Lecture Notes in Social Networks

Anthony Masys *Editor*

Disaster Management: Enabling Resilience

Springer

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ISSN 2190-5428 ISSN 2190-5436 (electronic)
ISBN 978-3-319-08818-1 ISBN 978-3-319-08819-8 (eBook)
DOI 10.1007/978-3-319-08819-8

Library of Congress Control Number: 2014948746

Springer Cham Heidelberg New York Dordrecht London

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Preface

Introduction

Several disasters over the past number of years have exposed serious weaknesses and vulnerabilities in the emergency management capabilities within the global communities. Events such as BP Deepwater Horizon Oil spill (2010), Fukushima tsunami and nuclear disaster (2011), earthquake in Haiti (2010), Hurricane Sandy (2013), and Typhoon Haiyan (2013) highlight the devastating effects that man-made and natural disasters have on the population and infrastructure. These examples highlight how ‘hyper-risks’ emerge from our ‘hyper-connected world’ [1] pointing to the requirement for enabling resilience to support disaster management. A recent Chatham House report ‘Preparing for High-Impact, Low-Probability Events’, found that governments and businesses remain unprepared for such events [2]. As described in the Chatham House Report [2], the frequency of ‘high-impact, low-probability’ (HILP) events in the last decade signals the emergence of a new ‘normal’. With regard to the BP Deepwater Horizon Oil spill (2010), the various failures described in the Presidential Report (2011) highlight the lack of a suitable approach for anticipating and managing the inherent risks, uncertainties and dangers associated with deepwater drilling operations, and the failure to learn from previous near misses. Many of the risks that are associated with man-made and natural disasters often arise from unanticipated consequences stemming from interactions within and between different types of systems. Recurrent events, such as flooding, droughts, tornadoes, and even pandemic outbreaks have been shown to have equally serious impacts, raising new questions about how we can ‘design’ and enable resilience in systems and communities.

Resilience, resilient communities, and resilient livelihoods are becoming a focus of local, regional, national and global governments, and agencies. Researchers along with disaster management agencies are seeking to address the underlying fragilities that turn shocks and stresses into crises and how to enable resilience to support risk, crisis, and disaster management.

Resilience Thinking

Today we see unprecedented interconnectedness and interdependencies at the local and global scale. As described by Sambharya and Rasheed [3] 'risks are rarely confined to a nation, an industry, or a firm. Instead, today's risks are systemic, their contagion rapid, and their consequences devastating and unpredictable. This calls for new approaches to understand measure and respond to risks'. The concept of resilience, in particular associated with disaster risk reduction, has gained significant interest and attention. Within the context of such threats as pandemics, climate change, financial crisis, natural hazards, and technological disasters, resilience thinking has emerged as a concept that recognizes the complex, nonlinear and dynamic properties of interdependent systems (social, political, economic, ecological). "Resilience thinking" supports a systems view of the disaster management domain to reveal new ways of understanding the world and a new approach to managing disasters. The systems lens that supports resilience thinking embraces network analysis to reveal insights into politics, governance, and power relationships that permeate the system as described in Masys [4]. It embraces human, technical, and natural systems as complex entities continually adapting through cycles of change. A resilience thinking approach examines how these interacting systems of people, technology, and nature can be managed to facilitate safety and security.

As part of the Springer book series: *Lecture Notes in Social Networks*, this edited volume: *Disaster Management: Enabling Resilience*, focuses on the contribution of resilience thinking along the following broad themes:

- Urban Domain
- Cyber Domain
- Organizational/Social Domain
- Socio-ecological Domain

This book comprises 15 chapters from leading researchers engaged in resilience thinking within the risk, crisis, and disaster management domain. The chapters present state-of-the-art research on resilience thinking tools, techniques, and applications supported by case studies and computational simulation.

Content

Part I: Introduction

The first two chapters provide a powerful introduction to the notion of resilience within the disaster management domain. The chapter "Resilience Undefined: A Framework for Interdisciplinary Communication and Application for Real-World Problems" by Thomas G. Koslowski and Patricia H. Longstaff describe how resilience scholars from multiple fields continue to look for a universally accepted definition of resilience. But is a universal definition across disciplines possible or even desirable in the near future? The proposed framework enables a more holistic understanding of the various fields of resilience research and makes communication across several domains more productive by placing the discussions into four types of resilience that are broad enough to facilitate discussion, but specific enough to allow for the translation of resilience into specific policies, practices, and outcomes.

Erik Hollnagel (well known through his contributions to resilience engineering) in his chapter "Disaster Management, Control and Resilience", looks at disaster management as a form of safety management, using the perspective of resilience engineering. In safety management, control can be lost by not being ready to respond, by having too little time, by lacking knowledge of what is going on, or by lacking the necessary resources. To maintain control unsurprisingly requires the converse of these conditions. Resilience engineering looks at how systems can sustain required operations under both expected and unexpected conditions by adjusting its functioning prior to, during, or following changes, disturbances, and opportunities. To do so requires the abilities to respond to what happens, to monitor the situation, to learn from what has happened, and to anticipate what may happen. The same type of analysis can be applied to disaster management, to better understand how it succeeds.

Part II: Urban Domain

The part on Urban Domain resilience comprises four insightful chapters. Oliver Chikumbo, Steve Lewis, Hugh Canard, and Tony Norris in their chapter entitled "Futuristic Smart Architecture for a Rapid Disaster Response" describe how the ability to control and contain an unexpected disaster event such as a bushfire or flooding in real-time is fraught with logistic and planning challenges. Information is difficult to assimilate both from structured and unstructured data that may be collected in real time—unreliability of mostly unstructured data from social media and mobile devices, though extremely helpful, can make it difficult to deploy needed help/assistance in time. Also when part of the infrastructure is destroyed that normally is relied on for collecting structured data, the situation can even make it harder for ad hoc planning specifically targeted at saving lives first. In such situations, a combination of unstructured data that carries uncertainties and limited structured data from infrastructure that might still be working after/during a disaster event can be used to the best of advantages and still enhance the control process to better achieve desired outcomes: i.e., real-time event monitoring through real-time limited and high uncertainty data; filtering unstructured data through crowd sourcing, not only for reliability but sometimes for language translation as well; short-term predictions of anticipated changes from already existing interoperable simulation models, using the limited structured data from infrastructure that might be still standing following a disaster; and all this with the aim of appropriate, timely responses to saving lives in a rapidly evolving environment. A generic management framework designed to be used during a "phase transition" between pre- and post events, and characterized by the interoperability of distributed simulation models, and the collection and sharing of structured and unstructured data via cloud services and "connected devices", is essential for the consistent provision of highly effective responses. Chikumbo et al. explores this framework from a science and innovations perspective, advocating "antifragility" for emergency response system designs. For antifragility systems, failures do not stand for a breakdown or malfunctioning of normal system functions, but rather represent the adaptations necessary to cope with the real-world complexity through the management of "robustness trade-offs" as it occurs in dynamic and real-world contexts.

The chapter entitled "Building in Resilience: Long-term Considerations in the Design and Production of Residential Buildings in Israel" by M. Sever, Y Garb, and D. Pearlmutter develop ideas from previous work regarding architectural awareness of earthquake resistance. They introduce three levels of integration needed when designing for resilience: (1) integration in multidisciplinary design teams; (2) integration in the design process, i.e., integrated design or co-design, and (3) integration of long-term and short-term considerations. The aim of this chapter is to examine barriers to the integrated design of resilient buildings by looking at disincentives for nonlinear co-design processes along the extended building supply chain.

In their chapter "Urban Resilience and Sustainability: The Role of a Local Resilience Forum in England", Julie Fisher, Ksenia Chmutina, and Lee Bosher argue that the urban environment is prone to impacts of hazards, threats, and major accidents. In light of this it is crucial to plan, design, build, manage, and operate urban environment in a resilient and sustainable manner. The compatibility and conflict between resilience and sustainability has received increasing attention in recent years in academic literature, however, its application on local and national levels has not yet been widely attempted. The Local Resilience Forum (LRF) is an important mechanism for facilitating the complex multi-stakeholder interactions required to deliver urban resilience in England, however, sustainability does not appear to be a priority. This study explores how emergency planning and the design of the built environment can further both agendas. A range of promising practices was found that potentially could not only increase the resilience of, but that are also integral to the sustainability of the built environment.

Alexandra JaYeun Lee delves into the world of wicked problems and complexity in her chapter "Wicked Problems Framework: Architectural Lessons from Recent Urban Disasters". Urban issues such as informal settlements, poverty, and overcrowding, are merely the physical symptoms of deep systemic issues beyond the control of planners and architects alone, and hence, are 'wicked'. Rittel, a thought leader of design thinking, coined the expression "Wicked Problems" in 1973 to describe the complex issues of society situated in the real world that cannot be solved using rationality alone. In fact, such issues need transdisciplinary understanding and action to optimize decision-making based on multiple viewpoints and methods of inquiry.

Many of the 'wicked' attributes of society are amplified in a state of chaos such as in urban disasters, and this chapter argues that the wicked problems framework can lead to alternative visions through democratic, transdisciplinary design strategies. The Rittelian framework is still relevant in today's complex societies, particularly in community development projects. This chapter presents some of the key findings from three post-disaster case studies, tracing some of the successful design decisions that were made by local stakeholders with and sometimes without architects.

Part III: Cyber Domain

The pervasiveness and impact of cybercrime on national and global systems is significant. Chris Johnson in his chapter "Architectures for Cyber-Security Incident Reporting in Safety-Critical Systems" highlights how cyber-attacks can have a devastating impact on safety-critical systems. The increasing reliance on mass market Commercial Off-The Shelf (COTS) infrastructures, including Linux and the IP stack, have created vulnerabilities in applications ranging from Air Traffic Management through to Railway signalling and Maritime surveillance. Once a system has been attacked, it is impossible to demonstrate that malware has been completely eradicated from a safety-related network. For instance, recent generations of malware use zero day exploits and process injection with command and control server architectures to circumvent existing firewalls and monitoring software. This creates enormous problems for regulators who must determine whether or not it is acceptably safe to resume operations. It is, therefore, important that we learn as much as possible from previous cyber-attacks without disclosing information that might encourage future attacks. This chapter describes different architectures for encouraging the exchange of lessons learned from security incidents in safety-critical applications.

Building upon the insights emerging from Chris Johnson's chapter, Anthony J. Masys presents "The Cyber Ecosystem-enabling Resilience Through the Comprehensive Approach". The pervasiveness of the global cyber infrastructure is instrumental for economic prosperity and national security. Helbing [1] poignantly argues that 'Globalization and technological revolutions are changing our planet. Today we have a worldwide exchange of people, goods, money, information, and ideas, which has produced many new opportunities, services, and benefits for humanity. At the same time, however, the underlying networks have created pathways along which dangerous and damaging events can spread rapidly and globally'. With this in mind comes the realization that '…most cyber infrastructure is not secure and is vulnerable to attacks from malicious actors potentially leading to failure of critical infrastructure, exploitation of sensitive information, and loss of intellectual property' [5] .

The challenge in dealing with such cyber threats stems from the fragmented and disconnected approaches and solutions which as noted by Pawlak and Wendling [6] '…are driven by policy, legal, or technological considerations and as such rarely include all stakeholders: public administration, businesses, citizens, the research community or relevant international players'. To address the pervasiveness and severity of the cyber threats requires an approach that recognizes the cyber security risks from a 'systems perspective' recognizing the complex interdependencies between the physical, human, and informational domains [7–9]. This chapter approaches this 'complexity' dilemma through the application of systems thinking and the comprehensive approach [7, 8].

Part IV: Organizational/Social Domain

The organizational and social domains are explored in a number of chapters. In the Chapter entitled "Enabling Resilience: An Examination of High Reliability Organizations and Safety Culture Through the Lens of Appreciative Inquiry"

Jerson Wattie and Anthony J. Masys focus on shaping a safety culture through the strength-based approach of appreciative inquiry. Dulac [10] argues that complex socio-technical systems have a tendency to slowly drift from a safe state toward a higher risk state, where they are highly vulnerable to small disturbances whereby seemingly inconsequential events can precipitate an accident. Recent socio-technical disasters such as the 2011 Fukushima Nuclear accident, 2010 Deepwater Horizon accident and 2005 refinery explosions at BP's Texas City all highlight major disasters in which a safety culture was not working. Many industries around the world are showing an increasing interest in the concept of 'safety culture' as a means of reducing the potential for large-scale disasters, and accidents associated with routine tasks [11]. Traditional root cause methods of analysis examining safety culture apply a deficiency model in which problems are identified to support corrective action and transformational change. Within this paradigm one asks: "What are the problems?", "What's wrong?" or "What needs to be fixed?". Here we introduce a paradigm shift from a deficiency-based approach to a strength-based approach through the advent of "Appreciative Inquiry" (AI). The Appreciative Inquiry model is based on the assumption that the questions we ask will tend to focus our attention in a particular direction. Appreciative Inquiry stands out as a methodology that can facilitate examination and 'construction' of safety culture. As a high engagement, strength-based approach to organizational change, AI focuses on aligning strengths of the organization with opportunities, aspirations and desired results, and transforming goals into action fostering organizational learning at its core. Drawing upon the literature on AI, High Reliability Organizations and safety culture, this chapter presents appreciative inquiry as a tool-set to facilitate structured analysis and construction of the qualities of a safety culture of excellence to support a High Reliability Organization.

Simon Bennett describes in his chapter "Unintended Consequences. What Lessons Can Risk-Managers Learn from the Use of Armed Remotely Piloted Vehicles for Counter-insurgency in Pakistan?" how actions have intended and unintended consequences, some of which are functional, some not. The CIA's drones-first Pakistan counterterrorism strategy is used to illustrate how a well-intentioned policy may generate adverse outcomes sufficient to undermine that policy. The adverse outcomes (in Merton's argot 'latent dysfunctions') generated by the CIA's counterterrorism strategy may be so numerous and grave as to undermine the War on Terror. Adverse outcomes include collateral damage, radicalization, destabilization, and diplomatic schism. Several lessons are drawn. For example, the latent dysfunctions can undermine, if not fatally compromise, purposive action. It is far from certain that the CIA's drones-first counterterrorism strategy is making a net contribution to the War on Terror. Latent dysfunctions could render the War on Terror a zero-sum game. The author concludes that a timely response to contra-indications (Langer's 'mindfulness' and Toft's 'active learning') makes policy success more likely. Inhibitors to mindfulness include ignorance, prejudice, dogma, groupthink, and collective amnesia.

In the chapter "*Extra-fragile* in Disaster: People with Disabilities in a Bombarded Zone", Rita Sever describes how although some guidelines and manuals support the specific inclusion of people with disabilities in emergency considerations, most programs focus on disability as a cross cutting issue, or on protecting people with disabilities as a vulnerable group, rather than on the specifics of inclusion and overcoming barriers. There is little evidence that these guidelines are used to any effect with people with disabilities.

In emergencies, handicapped people may encounter particular difficulties that make the general facilities and assistance inaccessible to them. At the same time, services that usually cater to their special needs also suffer damage and become less effective or even unavailable. The social and personal supports that surround people with disabilities are fragile and appear to be particularly susceptible to the type of disruption that disasters incur.

This is what was happening in Israel in summer 2006. The existing public services were inadequate for people with disabilities living in the bombarded North which became a disaster zone, and third sector organizations stepped in to fill the void. A program was created by NGOs to respond to a deluge of requests for assistance from people with disabilities living in their communities within the disaster zone.

The research presented in this chapter is a mixed-methods case-study that studied this program. It is based on documentary material, program records, in-depth interviews with the partners and staff members of the program, and a survey of a representative sample of people with disabilities who requested assistance from the project. In addition to complementing findings of other researches, this study has unveiled some of the problems and dilemmas encountered by the project and has highlighted several issues that have not gained ample consideration, if at all, in the existing literature on disaster management and planning for resilience: unintended consequences of the participatory approach; managing and coordinating volunteers; and the double jeopardy of people with physical or mental disabilities who are also culturally and/or linguistically different from the mainstream population.

In the chapter "Disaster Management: Enabling Resilience" Regan Potangaroa, Happy Santosa, and Suzanne Wilkinson looks at one way to possibly measure resilience as a first step toward perhaps managing it. This issue of metrics seems to be at the core of the resilience discussion. The approach discussed uses a Quality of Life (QoL) Tool that was theoretically adapted for its application in the field.

In the chapter "Defining and Negotiating a Shared Responsibility for Disaster Resilience", Bede Wilson applies Cultural Theory to examine how the community of Springbrook, Australia, defines and negotiates a shared responsibility for disaster resilience. The influence of this process on the community's disaster management plan is also assessed. The Springbrook example shows that initiatives that promote mutual understanding of world views are an effective way to develop disaster resilience. Through deliberation these world views may form alliances that address the limitations of any single approach. Such alliances are both exclusive and temporary however, suggesting that a broader range of initiatives, rather than broader participation itself, is required to support widespread and sustained resilience.

