TEPHRA
KIA TAKATU TAHI TATOU
July 2009 • Volume 22

Community Resilience:

research, planning and civil defence emergency management

Te Rākau Whakamarumaru
Ministry of Civil Defence & Emergency Management

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Volume 22, July 2009

ISSN 0112-1359

Published by the Ministry of Civil Defence & Emergency Management

Cover illustration: Dean Gray Illustration

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Page layout: Byword Pacific Limited

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Tephra: *n.* fragmented rock, ash etc ejected by a volcanic eruption [from the Greek word for ash]. *Concise Oxford Dictionary*.

New Zealand Government

Community Resilience:

Research, planning and civil defence emergency management

TEPHRA
Volume 22

Contents

Director's Foreword

Welcome to our relaunch of *Tephra* as the Ministry's science and education publication. Our aim is to provide a professional publication with each edition addressing one civil defence emergency management (CDEM) topic in some detail.

In a modern society we live in a complex network of natural, social, economic and built environments. Failure in one place can have surprising, and potentially disastrous, consequences in others. Our objective of safer, more resilient communities can be achieved only by drawing together knowledge and expertise from across all the environments in which we live.

This issue explores important links between disciplines that have at times been uncomfortable bedfellows: science, policy, planning, and their application in CDEM.

Effective risk management involves integrating research, policy, planning, and operations, and doing that across many disciplines. That includes geological, water and atmospheric sciences; understanding how people behave; how best to build cities, towns and infrastructure; and knowledge of the formal and informal systems and interconnections that make up a community.

Tephra is intended to be a source of ideas and a reference for scientists, engineers, policy makers, planners, managers and CDEM professionals. These are people working as researchers, consultants, advisers and decision makers in all levels of local, regional, and central government, and, where applicable, in the private sector. We hope that the ideas and information presented here are useful, important and interesting, and that *Tephra* will help provide contacts and links between people and organisations and contribute to the generation of more resilient communities.

Thank you to all those who have contributed articles and supported the publishing of *Tephra*. Without the commitment of the authors and their organisations this publication would not be possible. I encourage you to take time to read and think about the ideas presented here and to not hesitate to discuss them with colleagues and the authors.

John Hamilton
Director

CDEM, Integrated Planning and Resilience

What is the connection?

Dr Ljubica Mamula-Seadon
Ministry of Civil Defence & Emergency Management

INTRODUCTION

This issue of *Tephra* is dedicated to community resilience, integrated planning and research related to these disciplines. Most papers discuss the state of practice and propose strategies, methods and tools for implementation of integrated solutions that lead to resilience.

This paper aspires to provide a context for the topic by introducing a theoretical background to the link between integrated planning and resilience, and by pointing out how the issues and solutions are addressed in the papers that comprise this journal.

At the close of the 20th century "risk, not technological optimism, has become a dominant cultural theme".

CHANGING RISKSCAPE

"At the close of the century, risk, not technological optimism, has become a dominant cultural theme." This statement from Jaeger and others (2001) succinctly defines the tone that many believe echoes global consciousness today. Social theorists of the 1990s argued that the world is witnessing an unprecedented change in social and institutional structures, so much so that it is transformed into a "new social world" (Beck, 1992). Risk is seen as the core component of this new social order. "*The spirit of our age is the universal concern with hazards in the contemporary world, the vulnerability of the environment, and the human species itself*" (Jaeger et al., 2001). The effects of natural hazards and global changes such as nuclear and chemical disasters and related pollution, water pollution and scarcity, deforestation, climate change, genetic modification, terrorism and others are widely publicised, and often politicised. At the same time, the globalised interdependences of production, consumption and geopolitical arrangements mean that people everywhere are coming to share common sets of risks.

This changing 'riskscape' demands analytical tools that will adequately anticipate the consequences of hazards on the physical and human environment. In Western countries this takes place in the context of ever-increasing complexity of social and environmental problems. It is also accompanied by a groundswell of civic movements promoting participatory democracy and devolution of powers and responsibilities to local communities.

Central to the political debate surrounding the issue of risk and society has been the notion of the *public interest* and the way different approaches view it. It is this recognition of the public interest that has led, in part, to the concept of 'sustainable development', and its relationship with environmental risk management, including emergency management. The associations between the concept of sustainability, its expression in sustainable development, and the influence its theories and practice had on the development of environmental risk management practice have resulted in profound changes in the practice of emergency management.

SUSTAINABILITY, INTEGRATED PLANNING AND RESILIENCE

The terminology that has emerged around sustainability has resulted in a large number of definitions and related debate. It is not intended to examine this in its broadest scope, apart from acknowledging that, at its simplest, sustainability is about the relationship between providing for current generations while protecting the interests of future generations (WCED, 1987). Efforts to define sustainability have typically stressed the principles of support, persistence, balance, and, most importantly, ***resilience*** (Mazmanian and Kraft, 1999).

When discussing sustainability, it is helpful to note that there has been much dispute about the meaning and implications of the concept, and also much criticism of the actual behaviour of bodies who have claimed devotion to it. Gradually, however, some basic characteristics of sustainable development embracing public and environmental wellbeing have become clear. In researching numerous sustainability programmes in developed nations, it becomes obvious that the designs of these programmes incorporate *five key dimensions* of planning and intergovernmental implementation theories, as shown in Table 1.

Integrating this mix of dimensions has meant that new sustainability initiatives retain, and perhaps increase, the planning complexities that were problematic under earlier regulatory mandates. However, since the 1992 Rio Earth Summit, *integrated planning* has been accepted internationally as an essential tool for achieving sustainable development. Cousins (2002) defines integrated planning as effective multidisciplinary, whole-of-government planning, applying broad means for implementation of plans, that requires vertical and horizontal integration. Vertical integration is strategic and policy-driven, whereas horizontal integration is achieved through cooperative action within and between different tiers of government, best reflected in shared governance. The integration needs to be maintained over time.

Furthermore, *transparency* and *consistency* are principles central to integrated planning. *Policy transparency* refers to how clear and accessible public policies are to all stakeholders. *Policy consistency* refers to the need for objectives and structures of the integrative framework to be aligned and to mutually support plan implementation. In other words, higher-order policies, strategies and plans should 'roll-down' through the system to guide day-to-day operations and service delivery. Together, principles of transparency and consistency should visibly guide decision making and actions (Cousins, 2002).

The New Zealand statutory framework for risk management is modelled upon this approach.

Whereas the concept of sustainability implies resilience, the concept of resilience has come to prominence in the past decade, particularly in relation to resilience to disasters, including terrorist attacks. Resilience can be viewed as a 'subset' or a 'special case' of sustainability and, not unlike

Table 1:
Five principles of sustainable development

1	Achievement of national goals through **integrated planning** (rather than single-purpose mandates) and, as a corollary:
2	**Cooperation** between national and local governments (rather than coercion);
3	**Regulation** of environmental outcomes of activities – **consequences** (rather than the activities themselves);
4	National (and state) efforts at **building local capability** (rather than hoping local implementation will occur on its own); and
5	**Citizen participation** in setting the agenda (rather than bureaucratic decision making).

See Cousins (2002).

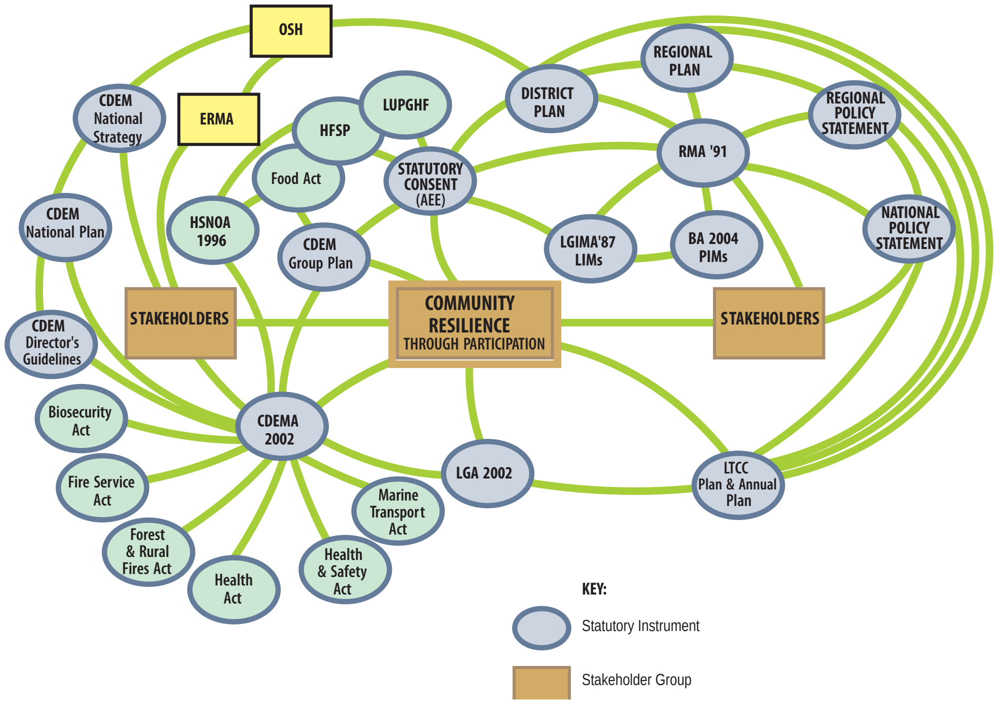

Figure 1: **An illustration showing legislative instruments that support integrated planning framework for hazard risks in New Zealand**

sustainability, there is no one agreed definition of resilience that specifically qualifies it. Also, not unlike sustainability, a common understanding of resilience as 'the society's ability to withstand, recover from and thrive after a major impact (disaster)' is shared universally. Specific characteristics, however, are spatially and temporally determined by affected communities.

As is the case with sustainability, resilience-related research identifies that the design of resilience programmes needs to incorporate the same principles and the same five key dimensions of planning and intergovernmental implementation theories applicable to broader sustainability programmes and discussed earlier (see Table 1).

FROM CIVIL DEFENCE TO CIVIL DEFENCE EMERGENCY MANAGEMENT AND COMMUNITY RESILIENCE

New Zealand was one of the first countries to adopt principles of sustainable management and incorporate them into the government reforms of the late 1980s. The reform of civil defence that occurred in the 1990s reflected those changes. The new principles of emergency management were introduced to ensure that risks are managed at the most appropriate level and as an integral part of decision-making processes. The approach promotes an integrated risk management focus, in an environment where decision making is decentralised (Britton and Clark, 2000; DPMC, 2001). The reforms introduced a comprehensive and integrated hazard risk management approach, moving from the traditional civil 'defence' response focus towards a more realistic civil defence emergency management approach for addressing risks in complex environments. This meant taking a holistic approach and dealing with the consequences of all hazards, both natural and technological, through the 4Rs of risk – Reduction, Readiness, Response and Recovery. Coordinated involvement of all CDEM stakeholders that have a role in managing risks is promoted (MCDEM, 2005).

The intent of integrated planning is well illustrated in legislative instruments. Broadly speaking, in statutory terms, environmental risk management in New Zealand is mainly framed by the Civil Defence Emergency Management Act 2002 (CDEM Act) and the Resource Management Act 1991, with a whole array of related legislation. An illustration of the complex planning framework is shown in Figure 1, which depicts main statutory instruments and some of the stakeholders, as they relate to the CDEM Act.

All these legislative instruments have sustainable management as an overarching goal and promote the five principles of management for sustainable development and resilience discussed earlier.

Central to civil defence emergency management is community resilience – communities understanding and managing their hazard risks (National CDEM Strategy 2007). In this context, resilience has usually been interpreted as the result of the systematic and comprehensive risk

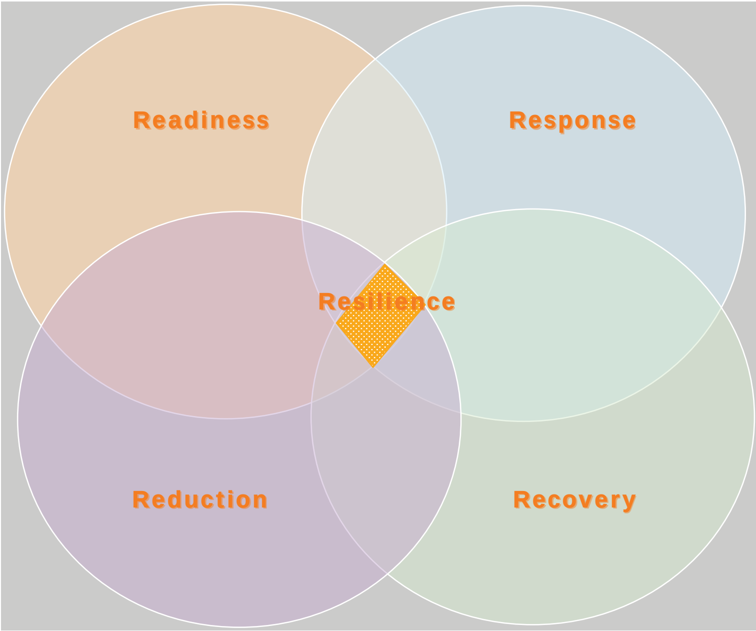

Figure 2: **Resilience as an 'emergent property' resulting from comprehensive risk management across the 4Rs of risk – Reduction, Readiness, Response and Recovery**

management across the 4Rs of Reduction, Readiness, Response and Recovery, as illustrated in Figure 2. It has to be born in mind, however, that comprehensive risk management across the 4Rs is underpinned by the integrated framework (Figure 1). Research and practice have demonstrated that, only when all the essential elements and processes of this framework are present, functional and balanced against each other, can the framework be considered resilient (CAENZ, 2004; Mamula-Seadon, 2007).

In practice, however, the result is often like this (Figure 3). Whereas all the '4Rs' of Reduction, Readiness, Response and Recovery are commonly addressed in emergency management, the debate on the right balance and functionality of the framework is still open.

MANAGING FOR RESILIENCE

Practice has demonstrated that comprehensive, integrated management of hazard risks is in itself a complex, multifaceted process. Whereas the underpinning legislation, its intent and the basic principles for implementation may be well established, the delivery of desired outcomes and coherency of policies with those outcomes are still challenging (for example, Ericksen et al., 2003; CAENZ, 2004). There is no one prescribed way to deliver effective integrated frameworks and resilience. In evolving practice, solutions for complex problems require adaptivity, creativity and persistence. Typically, it is the journey that is as important as the outcome. Solutions are often context-dependent, local and innovative. Methods and tools may be many and varied. Sharing experience and creating opportunities for learning is one of the essential prerequisites for integrated planning and management for resilience.

This issue of *Tephra* aspires to provide some methods and tools for practitioners, as well as a platform for exchange of information and ideas related to the practice of integrated planning and resilience building in communities, in the civil defence emergency management context.

As discussed, fundamental principles of management for resilience require focus on community needs (public good) and integrated planning. Integrated planning in this context means vertical integration through common goals and strategic policy, principally at the central government level, and horizontal integration through cooperative action at all levels, and particularly locally. Integration is also required across all relevant stakeholders and processes.

Authors of papers in this issue of *Tephra* have undertaken to demonstrate how those principles operate in practice. They provide

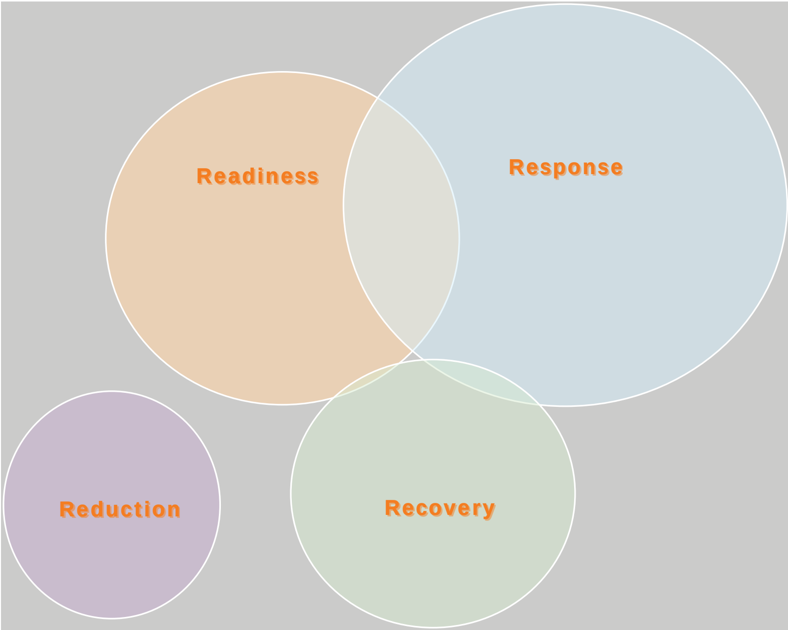

Figure 3: **'Comprehensive' risk management over the 4Rs in practice may look like this**

examples of issues, strategies and tools that address resilience building through integrated planning.

A paper by Daly and others discusses the concept of community resilience and introduces a set of possible indicators of resilience that can be utilised to develop strategies for action that lead towards resilience building. Similarly, Seville discusses resilience from the organisational resilience perspective, but firmly focused on societal needs and interconnectedness of organisations and society. The paper by Chang and others investigates the great Wenchuan earthquake and the community-centred recovery and reconstruction measures the Chinese government is introducing – a community resilience-based approach and a significant change to traditional practice. This view is reinforced in a paper by Wright and others, who recommend pre-recovery planning in order to empower communities to plan for their towns, should a disaster occur. A paper by Walton and others uses community behaviour patterns to plan for response – a resilience-based approach to response.

A paper by Fookes reflects on the history of integrated planning in New Zealand, and particularly on the development of the Resource Management Act. The paper discusses early ideas, intentions and subsequent differences in practice. The paper by Helm complements those articles by elaborating on the principles of security (including emergency) management in New Zealand. Helm's paper also discusses the difference between resilience and the 4Rs and introduces two powerful tools for management of complex issues – a systems approach and adaptive management. Saunders and Glavovic offer interesting examples of opportunities for community intervention in integrated planning.

The papers by Cowan and Smith draw attention to the importance of research connected across disciplines and organisations, and the value provided in the form of a robust evidence base. Those cannot be overlooked, particularly when dealing with complex, 'wicked' issues that often present themselves to civil defence emergency management and planning practitioners.

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Resilience: Great Concept

... But What Does it Mean for Organisations?

Dr Erica Seville
Resilient Organisations, University of Canterbury

In 2003, when our Resilient Organisations[1] research team first embarked on resilience research, few organisations were talking 'resilience'. The term had been used in a variety of academic disciplines ranging from ecology through to psychology, but it remained quite a theoretical concept; there was little advice available on how to achieve greater resilience for organisations. Rolling forward to 2009 and one of our Steering Committee members recently joked that "resilience is the new black". Everywhere you turn, the word resilience just keeps cropping up. Like the concept

Δ Businesses struggling to reopen after the Boxing Day tsunami in Thailand

1 Resilient Organisations Research Programme, www.resorgs.org.nz. Author's email: erica.seville@canterbury.ac.nz.

Organisational resilience is the ability of an organisation to survive and even thrive through times of crisis.

'sustainability', it seems that resilience is being presented far and wide as a shining goal for the future – but many are still unsure what it actually means in practice. This article describes what resilience means for organisations and the characteristics that more resilient organisations are likely to exhibit.

There are several dimensions to resilience for organisations. It is

1. the ability to prevent negative consequences occurring
2. the ability to prevent negative consequences worsening over time
3. the ability to recover from the negative consequences of an event (McManus, 2008).

Organisational resilience is also about finding the 'silver lining' – seeking out the opportunities that always arise during a crisis to emerge stronger and better than before.

From case study research (McManus et al., 2007), the qualities that more resilient organisations tend to exhibit over those that are less resilient include

- an **organisational ethos** to constantly strive for improved resilience
- good **situation awareness** of the threats and opportunities facing the organisation through the active monitoring of strong and weak signals
- a strong commitment to proactively identify and manage **keystone vulnerabilities**
- a culture that promotes **adaptive capacity**, agility and innovation within the organisation.

These terms, as well as 23 indicators for evaluating organisational resilience, are further described in the later textbox.

RESILIENCE OF ...?

It is important to recognise that while this article focuses on the resilience of organisations (businesses, government agencies, institutions etc), an organisation sits within an ecological-like system and resilience is required at all levels of this system.

No organisation is an island; the resilience of an organisation is directly related to the resilience of the other organisations on which it depends (customers, suppliers, regulators, and even competitors). In addition to this, an organisation is dependent on the individual resilience of its staff and the communities that they live in. In a symbiotic relationship, an organisation, in turn, contributes to the resilience of these communities. Similarly, an organisation's resilience is directly related to the resilience of its sector, and the sector's resilience is intertwined with the resilience of the nation.

The fact that resilience concepts apply at all these levels offers both challenges and opportunities. The challenge comes from the sense that 'resilience encompasses everything' – making the problem too big. The opportunity comes from the ability to leverage common concepts and terminology to raise the game at several levels in society simultaneously.

The multiple levels of resilience can be likened to the generic risk management process. The principles are the same but the application and the scope shifts depending on the focus on risks for the entire enterprise, risks for a single business unit, or risks for a single project. The trick comes in defining the context so that the questions are framed appropriately, and therefore the answers are relevant to the actual problem at hand.

RESILIENT TO ...?

Each organisation has its own 'perfect storm' – a combination of events or circumstances that has the potential to bring that organisation to its knees. For a financial system, the worst nightmare might be sudden loss of customer confidence creating a snowballing 'run on the bank'. For other organisations it may be the failure of a key supplier, contamination on the production line, a disgruntled employee wreaking havoc, etc. Similarly an organisation may be very resilient to some types of crisis,

An investment in resilience is an investment to give an organisation the best possible chance of turning a crisis into its finest hour; it is no guarantee of it ...

but less resilient to others. This creates challenges when trying to benchmark the resilience of one organisation against another. To overcome this, it is important to define organisational resilience, independent of the cause of crisis. It is also important to recognise that even though an organisation may be very resilient, there are always sets of circumstances where the chances of survival are minimal, and thresholds above which an organisation may choose not to invest to become resilient to.

An investment in resilience is an investment to give an organisation the best possible chance of turning a crisis into its finest hour; it is no guarantee of it …

RESILIENCE IS DYNAMIC

Bruce Glavovic (2005) uses great imagery when talking about resilience; he talks of "waves of adversity and layers of resilience". What he is referring to is the dynamic nature of resilience and threat environments. To extend Bruce's analogy, during peace-time an organisation strives to build up layers of resilience – a bit like sand building up a sand-dune. A big storm comes along and takes some of that sand away, but so long as the dunes are high enough, the storm surge causes little damage. After the storm passes, the dunes start rebuilding again. With any luck, the sand dunes will be high enough by the time the next major storm arrives.

In the same way, the ability of an organisation to survive a major crisis is influenced by what has come before. The organisation may be highly resilient to begin with, and may bounce back from their first crisis very well. However, by the time the organisation has suffered three or four crises in quick succession, even the best will become battle-weary, with resources stretched and defences weakened by earlier events.

The resignation of a key staff member, a fractious round of wage negotiations, or the installation of a new IT system can all shift the resilience space that an organisation is operating in. This dynamic nature of resilience therefore requires constant vigilance and effort to achieve maximum potential resilience given the circumstances.

RISK AND RESILIENCE

A question that often arises is how resilience fits with risk management. Risk management provides a good framework for organisations to be more proactive in thinking about and managing the unexpected. However there are limitations in the way that risk management is applied within many organisations.

Risk managers the world over are faced by the challenge of the things that 'we don't know that we don't know' (also commonly referred to as 'unknown unknowns', or in more technical language, 'ontological uncertainties'). These are the risks that are not identified during the risk identification process. The problem with unidentified risks is that the unexpected and unpredicted tends to happen more frequently than we like to admit! It is important that having a good risk management process in place does not lead to over-confidence that all risks are being managed appropriately.

Risks are also often evaluated in isolation. Crises tend not to happen because 'one thing went wrong', but emerge from a pattern of several issues coinciding in space and time. Risk registers tend to struggle with this concept, and although we have techniques for addressing interdependencies and combinations of risks from a quantitative risk perspective, it is rarely addressed adequately during the more common qualitative risk assessment approach.

Resilience requires strategies to be in place for managing those risks that haven't been identified – the hidden interdependencies, the complex risks that are lurking in the background waiting to surprise us. It is important to also invest in adaptive management strategies that can get us out of a crisis situation, just in case our risk management is not quite as effective as we would have liked it to be … In the end, well-managed risks and effective planning are still no substitute for great leadership and a culture of teamwork and trust which can respond effectively to the unexpected. The concept of resilience provides a framework for incorporating these aspects, which are rarely addressed on an organisation's risk register.

Recognising that what gets measured gets managed, through our research we have developed a series of 23 indicators (see below) that can be used to evaluate an organisation's resilience.

INDICATORS OF RESILIENCE

Resilience Ethos: A culture of resilience that is embedded within the organisation across all hierarchical levels and disciplines, where the organisation is a system managing its presence as part of a network, and where resilience issues are key considerations for all decisions that are made.

Indicator	Description
Commitment to Resilience	A belief in the fallibility of the organisation as well as the ability to learn from errors as opposed to focusing purely on how to avoid them. It is evident through an organisation's culture, training and how it makes sense of emerging situations.
Network Perspective	A culture that acknowledges organisational interdependencies and realises the importance of actively seeking to manage those interdependencies. It is a culture where the drivers of organisational resilience, and the motivators to engage with resilience, are present.

Situation Awareness: An organisation's understanding of its business landscape, its awareness of what is happening around it, and what that information means for the organisation now and in the future.

Indicator	Description
Internal & External Situation Monitoring & Reporting	The creation, management and monitoring of human and mechanical sensors that continuously identify and characterise the organisation's internal and external environment, and the proactive reporting of this situation awareness throughout the organisation.
Informed Decision Making	The extent to which the organisation looks to its internal and external environment for information relevant to its organisational activities and uses that information to inform decisions at all levels of the organisation.
Recovery Priorities	An organisation-wide awareness of what the organisation's priorities would be following a crisis, clearly defined at all levels of the organisation, as well as an understanding of the organisation's minimum operating requirements.
Understanding & Analysis of Hazards & Consequences	An anticipatory all-hazards awareness of any events or situations that may create short- or long-term uncertainty or reduced operability. An understanding of the consequences of that uncertainty to the organisation, its resources and its partners.
Connectivity Awareness	An awareness of the organisation's internal and external interdependencies and links and an understanding of the potential scale and impact that expected or unexpected change could have on those relationships.
Roles & Responsibilities	Roles and responsibilities are clearly defined and people are aware of how these would change in an emergency, the impact of this change, and what support functions it would require.
Insurance Awareness	An awareness of insurance held by the organisation and an accurate understanding of the coverage that those insurance policies provide. (Note – this indicator seems at a more micro-level than the others, but we regularly observed organisations using insurance as a security blanket, without a good understanding of the limitations of that cover!)

