Post-disaster Reconstruction—What Does It Mean to Rebuild with Resilience?

Kristen MacAskill and Peter Guthrie

Abstract There is a growing awareness that we live in times of uncertainty and change; this is fuelling increased consciousness of city and community vulnerability to natural and man-made hazards. In recent years the concept of resilience—the ability to both withstand and recover from a "shock"—has become a core term in international, national and local policy for urban development. Because resilience has been adopted in a range of decision-making contexts, various interpretations of the concept are potentially confusing for those attempting to adopt it in their own decision making. To help provide clarity, this chapter presents a framework that captures different interpretations of resilience as a concept to frame decisions for disaster risk reduction in our communities and cities. This framework acknowledges that resilience is a trans-disciplinary concept; its purpose is to help create a coherent understanding of how sector-specific applications of resilience lie within a broader conception of resilience in disaster risk management. More specifically, the framework is used to examine how resilience is considered in the post-earthquake reconstruction of infrastructure networks in Christchurch, New Zealand. There is still much to learn from case studies of post-disaster recovery, where the recovery environment introduces different and perhaps unfamiliar levels of complexity in decision-making compared to business as usual planning and development.

Keywords Resilience · Post-disaster recovery · Disaster risk management

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1 Introduction

This chapter comprises three main parts. Firstly, we provide background context through briefly addressing developments in international policy related to disaster risk management (DRM) and the emergence of resilience as a guiding concept.[1] We then introduce a framework that captures different interpretations of resilience in DRM, where resilience is essentially about the ability of being able to resist or recover from a shock. Finally, we use the framework to examine the institutional and organisational arrangements for reconstructing infrastructure networks in the post-disaster environment in Christchurch, New Zealand, following a series of earthquakes that occurred over 2010–2011. The rebuild of infrastructure networks such as water supply, wastewater reticulation and roads is often overlooked in post-disaster recovery case studies. This is (at least) in part because discussion on disaster risk reduction is often oriented towards less developed countries where such networks may not exist in a substantial form. Yet, developed countries are also vulnerable to disaster and infrastructure networks provide services critical to supporting developed urban areas. Our resilience framework will provide a basis for analysing roles and responsibilities for decisions that shape the recovery of Christchurch's infrastructure, with references to the broader recovery processes occurring in the city. This analysis demonstrates how the resilience framework can be a useful tool for understanding how sector-specific resilience strategies can contribute to a broader, integrated approach.

2 Background to Resilience in Disaster Risk Management Policy

As Coaffee et al. (2009) describe in their historical review of security policy, resilience has long been a core element of city development, even if it has only more recently become an explicit term in policy. The Sendai Framework for Disaster Risk Reduction 2015–2030, coordinated by the United Nations Office for Disaster Risk Reduction, represents the epitome of the growing global concern around the on-going viability of our communities and cities. The Sendai Framework, following its predecessor the Hyogo Framework for Action, will continue to lead international policy, guiding efforts towards building the resilience

[1]We adopted the UN definition of DRM, which is: "The systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster" (United Nations Office for Disaster Risk Reduction 2009, p. 10).

of nations and communities to the impacts disaster.[2] Its goals are clearly designed around the idea of building resilience through DRM. The Hyogo Framework for Action has been successful in raising awareness and generating political commitment, with action from stakeholders from local to global level.[3] Priority for the future action under the Sendai Framework includes a need to:

> …focus action on understanding risk and how it is created; strengthen governance mechanisms at all levels; invest in economic, social, cultural and environmental resilience; and enhance preparedness, response, recovery and reconstruction at all levels.
>
> United Nations 2014, p. 5

Note here both the emphasis on resilience in enhancing all phases of the DRM cycle—not just longer term planning, but also the process of recovery. It is the recovery aspect that forms the focus of discussion in this chapter.

Supporting progress at an international level, the World Bank's Global Facility for Disaster Reduction and Recovery (GFDRR) released a *Guide to Developing Disaster Recovery Frameworks* in September 2014. The aim of that guide is to help governments and other stakeholders plan for a "resilient" post-disaster recovery that aligns with goals for longer-term development, rather than just responding to the immediate hazard. The guide itself does not outline a resilience assessment process, but uses the concept of resilience as descriptor of what recovery should be, even though this is difficult to define:

> The notion of Resilient Recovery is much more nuanced, less understood and inconsistently perceived by most development practitioners. As countries develop their own standards and definitions on what constitutes resilience in recovery, due consideration might be given to: building back better; concerns over gender, equity, vulnerability reduction; natural resource conservation, environmental protection and climate change adaptation.
>
> GFDRR (2014a, p. 21)

The guide offers counsel on policy and institutional arrangements with a strong emphasis on governance of the recovery process.[4] It covers various key topics associated with recovery governance, including: conducting disaster assessments; policy and strategy setting, institutional frameworks; financing; implementation arrangements and recovery management; and institutionalising recovery in national and local governance systems. It does not give prescriptive advice, but provides a platform for learning through case study examples. No clear definition is given

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[2]Evidence of progress to-date can be viewed through national progress reports accessible from the United Nations Office for Disaster Risk Reduction portal for disaster reduction knowledge: http://www.preventionweb.net/english/hyogo/framework/progress/.

[3]The Sendai Framework was agreed at the time of finalising this chapter. The Hyogo Framework for Action has led progress to date. Its goals were: the integration of disaster risk reduction into sustainable development policies and planning; development and strengthening of institutions, mechanisms and capacities to build resilience to hazards; the systematic incorporation of risk reduction approaches into the implementation of emergency preparedness, response and recovery programmes (United Nations Office for Disaster Risk Reduction 2007).