Part V: Socio-Ecological Domain

Socio-ecological resilience is addressed by Michael R. Czaja in his chapter "Wildland Fire Management: Movement Towards Enabling Resiliency?". Wildfires in the western US are changing. Research suggests they are expanding in size and duration. The results include civilian and firefighter fatalities, record destruction and damage to homes and infrastructure, and increasing costs to agencies responsible for fire management. Two developments within the framework of wildland fire management suggest potential movement toward enabling resiliency. One of these is development of the National Cohesive Wildland Fire Management Strategy. The other is a state-level initiative, Colorado's Task Force on Wildfire Insurance, and Forest Health. A goal of both processes is to seek methods which allow human populations and infrastructure to withstand a wildfire without loss of life and property. One implication will be how these initiatives enable resiliency within the larger subject of disaster management. Another will be to potentially apply this type of strategy development and working group methodology to other appropriate fields of disaster management.

In the chapter "Vulnerabilities and Co-evolutionary Dynamics in Morelia Michoacan, Mexico: A Case Study" L. Aguilar-Armendariz and A.N. Martinez-Garcia suggests that human populations' vulnerability to environmental hazards relates to sustainability and complexity sciences, given the global, multi-disciplinary, and dynamic nature of the issues currently faced by humanity. Among the human population affected by environmental disasters (being of hydrometeorological, geological, biological, technological, and even socioeconomic nature), the poor are usually the most affected (BID 1999, UNDP 2004). Not only the lack of basic infrastructure, education, goods, and services make the human poor more vulnerable to disasters, poverty issues also hinder the response of governments after each event. Human populations' vulnerability to environmental hazards can be understood as a dynamical process among physical, economic, ecologic, and sociocultural factors. Depending on the dynamic outcome among them, these factors either contribute or hinder human societies' sustainability. The case study for this chapter is Morelia, which is the capital city of Michoacan State, Mexico. The city had 729,279 residents in 2010, and it is vulnerable to extreme rainfall events, which result in flooding of given areas of the city every raining season. There are also geological fault lines where inhabited sections of the city have been constructed. This study considers social, economic and ecological variables, using metadata from the National Institute of Geography and Statistics (INEGI 2000, 2005, 2010) and the National Council for the Assessment of Social Development Policies (CONEVAL, 2010) of Mexico.

Collectively, the chapters present the reader with a broad overview of resilience thinking across the Urban Domain, Cyber Domain, Organizational/Social Domain, and Socio-ecological Domain. It advances our understanding and state of the art regarding resilience within the risk, crisis, and disaster management domain and lays the foundation for continued exploitation and development of resilience thinking tools and techniques.

References

1. Helbing D (2013) Globally networked risks and how to respond. Nature 497: 51–59
2. Lee B, Preston F, Green G (2012) Preparing for high-impact, low-probability events: lessons from eyjafjallajokull. A Chatham House Report, London
3. Sambharya RB, Rasheed AA (2012) Global Risk in a changing world: new paradigms and practice. Organizational Dynamics 41:308–317
4. Masys AJ (2012) The emergent nature of risk as a product of ‘heterogeneous engineering’: A relational analysis of the Oil and Gas Industry safety culture. In: Bennett S (ed) Innovative thinking in risk, crisis and disaster management, Gower Publishing, UK
5. Kelic A, Collier ZA, Brown C et al (2013) Decision framework for evaluating the macroeconomic risks and policy impacts of cyber attacks. Environ Syst Decisions 33:544–560
6. Pawlak P, Wendking C (2013) Trends in cyberspace: can governments keep up? Environ Syst Decisions. 33:536–543
7. Masys AJ (2014) Critical infrastructure and vulnerability: A relational analysis through actor network theory. In Masys AJ (ed) Networks and network analysis for defence and security. Springer Publishing
8. Masys AJ (2014) Dealing with Complexity: thinking about networks and the comprehensive approach. In Masys AJ (ed) Networks and network analysis for defence and security. Springer Publishing
9. Collier ZA, Linkov I, Lambert JH (2013) Four domains of cybersecurity: a risk-based systems approach to cyber decisions Environ Syst Decisions 33:469–470
10. Dulac N (2007) A framework for dynamic safety and risk management modelling in complex engineering systems. Ph.D. Dissertation, MIT, Cambridge, MA
11. Cooper MD (2000) Towards a model of safety culture. Saf Sci 36:111–136

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Part I
Introduction

Resilience Undefined: A Framework for Interdisciplinary Communication and Application to Real-World Problems

Thomas G. Koslowski and Patricia H. Longstaff

Abstract Resilience scholars from multiple fields continue to look for a universally accepted definition of resilience. But is a universal definition across disciplines possible or even desirable in the near future? The proposed framework enables a more holistic understanding of the various fields of resilience research and makes communication across several domains more productive by placing the discussions into four types of resilience that are broad enough to facilitate discussion, but specific enough to allow for the translation of resilience into specific policies, practices and outcomes.

Keywords Resilience definition · Multidisciplinary resilience framework · Resilience translators

1 Introduction

The increasing complexity of today's inter-connected social systems has resulted in calls for greater understanding and development mechanisms for coping with turbulence and uncertainty [38, 73]. The skills for translation between academic disciplines and between the academy and practitioners will almost certainly need to happen for productive discussions among ecologists, engineers, physicists and

A preliminary version of this research paper [37] was presented at the 5th International Symposium on Resilience Engineering, Soesterberg, Netherlands.

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A. Masys (ed.), *Disaster Management: Enabling Resilience*,
Lecture Notes in Social Networks, DOI 10.1007/978-3-319-08819-8_1

psychologists (who have all developed their own definitions and lexicon) in order to build new approaches to the complex problems facing many organizations and all governments [33].

Resilience has been studied and described by various academic disciplines as a potential answer to move beyond survival and even prosper in the face of challenging conditions [11]. These disciplines include: ecology [27], psychology [43], socio-technical studies related inter alia to safety management [29], disaster research [51] and a broad range of organizational studies (http://link.springer.com/chapter/10.1007%2F978-3-642-41098-7_12) [34, 44, 61, 73]. Publications concerning the concept have increased dramatically.

The concept of resilience has emerged relatively recently in the scientific debate. The number of publications dealing with resilience is strongly increasing over the last years. Taking into account a general increase in publications per year (about doubled since 1995), scientific articles containing the keyword resilience grew more than ten-fold since 1995, corresponding to a larger application of the resilience concept and a wider diffusion to other scientific areas. Figure 1 shows the number of publications dealing with resilience in all scientific disciplines. Searching for the keyword "resilience" in only scientific articles on the scientific database web of knowledge yields 9,272 results (Sept. 2011).

The increasing popularity of the term 'resilience' has caused some (e.g., Lorentz [39, 63] to believe that resilience is in danger of becoming another linguistic fashion or buzzword with little or no meaning or validity. While there may be some transient fashion involved, the increased popularity of resilience also signals an alternative focus for the challenges of uncertainty and variability that arise from the increasing complexity and interconnectedness of modern systems. This has led to new worldwide efforts to recognize and deal with systems that cross traditional academic boundaries and corporate as well as governmental regulatory divisions. For example, the Resilience Alliance has developed an interdisciplinary "Resilience Thinking" as a framework for understanding change

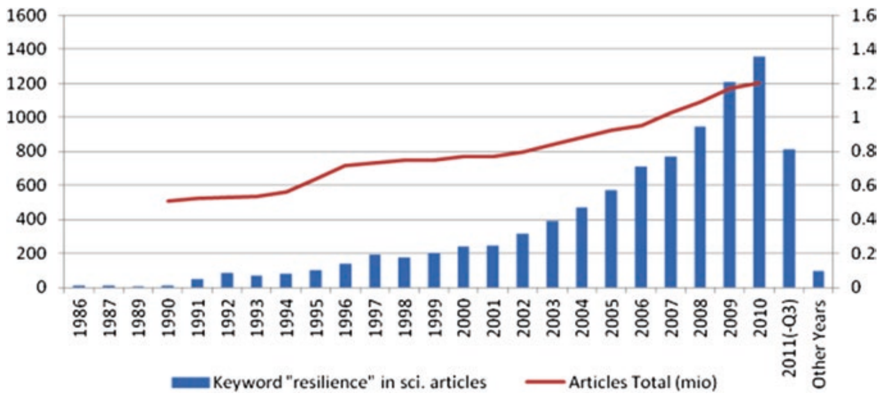

Fig. 1 Resilience publications (1996–2013)

in social-ecological systems [58, 71]. An emerging community of engineers from a variety of subspecialties is developing ‘Resilience Engineering’ as “a new way of thinking about safety” [59].

Against the backdrop of varied conceptual usage across multiple fields, it is not surprising that extant resilience research is surrounded by diversity and ambiguity of definitions, scope conditions, antecedents and outcomes e.g. Lorenz [39] and Norris et al. [51]. Is resilience a metaphor, a capacity, a capability, a strategy, a goal, a guiding principle, a philosophy, a measure or a behavior? Although an elastic notion of resilience may facilitate communication across disciplines (or even divergent lines of research within a discipline [7, 63]), a lack of clarity confusion may hinder operationalization in specific contexts and lead to unclear or even contradicting evaluations of results. A definition that is too broad would also hinder empirical research results and even cause some to question the relevance of the concept [63, 64]. As Suddaby [64] states, a clear construct might not only facilitate communication between scholars, it also “enhances researchers’ ability to empirically explore the phenomena” and further enhance outcomes by “allowing managers to redefine problems in ways that are more amenable to resolution” (p. 352).

As various disciplines and domains continue to develop data about resilience in their specific setting they will inform the development of definitions. Experiments will inform theory while adapted theories and definitions will enable new experiments. Unfortunately, a holistically agreed upon definition will be difficult and problematic in the short term. And the world cannot wait for the perfect definition before it begins to tackle the dangers and uncertainties from which we must bounce back or forward. Fortunately, a variety of definitions can exist as long as they are acknowledged [63] and there are people or mechanisms that can translate between them. The intention of this paper is to build bridges between definitions so that both scholars and practitioners can confront important problems.

2 Translation as an Interim Step

> ***Translate***, v. To bear convey, or remove from one person, place or condition to another, to transfer or transport…. (Oxford English Dictionary)

Most of us are familiar with the translation of languages. Many have been surprised at how a word or concept from another language gets converted by translation software or even professional translators who are proficient in both. Sometime words carry with them the culture and/or conceptual orientation of the speaker that are not shared by the listener. Misunderstanding is almost certain in such cases. But centuries of dealing with people who speak other languages or speak the same language but come from other cultures have given us some tools for managing the potential confusion and misconstructions. Interdisciplinary and international problem-solving is hard work and there are often communication errors so it is important to know what level of translation matters for the problem at hand. Does the problem require the participants to share broad definitions or to agree on very precise ones?

The framework proposed here will help begin the process of translation and this will help identify the *modi operandi* (strategies and mechanisms used) that are more likely to allow a system (such as a community or a technical system) to achieve resilience. The four perspectives are broad enough to allow for differences in particular situations, but concrete enough to allow for the discussion of how and to whom resources for recovery or adaption are allocated [4] and help identify other trade-offs with regard to the arsenal of resilience mechanisms and policies that are employed.

Notwithstanding some substantial commonalities among the disciplines, substantial distinctions of the concept exist with regard to [1] the level of complexity that is assumed (reductionism versus holism orientation) and [2] the degree of normativity included in the perspective (descriptive vs. normative orientation). After analyzing these meanings, we will discuss the applicability of our conceptual framework as a blueprint for facilitating real-world problem solving and cross-disciplinary resilience research by giving options for re-contextualizing the appropriate resilience type to the respective object of investigation. This allows for the concept of resilience to continue to evolve as disciplines begin to talk to each other and as practitioners discover new mechanisms for systems to recover from shocks they cannot avoid.

That does not mean that there is one best way to accomplish resilience, at least not at the moment. That is unlikely to be the immediate outcome of international, interdisciplinary, and inter-organizational efforts to deal with a wide variety of uncertainties. The first step in managing such an effort is to acknowledge all the potential opportunities and all possible difficulties. The next steps are to make the goal clear in each case, decide how success will be judged, and determine how (or if) the lessons learned in one place can be translated into another place or knowledge domain.

3 A Brief Walk in the Definition Thicket

> ***Resilience***, n. 1. The action or an act of rebounding or springing back; rebound, recoil. 2. a. Elasticity; the power of resuming an original shape or position after compression, bending, etc. b. The energy per unit volume absorbed by material when it is subjected to strain; the value of the elastic limit. …. 5. The quality or fact of being able to recover quickly or easily from, resist being affected by, a misfortune, shock, illness, etc.; robustness; adaptability (Oxford English Dictionary).

The English word “resilience” is derived from the Latin words *resilire* and *salire*, meaning to leap back, recoil, spring and spring again, re-flow, et cetera. In general terms, resilience is often said to reflect any system’s response to change or forces outside itself. The evolution of the term across different disciplines and fields of application has led to a diverse and sometimes confusing definitional lexicon. An extensive review of the literature reveals that the word resilience has been used to indicate a metaphor, a capacity of a systems and a strategy to cope with uncertainty [51]. Several conceptual and review papers have been written to clarify resilience in various fields: Klein, Nicholls, and Thomalla (2003) review resilience in natural hazards, Brand and Jax [7] in sustainability science; Norris et al. [51] in community resilience; Hollnagel et al. [29] for engineered systems; and Strunz [63] has applied resilience to the "vague /precise concept" debate in philosophy of science.

After looking at the definitions of resilience from a wide variety of disciplines, one can see that they almost always contain the basic idea of bouncing back from challenges or dangers that the individual or system could not resist (stop from happening). It involves the survival or persistence of something over time even if there is a change, a surprise and/or uncertainty. In this section we will systemize the multidisciplinary research body based on theoretical observations extending to a high level of abstraction, independent of the specific context and discipline in order to make differing applications comparable according to [1] *the level of complexity* and [2] *the degree of normativity.*

The *level of complexity* reflects the assumptions about system behavior, ranging from a reductionist view of single-equilibrium, linearity and predictability to complex system view of multi-equilibria, non-linearity and emergence. The *degree of normativity* covers the distinct conceptualizations from a descriptive system property to developmental processes with desirable outcomes. According to specific combinations across the two dimensions, one can help appreciate the specific nature of resilience. The section will firstly address the axis of matrix by giving readers a comprehensive look at how the word is used in several disciplines.

3.1 Complexity

Reductionist approaches. Perhaps the most comprehensive development of resilience frames the concept as a return to normalcy or a single equilibrium. At this simplest level, resilience refers to dynamics close to a stable equilibrium and is defined as the (speed) time required for a system to return to its original state following a disturbance event[1] [55]. This meaning presumes an equilibrium before the shock, so that the definition is similar to a stability property such as *elasticity, resistance, maintenance* [23] or rapidity of a system for restoration [45]. Hence, the interest and focus of the often termed "engineering resilience" [27] are on (often designed) systems with a single equilibrium, such as standard bridge load but also similar to the speed of homeostasis of body temperature or a fertility replacement rate.

[1] This is close to the term found in physics/material science, where resilience is the property of a material to absorb energy when it is deformed elastically and then resume its initial form.

This approach to resilience tends to dominate in the fields of engineering, natural science as well as earlier psychology and disaster studies; all of which seek to understand why people, infrastructure and places recover from disturbances and stress. For example, psychological resilience literature has tended to examine how children develop normally and successfully despite adverse conditions; consequently, resilience referred to as "bouncing back" like a spring to our former pre-crisis or pre-trauma behavior [5, 43]. As this stream focuses on efficiency, constancy, predictability [27] the single equilibrium bears a close affinity to the more traditional views of reductionist theories such as conservation law of energy in physics [19] or Milton Friedman's "plucking-model" of business fluctuations [18] in economics. For materials scientists, resilience is an expression of how a material responds to external force by either bending or breaking [66]. A material is either ductile or brittle. A resilient (or ductile) material can bend when force is applied and return to its original condition once that force is removed. The material will exhibit "stretching" along with unfolding and refolding at the molecular level. This is referred to as "reversible unfolding." The more tightly bound a substance is at the molecular level the more brittle it is [8]. The strength of molecular bond is measurable and so the ability of the material to bounce back is predictable.