Management of Keystone Vulnerabilities: The identification, proactive management, and treatment of vulnerabilities that, if realised, would threaten the organisation's ability to survive.

Indicator	Description
Robust Processes for Identifying & Analysing Vulnerabilities	Processes embedded in the operation of the organisation that identify and analyse emerging and inherent vulnerabilities in its environment, and enable it to effectively manage vulnerabilities to further the networks' resilience.
Planning Strategies	Effectiveness of organisational planning strategies designed to identify, assess and manage vulnerabilities in relation to the business environment and its stakeholders.
Participation in Exercises	Participation of organisational members in rehearsing plans and arrangements that would be instituted during a response to an emergency or crisis.
Capability & Capacity of Internal Resources	The management and mobilisation of the organisation's physical, human, and process resources to effectively respond to changes in the organisation's operating environment.
Capability & Capacity of External Resources	Systems and protocols designed to manage and mobilise external resources as part of an interdependent network to ensure that the organisation has the ability to respond to crisis.
Organisational Connectivity	Management of the organisation's network interdependencies and the continuous development of inter-organisational relationships to enable the organisation to operate successfully, and to prevent or respond to crisis and uncertainty.
Staff Engagement & Involvement	The engagement and involvement of staff so that they are responsible, accountable and occupied with developing the organisation's resilience through their work because they understand the links between the organisation's resilience and its long-term success.

Adaptive Capacity: The organisation's ability to constantly and continuously evolve to match or exceed the needs of its operating environment before those needs become critical.

Indicator	Description
Strategic Vision & Outcome Expectancy	A clearly defined vision which is understood across the organisation and reflects its shared values and empowers its stakeholders to view the organisation's future positively.
Leadership, Management & Governance Structures	Organisational leadership that successfully balances the needs of internal and external stakeholders and business priorities, and that would be able to provide good management and decision making during times of crisis.
Minimisation of Silo Mentality	Reduction of cultural and behavioural barriers that can be divisive within and between organisations, which are most often manifested as communication barriers creating disjointed, disconnected and detrimental ways of working.
Communications & Relationships	The proactive fostering of respectful relationships with stakeholders to create effective communications pathways which enable the organisation to operate successfully during business-as-usual and crisis situations.
Information & Knowledge	The management and sharing of information and knowledge throughout the organisation to ensure that those making decisions or managing uncertainty have as much useful information as possible.
Innovation & Creativity	An organisational system where innovation and creativity are consistently encouraged and rewarded, and where the generation and evaluation of new ideas is recognised as key to the organisation's future performance.
Devolved & Responsive Decision Making	An organisational structure, formal or informal, where people have the authority to make decisions directly linked to their work and, when higher authority is required, this can be obtained quickly and without excessive bureaucracy.

BENCHMARKING RESILIENCE – AUCKLAND

In conjunction with the Auckland Civil Defence Emergency Management Group we are currently running a Resilience Benchmarking study involving 1000 organisations in the Auckland region. This benchmarking study will provide a snapshot of common resilience issues facing New Zealand organisations. It will also provide those organisations that participate with a detailed and confidential report on what their specific resilience strengths and weaknesses are, as well as a comparison against where they sit against organisations of a similar size and in a similar sector.

For more information, or to nominate your organisation to participate, go to www.resorgs.org.nz/benchmark. Once this pilot study is completed in the Auckland region, we will be offering the opportunity for organisations around New Zealand to take part.

Ultimately our goal is to get organisations both thinking about and proactively managing their resilience and ability to cope with change and adversity as their 4th bottom line. How would your organisation measure up?

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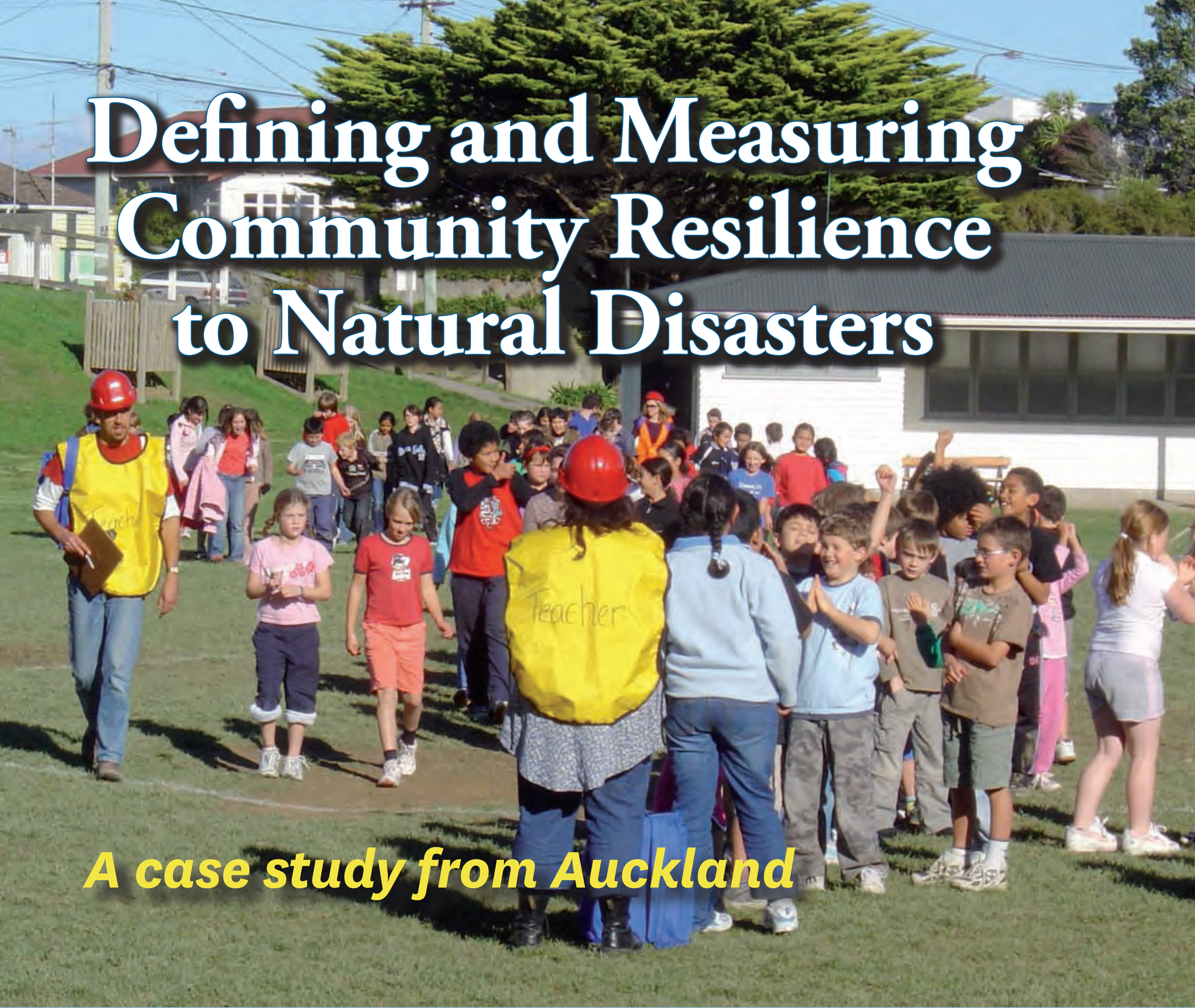
Defining and Measuring Community Resilience to Natural Disasters

A case study from Auckland



Michele Daly, *Kestrel Group*
Julia Becker, *GNS Science*
Bruce Parkes, *Private Consultant*
David Johnston, *Joint Centre for Disaster Research, Massey University and GNS Science*
Douglas Paton, *University of Tasmania*

Δ Building adaptive capacity and resilience at school level – children participating in an evacuation drill (Photo: David Johnston)

A RESILIENT NEW ZEALAND

New Zealand's Civil Defence Emergency Management (CDEM) vision is, "A Resilient New Zealand – communities understanding and managing their hazards". When reflecting on this vision, several questions immediately come to mind: what is resilience? how can it be developed? how can it be measured? and how resilient are we right now?

To try and answer these questions in the context of community[1] resilience, a research project was undertaken

1 Community in this context applies to the 'public'; individuals and their interactions with one another, other groups and societal institutions.

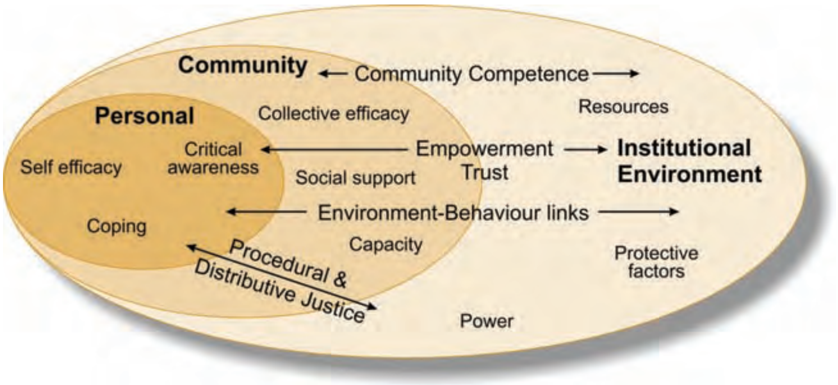


Figure 1: **A model of community resilience, showing selected indicators at each level (personal, community and institutional) and relationships between them** (adapted from Paton, 2006)

in Auckland between 2004 and 2007 (Paton, 2007; 2008a; Paton et al., 2008a). The overall goal of the project was to identify key generic attributes of community resilience and develop a way of measuring these, which could be used both at different levels (e.g. suburb, town, district, region) and for different demographic groups.

The research has provided us with a better understanding of what resilient communities look like. It has also enabled us to realise that one of the ways we can manage risk is by influencing community members' ability to cope with and adapt to the consequences of disasters. As a result, a growing number of emergency managers are challenging the way they view, understand and interact with their communities.

WHAT IS RESILIENCE?

Since the time of Charles Darwin, scientists studying evolution have sought to understand how some species have been able to survive changes in their environment while others have not. They have identified the key criteria to survival and growth as being the ability of those species to adapt to their changing environment.

In keeping with this theme, one aspect of 'resilience' is an 'adaptive capacity' – society's capability to draw on its individual, collective and institutional resources and competencies to cope with, adapt to and develop from the demands, challenges and changes encountered before, during and after a disaster (Paton, 2006).

In this context, resilience comprises four general components (Paton, 2000):

1. Communities, their members, businesses and societal institutions must have the resources (e.g. household emergency plans, business continuity plans) required to deal with their safety and continuity of core services after a disaster.
2. Communities, their members, businesses and societal institutions must have the competencies and procedures (e.g. problem-solving ability, community cohesiveness, trained staff, devolved decision making) required to organise and use these resources to deal with the problems encountered and adapt to the reality created by a disaster.
3. The planning and development used to facilitate resilience must be designed to integrate the resources available and to ensure opportunities for change and growth are capitalised on.
4. Mechanisms must be in place to ensure the sustained availability of these resources and the competencies required to use them over time and against a background of hazard quiescence and changing community membership, needs, goals and functions.

A RESILIENCE MODEL

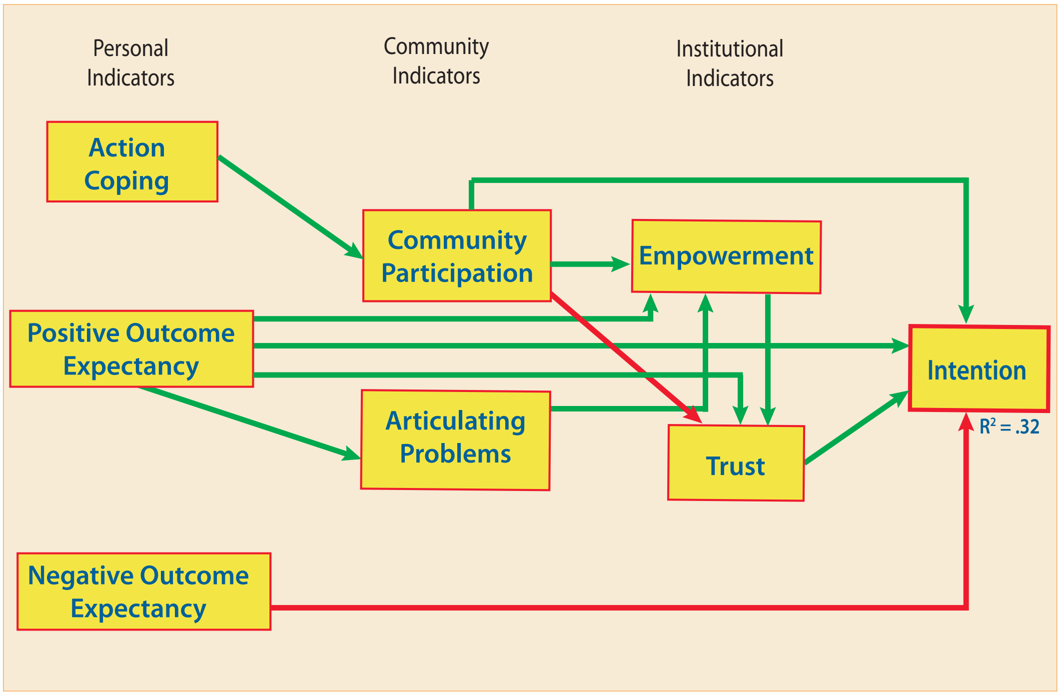
Work by Paton (2006; 2008b) and Paton et al. (2008a, b) has led to the development of a generic model of community resilience, which draws together the components described above. The resilience model is based on a number of indicators, and the interaction (pathways) between them.

One of the benefits of using a generic model is the ability to develop a framework that allows comparable assessments to be made across all hazards (all hazards planning), all demographic groups, and at different levels of analysis (e.g. suburb, district, region).

The research undertaken in New Zealand and overseas on the above model has shown that some of the indicators in Figure 1 play a more important role than others in predicting whether an individual will take some action to prepare for a disaster or not. The most important indicators from the Auckland pandemic study are shown in Figure 2.

Figure 2: **Resilience model, illustrating the linkages between the different personal, community and institutional indicators as tested in Auckland for a pandemic scenario** (Paton, 2008a).

Green lines indicate a positive link between indicators, while red lines indicate a negative link. (Persons with a negative outcome expectancy are unlikely to develop any intention to prepare for a disaster, and participating in community activities in itself won't necessarily build trust with institutions such as councils. The key factor here is to ensure that the community is empowered in the engagement process.)



Broadly the indicators of most relevance can be grouped into three areas:

1. **personal**, where people need to know that the small things they do can make a positive difference for themselves, their families and their neighbours (*outcome expectancy and action coping*)
2. **community**, where people actively participate in their communities to identify and discuss their issues and risks and determine collective solutions (*community participation and problem articulation*)
3. **institutional**, where communities are supported by civic agencies that encourage and empower community-led initiatives and where mutual trust and respect exist (*empowerment and trust*).

While people, communities and societal institutions make different contributions, the model indicates that developing resilience as a component of an effective risk management programme will only occur when their respective roles are integrated.

HOW RESILIENT ARE WE NOW?

It is possible to measure the indicators outlined above, and link this information to how resilient a community is currently. It is also possible to compare and contrast groups and regions and combine data from different groups or areas to construct a composite regional assessment.

Table 1: **Levels of Resilience in Auckland as assessed for a Pandemic Scenario (H=High; M=Medium; L=Low) (regional sample size of 400)** (after Paton, 2008a)

Intention to prepare	M
Action Coping	L
Negative Outcome Expectancy	M
Positive Outcome Expectancy	L
Community Participation	M
Articulating Problems	L
Empowerment	M
Trust	M
Readiness measures in place	L

A valid generic model allows for the use of an evidence-based approach to guide planning and intervention and provides emergency managers with a common assessment framework to

- measure and assess resilience levels of communities (Table 1)

- identify aspects of personal and community competencies that will benefit from their development (Table 1)
- facilitate resource allocation decisions by focusing for example on communities that show low levels of some indicators
- adjust education and engagement programmes based on resilience measurements
- monitor change in levels of resilience and its predictors over time.

INTERVENTION STRATEGIES

Understanding what drives your community's resilience helps to come up with better risk communication strategies and practical tools for working with the community; once you have an understanding of the resilience factors that are important in your community, how they interact, and to what level they currently exist, you can develop programmes that target them. Summarised below are three key areas that can be focused on for building resilience and that relate to the indicators discussed previously:

1. At a *personal level* – develop people's problem-solving skills (action coping), increase their belief in the benefits of hazard mitigation (outcome expectancy) and their belief that what they personally can do will make a difference (reduce negative outcome expectancy).
2. At a *community level* – encourage active involvement (community participation) in community affairs and projects and develop the community's ability to resolve collective issues (articulating problems).
3. At an *institutional level* – develop an individual's ability to influence what happens in their community (empowerment) and the level of trust they have in different organisations (trust).

As many resilient indicators can be developed by undertaking community development, it is advised that the CDEM sector work with others involved in building community and social capital. This means that a number of groups alongside CDEM have a role to play including urban design and environmental planners, representatives of wards/community groups, and agencies with responsibility for facilitating community development outcomes through community engagement processes (Finnis, 2007; Finnis et al., 2007).

Communities differ with regard to their specific mix of demographics, their hazard history, existing levels of resilience and vulnerability, and the resources they have available. Interaction between these factors will determine the most appropriate strategy for the development of resilience, and will differ from one community to another. Using a central planning process for intervention development and delivery is therefore difficult. However, a generic framework provides the means to identify the factors (e.g. positive outcome expectancy, community participation) that intervention strategies will target. It provides guidelines for local initiatives with the specific change strategy being developed at this level.

Even though the goal is the same (e.g. increase positive outcome expectancy or community participation), community diversity (e.g. hazard history, risk, demographics, stage of development) means that the strategies used to promote increased resilience must be tailored to the specific characteristics and needs of each community. For example, differences in baseline levels of hazard knowledge, opportunities for community participation and the groups available to be targeted for intervention (e.g. Rotary, religious congregations, social groups) will influence both the factors that need to be targeted in a given community and the most appropriate way to develop each factor within each community.

Devolving responsibility for developing intervention strategies capable of facilitating local change increases the likelihood that intervention will be consistent with the needs, goals, expectations and competencies of each community. Local representatives are best placed to make these choices. It also ensures a more cost-effective use of resources provided meets local needs, and that the process builds commitment to sustaining resilience over time and against a backdrop of changing community membership and needs. This is particularly important given that it is impossible to predict when a disaster may strike and any gains in resilience must be sustained over an indefinite period.

The resilience indicators also have specific implications for the design of educational materials, programmes and campaigns. Suggested strategies that may assist with increasing resilience include the following:

1. Involve those trusted by the public, including respected academic and scientific institutes, government agencies, teachers, community leaders, celebrity role models as much as possible.
2. Focus on solving the problem rather than on negative emotional consequences of not solving the problem.

Stallholders at a community event advocating preparedness for disasters (Photo: Julia Becker)

3. Provide evidence for the effectiveness of mitigation measures including how much of a difference to people's lives undertaking them would mean.
4. Help people to recognise the skills and resources that people have to increase their sense of personal effectiveness.
5. Be honest about what we do and do not know, and do not underestimate people's ability to deal with uncertainty.
6. Make it fun across the board (for adults and children alike) and encourage parent-child interactions.

WHAT'S HAPPENING NEXT?

Current research is looking at existing programmes under way where there has been a focus on developing one or more of these indicators to identify practical tools and intervention strategies. These will be used as practical examples to show how resilience can be built up in communities.

The preceding discussion outlines how resilience at household and community levels can be facilitated. It is, of course, important to integrate this level of analysis with other work being undertaken to develop infrastructure, economic, institutional and environmental resilience if a comprehensive level of societal resilience is to be attained.

CONCLUDING COMMENTS

Building resilience in the community requires a long-term approach and a long-term commitment. Changing demographics and exposure means managing risk is a perpetual challenge. The resilience model described here provides us with a basis on which we can better understand our communities in the context of disaster management and provides us with one way to understand how we might influence the way our community prepares for and responds to a disaster.

There is a benefit in understanding resilience in your community. Among other factors, increasing resilience has been shown to decrease recovery time after an event. Research has shown that a 30% increase in the key community indicators will reduce recovery time by up to 10% (Paton, 2007). Given the length of time it can take to recover from an event, this is significant.

It is, however, important to recognise that the only way we will know for sure how resilient a community is, will be to measure responses to an actual disaster. The work discussed here provides an evidence-based approach to getting the resilience ball rolling. By identifying the areas where intervention is likely to be most effective, emergency management agencies have at their disposal a cost-effective guide to developing resilience in their area.

ACKNOWLEDGMENTS

This work is being supported by the Foundation for Science, Research and Technology, EQC, the Auckland Region CDEM Group and the Ministry for Civil Defence and Emergency Management.

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Connections between *Research* and *Resilience*: The Role of EQC

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At a fundamental level the earthquake or volcano problem is one of risk reduction, but there are major challenges related to the transformation of scientific knowledge into sustainable community practices. Earthquakes and volcanoes have shaped the mythology and history of New Zealand since these islands were first settled by Māori in the 13th century. However, not since the eruption of Mount Tarawera (1886) and the period 1929–42 – in which large shallow earthquakes struck repeatedly – has New Zealand suffered major social disruption or serious economic setback due to geological hazards, although there have been local impacts (ODESC, 2007). The damaging earthquakes of that earlier period prompted the introduction of principles for seismic design, developed largely in Japan and California, which formed the basis of the first national building code in 1935. Those experiences contributed to an emerging research culture at Government laboratories and universities and later the development of widely emulated practices in seismic isolation (Skinner et al., 1993) and capacity design for reinforced concrete structures (Park and Paulay, 1975; Paulay and Priestley, 1992). Decades of relative seismic and volcanic quiescence since the 1930s, however, pose a challenge for the effective management of natural hazard risk. The number of urban dwellers has swelled and with it a dependency on networked services, while few residents or community leaders today have experienced personal loss to natural hazards. Competitive forces in commerce and public sector restructuring have added complexity to the sharing of knowledge and accountabilities for managing natural hazard risk. At the same time, legislative reforms have introduced new expectations of sustainable development with New Zealand's long-term resilience to natural hazards a significant determinant of planning outcomes at community level. Assessment and reduction of risk at all levels in the community varies according to the human capacity and financial resources of local communities and their commitment to strategic, as opposed to short-term, planning (CAENZ, 2004). Against this backdrop of culture and tectonics the Earthquake Commission (EQC, www.eqc.govt.nz) administers the scheme that insures homes, their contents

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and land against damage by earthquake, volcanic eruption, natural landslip, hydrothermal activity and tsunami, as well as from fire following any of these natural disasters. EQC also has a mandate to facilitate research and education about matters relevant to natural disaster damage, and methods of reducing or preventing such damage. In this paper, we illustrate with examples the imperatives that guide EQC's research facilitation and public education and its application to community resilience.

THE EARTHQUAKE COMMISSION

The Earthquake and War Damage Commission was created in 1944 as an instrument of social policy using the insurance model. It was recognised that economic recovery had been excessively slow in communities damaged by a large earthquake near Wellington in 1942 because of lack of insurance and limited access to capital for reconstruction. Later, cover for other geological perils was included and, later still, cover for war damage dropped and the insurance cover organised around residential property only. EQC was established by the Earthquake Commission Act 1993, taking over the functions and assets of the Earthquake and War Damage Commission. The EQC is defined as a Crown agent by the Crown Entities Act 2004. It is one of the Crown Financial Institutions that manage large funds (in EQC's case, the Natural Disaster Fund (NDF)) at arm's length from Government. EQC's principal role is to manage the insurance of residential property (buildings, contents and land) against damage by specified natural perils. Related to this function EQC manages the NDF and oversees arrangements by which the financial assistance defined under the Act will be deployed as quickly as possible after a major event. EQC also funds research into geological hazards and risk mitigation, and informs New Zealanders about how they can make their homes safer from the effects of natural disasters.

All residential property owners who buy fire insurance compulsorily acquire Earthquake Commission insurance cover – and those who do not buy private sector insurance do not get this cover. Dwellings are insured up to a maximum of $100,000 plus goods and services tax (GST), personal effects up to $20,000 plus GST, and land cover is provided in addition to these limits. This insurance is on a "first loss" basis, subject to a relatively small excess payment by the insured. For any claim in excess of the EQC "cap", top-up cover is provided by the private insurer. Premiums are paid through insurance companies and passed in bulk to EQC, less a small commission. The premium is undifferentiated throughout the country at a rate of 5c per $100 of cover taken. On this basis, EQC insures about 90% of New Zealand homes against damage caused by earthquake, volcanic eruption, tsunami, landslide, or hydrothermal activity (including fire following any of these), and the maximum premium payable is $67.50 per year, including GST. Of the remaining 10% of residential dwellings approximately half are owned and self-insured by the Crown entity, Housing New Zealand.

EQC's income is derived from insurance premiums plus the investment return on its capital and reserves – the NDF. The costs of meeting insurance claims and all other functions are usually met from premium income (Figure 1) with any annual surplus being credited to the NDF, which currently totals $5.6 billion. A large earthquake or prolonged volcanic eruption, however, could generate more than 100,000 claims. The Probable Maximum Loss scenario is a rupture on the Wellington fault, traversing the central business district of Wellington and the Hutt Valley. This Probable Maximum Loss event could result in 50% probability claims of $6.3 billion and 90% probability claims of $10.3 billion. To protect the NDF therefore, EQC exports part of the risk to international capital markets, and places one of the largest property catastrophe reinsurance programmes in the world. The Crown also underwrites EQC's liabilities with a guarantee in the event that the NDF is exhausted. These measures are complemented by planning and investment in tools to manage the aftermath of a disaster and the sudden surge of claims. The planning is informed by insights into disasters abroad, through EQC's extensive international links, and is maintained by regular testing. EQC's planning includes a system for lodging claims; mobilisation of sufficient accredited inspectors and loss adjusters; engagement of suitable numbers of management, processing and recording staff in matching accommodation and facilities; and procedures to handle the inevitable disputes that will still occur.

