 65, pp. 406–417.
- Frazier, T. G., Wood, N. and Yarnal, B. (2010) Stakeholder perspectives on land-use strategies for adapting to climate-change-enhanced coastal hazards: Sarasota, Florida, *Applied Geography*, 30(4), pp. 506–517.
- Friend, R., Jarvie, J., Reed, S. O., Sutarto, R., Thinphanga, P. and Toan, V. C. (2014) Mainstreaming urban climate resilience into policy and planning; reflections from Asia, *Urban Climate*, 7, pp. 6–19.
- Fünfgeld, H. and McEvoy, D. (2012) Resilience as a useful concept for climate change adaptation?, *Planning Theory & Practice*, 13(2), pp. 324–328.
- Garmestani, A. S. and Benson, M. H. (2013) A framework for resilience-based governance of social-ecological systems, *Ecology and Society*, 18(1), pp. 9–19.
- Gay, L. F. and Sinha, S. K. (2013) Resilience of civil infrastructure systems: Literature review for improved asset management, *International Journal of Critical Infrastructures*, 9(4), p. 330.
- Gemeente Rotterdam (2014) *Delta Rotterdam: Connecting water with opportunities*. Rotterdam.
- Gemeente Rotterdam (2016) *Rotterdam resilience strategy: Ready for the 21st century*. Consultation document. Rotterdam.
- Gersonius, B., Rijke, J., Ashley, R., Bloemen, P., Kelder, E. and Zevenbergen, C. (2016) Adaptive delta management for flood risk and resilience in Dordrecht, The Netherlands, *Natural Hazards*, 82(S2), pp. 201–216.
- Gilissen, H. K., Driessen, P.P.J., Mees, H.L.P., Rijswick, H.F.M.W. van, Runhaar, H.A.C., Uittenbroek, C. J. and Wörner, R. (2017) The climate resilience of critical infrastructural network sectors: An interdisciplinary method for assessing formal responsibilities for climate adaptation in critical infrastructural network sectors, in: S. Maljean-Dubois (Ed.) *The effectiveness of environmental law*, pp. 15–36. Cambridge, United Kingdom: Intersentia.
- Gläser, J. and Laudel, G. (2013) Life with and without coding: Two methods for early-stage data analysis in qualitative research aiming at causal explanations, *Forum Qualitative Social Research (FQS)*, 14(2), pp. 1–37.

- Glavovic, B. C., Saunders, W. S. A. and Becker, J. S. (2010) Land-use planning for natural hazards in New Zealand: The setting, barriers, ‘burning issues’ and priority actions, *Natural Hazards*, 54(3), pp. 679–706.
- Gleeson, B. (2008) Critical commentary. Waking from the dream: An Australian perspective on urban resilience, *Urban Studies*, 45(13), pp. 2653–2668.
- GMU (2007) *Critical thinking: Moving from infrastructure protection to infrastructure resilience*. Arlington, VA: George Mason University.
- Godschalk, D. R. (2003) Urban hazard mitigation: Creating resilient cities, *Natural Hazards Review*, 4(3), pp. 136–143.
- Goldstein, B. E. (Ed.) (2012) *Collaborative resilience: Moving through crisis to opportunity*. Cambridge, Mass.: MIT Press.
- Goldstein, B. E. and Butler, W. H. (2012) Collaborating for transformative resilience: Shared identity in the U.S. fire learning network, in: B. E. Goldstein (Ed.) *Collaborative resilience: Moving through crisis to opportunity*, pp. 339–358. Cambridge, Mass.: MIT Press.
- Government of New Zealand (2015) *Councils’ roles and functions*. http://www.localcouncils.govt.nz/lqip.nsf/wpg_url/About-Local-Government-Local-Government-In-New-Zealand-Councils-roles-and-functions. Accessed 21 September 2018.
- Graham, L., Debucquoy, W. and Anguelovski, I. (2016) The influence of urban development dynamics on community resilience practice in New York City after superstorm Sandy: Experiences from the Lower East Side and the Rockaways, *Global Environmental Change*, 40, pp. 112–124.
- Graham, S. (Ed.) (2010a) *Disrupted cities: When infrastructure fails*. New York: Routledge.
- Graham, S. (2010b) When infrastructures fail, in: S. Graham (Ed.) *Disrupted cities: When infrastructure fails*, pp. 1–26. New York: Routledge.
- Graham, S. and Thrift, N. (2007) Out of order: Understanding repair and maintenance, *Theory, Culture & Society*, 24(3), pp. 1–25.
- Groot, A.M.E., Bosch, P. R., Buijs, S., Jacobs, C.M.J. and Moors, E. J. (2015) Integration in urban climate adaptation: Lessons from Rotterdam on integration between scientific disciplines and integration between scientific and stakeholder knowledge, *Building and Environment*, 83, pp. 177–188.
- Gunderson, L. and Light, S. S. (2007) Adaptive management and adaptive governance in the everglades ecosystem, *Policy Sciences*, 39(4), pp. 323–334.
- Guy, S., Marvin, S., Medd, W. and Moss, T. (Eds.) (2012) *Shaping urban infrastructures: Intermediaries and the governance of socio-technical networks*. Hoboken: Taylor and Francis.
- Haas, P. M. (1992) Introduction: Epistemic communities and international policy coordination, *International Organization*, 46(01), pp. 1–35.
- Haddaway, N. R. and Macura, B. (2018) The role of reporting standards in producing robust literature reviews, *Nature Climate Change*, 8(6), pp. 444–447.
- Handley, K., Sturdy, A., Fincham, R. and Clark, T. (2006) Within and beyond communities of practice: Making sense of learning through participation, identity and practice, *Journal of Management Studies*, 43(3), pp. 641–653.

- Harman, B. P., Taylor, B. M. and Lane, M. B. (2015) Urban partnerships and climate adaptation: Challenges and opportunities, *Current Opinion in Environmental Sustainability*, 12, pp. 74–79.
- Hassink, R. (2010) Regional resilience: A promising concept to explain differences in regional economic adaptability?, *Cambridge Journal of Regions, Economy and Society*, 3(1), pp. 45–58.
- Hayward, B. M. (2013) Rethinking resilience: Reflections on the earthquakes in Christchurch, New Zealand, 2010 and 2011, *Ecology and Society*, 18(4).
- Healey, P. (1997) *Collaborative planning: Shaping places in fragmented societies*. London, s.l.: Macmillan Education UK.
- Hegger, D. L. T., Driessen, P. P. J., Dieperink, C., Wiering, M., Raadgever, G. T. T. and van Rijswijk, H. F. M. W. (2014) Assessing stability and dynamics in flood risk governance, *Water Resources Management*, 28(12), pp. 4127–4142.
- Hegger, D. L. T., Driessen, P. P. J., Wiering, M., van Rijswijk, H. F. M. W., Kundzewicz, Z. W., Matczak, P., Crabbé, A., Raadgever, G. T., Bakker, M. H. N., Priest, S. J., Larrue, C. and Ek, K. (2016) Toward more flood resilience: Is a diversification of flood risk management strategies the way forward?, *Ecology and Society*, 21(4).
- Helmke, G. and Levitsky, S. (2004) Informal institutions and comparative politics: A research agenda, *Perspectives on Politics*, 2(04), pp. 725–740.
- Hennink, M., Hutter, I. and Bailey, A. (2011) *Qualitative research methods*. Los Angeles, London, New Delhi, Singapore, Washington DC: Sage.
- Herbane, B. (2010) The evolution of business continuity management: A historical review of practices and drivers, *Business History*, 52(6), pp. 978–1002.
- Hodbod, J. and Adger, W. N. (2014) Integrating social-ecological dynamics and resilience into energy systems research, *Energy Research & Social Science*, 1, pp. 226–231.
- Hodson, M. and Marvin, S. (2010a) Urbanism in the anthropocene: Ecological urbanism or premium ecological enclaves?, *City*, 14(3), pp. 298–313.
- Hodson, M. and Marvin, S. (2010b) *World cities and climate change: Producing urban ecological security*. Berkshire, England: McGraw-Hill.
- Hohn, U. and Neuer, B. (2006) New urban governance: Institutional change and consequences for urban development, *European Planning Studies*, 14(3), pp. 291–298.
- Hokstad, P., Utne, I. B. and Vatn, J. (Eds.) (2012) *Risk and interdependencies in critical infrastructures: A guideline for analysis*. London: Springer London.
- Holling, C. S. (1973) Resilience and stability of ecological systems, *Annual Review of Ecology and Systematics*, 4(1), pp. 1–23.
- Holling, C. S. (1996) Engineering resilience versus ecological resilience, in: P. Schulze (Ed.) *Engineering within ecological constraints*, pp. 31–44. Washington: National Academies Press.
- Hollnagel, E., Woods, D. D. and Leveson, N. (Eds.) (2006) *Resilience engineering: Concepts and precepts*. Aldershot, England, Burlington, VT: Ashgate.
- Hommels, A. (2018) How resilience discourses shape cities: The case of resilient Rotterdam, in: S. Amir (Ed.) *The sociotechnical constitution of resilience: A new perspective on governing risk and disaster*, pp. 265–284. Singapore: Springer Singapore.