Single-equilibrium and reductionist approaches have some limitations, particular in situations when the costs of rebound outweigh the benefits and the resistance to change might fail or lead to further losses e.g. Handmer and Dovers [23]. In addition, management approaches based on stability and single-states tend to maintain a predictable world with maximized, consistent production as main goal. However, in a more dynamic and uncertain world [6] this assumption is questionable as adaption towards new environmental conditions may be more appropriate in the long run and may call for some rethinking on this perspective. For instance, engineers have attempted to deal with complex organizational structures that are intended to develop complex technology with concurrent engineering methods that integrate design, manufacturing and downstream uses. But the uncertainties in this process has led some to analyze it as a complex system that must deal with surprises [16, 74]. They have noted that some technological systems have high sensitivity to small perturbations—a characteristic of many chaotic systems and conclude that Complexity x Uncertainty = Fragility [16]. Others have concluded that these systems must avoid optimum solutions because this implies hypersensitivity to small perturbations and therefore fragility [42]. In fact, optimization may not be a meaningful term in complex and adaptive systems where order emerges from uncertainty—especially if one is trying to encourage adaptation or innovation [24]. Some resilience engineering scholars see a system's resilience as represented by the adaptations necessary to cope with the real world complexity [49, 50]. An engineered system's resilience might be measured by the time it takes to return to appropriate functionality. Sometimes this will be to bounce back to system specifications and sometimes this will mean bouncing forward to a new, adapted system that can cope with changed conditions [75], Mendonca [46].

But some engineering scholars argue that measurement is more problematic (e.g. [52]). Resilience in a complex systems context is a dynamic, emergent property that can only be observed in the context of a specific failure scenario [21]. As such, it is improper to think of engineering systems resilience as a static property of *state*, as in materials engineering, it cannot be predicted or calculated from aggregation of the individual components [29, 52]. Hence, scholars from different discplines promote a more complex system view of resilience.

Holistic approaches. System resilience appreciates the dynamism inherent to the process and is strongly influenced by theories on complex adaptive systems or complex science emphasizing system attributes such as non-linearity, feedbacks, emergence, self-organization and co-evolution e.g. [35]. This research stream evolved assuming the existence of multiple, dynamic states of equilibria in systems [28]. In contrast to the return to a single equilibrium (normalcy), the so called "(eco)system resilience" or "ecological" view looks beyond restoration and focuses on the magnitude of disturbance that a system can tolerate and absorb before it is pushed beyond its "elasticity threshold" into another stable state [7, 14, 23, 27]. According to this philosophy, resilience is "the capacity of a system to experience shocks while retaining essentially the same function, structure, feedbacks, and therefore identity" [70] and is a dynamic attribute associated with a process of permanent change and adaption. Similar, for ecologists associated with the Resilience Alliance [72], resilience is the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes. A resilient ecosystem can withstand shocks and rebuild itself when necessary. Resilience does not mean the system will look exactly like it did before the forest fire or the flood but many of the same species and their place in the ecosystem hierarchy will be preserved. It will still be a forest or a prairie even if the mix of species has changed. The ecosystem depends on the ability of individual species to adapt.

Advocates of the systems view of resilience further emphasize cross-scale dynamics (temporal and spatial) of co-evolving systems where only temporal or even no equilibrium state can be achieved, particularly through diversity in responses and functions [70]. Holling and Gunderson [28] propose the "adaptive cycle" as a metaphor of dynamic behavior in (socio-) ecological systems suggesting four cyclical phases of change in the structure and function of a system. But the relationship between resilience and adaptability is surrounded by confusion: While some ecosystem scholars [7, 63, 68] treat adaptability and resilience as related but distinct concepts, a number of definitions exist where the concepts are treated as equivalent [14, 48, 62]. Moreover, others consider adaptability as a subset of resilience [10, 17] or inversely, resilience as a subset of adaptive capacity [1].

In summary, the descriptive term of resilience is usually conceptualized as either an inherent property or as a potential outcome. The both tables below illustrate examples of resilience definitions as descriptive terms but varying levels of (... tables below (Table 1 and Table 2) illustrate.... 1) complexity:

Table 1 Definitions with low complexity, low normativity

Discipline	Definition	Author
Computer science	Resilience as an intrinsic system attribute is arising in every domain of system and software development. Resilience is an attribute often related to robustness, and survivability (and by this dependability) from one side, and sustainability from other side	[13]
Risk analyst	The resilience of a system is a manifestation of the states of the system. Perhaps most critically, it is a vector that is time dependent. […] 'the ability of the system to withstand a major disruption within acceptable degradation parameters and to recover within an acceptable time and composite costs and risks'	[21]
Engineering	resilience implies the ability to "bounce back" after undergoing deformation of some sort	[41]
Ecology	The speed at which the system returns to the stable point or trajectory following a perturbation"	[55]
Ecology	The ability of human communities to withstand external shocks or perturbations to their infrastructure, such as environmental variability or social, economic, or political upheaval, and to recover from such perturbations	[65]

3.2 *Resilience as a Normative Term*

Nonetheless, even in ecology, resilience has been often transformed towards a desirable outcome or ability, e.g. the maintenance of natural capital in the long-run [7]. Scholars from social science have expanded the concept by adding social and normative components [17]. For example, Carpenter et al. [10] include a system's ability to self-organize and the capability of learning and adaption. Although this conceptualization is consistent with 'ecosystem resilience' emphasis of persistence, the addition of learning particularly points to significant differences between social and ecological perspectives: They may feature significantly different response dynamics, exhibit additional capacities of intentionality, interpretation and foresight (for an overview see [26] and [39]). Thus, social systems are aware of being within an environment characterized by a given history and expectations about a certain future, which can be pro-actively influenced by its learning actors. Consequently, social resilience is often conceptualized as an ability to cope with external stresses and disturbances or rather the capacity to withstand external shocks in ecological or technical systems. The added social component of learning, intentionality and adaptability can be regarded as "the capacity of humans to manage resilience" [69] (Table 2).

Managing resilience or "resilience engineering" [29] are basically normative (goal-oriented) activities as they aim to either maintain a desirable state (*bounce back*) or adapt and transform towards an alternative desirable state (*bounce forward*). This active and normative conceptualization of resilience [32] is not

Table 2 Definitions with high complexity, low normativity

Discipline	Definition	Author
Ecology	Resilience is the magnitude of disturbance that can be tolerated before a socioecological system (SES) moves to a different region of state space controlled by a different set of processes	[10]
Ecology	The ability of the system to maintain its identity in the face of internal change and external shocks and disturbances	[14]
Ecology	… The capacity of a system to experience disturbance and still maintain its ongoing functions and controls	([25], p. 1)
Sociology	Resilience is a relational concept that saliently marks the importance of a balanced relation between a system and its environment, as well as their seminal adjustment with regard to the system's persistence in the future	[39]
Ecology	Resilience is the capacity of a system to experience shocks while retaining essentially the same function, structure, feedbacks, and therefore identity	[70]

exclusive to the higher level of analysis of socio-ecological [20] and socio-technological systems [52]: The most prominent introduction of normative aspects is also found on the individual level in psychology, where scholars define it either as "good outcomes in spite of serious threats to adaptation or development" [43], as "dynamic process encompassing positive adaptation within the context of significant adversity" [40] or as "a process linking a set of adaptive capacities to a positive trajectory of functioning and adaption" [51].

This process view of individual and social resilience explicitly includes not only surviving but also thriving [43] and exemplifies that the holistic view of resilience can be regarded as normative. Supporters of the normativity, particularly in psychology and related social studies such as disaster research emphasize the capacity for successful adaption when confronted by challenges. They further conclude, that resilience is better conceptualized as an ability or process rather than an outcome, and focusing on the adaptive rather than the recovery aspect of resilience [23, 38, 51].

A wide set of resilience definitions as normative terms are illustrated in the two tables below. While Table 3 consists of normative definitions with low levels of complexity, Table 4 entails normative definitions with higher complexity.

Despite the different conceptualizations, the reader will have noted that there are clearly ideas that are common among one or more of these disciplines. In fact, there is some evidence that resilience is most likely to be found in systems that:

- Build the right amount of diversity and robustness for increasing options and spreading risk
- Increase their range of knowledge for learning and problem solving
- Create opportunities for self-organization, including strengthening local functions, building cross-scale links, and building problem-solving networks
- Organize with the right balance of tight and loose coupling

Table 3 Definitions with low complexity, high normativity

Discipline	Definition	Author
Economics	Resilience is defined as the ability of an economy to reduce the probability of further deep crises or at least to mitigate the effects of a crisis	[2]
Risk analyst	Resilience is defined as the ability of the system to withstand a major disruption within acceptable degradation parameters and to recover within an acceptable time, and composite costs, and risks	[3]
Business	The organization's ability to adapt to risk that affects its core operational capacities. Operational resilience is an emergent property of effective operational risk management, supported and enabled by activities such as security and business continuity	[9]
Psychology	Good outcomes in spite of serious threats to adaptation or development	[43]
Business	The adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function	[56]
Economics	Refers to the inherent and adaptive responses to disasters that enable individuals and communities to avoid some potential losses. It can take place at the level of the firm, household, market, or macroeconomy. In contrast to the pre-event character of mitigation, economic resilience emphasizes ingenuity and resourcefulness applied during and after the event	[60]
Disaster studies	The act of rebounding or springing back" from a disaster, and a resilient organization often is described as one which is able to quickly return to normal (or even improved) operations after such an event has occurred	[76]

And there is some evidence that resilience will be a tradeoff for other desirable traits for the system. For example:

- Things that increase resilience may decrease some kinds of efficiency
- Efforts to increase the stability can lower adaptability and resilience.
- Resilience at one scale can reduce it at another

(e.g., [5, 15, 38, 75]

For human organizations that are good at dealing with uncertainty:

> "The traits of resilience include experience, intuition, improvisation, expecting the unexpected, examining preconceptions, thinking outside the box, and taking advantage of fortuitous events. Each trait is complimentary and each has the character of a two-edged sword."
>
> [49], p. 7)

Therefore there is hope for some sort of definitional structure that is broad enough to allow for translation between them all, even as we allow for the particulars to remain at the disciplinary level.

Table 4 Definitions with high complexity, high normativity

Discipline	Definition	Author
Business	The ability of a system to return to its original state or move to a new, more desirable state after being disturbed	[12]
Business	Resilience is a fundamental quality of individuals, groups, organizations, and systems as a whole to respond productively to significant change that disrupts the expected pattern of events without engaging in an extended period of regressive behavior	[30]
Business	Ability to dynamically reinvent business models and strategies as circumstances change […] It's about continuously anticipating and adjusting to deep, secular trends that can permanently impair the earning power of a core business	[22]
Disaster studies	A three-class typology of resilience (resistance to change; change at the margins; openness and adaptation)	[23]
Business	…properties that increase a firm's ability to understand its current situation and to develop customized responses that reflect that understanding. Resilience capacity is a multidimensional, organizational attribute that results from the interaction of three organizational properties: cognitive[…], behavioral […], and contextual resilience	[34]
Business	The main aspects of organizational resilience in this context are the continuing capacity to recover from disturbances as well as the capacity to rebound from adversity in a strengthened and more resourceful way	[36]
Business	The capacity for an enterprise to survive, adapt, and grow in the face of turbulent change	[54]
Business	The capability to self-renew over time through innovation	[57]
Business	As the maintenance of positive adjustment under challenging conditions such that the organization emerges from those conditions strengthened and more resourceful	[67]

4 Multidisciplinary Resilience Framework

It helps to think of each discipline or domain as looking at a resilience problem through their own "frame": Think of a group of people each standing with an empty picture frame and looking through it at a scene while ignoring everything outside their frame. It becomes clear that only by putting all the frames together will we get a good picture of the scene. And while that ultimate construction for resilience may not be available to us in the near future, we can put some frames together where we know they look at the same things and pulling them apart where we know they are looking in very different directions. Translation enables us to construct some broader frames that can be used by more people.

There are two main differences that must be bridged in translating resilience ideas between disciplines. First, the various disciplines differ with regard to their assumptions about their system's potential for stability and equilibrium. Some have a Newtonian outlook (everything can be counted and predicted) while others take complexity/unpredictability outlook (the system has so many dimensions or variables that it is mathematically intractable and/or emergent properties that make prediction difficult or impossible) (Lewin and Regine [35, 47]. And second, the degree of normativity (resilience as a coping capacity versus a desirable outcome). The framework presented below puts these two differences in a framework that allows us to make some distinctions that are broad enough to find commonality but narrow enough to recognize differences. It is the contention of this paper that these fields are not mutually exclusive and that a fuller understanding of resilience would encapsulate many (if not all) of these views.

We have also differentiated resilience that is seen as a capacity or a capability of the system. The choice of these terms is somewhat arbitrary but reflects (we think) the most commonly understood ideas behind those words. We use the term capability to denote human/animal skills or abilities to perform or achieve certain actions and outcomes through a set of functions or processes. The term capacity is often used as a description for anything you can hold/measure. There are obviously no bright lines between the two because you can sometimes measure skills [31]. But the distinction is worth noting because it affects how disciplines look at the systems they study and how they describe and (sometimes) measure what they call "resilience."

The Multidisciplinary Resilience Framework outlines four applications based on the differing fields of study. The boxes on the left of the Framework focus on system's level of complexity. In the upper box, the state of the system and the impact of a disturbance are both predictable and measurable. In the lower box the system has multiple possible states due to high levels of complexity/non-linear behavior and there are often high levels of uncertainty. Measurement and prediction in the bottom box is thus more problematic.

The boxes on the top of the matrix focus on the level of normativity that is applied to describing the resilience of a system, that is, the extent to which humans determine how things should be, how to value the state of the system, and which strategies are good or bad. Normativity can be contrasted with Positivity which is generally described as producing factual statements that attempt to describe reality.

Type I Resilience: The Capacity to rebound and recover (low complexity/low normativity): The systems/disciplines that fall in this box see resilience as a purely descriptive measure of elasticity against perturbations and the rapidity of the recovery to a pre-defined (usually intended) state. Resilience can be seen as a system property or measure of stability. This view of resilience is predominantly adopted in traditionally engineered and other designed systems. It is most feasible in situations where the normal system state is assumed to be a reliable (if not necessarily optimal) state for the system or the adaption of the previous system state toward an alternative state is too difficult in terms of time and/or costs.

Type II Resilience: The capability to maintain a desirable state (low complexity/high normativity) This is described in systems/disciplines that have a low level of complexity and focuses on the maintenance of some predetermined state or equilibrium that is judged to be either a desirable outcome or as a process of positive adjustments that leads the system back to that predetermined, desirable state [40]. Predominantly employed in business, psychology and other social studies, resilience in these systems is regarded as something positive and bouncing back to an approved equilibrium proves the existence of resilience.

Type III resilience: The capacity of the systems to withstand stress (high complexity/low normativity). The disciplines in this box often describe resilience as the relationship between the current system state and a potential system shift that will flip the system into a different state often called a "regime shift." The focus is on persistence thresholds. The distance between the current state and a potential flip is a measurable indicator of resilience levels. High resilience implies sufficient robustness and buffering capacity against a regime shift and/or the ability of system components to self-organize and adapt in face of fluctuations. If resilience is low, the system loses its original identity and moves toward a new regime or "basin of attraction." None of the potential system states or regimes is preferable to the system itself since it cannot make good/bad distinctions (Fig. 2).

Type IV Resilience: The capability to adapt and thrive (high complexity/high normativity). Resilience in social systems and psychology is often conceptualized as skill that an individual or group can bring to a disturbance that will allow it to reach a level of functionality that has been determined to be "good." Human beings and human systems have high complexity and a determination of what is

Degree of Normativity / **Level of Complexity**	**Low: Descriptive** ***Perception of Deviation:*** *symptoms of change and strain* ***Conceptual Orientation:*** *Outcome and capacity*	**High: Normative** ***Perception of Deviation****: To be avoided/reduced symptoms of adversity and inefficiencies* ***Conceptual Orientation****: Process and capability*
Low: Reductionism ***Aspect of stability:*** *Single State* ***Environmental characteristics:*** *Short-term, Linearity and Predictability* ***Dominant Logic:*** *Bounce back (absorb and recover)*	**(I) Capacity to rebound and recover** • Elasticity (capacity to absorb deformation[1]) • Rapidity/rate (**time required** to return to pre-defined state/normalcy[2]; • Robustness (resistance against perturbation)[3].	**(II) Capability to maintain desirable state:** • Maintaining systems identity and functions[9]; • Ability to withstand and recover within acceptable parameters[10];
High: Holism ***Aspect of stability:*** *Multiple States* ***Environmental characteristics:*** *Long-term; Non-Linearity and Uncertainty* ***Dominant Logic:*** *Bounce forward (adapt and transform)*	**III) Capacity to withstand stress** • Magnitude of disturbances[4]; • Elasticity threshold[5]; Transition probability between states[6]; • Emergent system property[7]; • Balanced contingency between system and its environment by adjustments[8].	**(IV) Capability to adapt and thrive:** • Inherent and adaptive responses to disasters[11]; • dynamic process encompassing positive adaptation within the context of significant adversity [12]; • Degree of capability to self-organize, adapt and learn[13].