EQC has a staff of 22, one permanent office in Wellington (with an outsourced claims administration facility in Brisbane, Australia), and a "warm" back-up site in Auckland. A Board oversees the activities of the Commission and is responsible to the Minister of Finance. As a "virtual corporation" EQC has outsourced all but its core function of managing risk. The number of EQC staff is adequate for overseeing the few thousand claims processed each year on average and for maintaining the contingent capabilities required to handle big events. The outsourcing arrangements operate at all times in order to give parties knowledge and

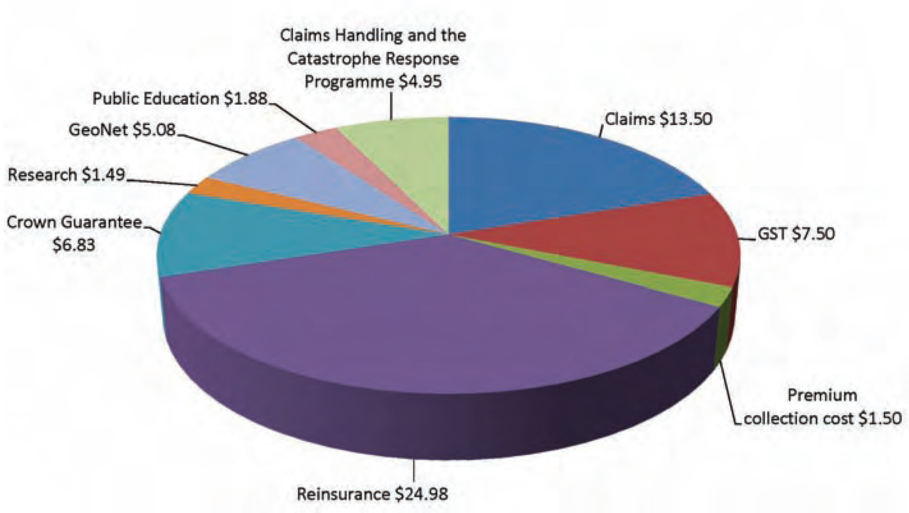

Figure 1: **Breakdown of insurance claims and other EQC functions for the 2007/08 financial year.**

All costs are met from premium income, with any annual surplus being debited from (or credited to) the Natural Disaster Fund. All residential property owners who buy fire insurance compulsorily acquire Earthquake Commission insurance cover – and those who do not buy private sector insurance do not get this cover.

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experience of the services expected by EQC and ensure the capability will be there at the critical time. Responding to a major event is a matter of scaling up to the necessary levels what is already in place, not trying to activate an arrangement that has, at best, only been tested or exercised in rather artificial circumstances.

RESEARCH AND EDUCATION

Direct incentives to mitigation through insurance systems are sometimes advocated for reducing the damaging effect of disasters. The New Zealand approach with its compulsory EQC insurance scheme instead emphasises solidarity and avoids the adverse risk selection and low penetration commonly associated with free markets elsewhere[1]. An important benefit is cheaper prices for all, at the cost of not making more explicit the ownership and management of the risks. In practice, however, it would be difficult to differentiate fairly between localities since all New Zealand communities are exposed to one or more of the listed perils. A major earthquake or volcanic eruption would affect the whole population in one way or another, and then there is the question of needing to balance hazard versus vulnerability. For instance, considering the case of earthquake alone, what should the differential be between an older brick house built on soft soils in a region of lower seismic hazard, and a modern timber-framed home built on rock in a region of higher hazard?

EQC instead aims to facilitate improvements in practice through research and public education about natural disaster damage and its mitigation. To achieve this EQC invests in research capabilities as well as research itself. The largest of these investments supports geophysical monitoring and research with the enabling technologies and underpinning expertise in data management. "GeoNet", as this major research equipment facility is known, also underpins New Zealand's civil defence emergency management readiness and response to geological hazards. Faculty positions at four New Zealand universities are supported to provide vision and leadership in relevant fields of scholarship and to address gaps in New Zealand's capability to assess and mitigate geological risk. EQC grants for research are contestable and proposals are required to meet standards of open science review in keeping with international norms. One funding pool is offered to experienced researchers in alternate years, and a second pool supports postgraduate student and early career research. A grant to the Fulbright Foundation provides a promising student each year with PhD research opportunities in the USA. Other grants facilitate technical meetings for relevant professional societies and engineering lifelines groups, post-disaster investigations and wider dissemination of knowledge resulting from EQC-funded research. Project funding for

1 For example, in California, where residential earthquake insurance is voluntary, a homeowner in Los Angeles or San Francisco will purchase cover typically at a cost of several thousand dollars per year, with a deductible of 10–15% of the property value. Only an estimated 12% of California households have earthquake insurance, so it is unclear how many will be able to afford to rebuild following a devastating earthquake (California Department of Insurance, 2006).

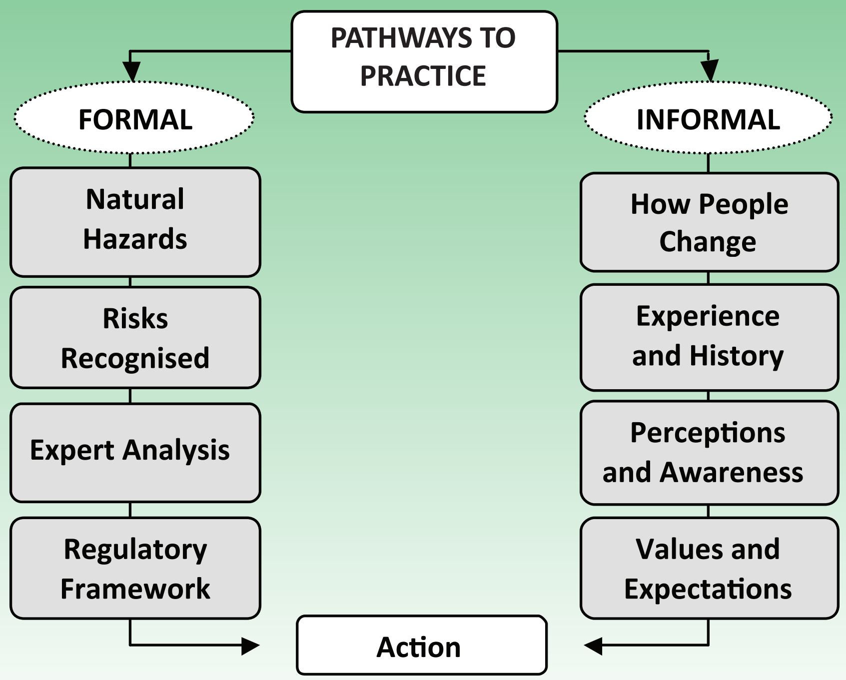

Figure 2: **Formal and informal processes link the acquisition of knowledge and its uptake by people with a variety of backgrounds.**

A research culture responsive to the totality of the risk environment must demonstrate integration of physical, engineering and social sciences and understanding of these processes. (adapted from CAENZ, 2004)

the national standards organisation, Standards New Zealand, contributes to the revision of building codes and guidelines. EQC periodically funds research to address specific operational needs, and such work is offered through a tender process or negotiated in those cases where natural monopolies or complexity of scope make a consortia approach preferable. The services of a small number of technical advisers are retained to support grant allocation processes, under the direction of a research manager who is a member of the EQC executive management team. EQC Board oversight of the research function is delegated to the Research Committee of the Board.

PATHWAYS TO PRACTICE

A well-known principle of system design is that all components and linkages need to be upgraded evenly if the entire system is to perform optimally, with an equivalent improvement of outcome (Elms, 1992). EQC aims to apply this principle to research facilitation, while accepting that the knowledge that drives innovation is augmented by experience and events, regardless of formal planning and direction (Figure 2). A basic premise of the research programme recognises the dynamic essence of knowledge and the interdependencies that link knowledge to innovation and its application to best practice. Over the years this approach has evolved into a strategy that consists of a few principles that guide action from below, not precise planning from the top. One is to build alliances across organisations, in order to encourage collaborative problem solving and decision making. Another is to foster an adaptive research culture, which demands integration of the physical, social and engineering sciences to address the totality of the risk environment, and flexibility in the approach to funding. In this way, niche opportunities are less likely to be neglected and new ideas can emerge in spite of priority settings. As an agency that facilitates theme-specific rather than sector-specific research, EQC seeks to ensure a broad perspective is maintained through the following objectives:

- the imperative to address gaps in knowledge about New Zealand's exposure to geological hazards and methods applied to reduce the severity of future impacts
- the importance of mentoring arrangements that build intellectual capital and international linkages
- the need for niche support for training and capability development in relevant disciplines, supplementary to baseline public investment in higher education and basic research
- the need for stewardship and renewal of enabling technologies to support modern science and engineering research.

By parallel investment in public education EQC aims to see increased numbers of people taking actions to reduce and prevent damage caused by natural disasters. For more than a decade EQC has used various tools to promote this outcome, and the results of regular consumer surveys have been seen as the way to determine the effectiveness of these measures, which included television commercials, internet and billboard advertising, schools information kits, museum and science-centre sponsorships, ethnic minority education and brochure translations, a mitigation website (www.eq-iq.org.nz) and display road-shows. Research has provided insight into the efficacy of EQC's education and outreach activities, identifying both the strengths and limitations. Surveys have shown that while reported awareness of mitigation methods and solutions has risen, mitigation activity has remained static. EQC's television and print media messages to encourage greater home safety have clearly raised awareness, but other methods will be needed if people are to be motivated to more effectively mitigate risk in their own homes. Research conducted for EQC has provided insight into the barriers to mitigation actions (Paton et al., 2003; McClure et al., 2007). Common factors include perceptions that the problem is insurmountable and the mitigation tasks too difficult to undertake, and the tendency to attribute responsibility for action to others. EQC is now adapting its public education strategy to tailor the timing and delivery of key messages to an increased number of specific audiences, through community-based partnerships, in order to maximise their effectiveness. This approach acknowledges that the media are increasingly diverse and that natural disaster education is a lifelong process.

RISK ASSESSMENT AND LOSS MODELLING

Hazard Monitoring

Risk assessment is the fundamental basis for the process of risk management, requiring adequate knowledge of the hazard and the ability to evaluate trends. To manage a risk, it must first be understood. Without the resources to support and deliver such insight the risk management process has no adequate basis. The diversity of New Zealand's natural landscapes is among attributes ranked highly by those who live here. The same features attest to an active landscape, including seismic activity almost comparable to that of California, steep terrain susceptible to landslip and volcanoes with the dubious distinction of being among the most "productive" magma systems on the planet. To provide essential insight into the country's geological hazards and accurate information during emergencies, New Zealand needs a vigorous, multidisciplinary monitoring programme supported by modern equipment and communications. GeoNet is a distributed network of geophysical instruments and software applications, supported by skilled personnel, that facilitate data gathering and dissemination of information about New Zealand earthquakes, volcanic activity, large landslides and the slow deformation that precedes large earthquakes. Designed and operated by GNS Science, the GeoNet facility represents an approximately $50 million investment by EQC so far, with additional contributions from other agencies, in particular Land Information New Zealand and the Department of Conservation. Management of GeoNet, under an agreement with EQC in force since 2001, includes the public provision of data through a website (www.geonet.org.nz) at specified levels of accuracy and reliability.

GeoNet not only gathers fundamental data necessary to continue high-quality research, but also provides coverage and resolution that allows the research to make gains in applicability and confidence limits, and opportunities for increased research collaboration – necessary for effective analysis of a large data resource. The high degree of system automation in near real-time also permits the delivery of rapid alerts and, in certain circumstances, warnings, for example to support aviation forecasting of ash plume dangers and to evaluate the likelihood of tsunami generated by earthquakes offshore. One of the most exciting developments arising from GeoNet so far is the discovery of "slow earthquakes" (Photo 1), by which some of the movement between the Pacific and Australian plates periodically is released over days or weeks rather than the seconds to minutes, characteristic of damaging earthquakes. The recognition of slow earthquakes is reshaping our understanding of earth deformation beneath the North Island, and providing new insight into seismic hazard.

Loss Modelling

An important dimension to our understanding of natural hazard risks comes from modelling in which we attempt to reproduce the world as we see it and then introduce perturbations to our model(s) to test our assumptions about the "likelihood", "magnitude" and "consequence" of scenario events. Until recently, the assessment of New Zealand's earthquake risk by reinsurance underwriters relied upon a small number of commercially available hazard models, derived largely from offshore (mainly Californian) experience and conditions. Those models incorporated some New

Photo 1: **Silent "slow earthquakes" are pushing parts of the North Island out of shape.** More than a dozen of these events have been recorded since 2002, revealing new insight into the seismic forces at work beneath New Zealand. As more continuous recording GPS instruments are installed as part of the GeoNet project, scientists will be able to track slow earthquakes with increased precision and greater understanding.
(Photo courtesy GNS Science)

Zealand data, but about 10 years ago EQC became aware of growing discrepancies between the output of some models and the indications of hazard emerging from local science research. EQC wanted to have more direct control over its modelling (to avoid the "black box" syndrome), and be able to incorporate local science as it came on stream. A new tool, "MINERVA" (the Roman god of wisdom and good counsel), was subsequently commissioned by EQC, incorporating a decade or more of scientific results from publicly funded hazards research. The output from MINERVA differed markedly from the commercial equivalents, so EQC took this up with the vendors and with its reinsurance providers worldwide.

MINERVA assists in financial and operational planning for a catastrophe response and informs the reinsurance market. In the absence of a database of its own policyholders, EQC relies on the national records of Quotable Value as its basis for exposure. In addition to identification and geo-code location of all 1.5 million residential properties in New Zealand, this database is the source of the date of construction, building area, number of storeys, and construction material. The property database is coupled with a database of construction replacement cost rates and a database of mapped ground conditions to arrive at the data required to determine individual vulnerability values and ground shaking amplification and liquefaction potential criteria. Such models as MINERVA produce a range of results because they cannot forecast the future, only suggest likely outcomes. They are reliant on the data available, and the accuracy of this can be maximised by ongoing and relevant research. New Zealand research institutions are at the leading edge in this area.

SCIENCE TO PRACTICE – THE TRANSFORMATION CHALLENGE

Learning from Disasters

Disasters of any kind sooner or later trigger the review of procedures and practices. In the case of earthquakes, this is land use, building design and construction practice. Each major event reveals or highlights specific issues. The 1994 Northridge (California) earthquake revealed deficiencies in pre-cast concrete construction which were observed by New Zealand engineers during their field inspections following that event (Norton et al., 1994). Concerns were raised about the seismic performance of precast floors in particular. Precast hollow-core floor units had become popular during the 1980s because their reduced weight and speed of emplacement offered significant commercial benefits relative to traditional cast in situ methods. Subsequent full-scale testing by the University of Canterbury of one of the prevalent floor assemblies of that period indicated serious deficiencies in seating and detailing at lower than expected seismic displacements (Matthews, 2004). A multi-agency technical advisory group set up to review the work went on to recommend changes in design approaches. An amendment to the Concrete Design Standard, NZS 3101, was adopted in 2004 and later cited by the Government agency responsible for national building controls (formerly the Building Industry Authority, now the Department of Building and Housing) as a means of compliance with the national Building Code. At that time, public disquiet about the effect of reforms to the regulatory environment of the building industry more than a decade earlier spawned reviews by Government of engineering design and construction practices, including the use of hollow-core floors. The objective was to determine the extent and nature of the use of these systems nationally, to relate that use to the concerns raised by the University of Canterbury tests and to advise the industry of any corrective actions that might be required. A number of existing buildings were identified with potential vulnerabilities in cities exposed to higher levels of earthquake hazard. Local government officials responsible for building controls in those areas were notified and advised to inform the respective building owners to make more detailed checks. Further testing at the University of Canterbury in accordance with details recommended in the revisions to NZS 3101 showed markedly improved performance from the original detail (Lindsay, 2004; MacPherson, 2005). A practice advisory and more general policy have since been published to communicate publicly the Government's position on the hollow core issue (DBH, 2007) and further refinements to the Concrete Standard may be anticipated.

Landslip Risk – Who Owns It?

Many New Zealand communities are vulnerable to landslips, with EQC receiving an average of 770 claims each year over the past five years. Determining the balance between allowing people to develop or use land and restricting their exposure to natural hazards is complex. Understanding how a variety of professionals across the planning spectrum evaluate natural hazard risks, what influences their decisions and how well planning assumptions carry through to performance are not well documented. Important work already undertaken through wider government research has identified best practice in land use planning for landslip-prone areas (Saunders and Glassey, 2007). EQC is now facilitating a follow-up study involving different organisations and local communities to gauge the difference between current practice and best practice, specifically seeking insight into factors that may affect the quality of decisions for the use of landslip-prone land. These factors include the perception of acceptable risk, the influence of legal liability, access to existing technical information, local government resources and internal processes that support decisions on land use, and compliance with, legislation and policies. The findings will be used to map relationships and influences on decision making, with the goal to identify practical ways to improve planning for the management and use of landslip-vulnerable land. Investigation of the capacity and willingness of engineering and planning practitioners to apply the new guidelines also forms part of this assessment.

Adaptation of Standards

Engineering practice in New Zealand follows worldwide trends including principles, guidelines and recommendations, but in some cases changes to design rules may lead to uncertainties about the appropriateness of product or practice refinements. The uplift of a structure from its foundation and rocking during a strong earthquake is a commonly observed phenomenon which has to be accommodated by design, and may also offer the potential to dissipate seismic energy. Special studies are recommended where dissipation of energy is to be accommodated by rocking of foundations, because dynamic interactions between foundations and the soil are non-linear, and neither the structural deformations nor the associated redistribution of forces can be modelled using conventional linear elastic analysis. Although pioneering work on this topic has been published in New Zealand

(Priestley et al., 1978), and recent work at the University of Auckland is aimed at wider implementation of rocking protection as a retrofitting solution (Ma et al., 2006), the revision of the New Zealand Loadings Standard (NZS 4203:1992) has created an immediate need for guidance information for practitioners. In its previous form the Standard allowed simplified design procedures if the assumed ductility of a structure indicated uplift would occur at no less than 50% of the full elastic load – a restriction met by many low-rise, shear wall buildings. However, the revised Standard (NZS 1170.5:2004) requires special studies wherever rocking structures are contemplated, reflecting concerns that the previous rules were not adequately supported by science. The absence of published guidelines to accompany this change posed difficulties for design offices that lack specialised modelling software and expertise. The change affects low- to medium-rise structures in particular, for which alternative design methods to prevent rocking would be uneconomic. This gap in guidance information, which lay squarely between science and practice, has now been addressed with guidelines completed and presently in review (Kelly, 2008). The aim of the new guidelines is to provide a sufficiently robust alternative to the special study currently required by NZS 1170.5, suitable for implementation in a spreadsheet format. The guidelines do not fully quantify non-linear soil properties, radiation damping and other complexities, but should provide guidance information at a level of detail applicable to design office assessment of moderate rocking and relatively simple and regular structures.

Fostering Collaboration – Engineering Lifelines

An example of successful community engagement fostered by EQC since the early 1990s, which has seen the challenge taken up by asset owners, local authorities and professional societies, is the New Zealand Engineering Lifelines process, through which a number of studies of vulnerability and mitigation options have now been completed in the metropolitan and provincial centres (Brunsdon, 2000). There are now lifelines projects and groups established or being planned in most regions of New Zealand, and the process represents an effective regional-scale collaborative model for integrating technical processes with other community considerations. The process is based on the international risk management Standard AS/NZS 4360 (SA and SNZ, 1999, 2004), and is applied on a regional, rather than on an organisation-by-organisation, basis; responsibility for mitigation and preparedness remains with each participant organisation. The relationships and practices fostered through these activities over two decades are now being extended to mainstream, civil defence emergency management planning (Brunsdon and Evans, 2003).

The New Zealand Engineering Lifelines process, through which a number of studies of vulnerability and mitigation options have now been completed in the metropolitan and provincial centres, represents an effective regional-scale collaborative model for integrating technical processes with other community considerations.

A WORK IN PROGRESS

New Zealand is a country subject to a high risk from natural hazards, but with only two severely damaging earthquakes during the past 40 years (1968 and 1987), one moderate volcanic eruptive episode (Ruapehu 1995 and 1996) and one large mass movement affecting an urban area (Abbotsford, 1979). International experience instead has provided the exposure needed for benchmarking of local practice as it evolves. For many professionals such experiences provide a uniquely personal and enduring context for their careers in hazards research and mitigation. The gains from such learning, combined with advanced education and research are accrued over time and applied across three levels of civil administration in New Zealand (central, regional and local government) which play a vital role transforming hazards data and information into processes that improve disaster risk management. Territorial local authorities (73 city and district councils) are responsible for daily planning and consenting processes; regional councils (12) are responsible for environmental policy direction; unitary authorities (4) perform the combined functions of regional and local councils; and central government. Local government both administers and operates within key provisions of legislation that regulate community exposure to natural hazard risk.

For the EQC, a government entity now approaching 65 years of operation, there are opportunities to improve the sharing and application of knowledge related to natural disaster risk across these boundaries as well as those of the relevant technical disciplines. The examples presented above were selected from a diverse pool of research to which EQC has contributed sponsorship often in tandem with industry partners, professional associations and other public sector agencies. The aim here is to illustrate the principle that some research can only be, or is best, undertaken locally, because the knowledge needs are unique – no one else will do it – and it provides essential support to important sectors of the economy and society. Parallel needs exist to nourish the intellectual capabilities that are required to utilise, adopt or adapt science-related knowledge, products and technologies that have been developed elsewhere. To be able to appreciate the significance of trends and technologies that arise elsewhere and to evaluate their relevance and priority for potential use and further local involvement are attributes to which any small country might aspire and EQC seeks to maintain. Improving these outcomes is central to the EQC research strategy and complementary to its investment in skills, research capacity and knowledge. Both elements are a growing determinant of planning outcomes for commerce and government and critical to New Zealand's long-term resilience to natural hazards.

ACKNOWLEDGMENTS

The authors gratefully acknowledge David Brunsdon (Kestrel Group), Des Bull (University of Canterbury), Falyn Edlin and Joanna Martin (EQC), David Hopkins (Department of Building and Housing), Trevor Kelly (Holmes Consulting Group), Jose Restrepo (University of California, San Diego) and Richard Smith (MCDEM) for discussion and helpful guidance in the preparation of this paper.

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Rational *Chaos*:

Human and Traffic Behaviour in Earthquake Events

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Our research into community resilience examines New Zealanders' needs for information and mobility after a natural hazard event, and how these can be met to promote recovery. It is generally conceded that panic behaviour after an emergency is unusual, that individual behaviour is rational and goal-directed. Despite this, we find evidence that the collective rationality of society is lost in the disaster scenarios we examined; a result verified by our study of the Gisborne 2007 earthquake. It is argued here that we should not underestimate how dependent individuals are on various elements of modern society. Reliance on media, communications, and the ability to easily travel greater distances by modern personal transportation modes makes us less able to coordinate ourselves well as individuals and small groups after an emergency event. From the results of four research projects we present some insight into New Zealanders' likely reactions to a major earthquake or landslide.

Modern technology makes everyone available, all the time, almost everywhere. Cell phones make us accessible, email makes us approachable, social networking sites make us global. Our interconnectedness has increased and our vulnerability to these interdependencies is acknowledged (ODESC, 2007). We reach out further than before and we rely on increasingly sophisticated systems to manage our communication and travel.

These advances in the way we communicate and travel increase the risk imposed to society from a hazard event large enough to disrupt communications and transport. When asked, risk analysis experts and civil engineers can describe scenarios involving a large-scale earthquake, but there is a tendency to represent the predicted damage to the transport and communications networks separately within the overall scenario (for example Prentice and Davey, 2004). Follow-up investigations of actual earthquakes that consider the communications and transport systems also tend to consider each individually within their analysis (Bourque, Russell and Gortz, 1996). While we consider these things as different sorts of infrastructure (i.e. they sustain different types of damage), the way people rely on them is basically the same. Following a major earthquake it is well accepted that people will quickly overwhelm any functioning communications network because our need for information exceeds the system's upper capacity limit. The transport network is also basically a form of communication, or at least operates according to the same principles. After even a minor damage-causing earthquake, landslide or other emergency event, a similar behavioural pattern can emerge and we can face the reality of overwhelming what is likely to be a damaged transport network.

Most contemporary disaster research has found that immediate 'panic' responses to threatening situations are quite uncommon. Overall, response behaviour has been characterised as controlled and adaptive with very few documented cases of looting following natural disasters.

THE NATURE OF TRANSPORT AND COMMUNICATIONS RESEARCH

It is our observation that much of the research literature in this area is model-focused, rather than theory-driven. Researchers have developed traffic simulations, and strategies to manage traffic during the recovery process (Arnott, De Palmer and Lindsey, 1991; Abdel-Aty et al., 1995; Yee, Nystrom and Leung, 1996; Deakin, 1997; Gould, 1998), but these rely on questionable assumptions that lack validation, undermining the applicability and usefulness of some models. In this area, models of human decision making are often based on unsupported assumptions. For example, models of evacuations suggest those with cars will efficiently collect children and others without access to cars (Murray-Tuite and Mahmassani, 2005). Models assume "that the risk analysis is informed by the best available social science, while recognising that general principles ... are interpreted in the context of specific emergencies" (Dombroski, Fischoff and Fischbeck, 2006, p. 1675). Lindell and Prater (2007) note, however, that there is a general tendency for social science research to be poorly integrated into evacuation models, with the underlying assumptions being either unrealistic or not based on empirical data.

Researchers recognise that their models assume typical public response behaviours but they do so with an apologetic concern for the poverty of information on how people might actually behave. At least one reason for this is that response behaviours vary according to the amount of 'warning' associated with the event. A sophisticated literature is being developed in America from the nearly routine concern for hurricane and tornado events, but the lessons learned are unhelpful to researchers trying to understand behaviour consequent to earthquakes and volcanic eruptions. The situation is further complicated by the cultural context. Earthquakes in Europe or Asia only approximately inform us of the types of response behaviours we might encounter in New Zealand. Response behaviours are separate from recovery behaviours and in general, our understanding of behaviours is less well developed for the weeks and months after the events than for the immediate responses.

Some good gains have been made in social science by revealing common myths about post-disaster event behaviours. The first of these myths is that there will be widespread panic among the general public due to intense fear caused by emergency situations, and the second is that there will be widespread looting. Most contemporary disaster research has found that immediate 'panic' responses to threatening situations are quite uncommon. Overall, response behaviour has been characterised as controlled and adaptive with very few documented cases of looting following natural disasters (Quarantelli and Dynes, 1970; Quarantelli, 1988). This challenge is based on follow-up event observation or surveys, and represents a very limited methodology. What we need is a basic understanding of the motivations underlying people's behaviours, and the influences on their decision making; an understanding that could be flexibly applied to many hazard types, severities, contexts and locations. We also need to develop methodologies appropriate to revealing this information without relying only on actual disaster events.