- Hommels, A. (2020) STS and the city: techno-politics, obduracy and globalisation, *Science as Culture*, pp. 1–7.
- Hommels, A., Mesman, J. and Bijker, W. E. (Eds.) (2014) *Vulnerability in technological cultures: New directions in research and governance*: Massachusetts Institute of Technology.
- Huang, C.-N., Liou, J. J.H. and Chuang, Y.-C. (2014) A method for exploring the interdependencies and importance of critical infrastructures, *Knowledge-Based Systems*, 55, pp. 66–74.
- Huck, A. and Monstadt, J. (2019) Urban and infrastructure resilience: Diverging concepts and the need for cross-boundary learning, *Environmental Science & Policy*, 100, pp. 211–220.
- Hudson, B., Hunter, D. and Peckham, S. (2019) Policy failure and the policy-implementation gap: Can policy support programs help?, *Policy Design and Practice*, 2(1), pp. 1–14.
- Hughes, S., Chu, E. K. and Mason, S. G. (Eds.) (2018) *Climate change in cities: Innovations in multi-level governance*. Cham: Springer International Publishing.
- Humby, T.-L. (2014) Law and resilience: Mapping the literature, *Seattle Journal of Environmental Law*, 4(1), pp. 85–130.
- Hutter, G., Kuhlicke, C., Glade, T. and Felgentreff, C. (2013) Natural hazards and resilience: Exploring institutional and organizational dimensions of social resilience, *Natural Hazards*, 67(1), pp. 1–6.
- Ilmola, L. (2016) Approaches to measurement of urban resilience, in: Y. Yamagata and H. Maruyama (Eds.) *Urban resilience: A transformative approach*, pp. 207–238. Cham: Springer.
- Ingold, K., Driessen, P. P.J., Runhaar, H. A.C. and Widmer, A. (2018) On the necessity of connectivity: Linking key characteristics of environmental problems with governance modes, *Journal of Environmental Planning and Management*, 23(4), pp. 1–24.
- IPCC (2014) *Climate change 2014: Impacts, adaptation, and vulnerability*. Working Group II contribution to the fifth assessment report of the Intergovernmental Panel on Climate Change : Part A: Global and sectoral aspects. Cambridge: Cambridge University Press.
- Jabareen, Y. (2015) *The risk city*. Dordrecht: Springer Netherlands.
- Janssen, M. A., Bodin, Ö., Anderies, J. M., Elmqvist, T., Ernstson, H., McAllister, R. R. J., Olsson, P. and Ryan, P. (2006) Toward a network perspective of the study of resilience in social-ecological systems, *Ecology and Society*, 11(1), [online].
- Joffe, H., Rossetto, T. and Adams, J. (Eds.) (2013) *Cities at risk: Living with perils in the 21st century*. Dordrecht: Springer.
- Johnson, C. and Blackburn, S. (2014) Advocacy for urban resilience: UNISDR’s Making Cities Resilient Campaign, *Environment and Urbanization*, 26(1), pp. 29–52.
- Jordan, A. and Schout, A. (2006) *The coordination of the European Union: Exploring the capacities of networked governance*. Oxford, New York: Oxford University Press.
- Joseph, J. (2013) Resilience as embedded neoliberalism: A governmentality approach, *Resilience*, 1(1), pp. 38–52.
- Kastenhofer, K. (2007) Converging epistemic cultures?: A discussion drawing on empirical findings, *Innovation: The European Journal of Social Science Research*, 20(4), pp. 359–373.

- Keenan, J. M. (2018) Types and forms of resilience in local planning in the U.S: Who does what?, *Environmental Science & Policy*, 88, pp. 116–123.
- Kernaghan, S. and da Silva, J. (2014) Initiating and sustaining action: Experiences building resilience to climate change in Asian cities, *Urban Climate*, 7, pp. 47–63.
- Khan, J. (2013) What role for network governance in urban low carbon transitions?, *Journal of Cleaner Production*, 50, pp. 133–139.
- Kimble, C., Grenier, C. and Goglio-Primard, K. (2010) Innovation and knowledge sharing across professional boundaries: Political interplay between boundary objects and brokers, *International Journal of Information Management*, 30(5), pp. 437–444.
- King, D. (2008) Reducing hazard vulnerability through local government engagement and action, *Natural Hazards*, 47(3), pp. 497–508.
- Klein, R. J. T., Nicholls, R. J. and Thomalla, F. (2003) Resilience to natural hazards: How useful is this concept?, *Environmental Hazards*, 5(1), pp. 35–45.
- Klijjn, E.-H. and Koppenjan, J. F. M. (2016) *Governance networks in the public sector*. Abingdon, Oxon, New York, NY: Routledge.
- Norr-Cetina, K. (1981) *The manufacture of knowledge: An essay on the constructivist and contextual nature of science*. Burlington: Elsevier Science.
- Norr-Cetina, K. (2003) *Epistemic cultures: How the sciences make knowledge*. Cambridge, Mass.: Harvard University Press.
- Norr-Cetina, K. and Reichmann, W. (2015) Epistemic cultures, in: J. D. Wright (Ed.) *International encyclopedia of the social & behavioral sciences*, pp. 873–880. Amsterdam: Elsevier.
- Kourtit, K., Nijkamp, P. and Scholten, H. (2014) The future of the new urban world, *International Planning Studies*, 20(1-2), pp. 4–20.
- Kröger, W. (2008) Critical infrastructures at risk: A need for a new conceptual approach and extended analytical tools, *Reliability Engineering & System Safety*, 93(12), pp. 1781–1787.
- Kröger, W. and Zio, E. (2011) *Vulnerable systems*. London: Springer London.
- Krumme, K. (2016) Sustainable development and social-ecological-technological systems (SETS): Resilience as a guiding principle in the urban-industrial nexus, *Renewable Energy and Sustainable Development*, 2(2), pp. 70–90.
- Labaka, L., Hernantes, J., Comes, T. and Sarriegi, J. M. (2014) Defining policies to improve critical infrastructure resilience, in: S. R. Hiltz, M. S. Pfaff, L. Plotnick and P. C. Shih (Eds.) *Conference proceedings: 11th international ISCRAM conference*.
- Labaka, L., Hernantes, J. and Sarriegi, J. M. (2015) Resilience framework for critical infrastructures: An empirical study in a nuclear plant, *Reliability Engineering & System Safety*, 141, pp. 92–105.
- Labaka, L., Hernantes, J. and Sarriegi, J. M. (2016) A holistic framework for building critical infrastructure resilience, *Technological Forecasting and Social Change*, 103, pp. 21–33.
- Lang, T. (2011) Urban resilience and new institutional theory: A happy couple for urban and regional studies?, in: B. Müller (Ed.) *German annual of spatial research and policy 2010: Urban regional resilience: How do cities and regions deal with change?*, pp. 15–24. Berlin: Springer.

- LaPorte, T. R. (2007) Critical infrastructure in the face of a predatory future: Preparing for untoward surprise, *Journal of Contingencies and Crisis Management*, 15(1), pp. 60–64.
- Lave, J. and Wenger, E. (1991) *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.
- Lebel, L., Anderies, J. M., Campbell, B., Folke, C., Hatfield-Dodds, S., Hughes, T. P. and Wilson, J. (2006) Governance and the capacity to manage resilience in regional social-ecological systems, *Ecology and Society*, 11(1).
- Lechner, F. J. and Boli, J. (Eds.) (2019) *The globalization reader*. Hoboken, NJ: Wiley-Blackwell.
- Leech, N. L. and Onwuegbuzie, A. J. (2008) Qualitative data analysis: A compendium of techniques and a framework for selection for school psychology research and beyond, *School Psychology Quarterly*, 23(4), pp. 587–604.
- Leitner, H., Sheppard, E., Webber, S. and Colven, E. (2018) Globalizing urban resilience, *Urban Geography*, 39(8), pp. 1276–1284.
- Lindseth, B. (2011) *The pre-history of resilience in ecological research*. <https://escholarship.org/uc/item/9zroj58f>. Accessed 11 March 2019.
- Linkov, I. and Palma-Oliveira, J. M. (Eds.) (2017) *Resilience and risk: Methods and application in environment, cyber and social domains*. Dordrecht: Springer.
- Little, R. G. (2010a) Controlling cascading failure: Understanding the vulnerabilities of interconnected infrastructures, *Journal of Urban Technology*, 9(1), pp. 109–123.
- Little, R. G. (2010b) Managing the risk of cascading failure in complex urban infrastructures, in: S. Graham (Ed.) *Disrupted cities: When infrastructure fails*, pp. 27–39. New York: Routledge.
- Lowndes, V. (2001) Rescuing aunt Sally: Taking institutional theory seriously in urban politics, *Urban Studies*, 38(11), pp. 1953–1971.
- Lu, P. and Stead, D. (2013) Understanding the notion of resilience in spatial planning: A case study of Rotterdam, The Netherlands, *Cities*, 35, pp. 200–212.
- MacAskill, K. (2016) *Rebuilding with resilience?: A case study of post-disaster infrastructure reconstruction in Christchurch, New Zealand*. PhD Thesis. Cambridge.
- MacAskill, K. and Guthrie, P. (2015) A hierarchy of measures for infrastructure resilience – learning from post-disaster reconstruction in Christchurch, New Zealand, *Civil Engineering and Environmental Systems*, 32(1-2), pp. 130–142.
- MacAskill, K. and Guthrie, P. (2016) Disaster risk reduction and empowering local government – a case comparison between Sri Lanka and New Zealand, *International Journal of Disaster Resilience in the Built Environment*, 7(4), pp. 318–329.
- MacAskill, K. and Guthrie, P. (2017) Organisational complexity in infrastructure reconstruction – A case study of recovering land drainage functions in Christchurch, *International Journal of Project Management*, 35(5), pp. 864–874.
- MacAskill, K. and Guthrie, P. (2018) Funding mechanisms for disaster recovery: Can we afford to build back better?, *Procedia Engineering*, 212, pp. 451–458.
- Magis, K. (2010) Community resilience: An indicator of social sustainability, *Society & Natural Resources*, 23(5), pp. 401–416.

- Mamula-Seadon, L. and McLean, I. (2015) Response and early recovery following 4 September 2010 and 22 February 2011 Canterbury earthquakes: Societal resilience and the role of governance, *International Journal of Disaster Risk Reduction*, 14, pp. 82–95.
- Marana, P., Labaka, L. and Sarriegi, J. M. (2018a) A framework for public-private-people partnerships in the city resilience-building process, *Safety Science*, 110, pp. 39–50.
- Marana, P., Labaka, L. and Sarriegi, J. M. (2018b) A framework for public-private-people partnerships in the city resilience-building process, *Safety Science*, 110, pp. 39–50.
- Markolf, S. A., Chester, M. V., Eisenberg, D. A., Iwaniec, D. M., Davidson, C. I., Zimmerman, R., Miller, T. R., Ruddell, B. L. and Chang, H. (2018) Interdependent infrastructure as linked social, ecological, and technological systems (SETSS) to address lock-in and enhance resilience, *Earth's Future*, 6(12), pp. 1631–1681.
- Massey, E. and Huitema, D. (2013) The emergence of climate change adaptation as a policy field: The case of England, *Regional Environmental Change*, 13(2), pp. 341–352.
- Matyas, D. and Pelling, M. (2014) Positioning resilience for 2015: The role of resistance, incremental adjustment and transformation in disaster risk management policy, *Disasters*, 39(S1), 1-18.
- McConnell, A. and Drennan, L. (2006) Mission impossible?: Planning and preparing for crisis, *Journal of Contingencies and Crisis Management*, 14(2), pp. 59–70.
- MCDEM (2002) *Civil Defence Emergency Management Act 2002: CDEM Act 2002*. Wellington N.Z.
- McDonald, L. (2018) *Christchurch's red zone: Who will own it? Who will look after it?* <https://www.stuff.co.nz/national/109269226/christchurchs-red-zone-who-will-own-it-who-will-look-after-it>. Accessed 24 November 2019.
- McFarlane, C. and Rutherford, J. (2008) Political infrastructures: Governing and experiencing the fabric of the city, *International Journal of Urban and Regional Research*, 32(2), pp. 363–374.
- McLean, I., Oughton, D., Ellis, S., Wakelin, B. and Rubin, C. B. (2012) *Review of the civil defence emergency management response to the 22 February Christchurch earthquake*. <https://www.alnap.org/system/files/content/resource/files/main/reviewofthecdemresponseto22febchcheearthquake-final-report-4-july-2012.pdf>. Accessed 5 October 2018.
- McPhearson, T., Andersson, E., Elmqvist, T. and Frantzeskaki, N. (2015) Resilience of and through urban ecosystem services, *Ecosystem Services*, 12, pp. 152–156.
- Medd, W. and Marvin, S. (2005) From the politics of urgency to the governance of preparedness: A research agenda on urban vulnerability, *Journal of Contingencies and Crisis Management*, 13(2), pp. 44–49.
- Meerow, S. and Newell, J. P. (2019) Urban resilience for whom, what, when, where, and why?, *Urban Geography*, 40(3), pp. 309–329.
- Meerow, S., Newell, J. P. and Stults, M. (2016) Defining urban resilience: A review, *Landscape and Urban Planning*, 147, pp. 38–49.
- Mikulewicz, M. (2019) Thwarting adaptation's potential?: A critique of resilience and climate-resilient development, *Geoforum*, 104, pp. 267–282.
- Miller, T. R. (2019) Imaginaries of sustainability: The techno-politics of smart cities, *Science as Culture*, 29(1), pp. 1–23.