[4]This emphasis on "governance" for resilience is an important concept that we will address in the development of a conceptual framework later in the chapter.

around what constitutes "Resilient Recovery", reinforcing the view that it will change in different contexts. Rather, the case studies describe elements of recovery that governments and stakeholders can learn from or choose to emulate in some way. Beyond the guide's focus on governance for "Resilience Recovery", resilience is also referred to in relation to more particular aspects of case studies, such as through:

- Physical measures in construction of housing—for example building houses on higher ground or on plinths to reduce risk of flood damage.
- Infrastructure interventions such as development of embankments to increase public safety.
- Increasing resistance in vulnerable points of a road network through slope stabilisation, drainage and surface treatments.
- Adoption of design codes for seismic design.
- Allowing a more participatory approach to recovery.
- Improving hazard assessment process to make more informed land use decisions.
- Institutionalisation of resilience through policies that focus on risk management.

At times it is not clearly explained in the case studies what is meant by incorporating resilience, such as a reference to "community resilience projects" in Yemen where there is no explanation of what those projects actually were and how they supported community resilience (GFDRR 2014b). However, it is clear from these examples that resilience may be adopted through a variety of perspectives and applied to different systems—covering communities, physical infrastructure, land use and institutional arrangements. It is this variety of perspectives that formed our motivation for creating a framework to capture different interpretations of resilience.

3 Development of the Conceptual Framework

This section outlines how we developed a conceptual framework to describe the facets of resilience as a concept for informing decisions in DRM. For those less concerned with the more formal construction of our approach, go straight to Sect. 4 for discussion on the Christchurch recovery.

Resilience has developed into a concept far beyond its literal definition as a term describing a property or quality of resistance, or bouncing back from adversity. It represents a way of thinking, a process to understand system (or people's) behaviour and performance. The idea has developed to a point where resilience is not necessarily a property of a system, but a means for governance, as demonstrated through the GFDRR framework for disaster recovery.

It is widely acknowledged that there are multiple interpretations of resilience. It has proven a useful concept to describe and understand phenomena in many facets of life, including ecology, psychology, community development, organisational

performance and engineered systems. It is an idea that has resonated in popular culture. For example, Zolli and Healy's *Resilience*: *Why Things Bounce Back* (2012) drew the public's attention to the concept of resilience as a way of understanding the global economy. The book provides a narrative of how major, complex systems work, promoting resilience as a useful concept for shaping organisational and development decisions. More recently, Rodin (2014), President of the Rockefeller Foundation, authored *The Resilience Dividend*: *Being Strong in a World Where Things go Wrong*. Rodin focuses on cities and government, providing stories from around the world on how communities have responded to disruption. There are also a growing range of more formalised processes for resilience assessments described in academic literature. For example, Longstaff et al. (2010) discuss a framework of assessment for building resilience of communities, addressing resilience in terms of core attributes in a community system. Their framework (outlined in Fig. 1a) establishes a community model of resilience that involves an analysis of resources available to a community (to determine robustness of the community) and the ability of the community to utilise them (to determine the adaptive capacity of a community). Longstaff et al. outline what communities might theoretically consider in a self-assessment for resilience. As a comparison, Chang et al. (2014) also express an interest in community resilience, but their approach involves analysing the infrastructure systems that support communities. Through a case study, they collect expert opinions to determine potential disruptions and interdependences in infrastructure services, based on various hazard scenarios. Resilience here is essentially represented in terms of classifying service disruption interdependencies between infrastructure networks (see Fig. 1b).

Various forms of 'resilience assessments', such as in the examples outlined above, are emerging in abundance to help prioritise investment in ecosystems,

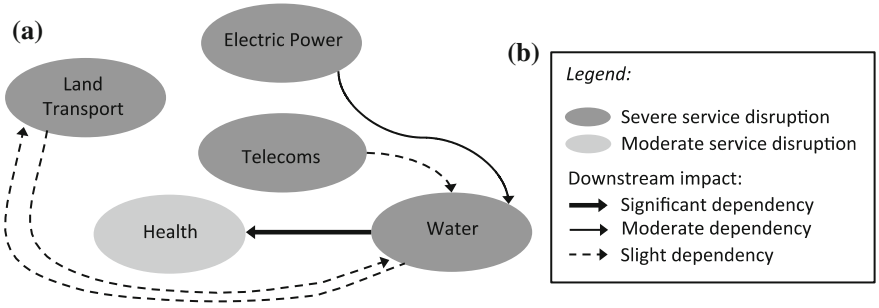

Fig. 1 Comparison of interpretations of resilience in DRM: **a** a general framework for community resilience reproduced from Longstaff et al. (2010) and **b** a model of infrastructure interdependencies produced in Vancouver case study showing expected service disruption immediately after an earthquake, reproduced from Chang et al. (2014). For simplicity, this diagram is only a partial reproduction, highlighting the immediate dependencies associated with water infrastructure only

cities, infrastructure and communities. Some commentators (such as Manyena 2006) highlight the risk that the term "resilience" can lack substance rather than be a useful concept. Nearly a decade on, Manyena's sentiments remain understandable, as there is not a basis for finding common ground between different analyses of resilience. However despite differing interpretations, resilience is proving to be a useful concept in which to define a problem and frame appropriate solutions.

Given the broad application of resilience, we sought a way to systematically understand how different applications correlated within the broader context of DRM. DRM involves a range of different actors with different priorities and interests. These actors will naturally construct different meanings or realities when given the same information (as discussed by Fischer 2003 in relation to public policy), each following their own "internal logic" (Aldunce et al. 2014 p. 261).[5] The intent of our framework is to recognise sector-specific and trans-disciplinary applications of resilience within DRM. The framework does not provide a new interpretation of resilience, but captures how resilience is applied in different ways, understanding boundaries around specific interpretations and how better connections may be made across different disciplines.