OUR CONTRIBUTION TO RESEARCH

Our researchers have stepped into the area of natural hazards research based on our experience with, and understanding of, transportation systems and the integration of physical systems with social responses to those systems. The ecological approach adopted in ergonomics (Gibson, 1979) is extended to study human interaction with infrastructure, recognising that because infrastructure has multiple users, social psychology is a necessary component of the explanation of relationships. Two of the objectives of the research programme

Video simulations of four earthquake scenarios were created by Opus as a context for survey participants. These videos were created for a moderate (6.8 on the Richter Scale event) and a severe (7.5 on the Richter scale) earthquake event in a home and work setting. Above is the home setting before and after the severe event.

focus on this dependence on modern technologies. The first is on travel – the need for mobility in response, the extent to which this need will be met, and how improving this mobility will help in recovery. The second is in terms of information needs – with many sources available to us quickly, it examines the need for information, the sources chosen (particularly for "good" information), and the availability and ability of the media to provide this information.

The immediate difficulty of studying behaviour connected with natural disasters is the limited sample of people who have experienced any such event. To overcome this problem, a new method was developed that presents multimedia earthquake scenarios to members of the general public using laptop computers. Response behaviours under two scenarios of differing severity (Prentice and Davey, 2005) were examined. Scenario 1 was a moderate event registering 6.8 on the Richter scale, causing approximately 230 injuries, 15 fatalities and moderate damage to infrastructure. Scenario 2 modelled a more severe event, a magnitude 7.5 on the Richter scale causing approximately 3,740 injuries, 490 fatalities and severe damage to infrastructure. These scenarios were represented to the public using what became known as the 'Shake Videos'. A full-size set was built on a hydraulically powered shaking table (that allowed lateral movement only) at Opus Central Laboratories that was dressed to resemble a typical dining room and then an office. Two versions of each setting were filmed for each of the two differing earthquake magnitudes. The beginning and end frames of the 40-second video of the large event scenario are represented in the images above.

The response behaviour of the participants was examined by showing them the videos and asking questions about what they would do if they experienced the event as depicted. We varied both the location (home or office) and the severity of the event (moderate or major event). Two studies were conducted using this method; the first examines information needs (Walton, Lamb and Dravitzki, 2007), and the second examines travel behaviour (Walton and Lamb, 2009) after an earthquake.

INFORMATION SEEKING SIMULATION

A disaster event essentially creates a situation where individuals have a greatly increased need for information (i.e. to determine the safety of friends and family), while their ability to acquire this information through normal channels is vastly diminished (i.e. because of loss of electricity, phone, and reduced ability to travel). The first study, conducted with 562 members of the public, examined preferences for different media (TV, radio and internet) after viewing one of the four earthquake simulation videos. Subsequently the effect that media information had on perceptions of the earthquake's severity was assessed.

Before viewing the earthquake simulation video, the majority of people believed that radio information would be the fastest to respond, most useful, most accurate, and most trustworthy source of information. Subsequently, after watching the simulation, two-thirds of participants selected radio first. Initially people tended to overestimate the level of damage that the earthquake caused. Instead of bringing

As well as the earthquake scenario videos, a number of images were created showing the type of damage that could occur. Above is a manipulated image of the potential damage to the Thorndon bridge in the severe event scenario.

perceptions of severity closer to an accurate representation, viewing media increased their already inflated judgments of severity. Television caused the largest distortion in perceptions of severity, likely because of the strong impact of visual imagery. Typically the news media focus only the worst parts of the damage, showing these repeatedly, while neglecting to show surrounding areas that suffered less damage (Smith, 1992; Walters and Hornig, 1993). Participants were egocentric in their view that their experience of the event was at the epicentre of the earthquake. While the major event was judged more severe than the moderate event, location (i.e. work or home) had no effect on judgments of severity, or news media.

These findings stressed the importance of information, and the sensitivity of people to the information they receive regardless of its accuracy. This led to results supporting the theory that post-earthquake travel is a form of information seeking.

TRAVEL BEHAVIOUR SIMULATION

Our second study concerned travel behaviour in Wellington after the event (Walton and Lamb, 2009). A group of 803 people were shown one of the four earthquake videos, and told that the event occurred at 9:10 on a weekday morning. Participants were then asked to indicate their likely travel behaviours over the next 48 hours. To facilitate this task, participants were given four main options: travel, seek information, assess the current location or stay at the current location. Each activity had an associated duration, which was automatically updated each time the participant made a choice. These four options were cycled through until either the 48 hours were over, or the participant indicated they would not travel any more. The survey was integrated with geographic information systems (GIS) mapping software that allowed the participant to indicate the actual location of their work or home, and where they would subsequently travel to. The shortest path via road was calculated for each trip indicated, and distance and predicted trip time were determined.

Around 60% of people indicated they would travel within half an hour of the earthquake occurring. People at work at the time of the event were 3.5 times more likely to travel than those at home. To put this in perspective, the modelled volume of traffic produced by the moderate earthquake approximated 1.1 to 2.3 times the volume of travel that would be observed at 6 pm on an average weekday in Wellington (based on data from the Ministry of Transport's New Zealand Continuous Household Travel Survey). In comparison, the major event would likely result in 0.9 to 1.8 times normal peak-hour travel. The lower proportion of travel observed in the major is event is probably because of an increased reluctance to travel on a severely disrupted network.

Between 25% and 33% of participants indicated they would travel by motor vehicle, which would lead to gridlocked traffic with increased journey times or a high incidence of car abandonment, or to some combination of the two. The likelihood of driving increased with distance of the trip to be undertaken. On aggregate, people were more likely to walk trip distances up 3.25 km, after which people became more likely to drive.

Participants were not specifically informed of the state of the road network in the study; however, the increased damage to infrastructure in the major event would substantially impede the ability of people to travel by motor vehicle. Despite this, the volume of intended travel was similar under both scenarios. In this case it is more likely that people would be forced to abandon their cars and walk, which has been observed following earthquakes in Japan (Takuma, 1978; Mikami and Ikeda, 1985).

As event severity increased, so did the motivation to travel. Overall, 33% of participants indicated they would travel despite official advice to stay where they were, and 30% indicated that if necessary they would find a way to bypass police roadblocks. While significantly more people travel from work than home, people at home still travel.

People from work predictably travel home first, but travel from home is for a variety of purposes, usually to check on, or simply be around, other people.

REAL EVENT VALIDATION

Although the findings of our travel and information needs simulation research supported overseas research literature they needed to be validated against a real event in New Zealand. The relatively small 2007 Gisborne earthquake provided an opportunity for some validation of our findings (Lamb and Walton, 2009a). Reports that roads were "packed with traffic" and telecommunications were severely affected (ONE News, 2007), as well as the earthquake size and proximity to a city centre, made this event a very good comparison to the moderate event scenario modelled. We undertook a validation survey of 438 Gisborne residents, about three months after the event. Despite most residents experiencing the earthquake at home (the event occurred at 8:50 pm), a large volume of traffic flooded the network. Nineteen percent of individuals travelled within 25 minutes of the event; this rose to 37% within an hour. The consequent volume of traffic approximated peak weekday traffic (5–6 pm on a weekday) within an hour of the shake.

The small numbers of respondents who were away from home were five times more likely to travel than those at home. The stated purpose for most travel was to reunite with other people (47.2%), followed by to assess damage (28.2%). The finding supports the theory that family and friends are the first priority (Mileti and Nigg, 1984; Mikami and Ikeda, 1985; Quarantelli, 1988). Only 7.7% of people stated they moved to higher ground. People were not aware that the earthquake could trigger a tsunami or were not concerned by the possibility; alternatively, some may have had knowledge of Gisborne District Council hazard maps and known they were not at risk. Despite official advice to avoid travel by motor vehicle unless injured, 95% of all trips were made using private motor vehicles. Eighty-seven percent of people indicated that the only reason they did not travel was because they had no need to. This evidence suggests that peoples' actions and beliefs are rational, but self-interested. This sudden influx of traffic and the over-reliance on motor vehicles is a form of social chaos that is problematic for emergency services as they are not free to move about the emergency zone unimpeded. The opportunity to manage public behaviour through measures such as cordons (as were used in Gisborne) can be undermined by the scale of event or the motivations of the public to ignore them.

The basis of the research has largely been computer-based surveys with the general public. Above is one such survey set up at Te Papa Earth Rocks event 2008.

Despite the population and geographical differences between the simulated event in Wellington, and the actual behaviours exhibited in Gisborne, the behaviours identified were fundamentally the same. The event creates a need to travel because of the desire to obtain information and to check on friends and family that is achieved through travel. Both events also highlight the problematic role of motor vehicles.

THE PROBLEM OF ABANDONED VEHICLES

The abandonment of vehicles was specifically examined in a fourth study (Lamb and Walton, 2009b) using a similar methodology, where participants were presented with a scenario in which their trip home by motor vehicle is disrupted by a landslide blocking the road. When the landslide was encountered, 49% of participants abandoned their vehicle and continued on foot, and 31% turned their vehicle around and attempted to find an alternative route. Of all the drivers surveyed, 32% adopted a strategy of minimising potential walking distance by driving as far as they could before abandoning their vehicle to continue on foot. The behaviour of others was found to influence this decision, as participants who observed other people abandoning their vehicles and walking were 2.6 times more likely to mimic this behaviour than people who encountered the landslide alone. This social influence not

We can imagine a scenario where the major problem is not the event causing the disruption but the behaviour of people consequent to the event.

only affected their intended behaviour, but also their belief that the distance home was actually a walkable distance.

CONCLUSIONS

The research programme reveals evidence of response behaviours that binds together pieces of theory from previous investigations. We find respondents to our surveys can consider the event ahead of experiencing it; the decision making observed in simulations is also observed in post-event evaluations in overseas studies and in our validation study considering Gisborne in 2007. We find rational, goal-directed behaviour, but it is not coordinated or responsive; it is idiosyncratic and collectively uncontrolled. This behaviour can be considered a problem in and of itself. We can imagine a scenario where the major problem is not the event causing the disruption but the behaviour of people consequent to the event. Abandoned cars, traffic jams and highly motivated people all wanting to get home at once face delays and frustration made worse by people crisscrossing a damaged network to locate friends and family and the need of emergency workers to coordinate their own logistics. Our evidence suggests the usual workday rush hour is a comparatively ordered event.

The major underlying motivation for the activity is the natural and reasonable attempt to unite with people in small groups. The first choice is one's immediate family. The second choice is our friends or relatives who are nowadays, problematically, scattered across a wide geographical area. New Zealanders' usual reliance on vehicles is invoked to achieve the basic goal of getting together. Travel behaviours are made worse if the communications network is disrupted so that our concern for the welfare of others, and the need to communicate or share the circumstances of the event, cannot be assuaged with different media.

We do not promote a solution to the problems identified. Opus is developing software that models travel movements on a disrupted network, to assist those who manage emergency events and to be used in research to understand how people might respond in the longer term following a major disruption to the road network. Other parts of the programme consider the long-term decision making influencing return to work behaviours. A basic premise of the research programme remains an active concern. The need is to understand the influences on individuals' decision making under emergency situations and to question the differences in circumstances, technology and context that may make New Zealanders' responses to emergency events unlike those observed anywhere else.

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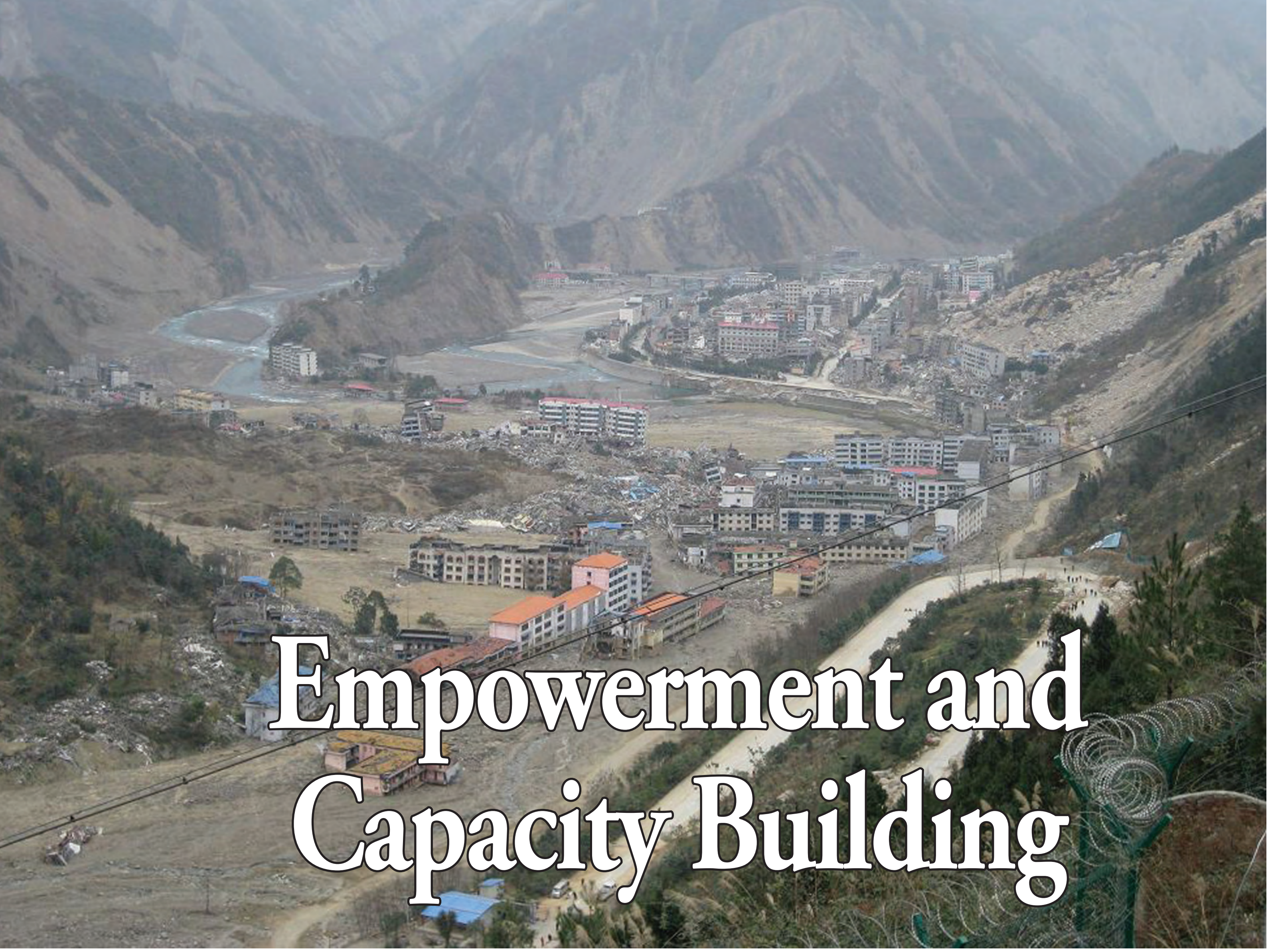

Empowerment and Capacity Building

Recovery Lessons from an Earthquake in China

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On 12 May 2008 an earthquake measuring 8.0 on the Richter scale struck Western China's province of Sichuan and its neighbours, killing 69,266 people, injuring 374,643 people and leaving 17,923 people missing (as of noon, 11 September 2008).

▲ The town of Beichuan in December 2008, six months after the earthquake in Sichuan province

The earthquake caused widespread destruction to buildings and infrastructure. Approximately 34,125 kilometres of highways, 1,263 reservoirs, 7,444 schools, 11,028 medical institutions and numerous urban structures, rural residences and factories were devastated by the earthquake with direct economic losses reaching RMB$843.77 billion (State Planning Group of Post-Wenchuan Earthquake Restoration and Reconstruction, 2008). The subsequent persistent heavy rains and numerous aftershocks further compounded the situation, leading to a large number of secondary hazards such as landslides, landslips, mud-rock flows and "quake lakes".

According to the China Earthquake Administration (2008), the earthquake originated on the Longmenshan fault. The energy source of the Wenchuan earthquake and Longmenshan's southeast push came from the crush of the Indian Plate onto the Eurasian Plate and its northward push. The inter-plate relative motion caused large-scale structural deformation inside the Asian continent, resulting in a thinning crust of the Qinghai-Tibet Plateau, the uplift of its landscape and an eastward extrude. Near the Sichuan Basin, Qinghai-Tibet Plateau's east-northward movement met with strong resistance from the South China Block, causing a high degree of stress accumulation in the Longmenshan thrust formation, which finally caused a sudden dislocation in the Yingxiu-Beichuan fracture, leading to the violent earthquake of M8.0.

In the days following the disaster, many domestic and international reconnaissance teams of engineers made detailed preliminary surveys and assessment of damaged buildings. The findings showed a variety of reasons for the failure of structures to withstand the earthquake. Besides the distinctive mountainous topology and seismicity, another major issue attributable to construction failure was the construction method used in the damaged region. Due to local custom, brick masonry was the predominant type of construction in Sichuan Province, particularly used for housing in rural and mountainous terrain areas. Construction defects including poor-quality cement and bricks, an improper concrete-making operation, insufficient drawings, scant attention to building codes, and lack of seismic-resistant structures and qualified skilled construction staff were primarily responsible for structural collapses and damage during the earthquake.

RECOVERY

After the earthquake, the emergency response was impressively rapid and decisive with enormous effort focused on rescue and resettlement. The People's Liberation Army (PLA) played a significant role in searching, rescuing, repairing access and maintaining order. The State Council quickly established an Earthquake Rescue and Relief Headquarters providing the fundamental principles and priorities for resuming the livelihoods and physical environment of 51 counties in the 132,596 km^2 affected region and its 20 million residents (US Earthquake Engineering Research Institute, 2008). The General Coordinating Office for Earthquake Relief in each affected municipal area was established to organise and coordinate relief work of the army, police, medical staff, non-governmental agencies and other social assistant individuals or groups.

The State Council took swift legislative action to establish a multi-governmental management framework for the recovery endeavour. The *Regulations on Post-Wenchuan Earthquake Restoration and Reconstruction*[1] sets guidelines for the reconstruction and provides an important legal ground for various departments and government agencies, both inside and outside the quake-hit region, to assist with recovery and reconstruction.

As a supplementary policy to aid the full implementation of the regulations, *One-on-One Assistance Program for Wenchuan Post-earthquake Restoration and Reconstruction* became a key constituent of China's post-disaster management framework. The earthquake-stricken areas of Sichuan, Gansu and Shaan-xi provinces were divided into 24 districts and twinned with 24 relatively developed localities across China. For instance, the historical tourist city Dujiangyan is sponsored by Shanghai municipality and the well-known industrial city Mianzhu is assisted by Jiangsu province in China's developed east coast. Sister localities have been tasked over the next three years with funding 1% of their GDP, provision of human resources and temporary housing units, and in-kind support from planning institutions and other departments in association with disaster reconstruction.

Many recovery programmes at local level aimed specifically at livelihood issues have been effective in addressing employment needs and community capacity with a view to restoring the normal living conditions of the stricken community in a short time (Photo 1).

1 Came into effect on 4 June 2008.

Photo 1: **With livelihood and public facilities returning to normal, post-earthquake, children play in Beichuan 'Hope Primary School' established by the Chinese Academy of Sciences.**

RECONSTRUCTION

The guarantee of people's well-being was deemed the fundamental issue in post-Wenchuan earthquake restoration and reconstruction. The top priority was, therefore, given to repairing and rebuilding urban and rural residential houses and restoring public facilities and infrastructures, to ensure the resettlement, stability and reassurance of the affected population (Photo 2).

Three months after the earthquake a comprehensive reconstruction plan, *The State Overall Planning for Post-Wenchuan Earthquake Restoration and Reconstruction*, was developed in partnership with all parties involved and was released for public review. As the recovery steps entered into an overall rebuilding stage, the role and responsibilities of the Chinese Government have shifted to technical support and supervision of reconstruction implementation with less administrative intervention.

One of the most pressing challenges is to ensure higher seismic standards and construction quality in rebuilding in order to minimise vulnerabilities of buildings to future disasters. In rural areas, a capacity building programme combined with a targeted monetary incentive campaign was initiated locally to integrate disaster risk reduction into the reconstruction process. The local government organised experienced engineers and technicians to advise and provide training on safe rebuilding. Picture books, simplified construction guidelines, checklists, and on-site demonstrations and inspections were provided to house-owners to convey the knowledge of disaster risk mitigation and to change the prevailing construction practices. RMB$16,000 subsidies were only granted to rural households on the premise of better understanding and compliance with construction standards. Likewise, in urban areas, a 'filing system' was launched by local government. Only when drawings and schemes for rebuilding or retrofit were provided, were subsidies varying from RMB$1,000 to RMB$8,000 given to the household in need.

The 'One-on-One Assistance Program' featured prominently in the reconstruction, through assistance with rebuilding infrastructure such as roads, water and sewage, electricity, and broadcasting, as well as public buildings such as schools, hospitals, clinics, and key sectors of the economy, such as tourism and production facilities. Sponsor localities and their local reconstruction counterparts have been communicating and cooperating. As winter drew near, reconstruction works were accelerated in some quake-hit areas where local officials had promised that no people in the quake-hit area would live in the makeshift tents during the wintertime. The time pressure had been best met before Chinese traditional New Year through partnerships between government institutions and communities.

At the early stage of reconstruction, most material production institutions were still in a paralysed state, which created a disproportionate imbalance between construction material demand and supply, resulting in soaring price escalations. The most needed resources were bricks, cement and aggregate with 127%, 30%, and 125% rate increases respectively thus far.[2] Precipitous wage increases of local labourers also served to undermine the sustainability of the reconstruction trade market. A consortium of government interventions and price limitation policies including setting maximum rates, profit control for material retailers, designating production supply, and assigning inspectors to monitor selling prices, have, to some extent, helped the reconstruction effort.

LESSONS FOR NEW ZEALAND

It is widely acknowledged that China coped with this large-scale natural disaster well and effectively, and efficiently dealt with relief and recovery in the aftermath of the Wenchuan Earthquake. Nevertheless, many of the challenges that faced the Chinese Government and reconstruction practitioners

2 Price contrast between in pre-earthquake April 2008 and in post-earthquake February 2009.

are still visible. The coordination problems among different players and imbalance between Government's macro-control and market self-regulation remain a serious concern.

There are lessons to be drawn from the disaster for both China and international society. There is a need for speed and efficiency in relief work, a need to build a strong organisational structure to deal with reconstruction, and a need to keep social communities fully involved in planning and implementing reconstruction throughout all post-disaster stages.

Central policy planning with a decentralised mechanism to ensure decision making and involvement of all players and implementation of the recovery plan made recovery relatively smooth. The special powers from all parts of government, across different sectors, at national, provincial and county levels were consistent. Statutory procedures were circumvented using a 'Green Lane' open routine.

The *Regulations on Post-Wenchuan Earthquake Restoration and Reconstruction* set the legal requirements for reconstruction. The appropriate legal system in line with a series of policy changes for recovery made effective coordination and delivery of reconstruction works possible.

The sustainable reconstruction process was well planned and implemented with a wide variety of community participatory approaches that incorporated hazard mitigation and risk reduction measures into a holistic reconstruction framework.

The Wenchuan Earthquake recovery and reconstruction serves as an example of success in what was a disastrous and complex environment. Further study of this recovery and reconstruction should be capitalised upon by New Zealand in order that the potential for improving our own recovery, reconstruction and community resilience can be realised if New Zealand faces a similar disaster.

The sustainable reconstruction process was well planned and implemented with a wide variety of community participatory approaches that incorporated hazard mitigation and risk reduction measures into a holistic reconstruction framework.

Photo 2: **Traditional cultural features were integrated into the reconstruction design and building.**

ACKNOWLEDGMENTS

We greatly appreciate the hospitality and assistance with our reconnaissance provided by Professor Qingyuan Wang, Dean of Faculty of Architecture and Environmental Engineering of Sichuan University and Professor Dalu Tan, Head of Department of Construction Management in Sichuan University. We would like to thank all those people who made efforts to facilitate our trip to China.

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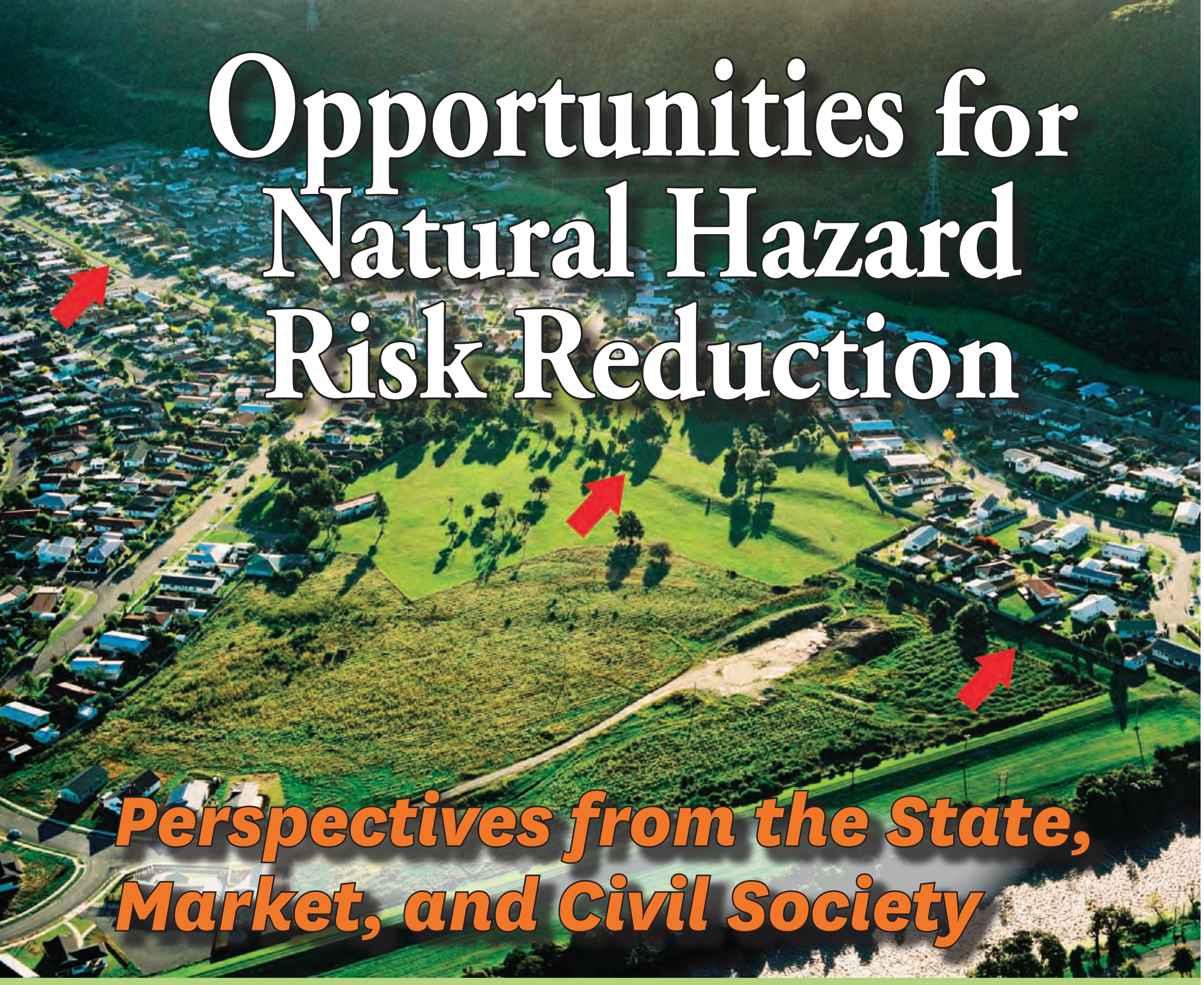
Opportunities for Natural Hazard Risk Reduction

Perspectives from the State, Market, and Civil Society



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▲ *Photo 1:* **Aerial view of Totara Park, with the location of the Wellington Fault shown** (Source: M. Low, GNS Science)

INTRODUCTION

Risk reduction is embedded in the emergency management sector in New Zealand, with it being included as one of the '4Rs' (readiness, reduction, recovery, response) of emergency management. However, risk reduction is not just an emergency management responsibility – risk reduction is also required to be considered under the Resource Management Act 1991 (refer to Saunders et al., 2007a; Saunders et al., 2007b).