- Ministry of Infrastructure and the Environment (2016) *National adaptation strategy*. The Hague.
- Ministry of Infrastructure and Water Management (2018) *Delta programme 2019: Continuing the work on the delta: Adapting the Netherlands to climate change in time*. The Hague.
- Molin Valdés, H., Amaratunga, D. and Haigh, R. (2013) Making cities resilient: From awareness to implementation, *International Journal of Disaster Resilience in the Built Environment*, 4(1), pp. 5–8.
- Monstadt, J. (2009) Conceptualizing the political ecology of urban infrastructures: Insights from technology and urban studies, *Environment and Planning A*, 41(8), pp. 1924–1942.
- Monstadt, J. and Schmidt, M. (2019) Urban resilience in the making?: The governance of critical infrastructures in German cities, *Urban Studies*, 56(11), pp. 2353–2371.
- Muñoz-Erickson, T., Miller, C. and Miller, T. (2017) How cities think: Knowledge co-production for urban sustainability and resilience, *Forests*, 8(6), 203–219.
- Münzberg, T., Wiens, M. and Schultmann, F. (2017) A spatial-temporal vulnerability assessment to support the building of community resilience against power outage impacts, *Technological Forecasting and Social Change*, 121, pp. 99–118.
- NCTV (n.d.). https://english.nctv.nl/topics_a_z/critical_infrastructure_protection/index.aspx. Accessed 19 July 2019.
- New Zealand Government (2019) *National disaster resilience strategy: Rautaki ā-Motu Manawaroa Aituā*. Wellington N.Z.
- Normandin, J.-M., Therrien, M.-C., Pelling, M. and Paterson, S. (2019) The definition of urban resilience: A transformation path towards collaborative urban risk governance, in: G. Brunetta, O. Caldarice, N. Tollin, M. Rosas-Casals and J. Morató (Eds.) *Urban resilience for risk and adaptation governance*, pp. 9–25. Cham: Springer International Publishing.
- North, D. C. (1990) *Institutions, institutional change and economic performance*. Cambridge: Cambridge Univ. Press.
- Nowotny, H. (Ed.) (2006) *Cultures of technology and the quest for innovation*. New York: Berghahn Books.
- Oels, A. (2013) Rendering climate change governable by risk: From probability to contingency, *Geoforum*, 45, pp. 17–29.
- Office of the Auditor-General (2012) *Roles, responsibilities, and funding of public entities after the Canterbury earthquakes*. Wellington N.Z.: Office of the Auditor General.
- Office of the Auditor-General (2013) *Effectiveness and efficiency of arrangements to repair pipes and roads in Christchurch*. Wellington: Office of the Auditor General.
- Offner, J.-M. (2000) 'Territorial deregulation': Local authorities at risk from technical networks, *International Journal of Urban and Regional Research*, 24(1), pp. 165–182.
- Olazabal, M., Chelleri, L. and Waters, J. J. (2012) Why urban resilience?, in: L. Chelleri and M. Olazabal (Eds.) *Multidisciplinary perspectives on urban resilience: A workshop report*, pp. 7–18. Bilbao: BC3, Basque Centre for Climate Change.
- Orlikowski, W. J. (2002) Knowing in practice: Enacting a collective capability in distributed organizing, *Organization Science*, 13(3), pp. 249–273.

- Ostrom, E. (2015) *Governing the commons: The evolution of institutions for collective action*. Cambridge: Cambridge University Press.
- Padt, F., Termeer, C., Opdam, P. and Polman, N. (Eds.) (2014) *Scale-sensitive governance of the environment*. Chichester, UK: Wiley-Blackwell.
- Pahl-Wostl, C. (2006) Transitions towards adaptive management of water facing climate and global change, *Water Resources Management*, 21(1), pp. 49–62.
- Pahl-Wostl, C. (2009) A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes, *Global Environmental Change*, 19(3), pp. 354–365.
- Parker, B. and Farrington, T. (2012) *Ripped apart: A city in chaos*. Kerikeri, N.Z.: Antares Pub.
- Pathak, M. and Mahadevia, D. (2018) Urban informality and planning: Challenges to mainstreaming resilience in Indian cities, in: Y. Yamagata and A. Sharifi (Eds.) *Resilience-oriented urban planning*, pp. 49–66. Cham: Springer International Publishing.
- Pearce, L. (2003) Disaster management and community planning, and public participation: How to achieve sustainable hazard mitigation, *Natural Hazards*, 28(2/3), pp. 211–228.
- Peck, J. and Tickell, A. (2002) Neoliberalizing space, *Antipode*, 34(3), pp. 380–404.
- Perelman, L. J. (2007) Shifting security paradigms: Toward resilience, in: *Critical thinking: Moving from infrastructure protection to infrastructure resilience*, pp. 23–48. Arlington, VA: George Mason University.
- Perrow, C. (1994) The limits of safety: The enhancement of a theory of accidents, *Journal of Contingencies and Crisis Management*, 2(4), pp. 212–220.
- Pizzo, B. (2015) Problematizing resilience: Implications for planning theory and practice, *Cities*, 43, pp. 133–140.
- Port of Rotterdam Authority (n. d.) *Facts & figures: A wealth of information*. <https://www.portofrotterdam.com/sites/default/files/facts-and-figures-port-of-rotterdam.pdf>. Accessed 19 July 2019.
- Porter, L. and Davoudi, S. (2012) The politics of resilience for planning: A cautionary note, *Planning Theory & Practice*, 13(2), pp. 329–333.
- Prins, R., Cachet, L., Ponsaers, P. and Hughes, G. (2012) Fragmentation and interconnection in public safety governance in the Netherlands, Belgium and England, in: H.J.M. Fenger and V.J.J.M. Bekkers (Eds.) *Beyond fragmentation and interconnectivity: Public governance and the search for connective capacity*, pp. 19–43. Amsterdam: IOS Press.
- Prior, T. and Hagmann, J. (2013) Measuring resilience: Methodological and political challenges of a trend security concept, *Journal of Risk Research*, 17(3), pp. 281–298.
- Raju, E. and van Niekerk, D. (2013) Intra-governmental coordination for sustainable disaster recovery: A case-study of the Eden District Municipality, South Africa, *International Journal of Disaster Risk Reduction*, 4, pp. 92–99.
- Redman, C. L. (2014) Should sustainability and resilience be combined or remain distinct pursuits?, *Ecology and Society*, 19(2).
- Restemeyer, B., van den Brink, M. and Woltjer, J. (2016) Between adaptability and the urge to control: Making long-term water policies in the Netherlands, *Journal of Environmental Planning and Management*, 60(5), pp. 920–940.

- Rinaldi, S. M., Peerenboom, J. P. and Kelly, T. K. (2001) Identifying, understanding, and analyzing critical infrastructure interdependencies, *IEEE Control Systems Magazine*, 21(6), pp. 11–25.
- Rogers, C. D. F., Bouch, C. J., Williams, S., Barber, A. R. G., Baker, C. J., Bryson, J. R., Chapman, D. N., Chapman, L., Coaffee, J., Jefferson, I. and Quinn, A. D. (2012) Resistance and resilience – paradigms for critical local infrastructure, *Proceedings of the Institution of Civil Engineers - Municipal Engineer*, 165(2), pp. 73–83.
- Rotterdam Climate Initiative (2013) *Rotterdam climate change adaptation strategy*. Rotterdam.
- Runhaar, H., Wilk, B., Persson, Å., Uittenbroek, C. and Wamsler, C. (2018) Mainstreaming climate adaptation: Taking stock about “what works” from empirical research worldwide, *Regional Environmental Change*, 18(4), pp. 1201–1210.
- Saito, N. (2013) Mainstreaming climate change adaptation in least developed countries in South and Southeast Asia, *Mitigation and Adaptation Strategies for Global Change*, 18(6), pp. 825–849.
- Salet, W. (2018) Institutions in action, in: W. Salet (Ed.) *The Routledge handbook of institutions and planning in action*, pp. 3–23. Boca Raton, FL: Routledge an imprint of Taylor and Francis.
- Sanchez, A., van der Heijden, J. and Osmond, P. (2018) The city politics of an urban age: Urban resilience conceptualisations and policies, *Palgrave Communications*, 4(1), pp. 1–12.
- Sapountzaki, K., Wanczura, S., Casertano, G., Greiving, S., Xanthopoulos, G. and Ferrara, F. F. (2011) Disconnected policies and actors and the missing role of spatial planning throughout the risk management cycle, *Natural Hazards*, 59(3), pp. 1445–1474.
- Saunders, W.S.A. and Becker, J. S. (2015) A discussion of resilience and sustainability: Land use planning recovery from the Canterbury earthquake sequence, New Zealand, *International Journal of Disaster Risk Reduction*, 14, pp. 73–81.
- Scharpf, F. W. (1978) Interorganizational policy studies: issues, concepts and perspectives, in: K. Hanf and F. W. Scharpf (Eds.) *Interorganizational policy making: Limits to coordination and central control*, pp. 345–370. London: Sage Publ.
- Scheuerman, W. E. (2001) Reflexive law and the challenges of globalization, *Journal of Political Philosophy*, 9(1), pp. 81–102.
- Seager, T. P., Clark, S. S., Eisenberg, D. A., Thomas, J. E., Hinrichs, M. M., Kofron, R., Jensen, C. N., McBurnett, L. R., Snell, M. and Alderson, D. L. (2017) Redesigning resilient infrastructure research, in: I. Linkov and J. M. Palma-Oliveira (Eds.) *Resilience and risk: Methods and application in environment, cyber and social domains*, pp. 81–120. Dordrecht: Springer.
- Smith, G. and Birkland, T. (2012) Building a theory of recovery: Institutional dimensions, *International Journal of Mass Emergencies and Disasters*, 30(2), pp. 147–170.
- Smith, K. and Petley, D. N. (2009) *Environmental hazards: Assessing risk and reducing disaster*. Milton Park, Abingdon, Oxon, New York: Routledge.
- Spaans, M. and Waterhout, B. (2017) Building up resilience in cities worldwide: Rotterdam as participant in the 100 Resilient Cities programme, *Cities*, 61, pp. 109–116.