An initial version of the framework was first published as a conference paper at the *4th International Conference on Building Resilience* in 2014 (MacAskill and Guthrie 2014).[6] The structure of the framework emerged through an adaptation of a linguistic study that examined the changing meaning of a concept over time and through culture. In the study, different definitions of the same concept were displayed in a simple sunburst-style diagram as a way of showing categories of interpretation in a multi-level, radial format. For resilience, we found there were not just different conceptions of the term, but a number of key themes or categories that give shape to any interpretation of resilience. Thus, we set out to identify key differences in application as a way of developing the main categories. These categories were established through an iterative literature review covering a range of texts focused on resilience in DRM. This has been an inductive, iterative process and the framework shown Fig. 2 is a refined version of our initial published framework, where we have made adjustments based on feedback and further review.

Essentially, Fig. 2 catalogues various conceptions of resilience, grouped under broader themes. The first level of definition highlights two main aspects that shape any interpretation—context and application.

[5]Perceptions of different groups of people is also discussed in Duijnhoven and Neef's chaper in this book on "disentangling wicked problems".

[6]This conference bought together practitioners and academics to explore the concept of resilience as a framework for analysis of how society can cope with the threat of hazards.

Fig. 2 A conceptual framework for defining resilience in DRM (updated from MacAskill and Guthrie 2014)

Context factors describe the environment in which resilience is applied. The environment may influence what categories within the application theme are emphasised. The *societal* factor refers to the level of economic development of the location. This is represented by a basic distinction between *developed* and *developing* countries, where developed countries typically have more stable institutions, greater access to capital and higher levels of technological sophistication in the structure of urban areas. The *scale* indicates a focus on the *community*, *city*, or *nation/state* scale, where the scale can have an impact on perspective and nature of an analysis. *Threat* describes the stimuli for considering resilience, where responses to acute shock such as a hurricane or an earthquake are markedly different than planning to mitigate impacts of chronic stress such as climate change. Different areas are exposed to different threats, thus the nature of focus of what communities are seeking to be resilient *to* will change. This may have an impact on what perspectives or objects of resilience are prioritised.

The *application* theme describes the nature of the analysis in terms of the system or network under consideration. The *perspective* category defines the type of system that forms the focus of assessment, which may be related to: the development of *infrastructure/urban structure*; *organisational* performance; *institutional* arrangements that set the overarching political and economic framework; or more of a *social* focus, concerned with capabilities and resources available to communities. This relates to United Nations Office for Disaster Risk Reduction's definition of resilience, which emphasises a similar multiplicity of perspective in terms of what is exposed to a hazard, where resilience is described as:

> The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions
>
> United Nations Office for Disaster Risk Reduction (2009, p. 24)

The *object* describes the mode of resilience, that is, way or manner in which resilience is taking place. This may be by way of *governance* (which tends to be associated with a decision process), a measure of a *system* or a *component* property that supports the preservation or restoration of basic structures or functions. The idea of governance in resilience is the most unusual interpretation in terms of the more literal understanding of resilience as a quality or property *of* something. However the role of governance, institutions and the ability to gather knowledge and learn has become part of a broader understanding of how resilience is achieved. These factors form a critical part of the ability of systems to recover. As such, they were recognised in the Hyogo Framework for Action, where one of the five priorities was to: "Use knowledge, innovation and education to build a culture of safety and resilience at all levels." That is, the process of governing a system has become a representation of the system's resilience. As another example, Park et al. (2013) describe resilience as an approach to the design and development of engineering systems that requires a recursive cycle of sensing, adaptation, anticipation and learning. They maintain Hollnagel et al.'s (2011) view that resilience of an engineered system is informed by expert knowledge and judgement, rather than through an analytic analysis. This view is supported by other authors such as Olsson et al. (2006), who describe adaptive governance for social-ecological systems, and Davoudi (2012) who reinforces that system governance is an essential part of the scope of a resilience, which is a dynamic concept that spans scale and time.

While governance for resilience is coming into significant focus, physical and system properties are still relevant. Park et al. (2013, p. 4) argue against this, suggesting that resilience is not a "static property of state" but an "ongoing adaptive *process*". However to claim that physical property does not contribute to resilience of a system is to ignore part of the broader understanding of resilience. Indeed, a reference to the basic definitions of resilience demonstrates this. The Oxford English Dictionary provides definitions for both literal applications and figurative uses. Literal applications define resilience as the action or act of rebounding and the property of elasticity or ability to absorb energy. Figurative uses include some obsolete or rare interpretations such as "going back upon one's word", an instance of recoiling from something or a representation of antagonism. The final figurative definition outlines resilience in a way that is more fitting to much of our discussion thus far, that is:

> The quality or fact of being able to recover quickly or easily from, or resist being affected by, a misfortune, shock, illness, etc.; robustness; adaptability.
>
> OED Online. December 2014.

Both the literal interpretations and the figurative usage do not exclude the idea of resilience as a property of state. This is reflected in the United Nations Office for Disaster Risk Reduction's outline for a holistic approach to resilience that embraces both structural and non-structural measures in the *application* of resilience:

> **Structural measures**: Any physical construction to reduce or avoid possible impacts of hazards, or application of engineering techniques to achieve hazard resistance and resilience in structures or systems.
> **Non-structural measures**: Any measure not involving physical construction that uses knowledge, practice or agreement to reduce risks and impacts, in particular through policies and laws, public awareness raising, training and education.
> United Nations Office for Disaster Risk Reduction (2009 p. 28)