There are three key groups of stakeholders that have an influence on integrating risk management and risk reduction: the state, the market, and civil society. This article discusses the role and relationships of each of these key stakeholders, and how they can have an influence on the natural environment. The article begins by outlining the relationships of all stakeholders, then provides examples where each of these stakeholders has taken a lead in natural hazard risk reduction in New Zealand.

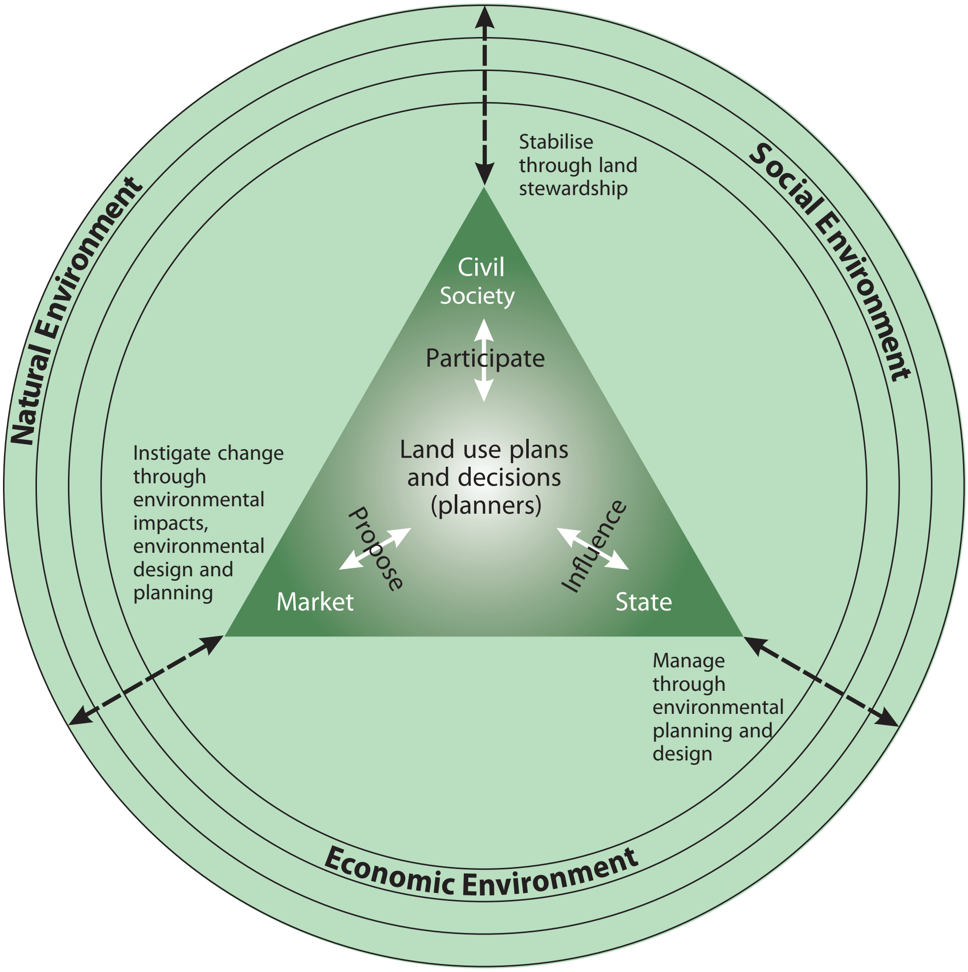

Figure 1:

Participants and relationships in environmental planning and management with the natural environment (after Saunders & Glavovic, *in prep*)

THE RELATIONSHIPS BETWEEN THE STATE, MARKET, CIVIL SOCIETY AND THE NATURAL, SOCIAL, AND ECONOMIC ENVIRONMENTS

Land use planning is undertaken by three key sectors of a community – by the state (i.e. regional councils and territorial authorities), in that it sets policies and rules for development; the market, in that developers design developments within the constraints of the policies and rules set by the state; and civil society, whose interests are represented by elected officials on councils, and live in communities developed by the market under state regulations. Civil society is able to assert a certain amount of pressure on the market for more sustainable developments (i.e. eco-villages, energy efficient housing).

Figure 1 represents the key participants and power relationships in environmental planning, and integrates insights from three models developed by Kaiser et al., 1995; Randolph, 2004; and Berke et al., 2006. In this figure, three groups are represented in a triangular formation: civil society, the state, and the market. In the middle of the formation linking all three are land use plans and decisions, which are managed and administered by planners. Surrounding this triangle is the natural environment, which includes natural hazards, and incorporates sub-sets of the social and economic environments – all of which may be affected by natural hazard events. These concentric circles reflect a 'strong sustainability' perspective to reflect the inherent limits and finite character of natural systems within which social and economic systems are embedded (e.g. Neumayer, 2003).

When the market economy is strong, the market (representing private activities) to a large extent determines the fate of the environment. For example, developers, farmers and industry have effects on the environment, respond to and implement environmental regulations and programmes, and develop new technologies and approaches to be sustainable. Although their actions may produce a negative impact on the environment, planners and designers interacting with this group are often responsible for innovative practices and designs that protect and preserve the environment (Randolph, 2004), ultimately resulting in a better outcome than had this interaction not occurred.

The state (government), at central, regional, and territorial level, plays an important role using the power vested in it by citizens to regulate and thus influence private activity that affects the environment. For example, growth strategies and structure plans aim to manage growth by controlling land use and development (Randolph, 2004). This can involve regulatory tools, including zoning, subdivision regulations, and more innovative performance standards to control the location and impact of development. Non-regulatory tools are also becoming more popular (Randolph, 2004), including design guidelines, maps, and guidance notes (see www.qualityplanning.org.nz for examples of these).

The final group is civil society, which includes non-governmental organisations, environmental and citizen groups, land trusts, property owners, and others with an interest in the activities of the market and the state (Randolph, 2004). These groups can affect the activities of the market and the state in a number of ways: by participating in government planning and decision making; by pressuring or directly negotiating private development project proposals; or by actively preserving environmental resources through land trusts and conservation easements (Randolph, 2004).

Environmental planning and design interacts with the natural environment (and thus the social and economic environments) at state and market levels, with the expectation of limiting effects of development on the natural environment via planning controls.

The state interacts with the market, via growth management, regulation and enforcement, planning and design, and collaboration. The market is both constrained and enabled by what policies and rules exist in plans, including those for natural hazard risk reduction. The state also interacts with civil society, and represents the interests of civil society through policies and plans. However, civil society can also exert political pressure on the state via the consultation process to determine policy outcomes.

Figure 1 show these relationships with graduated shading, reflecting that the relationships are dynamic, in that one key group may exert more influence than the other two, depending on the circumstances and stage of the planning and development process. The following section provides examples where the state, market and civil society have each taken the lead in a natural hazard risk reduction initiative.

CASE STUDY EXAMPLES

THE MARKET: TOTARA PARK, UPPER HUTT

The Wellington Fault runs through the Upper Hutt suburb of Totara Park, which has been planned with a number of special features to protect residents from a potential fault rupture. One section that the fault traverses has been set aside as a recreation reserve (California Park). Through the rest of the suburb, the fault line runs down the centre of California Drive, which has two lanes separated by a wide grassed berm that covers the fault trace (see Photo 1, an aerial view of Totara Park, with the location of the Wellington Fault shown). No house is closer than 20 metres to the fault, and very few service lines (such as water, gas and sewer systems), cross the fault. Those that do cross it have flexible joints to withstand ground shaking (Te_Ara).

These measures are a result of a 1960s subdivision designed and built before its time. Originally, the greenfield development consisted of not only housing, but also included a hospital, school, and an industrial estate. The subdivision plan had been created without any regard to the fact that the entire subdivision was crossed by the Wellington fault scarp. The well defined and prominent 3 m high scarp ran virtually in a straight line across the paddocks of the original farm land (Stevens, 2005, as shown in Photo 1).

The proposed subdivision went to the Planning Tribunal, as a proposed zoning change was required. Evidence was given at the hearing on the location of the fault (which had been mapped by the New Zealand Geological Survey's (NZGS) chief geologist), however the subdivision was approved as it was submitted, with developments crossing the Wellington fault (Stevens, 2005).

Although the actual case had been lost, the scientific evidence had struck a chord with the developer, as they later asked the NZGS to accurately peg the trace of the fault. A new subdivision plan was then drawn up, taking full account of the location of the fault line. A segment of California Drive, one of the main roads, was designed as a dual carriageway, with a centrally placed grassed strip aligned along the fault. The combined width of the strip and dual carriageway is sufficient to ensure that buildings are located on either side of the fault (at least 20 m away from the fault line), and so are well back from any potential fault movement. Non-return valves were installed on pipelines crossing the fault line. Also, the planned hospital

Photo 2: **Signage over the Wellington Fault, California Park** (Source: M. Low, GNS Science)

and industrial area (which were originally sitting on or very close to the fault line) were removed from the plans and the proposed school shifted to a site some distance away from the fault (Stevens, 2005).

The segment of the fault scarp extending northwards from California Drive to the edge of the Hutt River was allocated as the subdivision's reserve contribution, and named California Park. North of the Hutt River, the owner of the land (Mr Harcourt, of Harcourt's Real Estate) set aside as a reserve the strip of land to either side of the fault (now known as Harcourt Park), where displaced terraces from past earthquake fault rupture events are now well displayed and signposted (Stevens, 2005) (see Photo 2).

The final subdivision design was directed by the developer, representing the 'market' in Figure 1. The developer took the lead in reducing the risk to the community from fault rupture by incorporating the Wellington Fault into the design of the subdivision, resulting in a positive outcome for those who now live in Totara Park. It is questionable as to whether, given the same circumstances, a developer would react in the same responsible manner in today's climate, especially if the subdivision has already been approved as in this instance.

THE STATE: THAMES-COROMANDEL DISTRICT COUNCIL

Areas of the Thames-Coromandel District are prone to flooding. In recent times, residents have experienced a number of devastating storms, the most recent notable event being the 2002 "weather bomb". Local and central government agencies now wish to ensure future (and potentially more intense) events cause the least possible damage to people, land and property. The focus is on ensuring patterns of land use are sustainable in the long term and that with time communities respond wisely to the predicted increase in frequency and intensity of storm events associated with climate change (TCDC, 2008).

To improve the management of risk associated with flooding, the Thames-Coromandel District Council is proposing a number of changes to the way things have been done in the past. The changes include a significant commitment to vegetation and pest control, improvements to Civil Defence procedures and physical works such as stop banks, and improved roading. A number of these changes have been approved as part of a package of work called the Peninsula Project (a growth strategy for the district), and include a plan change and variation to the flooding part of the natural hazards section in the District Plan (TCDC, 2008). The plan change/variation proposes to amend the existing objectives, policies and rules in the District Plan relating to natural hazards and subdivision, use and development in areas subject to flooding. The council is also considering formalising further commitments to a package of non-statutory works via a natural hazards strategy or its equivalent, although this has yet to be decided (TCDC, 2008).

The Thames-Coromandel District Plan (currently operative in part) identifies Natural Hazards as a 'Significant Resource Management Issue' and contains a number of objectives and policies related to Natural Hazards. It is proposed to make alterations to the objectives, polices and rules via a plan change and variation to avoid risk to life from flooding and reduce risk to property and infrastructure. The proposed changes are intended to provide greater clarity regarding the intended outcomes and assist efficient plan administration and implementation (TCDC, 2008). The proposed plan change and variation will result in 18 sections of the District Plan being amended.

The proposed plan change and variation is yet to complete the consultation process at the time of writing (see http://www.tcdc.govt.nz/ConsultationsAndSubmissions/default/ for details). However, regardless of the final outcome, the plan change and variation shows a clear intention by the council to have more of an influence in directing sustainable development that incorporates flood risk. This in turn will have an impact on the market (i.e. any future development within a flood risk area, as new controls will have to be met) and civil society (in that the future flood risk may be reduced).

CIVIL SOCIETY: COAST CARE BAY OF PLENTY

Dunes are the backbone of our beaches, the buffer between the land and the sea. A properly functioning beach system will contain a wide, well-vegetated and gently sloping dune, which is a reservoir of sand. During a storm the dune is a sacrificial zone, buffering the effects of large waves. Native dune plants play a vital role in stabilising dunes, by capturing light sand which blows onto the beach. Without these plants, the sand blows away and dunes disappear leaving the remaining land vulnerable to erosion. Grazing by stock, excavation for development, introduction of exotic plant species and inappropriate pedestrian pathways have significantly reduced the abundance of these specialised native dune plants. When the dunes are gone, structural works such as rock sea walls are often installed to protect property from storm waves, and often the sandy beach is lost as a result (see EBOP). To help improve the condition of the dunes in the Bay of Plenty (BOP), a community group called Coast Care was created, where volunteers restore the function of their beaches by replanting native plants onto the dunes which will hold windblown sand.

Coast Care was first established in the BOP in 1994 by collaboration between Environment BOP (the regional council), coastal territorial authorities and the Department of Conservation. The aim of the group was to investigate best dune management options, then inform and involve communities in the most appropriate methods for reversal of dune instability and the consequential erosion problems (Hall, 2006). The primary activities of community Coast Care groups (of which there are over 30) includes volunteers planning their projects, and replanting and fertilising the native plants which were historically abundant on their dunes (Jenks and O'Neill, 2004).

One of the strengths of the Coast Care programme is its operation by and through local community members who are taking an active role in managing their own beaches – and in doing so are providing local solutions for local problems. Groups decide the way in which they wish to operate, i.e. whether or not to have a formal structure like a committee (Jenks, 2004). Coast Care BOP projects and objectives enjoy high community awareness and support through newsletters, attractive signage, media articles and an excellent school education package. Because they are community initiated and implemented, Coast Care projects have very strong community support and empathy in the Bay of Plenty (Jenks and O'Neill, 2004).

The results of the Coast Care projects are impressive – many dunes are now well vegetated, sufficiently wide, and improving the sand reservoir on beaches with restored natural character. Animal and plant pests are being controlled as part of the programme, and many rare and

Photo 3
Motiti Road, Papamoa East June 1997
(Source: Environment Bay of Plenty)

Photo 4
Motiti Road, Papamoa East, March 2004
(Source: Environment Bay of Plenty)

threatened plant species are providing habitat for native insects, skinks, geckos and birds (Jenks and O'Neill, 2004). The programme has transformed eroding coastal environments into dune accretion areas, which provide superior abilities to absorb the impacts of storms, and to self-repair after a storm (Jenks, 2004). Photos 3 and 4 show what a success the Coast Care programme has been – Photo 4 was taken after the impact of 10 m waves from Cyclone Ivy, and no appreciable damage can be observed. Further photographs showing the huge differences pre- and post-Coast Care initiated projects can be seen at http://www.mfe.govt.nz/issues/climate/resources/workshops/preparing-climate-change/restoring-natural-dune-resilience.html.

Community support and understanding of natural coastal processes is increasing as the physical results of this work and informative publicity change the attitudes of even once-doubtful observers (Jenks and O'Neill, 2004).

The Coast Care programme provides an example of civil society – in this case, coastal communities – taking the lead and participating in protecting and enhancing valuable dune systems (this is shown as 'land stewardship' in Figure 1). While this programme is supported by a collaboration of state agencies (councils, Department of Conservation), it is only successful because the local communities are taking ownership and managing their own projects. By reinstating dune systems, the effects of erosion, sea level rise, storm surge, and impacts from tsunami of all sizes are greatly reduced.

CONCLUSION

As shown by the case study examples, hazard risk reduction initiatives can be led either by the state, market, or civil society. However, they do not work in isolation from each other: policies made by the state impact on both the market and civil society; the market can influence state policies and is influenced by civil society; and civil society is represented by elected members of the community who influence local policies and objectives; and can take a community lead in risk reduction after development has proceeded. Set within a broader sustainability context, natural hazards have an impact on the natural, social and economic environments. However, natural hazards do not cause a risk unless people and property are located within vulnerable areas. It must not be forgotten that natural hazard events have the potential to overwhelm the state, market and civil society – a scenario we all must be prepared for.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the support of the Foundation for Research, Science & Technology 'Geological Hazards & Society' research programme undertaken at GNS Science; Zonta/Building Research Award; and Julia Becker of GNS Science for her review.

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Pre-Event Recovery Planning for Natural Hazards

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GNS Science

Communities can be severely disrupted by disasters – physically, socially and economically. Recovery of communities follows, and often coincides with, the immediate response phase of a disaster. The recovery process is complex, involving coordination and cooperation from many parties to achieve holistic community regeneration.

The need to consider recovery issues prior to disasters is advocated widely in both international and New Zealand-based literature (e.g. Norman, 2004; Topping, 2008).

The process of recovery can be greatly improved by working through issues and solutions before an event occurs.

In New Zealand, recovery is considered in the context of the Four R's emergency management continuum: risk reduction, readiness, response and recovery. While the recovery phase is commonly considered to be an opportune time for risk reduction activities to occur, it is also the case that the risk reduction and readiness phases of emergency management planning are appropriate times to plan for recovery. This article is specifically focused on pre-planning for land use recovery. A methodology based on the AS/NZS 4360/2004 Risk Management Standard, has been developed for pre-event recovery planning for land use to guide integration of emergency management planning and land use planning for recovery. Land use recovery pre-planning can result in better coordination, efficiency and appropriately targeted reinstatement of affected areas (Becker et al., 2008).

While this article deals primarily with land use, the responsibility for recovery under New Zealand legislation falls upon many agencies and departments, and

▲ **Flooding, Lower Hutt, February 2004.** (Source: MCDEM)

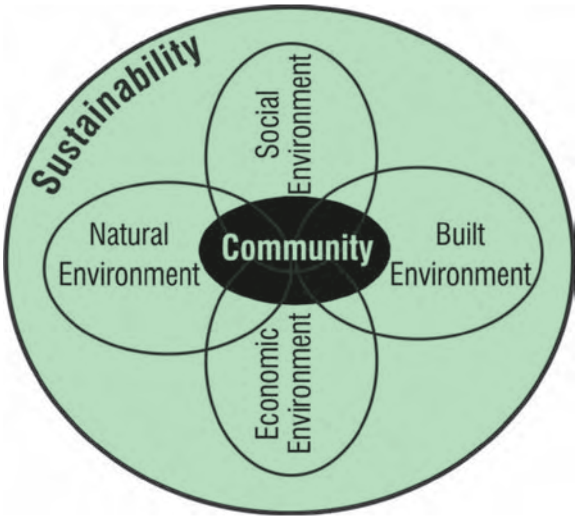

Figure 1: **The integrated and holistic recovery system used in New Zealand** (adapted from MCDEM, 2005)

therefore the methodology is relevant to land use planners, emergency managers, asset managers, the insurance sector, hazard analysts, lifeline utilities and community liaison officers.

WHAT IS RECOVERY?

Recovery can be broken into phases including short-term and long-term recovery. Short-term recovery is focused on restoring services, while long-term recovery is concerned with returning the community to conditions that existed prior to the event, while taking into account any improvements (Schwab et al., 1998). Recovery involves a range of stakeholders, including federal/central and local governments, emergency management, non-government organisations, volunteers, businesses, insurance companies, infrastructure providers, communities and individuals.

The Ministry of Civil Defence and Emergency Management (MCDEM) defines recovery as "The coordinated efforts and processes to effect the immediate, medium and long-term holistic regeneration of a community following a disaster" (MCDEM, 2005).

For recovery planning purposes, four environments which contribute to community well-being and sustainability are considered: the social, built, economic, and natural environments (Figure 1). For community recovery to be long term, holistic, and sustainable, it must address regeneration of all these environments. Land use planning impacts on all of these environments, and therefore is a keystone to community recovery. Recovery activities are primarily recognised under the Civil Defence Emergency Management Act 2002 and hazards management (including mitigation) under the Resource Management Act 1991. Planning for recovery therefore requires integration of the various methods, policies, tools and rules that are drafted under these Acts. While emergency managers may be charged with overseeing effective recovery, they may have little or no input into decisions about the hazards that communities face through land use planning choices. Likewise, land use planners can be integral in facilitating risk reduction through planning tools if they are included in recovery planning undertaken by CDEM managers (Saunders et al., 2007).

WHY PRE-PLAN FOR LAND USE RECOVERY?

After disasters the sentiment often expressed from those impacted, and in authority, is a desire to restore the existing land use as quickly as possible. This could mean restoring or rebuilding in areas of known hazard, effectively placing people back into vulnerable locations. It is understandable that those impacted would want "to get back to normal" as rapidly as possible. However, when "normality" involves having activities, livelihoods, or homes located in risky locations, the long-term physical, social and psychological sustainability of a community can be compromised (Spee, 2008). The post-event recovery phase is considered to be opportune for risk-reduction activities. In reality, communities experiencing the effects of economic, social and physical loss following a disaster do not often make decisions about changes in land use that would reduce future risk and loss (Gordon, 2008). Authorities, similarly, are reluctant to impose risk-reducing land use changes at this time, as these are considered a further imposition on an impacted community.

Before an event it is possible to think through what types of impacts might be experienced in a disaster and how land use, and therefore everyday life, economies, and community assets may be affected. The benefits of pre-planning are as follows (Becker et al., 2008):

- Ideas, options and plans can be developed and discussed by communities before an event.
- The speed and quality of post-disaster decisions can be improved.
- Recovery is proactive, rather than reactive which can lead to poor decision making.
- Recovery can incorporate principles of sustainability.
- Recovery can begin without the need to think about and/or plan for changes.

- Future hazard risks can be reduced during recovery.
- Enhancement projects (e.g. urban renewal/ intensification, economic centre planning, and heritage restoration) can be integrated with pre-event recovery planning to allow for improved land use post-event.
- Permits can be gained in advance for spoil disposal sites, including those for contaminated materials i.e. road slip material, building debris, volcanic ash disposal.
- Plans are developed proactively to reduce or avoid the level of impact of a hazard event.
- The community can assume the role of active participants in recovery planning, rather than be victims who have recovery decisions imposed on them from top-down.

Because local authorities in New Zealand are already overburdened with legislative responsibilities, and there is no legislative requirement for pre-event recovery planning, it is suggested that tools and methods for pre-event recovery planning be incorporated into existing plans, rather than be identified in a stand-alone document. With linkages to other plans addressing recovery, consistency and integration of recovery planning will be enhanced. Suggested plans which can be used to incorporate recovery planning include Civil Defence Emergency Management Group Plans, Regional and District Plans, Asset Management Plans, Long-Term Council Community Plans, Growth Strategies and other non-regulatory documents (e.g. business continuity plans).

PRE-EVENT RECOVERY PLANNING METHODOLOGY

Using the AS/NZS 4360/2004 Risk Management Standard as a template, the methodology proposes a flow-chart model (Figure 2) to facilitate recovery planning before a disaster or hazard event happens, or alternately after an event but before reconstruction commences. The suggestions provided in the model are prompts only, and are not an exhaustive list of suggestions. The five major steps identified in the model are

- establishing the context for land-use recovery and identifying risks
- identifying gaps
- analysing risks and developing options for land-use recovery
- evaluating risks and prioritising options for land-use recovery
- treating risks (implementation).

Establishing the context for land use recovery and identifying risks

This part of the process requires that each hazard be considered separately. The likelihood, magnitude and location of the hazard must be considered to provide local context for the assessment. For each hazard, assets at risk and stakeholders are identified and the potential consequences of hazard impacts need to be understood. This step relies on the ability to access and synthesis extensive sources of information form hazard experts, the community, emergency managers, risk assessors, and land use planners.

Identify gaps

Where gaps in information or knowledge are identified that may be a barrier to analysing risks and informed decision-making, these need to be addressed. This may involve further research or consultation.

Analysing risks and developing options for land use recovery

Analysis of risk involves reviewing the potential consequences of the hazard and determining how potential hazard impacts to land use could be managed. This is a critical stage in the process for exploring new options for land use with all stakeholders in times of normality rather than in the post-event stress period.

Evaluate risks and priorities

This process involves evaluating each asset at risk based on the options provided by step three of the process. For example, a rest home is situated in a flood plain; the consequences of an event depend on the magnitude of the flood. The options for recovery could be to repair any flood damage; rebuild the rest home if destroyed; relocate the rest home to an area outside the flood hazard zone; or accept the risk and buy insurance and develop an emergency evacuation plan. Each of these options would be evaluated in the context of what is at risk, what are the costs of each type of treatment option, and what are the benefits and risk associated with each treatment option.

Treat risks

Once recovery options have been agreed upon they can be included in relevant plans and documents as planning cycles allow. If an event happens prior to the updating of plans, at least discussions have been held and the possibility exists for a reconstruction moratorium to be put in place until any discussed intentions can be implemented.