- Star, S. L. (1999) The ethnography of infrastructure, *American Behavioral Scientist*, 43(3), pp. 377–391.
- Stump, E.-M. (2013) New in town?: On resilience and “resilient cities”, *Cities*, 32, pp. 164–166.
- Surminski, S. and Leck, H. (2016) You never adapt alone: The role of multi-sectoral partnerships in addressing urban climate risks, *Centre for Climate Change Economics and Policy Working Paper*, 262.
- Tavernor, R. (2010) Introduction to the London Plan 2000–2010: A decade of transformation, *City, Culture and Society*, 1(2), pp. 45–46.
- Teubner, G. (1983) Substantive and reflexive elements in modern law, *Law & Society Review*, 17(2), p. 239.
- Toubin, M., Laganier, R., Diab, Y. and Serre, D. (2015) Improving the conditions for urban resilience through collaborative learning of Parisian urban services, *Journal of Urban Planning and Development*, 141(4), p. 5014021.
- Uittenbroek, C. J. (2015) From policy document to implementation: Organizational routines as possible barriers to mainstreaming climate adaptation, *Journal of Environmental Policy & Planning*, 18(2), pp. 161–176.
- Uittenbroek, C. J., Janssen-Jansen, L. B. and Runhaar, H. A. C. (2013) Mainstreaming climate adaptation into urban planning: Overcoming barriers, seizing opportunities and evaluating the results in two Dutch case studies, *Regional Environmental Change*, 13(2), pp. 399–411.
- Uittenbroek, C. J., Janssen-Jansen, L. B., Spit, T. J.M., Salet, W. G.M. and Runhaar, H. A.C. (2014) Political commitment in organising municipal responses to climate adaptation: The dedicated approach versus the mainstreaming approach, *Environmental Politics*, 23(6), pp. 1043–1063.
- UN-Habitat (2017) *Trends in urban resilience: 2017*. Nairobi.
- United Nations (2019) *World urbanization prospects: The 2018 revision*. New York: United Nations.
- Urban Institute (2018) *Institutionalizing urban resilience: A midterm monitoring and evaluation report of 100 Resilient Cities*. Washington, DC.
- Vallance, S. (2015) Disaster recovery as participation: Lessons from the Shaky Isles, *Natural Hazards*, 75(2), pp. 1287–1301.
- van House, N. A. (2002) Trust and epistemic communities in biodiversity data sharing, in: *Proceedings of the 2nd ACM/IEEE-CS joint conference on digital libraries*, pp. 231–239. New York: Association for Computing Machinery.
- Vedeld, T., Coly, A., Ndour, N. M. and Hellevik, S. (2016) Climate adaptation at what scale?: Multi-level governance, resilience, and coproduction in Saint Louis, Senegal, *Natural Hazards*, 82(S2), pp. 173–199.
- Wagenaar, H. and Wilkinson, C. (2015) Enacting resilience: A performative account of governing for urban resilience, *Urban Studies*, 52(7), pp. 1265–1284.
- Wakefield, S. (2019) Miami Beach forever?: Urbanism in the back loop, *Geoforum*, 107, pp. 34–44.
- Walker, B., Vries, H. P. de and Nilakant, V. (2017) Managing legitimacy: The Christchurch post-disaster reconstruction, *International Journal of Project Management*, 35(5), pp. 853–863.
- Walker, J. and Cooper, M. (2011) Genealogies of resilience: From systems ecology to the political economy of crisis adaptation, *Security Dialogue*, 42(2), pp. 143–160.

- Walsh, B. (2013) Adapt or die: Why the environmental buzzword of 2013 will be resilience, *Time*, 08.01.2013.
- Wamsler, C. and Pauleit, S. (2016) Making headway in climate policy mainstreaming and ecosystem-based adaptation: Two pioneering countries, different pathways, one goal, *Climatic Change*, 137(1-2), pp. 71–87.
- Watts, R. H. (2011) *The Christchurch waterways story*. Lincoln, N.Z.: Manaaki Whenua Press, Landcare Research.
- Weichselgartner, J. and Kelman, I. (2015) Geographies of resilience: Challenges and opportunities of a descriptive concept, *Progress in Human Geography*, 39(3), pp. 249–267.
- Welsh, M. (2014) Resilience and responsibility: Governing uncertainty in a complex world, *The Geographical Journal*, 180(1), pp. 15–26.
- Wenger, E. (2000) Communities of practice and social learning systems, *Organization*, 7(2), pp. 225–246.
- Wenger, E. (2006) *Communities of practice: a brief introduction*. http://www.linqed.net/media/15868/COPCommunities_of_practiceDefinedEWenger.pdf. Accessed 17 August 2017.
- Wenger, E. (2008) *Communities of practice: Learning, meaning, and identity*. Cambridge: Cambridge University Press.
- Wheeler, S. M. and Beatley, T. (Eds.) (2014) *The sustainable urban development reader*. London, New York: Routledge Taylor & Francis Group.
- White, I. and O’Hare, P. (2014) From rhetoric to reality: Which resilience, why resilience, and whose resilience in spatial planning?, *Environment and Planning C: Government and Policy*, 32(5), pp. 934–950.
- Wilkinson, C. (2012) Urban resilience: What does it mean in planning practice?, *Planning Theory & Practice*, 13(2), pp. 319–324.
- Winner, L. (1980) Do artifacts have politics?, *Daedalus*, 109(1), pp. 121–136.
- Woodruff, S. C., Meerow, S., Stults, M. and Wilkins, C. (2018) Adaptation to resilience planning: Alternative pathways to prepare for climate change, *Journal of Planning Education and Research*, 66(1), 1-12.
- World Bank Group (2015) *CityStrength diagnostic: Methodological guidebook*. <http://documents.worldbank.org/curated/en/557791467992483926/City-strength-diagnostic-methodological-guidebook>. Accessed 5 July 2018.
- Wuijts, S., Driessen, P. P. J. and van Rijswijk, H. F. M. W. (2018) Governance conditions for improving quality drinking water resources: The need for enhancing connectivity, *Water Resources Management*, 32(4), pp. 1245–1260.
- Wyborn, C. (2015) Co-productive governance: A relational framework for adaptive governance, *Global Environmental Change*, 30, pp. 56–67.
- Yin, R. K. (2018) *Case study research and applications: Design and methods*. Los Angeles, London, New Dehli, Singapore, Washington DC, Melbourne: Sage.
- Young, O. R., King, L. A. and Schroeder, H. (Eds.) (2008) *Institutions and environmental change: Principal findings, applications, and research frontiers*. Cambridge, Mass.: MIT Press.
- Yumagulova, L. (2012) Infrastructure planning as a component of urban/regional resilience, in: L. Chelleri and M. Olazabal (Eds.) *Multidisciplinary perspectives on urban resilience: A workshop report*, pp. 21–25. Bilbao: BC3, Basque Centre for Climate Change.

Zaidi, R. Z. and Pelling, M. (2015) Institutionally configured risk: Assessing urban resilience and disaster risk reduction to heat wave risk in London, *Urban Studies*, 52(7), pp. 1218–1233.

APPENDICES

Appendix 1: Overview of interviews – Chapter 3 (Rotterdam)

Inter- view #	Organisation	Date	Place	Main topic of interview
1	Municipality of Rotterdam – Spatial planning	04.10.2017	Rotterdam	Climate adaptation, municipal strategies
2	Municipality of Rotterdam – Spatial planning	06.10.2017	Rotterdam	Municipal organisation and project management
3	Municipality of Rotterdam – Water Management	13.10.2017	Rotterdam	Emergency management, local, regional and national flood management
4	Municipality of Rotterdam – Resilience Team	25.10.2017	Rotterdam	Rotterdam Resilience Strategy
5	Ministry of Infrastructure and Water Management – ‘vitaal & kwetsbaar’	27.10.2017	The Hague	Critical infrastructures, climate adaptation, national perspective
6	Next Generation Infrastructure	30.10.2017	Delft	Critical infrastructure resilience
7	Evides – crisis and contingency management	31.10.2017	Rotterdam	Crisis and contingency management
8	Municipality of Rotterdam – Resilience Team	01.11.2017	Rotterdam	Rotterdam Resilience Strategy, Cyber security
9	Municipality of Rotterdam (2 interviewees) – Asset management	01.11.2017	Rotterdam	Asset management, underground infrastructures
10	Municipality of Rotterdam – policy adviser	06.11.2017	Rotterdam	Energy Transition, municipal strategies
11	Safety Region – risk management	29.11.2017	Rotterdam	Emergency management, regional risk management, Rotterdam Resilience Strategy
12	Port of Rotterdam – Asset management	06.12.2017	Rotterdam	Asset management, resilience management in the port
13	Stedin – crisis and contingency management	08.12.2017	Utrecht	Crisis and contingency management
14	TNO (retired)	13.12.2017	Utrecht	Critical infrastructure resilience
15	TNO	13.12.2017	The Hague	Critical infrastructure resilience, Rotterdam Resilience Strategy, Cyber resilience

16	Rijkswaterstaat	20.12.2017	Utrecht	Water safety, critical infrastructure resilience
17	Rijkswaterstaat	20.12.2017	Utrecht	Water safety, critical infrastructure resilience
18	100 Resilient Cities	12.01.2018	Skype interview	100 Resilient Cities, Rotterdam Resilience Strategy
19	Ministry of Security and Justice – National Coordinator for Security and Counterterrorism (NCTV)	23.01.2018	The Hague	Cross-sector infrastructure resilience, NCTV
20	Ministry of Security and Justice – National Coordinator for Security and Counterterrorism (NCTV)	04.04.2019	The Hague	Follow-up to interview #19
21	Ministry of Infrastructure and Water Management – ‘vitaal & kwetsbaar’	04.04.2019	The Hague	Ministerial cooperation, critical infrastructures and climate adaptation
22	Municipality of Rotterdam – Resilience Team	26.04.2019	Skype interview	Follow-up to interview #4
23	Municipality of Rotterdam – Asset management	16.05.2019	Skype interview	Follow-up to interview #8
24	Municipality of Rotterdam – Resilience Team	16.05.2019	Skype interview	Follow-up to interview #9
25	Safety Region – crisis response	21.05.2019	Rotterdam	Emergency management, critical infrastructure resilience
26	Safety Region – risk management	21.05.2019	Rotterdam	Emergency management, municipal planning