However, such broad coverage typically only appears in the form of international or national policy frameworks (such as in the goals in the Hyogo or Sendai Frameworks). Applications closer to planning and implementation tend to be narrower in scope, focusing in on a specific selection of measures. Such as (using our previous example) in Park et al. (2013), who describe approaches to catastrophe management in engineering systems. Their focus is very much on the governance of physical infrastructure through processes associated with design and management. They pointedly do not address resilience as a physical property, taking a view that resilience lies in the process of governance. They also do not discuss community resilience. Chang et al. (2014) also focus on infrastructure systems (their approach was previously shown in Fig. 1), but take a broader view of governance, system and physical properties of resilience, addressing system interdependencies in service disruption. By way of contrast, Allan and Bryant (2014) look at resilience in urban theory—analysing the system properties of urban environments and how communities interact within these environments in a recovery situation. These examples are just a small selection from recent literature, but represent a wider trend where resilience is used as a concept for analysing system performance. We are not criticising the authors of these works for taking a sector specific view. In fact, we have yet to find a paper that analyses the full spectrum of categories associated with the *application* segment of the resilience framework. There is a higher level of complexity associated with attempting to cover all perspectives in one analysis, to the point where it compromises the ability to come to meaningful conclusions. However, the key point is that each interpretation needs to be made with an awareness of the broader context of resilience in DRM. The purpose of our framework is not to place different interpretations at odds, but to discover how these interpretations may be complementary or where there are potential points of divergence that need to be addressed in any approach to building resilience.

We also do not propose that the framework provides definitive way to categorise resilience. While the diagram implies definite categories, the reality is the boundaries are fuzzy. We have ourselves adapted it over time as our thoughts developed around how to best represent various categories and to better capture differences in use. Our aim was to keep the framework simple enough that it is accessible as a quick reference, but with enough detail that it acts as a useful and constructive tool

for understanding how sector-specific interpretations lie within broader considerations of resilience.

While the framework identifies different systems and types of resilience (the "what"), it does not go as far as highlighting measures (the "how")—i.e. it does not describe measures or metrics of resilience, which may be entirely sector specific. In terms of reconstruction for example, it is difficult to define exactly how building resilience should (or could) be incorporated into the process. It is not just a matter of the cost involved in building back better, but the time needed to understand the impacts and consult on alternative options, all while considering context-specific factors. It is possible that methods associated with "how" to build in resilience could form another layer in the hierarchy. This relates to both methods of implementation and capacity or willingness to ultimately implement the required action. This however, adds another layer of complexity and the framework has value in simply highlighting different perspectives, as will be demonstrated in the Christchurch case study.

4 Post-earthquake Reconstruction in Christchurch New Zealand

The resilience framework is broadly applicable to all phases of DRM but it is longer-term recovery to which we pay particular attention in this section. The following analysis of post-earthquake reconstruction in Christchurch demonstrates how the framework can be useful in shaping insights into the complexity of a multi-sector process. To provide some context, we will briefly introduce the institutional environment for DRM in New Zealand. We will then move into a more detailed analysis of the recovery process currently underway in Christchurch—the second largest city in the country with a population of approximately 370,000 (see Fig. 3 for a simple map of New Zealand, locating Christchurch). We discuss the recovery in terms of different perspectives in the resilience framework, with a focus on the recovery of publically owned and operated infrastructure networks—roads, stormwater, wastewater and water supply. This study of Christchurch is informed by a broader research project involving a longitudinal study of infrastructure network recovery in New Zealand. The research involves interviews with engineers and executives leading the reconstruction in Christchurch, supported by a range of documentation such as design reports, recovery plans and government reviews.

We have completed a similar analysis for a special issue journal on resilience for Elsevier's Civil Engineering and Environmental Systems (MacAskill and Guthrie 2015). However, this earlier paper focuses on a range of interventions associated with resilience in infrastructure recovery, that is, "how" resilience has been integrated into the infrastructure networks during reconstruction. While we borrow some examples from this earlier paper, we are more concerned here with the broader interpretation of resilience in DRM and how the institutional and

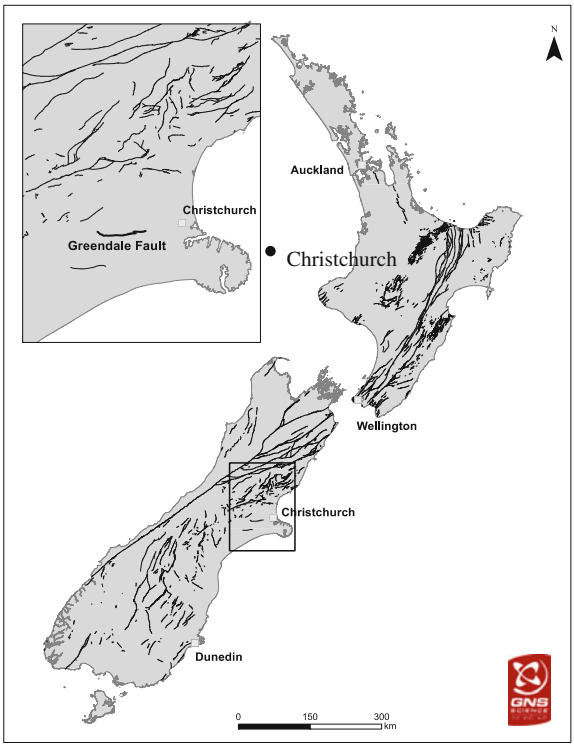

Fig. 3 Map of New Zealand indicating active faults. New Zealand is a geologically active country, sitting on the boundary between the Australian and Pacific plate. The Greendale Fault (see inset) was the major cause of the September 2010 earthquake in Canterbury. See www.gns.cri.nz for a more detailed analysis. Map courtesy of William Ries, GNS

organisational arrangements facilitate or prevent a holistic approach to a "Resilient Recovery" (GFDRR 2014a) in Christchurch. We maintain a focus on the restoration of infrastructure services, but with more emphasis on how infrastructure recovery sits within the wider recovery arrangements in Christchurch.