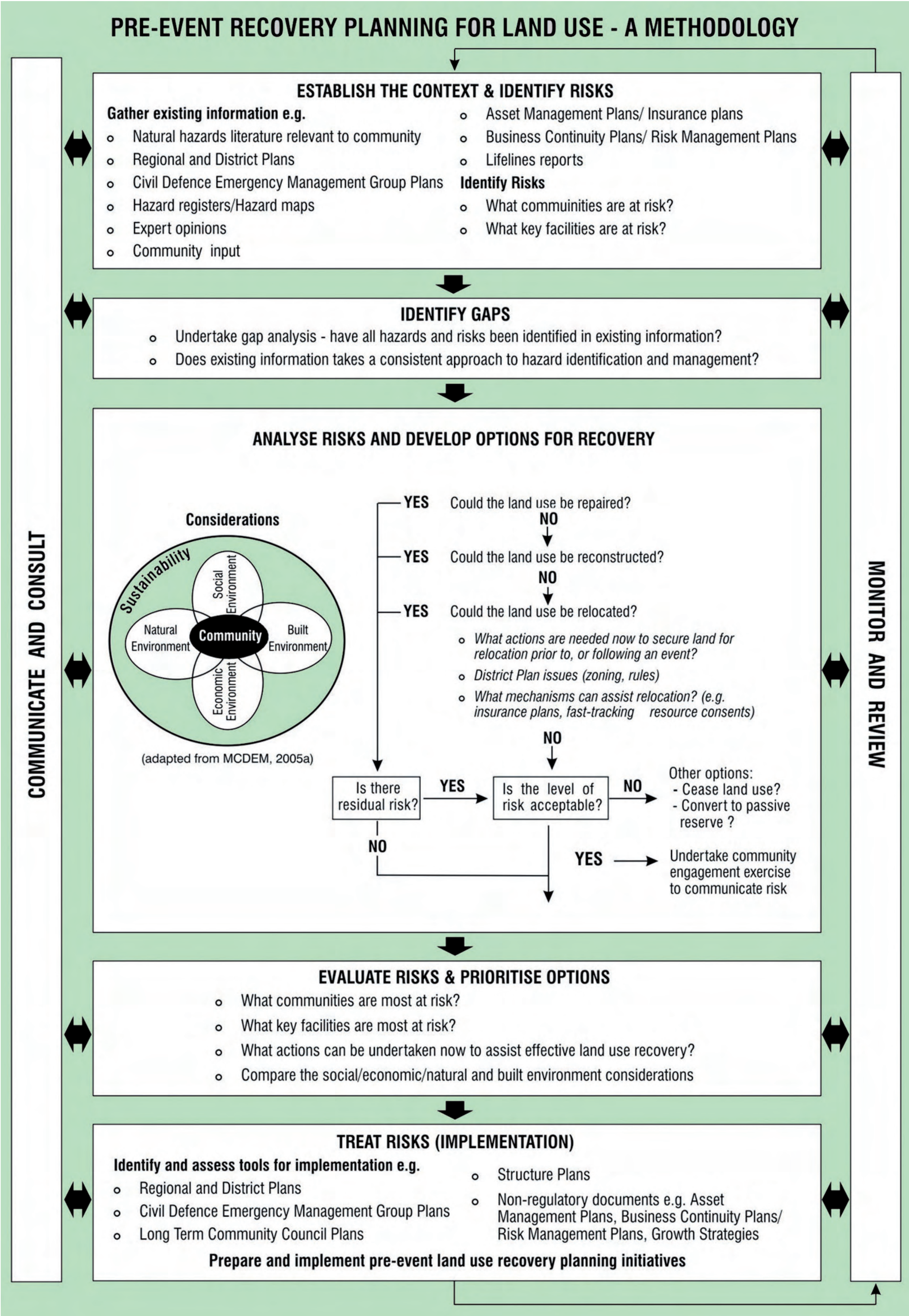

Figure 2: **Pre-event recovery planning for land use – methodology flow chart** (Becker et al., 2008)

Table 1: **General planning measures that can be of use for immediate land-use recovery purposes after an event** (after Schwab et al., 1998; Becker et al., 2008)

Measures	Framework for incorporation
Damage assessments after an event (which can be integrated with global positioning systems (GPS) and geographical information systems (GIS))	CDEM (damage assessments)
Identify new lessons discovered during response and initial recovery after the event	CDEM (damage assessments), RES
Development moratorium, whereby development decisions are halted for a period of time after an event	DP, RP
Emergency consents (e.g. for removal of debris)	DP, CDEM Act, RP
Regulations that deal with demolition issues	DP, BA
Zoning for temporary housing	DP
Setting priorities for infrastructure repairs before an event	ASSET, LTCCP
Identify sites for emergency operations	CDEM, DP, BUS
Feasibility of emergency evacuation	CDEM
Historic preservation (e.g. What to do with a historic building that has been damaged?)	DP, LTCCP

Key: DP – District Plan, RP - Regional Plan, RPS – Regional Policy Statement, CDEM – DEM Group Plan, BA - Building Act, LTCCP – Long-Term Council Community Plan, ASSET – Asset Management Plans, RES – general research, BUS – Business continuity plans.

Throughout each of the five steps are the two critical processes of communicating and consultation on the pre-event planning and monitoring and reviewing the robustness and effectiveness of each of the five steps.

EXAMPLES OF SHORT- AND LONG-TERM PRE-EVENT RECOVERY PLANNING MEASURES

Some examples of the types of general measures that could be considered under the pre-event recovery planning methodology are shown in Table 1 (short-term measures) and Table 2 (longer-term measures). Examples of hazard-specific measures are given in more detail by Becker et al. (2008).

By considering these measures and how they will be incorporated into existing frameworks prior to events, the process of recovery can provide more sustainable, risk-reducing outcomes that have been discussed with all parties in times of normalcy.

SUMMARY

The period immediately after a disaster is normally when recovery activities are expected to occur. Recovery presents a prime opportunity for risk reduction so communities are not placed back into situations of equal or greater vulnerability after disasters. Thus consideration of recovery issues should take place ideally before an event occurs and should be incorporated into regular planning processes. Pre-event recovery planning in times of normalcy can enhance risk reduction processes by considering alternative land uses for areas likely to be impacted before an event occurs. Pre-event recovery planning can also enhance decision making, as discussions are held when stakeholders are not impacted or stressed by losses or pressures of responding to the immediate event. The pre-event recovery planning methodology has been designed to assist those responsible for land use planning and disaster recovery activities, and is designed as a participatory process that enhances integration between

Table 2: **Longer term planning measures which can be used as part of pre-event preparation** (after Schwab et al., 1998; Becker et al., 2008)

Measures	Framework for incorporation
Damage assessments after an event (which can be integrated with global positioning systems (GPS) and geographical information systems (GIS))	CDEM (damage assessments)
Identify new lessons discovered during response and initial recovery after the event	CDEM (damage assessments), RES
Development moratorium, whereby development decisions are halted for a period of time after an event	DP, RP
Emergency consents (e.g. for removal of debris)	DP, CDEM Act, RP
Regulations that deal with demolition issues	DP, BA
Zoning for temporary housing	DP
Setting priorities for infrastructure repairs before an event	ASSET, LTCCP
Identify sites for emergency operations	CDEM, DP, BUS
Feasibility of emergency evacuation	CDEM
Historic preservation (e.g. What to do with a historic building that has been damaged?)	DP, LTCCP

Key: DP – District Plan, RP - Regional Plan, RPS – Regional Policy Statement, CDEM – CDEM Group Plan, BA - Building Act, LTCCP – Long-Term Council Community Plan, ASSET – Asset Management Plans, RES – general research, BUS – Business continuity plans.

planners and communities. The methodology provides a step-by-step process which is based on the AS/NZS 4360/2004 Risk Management Standard.

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Urban Resilience *and the* Open Space Network

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New Zealand is a good place to study resilience. While the world is suffering from the combined impacts of global warming and economic recession, New Zealanders must also deal with the threats associated with being one of the youngest and most geographically remote islands on earth. The *National Hazardscape* report released by the Ministry of Civil Defence & Emergency Management in 2007 warns that we need to be prepared for at least 17 hazards, suggesting that while flooding is the most frequent of these, earthquakes and tsunamis are potentially the most damaging and disruptive, and volcanic eruption the most underrated (ODESC, 2007). In the face of these increasingly frequent, intense and unpredictable events, traditional control-based approaches to hazard management are proving to be less effective. An increasingly popular strategy is to develop resilience by shifting the focus away from the threat to building adaptive capacity in that which is threatened.[1]

As most of our population is concentrated in cities, it makes sense to focus on developing urban resilience; the capacity of a city to continually respond and adapt to change. Much of the current research on this topic focuses on building the adaptive capacity of communities or ecologies (Bengtsson et al., 2003; Campanella, 2006). Very little has been written about how cities can be designed to influence resilience; most of the interest from planners and designers in urban resilience tends to be focused on process and policy or on the recovery and reconstruction of cities after a cataclysmic disaster (Vale & Campanella, 2005).

The Landscape Architecture Programme at Victoria University Wellington has begun to investigate this issue. Our current research focuses on open space as an important component of a city's infrastructure. We are currently part way through a research programme that will suggest the way open space can influence a city's capacity to adapt and respond to change. We are looking for tools to precisely assess and evaluate that influence. We are also looking for strategies to enhance urban resilience through design.

Wellington has a great deal of open space (see Figures 1 and 2), which includes the waterfront, pocket parks, gardens, community parks, sports parks and two town belts. (Council estimates that public open space constitutes 49% of the city's footprint, surely one of the highest proportions of any city in the world.) Our current task is to discover how designers can act as a catalyst to realise that potential and 'prepare the ground' to ensure resilience to a wide range of unspecified disturbances.

1 The relationship between the two can be compared with the difference between standard western medicine, which aims to control or prevent disease, and alternative medicine with its holistic focus on health rather than the absence of disease.

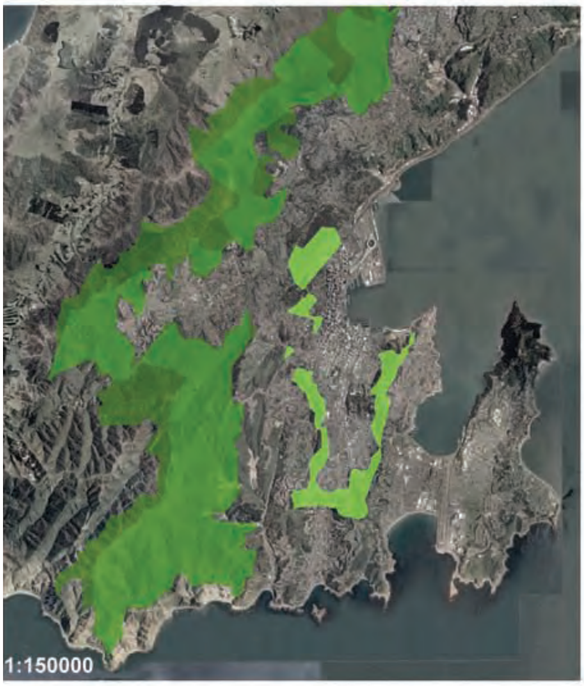

Figure 1: **Green belt comparison:**
Above: **Havana green belt** (from Hirt and Scarpaci, 2007).
Below: **Wellington inner and outer green belt network**.

Our research will be undertaken in four stages:

1. **investigation:** definition of terms and the investigation of interdisciplinary resilience models
2. **testing:** evaluating models for urban design and urban resilience by applying them to specific urban design 'problems' such as "How resilient is open space and how does it influence urban resilience?"
3. **design:** using the appropriate models to design resilient urban systems
4. **evaluation:** evaluating the models through testing design outcomes against a range of scenarios.

For the purposes of this paper we will describe the investigation and testing of one of a number of models; hereafter called the 'ecological model of resilience'.

Resilience is rarely defined clearly. As a popular concept, it is usually loosely defined and too general in

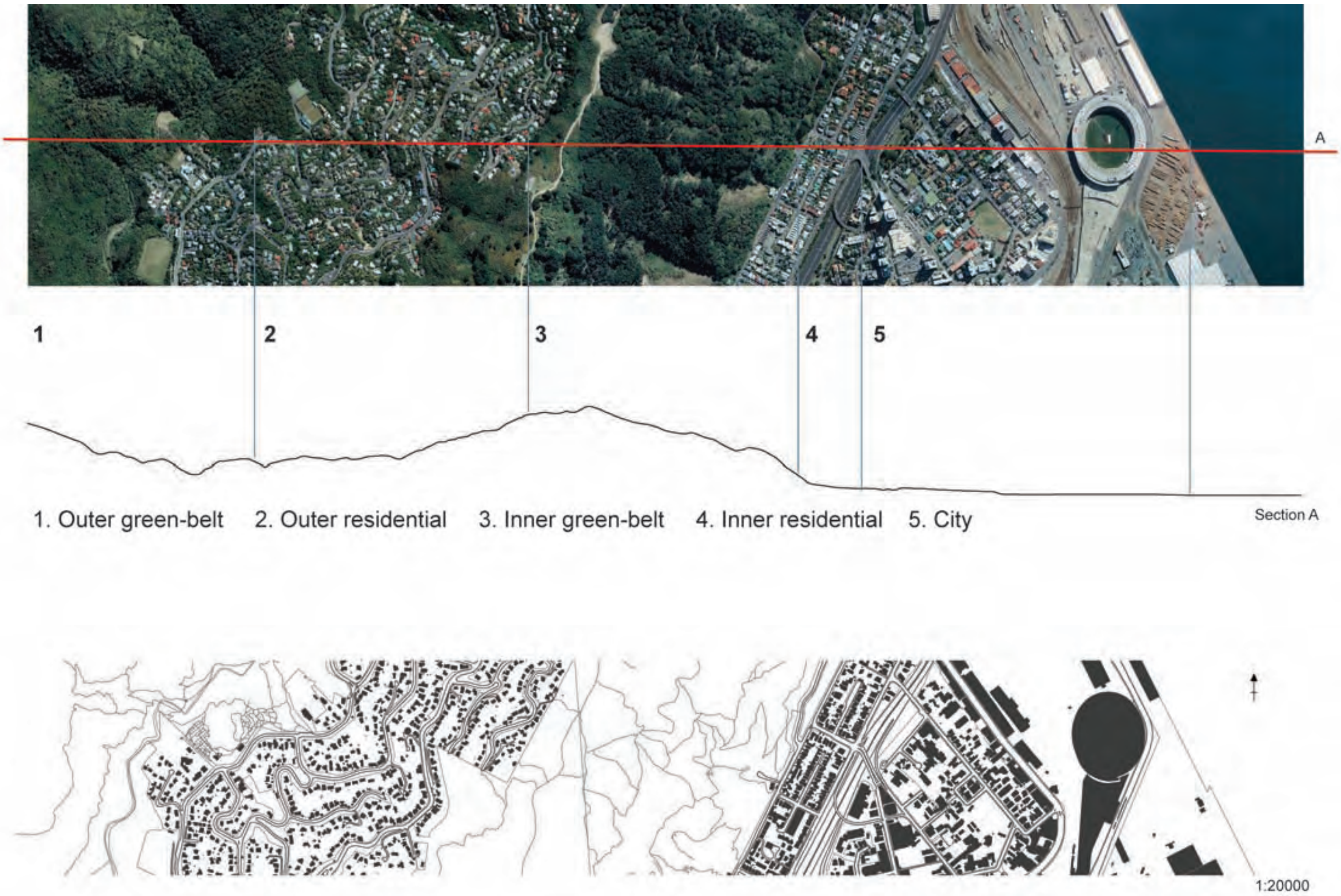

Figure 2: **Transect across the Wellington green belt showing the inner and outer zones of the belt and residential land use.**

meaning to be of much use. A definition derived from Canadian ecologist C.S. Holling's early work (Holling, 1973) on ecological resilience provides a more specific and therefore useful definition. Resilience is

> the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks (Walker et al., 2004).

This definition is accompanied by a model or theoretical framework describing the way resilience works. It is complex but extremely useful as a model for the design of urban resilience and has been simplified here to explain its relevance.

The model suggests that if a system is disturbed, its capacity to absorb that disturbance is influenced by its

- **latitude** ('room to move', flexibility – the amount the system can shift without altering its basic structure and function)
- **resistance** (feedback mechanisms that operate in response to disturbance)
- **precariousness** (its inherent instability).[2]

Other important resilience concepts associated with this model are

- **adaptability:** the capacity of 'actors' in the system to influence resilience[3]

2 An example often used to explain the relationship between these concepts is the human body. Life is possible within fairly narrow thermal parameters (36–42 °C) – its **latitude**. The body is constantly exposed to environmental disturbances that could lead to excessive temperatures and ultimately a loss of life. Negative feedback mechanisms (**resistance**) ensure that the body's temperature is maintained. However, repeated stress makes the body less resilient; more **precarious** and less responsive to the effects of latitude and resistance. A breach in the temperature threshold results in a different state (illness or death).

3 In cities the action of governments and communities are the actors who can actively enhance resilience.

- **the adaptive cycle:** ecologies and cities are both inherently unstable and cycle through phases of conservation, release, innovation and growth[4]
- **cross-scale influences:** what happens at one scale in the system can influence or even drive what happens at other scales[5] (Walker and Salt, 2006).

The model has more recently been supported by an experimental document, the 'resilience workbook', designed for scientists and resource managers to assess and manage resilient social-ecological systems (Resilience Alliance, 2007). With a series of targeted questions, it guides the scientist/manager/'actor' through the identification of a system and its variables at different scales, past histories, adaptive cycles, potential alternative states (or scenarios) and tipping points. The benefit of the workbook is that it is a step-by-step, rigorous and targeted assessment. It shows how and where to encourage resilience in quite specific detail. Although intended as a tool to assess and manage the resilience of natural systems (e.g. rangeland in Australia or coral reefs in the Bahamas), it is abstract enough to apply (with modifications) to any system. Our research thus far has been to test the benefits of applying this model to Wellington's open space system as a tool for understanding, assessing, and designing a resilient city.

The testing stage of our research programme consists of two parts:

1. assessing the resilience concepts against known examples or case studies of urban resilience
2. applying the workbook to Wellington's open space network.

PART 1: INVESTIGATION: THE CASE OF URBAN AGRICULTURE IN CUBA

The relative precariousness of Wellington's food supply is in some ways similar to Cuba, as is the city's relationship to the town belt and other less formally acknowledged types of open space. These spaces proved to be significant assets in the Cuban example of urban adaptation.

Cuba has an enormously successful urban agriculture programme (Pena Diaz and Harris, 2005). It has been so successful, in fact, that it is now exporting its expertise in urban agriculture to other South American countries. In the capital city of Havana, every imaginable type of open space in the city is used to grow fruit and vegetables: on rooftops, between buildings, on vacant lots. But this has not always been the case. Until the 1990s Cuba relied heavily on imported food and most agriculture involved the mechanised production of 'exotic' cash crops and an intensive use of chemical pesticides.

The collapse of the Soviet bloc and the tightening of the US trade embargo in the 1990s created massive economic dislocation and social pressure. By 1994, agricultural production levels had dropped by 45%. The average Cuban adult lost 20 pounds because of food shortages. The crisis precipitated a shift in behaviour from individuals, communities and eventually from government. Individuals and communities began to see the agricultural potential of the urban environment. Out of necessity, people grew food where they could, communities grouped together to learn from each other, and the government eventually realised that it needed to change land use policies in the cities to further encourage alternative land-use practices.[6]

Cuba's cities were in a precarious (unstable) state because they were so reliant on imported food. The crisis, which led to severe food shortages, encouraged locals to see the urban environment as a 'productive surface'. They exploited the latitude (flexibility) in the urban environment, in particular, the city's network of open spaces to enhance the resilience of the city as a whole. As actors in the system they influenced the adaptability of the city by creating a negative feedback link within the system (less imported food/more home-grown food). Innovative actions at a smaller scale (the individual and the community), encouraged by a relaxation of policy, influenced the resilience of the city at the larger scale. The city maintains its basic structure and function because the open space network can absorb the impacts of the crisis.

The Cuban case study is an example of 'specific' resilience – a city and its people responding to a specific threat. But it also begins to describe how in times of crisis

4 For example, the energy in a mature forest is devoted to maintaining its structure and function. A disturbance such as a major bushfire can cause release of nutrients and a dramatic increase in light levels, which in turn encourages the growth of new types of vegetation. Cities display the same type of behaviour; Wellington's waterfront was managed as a working port for years until shipping efficiencies in the 1960s and 1970s reduced the need for so much space. The retraction of the port to the north of the city space released valuable open space for a whole series of completely different activities, changing the face of the city.

5 For example, Cuba's successful shift from largely imported to locally grown produce was precipitated by political and global influences; Castro's introduction of a productive green belt surrounding the city in the 1960s and the subsequent oil crisis and collapse of the Soviet bloc in the 1990s.

6 Cubans are allowed to 'claim' vacant land in the city by contacting the owner. If the owner does not develop the land within 6 months, the claimant can use the land temporarily to grow food.

In times of crisis people adapt in innovative ways by exploiting the latent potential of their environment

people adapt in innovative ways by exploiting the latent potential of their environment. It also provides a good example of the way that political, economic, environmental and physical factors 'prepare the ground' for response to change.

PART 2: TESTING AND APPLICATION TO WELLINGTON'S OPEN SPACE NETWORK

Viewed in relation to the case study above, Wellington's open space is in fact far more intricate and widely pervasive than is apparent on its District Plan. Specific cultural and developmental responses to this place have resulted in a suite of spaces such as shared access ways, remnant land, revegetated gullies and road frontages which, while not formally recognised as open space, offer potential grounds for adaptation in response to change. Indeed it is the fact that these spaces are managed and valued with a common interest which places them at the forefront of societal response in the event of change. This is why they have value.

We are applying the Resilience Alliance workbook to a transect across the city (see Figure 2) to identify a range of different types of open space at a variety of different scales (local, neighbourhood, urban, regional). The initial intention is to provide a more inclusive definition of open space units appropriate to Wellington prior to selecting individual units as the "site" for design. Following this, design proposals will be made, informed by resilient open space strategies derived from case study research. The resilience of these proposals will be tested through the imposition of a range of hazard and disturbance scenarios (e.g. earthquake, flooding, failure of infrastructure). The final outcomes are expected to include guidelines for the amount, location, configuration and design of public open space needed to enhance both general and specific urban resilience across varying scales and contexts, as well as design strategies that will encourage adaptive and innovative behaviours in Wellington's open space network.

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A Perspective on Integration in Resource Management and Planning:

The New Zealand Resource Management Act

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This short article has as its purpose a personal recollection of what was intended when the Resource Management Act 1991 (RMA) was undergoing its policy stages through the Resource Management Law Reform (RMLR) (1986–91). Hence it is one perspective of the idea of integration in resource management and planning. Such a perspective provides a backdrop for the subsequent implementation and evolution of the RMA.

WHAT IS INTEGRATED RESOURCE MANAGEMENT AND PLANNING?

When considered in the context of developing policy that leads to the drafting of law, integration tends to be related to a number of parts of the new policy, as occurred in the RMLR. There are other definitions as will become apparent in this issue of *Tephra*. In addition the overseas literature addresses other issues, making this a complex issue of definition. For example, the Resource Renewal Institute in San Francisco (RRI) has maintained a campaign through the past 20 years to present models of integrated plans, which it calls "Green Plans" (www.rri.org). Its view of integrated plans is summed up by a set of principles expressed as "defining features" (see box).

Of interest to this article is that the RRI has shown a considerable amount of interest in the RMA, considering it a world-leading example of a statutory basis for Green Plans. These 10 defining features, and how the RMA relates to them, will be returned to later.

RECOLLECTIONS ON THE INTENTIONS FOR THE RMLR/RMA

My career path includes study and work in the field of "ekistics", the science of human settlements. Underlying the theory and practice of ekistics is the principle of integration because it is based on the premise that all disciplines that contribute to an understanding of human settlements need to be brought together in a trans-disciplinary form. In the 1960s Doxiadis identified this trans-disciplinary approach as "ekistics"; today we can connect this with another trans-

10 Defining Features of Environmental Planning	
Long-term	Represent a society's ongoing commitment to the goal of sustainable development
Comprehensive	Management solutions that address the full array of priority issues, across media (e.g. air, water, land) and their impacts on the environment, economy, and society as a whole
Dynamic	Capable of adapting to evolving problems, ideas, goals, and information without radical changes to their structure and function – within which an ongoing planning process can take place
Cooperative	All facets of the community, all types of businesses, and all branches of government participate in a highly cooperative process of developing trust, identifying common values, and working toward a shared vision of the future
Integrated	Enables a fusion of economic, environmental, and societal needs by accounting for the many complex interrelationships that together determine quality of life
Informed	Policy decisions guided by a reliable information base that aggregates environmental, economic and societal conditions in order to accurately depict significant trends (past, present, future) and devise a responsive set of new programmes
Flexible	(Combines) a commitment to realising targeted environmental goals and objectives, and, providing participants with more freedom in developing the necessary technical and/or institutional improvements. The long-term nature of this arrangement creates a more stable and predictable regulatory environment that benefits all parties
Strategic	Apply a strategic management approach, with a continuous process of setting goals, developing timelines, and monitoring and reporting on results
Purposeful	Demand the level of focused, resolute, and results-oriented initiative necessary for the pursuit of sustainable development
Investment-intensive	For effective implementation – require adequate funding from both government and industry, recognising that the stakes of a sustainable future could not be higher and that success mandates a substantial long-term investment

Source: *Green Plans: Working Strategies for a Sustainable Future – A Primer* (RRI, 2001, p. 9).

disciplinary field – "sustainability". With this ekistic world-view in mind I was quite comfortable with Sir Geoffrey Palmer's aspiration to spearhead a law reform that would see the integration of the policy fields of natural and physical resources and the processes affecting land, air, water and the coast (and initially Crown minerals). As this law reform was shaped through public consultation the idea of "integration" began to take a number of forms. As I recall these forms they included:

- *Integration* as bringing legislation together (i.e. to integrate the law pertaining to land, water and air (including hazardous substances and new organisms) and giving it an overarching purpose (i.e. sustainable management). It also provided a basis for interdisciplinary responses, as reflected not only in the RMA Part 2 (Purpose and Principles) but also the integration of environmental impact assessment (EIA) (known at that time as Environmental Protection and Environmental Enhancement Procedures – EP&EP).
- *Integration* as recognising the interconnected nature of the organisational and administrative systems, and thematic structure, and operating on that basis. While most of the administrative structures had previously existed in such state organisations as the Ministry of Works and Development (MWD), the Wildlife Service, and the Mines Department, they were being restructured post-1984. By 1987 the MWD had seen its town and country planning, and water and soil conservation functions (to name two) dispatched to a new Ministry for the Environment (and the engineering-related functions readied for privatisation – see Opus International). The Wildlife Service and parts of the Forest Service had been transformed into the Department of Conservation.
- *Integration* as using major river catchments as administrative units for regional councils. The recognition that the water and soil conservation functions needed an administrative structure that recognised the integrity of the natural processes involved was stimulated in part by the existing

system where river catchments were administratively divided within a river system (e.g. the Waikato River) or between two administrative bodies using the centre of the river (as in the South Island). Concurrent with the redrawing of boundaries was the establishment of a regional council level of local government throughout the country.