1(Timmerman, 1981; Wildavsky, 1988), 2 (Pimm, 1984; Zobel, 2011), 3 (Antunes 2011; Grimm/Wessels 1997; Zobel 2011), 4 (Gunderson/Holling 2002; Holling 1996), 5(Folke et al., 2004; Walker 2004), 6 (Holling 1973; 2001; Brock et al., 2002), 7 (Boin/McConnell 2007), 8 (Lorenz 2010), 9 (Cumming, 2005; Walker/Salt 2006), 10 (Aiginger 2009; Aven 2011); 11 (Rose 2004), 12 (Luthar 2007), 13 (Carpenter, 2001 ; Folke 2006; Walker et al. 2002).

Fig. 2 Multidisciplinary resilience framework good or "adaptive" in these systems is often highly high normative. The disciplines in this box acknowledge the existence of multiple possible states, but also explicitly call for a successful adaption before or after a disturbance occurs. This contrasts to Type II resilience, which focuses on a successful return to an assumed normal state. Hence, a positive adjustment can involve different desirable states ranging from a worse, but acceptable level to an even better post-disturbance state. Managing resilience as a normative activity or outcome involves human capabilities such as anticipation, sense-making and learning.

4.1 Using the Framework for Translation

The categories in the descriptive boxes of the framework will allow participants to ask questions about how the other participants see the level of complexity/predictability of the system(s) they are trying to deal with. The framework will also help them discuss how they see the role of shared norms. A discussion of the four Resilience Types will further identify shared or differing goals (e.g., bounce back or bounce forward). So, for example, people in government are likely to be in category II with a high degree of normativity about outcomes and a seeking short-term linearity and predictability for their actions. Engineers at the table may be less sure of predictability for anything that requires a human interface but less interested in the norms that applied to outcomes so they would be in category I or category III. Ecologists may be more comfortable with designing systems that can adapt, so might be in category IV.

Once the similarities and differences have been identified the next steps are to make clear what the goal is in each case, how success will be judged (or measured), and how (or if) the lessons learned in one place can be translated into another place or knowledge domain. Does the problem require a capacity or a capability? Does the system have to be maintained as it is or should it be capable of adaptation? How will that adaptation be judged? Can the adaptation be designed in advance or will it have to emerge from the conditions that are presented? Once these questions are answered the group can narrow down its search for definitions and mechanisms that are found in similar systems to the Resilience Type they are dealing with. Of course there is the possibility (and in some cases a likelihood) that a particular problem will involve multiple types of resilience. So, for example there might be a team with resilience frames like this:

- **Chemists**: Type One (predictable reactions, no best state)
- **Government officials**: Type Two (high degree of normativity about outcomes and seeking short-term, linearity and predictability for their actions)
- **Ecologists**: Type Three or Four (comfortable with systems that adapt but may see one system state as better)
- **Engineers**: Type One or Two or Three? (not always sure of predictability, comfortable with adaptable systems, but sometimes less interested in the norms that apply to outcomes)

Just acknowledging the different frames will be a good first step in getting this team closer to their goal. In these cases the role of translators becomes critical as they help the team work together toward resilience for the system in question without harm to other systems. If the resilience of one system requires the rules of the other to be ignored for a time, how does that get decided and by whom? If action by one or both is called for in response to some danger (or opportunity) does this require the measurement of something that they measure differently? This does not require that the two systems (or disciplines or organizations) respect each other's methods. But it does require agreement on the goals and that they actually understand what the others are saying.

5 Conclusion

It seems certain that the need to find ways to make things bounce back will only continue to grow. The groups who come together to deal with these issues will only become more diverse. The framework proposed here allows researchers and practitioners from various disciplines and/or economic sectors to communicate and concentrate their efforts on specific types for resilience goals by allowing broad definitions where that is possible, and identifying where specific definitions are necessary to deal with the issues at hand. The words used to designate these efforts will undoubtedly adapt, splinter into subgroups, and go in and out of fashion. Translation and translators will only become more important.

References

1. Adger WN (2006) Vulnerability. A cross-cutting theme of the international human dimensions programme on global environmental change resilience. Glob Environ Change 16(3):268–281
2. Aiginger K (2009) Strengthening the resilience of an economy. Intereconomics 44(5):309–316
3. Aven T (2011) On some recent definitions and analysis frameworks for risk, vulnerability, and resilience. Risk Anal: Int J 31(4):515–522
4. Baker SM (2009) Vulnerability and resilience in natural disasters. a marketing and public policy perspective. J Public Policy Mark 2009(28):114–123
5. Berkes F (2007) Understanding uncertainty and reducing vulnerability: lessons from resilience thinking. Nat Hazards 41(2):283–295
6. Boisot M, McKelvey B (2011) Connectivity, Extremes, and Adaptation: A Power-Law Perspective of Organizational Effectiveness. J Manage Inq 20(2):119–133
7. Brand FS, Jax K (2007) Focusing the meaning(s) of resilience: resilience as a descriptive concept and a boundary object. Ecol Society 12(1):23
8. Campbell FC (2008) Elements of metallurgy and engineering alloys. ASM Int, Materials Park, Ohio
9. Caralli RA, Allen JH, Curtis PD, Young LR (2010) CERT resilience management model, version 1.0, CMU/SEI-2010-TR-012, Carnegie Mellon University, Pittsburgh

10. Carpenter S, Walker B, Anderies JM, Abel N (2001) From metaphor to measurement: resilience of what to what? Ecosystems 4(8):765–781
11. Carpenter SR, Arrow Kenneth J, Barrett S, Biggs R, Brock WA, Crépin A-S (2012) General resilience to cope with extreme events. Sustainability, 12(4):3248–3259
12. Christopher M, Peck H (2004) Building the resilient supply chain. Int J Logistics Manage 15(2):1–14
13. Crnkovic I (2011) Predictability and evolution in resilient systems. software engineering for resilient systems. In: Troubitsyna E (ed) Lecture notes in computer science, vol 6968. Springer, Berlin, pp 113–114
14. Cumming GS, Barnes G, Perz S, Schmink M, Sieving KE, Southworth J, Binford M, Holt RD, Stickler C, Holt T (2005) An exploratory framework for the empirical measurement of resilience. Ecosystems 8(8):975–987
15. Dorner D (1996) The logic of failure: recognizing and avoiding error in complex situations. Metropolitan Books, New York
16. Efatmaneshnik E, Reidsema C (2007) Immunity as a design decision making paradigm for complex systems. a robustness approach. Cybernet Syst: Int J 38:759–780
17. Folke C (2006) Resilience: the emergence of a perspective for social-ecological systems analyses. resilience, vulnerability, and adaptation: a cross-cutting theme of the international human dimensions programme on global environmental change. Glob Environ Change 16(3):253–267
18. Friedman M (1993) The plucking model of business fluctuations revisited. Econ Inq 31(2):171–177
19. Griffiths DJ (2013) Revolutions in twentieth-century physics. Cambridge University Press, Cambridge
20. Gunderson LH (Ed) (2002) Panarchy: understanding transformations in human and natural systems, Island Press, Washington, DC
21. Haimes YY (2009) On the definition of resilience in systems. Risk Anal: Int J 29(4):498–501
22. Hamel G, Välikangas L (2003) The quest for resilience. Harvard Bus Rev 81(9):52–63
23. Handmer JW, Dovers SR (1996) A typology of resilience: rethinking institutions for sustainable development. Organ Environ 9(4):482–511
24. Holland J (1998) Emergence: from chaos to order. Basic Books, New York, pp 244–246
25. Holling CS (1973) Resilience and stability of ecological systems. International Institute for Applied Systems Analysis, Laxenburg
26. Holling CS (2001) Understanding the Complexity of economic, ecological, and social systems. Ecosystems 4(5):390–405
27. Holling CS (1996) Engineering resilience versus ecological resilience. In: Schulze PC (ed) Engineering within ecological constraints. The National Academies Press, Washington, D.C
28. Holling CS, Gunderson LH (2002) Resilience and Adaptive Cycles, in Gunderson, LH (Ed), Panarchy: understanding transformations in human and natural systems, Island Press, Washington, DC, pp 25–62
29. Hollnagel E, Woods DD, Leveson N (2006) Resilience engineering: concepts and precepts. Ashgate, Aldershot
30. Horne III JF, Orr JE (1998) Assessing behaviors that create resilient organizations, Employment Relations Today (Wiley), Vol 24, pp 29–39
31. IF4IT (2014) IF4IT Glossary. http://if4it.com/SYNTHESIZED/GLOSSARY/C/Capability.html. Accessed 22 Jan 2014
32. Klein RJT, Nicholls RJ, Thomalla F (2003) The resilience of coastal megacities to weather-related hazards. In: Kreimer A, Arnold M, Carlin A (eds) Building safer cities: the future of disaster risk. World Bank, Washington, D.C., pp 101–120
33. Le Coze J-C, Dupré M (2008) The Need for Translators and for new Models of Safety, in Hollnagel E, Nemeth CP, Dekker S (eds.) Resilience Engineering Perspectives 1. Remaining Sensitive to the Possibility of Failure, Ashgate, Aldershot, England, Burlington, VT. doi: 10.1007/978-3-319-08819-8_1

34. Lengnick-Hall CA, Beck TE (2005) Adaptive fit versus robust transformation: how organizations respond to environmental change. J Manage 31(5):738–757
35. Lewin R, Regine B (1999) On the edge in the world of business, in Lewin R (Ed) Complexity: life at the edge of chaos, 2nd edn., Wiley, Chicago, pp 197–211
36. Linnenluecke M, Griffiths A (2010) Beyond adaptation: resilience for business in light of climate change and weather extremes. Bus Soc 49(3):477–511
37. Longstaff PH, Koslowski TG, Geoghegan W (2013) Translating resilience: a framework to enhance communication and implementation, 5th International Symposium on Resilience Engineering, Soesterberg, Netherlands, June 25–27
38. Longstaff PH (2005) Security, resilience, and communication in unpredictable environments such as terrorism, natural disasters, and complex technology
39. Lorenz DF (2010) The diversity of resilience: contributions from a social science perspective, Natural Hazards, pp 1–18
40. Luthar SS, Cicchetti D, Becker B (2000) The construct of resilience: a critical evaluation and guidelines for future work. Child Dev 71(3):543–562
41. Madni AM, Jackson S (2009) Towards a conceptual framework for resilience engineering. Syst J 3(2), pp 181–191
42. Marczyk J (2002) Beyond optimization in computer-aided engineering, Barcelona
43. Masten AS (2001) Ordinary magic: resilience processes in development. Am Psychol 56(3):227–238
44. McCann JE, Selsky JW (2012) Mastering turbulence: The essential capabilities of agile and resilient individuals, teams, and organizations, 1st edn. Jossey-Bass, San Franciso
45. McDaniels T, Chang S, Cole D, Mikawoz J, Longstaff H (2008) Fostering resilience to extreme events within infrastructure systems: characterizing decision contexts for mitigation and adaptation. Glob Environ Change 18(2):310–318
46. Mendoca D (2008) Measures of resilient performance. In: E Hollnagel, CP Nemeth, and S Dekker (eds) resilience engineering perspectives 1. Remaining sensitive to the possibility of failure, pp 29–46, Aldershot, Hampshire, England, Burlington, Ashgate
47. Mitleton-Kelly E (2003) Complex systems and evolutionary perspectives on organisations: the application of complexity theory to organisations. Pergamon, Oxford
48. Nelson DR, Adger WN, Brown K (2007) Adaptation to environmental change: contributions of a resilience framework. In: Matson PA, Gadgil A (eds) Annual review of environment and resources. Annual Reviews Inc, Palo Alto, pp 395–419
49. Nemeth CP (2008) Resilience engineering: the birth of a notion. In: E Hollnagel, CP Nemeth, S Dekker (eds) Resilience engineering perspectives 1. Remaining sensitive to the possibility of failure, pp 3–9, Aldershot, Hampshire, England, Burlington, VT: Ashgate
50. Nemeth CP (2009) The Ability to Adapt. In: CP Nemeth, E Hollnagel, S Dekker (eds) Resilience engineering perspectives 2. Preparation and restoration. Ashgate, Farnham, pp 1–12
51. Norris FH, Stevens SP, Pfefferbaum B, Wyche KF, Pfefferbaum RL (2008) Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness. Am J Community Psychol 41(1–2):127–150
52. Park J, Seager TP, Rao PSC, Convertino M, Linkov I (2013) Integrating risk and resilience approaches to catastrophe management in engineering systems. Risk Anal 33(3):356–367
53. Perrow C (1999) Normal accidents. Living with high-risk technologies. Princeton University Press, Princeton
54. Pettit TJ, Fiksel J, Croxton KL (2010) Ensuring supply chain resilience: development of a conceptual framework. J Bus Logistics 31(1):1–21
55. Pimm SL (1984) The complexity and stability of ecosystems. Nature 307(5949):321–326
56. Ponomarov SY, Holcomb MC (2009) Understanding the concept of supply chain resilience. Int J Logistics Manage 20(1):124–143
57. Reinmoeller P, van Baardwijk N (2005) The link between diversity and resilience. MIT Sloan Manage Rev 46(4):61–65

58. Resilience Alliance (2014) Research on resilience in social-ecological systems. http://www.resalliance.org/. Accessed 22 Jan 2014
59. Resilience engineering association (2014) The official home of resilience engineering. http://www.resilience-engineering-association.org/. Accessed 22 Jan 2014
60. Rose A (2004) Defining and measuring economic resilience to disasters. Disaster Prev Manage 13(4):307–314
61. Sheffi Y (2007) The Resilient Enterprise. Overcoming vulnerability for competitive advantage. MIT Press Books, Cambridge
62. Smit B, Wandel J (2006) Adaptation, adaptive capacity and vulnerability. Glob Environ Change 16(3):282–292
63. Strunz S (2012) Is conceptual vagueness an asset? Arguments from philosophy of science applied to the concept of resilience. Ecol Econ 76:112–118
64. Suddaby R (2010) Editor's comments. Construct clarity in theories of management and organization. Acad Manage Rev 35(3):346–357
65. Timmerman P (1981) Vulnerability, resilience and the collapse of society: a review of models and possible climatic applications. Canada, Toronto
66. Trautwine JC (1907) The civil engineer's pocket-book. Wiley, New York
67. Vogus TJ, Sutcliffe KM (2007) Organizational resilience: towards a theory and research agenda. In: IEEE international conference on systems, man and cybernetics, pp 3418–3422
68. Walker B, Carpenter S, Anderies J, Abel N, Cumming G, Janssen M, Lebel L, Norberg J, Peterson GD, Pritchard R (2002) Resilience management in social-ecological systems: a working hypothesis for a participatory approach. Conserv Ecol 6(1):14
69. Walker B, Holling CS, Carpenter SR, Kinzig A (2004) Resilience, adaptability and transformability in social–ecological systems. Ecol Soc 9(2):5
70. Walker B, Gunderson LH, Kinzig AP, Folke C, Carpenter SR, Schultz L (2006) A handful of heuristics and some propositions for understanding resilience in social-ecological systems. Ecol Soc 11(1):13
71. Walker B, Salt D (2012) Resilience practice: Building capacity to absorb disturbance and maintain function, Island Press, Washington
72. Walker BH, Salt D (2006) Resilience thinking: Sustaining ecosystems and people in a changing world, Island Press, Washington, DC
73. Weick KE, Sutcliffe KM (2007) Managing the unexpected: resilient performance in an age of uncertainty, 2nd edn. Jossey-Bass, San Francisco
74. Wolfram S (1986) How can complex systems be used in engineering? approaches to complexity engineering. Physica D 22:385–399
75. Woods DD (2006) Essential charactersistics of resilience. In: Hollnagel E, Woods DD, Leveson N (eds) Resilience engineering: Concepts and precepts. Ashgate Publishing, Ltd, Burlington, pp 21–35
76. Zobel CW (2011) Representing perceived tradeoffs in defining disaster resilience. Decis Support Syst 50(2):394–403

Disaster Management, Control, and Resilience

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Abstract This chapter looks at disaster management as a form of safety management, using the perspective of resilience engineering. In safety management, control can be lost by not being ready to respond, by having too little time, by lacking knowledge of what is going on, or by lacking the necessary resources. To maintain control unsurprisingly requires the converse of these conditions. Resilience engineering looks at how systems can sustain required operations under both expected and unexpected conditions by adjusting its functioning prior to, during, or following changes, disturbances, and opportunities. To do so requires the abilities to respond to what happens, to monitor the situation, to learn from what has happened, and to anticipate what may happen. The same type of analysis can be applied to disaster management, to better understand how it succeeds.

Keywords Resilience · Control · Responding · Monitoring · Learning · Anticipating · Positive capacity

1 Introduction

Disaster management is an exercise in dealing with rare and therefore unexpected events. Safety management also deals with the unexpected, although the events on the whole are less surprising. In both cases the unexpectedness usually refers to the timing of what happens, in terms of the onset as well as the duration, rather than to the type of event as such. We know that a fuse may blow, that an engine may fail, or that torrential rains may flood an area, but we do not know *when* it will happen, *how serious* the consequences will be, or *how long* it will take before a stable condition has been re-established. The unexpectedness may, of course,

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A. Masys (ed.), *Disaster Management: Enabling Resilience*,
Lecture Notes in Social Networks, DOI 10.1007/978-3-319-08819-8_2

also refer to *what* happens as such, in the sense that the event or occurrence may be unusual or novel. This is obviously more unpleasant, since it is practically impossible to be prepared for events that have not happened before.