4.1 Institutional Context

New Zealand operates through two main tiers of government—central/national government and local government. There are then two parts to local government: regional councils are responsible for managing regional concerns such as water management, land transport and civil defence; district and city councils are responsible for the general well-being of the local communities and provision of infrastructure services.

A National Civil Defence Emergency Management (CDEM) strategy sets the strategic direction for hazard management across the country (Government of New Zealand 2013). The strategy is guided by an integrated approach to CDEM that addresses the lifecycle of DRM through what is known in the industry as the '4Rs':

reduction, readiness, response and recovery. The associated CDEM 2002 Act does not provide a prescriptive guide to recovery; it only requires councils and CDEM groups to facilitate recovery. As will be explained shortly, the nature of the recovery arrangements in Christchurch changed quite dramatically in a flexible response to different scales of damage.

From 2010 to 2011, the Canterbury region of New Zealand experienced a sequence of earthquakes. Amongst thousands of earthquakes recorded in this sequence were several major events that caused significant damage in Christchurch and the surrounding Canterbury region. The first major earthquake occurred in September 2010 with a magnitude of 7.1, centred approximately 40 km from Christchurch. The most damaging event occurred in February 2011 with a magnitude 6.3, located only 5 km from the city centre. This event resulted in 185 deaths (the only event in the sequence where there was loss of life) and damaged most of the buildings in Christchurch's central business district. While many of the buildings survived the earthquake, they were damaged beyond economical repair and have subsequently been deconstructed. There was also extensive damage in residential areas and infrastructure services across the city. Some areas experienced loss of water supply and wastewater reticulation along with severe damage to transport networks; it is the recovery of these infrastructure services that forms the focus of this case study.

Following the first earthquake in September 2010, Christchurch City Council set up an Infrastructure Recovery Management Office (IRMO). The key role of IRMO was to administer the overall programme management for reinstating services provided by roads, water supply, wastewater and stormwater. The repairs were to be completed through four separate design-build contracts with companies that specialise in civil construction. Each company was allocated a specific area of the city to repair. Progress under these contracts was just starting to gain momentum when the second major earthquake occurred in February 2011, just five months after the first event.[7] The larger scale of damage caused by this event called for a more integrated, city-wide approach to repair, where division of the city through four separate contracts was no longer an effective or efficient means for coordinating the recovery (more detail regarding the IRMO arrangements is provided in Office of the Auditor General's (OAG) report, 2012).

This led to the creation of an alliance organisation, SCIRT, under which the original design-build contracts were transferred into an alliance arrangement. An alliance contract is a collaborative arrangement where contract participants (the owner-participants and the service providers) work together as a team in a temporary or virtual organisation, with joint responsibility over project risks. It is worthwhile highlighting here that the alliance arrangement had not been a pre-determined concept for disaster recovery in New Zealand. It emerged as a result of a complexity of factors, where: alliance arrangements had been successfully used

[7]It is worth noting that the February earthquake generated unexpectedly strong ground movements relative to the magnitude of the earthquake.

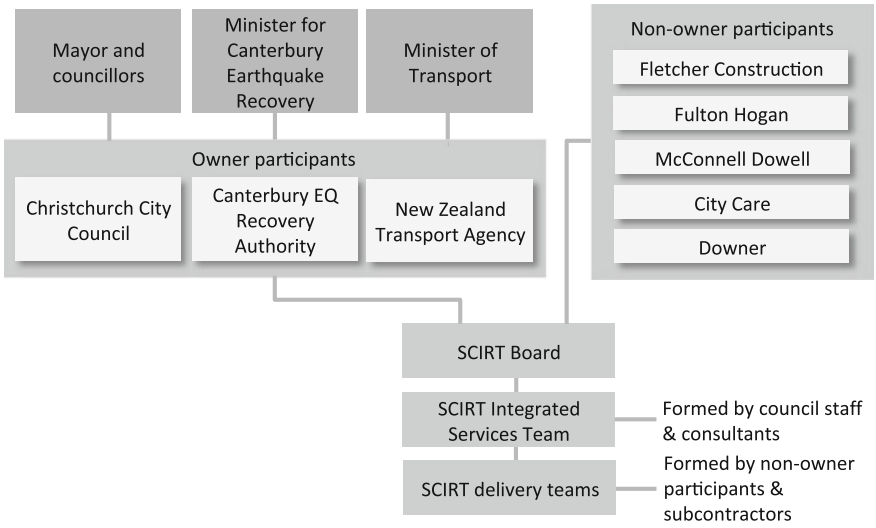

Fig. 4 Organisational arrangements at SCIRT (see OAG 2013 for a more detailed diagram)

on large projects in New Zealand; key leaders had prior experience in alliancing; and, there was no prescriptive policy on how recovery is to be managed. There was also an opportunity to develop an innovative arrangement while the existing IRMO arrangement continued to manage repairs—SCIRT was not formally established until September 2011. Christchurch City Council became a main client of SCIRT, with some council staff directly seconded into the alliance. SCIRT's work covers 85 % of the infrastructure rebuild in the city, with the remaining work covered by the Christchurch City Council's in-house operations (as outlined in the Stronger Christchurch Infrastructure Rebuild Plan, 2011). The estimated figures for the rebuild are in the order of $NZ 2 Billion.[8] The general organisational arrangements are outlined in Fig. 4. SCIRT has a five-year contract that is due for completion in 2016. As of January 2015, the reconstruction of the infrastructure networks was about 60 % complete.