Appendix 2: Overview of interviews – Chapter 4 (Christchurch)

Inter-view #	Organisation / former organisation	Date	Place	Type of interview
1	100 Resilient Cities – Asia Pacific: senior manager	15.02.2018	Darmstadt/ Singapore	skype
2	Resilient Organisations Ltd: senior manager	09.04.2018	Christchurch	face to face
3	Canterbury Civil Defence and Emergency Management Group: civil servant	16.04.2018	Christchurch	face to face
4	Stronger Christchurch Infrastructure Recovery Team: senior manager	19.04.2018	Christchurch	face to face
5	Canterbury University – Engineering: senior academic	20.04.2018	Christchurch	face to face
6	Lincoln University – Environmental management: senior academic	26.04.2018	Lincoln	face to face
7	Canterbury Lifelines Group: senior advisor	30.04.2018	Christchurch	face to face
8	Canterbury Earthquake Recovery Authority: senior manager	30.04.2018	Christchurch	face to face
9	Waimakariri District Council: civil servant	02.05.2018	Rangiora	face to face
10	Greater Christchurch Partnership: civil servant	03.05.2018	Christchurch	face to face
11	Development Christchurch Ltd: senior manager	04.05.2018	Christchurch	face to face
	National Infrastructure Unit: board member			face to face
12	Christchurch City Council: civil servant	07.05.2018	Christchurch	face to face
13	Christchurch City Council: civil servant	08.05.2018	Christchurch	face to face
14	Canterbury Lifelines Group: senior advisor	10.05.2018	Christchurch	face to face (follow-up)
15	National Lifelines Council: senior manager	14.05.2018	Christchurch/ Wellington	skype
	Land Information New Zealand: senior manager			skype
16	Canterbury Lifelines Group: senior advisor	21.05.2018	Christchurch	face to face
17	Christchurch City Council: civil servant	25.05.2018	Christchurch	face to face
18	Stronger Christchurch Infrastructure Recovery Team: senior manager	25.05.2018	Christchurch	face to face (follow-up)
19	Wellington Lifelines Group: senior manager	18.10.2018	Wellington	face to face
20	Christchurch City Council: civil servant	23.10.2018	Christchurch	face to face (follow-up)

21	Canterbury Earthquake Recovery Authority: senior manager	23.10.2018	Christchurch	face to face (follow-up)
22	Canterbury Earthquake Recovery Authority: senior advisor	25.10.2018	Tai Tapu	face to face
23	Canterbury CDEM Group: civil servant	26.10.2018	Christchurch	face to face
	Christchurch City Council: civil servant			face to face (follow-up)
24	Ministry of Civil Defence and Emergency Management: civil servant	30.10.2018	Christchurch	face to face
25	Orion: senior manager	31.10.2018	Christchurch	face to face
	Orion: senior manager			face to face
26	Canterbury CDEM Group: civil servant	01.11.2018	Christchurch	face to face (follow-up)
27	Resilient Organisations Ltd.: senior manager	15.11.2018	Christchurch	face to face (follow-up)
	Resilient Organisations Ltd.: senior manager		Christchurch/ Christchurch	skype
28	Christchurch City Council: civil servant	07.12.2018	Christchurch	face to face (follow-up)
	Christchurch City Council: civil servant			face to face
29	Christchurch City Council: politician	14.12.2018	Christchurch	face to face

Appendix 3: Overview of interviews – Chapter 5 (Rotterdam & Christchurch)

Inter-view #	Case study	Organisation	Date	Place
1	ROT	Municipality of Rotterdam: civil servant	04.10.2017	Rotterdam
2	ROT	Municipality of Rotterdam: civil servant	06.10.2017	Rotterdam
3	ROT	Municipality of Rotterdam: civil servant	13.10.2017	Rotterdam
4	ROT	Municipality of Rotterdam: civil servant	25.10.2017	Rotterdam
5	ROT	Ministry of Infrastructure and Water Management: civil servant	27.10.2017	The Hague
6	ROT	Next Generation Infrastructure: senior manager	30.10.2017	Delft
7	ROT	Evides Waterbedrijf: senior manager	31.10.2017	Rotterdam
8	ROT	Municipality of Rotterdam: civil servant	01.11.2017	Rotterdam
9	ROT	Municipality of Rotterdam: civil servant (2 interviewees)	01.11.2017	Rotterdam
10	ROT	Municipality of Rotterdam: policy advisor	06.11.2017	Rotterdam
11	ROT	Safety Region Rotterdam Rijnmond: civil servant	29.11.2017	Rotterdam
12	ROT	Port of Rotterdam: senior manager	06.12.2017	Rotterdam
13	ROT	Stedin: senior manager	08.12.2017	Utrecht
14	ROT	TNO: senior manager	13.12.2017	Utrecht
15	ROT	TNO: senior manager	13.12.2017	The Hague
16	ROT	Rijkswaterstaat: civil servant	20.12.2017	Utrecht
17	ROT	Rijkswaterstaat: civil servant	20.12.2017	Utrecht
18	ROT	100 Resilient Cities: senior manager	12.01.2018	Skype interview
19	ROT	Ministry of Security and Justice: civil servant	23.01.2018	The Hague
20	CHCH	100 Resilient Cities: senior manager	15.02.2018	Skype interview
21	CHCH	Resilient Organisations Ltd: senior manager	09.04.2018	Christchurch
22	CHCH	Canterbury Civil Defence and Emergency Management Group: civil servant	16.04.2018	Christchurch
23	CHCH	Stronger Christchurch Infrastructure Rebuilt Team: senior manager	19.04.2018	Christchurch
24	CHCH	Canterbury University: senior academic (engineering)	20.04.2018	Christchurch
25	CHCH	Lincoln University: senior academic (environmental management)	26.04.2018	Lincoln
26	CHCH	Canterbury Lifelines Group: senior advisor	30.04.2018	Christchurch
27	CHCH	Canterbury Earthquake Recovery Authority: senior manager	30.04.2018	Christchurch
28	CHCH	Waimakariri District Council: civil servant	02.05.2018	Rangiora
29	CHCH	Greater Christchurch Partnership: senior manager	03.05.2018	Christchurch
30	CHCH	Development Christchurch Ltd: senior manager & National Infrastructure Unit: board member (2 interviewees)	04.05.2018	Christchurch
31	CHCH	Christchurch City Council: civil servant	07.05.2018	Christchurch
32	CHCH	Christchurch City Council: civil servant	08.05.2018	Christchurch

33	CHCH	Canterbury Lifelines Group: senior advisor	10.05.2018	Christchurch (follow-up interview #26)
34	CHCH	National Lifelines Council: senior advisor & Land Information New Zealand: senior manager (2 interviewees)	14.05.2018	Skype interview
35	CHCH	Canterbury Lifelines Group: senior manager	21.05.2018	Christchurch
36	CHCH	Christchurch City Council: civil servant	25.05.2018	Christchurch
37	CHCH	Stronger Christchurch Infrastructure Rebuilt Team: senior manager	25.05.2018	Christchurch (follow-up interview #23)
38	CHCH	Wellington Lifelines Group: senior manager	18.10.2018	Wellington
39	CHCH	Christchurch City Council: civil servant	23.10.2018	Christchurch (follow-up interview #36)
40	CHCH	Canterbury Earthquake Recovery Authority: senior manager	23.10.2018	Christchurch (follow-up interview #27)
41	CHCH	Canterbury Earthquake Recovery Authority: senior advisor	25.10.2018	Tai Tapu
42	CHCH	Canterbury Civil Defence and Emergency Management Group: civil servant & Christchurch City Council: civil servant (2 interviewees)	26.10.2018	Christchurch
43	CHCH	Ministry of Civil Defence and Emergency Management: civil servant	30.10.2018	Christchurch
44	CHCH	Orion: senior managers (2 interviewees)	31.10.2018	Christchurch
45	CHCH	Canterbury Civil Defence and Emergency Management Group: civil servant	01.11.2018	Christchurch (follow-up interview #22)
46	CHCH	Resilient Organisations Ltd: senior managers (2 interviewees)	15.11.2018	Christchurch
47	CHCH	Christchurch City Council: civil servants (2 interviewees)	07.12.2018	Christchurch
48	CHCH	Christchurch City Council: politician	14.12.2018	Christchurch
49	ROT	Ministry of Security and Justice: civil servant	04.04.2019	The Hague (follow-up interview #19)
50	ROT	Ministry of Infrastructure and Water Management: civil servant	04.04.2019	The Hague
51	ROT	Municipality of Rotterdam: civil servant	26.04.2019	Skype interview (follow-up interview #4)
52	ROT	Municipality of Rotterdam: civil servant	16.05.2019	Skype interview (follow-up interview #8)
53	ROT	Municipality of Rotterdam: civil servant	16.05.2019	Skype interview (follow-up interview #9)
54	ROT	Safety Region Rotterdam Rijnmond: civil servant	21.05.2019	Rotterdam
55	ROT	Safety Region Rotterdam Rijnmond: civil servant	21.05.2019	Rotterdam

SUMMARY

Introduction and research aim

Due to their high population densities, their architectural structures, their economic importance and their geographical location (for instance, on deltas), cities are particularly vulnerable to various threats such as those deriving from climate change, terrorist attacks or natural hazards. The risk of cascading failures in coupled infrastructure systems across sectoral and territorial boundaries further intensifies these vulnerabilities. Under such circumstances, city managers, urban planners and infrastructure providers increasingly have to plan for risk, crisis and uncertainty. In response to a rising sense of urgency to adapt cities and their infrastructure networks to climate change and to cope with extreme weather events or other types of threat, scholarship on disaster risk management, climate adaptation, urban planning and infrastructure management has taken up the concept of urban resilience as a normative framework. From a governance perspective, these bodies of literature stress the need for collaboration and learning in multi-level, multi-sector, multi-actor and cross-territorial governance networks to enhance resilience capacities to resist, recover and adapt. Based on a review of relevant bodies of literature, four governance strategies for enhancing urban and infrastructure resilience can be derived.