- *Integration* as weaving the parts of a process (e.g. EP&EP) into an allied process (i.e. resource consents). With the bringing together of the processes for town and country planning, water and soil, clean air, mining, and the coast came a linking of process with the EP&EP procedure as mandated by Cabinet. Previously EP&EP was a standalone process, which applied to certain Government licences and permits, or public works. It was not universally applied to all development. The RMLR enabled the identifiable parts of EP&EP (e.g. public participation, notification, criteria for decision making) to be associated with the equivalent parts of the RMA. Hence the task of assessing the environmental effects (aka as AEE) as part of the resource consent process.
- *Integration* as providing for joint regional council and district council decision making (i.e. "one stop shop" approach to resource consents). This was recognition that the processing and hearing and decision-making stages, if handled separately, could delay matters. It also recognised that many of the issues and the related evidence covered in the AEE overlapped across the two jurisdictions, hence making an integrated process a sensible option.
- *Integration* as operating a unified process (cycle) of issue identification, policy making, plan making, implementation, monitoring and reviewing. This structure for preparing regional policy statements, regional plans and district plans was effectively the integration of standard policy making, EIA and plan-making processes into one integrated procedure.
- *Integration* as approaching issue identification on a thematic basis rather than a resource (e.g. water). For example the raft of matters concerning water in a river system such as the Waikato or Waitaki would be best handled under the general and integrated theme of River Management. This would enable the specific resource questions of river flow, competition for use of the rivers, and water quality to be brought together and considered in an integrated way.

The intentions in the RMA for achieving the various forms of *integration* explained above seem to fit neatly into the 10 defining features for Green Plans:

- *Long-term:* the continuing commitment to sustainability is found in RMA Part 2.
- *Comprehensive:* the coverage provided by focusing on not only sustainability but also natural and physical resources and the other matters in Part 2, and attention to adverse effects and consequences.
- *Dynamic:* a broadly based legal scope, which enables new consequences and outcomes to be identified in an evolving plan-based process.
- *Cooperative:* the adoption of an open standing public participation context, which enables involvement across the plan making and resource consent (and related) processes that is not only reliant on being directly affected.
- *Integrated:* the RMA's scope covers economic, environmental, societal and cultural needs, and enables their complex interrelationships to be included in problem solving.
- *Informed:* a policy and plan making process – as well as resource consent decisions – that is reliant on sound information provided within a lay and expert witness framework, which is (where necessary) ultimately overseen by the Environment Court.
- *Flexible:* the central place of defining a policy cascade of issues, objectives, policies and methods within plans creates opportunities to realise desired community outcomes in a flexible way.
- *Strategic:* underlying the RMA plan making process is the need for a strategic perspective that is comprehensive across economic, environmental, social and cultural dimensions.
- *Purposeful:* the inclusion of anticipated environmental results (AERs) expressed in the context of desired community outcomes provides a purposeful direction for plan making and implementation.
- *Investment-intensive:* the effective implementation of RMA policy statements and plans depends on an implicit need to adequately fund (through public and private sectors) the intended development and conservation.

The principal objective of integration across the provisions of the RMA has survived attempts to nibble away at the edges

IMPLEMENTING THE ACT

However, as the age-old adage says, "the road to hell is paved with good intentions". So while it can be said that the Green Plan framework with its intention of integration fits with the intentions of the RMA, the execution of these intentions has been uneven. While the first intention to bring legislation together was achieved, some statutes still managed to slip outside the new "package"; hence the separate adoption of legislation for Crown minerals and hazardous substances (and the creation of ERMA). The use of river catchments was only partially sustained with the later separations of Nelson-Marlborough into separate unitary authorities, following the example of Gisborne. The integration of the assessment of environmental effects and decision-making processes has survived various attempts to amend the Act, although integrated decision making by regional and district councils has been only partially pursued (e.g. Marsden Point Deepwater Port). The establishment of a policy cascade – issue, objective, policy, and method – has only partially survived. So too has the use of thematic issue identification since the advocates for specific natural and physical resources have pursued their specific interests (e.g. water resources, waste, urban design).

Nevertheless the principal objective of integration across the provisions of the RMA has survived attempts to nibble away at the edges and still provides a basis for further discussion of the issue of integrated resource management.

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A Systems Approach to Security Management

Governments have no more important responsibility than ensuring the protection and safety of their societies. … New approaches using systems behaviour and integrated risk management are helping to improve both the interpretation and the management of security issues.

Patrick Helm
Department of the Prime Minister and Cabinet

The gradual shift in modern concepts of security that has occurred over the past decade is having far-reaching implications for those who have responsibilities for managing such issues. In many countries civil emergencies and new societal risks are being managed alongside traditional security priorities in national planning.

Security issues have always presented difficult management challenges: they can affect society in complex ways; they are usually unpredictable or characterised by high levels of uncertainty; and they tend to involve multiple factors, often with complicated interdependencies. Governments have no more important responsibility than ensuring the protection and safety of their societies. Yet because of the difficulties involved, and the very wide range of possible challenges, the management of these issues has usually been more of an art than a science. New approaches using systems behaviour and integrated risk management are helping to improve both the interpretation and the management of security issues.

SECURITY TRENDS

A number of new factors are influencing security environments the world over and increasing the demands for better approaches to managing security. These are not just threats from terrorism and malevolence, but the insidious growth of new systemic risks and societal vulnerabilities. Disasters world-wide are increasing in number, in scale, in complexity, and in consequences. 'Normal' problems are being better managed, but those that are unusual in character or scale appear to be happening more often and are causing more complicated problems.

Many of the new systemic risks in particular are exceedingly complex (see box). Some have demonstrated potential to affect large numbers of people by cascading into critical sectors of society or infrastructure. Community vulnerability is increasing in certain sectors as businesses and individuals adopt some modern practices: as they become totally reliant on advanced technologies such as the internet;

as they accept the economies of 'just in time' production without fully understanding the limitations or assumptions; and as they increase their dependence on closely coupled infrastructure systems. Such situations can create opportunities for unexpected synergies to develop between otherwise independent factors, magnifying the scale of potential disasters.

The ways in which these new risks can affect security are not well understood, but several points can be made:

1. Many of the infrastructural assets and communal functions requiring protection now are critical in daily life, and failure can have wide community or national implications.
2. The increasing interdependence of security risks is creating complex new vulnerabilities in modern societies.
3. Problems in well-organised security systems do not happen usually from a single point of failure. They occur most often through multiple co-incidences and for mutually reinforcing reasons.
4. The security overheads of life are increasing. There are many reasons for this, but it raises questions as to whether the methods used for dealing with societal risks, based as they have been on largely disaggregated processes, are both appropriate and optimal.

Contemporary Security Issues

Natural	**Natural Hazard:** flood, earthquake, volcano, storm, drought, wildfire, etc.
	Biosecurity: plant and animal disease, foot & mouth, etc.
	Health Emergency: epidemic, SARS, H1 N1
Technology	**Infrastructure:** accident, engineering failure, service outage, utility loss
	Transport: aircraft, train, ship accident; road or bridge closure
	Hazardous Materials: chemical leakage, marine oil spill, plume
	Food: safety issues, quality, distribution, contamination, cumulative risk
	Supply Chain: fuel interruption, energy distribution, shortages of imports
Human	**Failings:** accidents, negligence
	Malice: malevolence, criminal activity, arson, protest
	Unconventional Attack: cyber-threat, hacking, service denial
	Sovereignty: border violation, espionage, trans-national crime, poaching
	Organised Threats: military, para-military, terrorism, asymmetric warfare

SECURITY STRATEGIES

Future strategies for security will increasingly need more pragmatic compromises in the balance of costs, benefits, and risks in order to deliver tolerable levels of safety and certainty for those who may be affected. For governments at both national and local levels this will force hard choices between ensuring that everyday problems are mitigated for vulnerable individuals, and controlling extraordinary dangers in ways that meet community expectations and enhance overall security.

Omnibus security strategies to manage wide-ranging risks will be hard to develop because of the sheer number and complexity of the interactions possible between sources of risk and exposed populations, organisations, and infrastructure. That said, it is becoming clearer that there is an underlying coherence to the analysis and treatment of most aspects of security. Notwithstanding the diversity of forms and the shifts in character that can occur from time to time, the fundamental nature of security is enduring.

Experience has shown that, regardless of cause or scale, there can be a great deal of commonality in the factors that influence society's vulnerability, the potential consequences at community and national levels, and the options available for helping to overcome disruptions from adverse events. The common features can help frame the problems and assist with the development of solutions through integrating systems approaches and risk management. New analytical methods for interpreting systemic risks show considerable promise for assessing the relative significance of disparate threats and hazards, for taking account of intangibles, and for developing options for management. Such methods have to be applied with care to achieve meaningful results, and they have to be accompanied by changes in security culture (e.g. less reliance on purely precautionary policies and risk avoidance).

SYSTEMS APPROACH TO SECURITY

In the security world, systems thinking is a powerful tool for analysing and interpreting risks, and for developing control options. It is best used in the widest possible context to encompass all of the decisions and activities that contribute towards the safety, stability, and security of society. The aim is to find balanced and efficient ways that enable people to live with confidence in the face of various natural, technological, and man-made risk exposures.

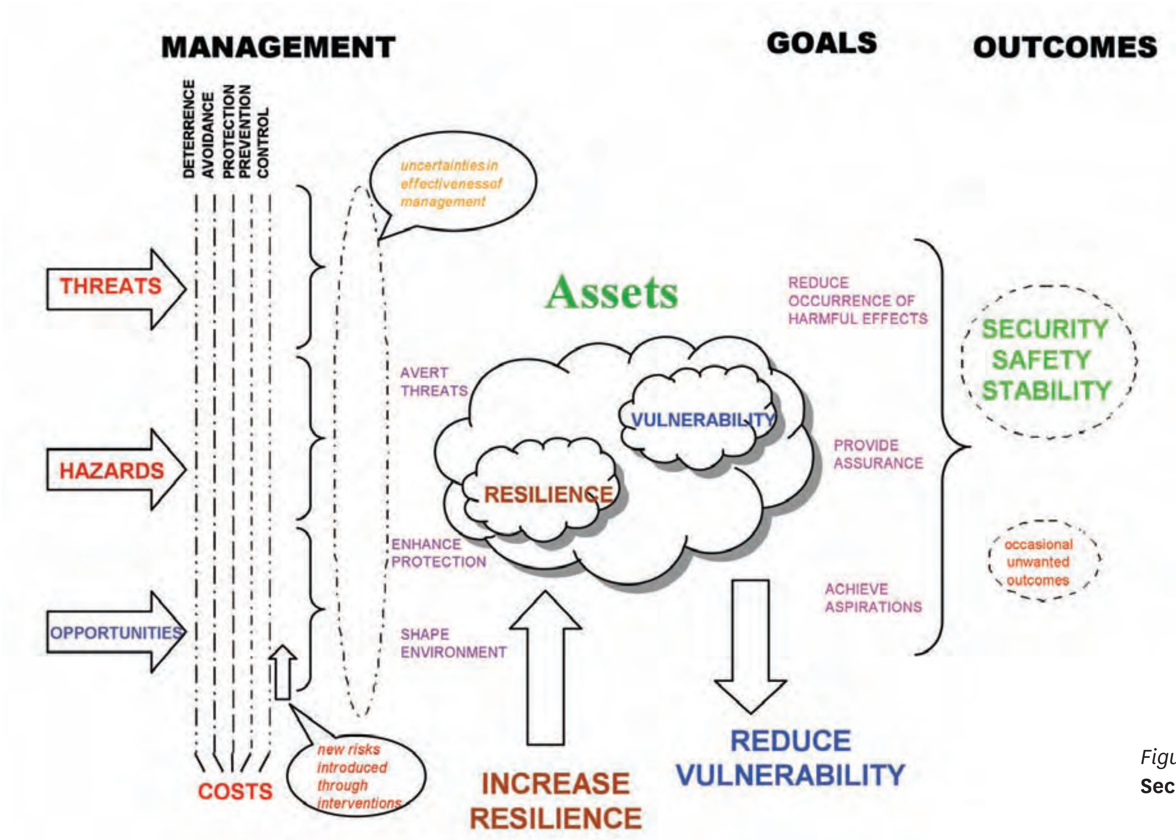

Figure 1:
Security system

Figure 1 illustrates the main ideas in a systems approach to security. At the heart of the security environment is a 'system' with assets which require protection – assets being a general term covering sub-systems, infrastructure, organisations, people, information, etc. The security of the system is shaped by two overarching characteristics: the *vulnerabilities* of assets exposed, which must be reduced or shielded with layers of defence; and the *resilience* inherent in the system, which should be enhanced where possible. Impinging on this environment are the threats, hazards, accidents, and opportunities that can affect the system or its assets.

Typically, the external influences are controlled through separate, individual, processes to mitigate the risks, although those measures may be only partially successful in averting unfamiliar threats or enhancing protection. Moreover, the management process itself, or internal factors, may, in practice, introduce further risks; and there may be uncertainties associated with available knowledge, or with the processes, which affect the goals in complicated ways. For these reasons the outcomes sought (reduction of harm, achievement of aspirations, etc) may not be fully met, and occasionally there also may be unintended consequences.

Having an understanding of the system is critically important. Unless those responsible for security understand the context, structure, and key elements of a system, they cannot begin to interpret what is happening or why. They can respond, but that is rarely the best way of dealing with security issues. A systems approach focuses on the *interactions* between the various elements in a system in order to understand the unique *relationships* these interactions produce. It helps in systems thinking to map out a model of the total system – the elements, concepts, relationships, processes, vectors, flows, feed-back loops, nodes, leverage points, and critical factors. From there it becomes possible to appreciate the system structure and to interpret observed behaviour: symptoms, patterns, sensitivities, cause-and-effect linkages, and so forth.

An understanding of system structure and behaviour, in both passive and dynamic circumstances, provides an important basis for controlling risks, building resilience, and developing management strategies to improve security, by

- testing risk management options, and quantifying the costs and benefits of mitigation
- creating a framework on which to build resilience over time

- providing a basis for response (i.e. assisting decision making for adaptive management).

The degree to which systems thinking will contribute to improved security depends largely on the forms of the interactions within the system. Some, such as engineering systems, can be relatively straightforward, which is why systems approaches have long been used in the engineering world. Increasingly, those systems methods are making powerful contributions beyond core engineering disciplines by reaching across their interface with society, the environment, and the economy. They have had considerable success in explaining complicated behaviours, enhancing positive features, identifying points for intervention, making systems more stable, and in optimisation, among others. In similar fashion, medicine increasingly draws on systems methods: the human body itself can be regarded as a complex set of sub-systems that collectively form a whole system with characteristics that are quite different from the components. The whole, moreover, belongs to higher-order systems such as families and organisations, which it both influences and is influenced by.

While systems methods are not yet widely used in security management, experience in related disciplines indicates that they will be an increasingly powerful tool for addressing complex security issues, and for setting management strategies at both local and national levels. This seems inevitable given the rapid advances in security management since the mid-1990s, especially with the convergence between new analytical techniques, comprehensive approaches for dealing with problems, and formal risk management standards (including process standards such as AS/NZS 4360, which shortly will become a new international standard – ISO 31000).

The experience of systems thinking in the engineering world provides some guidance for its application to the management of complex security issues. In any system, the aim is to maximise the overall fitness of the system to handle disruption from accidents, natural hazards, human failings, deliberate attacks, technical weaknesses, and other risks. That requires a comprehensive understanding of the total system, and assurance that all of the parts and control mechanisms are in an appropriate balance. The essential attributes of 'fit' systems are sometimes described in terms of the "5Cs":

- *coherence* across all elements
- *connectedness* between elements, and with other systems
- *completeness* so every significant element is included
- *clarity* of understanding about the total system
- *consistency* in terms of processes and standards applied.

MANAGEMENT OF COMPLEX PROBLEMS

It is impossible, of course, to eliminate all risks in society, and nor is it essential for safety or security. In reality, the best that can be expected is that in seeking to improve their security, communities will minimise the more obvious hazards and threats where possible, and then adapt to live with the residual risks. While reductionist methods of analysis that aim to break complex problems into component parts will not necessarily produce a truly comprehensive view of real risks to which a society is exposed, they can help to improve the understanding of the most significant dangers. Such knowledge is essential in order to prioritise control options and to foster improvements in security practices.

Among the many challenges facing those who manage security risks, the most difficult relate to system dynamics. For reasons that are not well understood, the management of collective security risks in national or community systems seems to require a different approach from the management of individual risks. Systems frequently behave in ways that cannot be explained by the aggregation of the component risks or those of sub-systems. Not only does this complicate the analysis of security systems, but it obliges those responsible to manage collective risks in more comprehensive ways – to take into account not only the technical aspects of risk but a wider range of human and organisational factors as well.

In large-scale disasters, in particular, or in situations where there are multiple interdependencies, the tight coupling in modern social systems can cause relatively ordinary risks to interact and cascade in unpredictable ways (Figure 2). This can create complex and unusual problems where the *whole* impact is not only *greater* than the sum of the parts but is *fundamentally different* from the sum of the parts.

Complex problems of this type are difficult to both analyse and control. With natural forces, for example, there are limits to what can be done to diminish or deflect the hazard when it is beyond a certain size or where the effects are complex. The value of attempting to mitigate specific risks can diminish when consequences cascade well beyond the source of the problem; the pathways between cause and effect can become so convoluted that efforts to reduce the effects may have little impact.

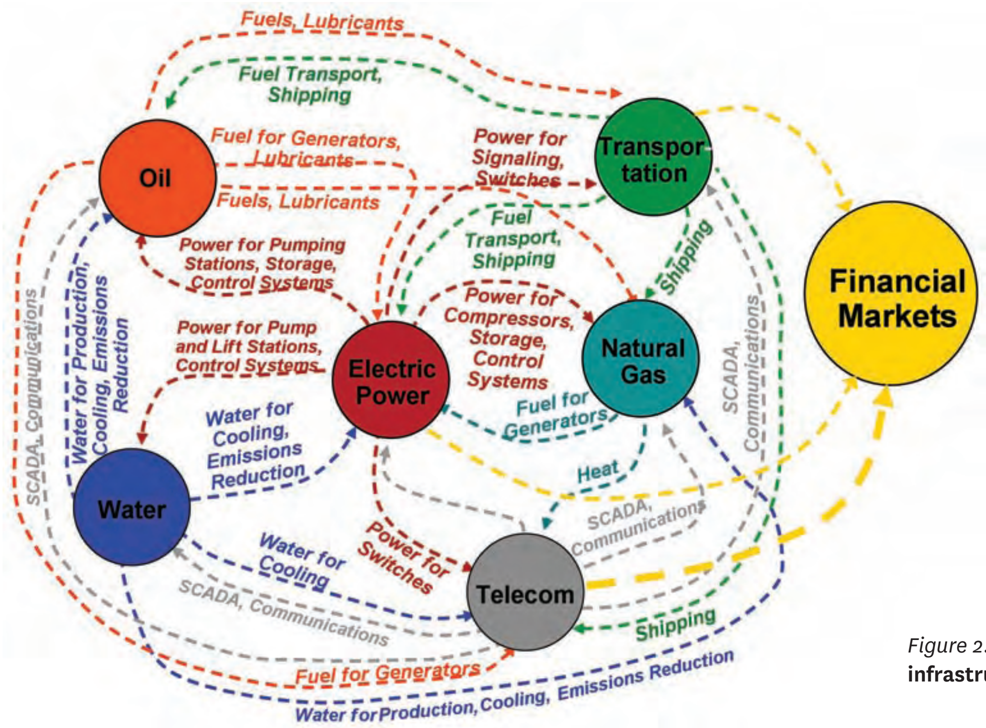

Figure 2: **The complexity of infrastructure interdependencies**

In practice, the uncertainties involved in the management of security are usually best covered by strategies involving two broad fronts:

- Regular hazards or threats that have well-understood impacts (floods, fires, accidents, diseases, etc.) should be controlled through normal risk management strategies, to the extent that can be justified on cost-benefit grounds.
- Large, complex, or unusual security problems may be better dealt with through having enhanced resilience in the communities that are likely to be affected, and ensuring that there are flexible governance arrangements in place to coordinate responses and make rapid decisions about specific consequences if and when they arise.

SYSTEMS PRACTICE FOR SECURITY

Typically there are four core issues to take into account in developing security strategies:

- What total resources should be applied across all issues to provide adequate security?
- Which risks matter most?
- For each threat, hazard, or potential problem, how should resources be apportioned between prevention, protection, response and recovery to achieve comprehensive management?
- Where should the balance be struck between, on the one hand, the management of specific risks and, on the other, the more general strategy for dealing with uncertainty by building resilience in the system and fostering adaptive management?

Historically, very serious risks tend to be underestimated because funding is more readily available for familiar problems. Low probability/high consequence events also have greater uncertainties, and can play out in unexpected ways. For these reasons, among others, there can be considerable utility in concentrating on building general resilience in the community and its infrastructure in order to withstand major disruptions, while at the same time putting in place generic capabilities to facilitate response and recovery.

In practice, complex security situations are best managed in ways that cover a wide range of possible outcomes. Where it is difficult to anticipate either the nature or scale of risks that might arise, a general systems approach is more likely to lead to better overall security than a strategy targeted at specific risks (Figure 3). Typically such a strategy would involve a combination of four elements:

- mitigation of discrete risks
- coherent management of the system
- enhancement of total system resilience
- adaptive management in response.

Resilience

Resilience may be defined in different ways depending on the situation, but in the context of security in society it can best be thought of as a measure of "the ability at every relevant level, to anticipate and, if necessary, to handle and recover from disruptive challenges".

There are two ideas contained in the notion of resilience: *resistance* and *recoil*. Both need to be taken into account, according to need, in planning for the comprehensive management of security. Those responsible must

- anticipate, and mitigate where appropriate (the "resistance" aspect)
- deal with the problem and its consequences if they arise (the "recoil" aspect).

Thus, a robust system for living with risk will be one where there is a balanced effort on two fronts:

- The source of peril is avoided, deflected, repelled, or attenuated to an extent that is practical, cost-effective, and accepted by the community.
- The exposure and susceptibility is reduced in elements likely to be affected in the total system, including all stakeholders, organisations, infrastructure, and assets; and they are enhanced so that normality can be restored quickly following any disruption.

Shifting the prime focus away from the source of problems to the management of the total "Source-Community" system can be expected to have wider benefits, especially when risks are poorly understood or even unknown. The dual approach of enhancing general resilience and strengthening arrangements for adaptive management if problems do arise will usually improve the overall management for a range of different hazards and other potential sources of disruption. This can create a multiplicative effect, and so, provided that the obvious steps have been taken in respect of individual hazards, there can be better value for money in respect of all hazards and threats.

It is important to understand that security in a system cannot be guaranteed just through mitigating threats/hazards or reducing vulnerabilities; that would presuppose a level of understanding of all risk sources and their ultimate effects that would be unrealistic. That principle is well understood in project management and reliability engineering, where experience has shown that strategies to avoid failure can be a more efficient approach to management than those that concentrate only on enhancing success. The practices needed to avoid failure can be less complicated and costly than those needed to achieve success. The two are not simple opposites.

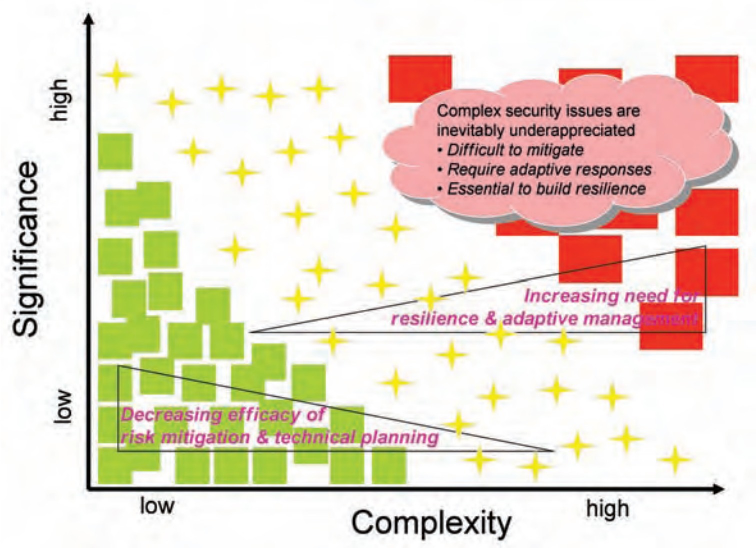

Figure 3: **Management over the spectrum of security issues**

Adaptive management

Having pre-planned arrangements in place in case mitigation or control measures should fail is a critical final element in layered defence systems. The speed with which analysis is undertaken on an emerging risk, and decisions made to initiate response and recovery operations, can have a great bearing on outcomes. For events that have low probability and high consequences – the difficult end of the risk spectrum – it is especially important to have flexible arrangements that can be adapted quickly to deal with unexpected outcomes.

In New Zealand there has been considerable change over the past two decades aimed at strengthening arrangements for rapid and effective management of a broad range of incidents, emergencies, and crises. This began in 1987 when government created a single centralised system for national security management known as Domestic and External Security Coordination (DESC).

The intention in so doing was to create a high-level collective decision-making arrangement that would provide government with a system for fast, flexible, adaptive management of all national security issues. Over time its mandate has been widened to include all hazards as well as deliberate threats. This mechanism has been successful in facilitating a whole-of-government approach to security, and in coordinating devolved sectoral and regional capabilities where a rapid national response is required. DESC does not override existing statutory powers and responsibilities of Ministers, departments, or local authorities.

The operational aspects of national issues are usually the responsibility of a designated lead department, which is supported by other government agencies working under DESC arrangements. Departments are encouraged to examine the significant risks they manage for government, identify particular vulnerabilities, develop strategies to control the risks, continually improve their preparedness and response capabilities, and participate in joint, coordinated management.

In over 20 years of continuous operation, the DESC system has dealt with a wide range of disasters and emergencies. It has overseen many initiatives to improve the management of national security issues in areas as diverse as biosecurity, border control, challenges to national interests, civil defence, counter-terrorism, cyber-threat, event security, food supply, hazardous materials, health emergencies, infrastructure failures, maritime security, military strategies, natural disasters, organised threats, pandemic planning, resources poaching, sovereignty issues, transport security, and unconventional attacks. Most of these issues are now being managed formally using risk methodologies, comprehensive management, and integrated operations across government.

Following reviews in the mid-1990s, government examined options for improving the way that local and regional emergencies were managed. It wanted to improve effectiveness by shifting from centralised, rules-based, response organisations towards more flexible arrangements based on principles, culture, mitigation, and local knowledge. It built on the ideas of risk-based, all-hazards, management, and through the Civil Defence Emergency Management Act 2002 enshrined new practices of comprehensive and integrated risk treatments. Under the Act responsibility for local risks was devolved onto regional CDEM groups tasked with the management of local civil defence emergencies.