Westrum [17] proposed a distinction between three types of threats based on how expected—or unexpected—they were: regular threats, irregular threats, and unexampled events. We can apply this distinction not only to threats but to events in general. The **regular events** are those that happen so often that an organisation is likely to have experienced them, which means that it is possible to recognise them and to learn how to respond. Regular events more importantly happen so often that it is cost-effective to prepare a standard response and to maintain a state of readiness even though it is uncertain *when* they will happen. Examples are the typical occurrences that make everyday work difficult such as interruptions and disturbances, delays, equipment malfunctions and failures, and the mistakes that generally lead to insufficient time, insufficient resources, insufficient information, etc. Any organisation must obviously be able to cope with the regular events in order to 'stay in business'. Coping with regular events is therefore not a defining feature of a resilient organisation, although it clearly necessary that it can do so.

The **irregular events** are those that happen rarely but where each event by itself is imaginable. Irregular events occur outside the everyday experience of an organisation and are therefore commonly portrayed as unique, unprecedented, or even beyond categorisation. Their number is so large that it is practically impossible to think of, let alone prepare, a response to more than a few of them. Irregular events are so infrequent that an organisation may never have encountered them, hence has no experience to refer to, although it may know about them from the general lore or shared war stories. Irregular events are of course always unexpected and may often be difficult to recognise because they go beyond the experience of everyday work. Since they furthermore happen rarely, it will not be cost-effective to prepare a response to them or to maintain a general response capability. Responding to them therefore requires the ability to make rapid adjustments on all levels of an organisation – in other words, resilience.

Finally, the **unexampled events** are those that have not happened before, and that exceed not only the experience of an individual organisation but the collective experience of all organisations of the same type, or even of the society. (The financial crisis in 2008–2009 was an example of that.) Since unexampled events are virtually impossible to imagine, it is clearly also impossible to prepare any kind of general response to them or even to consider a general readiness. Unexampled events are the catastrophes or apocalyptic events that take everyone by surprise and thereby severely challenge the resilience of an organisation.

The characteristic features of the three classes of events are summarised in Table 1.

1.1 Be Prepared

A main concern in safety management is the need to be prepared. This is accomplished by trying to identify every serious event that could happen and then

Table 1 Management demands of three types of events

	Regular events, everyday nuisances, incidents, accidents	Irregular events (critical accidents, disasters)	Unexampled events (catastrophes)
Frequency of occurrence	High, everyday	Low, but events are imaginable	Rare and mostly unimaginable (until they occur)
Magnitude of consequences	Low, and in most cases well-known	High, with reason for concern	Extremely high, may exceed the organisation's ability to cope
Relevant data or information	Statistics, event reports (regular)	Simplified models, shared experience	Hunches, intuition, 'expertise'
Readiness, preparedness to respond	High, and costs are justifiable	Low, and costs are disputed	No readiness, cost are prohibitive
Presence of resources to respond	Available and appropriate	In principle available, but never exclusively	Rudimentary or non-existent
Predictability (of occurrence or of development)	Very high on both accounts	Low on both accounts	Very low, guesswork. May challenge readiness and resources

prepare a response to those that cannot be eliminated. Since it is assumed that technological or industrial systems are well-known and well-structured it is possible, at least in principle, to identify all possible 'negative' events. This assumption is behind approaches such as 'safety through design' or 'prevention through design' [13]. Yet 'prevention through design' will always be limited, if for no other reason then because the cost of prevention for some of the irregular events may exceed what an organisation—or a society—is willing to bear. This has been recognised by the As Low As Reasonably Practicable (ALARP) principle [19], where 'as low as reasonably practicable' refers to a level of risk that cannot be reduced further without an increase in cost that is disproportionate to the gain in safety. The risks that in this way fall by the wayside will nevertheless happen every now and then, and it is necessary to be prepared for those. Safety management therefore often spends considerable efforts to calculate the probability that specific events—or rather, specific outcomes—may occur. In this way we try to convince ourselves that only the low probability events remain, hence that we can feel safe [2].

The situation is different for disaster management, regardless of whether the disasters are natural or human-made. Just like safety management, effective disaster management depends on the organisation's preparedness, its ability to respond and the presence of recovery plans that can lessen the impact of a disaster. Disasters differ from accidents mainly in terms of the magnitude of their consequences, which by definition are both substantial and long lasting—and furthermore rarely limited to the place where the initial event occurred. The type of events that are associated with disasters are usually known, such as earthquakes, floods, tsunamis, volcano eruptions, pandemics, uncontrolled large-scale releases of hazardous materials, catastrophic accidents, fires, or explosions. But unlike safety management it is practically impossible to prevent them even though they are known.

When unexpected events happen it is necessary to be able to control them and/or to absorb their impact. While this applies to both safety management and disaster management, it is more important for the latter because fewer of the events (earthquakes, floods, pandemics, etc.) can be prevented. The purpose of control—and, indeed, almost a definition of the term—is to change the developments of the event from being unforeseeable or uncontrolled to become foreseeable or controlled. The acute loss of control that follows an unexpected event will change the organisation from a normal and stable condition to an unstable condition. If it is possible to respond fast enough, it may be possible to regain control and return the organisation to the normal condition. If that is not possible, the organisation will sooner or later enter a state of disturbed condition from which it is impossible to recover directly to a normal state. When control eventually is regained, the organisation will enter a recovered, stable condition and may from there transition to the previous normal condition by a full restoration of control. The restored stable condition need, however, not be identical to the previous one, but will often represent a new equilibrium.

1.2 Surprises

Unexpected events are always to some degree surprising. Lanir [11] has proposed that surprises can come in two forms, called situational and fundamental surprises respectively. An event is called a **situational surprise** if it happens when it was not expected. It is not a surprise because of *what* it is—its nature—but because of *when* it occurs. Once it has happened, the further evolution is generally predictable and will therefore presumably be matched by the prepared responses. An event is a **fundamental surprise** if it either is a kind of event that had not been imagined, or if it develops—spreads or propagates—in ways that have not been envisaged. A fundamental surprise may challenge the existing assumptions about the world either in terms of the type of event that can happen or in terms of how events may develop. The former is characteristic of classical safety management while the latter is characteristic of disaster management.

Disaster management and safety management both start by the occurrence of an unexpected event and look for ways by which it can be contained or controlled. Disaster management must nevertheless more often face fundamental surprises, for which it is impossible to think of, let alone prepare a set of responses. This is why resilience engineering becomes of interest.

2 Resilience Engineering

The difference between 'classical' safety management and resilience engineering is made clear by the definitions of safety that the two approaches use. Safety is commonly defined as a condition where as little as possible, and preferably nothing, goes wrong. A typical definition is thus that safety is the "freedom from unacceptable risk" [13]. As a consequence of that, the main concern of safety has been with situations where things go wrong, particularly if there have been significant adverse consequences, such as major industrial accidents. But these are also the situations where safety by definition is absent, rather than present. Safety science and safety management has thus strangely enough been occupied with the logical opposite of safety [6]. The accepted way to accomplish this is by preventing failures and malfunctions from happening, for instance as in 'prevention through design'. Resilience engineering avoids this problem by defining safety as the ability to succeed rather than as the 'freedom from unacceptable risks', hence as associated with situations where things go well and where safety therefore is present. Resilience is more precisely defined as "the intrinsic ability of a system to adjust its functioning prior to, during, or following changes, disturbances, and opportunities so that it can sustain required operations under both expected and unexpected conditions" [5]. (This definition logically includes the classical definition of safety, since 'the ability to sustain required operations' is tantamount to the 'freedom from unacceptable risks.')

The definition of resilience engineering also points to qualities that are central to disaster management, namely the ability to restore or sustain required operations by responding in the situation (adjusting performance during the disaster), by being prepared when the disaster happens (adjusting performance prior to the disaster), and finally by using the lessons learned to rearrange or restructure how it works (adjusting performance after the disaster).

According to the definition of resilience proposed above, the goal of resilience engineering is to establish and maintain resilience in an organisation, which more precisely means that an organisation can function in a resilient manner. This can be achieved by focusing on four fundamental abilities: the ability to respond, the ability to monitor, the ability to learn, and the ability to anticipate. The four abilities are, of course, not independent of each other, and the dependencies must be carefully considered in planning any changes. Neither is it possible to define an ideal 'mixture' or proportion in general. Although it may be argued that an organisation cannot be resilient if any of the four is missing, the proper balance among them can only be established from a thorough understanding of the organisation and its typical operational environment.

2.1 The Ability to Respond

No organisation or system—indeed, no living organism—can survive unless it is able to respond to what happens. If this ability is missing, the survival will be endangered in either the short or the long term, depending on how unstable the environment is. The ability to respond entails knowing what to do when confronted with regular and irregular disruptions and disturbances as well as with opportunities. The response can either be the implementation of a prepared procedure or activity, or the temporary adjustment of the ongoing functioning to match the new conditions. Since the ability to respond is a question of maintaining control of the situation, the inability to take advantage of an unexpected possibility may be as serious as the inability to respond to a threat.

The ability to respond can be elucidated by considering what is necessary for a response to be made. The organisation must first of all detect that something has happened; it must then recognise what has happened and determine whether it, given the circumstances, is so serious that a response is needed; and it must finally be able to deliver an appropriate response in the sense that it can bring about the desired outcome or change before it is too late.

In order to take action it is necessary either to have the requisite resources ready or to be flexible enough to make the necessary resources available when needed. If the event is a serious one, it may be necessary for the organisation to change from a state of normal operation to a state of increased readiness before it is able to respond. This points to other issues, such as the availability of resources, the urgency of the response, the ability to sustain a response for a prolonged period of time, the monitoring of the effects, etc.

A focus on the ability to respond can be the starting point for more specific questions about how the organisation works. One question concerns the events for which the organisation is able to respond. No organisation can be ready to respond to every situation or event—quite apart from the impossibility of thinking of everything. But it is important to know how the set of events (for which a response is possible) has been selected or defined, and whether the set—and the responses—are ever revised. Another question concerns the threshold for responding, i.e., how strong or clear a 'signal' or condition must be before something is done. It may be damaging to miss a critical situation, but it may also be damaging to respond to too many false alarms. Yet another concern is how the readiness to respond is maintained, for instance how plans are kept up-to-date, and equally important how the readiness to respond is verified.

2.2 The Ability to Monitor

Next in importance to the ability to respond, and in some sense inseparable from it, is the ability to monitor. Monitoring refers to the ways the organisation looks for that which may happen at the next moment or in the short term, both in the sense of opportunities and threats. The monitoring must include both that which happens in the environment, outside the organisation's boundaries, and that which happens in the organisation itself, i.e., its own performance. A prerequisite for monitoring is, of course, knowing what to look for. The essence of monitoring is actively to look for signs of what may happen rather than passively noticing what happens.

One obvious benefit from monitoring developments is that it becomes possible to respond faster, or perhaps even to respond pre-emptively. (Prevention is better than cure, as the saying goes.) Indeed, without some kind of monitoring all responses will be reactive because they will follow events; without monitoring, responding regresses to unsystematic and ineffective fire-fighting. The disadvantages of that are well known, such as losing time or spending more resources than necessary because (negative) consequences have had more time to spread. Effective monitoring enables the organisation to address possible changes before they become reality, both changes in the situation or environment—progress as well as deterioration—and changes inside the organisation, for instance depletion of resources or growing brittleness.

An analysis of monitoring cannot be separated from an analysis of the indicators or signals that the organisation looks for. Two important categories are lagging or leading indicators, respectively (e.g., [8]). Lagging indicators show what has happened—often with a considerable delay, such as the number of injured or dead, while leading indicators are *bona fide* precursors for changes and events that are about to happen. The main difficulty with 'leading' indicators is that their interpretation requires an articulated description or model of the process they represent. In the absence of that, 'leading' indicators are just defined by association or spurious correlations. Another important distinction is between clear and weak signals, and the trade-offs that the organisation must make in that respect. To play it safe, most organisations rely on clearly defined lagging indicators, such as on-line process measurements and accident statistics. The dilemma of lagging indicators is that while the likelihood of a successful response increases the smaller the lag is (because early interventions are more effective than late ones), the validity or certainty of the indicator increases the longer the lag (or sampling period) is.

A focus on the ability to monitor can also be the starting point for asking more specific questions about how well the organisation works. Just as for the ability to respond, one central question is how the indicators or signals have been chosen or defined, whether they are traditional or based on an articulated understanding of how the organisation and its environment functions. Another important question, already alluded to above, is whether the indicators are leading or lagging. A further question is how and when the indicators are 'read'. Is it done continuously, regularly, or when the situation seems to make it necessary? This can also be seen as a trade-off between efficiency and thoroughness of data collection, which is a question of costs and benefits. Yet another question is about the validity of the indicators and the validity of the signals or measurements that are being monitored. Is the validity based on a general agreement ('common sense') or does it have an empirical basis?

2.3 The Ability to Learn

The ability to respond depends on the ability to monitor, in the sense that the timing and precisions of responses can be improved by effective monitoring. But the ability to respond and the ability to monitor also both depend on the ability to learn. Neither responding nor monitoring can improve unless some kind of learning takes place. Learning is the ability to make use of experience and is generally defined as ‘a change in behaviour as a result of experience.’ Yet while it is indisputable that future performance only can be improved if something is learned from past performance, it is essential to learn the right lessons from the right experience—to learn from what went well as well as from what went badly.

In areas where safety is important—safety management and disaster management—the accepted wisdom has been that one should learn from failures in order to avoid making them again. Learning has therefore typically been in the form of a post mortem or an autopsy of what went wrong. Consistent with that philosophy, it has been assumed that more can be learned from events with serious outcomes—unusual accidents and catastrophes—than from events with minor outcomes—everyday accidents and incidents. Nothing could be farther from the truth.

The effectiveness of learning depends on the basis for learning, on which events or experiences the organisation takes into account, as well as on how the events are analysed and understood. General learning theory tells us that effective learning requires three conditions. First, that there is sufficient opportunity to learn. Second, that there is some similarity between the situations or events. And third, that it must be possible to confirm that something has been learned. Learning is not just a random change in behaviour but a focused change that makes some outcomes more likely and other outcomes less likely. It must therefore be possible to determine whether the learning (the change in behaviour) has occurred and has had the desired effect. If learning has had no effect then it has not been effective, and if it has had the opposite effect then it has certainly been wrong.

In learning from experience it is important to separate what is easy to learn from what is meaningful to learn. The three conditions mentioned above favour events that happen frequently rather than events that happen rarely, which means events with minor or moderate outcomes rather than events with serious outcomes. Furthermore, since the number of things that go right, including near misses, is many orders of magnitudes larger than the number of things that go wrong, it makes good sense to try to learn from everyday events rather than from failures alone. Learning should also be qualitative rather than quantitative. Although it often is convenient to express experience in terms of the number or frequency of occurrence of specific types of events or outcomes, compiling extensive accident/outcome statistics does not mean that anyone will actually learn anything.

A focus on the ability to learn can in the same manner as before be the starting point for asking more specific questions about how the system works. The primary concern here is whether learning is based on what failed or went wrong (avoidance learning) or on what worked or went right (approach or audience learning). Another issue is when learning takes place. Here the big difference is whether learning takes place—and is supported—continuously, or whether learning takes place—and is supported—only in the aftermath of a significant (attention attracting) event. A further issue is how learning is implemented, i.e., the target of learning. One example is that learning takes the form of (re)education of personnel, another that it takes place as revision of procedures or design of equipment. A fourth and for now final issue is how the effects of learning are verified—and importantly how the effects of learning are maintained—forgetting (individual and organisational) being what it is.

2.4 Ability to Anticipate

While monitoring makes immediate sense, it may be less obvious that it also is useful to look at the more distant future. Monitoring refers to what happens at the moment, and to the consequences of the actions that are taken. But the choice of which actions to take must include some kind of anticipation or consideration of the future, lest they be reduced to routine and reflective responses. The difference between monitoring and anticipation is whether the time horizon is limited to the current situation and the current activities (responses), or whether it is expanded to include parts of the future. Monitoring is associated with what is being done here and now, whereas anticipation is associated with tactics and strategy [14].

Risk assessment can be seen as a formalised form of anticipation that looks at future threats. Risk assessment is suitable for systems where the principles of functioning are known, where descriptions do not contain too many details, where descriptions can be made relatively quickly, and where the systems—and their environments—are sufficiently stable for their descriptions to remain valid for reasonable time after they have been made. For many present day systems these conditions are unfortunately not likely to be fulfilled.