4.2 Integrating Resilience into Infrastructure Recovery

SCIRT's primary focus is on restoring infrastructure services. A guiding document, the *Infrastructure Recovery Technical Standards and Guidelines* (IRTSG), was

[8]For a rough comparison $NZ 1 is approximately $US 0.84 (12 month rolling average to December 2014). Note the mid-month rate for December 2014 was $US 0.77.

developed as to provide scope and context to the repair and reconstruction process. This document specifies the primary objective of SCIRT, which is

> To return the infrastructure networks to a condition that meets the levels of service prior to the 4 September 2010 earthquake within the timing constraints of the rebuild.

This is supported by a secondary objective:

> Where restoration work is undertaken, and where reasonably possible and economically efficient and viable, greater resilience is to be incorporated into the network.

The critical element for discussion here is the IRTSG definition of resilience:

> **Resilience:** the ability of a system to withstand or quickly recover from significant disruption. The important concepts are as follows:
>
> - Service interruptions are expected
> - Quick restoration of service is required
> - Infrastructure networks must be robust
> - Infrastructure networks must be flexible
>
> **Resilience Measures** include additional components to ensure that modern materials can withstand, or quickly recover from, significant hazards or disruption. This includes network system components for the same purpose, beyond a standard modern design and may include additional levels of redundancy and network connectivity.
> SCIRT IRTSG (2013)

Clearly, resilience forms a key part of the decisions around restoration or repair in Christchurch, but it is inevitably a sector-specific perspective. In terms of the day-to-day business in SCIRT, resilience is defined as a concept that addresses the physical and system properties of the infrastructure networks. Figure 5 demonstrates this application of resilience in the framework.

The IRTSG definition guides the integration of resilience principles for reinstating infrastructure services through interventions in *component* and *system* properties. Enhanced infrastructure resilience may be through the use of modern materials and design standards. Greater strength (such as ground reinforcement and improved structural design) and flexibility (such as the use of flexible plastic materials in piping) are often inherent in the use of modern materials. Also, some standard design details were adjusted in Christchurch to help vulnerable points in the systems better withstand earthquake damage. These changes in *components* are the most widely applied means of increasing resilience. Also, designs for the worst affected areas have involved some significant changes in *system* properties. These are areas where the level of damage justified complete reconstruction of the infrastructure assets, rather than more patch-type repair. One such change has been the introduction of pressure sewer technology in some locations. Engineers at SCIRT judged that pressure sewer technology would be better able to withstand earthquake damage compared to the existing gravity-fed systems (reliant on relatively low grades to carry wastewater towards the treatment plant), which sustained complete loss of service in some areas. This is because gravity-fed systems are vulnerable to land movement and differential settlement associated with earthquakes; without sufficient pipe gradient in the right direction, these systems fail to

Fig. 5 Interpretation resilience at SCIRT: Resilience in the recovery of Christchurch's infrastructure. Our analysis here is focused on the post-earthquake context, following a rapid-onset natural disaster that had city-wide impact. Key aspects of resilience in this case are emphasized in *dark grey*

operate. Significant system changes also included relocation of wastewater pump stations away from ground vulnerable to liquefaction, reducing the risk of structural damage in a future earthquake.

There have also been major *urban structure* interventions in Christchurch that impact the reinstatement of infrastructure networks. A Residential Red Zone was created in particularly liquefaction-prone or rock-fall-prone areas of land. The red zone has effectively become areas of interim retreat, with no clear plan regarding future land use. Given this uncertainty, reconstruction of infrastructure has been avoided, where possible, in these areas. While avoiding vulnerable ground could assist in providing infrastructure system resilience, decisions regarding land use were made at a national and political level. SCIRT responded to these decisions through the design process, but the major decision directing this response was beyond the organisation's remit and is thus not clearly reflected in the organisation's definition of resilience.[9]

This leads us to the challenges in organisational, technical and financial arrangements of the infrastructure rebuild in Christchurch that influence how much resilience may be added to the systems. We discuss several of these points in MacAskill and Guthrie (2015). Firstly, there is marginal utility in paying for interventions and a subsequent differential investment in networks, where some resilience interventions are more cost effective than others. Also, the fixed scope of work of an organisation and the level of autonomy the organisation has over

[9]All these examples regarding physical, system and land use intervention are discussed in greater detail in MacAskill and Guthrie (2015).

decisions will impact on the feasibility of possible interventions for resilience. There is also a matter of scale, where it is only the result of considerable damage where extensive, systemic intervention is justified. Finally, financing arrangements have significant impact, not just in terms of the amount of funding available but also because there are restrictions on what funds can be used for. For example, insurance policies are typically structured around the concept of like-for-like replacement.

While the sector-specific interpretation of resilience at SCIRT reduces some of the complexity surrounding recovery decisions, complexity remained in determining exactly what introducing resilience meant in reality. SCIRT is an engineering-based organisation that operates on the basis of a technical interpretation of resilience. Resilience assessment at SCIRT is aimed at informing design decisions for the reconstruction of infrastructure. However, despite this relatively narrow perspective (compared to all perspectives in the resilience framework), resilience is just one factor in the design process, evaluated alongside other technical and financial considerations. There is an important qualification in SCIRT's objectives in that resilience is introduced "where reasonably possible and economically efficient and viable". This fuzziness is also reflected in the United Nation's definition which describes recovery as the "restoration, and improvement *where appropriate*, of facilities, livelihoods and living conditions of disaster-affected communities, including efforts to reduce disaster risk" (United Nations Office for Disaster Risk Reduction 2009 p. 23, emphasis ours). Initially, determining an "appropriate" solution for damaged infrastructure was not completely clear in Christchurch. Designing infrastructure repairs involved a process of testing boundaries of the guidelines on a case-by-case basis. This process was formalised through a "Scope and Standards" committee, whereby client representatives would consider: what level of intervention was appropriate, where extra funds should be spent and what precedents might set for projects scheduled later in the programme.