CONCLUSIONS

Managing complex security risks is becoming increasingly difficult but there can be considerable benefit from using a systems approach, starting with an understanding of key elements in the system. In the past decade or so, new approaches to systems analysis and integrated risk management are allowing them to make significant contributions to dealing with the problems of new systemic risks and security issues in society. Such risks are best controlled through a balanced combination of

- mitigation of discrete risks
- coherent management of the system
- enhancement of total system resilience
- adaptive management in response.

Strategies that combine specific risk controls, where possible, as well as more general improvements to resilience in society, provide a pragmatic means of addressing unfamiliar security issues, especially those involving multifarious risks, large-scale problems, or issues with high uncertainty, ambiguity, or complexity.

Managing uncertainty is the core issue in every phase. Where there is uncertainty, there is insecurity. There are very few absolutes in the security world, just different degrees of confidence and doubt. Today's security environment is moving from 'prevention of the known' to 'management of the unknown' – from *risk avoidance* to *risk management* within a systems framework. In much the way that modern businesses consciously take on investment risks for profit making, it is clear that governments and communities will increasingly need to learn how to improve their quality of life and strengthen security while living *with* risk.

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Research, Science and Emergency Management

Partnering for Resilience

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Δ **A fortuitous orbit of the International Space Station allowed the astronauts this striking view of Sarychev volcano (Russia's Kuril Islands, northeast of Japan) in an early stage of eruption on June 12, 2009. (Photo: NASA)**

Effective and comprehensive civil defence emergency management (CDEM) is critical because New Zealanders are vulnerable to a broad range of hazards with disaster potential. The National CDEM Strategy articulates the Crown's vision for a "Resilient New Zealand – communities understanding and managing their hazards".

The approach to realising this vision of disaster resilience derives from the Civil Defence Emergency Management Act 2002, and requires a comprehensive risk management approach in addressing the consequences of hazards, across the four elements of emergency management – reduction, readiness, response and recovery.

THE ROLE OF RESEARCH AND SCIENCE IN EMERGENCY MANAGEMENT

Building disaster resilience relies on us understanding a complex set of dynamic factors within the natural, social, economic and built environments, and applying evidence-based, cost-effective and sustainable solutions. We require new knowledge and tools, and must draw on and develop professional skills across a wide range of disciplines. Science and research are at the heart of these developments, although their contribution to CDEM is often understated. The National CDEM Strategy and the *National Hazardscape Report* (ODESC, 2007) emphasise the importance of well-promoted, coordinated and accessible hazards and disaster research as a specific national objective.

In what different ways does research and science contribute to emergency management?

Developing knowledge and supporting innovation

Science research continuously develops existing areas of knowledge and opens up new areas. The physical sciences are essential to characterising, quantifying and understanding the hazardscape, among other contributions. The physical sciences and engineering together are vital for determining the likelihood and consequences of associated risks, and for the robust design of risk-based technical planning standards and risk mitigation measures.

The social sciences (including economics) are the key to understanding the human dimensions of risks and disasters. This includes how people perceive, communicate and manage risks, and other human behaviour before, during and after emergencies. Also, the social sciences are indispensable for innovation of the systems and resources that enable successful planning and resilience building. For all of the sciences, New Zealand both benefits from, and is an active contributor to, the global knowledge pool.

Examples of science and research application

To illustrate aspects described above, examples are given of different ways in which research and science have been applied including

1. targeted research addressing specific solutions
2. development of experimental approaches and tools
3. a body of knowledge applied to establishing best practice approaches
4. incremental advances through new knowledge.

Further examples of the application of research into practice are given in the articles of this issue of *Tephra*.

Targeted research applied to a specific planning issue

Increased perception of tsunami risk after the 26 December 2004 Indian Ocean event prompted the commissioning of research to assess New Zealand's level of risk (Berryman, 2005) and levels of preparedness (Webb, 2005). This work is the basis of a range of subsequent targeted research activities to address specific problems for tsunami planning including improved understanding of tsunami hazard and risk, warning system effectiveness, evacuation planning and public education. One aspect of this programme is the commissioning of detailed modelling of Pacific Rim tsunami sources and propagation, to fill knowledge gaps. These source and propagation models are being applied directly to development of threat assessment tools for use in New Zealand's tsunami emergency response.

The response planning for the Ruapehu crater lake break-out lahar of March 2007 is another example of a specific planning issue underpinned by strong science, including quantitative risk assessments, cost-benefit analyses, and scenario modelling (Galley and others, 2004, and references within). Additionally, the anticipated lahar event was a unique scientific opportunity in New Zealand. Research activities included developing and testing physical and numerical models of Ruapehu's lahars, observing planning and response activities, and building and testing the technology used in new detection and warning systems.

Development of experimental approaches and tools

Another way in which research and emergency management interface is through application of existing research knowledge to developing novel approaches or experimental tools. A specific example includes work on understanding organisational resilience (McManus and others, 2008; Seville, this issue of *Tephra*). This work has evolved a strong theoretical basis, drawing on research from well outside the sphere of emergency management. The result is a very practical framework and a prototype tool for assessing an organisation's resilience, defined by situational awareness, ability to manage key vulnerabilities, and its adaptive capacity.

Application of a body of knowledge to strategies and frameworks

Another example of research application is through the accumulation of a body of knowledge by applied research activities over many years, used to establish frameworks and establishing 'good practice' approaches to emergency management. The human behavioural sciences are particularly relevant here, as successful implementation of emergency management requires an understanding of communities. An example in the New Zealand context is the development of the Recovery Management framework (MCDEM, 2005), which is underpinned by decades of strong international social science research and international experience about individual, community, and business behaviours in the aftermath of emergencies.

New knowledge from curiosity-driven research

The continuous stream of data from global positioning sensors around New Zealand (part of the GeoNet geophysical

Phases of science	Benefits to CDEM	Benefits to science
Ongoing Research		
Curiosity-driven (basic) research to advance understanding of the natural environment, risks, and human behaviour	· Science capability developed in this endeavour is available for application to operational CDEM · Develops knowledge from which emerges (over years and decades) the evidence basis for CDEM planning, new approaches, practice, and technologies	· Advancement of theory and the discipline · Capability building · Professional advancement
Targeted/Applied research to develop practical tools and solutions	· Development (over months to years) of new tools and solutions to address specific problems · Provides the evidence basis (from the physical and social sciences, and engineering) for emergency planning	· Testing of theory and models · Professional development through practical application of knowledge
During Emergencies/Events		
Provision of warnings and advice during emergency response/recovery	· Timely and authoritative scientific warnings · Information and advice (from the physical and social sciences, and engineering), for evidence-based response/recovery actions	· Opportunities to gain operational experience · Testing physical and social science theory and models · Professional development through practical application · Advocacy by emergency managers for science funding
Event and post-event investigations	· Provision of quality event information and data on physical impacts and social/economic consequences · Evidence basis for future emergency planning	· Opportunities to capture rare, perishable event data, validate existing models, and develop new models · Capability building · New research opportunities

monitoring system) might not seem particularly relevant to everyday emergency management. However, the recognition of 'slow earthquakes' occurring beneath parts of the eastern North Island, associated with plate boundary movement, is new knowledge that contributes to emergency management through potentially reducing uncertainty in New Zealand's earthquake hazard models.

Operational information and science advice

Perhaps an obvious application of science expertise within emergency management is its daily use in monitoring the hazardscape to anticipate events, and the provision of warnings and advice during emergencies to support decision making. Examples include the

- meteorological and hydrological sciences providing severe weather watches and warnings
- geophysical sciences providing warnings and characterising geological hazard events such as earthquakes, distant and regional source tsunami, volcanic unrest, and landslides
- biomedical sciences underpinning biosecurity and human pandemic responses (which are characteristically strongly science driven).

Such scientific advice is indispensable for modern, comprehensive emergency management, and is possible only through long-term investment in science capability.

BENEFITS FOR SCIENCE ENGAGING IN EMERGENCY MANAGEMENT

The examples given above perhaps imply that the flow of benefits from science engagement in emergency management is one way, when in fact emergency management provides fertile ground for scientists and researchers. Hazards, risks and emergency management all represent extensive fields of study for a diverse range of basic, targeted, and applied research, of international scope. Emergencies present unique opportunities to obtain valuable and in many cases perishable data. Similarly, it is in the 'crucible' of hazard events (or the emergencies they may cause) that scientific models are subject to perhaps the ultimate test, and valuable practical experience in the field is gained by physical and social scientists and engineers.

The table (page 73) summarises the phases and scope of the science contribution (across the physical and social sciences, and engineering), and the benefits derived by both the users and providers of researcher.

CHALLENGES FOR THE SCIENCE AND EMERGENCY MANAGEMENT PARTNERSHIP

So the benefits of a close partnership between the sciences and emergency management are potentially reciprocal. What, if any, are the challenges and obstacles that may limit the effectiveness of the partnership? What isn't working, why isn't it working, and what might be done differently to reduce the obstacles, and improve the uptake and application of existing research findings and new research?

Accessibility and relevance

One of the key challenges for emergency managers engaging with science is the sheer diversity of physical and social science disciplines and scope of research of potential relevance. The pathways for application of research need to be clear if research of relevance is to be picked up and applied (see comment in the article by Cowan and others, this issue). Another challenge is reconciling the long time frames that might be involved in some types of curiosity-driven research, with the operational imperatives of emergency management, which may be quite short-term and require the direct application of existing knowledge. This is particularly acute for the science of rare hazard events (those that have low likelihood but high consequences, such as most of the geological hazards), because their infrequent occurrence constrains the way the science advances. However, 'basic' (or 'pure') research is the lifeblood of scientific progress and the ultimate source of the knowledge applied to solving specific problems and creating tools that are of more obvious practical use. Also, basic research is the core activity for building scientific capability and for advancing the theory of a discipline (especially in the physical sciences), and consequently there are very strong professional incentives to focus on this type of research.

Science in silos

The incentives described above, together with the sheer hard work required to advance knowledge, naturally encourage the pursuit by researchers of fields of study that may narrow and specialise. 'Silos' can be defined as inwardly focused organisational units where external relationships are given insufficient attention (Fenwick and others, 2009). For emergency management, science silos can mean that additional energy, cost and time are required to connect with or cross-fertilise multiple disciplines (or organisations), in order to realise robust and holistic solutions.

Competition in science funding

The New Zealand science environment is acknowledged as one of the most highly competitive in the world (OECD, 2007). The science reforms starting in the early 1990s created the Crown Research Institutes, led to the progressive introduction of highly contestable funding schemes, brought a performance focus to university research, and encouraged the private sector to invest in research, science and technology. The reforms largely relied on a competitive funding process, which has been effective in selecting and funding leading edge science, fresh ideas and new entrants. In recent years, though, it has been found not well suited to

- nurturing the larger, longer-term research needs
- encouraging cross-organisation and inter-discipline collaboration and coordination, or
- delivering on the strategic outcomes New Zealand is seeking.

Capability and capacity in emergency management

A common refrain by researchers is that valuable information and ideas are languishing because of limited uptake by practitioners and policy makers. The reasons for this are various, but generally include

- perceived misalignment between research outputs and user needs and time frames
- limited capability and capacity within operational and policy environments to transfer and apply research findings.

Solutions to these problems require meaningful and ongoing communication between researchers, policy makers and practitioners, to enhance connectivity and develop relationships. Dialogue is necessary to broaden perspectives and improve understanding of the constraints and requirements of each other's operating environments. From strong relationships built on trust and transparency

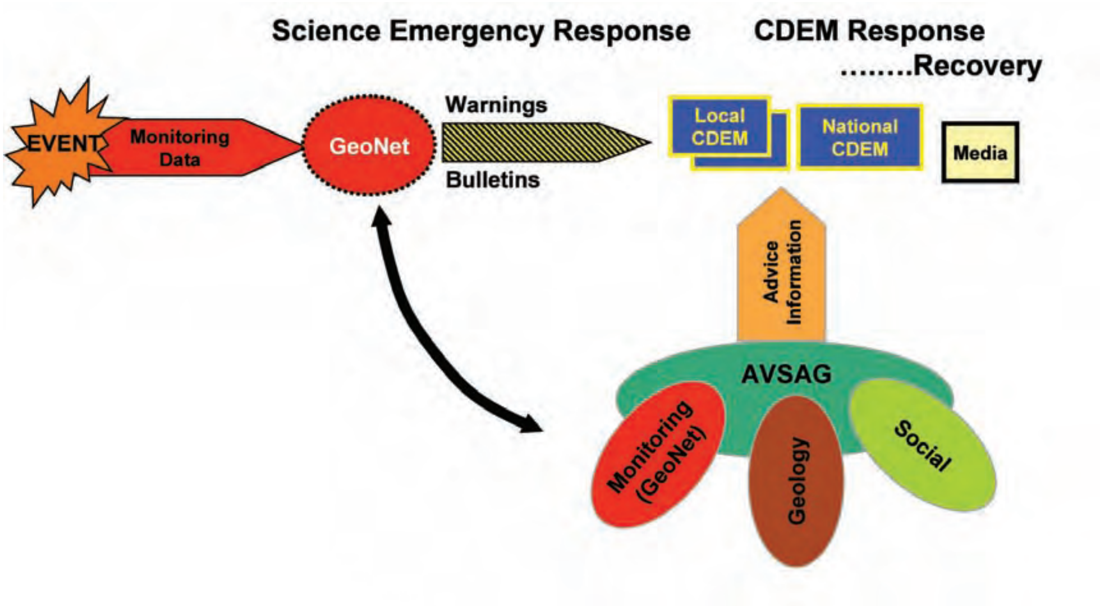

Figure 1: **A depiction of the operating structure of the AVSAG and its relationship to GeoNet and CDEM** (see "The Exercise Ruaumoko experience")

shared interests are more easily recognised and opportunities created. This applies as much within the sciences as between science and CDEM. Improved scientific literacy of emergency managers will also come from ongoing professional development – building the skills to better leverage national and international research in the physical and social sciences.

IMPROVING CONNECTIVITY AND COHESION WITHIN SCIENCE AND WITH NZ EMERGENCY MANAGEMENT

A central tenet of modern emergency management is collaborative, coordinated action, involving integration across clusters of organisations performing similar functions. The objective is to efficiently draw capacity and capability from collective effort. Coordination and cohesion between research organisations, as well as between researchers and research users, are recognised as important issues requiring attention (e.g. Reid and others, 2004; FRST, 2008; MCDEM, 2008).

Development of a pilot natural hazards research platform

A connected and coordinated science environment is necessary to answer complex research questions. A stable funding environment has been accepted as essential for nurturing long-term research that delivers beneficial national outcomes (FRST, 2008). 'Natural Hazards' research has been identified as a research area of critical strategic importance to New Zealand, with outcomes that directly support the achievement of government strategies for improved community resilience. A multi-agency Natural Hazards Platform, led by the Foundation for Research, Science and Technology, is under development to provide a framework for improved alignment of effort and dialogue between researchers and research users.

The National CDEM Strategy is providing the direction for the Natural Hazards Research Platform. Broadly defined, research will encompass capabilities to understand, identify and manage those risks with the potential to have significant economic, social and environmental impacts on New Zealand. Specifically these are the risks associated with the physical hazards stemming from earthquakes, tsunamis, volcanic eruptions, and severe weather. The Platform will also address social, economic and infrastructure resilience to the above natural hazards. Science capability supported by the Platform will also be available to assist decision makers during significant hazard events.

The draft strategy for the Platform intends that research priorities should

- be established with sound consideration of the national science capability requirements
- consider the knowledge needs across the 4Rs and the four 'environments' of communities (natural, built, social and economic)
- be aligned with the National CDEM Strategy goals and objectives.

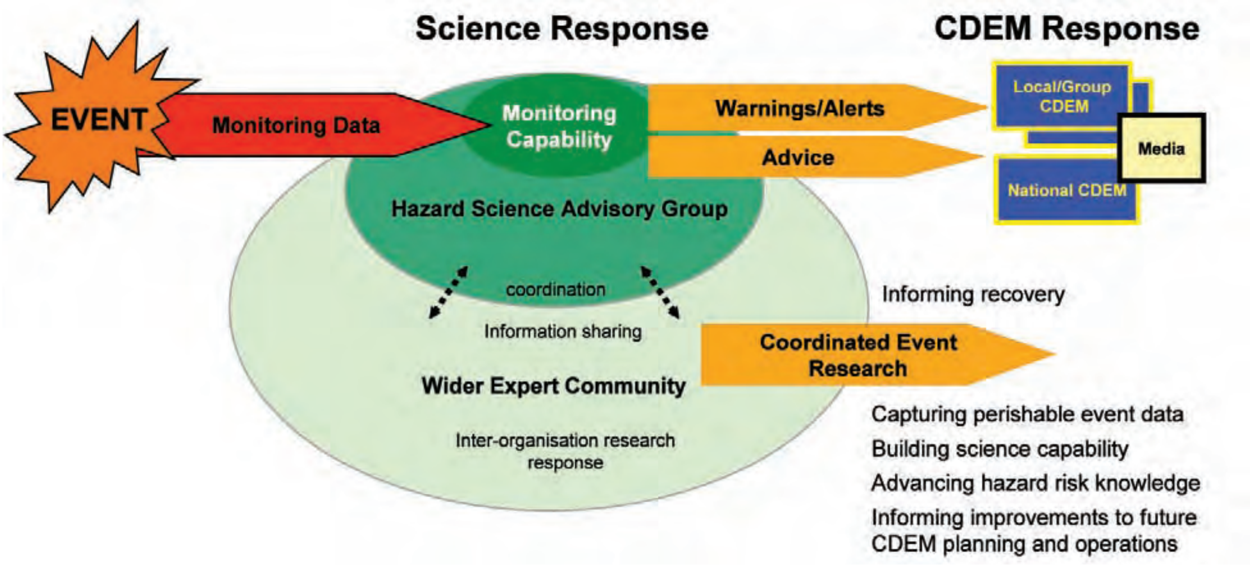

Figure 2: **A model for a hazard science advisory group, to enable integration of nationwide science capability.** The advisory group would be made up of appropriate subject experts from across universities, crown research institutes and other science organisations including consultancies. The advisory group could play both an operational role (during events) and a strategic role for planning science activities.

Development of multi-agency science advisory groups

The Exercise Ruaumoko experience

Exercise Ruaumoko, an all-of-government CDEM exercise based on the build-up to an eruption in the Auckland Volcanic Field, was conducted in two phases over four months from November 2007 to March 2008. An important element of Exercise Ruaumoko was the operational testing of the provision of science advice to emergency managers. Planning for this aspect (and the broader CDEM aims) contributed to relationship building between scientists and CDEM.

In preparing for the exercise (and in accordance with the Auckland Volcano Contingency Plan; ARC, 2002), the Auckland CDEM Group established the Auckland Volcano Science Advisory Group (AVSAG) with representation from Auckland, Waikato, and Massey universities, GNS Science, MetService, Kestrel Group, and local and national CDEM. The AVSAG structure consisted of three subcommittees addressing monitoring, geology, and social science (Figure 1).

The formation of the AVSAG provided a useful opportunity for establishing principles for integrating science capabilities, and formalising arrangements for support to CDEM. The science advice during Exercise Ruaumoko has been widely praised in the exercise evaluation (MCDEM, 2008). The final exercise report (MCDEM, 2008) identified lessons and opportunities for improvements to advisory group structures and processes. Key issues were the limited agility of the subcommittee structure and a potential for disconnect between local and national science elements.

Included in the Exercise Ruaumoko Report recommendations is for MCDEM to work with CDEM Groups and science agencies to

1. Consider options for integrating local and national science capabilities and processes
2. Facilitate collaborative planning by science agencies, including universities, for post-event science investigations.

MCDEM has been facilitating dialogue between volcano scientists as to how the skills of scientists from different organisations (including universities, Crown Research Institutes, consultancies and councils) can be integrated, especially in support of a national science agency such as GNS Science that has responsibilities under the National CDEM Plan for providing warnings and advice. Coordination of scientific expertise in this way recognises the limited knowledge pool and resources likely available for any particular hazard event in any one organisation or region, and that an effective science response will require the coordinated action of the New Zealand-wide pool of scientific expertise. In cases where no local science capability exists (e.g. for tsunami), then national arrangements will be essential.

Progressing a science cluster model
Building on the lessons of Exercise Ruaumoko, an advisory group model is evolving to address the need for mobilisation of New Zealand-wide science capability, while remaining responsive to local CDEM needs. The model (Figure 2) has at its core national hazard monitoring capability and processes (e.g. GeoNet), with involvement of additional capability from universities and other science organisations based on thresholds of response. The intent is that GeoNet (both the technology and the science expertise of GNS Science) be the hub of any science response for earthquake, volcano, tsunami or landslide events. The principles of this structure could be applied to other hazard types for which there is a mandated national agency.

Alignment of local and national levels
A number of regions have existing scientific or planning advisory groups with a volcanic and/or earthquake focus. The intention is not that any national coordination override local advisory group arrangements but rather that it be complementary and provide for a level of consistency for how New Zealand-wide science capability is mobilised when a large-scale science response is needed.

Strategic benefits from clustering for science and CDEM
While the focus of the science advisory group model described above is operational response (in both science and CDEM), a core national science advisory group could play an important strategic role in such areas as

- facilitating coordinated post-event investigations (drawing on US experience, Holzer and others, 2005), including data sharing arrangements (Figure 2)
- providing strategic advice on research direction and priorities
- fostering connectivity across the physical and social sciences
- supporting alignment between researchers and research users.

SUMMARY

Building disaster resilience requires us to develop new knowledge, new techniques, and new levels of competency. Research science is at the heart of these developments. It is at the core of successful response and recovery operations, and fundamental to evidence-based approaches to reduction and readiness planning. Full realisation of the science contribution to emergency management requires enhanced capabilities in the practitioner and policy environments to access and take up relevant research, better integration across science disciplines and organisations, and improved alignment between researchers and research users.

Addressing all these dimensions presents a challenge for both the science sector and emergency management sector. However, engagement between science and emergency management is growing in strength and vibrancy, and there is increasing understanding within science organisations of the shared interests and mutual benefits to be derived from coordinated and connected activity. Facilitating this connectivity is an important function of organisations such as MCDEM and EQC. Work is under way to develop and promote hazard-science advisory groups among agencies with overlapping or shared objectives, and to establish a new research management framework to support the National CDEM Strategy.

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GET READY GET THRU
YOU COULD BE ON YOUR OWN FOR 3 DAYS

- ☐ Make sure you have a Household Emergency Plan
- ☐ Ensure you have emergency survival items to cope on your own for up to three days or more
- ☐ In an emergency, do not use the phone unless urgent. For Police, Fire or Ambulance dial 111
- ☐ Listen to the radio for civil defence advice. Tune in to National Radio, Newstalk ZB, Classic Hits, More FM, or Radio Live

WHAT TO DO – YOUR SURVIVAL GUIDE

EARTHQUAKE

Before an earthquake
- Identify safe places very close to you at home, school or workplace, such as under a sturdy table, or next to an interior wall
- Protect property. Secure objects and your home, keep insurance up to date

During an earthquake
- Move no more than a few steps to a safe place, drop, cover and hold
- Do not run outside
- If in a lift, stop at the nearest floor and get out, drop, cover and hold
- If you are driving, pull over to the side of the road and stay in the vehicle until the shaking stops

When the shaking stops
- Treat injuries and put out small fires
- Turn off water, electricity, gas and heating at mains if it is safe
- Evacuate if fires cannot be controlled
- Check on your neighbours
- Be prepared for aftershocks

STORM

When a strong wind warning is issued
- Bring pets inside and move stock to shelter
- Secure outdoor furniture
- Tape across large windows to prevent shattering

During a severe storm
- Stay indoors
- Close the curtains and keep away from doors and windows
- Partially open a window on the sheltered side of the house
- Avoid driving, unless absolutely necessary
- Avoid damaged power lines and report these to your power company

TSUNAMI

- If you live in a tsunami risk zone, find out what warning systems are in place in your community and what you need to do
- If you are on the beach or near a river when a strong earthquake occurs, move inland to higher ground immediately
- Go at least one kilometre inland or 35 metres above sea level
- Do not go sightseeing to the beach or river
- Listen to the radio for information and follow civil defence instructions

EMERGENCY SURVIVAL ITEMS

- **Water (3 litres per person, per day, for up to 3 days or more)**
- **Canned, non-perishable food**
- **Torch and Radio (with batteries)**
- **Toilet paper, plastic bags and bucket**
- **First Aid Kit and essential medicines, including paracetamol for fever**
- **BBQ or other means of cooking**
- **Face and dust masks**

TO FIND OUT MORE CONTACT YOUR LOCAL COUNCIL OR GO TO www.getthru.govt.nz

VOLCANIC ERUPTION

Before a volcanic eruption
- If you live in an active volcanic zone, learn about your community's warning systems and emergency plans and what you need to do
- If your area is at risk from a lava flow, know a quick route to safe ground

During a volcanic eruption
- Stay indoors with your pets as much as possible
- Save water at an early stage as supplies may become contaminated
- Keep gutters and roof clear of ash to prevent roof collapse
- Do not go sightseeing
- If you must go outside, use protective clothing, cover your head, breathe through a mask or cloth and carry a torch

FLOOD

Before a flood
- Find out about the flood risk in your locality and know how to reach the nearest safest ground
- Keep your insurance cover up to date

When a flood threatens
- Listen to the radio for information and follow civil defence instructions
- Disconnect electrical appliances
- Raise valuables, weedkillers and chemicals above floor level, or remove
- If you have to be evacuated, turn off electricity and gas at the mains and take your getaway emergency kit with you
- Avoid flooded areas
- Do not drink floodwater, as it could be contaminated

PANDEMIC – WORLDWIDE DISEASE OUTBREAK

- Stay home if you are sick, keep away from other people and avoid visitors
- Wash and dry your hands before handling food and after coughing, sneezing, using the bathroom, wiping children's noses and when looking after sick people
- Use tissues to cover coughs and sneezes. Throw used tissues in bin
- Give fluids to people who have a fever and/or diarrhoea. Paracetamol can be used to bring down high fevers
- For more information, see the Ministry of Health website: www.moh.govt.nz/influenza

IF YOU HAVE TO BE EVACUATED

You need to take
- Essential medicines, toilet items and baby needs
- Important documents (identification, insurance)
- Radio and torch (with batteries)
- Emergency bottled water
- Extra clothing and footwear

Before you leave
- Consider your pets
- Turn off water, electricity, gas and heating at mains
- Lock your property

When you have reached safety
- Listen to the radio for information and follow civil defence instructions

GET READY GET THRU

CIVIL DEFENCE

"RESILIENT NEW ZEALAND – COMMUNITIES UNDERSTANDING AND MANAGING THEIR HAZARDS"

"AOTEAROA MANAHAU – HE PŪIOIO NGĀ HAPORI, HE MĀRAMA KI Ō RĀTOU PŪMATE ME TE WHAKAHAERE"

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