Anticipation is similar to monitoring because it must consider both opportunities and threats. But anticipation differs by looking to the potential changes in the environment, rather than the potential changes in the organisation itself. One reason is that future changes in an organisation are more likely to be a function of changes in the environment than the other way around.

The purpose of looking for what may potentially happen is to identify possible future events, conditions, or state changes that may affect the organisation's ability to function in either a positive or negative way. The inevitable problem of anticipation is that the longer one looks into the future, the more uncertain the predictions will be. This is, however, not an acceptable reason for refraining from trying to anticipate, although that sometimes is the case. Neither should anticipation be skipped because it is 'unscientific', in the sense that it a qualitative rather than a quantitative endeavour.

The anticipation of threats or hazards has already been mentioned above. This type of activity has considerable support in formalised risk assessment methods such as FMEA, HAZOP, PRA, Fault Trees, and the like. The anticipation of future opportunities has little support in current methods, although it rightly ought to be considered just as important as the search for threats. This shortcoming is at least acknowledged by resilience engineering.

The ability to anticipate can be expressed in more operational terms by looking into some central issues, just as for the other abilities. One issue is what the organisation's view or 'model' of the future is, i.e., which assumptions are made about the future. Here we can distinguish between three characteristic views. In a *mechanistic* view, the future is conceived of as a mirror image of the past, and anticipation is therefore mainly extrapolations from the past. Typically, things that have gone wrong in the past are seen as (more) likely to go wrong in the future. In a *probabilistic* view, the future is described as a (re)combination of past events and conditions. This is the view that dominates traditional risk assessment methods, which put great weight on quantification and precise formulae and on calculating the probability that a specific hazard is realised. Finally, the future can be recognised for what it is, namely something that has not been seen before. What is going to happen is, however, not completely random but involves a combination of known performance variability that usually is seen as irrelevant for safety. This third view, which may also be called the *realistic* view, corresponds to the ideas of requisite imagination [1, 16].

Another important issue is what the time horizon of the organisation is. Here we are not talking about the time horizon for managing the event or disaster, but the time horizon for looking into the future. Many different priorities may determine that, and strong economic concerns tend to shrink the time horizon. But it is clearly important for an industry or a rescue organisation to consider what the types of events (requiring responses) may be five or ten years from now, what the resources or possibilities will be, and what the constrains (legal, environmental, political) may be.

A third issue is which risks are acceptable. Looking into the future is always associated with uncertainty, and the further one tries to look into the future, the larger the uncertainty will be. Despite that it will be necessary to make some decisions—either to prevent something from happening or to be ready in case an opportunity should arise (for instance by having sufficient reserves to put in action)—and the organisations willingness to trust its own predictions is therefore of considerable interest. Finally, one may also look at how often the future is considered, whether it is a regular or irregular (most likely reactive) event, and by whom. For instance whether there are specific organisation functions to do that, or whether it is outsourced to consultants or a think tank.

The detailed issues that can be derived from each of the four abilities demonstrate how it is possible to think about resilience engineering in a practical manner, for instance by using the Resilience Analysis Grid. The abilities and the issues can be considered on all levels of the organisation, from the level of management and planning to the level of operations and maintenance. The four abilities should, however, not be considered in the abstract but always by referring to a specific domain or field of activity, or even to a specific organisation at a certain point in time. For any given domain or organisation it will also be necessary to determine the relative weight or importance of the four main abilities, i.e., how much of each is needed. The right proportion cannot be decided analytically, but must be based on expert knowledge of the system under considerations and with due consideration of the characteristics of the core business. Yet the minimum requirement is that none of the four can be left out if a system wants to be able to perform in a resilient manner.

3 Management as Control

A system that is resilient is by definition able to remain in control of both expected and unexpected conditions. In order to understand how the four basic abilities contribute to that, it is necessary first to consider the typical reasons for loss of control. The industry-wide experience, ranging from single individuals interacting with independent and relatively simple machines such as a truck-driver, to groups of people engaged in complex collaborative undertakings such as a team of doctors and nurses in the operating room, points to a number of common conditions that may lead to the loss of control. These conditions are [1] not being ready or prepared when the unexpected happens, [2] not knowing enough about the situation, [3] not having sufficient time to think and to do, and [4] not having sufficient resources. Conversely, the ability to remain in control is enhanced if the organisation is ready or prepared for what happens, if it has or can get the information it needs, if there is sufficient time to assess the situation and decide what to do, and if the resources needed to effectuate the responses are available. Thinking in terms of resilience engineering makes this more concrete.

3.1 Lack of Readiness/Preparedness

Not knowing how to respond when something unexpected happens is practically a recipe for disaster. It effectively means that the situation is not only unexpected but also unrecognised and perhaps even unimagined—possibly even a fundamental surprise. There are two main reasons why an organisation may not be ready to respond. One is that it has not learned anything from previous situations, from the past; the other that it has not been able to anticipate or imagine what could happen.

The failure to learn is the most serious because it indicates that the organisation has ossified or become stale in established routines. Since, in the words of Norbert Wiener [18] "the present is unlike the past, and the future is unlike the present", an organisation cannot rely on already established responses, but must constantly revise and update them. The most effective basis for that is learning from how well a response has worked in the past, both when it succeeded and when it failed. In relation to safety it has generally been taken for granted that it was best to learn from failures [9], and indeed that more could be learned the larger the failure or accident was. But as argued above, learning should consider the frequency of an event rather than the seriousness of the outcome.

Readiness can also be incomplete or deficient because the organisation has not been able or willing to think ahead or to anticipate. In some cases it may be due to a narrow focus on the current problems, hence a trade-off between thoroughness and efficiency. In other cases it may be due to oversimplified or overoptimistic assumptions about what the future might bring, either as a reluctance to look at potential problems and risks, or a confirmation bias. It may also be due to the general difficulties in acknowledging the importance of imagination, as in requite imagination described above.

The importance of being ready to respond was pointed out by Lagadec [10], who noted that:

> "… the ability to deal with a crisis situation is largely dependent on the structures that have been developed before chaos arrives. The event can in some ways be considered as an abrupt and brutal audit: at a moment's notice, everything that was left unprepared becomes a complex problem, and every weakness comes rushing to the forefront."

Considerable efforts in both safety management and disaster management should therefore be used to prepare for how to respond when something happens.

3.2 Lack of Knowledge

In addition to being ready or prepared to respond, which means knowing what to do once the situation has been recognised, the management of unexpected events and disasters may also suffer from a shortage of information about what is going on. This refers to the details of the situation, both the actual status and the way in which it is likely to develop. Even if responses are available, they should not be deployed without knowledge of the situation. Such knowledge can be critical in relation to the timing of responses (when to start and when to end) or the magnitude or focus of responses (how much effort to deploy and where).

Having sufficient knowledge about the situation clearly depends on the ability to monitor what is going on, both in the outside world—the objective situation—and in the organisation. Monitoring is itself an activity that may require resources, and will therefore to some extent compete with the need of resources for other purposes. Monitoring can also be time critical, for instance to ensure the synchronisation of responses with how the events develop.

Without sufficient knowledge about what is going on, all the time in the world will not make much difference. To take an extreme example, if you put an untrained person into a control room of a refinery, he or she will have no real chance of controlling the process. To take a less extreme example, if you put people in charge of a job without giving them proper training and instructions, then they are likely to lose control of the situation and to respond in ways that may have serious adverse outcomes [3].

3.3 Lack of Time

The loss of control of a situation very often happens because of a lack of time. Every dynamic process has certain demand characteristics because the process continues to develop and possibly changes state, even if the organisation does nothing. The concrete consequence is that there is limited time to understand what is going on and to plan, prepare, and execute actions. It is necessary to be ready to respond and to know what the situation is, but that is not in itself sufficient. Knowing what to do is no good if there is no time to do it. The control over unexpected events is closely related to the amount of time that is available to the organisation in two different, but complementary ways. Firstly, the realism of the expectations about what is likely to happen depends, among other things, on the available time. If the expectations or predictions are inaccurate, then additional unexpected events or developments are more likely to follow. Secondly, unexpected events inevitably require additional time, since they fall outside or interrupt the planned, ongoing activities. The organisation needs time to take in the new information, to decide what to do about it, and to update the current understanding.

The only practical ways in which to increase available time are to improve the efficiency of responding and monitoring. But in neither case should the temporal improvements (speeding up) be achieved by sacrificing thoroughness over efficiency. While doing so may provide a temporary respite, it will in the long run exacerbate the problems, because a lack of thoroughness in the present will be detrimental to efficiency in the future [4]. Thus being less precise in monitoring—a condition that may result from input information overload [7, 12]—or being less thorough in actions or responses will make the outcomes less predictable, hence only contribute to the unexpectedness of future events.

3.4 Lack of Resources

Finally, control may be lost if the necessary resources—other than time—are lacking. A lack of resources, whether it be equipment or supplies, can be the consequence of an acute condition, such as a loss of power or pressure, or of a systemic failure, for instance the result of latent conditions or a mistake made at the blunt end. One example was the spread of the influenza in Sweden in the winter of 2001. In early January it was realised the influenza epidemic was coming but that all the vaccine had already been used, hence that a number of people would be left exposed. An unfortunately more frequent example is wildfires. Here a fire can be regarded as a dynamic process, which is reasonably predictable (although random events such as changing winds may play an important role). In the case of a wildfire there are organisations ready to intervene and there are few problems in knowing what is going on or what should be done. There may sometimes be a lack of time, but the limiting factor is often that resources needed to extinguish the fire become depleted. The result may be that a wildfire goes out of control, such as the bushfire near Sydney in December, 2002.

Just as for the lack of readiness, a lack of resources can be the result of inadequate learning and inadequate anticipation. The experience from similar situations in the past, both those that failed and those that succeeded, is essential to plan ahead and to ensure that the proper resources are available. There is, however, a conflict that most organisations have experienced at one time or another. On the one hand the concern for safety, or even a concern for being able to operate, is an argument for having adequate resources. On the other hand, resources that are unused quickly come to be seen as a cost, hence as something that should be avoided. This is easily illustrated by Hansung Airlines, a low cost carrier in South Korea. When it began operations in August 2005, it only had stocked spare parts locally for highly likely situations, assuming that they could be flown in from Singapore should the need arise. When one of their three aircraft in October 2005 suffered a blowout of both left rear tires, it turned out to be impossible to transport the spares due to safety reasons. Because of that flights were cancelled for three days, with disastrous economical consequences for the company.

Even if such economic concerns are set aside, unrealistic (optimistic) anticipation may lead to serious problems. This happens, for instance, when the anticipation relies on assumptions that are widely shared but rarely questioned. In relation to nuclear power plants, for instance, a Level 1 Probabilistic Risk Assessment (PRA) assumes that the disturbance (e.g., loss of external power) will last for no more than 24 h. Resources are therefore designed to be sufficient for 24 h only. The contentious issue here is that imagination has become standardised and embedded in a methodology that is applied on the tacit assumption that it is adequate. But if anticipation is mindless rather than mindful [15] it erodes the organisation's ability to remain in control.

4 All in All

This chapter has looked at safety management and disaster management as the ability to deal with events that are unexpected, either in terms of *when* they happen or in terms of *what* they are. The greatest challenges are presented by what Westrum [17] called irregular events. Since these events occur outside the organisation's everyday experience, it may not always know how to respond nor have the proper resources available. In such cases the organisation's resilience plays a crucial role.

Resilience engineering has developed a consistent approach to analyse and understand resilient performance. The practical experiences so far have shown that it makes sense to describe resilient performance as based on four abilities: the ability to respond, the ability to monitor, the ability to learn, and the ability to anticipate. The four abilities should, however, not be thought of or described as independent factors. Each depends on one or more of the others and they must therefore be analysed and managed together in order to understand how they contribute to the organisation's overall ability to remain in control of a situation. This is summarised in Table 2, where the 'X' in a cell marks how an ability can counteract a loss of control.

The conclusion is that resilience engineering concepts can be used to understand how the unexpected can be managed (or controlled). One part of that is that the organisation is able to respond to and monitor the ongoing in an effective and flexible manner. Another is that the organisation is able to learn and

Table 2 RMLA and maintaining or sustaining control

	Lack of readiness/ competence	Lack of knowledge	Lack of time	Lack of resources
Respond			**X**	
Monitor		**X**	**X**	
Learn	**X**			**X**
Anticipate	**X**			**X**

anticipate—and also to monitor itself in both the short and the long term (proprioceptive mindfulness). Finally, to manage the unexpected we must accept that it can happen—not by proving it through probability calculations, but by acknowledging that our ability to produce socio-technical systems for some time has exceeded our ability to understand them.

References

1. Adamski AJ, Westrum R (2003) Requisite imagination: the fine art of anticipating what might go wrong. In: Hollnagel E (ed) Handbook of cognitive task design. Lawrence Erlbaum Associates, Mahwah, pp 193–220
2. Amalberti R (2006) Optimum system safety and optimum system resilience: Agonist or antagonists concepts? In: Hollnagel E, Woods D, Leveson N (eds) Resilience engineering: concepts and precepts. Ashgate, Aldershot
3. Furuta K et al (2000) Human factor analysis of JCO criticality accident. Cogn Technol Work 2(4):182–203
4. Hollnagel E (2009) The Etto principle: efficiency-thoroughness trade-off (why things that go right sometimes go wrong). Ashgate, Farnham
5. Hollnagel E (2011). Prologue: the scope of resilience engineering. In E Hollnagel, J Pariès, DD Woods, J Wreathall (Eds) Resilience engineering in practice: a guidebook (pp xxix–xxxiv). Ashgate, Farnham
6. Hollnagel E (2014) Safety-I and Safety-II: the past and future of safety management. Ashgate, Farnham
7. Hollnagel E, Bye A, Hoffmann, M (2000) Coping with complexity: strategies for information input overload. 2nd conference on cognitive systems engineering in process control (CSEPC 2000). Taejon, South Korea, Nov 22–24
8. Hopkins A (2009) Thinking about process safety indicators. Saf Sci 47:460–465
9. Kletz TA (2001) Learning from accidents. Routledge
10. Lagadec P (1993) Preventing chaos in a crisis strategies for prevention, control, and damage limitation. McGraw Hill Europe, Berkshire
11. Lanir Z (1983) Fundamental surprises. Center for Strategic Studies, University of Tel Aviv, Ramat Aviv
12. Miller JG (1960) Information input overload and psychopathology. Am J Psychiatry 116:695–704
13. National institute for occupational safety and health (2010) Prevention through design: plan for the national initiative (DHHS Publication No. 2011–121). Washington, DC
14. Schützenberger MP (1972) A tentative classification of goal-seeking behaviours. In: Emery FE (ed) Systems thinking. Penguin Books, Harmondsworth
15. Weick KE, Sutcliffe KM, Obstfeld D (1999) Organising for reliability: processes of collective mindfulness. Res Organ Behav 21:81–123

16. Westrum R (1993) Cultures with requisite imagination. In: Wise JA, Hopkin VD, Stager P (eds) Verification ad validation of complex systems: human factors issues. Springer, Berlin, pp 401–416
17. Westrum R (2006) A typology of resilience situations. In: E Hollnagel, DD Woods and N Leveson (eds) Resilience engineering: concepts and precepts. Ashgate, Aldershot, pp 55–65)
18. Wiener N (1954) The human use of human beings. Houghton Mifflin Co, Boston
19. Woodruff JM (2005) Consequence and likelihood in risk estimation: a matter of balance in UK health and safety risk assessment practice. Saf Sci 43:343–353

Part II
Urban Domain

Futuristic Smart Architecture for a Rapid Disaster Response

Oliver Chikumbo, Steve Lewis, Hugh Canard and Tony Norris

Abstract The ability to control and contain an unexpected disaster event such as a bushfire or flooding in real-time is fraught with logistic and planning challenges. Information is difficult to assimilate both from structured and unstructured data that may be collected in real-time. Unreliability of mostly unstructured data from social media and mobile devices, though extremely helpful, can make it difficult to deploy needed help/assistance in time. Ad hoc planning specifically targeted at saving lives may be severely hampered when part of the infrastructure is destroyed that is normally relied on for data collection. Also when part of the infrastructure is destroyed that normally is relied on for collecting structured data, the situation can even make it harder for ad hoc planning specifically targeted at saving lives first. In such situations, a combination of unstructured data that carries uncertainties and limited structured data from infrastructure that might still be working after/during a disaster event can be used to the best of advantages and still enhance the control process to better achieve desired outcomes: i.e. real-time event monitoring through real-time limited and high uncertainty data; filtering unstructured data through crowd sourcing, not only for reliability but sometimes for language translation as well; short-term predictions of anticipated changes from already existing interoperable simulation models, using

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A. Masys (ed.), *Disaster Management: Enabling Resilience*,
Lecture Notes in Social Networks, DOI 10.1007/978-3-319-08819-8_3

the limited structured data from infrastructure that might be still standing following a disaster; and all this with the aim of appropriate, timely responses to saving lives in a rapidly evolving environment. A generic management framework designed to be used during a “phase transition” between pre- and post events, and characterised by the interoperability of distributed simulation models, and the collection and sharing of structured and unstructured data via cloud services and “connected devices”, is essential for the consistent provision of highly effective responses. We explore this framework from a science and innovations perspective, advocating “antifragility” for emergency response system designs. For antifragility systems, failures do not stand for a breakdown or malfunctioning of normal system functions, but rather represent the adaptations necessary to cope with the real world complexity through the management of “robustness trade-offs” as it occurs in dynamic and real-world contexts.