Complexity also remains in the fact that infrastructure networks are inherently linked to the community, where a technical or infrastructure-oriented perspective of recovery will not be successful without acknowledging potential social impact or the needs and desires of the community. This is discussed in the following sections on linking the infrastructure reconstruction to the broader recovery and identifying where there is potential to create stronger links across perspectives of resilience.

4.3 Linking to the Wider Recovery

Despite a clear focus on the technical features of infrastructure resilience in recovery, it is recognised within SCIRT that infrastructure reconstruction does not occur in isolation of the wider community. In fact, SCIRT's core goal to create "resilient infrastructure that gives people security and confidence in the future of Christchurch" recognises that the infrastructure exists in order to serve the community.

Through interviews with staff at SCIRT, we identified two major factors that create a link between the infrastructure recovery facilitated by SCIRT and the wider community. The first relates to the overall prioritisation of the city-wide programme of repair over SCIRT's five-year contract. This programme was developed in coordination with staff at the Canterbury Earthquake Recovery Authority (CERA—one of SCIRT's owner participants), which gathered stakeholder views on the infrastructure rebuild in the context of the wider recovery. Consultation with representatives from groups concerned with issues such as economic development and social well-being brought to attention the factors of the wider community recovery that may be impacted by choices in prioritisation of suburbs. Such concerns were considered alongside the more traditional technical considerations of asset managers relating to operational priorities and network interdependencies. Generally, work in the worst affected areas was prioritised, which were often areas comprising more vulnerable communities.

The second factor is the nature of the communication strategy with the community throughout the rebuild programme. A communications team at SCIRT keeps Christchurch residents informed of infrastructure work in their community and across the city. We report here on some reflections from representatives of this team on the process of communication in recovery.

Initially, communities were generally accepting that the earthquakes had created a situation where disruptive repair work was necessary. However, tolerance levels declined over time with no clear ramp-up or ramp-down in construction work. There was a risk of 'consultation fatigue', a phenomenon recognised in attempts to create more participatory processes to policy-oriented decision-making. In light of this, the communications team recognised that sending more communication notices did not necessarily lead to a better informed community who will be more accepting of ongoing construction work. The team also learnt that even though a notice of work may have been delivered, the message might not have been completely received, understood or accepted. When it came to face-to-face discussions with the community in particularly vulnerable or badly affected areas, team members learnt to allocate extra time. This allowed time for residents to express frustrations surrounding the wider recovery process and to develop rapport before attempting to discuss infrastructure repairs in the area. The communication process was also not just about informing residents, but also creating transparency in the process through education. This included campaigns to explain what infrastructure services/utilities run through a road corridor and the process for repair for each service, or to explain why a different style of wastewater system is proposed for certain areas of the city.

These examples help to demonstrate the connections between the more technical aspects of the infrastructure reconstruction and the wider community recovery (Fig. 6). However, finding the right balance proved to be a difficult task. In terms of community involvement in decisions, typically, only an "inform" approach is

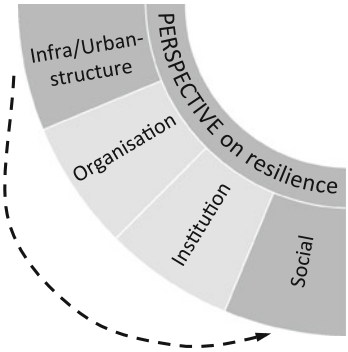

Fig. 6 Linking infrastructure recovery with a more social perspective

required where the recovery involves replacing assets that already existed.[10] This approach formed the basis of a lot of the communication programme at SCIRT. However, introducing change that has a tangible affect on the community requires gaining acceptance of affected parties through consultation. The Local Government Act 2002 provides guidance on requirements for consultation however the choice of appropriate method is a discretionary judgment and obligation to consult is dependent on the matters of significance. Contention over a particular case of infrastructure recovery in Christchurch led to a High Court hearing.[11] In Bailey versus Christchurch City Council (2013), a local resident challenged the legitimacy of Council's plans to introduce pressure sewer systems as a means of reinstating wastewater services in some Christchurch communities. The argument was essentially over the need for putting pumps on private property, which had not been part of the existing (but badly damaged) system. This required connecting the pumps to private dwelling electricity supply. The judge ruled that the Council failed to adequately consult when introducing new wastewater technology as a recovery solution. The judge found error in the decision not to consult with residents on the need to place pumps within private property boundaries, where the Council placed emphasis on the technical aspects of system performance without appropriate consideration of the potential social impact of the decision. This judgement reinforces that even during the time-constrained pressure of post-disaster recovery, there is a need to recognize that different perspectives among stakeholders will affect perception of priorities. In this case, there was conflict over the direct impact on private property versus reduction in risk of system damage in the future.

[10]See Arnstein (1969) for discussion on the "ladder of citizen participation". The "inform" level is at the lower end of participation in decision-making, where residents are informed of decisions, rather than actively participating in them.

[11]The High Court is mid-level court in New Zealand. It sits above the District Court below the Court of Appeal and the Supreme Court. It tends to deal the most serious criminal offences and civil cases that are beyond the jurisdiction of the District Court.