- *Knowledge co-production* – jointly producing resilience-relevant knowledge and enhancing learning across disciplinary and departmental boundaries.
- *Network management* – activating relevant public and private actors in decision-making processes, moderating potential and actual conflicts of interest, coordinating their action and providing strategic direction to resilience measures.
- *Enhancing connectivity* – enhancing vertical, horizontal or cross-territorial cooperation and coordination between relevant actors and organisations.
- *Mainstreaming* – aligning resilience objectives into existing sectoral policies and decision-making practices.

Despite its popularity in academic and policy discourses, empirical studies suggest that policymakers and planners struggle to institutionalise resilience and that their attempts tend to be incremental, ad hoc and reactive. In this vein, scholars report

an implementation gap between resilience as a policy objective and resilience as manifested in the implementation of risk management and urban planning practices. This practical problem is reflected in a lack of academic knowledge on how to institutionalise urban and infrastructure resilience. The existing literature mainly focuses on policy design and calls for stronger collaboration between stakeholders for policymaking. Yet only a few approaches systematically adopt an institutional perspective on the governance of urban and infrastructure resilience.

The main aim of the research described in this thesis was to gain a more detailed understanding of the implementation gap of urban and infrastructure resilience by analysing related policy making and planning in two cities – Christchurch and Rotterdam – using an institutional perspective. This understanding can then be used to derive suggestions for institutional reform to enhance urban and infrastructure resilience. In this thesis, institutional arrangements are understood to be a system of formal and informal rules and decision-making procedures such as laws, regulations, standards, routines, traditions and established epistemologies that guide the actions and interactions of public and private actors. The main research question examined in this thesis is:

How do current institutional arrangements shape the governance of urban and infrastructure resilience and how should they be restructured to address existing implementation gaps?

Empirical analyses and results

Chapters 2 to 5 each explicitly address one of the four identified governance strategies (knowledge co-production, network management, enhancing connectivity and mainstreaming), thereby contributing to a better understanding of how institutions shape the governance for urban and infrastructure resilience.

Chapter 2 addresses the strategy of *knowledge co-production* by analysing and confronting the literatures on urban resilience and infrastructure resilience. It shows that the concept of resilience has attracted considerable attention in both bodies of literature as well as in the respective policy discourses. However, a closer look at the joint enterprise, the shared repertoire and the mutual engagement of the respective knowledge communities in urban and infrastructure research and planning practice reveals that resilience is understood and dealt with in dissimilar ways. In particular, the concepts of urban resilience and infrastructure resilience are rooted in different histories, characterised by different disciplinary traditions and operationalised in separate communities of practice that make use of distinct instruments and techniques of knowledge production. This leads to diverging epistemologies, problem definitions and dissimilar visions of the future, creating knowledge boundaries between the respective communities, which can induce somewhat disconnected policy outcomes and governance practices. The chapter reflects on the importance of knowledge co-production for adaptive and networked governance and discusses the potential of resilience to serve as a boundary concept. It calls for respective knowledge communities to interact and engage more in collaborative processes of knowledge production that accommodate different epistemologies across disciplinary and sectoral boundaries.

Chapter 3 analyses strategies of *network management* deployed in the Dutch city of Rotterdam to enhance urban and infrastructure resilience. In particular, it addresses governance challenges resulting from making critical infrastructures an integral part of urban resilience policies and the potential role city administrations play in the resulting governance networks. The results reveal that the city administration of Rotterdam is limited in its authority and depends on decisions made by other public and private actors, particularly those relating to the integrated management of interconnected infrastructure networks such as those for water and energy provision. Although a range of cross-boundary resilience projects have been initialised in Rotterdam, the current institutional arrangements hamper effective network management because they do not sufficiently take into account the consolidation of vertical, horizontal and cross-territorial relationships between relevant actors and their collective action. The short-term character of many projects brings the risk that actors will relapse into siloed working habits after a particular project ends and that relationships will have to be re-established time and again. The results call for institutional adjustments that include the redefinition of roles and responsibilities for cross-territorial risk management, the cross-sectoral budgeting of infrastructure resilience measures and the cross-departmental budgeting of municipal projects, as well as for local actions and measures to be better aligned with those at regional and national scales of government.

Chapter 4 engages with the strategy of *enhancing connectivity* to cope with the complex demands on risk management and to contribute to adaptive and networked governance. It provides an institutional perspective on connectivity and analyses how institutional connectivity affects a city's particular resilience capacities to resist, recover and adapt. The analysis of the metropolitan area of Greater Christchurch, which experienced a series of devastating earthquakes in 2010/2011, reveals different forms and dimensions of connectivity. From an institutional perspective, connectivity may entail a) the integration or amalgamation of policy domains, policy levels or territorial jurisdictions into one coherent arrangement, b) institutionalised forms of cross-boundary collaboration and coordination or c) ad hoc, temporary or informal cooperation or information and knowledge sharing between actors across boundaries. In terms of governance, connectivity can comprise hierarchical as well as networked decision-making structures and it can be established top-down or bottom-up. The case study shows that different connectivity dimensions (vertical, horizontal, cross-territorial) had very specific impacts on the three resilience capacities of resistance, recovery and adaptability and that the uncertainties entailed by disaster situations considerably shape the efficacy of institutional connectivity. In addition, the results reveal that enhancing institutional connectivity is a resource-intensive and contested process that might induce negative trade-offs and conflicts between involved actors that arise from the reallocation of resources and the redistribution of authority. The chapter therefore calls for scholarly debates to put more emphasis on processes of institutional reform and to stress the political dimension of institution building for urban resilience.

Chapter 5 focuses on the governance strategy of *mainstreaming*, analysing how the two cities of Christchurch and Rotterdam are trying to align resilience goals into

sectoral policy and decision-making. It reveals common problems for mainstreaming that are apparent in both cities despite their contextual differences. The first is to make resilience a top priority for policymaking and planning because it competes with other urban development agendas for political commitment. Secondly, institutionalising cross-sector governance constitutes a problem because participation in the 100 Resilient Cities programme brings few incentives for institutional reforms. The third problem – to achieve active engagement of decision-makers from public and private sectors – arises because urban policymakers and planners are not sufficiently equipped to convince them to invest additional resources in terms of personnel, time and money. In light of these problems, I argue that relying solely on the 100 Resilient Cities blueprint of resilience policies would be naïve to some extent. Rather, mainstreaming resilience into policymaking and planning practice requires institutional adjustments to (1) procedural law and national policymaking to enhance political commitment, (2) the current system of incentives to support the establishment of governance networks including reluctant actors and (3) support mechanisms and training for urban policy makers and planners to raise active engagement of decision-makers from the private sector.

Conclusions and reflections

The results of this study suggest that so far, cities are institutionally ill equipped to significantly enhance particular resilience capacities to resist, recover and adapt. It reveals that current institutional arrangements often impede adaptive and networked governance strategies such as co-producing knowledge, network management, enhancing connectivity and mainstreaming. Rather they support knowledge on urban and infrastructure resilience to be developed in parallel and contingency and risk management to be organised within sectoral and territorial silos; moreover, they hamper knowledge and information sharing between different governance levels. Further, existing institutional arrangements do not provide municipalities with the necessary political mandate, legitimacy and authority to act as a network manager and to consolidate institutional connectivity. Institutional factors that hamper adaptive and networked governance range from rigid disciplinary traditions and working routines in separate communities of practice to the allocation of resources for risk management along sectoral lines. In addition, they include formal regulations and legislation that are malformed in terms of - or even lack mention of - cross-sector, multi-level and cross-territorial risk and contingency management. Within the current institutional arrangements, cities will remain particularly vulnerable to extreme weather events, natural hazards, terrorist or cyber-attacks and other potential shocks and stresses. In line with this main conclusion, this study provides four relevant insights for the academic debate on urban and infrastructure resilience:

Firstly, the results of this study confirm existing literature in that there is indeed an implementation gap of urban and infrastructure resilience. In extension to mainstream literature, which discloses policy silos or a lack of collaboration between different actor groups, the institutional lens applied in this research reveals some of the reasons for these phenomena, thus providing a more nuanced understanding of existing implementation gaps.

Secondly, the results of this study call for a critical reassessment of governance strategies to enhance urban and infrastructure resilience, because existing institutional arrangements do not equally support particular resilience capacities. Whilst mainstream literature makes use of resilience in a rather generic way, this study demonstrates that distinguishing between the three resilience capacities of resistance, recovery and adaptation contributes to a more nuanced understanding of how certain governance strategies may support the enhancing of urban and infrastructure resilience.

Thirdly, the insights provided in this study make clear that municipalities cannot be exclusively responsible for institutionalising urban and infrastructure resilience. Whilst some scholars contend that municipalities are becoming more and more important in their coordinating, networking, controlling and regulating functions, this study suggests that municipalities should be viewed as being embedded in complex territorialities of infrastructure systems and the multi-layered institutional arrangements involved in managing these systems.

Fourthly, approaches to institutionalise urban and infrastructure resilience prove to be highly political and contested processes that might induce negative trade-offs as they often encounter entrenched and conflicting interests of key actors and require the reallocation of resources and the redistribution of authority. Although urban resilience is often framed as a post-political concept, the way it is applied raises questions of politics, power and equity. These insights stand in contrast to the win-win paradigm underlying mainstream resilience literature, which suggests that different actor groups equally benefit from resilience measures.

With respect to the second part of the overall research question, it is possible to derive some recommendations for institutional adjustments in order to address existing implementation gaps and to enhance urban and infrastructure resilience.

- Formal legal reforms should complement informal approaches to stimulate adaptive and networked governance.
- National and regional governments should take a more proactive role in institutionalising urban and infrastructure resilience.
- Institutional arrangements for adaptive and networked governance should be designed to be adaptive and flexible themselves.

I suggest future research should consider in particular some issues that proved to be highly relevant in this study but that could not be addressed in detail. They include (1) the interdependent relationship between different governance strategies to enhance resilience, (2) the politics of governance strategies to enhance urban and infrastructure resilience, (3) the materiality of infrastructure systems and its co-constitutive character with respect to governance and decision-making, (4) the relationship between qualitative and quantitative ways to measure resilience capacities and (5) the comparative assessment of diverse cities that are in different parts of the world and are participating in different resilience programmes.