Keywords Robust-yet-fragile · Robust-yet-flexible · Antifragility · Phase transition · Collaborative scheduling · PlanIT OS™

1 Introduction

Natural disasters can be catastrophic leading to loss of lives and property in a short space of time, with long-running, post-event loss adjustments, and the arduous and costly rebuilding or “economic re-boot”. With the little we know about the increasing frequency and intensity of natural catastrophes (as evidenced by the claims from the insurance industry and the World Health Organisation), and also the fast compounding uncertainty from the increasing urbanisation with high population and infrastructure concentrations [32], civil defense has a far greater workload responding to emergencies. Emergency response systems (ERSs) are intermittently put to test in urban environments with each disaster occurrence that seems to bear little resemblance of the previous disasters. Better response times and recovery will mean, among other things, a shift in planning to create systems that are not only resilient [24]. Resilient or “robust-yet-flexible” systems are designed for variability in response to stressors (up to a point) and not to fail completely in extreme situations. The alternative is antifragile systems that thrive under stressors and not just tolerate them [64]—a concept that is difficult to grasp from an engineering perspective.

Although there are many things that can be done to minimize impacts in the pre-event period and also things that can be better managed in the post event period, it is the phase transition that seems to be ignored the most, mainly because it is a very difficult situation to handle. However, if done prudently with appropriate infrastructure in place, it is sure to minimize loss of lives and damage to property. The problem is how to do it prudently because it is a dynamic and hostile environment where every minute counts and any unnecessary delays may mean loss of lives. The difficulty arises from lackluster automation in machine-to-machine communication, lack of hardware and software ensemble designed to continue functioning in hostile environments, and an inability to prioritize and manage decentralized decision-making of emergency respondents on rescue missions. To develop emergency response systems that will overcome the identified difficulty and effectively reduce response times during the phase transition is nontrivial, and will require the following:

(a) An antifragile communications system;
(b) Tight integration platform for interoperability of different and disparate data/simulations for short-term predictions and real-time determination of intervention strategies; and
(c) An online scheduling timetable managed by a group of “scheduling and timetabling negotiators”, whose job is to make sure that rescue missions are assigned to the appropriate respondents who are monitored for backup, or completion times for reassignment to different missions, on a constantly updated web-based timetable visible to the public (to encourage volunteers to ring up negotiators for mission assignments that suit).

Note all three of the above are about in situ/real-time archiving, assimilation, visualization, modeling, and interpretation of the information from large volumes of data and the ability to synthesize these data from heterogeneous and potentially geographically distributed sources. The assignment of the rescue missions and maintaining a live, web-based timetable by the negotiators is a pressure cooker undertaking that has to be carried out until a threat/hazard has been contained, which may be hours to weeks of non-stop action for them. Many of the ideas, for instance, on the online scheduling have been gleaned from the complex scheduling of missions for NASA’s Deep Space Network (DSN), and also real-time monitoring of aircraft at an airport by air traffic controllers whose job is to provide clearance for takeoff and landing, and helping pilots to navigate the runway; guiding pilots during takeoff and landing; and monitoring a designated airspace by securing routes for planes in that airspace.

The rest of this chapter describes the theory of antifragility and how it impacts on the design of an antifragile communications system; how to determine real-time intervention strategies using a tight integration framework for interoperability of simulation models and data, based also on antifragility concepts; a description of the collaborative scheduling managed in real-time by a team of negotiators; and finally how this all links together into an antifragile framework that will manage a phase transition of a disaster event, and the potential collaborators to pioneer such a design, development and implementation of the framework.

2 Important Theoretical Background

There is an evolving science on resilient systems that looks at robust-yet-fragile, robust-yet-flexible, and antifragile systems. It is based on how networks can remain robust while at the same time being fragile, how they can suddenly disrupt without any obvious slow and sure warnings, what bits of them can fail with little or nothing happening and what bits can fail with a lot happening [8]. This is the science of complexity that includes tipping points, weak ties, catastrophes, bifurcations, power law (scale-free) distributions, order effects, phase transitions, redundancies and so on. The sensitivity to complexity science in research has led to the ushering in of the fourth paradigm, data intensive science [46], which integrates the first three paradigms (i.e. theory, experimentation, and computational simulation) and we are starting to see the first fruits of this fourth paradigm encapsulated in the Internet of Things (IoT). That, essentially is the basis of the ERS design we present in this chapter.

The search for general theories of complexity continues to engage scientists across many disciplines, and it has to for a successful implementation in everyday life. Some scientists are concentrating on aspects of predicting catastrophic events before they occur and initiating smaller disturbances designed to alleviate the catastrophic event from happening in the first place. This is the hunt for the dragon-kings, spearheaded by Sornette [63] and now co-researched by Cavalcante et al. [12]. Cavalcante et al. [12] set out to demonstrate the predictability of extreme events and how they can be suppressed by applying tiny perturbations to a system composed of coupled chaotic electronic oscillators. Dai et al. [20] experimented with budding yeast to show that critical slowing down and/or increased variability of measurable system quantities near the bifurcation point holds the key to forecasting an impending event. The experimental results may be critical in predicting and taking evasive action from natural disasters. Alternatively they may be applied to predict and control behaviour of man-made systems such as financial markets, power grids, or in our specific case, ERSs.

It is also important to note that the behaviour of such systems (described as networks of interconnected parts) cannot be inferred from the properties of the individual parts Motter [49]. For instance, the outage that affected Italy on the 28th September 2003, directly led to the failure of nodes in the Internet communication network, which in turn caused a further breakdown of power stations [10]. This caused the network to become fragmented (or interconnections pruned and shifted)—a case of bidirectional dependence (where power stations depend on the communication nodes for control, and communication nodes depend on power stations for their electricity supply). When diverse infrastructures such as water supply, transportation, fuel, and power stations are coupled, the interdependent networks are extremely vulnerable to random failure, such as a random removal of a small fraction of nodes from one network that may produce an iterative cascade of failures in several interdependent networks [10]. It is a two-edged sword with ERSs, because their failure to contain a disaster may, firstly lead to cascading failures in the system to be saved, and secondly to cascading failures in the ERS itself, putting a lot of lives and property at risk—seemingly a case of "*lasciate ogni speranza, voi ch'entrate*" [2] translated, "abandon all hope ye who enter".

It is this double-edged sword effect of ERSs that certainly makes the case for better network designs that will still function, even after random deletion of nodes, and allowing for constrained fragmentation that may mean reversible phase transitions, as observed in nature. For example, the anhydrobiosis of the tardigrade can suspend metabolism almost entirely for years under extreme dehydration, and becoming active again upon rehydration [33]. Fragmentation brings us to our next discussion, phase transition, which is a structural reordering, usually an order-disorder change, where everything gets connected (i.e. connectivity avalanche), forming stagnant and overcomplicated interactions. This is highly unstable and will collapse or fragment to be reconnected in a different way [9], or converge to an oscillating pattern (e.g. the predator-prey cycle), or pattern of erratic fluctuations [60].

It seems logical to study phase transitions of complex systems from physical systems (such as water changing from a liquid to a gas with increasing temperature), and mapping that to social or other systems. The idea is that if this change can be predicted, by understanding the processes at work, then there is a good chance of predicting a phase transition before it happens [12]. A study of these phases in ecosystems using sophisticated models show that the transitions can vary from smooth to discontinuous/sharp. The problem is that current mathematics begin to break down when applied to these phase changes, firstly because the parts (of the system) are neither independent nor coherent, and secondly because the system exhibit properties that occur across both phases in question. Connectivity avalanche in phase transitions is problematic because node connections can happen so fast, creating an unstable situation just prior to a transition and making it difficult to measure/observe the sequence of events. Sometimes the connectivity can be gradual without any perceptible signals, or until the last connectivity (sometimes described as the "butterfly effect") takes place, which will cause a phase change [3].

However, predictions can no longer be just based on the past, and that some knowledge of the future needs to be taken into account—this is the area of alternative stable states (or attractors), which a system may transition into. However, experimentally determining possible attractors of a complex system is non-trivial and their presence implies that a single stochastic event might push the system to another basin of attraction [60]. An important characteristic of attractors (that is essential in design) is that alternative states can co-exist (aka hysteresis) side-by-side, only to show a shift in spatial distribution pattern following an extreme event.

Holling [34] identified a complex system as a set of adaptive cycles that he called panarchy. The word panarchy was melded from two words i.e., Pan, the Greek god that epitomizes unpredictable change, and hierarchy to represent structure—thereby capturing the paradoxical coexistence/interplay of transformation (or change) and persistence of a complex system. The glue that enables this coexistence is a set of critical processes that invent/create and experiment to maintain the system in question. Although the panarchy concept exceptionally encapsulates the notion that complex systems are not static but that they go through a cycle of growth, accumulation, destruction and renewal, there is not much in the way of identification of the symptomatic signals of change from one state to the next. It is important to be aware of panarchy cycles if the focus is prediction (as in weather forecasts), but also important in designing large complex systems so as to minimise the possibility of catastrophic phase transitions due to unexpected perturbations to the system, be they sharp or smooth transitions.

2.1 Theory and Mathematical Abstractions

However, whether its about dragon-kings or phase transitions or attractors, the focus is still largely on predicting accurately an event, thereby taking corrective action to either end or mitigate the impacts. Breakthroughs in this area of complex systems will undoubtedly help in serving early warnings for certain kinds of pending disasters, but also in designing ERSs that will not break under extreme events. Kitano [41] takes a different view by focusing on finding a unified theory of robustness that will be developed within a solid mathematical framework. He builds on conservation principles applied to robustness and fragility trade-offs [19], that a system optimized for a specific perturbation inevitably entails extreme for unexpected perturbations. This obviously has mathematical expedience, as the approach leans heavily on robust control theory, a well-developed engineering discipline based on stabilising the performance of a monostable system so as to make it robust against model errors [72]. Kitano [42] demonstrated robustness trade-offs on his research on the efficacy and side effects of drugs. Chu and Chen [17] also considered robustness trade-offs for cancer by treating cancer as a robust system with fragilities, and applied a robust control theory approach based on microarray data. Wagner [69] adapted "distributed robustness" from the field of information technology (used to define a network free from any single point of failure) for metabolic networks, where elimination of a reaction would still see the network synthesize all the correct biomass compounds by rerouting the flow of matter via a different pathway, bypassing the eliminated reaction.

Howbeit, despite the mathematical expediency of robustness trade-offs approach, or distributed robustness, which excludes redundancies, we view the problem differently because speaking of robustness without reference to particular system characteristics or environmental uncertainty can be misleading [19]. For a start, by robustness we mean the maintenance of some desired system characteristic(s) despite fluctuations in the behaviour of its component parts or its environment [11], and at the other end of the spectrum there is fragility [27]. Therefore, robustness trade-offs tend to mask the intertwined variables that have to be traded off to achieve the balance between robustness and fragility such as, performance, feedback regulations, spiraling complexity, stress responses (to cascading failures), and resource demands. Obviously the explicit way to deal with as many trade-offs is to look at multi-objective optimization, which requires an understanding of the dynamics of the system in question well enough to simulate interacting dynamics of the subsystems from disparate models. The simulations from these disparate models may then be used to design the system's multi-dimensional search space for multi-objective optimization, with no perceived primacy in any of the objectives other than what is characterized by the system. This way a Pareto frontier, or set of non-dominated trade-offs, may be estimated and it is nontrivial [23].

The feedback regulations of the many variable/subsystem interconnections of the system create complex dependencies, uncertainties, circularities and conflicts, a recipe for "wicked dynamics" [44], implicated by any efforts to find an alternative state, which may only be viable for a moment of time. Because of the constantly changing dynamics, met by constantly changing alternative states, the problem is never permanently resolved—hence "taming" the problem rather than solving it [16]. This fits the multi-stable systems (as most systems in nature) that may not even have an explicit desirable state but many alternative states where the transitions are driven by the dynamic environment. To explain how this would implicate the design of antifragile ESRs we need to clarify the following: robust-yet-fragile, robust-yet-flexible, and antifragile systems.

2.2 Designing for Robust-yet-Fragile Systems

Increasing complexity in system design may be fuelled by the need to perform more functions that also have to be reliable. For example, our oxygen intake is governed by distributed complex feedback control mechanisms to ensure that both sufficient oxygen and protection from oxygen toxicity are maintained throughout our bodies, both acutely and chronically [19]. The problem is that this creates an environment conducive to parasites, a fragility that is managed for by yet another complex control system, the immune system. The immune system is also subject to other fragilities/failures such as the autoimmune disease, Sjögren's syndrome (an abnormal production of extra antibodies in the blood where the patient's white blood cells attack the saliva and tear glands). Therefore, the interacting feedback loops lead to spiraling complexity, adding robustness with each feedback loop, but also introducing fragility.

It is also interesting to note that *Escherichia coli* has approximately 4,000 genes and yet only 300 have been classified as essential for minimal cellular life, based on laboratory viability from single gene knockouts [50]. It is likely that the remaining number of genes is for complex regulatory activity for robustness.

Therefore, robust systems that invested heavily in avoiding failures cannot adapt to unpredictable, volatile, and random events or shocks to the system, because they have no built-in design to respond to variability, hence robust-yet-fragile. In terms of optimisation, it means that the system is highly structured for a single objective (which is mathematically expedient) and by ignoring the other objectives that may be merged into that one objective or formulated as constraints, leaves the real risk of fragility—i.e. the risk of rare but potentially catastrophic failure initiated by possibly quite small perturbations. The robust-yet-fragile phenomenon is also observed in nature, i.e. robust to what is common or anticipated but potentially fragile to what is rare or unanticipated—and also to flaws in design, manufacturing, or maintenance. Because robustness is achieved by very specific internal structures, when any of these systems is disassembled, there is very little latitude in reassembly (or phase transition reversal) if a working system is expected. Although large variations or even failures in components can be tolerated if they are designed for via redundancy and feedback regulation, what is rarely tolerated, because it is rarely a design requirement, is nontrivial rearrangements of the interconnection of internal parts [19].

2.3 Designing for Robust-yet-Flexible Systems

Robust-yet-flexible systems synonymous with resilience, are about the designing for variability in conditions—rather than the assumption that conditions will remain within measured or reasonable assumptions. Robust-yet-fragile systems mask stressors (up to a point), and they optimize for certain anticipated stressors and fail miserably for unanticipated stressors. The resilient systems improve on that because not only do they mask stressors, but also the stressors perturb the system, which has latitude to stretch—and the system fails gracefully. For instance, modern ship design after the Titanic have panels that can bend easily and not break as miserably, but will hold well in the face of an extreme stressor [24].

Robust (yet-flexible) engineering designs are now ubiquitous in modern constructions such as bridges, skyscrapers, etc., which are built to sway with the wind and earthquakes but not fail completely. Therefore, these structures last longer because the stressors are tolerated by "rolling" with them instead of resisting the shocks. In contrast, robust-yet-fragile designs would result in an accumulation of invisible damages that may eventually manifest as a complete failure triggered by just one more minor stressor.

2.4 Designing for Antifragility

Although nature is awash with examples of antifragility, which is better than resilience, there aren't many examples of mechanical systems, hinting an overdue paradigm-shift in engineering and design. For example, some neural systems exploit phase transitions as a source of novelty and flexibility which allows them to continually adapt to stimuli [29]. Freeman [26] showed that living neural systems (such as a cat's brain) exploit chaos as a source of novelty in creating memory patterns, from which Green et al. [29] asserted that novelty arises from the inherent unpredictability of connectivity patterns associated with phase transitions. Therefore, stressors make the system stronger, whereas with mechanical systems it is wear and tear from usage [24]. However, materials such as carbon nanotube show a unique combination of stiffness, strength, and tenacity compared to other fiber materials, and get stronger when faced with a stressor. Many objective optimization (>10 objectives) become critical in designing for antifragility and given that there is no unique solution but a set of non-dominated solutions, it makes it possible to identify and design for the alternative states or attractors. Therefore, designing for robust-yet-flexible systems may be akin to two-three objective optimization, a ubiquitous and well-researched area in literature [23].