4.4 Potential for Stronger Links Across Perspectives?

SCIRT's mandated role and objectives in Christchurch's recovery is unmistakably oriented towards the rebuild of infrastructure networks. The definition of resilience in the technical guidelines is expressed in terms of the physical and system resilience of these networks. However, there is also clear consideration of how actions associated with the reconstruction of infrastructure would impact on the community, managed through a major communications process. This required certain judgments to be made about appropriate levels of communication with the community, which were not always fully supported by all affected parties. This is in part due to the strong technical framing of resilience within SCIRT, but also due to lack of clear understanding as to how business as usual consultation processes may be affected in a post-disaster context. There was a perceived need at Council to fast-track infrastructure reconstruction projects, but this came into contention with requirements for consultation. This is an issue that spans a range of contexts in post-disaster recovery, as highlighted in one of the GFDRR case studies supporting the guide to recovery:

> The post-Sidr experience [in Bangladesh] has demonstrated that design and construction processes are largely driven by experts and engineers with limited community involvement. Owner-driven construction, on the other hand, is often perceived to be time consuming and difficult to implement in a deadline-driven situation. Although the use of private contractors is a feasible option, there is a need to strengthen communication between the private sector and humanitarian actors.
> GFDRR (2014c)

While humanitarian involvement is not a significant feature in the recovery of Christchurch, appropriate levels of community involvement in recovery decisions remains a contentious point. The High Court case highlighted inadequacies in the Council's focus on technical factors in their decision-making. While this approach ultimately meant the Council failed to execute due process according to its statutory obligations, this was done with the intention of a good outcome for the community, where the aim was to:

> …build stronger systems, better able to withstand any future earthquakes. Many thousands of residents were left without functioning toilets for several months because of significant earthquake damage to the system.
>
> We went through a thorough process to determine the best system for different areas of the city. In some areas, we concluded that the gravity system was not damaged enough to require replacement; in others we are introducing new pressure or vacuum sewers to make the system stronger…
>
> Terry Howes, Council's City Environment Acting General Manager, quoted in Christchurch City Council 2013

This quote demonstrates how the Council looked for a long-term solution for the community, where a stronger system would reduce the risk of loss of service to residents. However, this perspective of a "stronger" system was in contention with community concerns. This conflict resulting from a divergence in perspective

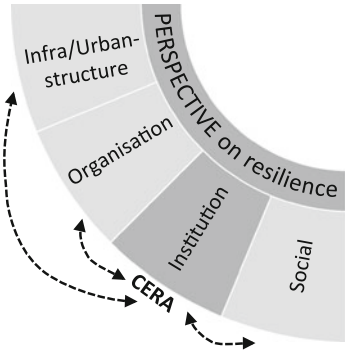

Fig. 7 CERA is the leading agency for the recovery effort in Canterbury (the wider region encompassing Christchurch). CERA administers the Canterbury Earthquake Recovery Act and works with other Councils, Te Rūnanga o Ngāi Tahu (the local Maori tribal council) and engages with the local communities, private and business sector to coordinate across the range of perspectives in recovery

ultimately led to the Council rescinding its decision to install pressure sewer systems. This has been followed by further consultation and a feasibility study of installing pumps in council-owned land, slowing the intended programme for reconstruction in these areas. This example confirms ideas raised earlier regarding different actors having their "own internal logic" regarding what is important and that there is a need to find ways to negotiate across different perspectives (Aldunce et al. 2014).

In terms of the broader recovery of the region, development of organisational and community resilience fall under the responsibilities of other organisations, overseen and coordinated by CERA (see Fig. 7). The relationship between CERA and other organisations involved in recovery is critical in achieving an integrated *application* of resilience in the process. However, these relationships have proved to be fractured and difficult to maintain. In 2013 an official review by the Office of the Auditor General (OAG) in New Zealand highlighted two main risks to the delivery of the infrastructure rebuild programme—lack of the CERA's engagement in the programme and lack of agreement over the exact nature of the scope of work. We will concentrate here on the first risk, where CERA's absence of engagement created uncertainty in the strategic leadership of the SCIRT alliance. This was due to lack of clarity around clear objectives and roles in leading the rebuild programme and an apparent lack of commitment from CERA to the infrastructure rebuild, where staff turnover and restructuring impeded development of a working relationship. The OAG report clearly stated that CERA "needs to facilitate better connections between SCIRT and other government agencies to better integrate the horizontal infrastructure with the rest of the Canterbury recovery" (para. 5.6). This issue was subsequently addressed, but there has been continued uncertainty over financial arrangements. For example, a cost-sharing agreement between the national and local government was signed in mid-2013, setting out funding commitments.

This agreement included a clause that allowed for future review, however different views remained amongst owner-participants in the alliance as to what this review would entail.

5 Conclusion

In this chapter, we have presented a framework that provides a means of placing different perspectives of resilience within a broader classification of resilience in DRM. An essential element of the framework is to demonstrate that a holistic approach to resilience in DRM addresses a range of perspectives covering infrastructure/urban structure, organisations, institutional arrangements and social considerations. The reality is that approaches to addressing resilience are often more limited in application, but they need to be considered within this broader context.

To demonstrate the merit of the framework, we used it as a basis for critiquing the post-earthquake recovery in Christchurch. We discussed how a technical, infrastructure-specific interpretation of resilience shaped decision making for reconstruction of infrastructure networks. This technical framing provided a clear basis on which to consider resilience in restoring infrastructure services. However, while engineers tend to treat infrastructure design as a technical process, infrastructure exists to provide services to the community. A purely technical interpretation of resilience focused on physical attributes of the infrastructure network itself will ultimately present shortfalls in implementing a successful recovery, which requires a broader, more integrated approach.

Despite an infrastructure-specific definition of resilience, infrastructure recovery goals in Christchurch were based on an awareness that infrastructure exists for the community and that the city-wide programme of infrastructure repair has a significant impact on residents. While an extensive consultation programme was in place, key decisions did not always achieve the right balance between technical rigour and consideration of community perspectives. Furthermore, competing perspectives within the governance of the infrastructure reconstruction have challenged the delivery of infrastructure reconstruction programme.

Such issues emerged through examining not just the basic arrangements of the recovery process, but a finer level of detail in terms of how certain perspectives influence the decision making process. The resilience framework provided a means of understanding the trade-offs that were made in integrating resilience in reconstruction and sources of conflict along the way. Insights gained from examining the Christchurch case demonstrate the usefulness of the resilience framework in understanding the role of resilience in DRM.

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