SAMENVATTING

Inleiding en onderzoeksdoel

Steden zijn door hun hoge bevolkingsdichtheid, bouwkundige structuur, economisch belang en geografische ligging (bijvoorbeeld in een delta) bijzonder kwetsbaar voor uiteenlopende bedreigingen zoals klimaatverandering, terroristische aanslagen of natuurrampen. Het risico van storingen die zich opeenstapelen in gekoppelde infrastructurale systemen en sectorale en territoriale grenzen overschrijden versterkt deze kwetsbaarheid nog verder. Deze omstandigheden nopen stadsbestuurders, planologen en aanbieders van infrastructuur om steeds meer rekening te houden met risico's, crises en onzekerheid. Er is een toenemend gevoel van urgentie om steden en de bijbehorende infrastructurale netwerken aan te passen aan klimaatverandering en om voorbereid te zijn op extreme weersomstandigheden en andersoortige bedreigingen. In reactie hierop wordt in de wetenschap op het gebied van rampenrisicomanagement, aanpassing aan het klimaat, ruimtelijke ordening en infrastructuurbeheer het concept van stedelijke veerkracht als een normatief kader gebruikt. Vanuit een governance-perspectief wordt in deze wetenschapsgebieden gewezen op de noodzaak tot samenwerking en leren in multi-level, multi-sector, multi-actor en cross-territoriale bestuurlijke netwerken om het weerstands-, herstel- en aanpassingsvermogen te versterken. Op basis van een overzicht van de relevante literatuur kunnen vier governance-strategieën voor het vergroten van de veerkracht van steden en infrastructuur onderscheiden worden:

- *Coproductie van kennis*: gezamenlijk kennis produceren die relevant is voor veerkracht en verbeteren van het leren over disciplinaire grenzen en expertisegebieden heen.
- *Netwerkmanagement*: relevante publieke en private actoren inschakelen in besluitvormingsprocessen, potentiële en feitelijke belangentegenstellingen verzachten, het optreden van actoren coördineren en strategisch richting geven aan veerkrachtmaatregelen.
- *Versterken van de connectiviteit*: de verticale, horizontale of interterritoriale samenwerking en coördinatie tussen relevante actoren en organisaties versterken.

- *Mainstreamen*: veerkrachtdoelstellingen integreren in bestaand sectoraal beleid en in de sectorale besluitvorming.

Ondanks de populariteit van het begrip veerkracht in het wetenschappelijke en beleidsdiscours, wijst empirisch onderzoek erop dat beleidsmakers en planologen moeite hebben om veerkracht te institutionaliseren en dat hun pogingen vaak incrementeel, ad hoc en reactief zijn. In dit verband signaleren wetenschappers een implementatiekloof tussen veerkracht als beleidsdoel en veerkracht die tot uiting komt in de implementatie van beleid op het gebied van risicomanagement en ruimtelijke ordening. Achter dit praktische probleem schuilt een gebrek aan wetenschappelijke kennis over het institutionaliseren van stedelijke en infrastructurele veerkracht. In de bestaande literatuur wordt vooral aandacht besteed aan beleidsvorming en wordt gepleit voor een intensievere samenwerking tussen de stakeholders bij het maken van beleid. Er zijn maar weinig benaderingen waarin governance van stedelijke en infrastructurele veerkracht systematisch wordt gezien vanuit institutioneel perspectief. Het hoofddoel van het onderzoek dat in dit proefschrift wordt beschreven was om een nauwkeuriger inzicht te krijgen in de implementatiekloof van stedelijke en infrastructurele veerkracht. Hiertoe is de relevante beleidsvorming en ruimtelijke ordening in twee steden – Christchurch (Nieuw-Zeeland) en Rotterdam – onderzocht vanuit institutioneel perspectief. Dit inzicht kan vervolgens worden gebruikt om suggesties te doen voor institutionele hervorming om de stedelijke en infrastructurele veerkracht te verhogen. In dit proefschrift worden institutionele structuren opgevat als een stelsel van formele en informele regels en besluitvormingsprocedures zoals wetten, voorschriften, normen, gewoonten, tradities en gevestigde kennisgevingen die richting geven aan het handelen en de interactie van publieke en private actoren. De centrale onderzoeksvraag van dit proefschrift is:

Hoe geven de huidige institutionele structuren vorm aan de governance van stedelijke en infrastructurele veerkracht en welke hervormingen zijn nodig om de bestaande hiaten in de implementatie aan te pakken?

Empirisch onderzoek en resultaten

De hoofdstukken 2 tot en met 5 behandelen elk een van de vier genoemde governance-strategieën (coproductie van kennis, netwerkmanagement, versterken van de connectiviteit en mainstreamen). Hierdoor ontstaat een beter begrip van de wijze waarop instituties de governance van stedelijke en infrastructurele veerkracht vormgeven.

Hoofdstuk 2 gaat in op de strategie van *coproductie van kennis* door de literatuur over stedelijke veerkracht en infrastructurele veerkracht te onderzoeken en deze twee literatuurbronnen tegen elkaar af te zetten. Het begrip veerkracht blijkt veel aandacht te krijgen in zowel de literatuur als het beleidsdiscours op beide gebieden. Uit een nadere beschouwing van de gezamenlijke aanpak, het gedeelde repertoire en de wederzijdse betrokkenheid van de respectievelijke kennisgemeenschappen op het gebied van stad en infrastructuur blijkt echter dat veerkracht in het onderzoek en de praktijk van ruimtelijke ordening verschillend wordt opgevat en benaderd. De concepten stedelijke veerkracht en infrastructurele veerkracht hebben beide een

verschillende geschiedenis, zijn geworteld in verschillende disciplinaire tradities en worden geoperationaliseerd in aparte praktijkgemeenschappen die elk gebruikmaken van hun eigen instrumenten en technieken van kennisproductie. Dit leidt tot afwijkende kennistheorieën en probleemdefinities en ongelijke toekomstvisies, waardoor kennisgrenzen tussen de respectievelijke gemeenschappen ontstaan, wat kan leiden tot enigszins onsamenvattende beleidsresultaten en governance-praktijken. In het hoofdstuk wordt stilgestaan bij het belang van coproductie van kennis voor een adaptieve en netwerkgerichte governance. Verder wordt ingegaan op het potentieel van veerkracht om als grensconcept te dienen. Het hoofdstuk eindigt met de oproep tot interactie tussen de respectievelijke kennisgemeenschappen en tot het aangaan van samenwerkingsverbanden voor kennisproductie waarin verschillende kennistheorieën die disciplinaire en sectorale grenzen overstijgen een plaats krijgen.

Hoofdstuk 3 beschrijft onderzoek naar strategieën voor *netwerkmanagement* die in de gemeente Rotterdam worden toegepast om de stedelijke en infrastructurele veerkracht te vergroten. Daarbij ligt de nadruk op uitdagingen op het vlak van governance die ontstaan wanneer essentiële delen van de infrastructuur worden aangemerkt als integraal onderdeel van het beleid inzake stedelijke veerkracht en op de potentiële rol die stadsbesturen spelen in de daaruit voortvloeiende governance-netwerken. Uit de resultaten blijkt dat het gemeentebestuur van Rotterdam beperkte bevoegdheden heeft en afhankelijk is van besluiten die door andere publieke en private partijen worden genomen. Daarbij gaat het vooral om besluiten op het gebied van het gecoördineerde beheer van onderling gekoppelde infrastructuurnetwerken, zoals die voor de water- en energievoorziening. Hoewel er in Rotterdam diverse grensoverschrijdende veerkrachtprojecten zijn geïnitieerd, belemmeren de huidige institutionele structuren een effectief netwerkbeheer. Dit komt doordat er onvoldoende aandacht is voor de consolidatie van verticale, horizontale en interterritoriale relaties tussen relevante actoren en hun collectieve optreden. Het kortetermijnkarakter van veel projecten brengt het risico met zich mee dat actoren na afloop van een bepaald project terugvallen in een verkokerde werkwijze en dat relaties steeds opnieuw moeten worden opgebouwd. De resultaten wijzen op de noodzaak van institutionele aanpassingen, waaronder het herdefiniëren van de rollen en verantwoordelijkheden voor interterritoriaal risicomanagement, de intersectorale budgettering van maatregelen voor infrastructurele veerkracht en de interdepartementale budgettering van gemeentelijke projecten. Ook zouden lokale initiatieven en maatregelen beter afgestemd moeten worden op initiatieven en maatregelen op regionaal en nationaal niveau.

Hoofdstuk 4 bespreekt de strategie van het *versterken van de connectiviteit* om te kunnen voldoen aan de complexe eisen van risicomanagement en bij te dragen aan een adaptieve en netwerkgerichte governance. Het hoofdstuk biedt een institutioneel perspectief op connectiviteit en gaat in op de invloed van institutionele connectiviteit op het specifieke weerstands-, herstel- en aanpassingsvermogen van een stad. Uit het onderzoek naar de stadsregio Greater Christchurch in Nieuw-Zeeland, die in 2010/2011 getroffen werd door een aantal verwoestende aardbevingen, komen verschillende vormen en dimensies van connectiviteit naar voren. Vanuit een institutioneel perspectief kan connectiviteit het volgende inhouden: a) de integratie of

samenvoeging van beleidsdomeinen, beleidsniveaus of territoriale jurisdicties tot één samenhangende structuur; b) geïnstitutionaliseerde vormen van grensoverschrijdende samenwerking en coördinatie en c) grensoverschrijdende samenwerking of het delen van informatie en kennis tussen actoren op ad hoc, tijdelijke of informele basis. In termen van governance kan connectiviteit zowel hiërarchische als netwerkbesluitvormingsstructuren omvatten. Ook kan connectiviteit top-down of bottom-up worden opgezet. Uit de casestudy blijkt dat verschillende connectiviteitsdimensies (verticaal, horizontaal, interterritoriaal) zeer specifieke gevolgen hadden voor de drie soorten veerkracht (weerstand-, herstel- en aanpassingsvermogen), en dat de onzekerheden die rampen met zich meebrengen in aanzienlijke mate bepalen hoe doeltreffend institutionele connectiviteit is. Daarnaast laten de resultaten zien dat het versterken van de institutionele connectiviteit veel middelen vergt en omstrepen is, wat kan leiden tot negatieve compromissen en conflicten tussen de betrokken actoren. Deze negatieve gevolgen hebben te maken met de herverdeling van middelen en bevoegdheden. Het hoofdstuk bevat daarom een oproep tot een wetenschappelijk debat om meer nadruk te leggen op processen van institutionele hervorming en op de politieke dimensie van het opzetten van een institutionele structuur voor stedelijke veerkracht.

Hoofdstuk 5 behandelt onderzoek naar mainstreamen als governance-strategie. Hierin wordt bekeken hoe de steden Christchurch en Rotterdam de veerkrachtdoelstellingen proberen te integreren in het sectorale beleid en de sectorale besluitvorming. Ondanks de contextuele verschillen tussen beide steden, blijken dezelfde problemen met mainstreamen op te treden. Ten eerste blijkt het moeilijk om veerkracht top-prioriteit te geven in de beleidsvorming en ruimtelijke ordening, vanwege de concurrentie met andere plannen voor stadsontwikkeling die op de politieke agenda staan. Ten tweede is de institutionalisering van intersectorale governance een probleem, omdat deelname aan het netwerk *100 Resilient Cities* weinig impulsen biedt voor institutionele hervorming. Ten derde blijkt het problematisch om actieve betrokkenheid van bestuurders uit de publieke en private sector te realiseren. Dit komt doordat stedelijke beleidsmakers en planologen niet voldoende toegerust zijn om bestuurders te overtuigen extra middelen in te zetten in de vorm van personeel, tijd en geld. Gezien deze problemen zou het tot op zekere hoogte naïef zijn om uitsluitend te vertrouwen op de blauwdruk voor veerkrachtbeleid van 100 Resilient Cities. Het mainstreamen en integreren van veerkracht in de beleids- en ruimtelijke ordeningspraktijk vereist veeleer institutionele aanpassingen van (1) het procesrecht en de nationale beleidsvorming om het politieke draagvlak te vergroten; (2) het huidige stelsel van stimuleringsmaatregelen ter ondersteuning van de vorming van governance-netwerken waarin ook terughoudende actoren participeren en (3) ondersteuningsmechanismen en opleidingen voor stedelijke beleidsmakers en planologen om de actieve betrokkenheid van bestuurders uit de private sector te vergroten.

Conclusies en overwegingen

De resultaten van dit onderzoek wijzen erop dat steden tot nu toe institutioneel slecht toegerust zijn om het weerstands-, herstel- en aanpassingsvermogen, drie aspecten van veerkracht, substantieel te verhogen. De huidige institutionele structuren blijken vaak een belemmering te vormen voor adaptieve en netwerkgerichte governance-strategieën zoals coproductie van kennis, netwerkmanagement, versterking van de

connectiviteit en mainstreamen. Deze structuren zorgen veeleer voor een parallelle ontwikkeling van kennis over stedelijke en infrastructurele veerkracht en een sectoraal en territoriaal verkokerde organisatie van eventualiteiten- en risicomanagement. Bovendien wordt hierdoor de uitwisseling van kennis en informatie tussen de verschillende governance-niveaus belemmerd. Daarnaast bieden de bestaande institutionele structuren gemeenten niet het benodigde politieke mandaat en de benodigde legitimiteit en bevoegdheid om op te treden als netwerkmanager en de institutionele connectiviteit te consolideren.

Institutionele factoren die een adaptieve en netwerkgerichte governance belemmeren, variëren van starre vakgerichte tradities en werkwijzen in afzonderlijke praktijk-gemeenschappen tot de toewijzing van middelen voor risicomanagement langs sectorale lijnen. Andere belemmerende factoren zijn formele wet- en regelgeving waarin onvoldoende of zelfs helemaal geen aandacht wordt besteed aan intersectoraal, multi-level en interterritoriaal risico- en eventualiteitenmanagement. Binnen de huidige institutionele structuren blijven steden bijzonder kwetsbaar voor extreme weersomstandigheden, natuurrampen, terroristische aanslagen, cyberaanvallen en andere potentiële schokken en bedreigingen. In het verlengde van deze hoofdconclusie biedt dit onderzoek vier relevante inzichten voor het wetenschappelijke debat over stedelijke en infrastructurele veerkracht.

In de eerste plaats bevestigen de resultaten van dit onderzoek de conclusie uit de bestaande literatuur dat er sprake is van een implementatiekloof op het gebied van stedelijke en infrastructurele veerkracht. Voortbouwend op de literatuur waarin wordt gewezen op beleidskokers en gebrek aan samenwerking tussen verschillende partijen, worden in dit onderzoek een aantal redenen hiervoor blootgelegd. Door deze materie te bekijken door een institutionele lens, ontstaat een genuanceerder inzicht in de bestaande hiaten in de implementatie.

Ten tweede is het op grond van de resultaten van dit onderzoek raadzaam om governance-strategieën ter verhoging van de stedelijke en infrastructurele veerkracht nog eens kritisch te bekijken, omdat verschillende aspecten van veerkracht niet in gelijke mate worden ondersteund in de bestaande institutionele structuren. Terwijl veerkracht in de literatuur vrij generiek wordt benaderd, wordt in dit onderzoek een onderscheid gemaakt tussen drie aspecten van veerkracht, namelijk het weerstands-, herstel- en aanpassingsvermogen. Dit onderscheid draagt bij aan een genuanceerder inzicht in de wijze waarop bepaalde governance-strategieën stedelijke en infrastructurele veerkracht kunnen vergroten.

Ten derde blijkt uit dit onderzoek dat de verantwoordelijkheid voor het institutionaliseren van stedelijke en infrastructurele veerkracht niet uitsluitend bij gemeenten moet liggen. Hoewel gemeenten volgens sommige wetenschappers steeds belangrijker worden door hun coördinerende, controlerende, regulerende en netwerkfunctie, plaatst dit onderzoek gemeenten in een ander licht. De resultaten wijzen erop dat gemeenten zijn ingebed in complexe territoriale aspecten van infrastructurele systemen en de gelaagde institutionele structuren die bij het beheer van deze systemen een rol spelen.

Ten vierde blijkt institutionalisering van stedelijke en infrastructurele veerkracht een zeer politiek gevoelig en omstreden proces te zijn dat negatieve gevolgen kan hebben. Dit komt doordat de hoofdrolspelers vaak gevestigde en tegenstrijdige belangen hebben en er veelal een herverdeling van middelen en bevoegdheden vereist is. Hoewel stedelijke veerkracht vaak wordt opgevat als een postpolitiek concept, roept de manier waarop het wordt toegepast vragen op over politiek, macht en rechtvaardigheid. Deze inzichten zijn in tegenspraak met het win-win-paradigma in de gangbare veerkrachtliteratuur, dat aangeeft dat verschillende partijen in gelijke mate profiteren van veerkrachtmaatregelen.

De beantwoording van het tweede deel van de centrale onderzoeksvraag leidt tot enkele aanbevelingen voor institutionele aanpassingen om de bestaande hiaten in de implementatie aan te pakken en de stedelijke en infrastructurele veerkracht te vergroten:

- Formele wetswijzigingen moeten een aanvulling vormen op informele benaderingen om adaptieve en netwerkgerichte governance te bevorderen.
- Nationale en regionale overheden moeten een proactievere rol spelen bij het institutionaliseren van de stedelijke en infrastructurele veerkracht.
- Institutionele structuren voor adaptieve en netwerkgerichte governance moeten zelf ook adaptief en flexibel zijn.

In toekomstig onderzoek zou aandacht besteed moeten worden aan enkele kwesties die in dit onderzoek zeer relevant zijn gebleken, maar niet in detail konden worden bestudeerd. Het gaat onder meer om: (1) de onderlinge afhankelijkheid tussen verschillende governance-strategieën ter vergroting van de veerkracht; (2) de politiek van governance-strategieën ter vergroting van stedelijke en infrastructurele veerkracht; (3) het materiële karakter van infrastructurele systemen en het co-constitutive karakter wat betreft governance en besluitvorming; (4) de relatie tussen kwalitatieve en kwantitatieve manieren om verschillende aspecten van veerkracht te meten en (5) een vergelijking tussen diverse steden in verschillende delen van de wereld die aan verschillende veerkrachtprogramma's deelnemen.

ABOUT THE AUTHOR

Andreas Huck was born in 1985 in Freiburg im Breisgau, Germany. He is an urban researcher, sustainability enthusiast and PhD candidate at Technische Universität Darmstadt and Utrecht University. He is part of the DFG Research Training Group KRITIS in Darmstadt. Andreas obtained his bachelor's degree (BSc) in spatial planning from Technische Universität Kaiserslautern, Germany in 2010 and his master's degree (MSc) in Regional Studies: Spaces and Places, Analysis and Intervention (research) from the University of Groningen, The Netherlands in 2013. During his studies he concentrated on environmental and social sustainability from the perspectives of spatial planning and urban development. He took part in different exchange programmes, visiting other universities in Europe and the USA, and received several scholarships and awards for his research. Andreas has working experience outside academia in the field of future research and technology assessment as well in various EU-wide projects under the aegis of Climate-KIC, Europe's largest climate innovation network: that work related to urban transition management, city-to-city-learning and professional education and certification.

© Andreas Huck, Universiteit Utrecht,
2020.

ISBN
978-94-91937-45-3

Design and production
André Diepgrond / In Ontwerp, Assen

Digital access
InPlanning Technical Team

This work is intellectual property and subject to copyright. All rights reserved, whether the whole or part of the material is concerned. Duplication of this publication or parts thereof is permitted only under the provisions of the 'Auteurswet' (Copyright Law) of the 23th of September 1912, in its current version, and permission for use must always be obtained from InPlanning. Violations are liable to prosecution under Dutch Law.

PhD Series InPlanning

// IN /
PLAN /
/ NING

Published by InPlanning
Oude Kijk in 't Jatstraat 6,
9712 EG Groningen, The Netherlands

info@inplanning.eu
www.inplanning.eu

InPlanning is legally registered as
cooperative under KvK 58997121

The InPlanning PhD Series supports the publication and distribution of PhD theses produced within Schools of Planning. The InPlanning PhD Series is part of the InPlanning portfolio of books, journals, posters, videos, documentaries and other information carriers. The InPlanning PhD Series is available via

www.inplanning.eu

ENHANCING URBAN AND INFRASTRUCTURE RESILIENCE

AN INSTITUTIONAL PERSPECTIVE



ANDREAS HUCK

Their high population densities, architectural structures, economic importance and geographical location (for instance, on deltas) make cities particularly vulnerable to various threats such as those deriving from climate change, terrorist attacks or natural hazards. Adding to their vulnerability is the risk of failures cascading through coupled infrastructure systems and across sectoral and territorial boundaries. So, city managers, urban planners and infrastructure providers increasingly have to plan for risk, crisis and uncertainty. This study of the cities of Rotterdam in the Netherlands and Christchurch in New Zealand shows that cities are still institutionally ill equipped to significantly enhance their resilience – their capacities to resist, recover and adapt. The study reveals that adaptive and networked governance strategies to enhance resilience are often impeded by formal regulations, legislation, informal traditions and work routines, and the allocation of resources. These general framework conditions support developing knowledge on urban and infrastructure resilience in parallel and organising and keeping contingency and risk management in “silos” (i.e. within sectors and administrative areas); moreover, they hamper the sharing of knowledge and information between different governance levels. The study’s findings suggest that to overcome these problems, there should be formal legal reforms to complement informal approaches to stimulate adaptive and networked governance. Furthermore, national and regional governments should be more proactive in institutionalising urban and infrastructure resilience.

WWW.INPLANNING.EU

ISBN 978-94-91937-45-3



9 789491 937453

// IN /
PLAN /
/ NING