Software development is showing promise for antifragility designs that will be a spillover to mechanical ensembles controlled by this software. Coupling with the IoT (which represents assignment of Internet addresses to a diversity of devices to enable connectivity or marriage of sensors, communications (be it wired, wireless, satellite, or mesh networks), smart devices, and big data analytics), will potentially create unprecedented efficiencies in almost every aspect of our lives. Examples include, urban planning, transportation, agriculture, healthcare, intelligent manufacturing, and emergency response [30].

2.5 Antifragile Software Examples

BitTorrent, a peer-to-peer file sharing protocol that allows users to join a swarm of hosts to download and upload from each other simultaneously, as opposed to the conventional single large server that distributes files, enables the efficient distribution of large files, accounting for 43–70 % of all Internet traffic [61]. In a peer-to-peer network all nodes play equal roles with no specialized client or server nodes [67]. The more a file becomes a traffic hotspot (i.e. more traffic stress on the network), the faster it gets to download it, because BitTorrent streams gain from hotspots and contention by exploiting the “network effect” (i.e. a good/service becoming more valuable as more people use it) to provide scaling [24].

Van Roy [67] took the third generation peer-to-peer network concept (i.e. a structured overlay network with a 2-level topology consisting of a ring complemented by a set of fingers/extra links) to another level and developed a large-scale distributed application, SELFMAN, from ground up as multiple interacting feedback loops (where each loop consists of an observer, corrector, actuator and subsystem). This topology, with atomic ring maintenance, exhibited self-organizing properties [34], i.e. surviving node failures, node leaves, node crashes (leaves, but without notification), and node joins, whilst maintaining its specification. Additional algorithms were also developed to deal with imperfect failure detection resulting from temporarily broken fingers, which only affected efficiency and not correctness. Van Roy [67] could identify the phase transitions based on node failure rates from the solid phase (low node failure rate with a connected ring that has fixed neighbours), to liquid phase (with a relaxed ring but no fixed set of neighbours) and gaseous phase (high failure rate with many separate small rings). Therefore, each phase with a defined behaviour was programmed for, which meant a full-functioning SELFMAN in realistically harsh environments encountered with distributed applications (that tap the Internet’s power by enabling millions of devices and programs to link up and work together).

SELFMAN led to the award winning open source, Scalaris (for the IEEE International Scalable Computing Challenge 2008), a self-managing scalable, transactional storage for large-scale distributed Web 2.0 services, that is self-healing (when it detects a computing node crush or network problem), requiring little or no human intervention in management tasks such as adding or removing nodes, and self-tuning (i.e. autonomously moves items to distribute the load evenly over the system to improve response times). Therefore, no teams of experts are needed to tweak, patch or protect system components coming online or dropping out or in response to communication or component breakdowns, and even deliberate attacks [54].

Although Van Roy’s work covers properties of phase transitions that characterize an isolated network, research has shown that interconnected networks exhibit different properties [25]. For example, structural and dynamical transitions [58] are usually continuous for isolated networks and discontinuous for interconnected networks and different phases/regimes may disappear or coexist [10]. Work needs to be done to see whether this discontinuity is analogous to supercritical fluids (which have industrial and scientific applications) and investigate the possibility of driving interconnected networks to supercritical regimes that may be useful in better designs and control of real world network systems [58]. Such an addition to the phase transition properties of SELFMAN would mean functionality over a much wider range of environments than what is currently possible. The Autonomic Service-Component ENSemble (ASCENS) project is superseding SELFMAN by becoming self-aware and exhibiting dynamic self-expression as multi-agent systems with local and distributed reasoning [68, 71].

3 Implications for ERSs

A number of modeling and simulation tools have been developed to address the challenges in disaster response ranging across application areas such as planning, training, identification, detection, vulnerability analysis and the provision of real-time response support [36]. Of interest is the development of technologies and algorithms that can integrate in real-time copious amounts of fragmented and incommensurable data (i.e. interoperability of data), generating useable and accessible forms of information. However, it is our view that more still needs to be done to address the anaemic interoperability of current disaster response models and data [5] by exploiting antifragile software and hardware platforms that will mean uninterrupted functioning during extreme events.

Improving information management during a disaster (through the timely collection, analysis, sharing and dissemination of data to the right people) will enhance the effectiveness of the response, verifiable through the minimization of loss of life and the containment of potentially cascading disasters [48]. To surpass existing systems is a difficult task, because an effective measure of improvement is notoriously difficult to test, as each disaster differs from another [48]. Central to disaster response is the coordination of a number of emergency respondents with different priorities and preferences, to save lives and protect property in uncertain and constantly changing environments [58]. These priorities may be conflicting and must be resolved concurrently during continuously changing circumstances, in order to perform specific tasks that will translate into rapid and timely rescue operations.

3.1 Identifying the Critical Phase Transition

We need to capitalize on the software breakthroughs such as SELFMAN/ASCENS coupled with IoT, in order to develop antifragile ESRs that will not fail in extreme conditions. If ESRs are to display invariance under phase transitions and continue to function effectively, then the emergency response times will be reliably kept low, a key to saving more lives and protecting property. The importance of antifragility in recovering quickly from natural and man-made disasters cannot be over-emphasized.

There are so many ideas out there on how to manage a disaster with the sole goal of saving lives and property. At most times recent literature on emergency response or disaster management, describes the “4Rs” [66], which always gives one a sense of *déjà vu* about disaster management, and they include—Reduction, Readiness, Response, and Recovery, followed by a prescription of each. Each of the 4Rs requires action at individual, business, community, and government levels without offering any real solutions other than emphasis on improvement or prioritisation of the Rs, and some recommendations based on some recent natural disaster. In other instances, it’s all about managing risk, where conventional

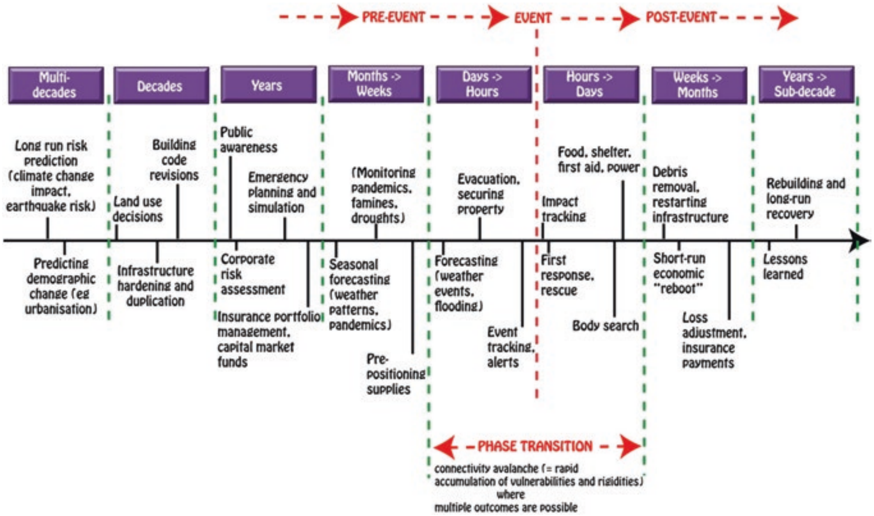

Fig. 1 Resilience as a process, spanning multiple activities and time-scales, both pre-event and post event [70], and the phase transition that requires antifragility treatment if short emergency response times are to be realised

risk management approaches in disaster management are based on hindsight and emphasize error tabulation and calculation of failure probabilities, which never really translate into antifragility.

IBM gives a compelling definition of resilience as a process, spanning multiple activities and time-scales, both pre-event and post event [53, 70] as shown in Fig. 1. The pre-event activities include long run risk prediction (e.g. climate change impact, earthquake risk), demographic changes, etc., for multi-decade timescale, to seasonal forecasting (i.e. weather patterns, pandemics etc.) for months-weeks timescale, and eventually evacuation, event tracking, etc., for days-hours timescale. Post-events include impact tracking, body search, food and shelter, etc., for hours-weeks timescale, to rebuilding and long run recovery for years-sub decade timescale. We like this definition of resilience, although our concentration is on the indicated phase transition (in Fig. 1), which is the weakest link in the whole process planning. This is where we feel the biggest impact may be made in emergency response, and it is about early intervention during the phase change to essentially steer the event to an alternative state (or attractor) that is desirable in terms of saving lives and arresting potentially cascading disasters. The effort is proactive and stands a better chance than waiting for fate to decide the alternate state, and then picking up the pieces. Because of the massive real-time data requirements for translation into actionable information, an antifragile infrastructure is essential. This will include, ready-to-run systems optimized for big data analytics available on a cloud platform or Infrastructure as a Service (IaaS), dedicated and mobile network links for low latency and high bandwidth steerable sensors for streaming data, and optimization capability for determining real-time intervention strategies related to alternative states/attractors.

Note that this is not about stopping an extreme event, rather to influence the inevitable by steering to a more manageable attractor where impact, as much as possible, may be at a minimum. As indicated earlier the dynamics during such a phase change are wicked, and as such the intervention we propose can only tame the phase transition.

3.2 Taming the Phase Transition

Taming the phase transition is a difficult task, as more of the world's population is now concentrated in the cities with a projected 70 % living in cities by 2050 [65]. That makes for a compeling case for governments to invest in antifragile ERSs, although it may be costly ab initio. If western governments can annually subsidise power stations (at the expense of global warming), agriculture (at the expense of deforestation and overgrazing), and fisheries (at the expense of overfishing), at the tune of USD100 billion, USD300 billion, and USD50 billion, respectively based on 1996 Worldwatch Institute estimates, then surely they can afford to subsidize investment in antifragile ERSs, which would be considerably less in comparison. However, we propose an antifragile ERS as shown in Fig. 2 and for clarity we have numbered different aggregates/ensembles from 1 to 6, which we will explain in the following subsections.

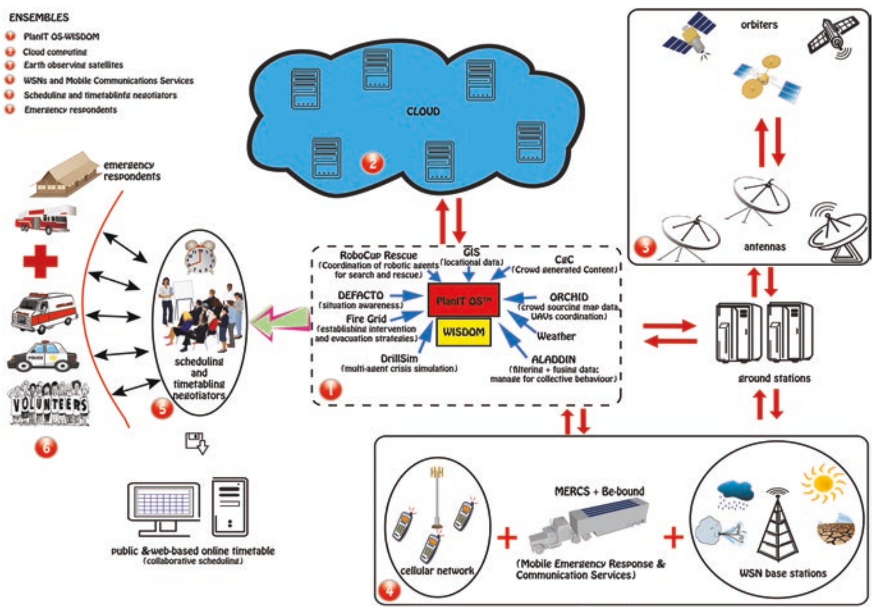

Fig. 2 An antifragile infrastructure for managing a phase transition to a more desirable attractor during an extreme disaster event

3.2.1 Ensemble 1: PlanIT OS-WISDOM

PlanIT OS-WISDOM is the "core technology" being developed under the partnership of Living PlanIT SA (a software company) and BEACON (Center for the Study of Evolution in Action, Michigan State University) that will be applied to a variety of problems. Living PlanIT SA was the recipient of the World Economic Forum's Technology Pioneer Award in 2012 for PlanIT OS™ middleware that provides, real-time sensing, control, spatial analytics and machine learning, data integration, security, support and provisioning of ubiquitous context relevant applications for the IoT. The PlanIT OS™ provides the infrastructure for solutions across a broad range of vertical markets from manufacturing through mining exploration. For the purposes of smart city, urban development and infrastructure markets, the PlanIT OS™ infrastructure is implemented as the PlanIT Urban Operating System™ (UOS™). UOS™ is the implementation of PlanIT OS™ for smart urban developments and machine-to-machine communications. WISDOM, an acronym for *WI*cked problem *S*olutions through a transparent *D*ecision making process involving many-objective *O*ptimisation and *M*ultiple stakeholders, is a software framework that was awarded the 2013 Wiley Practice Prize. WISDOM is a combined Evolutionary Multi-objective Optimisation (EMOO), Virtual Reality (VR)/Augmented Reality (AR) visualization (as in Fig. 3), and Multi-Criteria Decision Making (MCDM) toolkit, where the

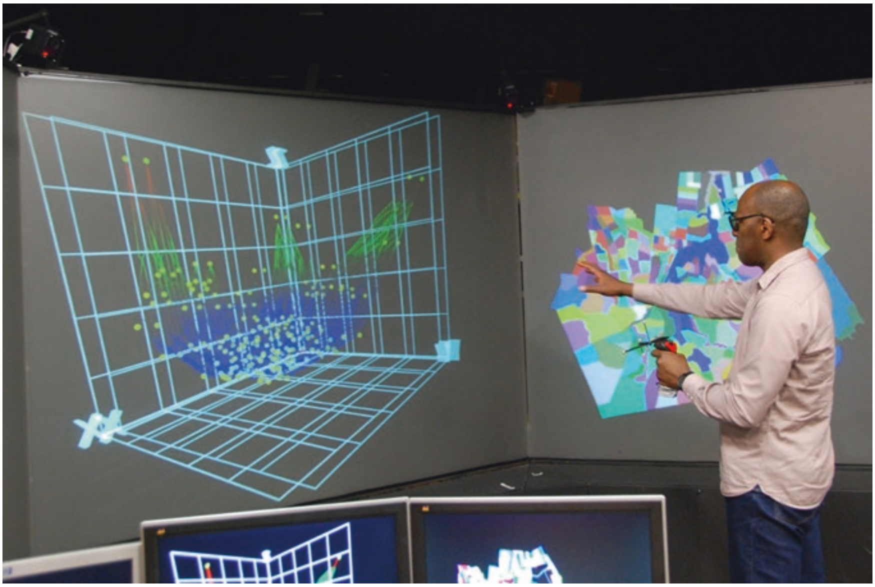

Fig. 3 The wisdom VR visualisation prototype at HITLab NZ, Canterbury University (New Zealand) demonstrating a 14-dimensional optimisation Pareto frontier, that has been collapsed into three dimensions being visualised using stereoscopic vision with sensors so that the cameras can track the movement of the viewer. Each point on the image represents 14 outputs at a planning period of 50 years at 1-yearly intervals coupled with time-series GIS maps showing land use change. The final product will give an "eBay-like" experience where the user can literally "shop" for solutions from the Pareto frontier based on the user's preferences and values

EMOO is a specialized many-objective (>10 objectives) optimization algorithm that consists essentially of a modified Reference-point-based Non-dominated Sorting Genetic Algorithm [22] augmented by simulated "epigenetic" operations [15].

The incorporation of WISDOM into PlanIT OS™, dubbed PlanIT OS-WISDOM, has largely been driven by a desire to solve large complex problems by combining human strategic capabilities with computational ones. Humans are very good at problem solving by deciphering strategies guided by preferences and values, and machines are second to none for brute force computation as evidenced by Garry Kasparov's loss to the IBM Big Blue computer in a game of chess in 1997. The complex world and the human strategic problem solving capability are separated by dimensionality, where the complex world is practically a web of hyperspaces which humans are not very good at understanding. To apply the human strategic problem solving capability to world challenges will require innovative ways to harness the brute force computational capability of computers and somehow collapsing those real-world hyperspaces into lower-dimensional virtual spaces that can be comfortably explored and analyzed.

PlanIT OS-WISDOM is data-hungry and relies on standalone structured and unstructured data, and simulations from an appropriate constellation of computational models, to generate multi-dimensional search spaces needed for multi-objective optimisation. These models would be fitted to a specified PlanIT OS™ framework in the form of an API, rendering the PlanIT OS-WISDOM platform relatively generic. Therefore, this core technology would contain:

(a) The interfaces to the user's simulation models for the problem domain;
(b) The evolutionary multi-objective optimization (EMOO) engine pioneered by Chikumbo et al. [15] and currently being further developed to run on high performance computing on a cloud (Ensemble 3) for antifragile performance;
(c) The VR/AR visualization tools that will allow communication with stakeholders/planners about their initial preferences among objectives and then, after optimization, their preferences among identified scenarios corresponding to Pareto-optimal plans; and
(d) The Multi-Criterion Decision Making (MCDM) tools used before and after the EMOO phase; and
(e) Improved infrastructure (based on interoperability for data standards through the services rendered by a Run Time Infrastructure (RTI)) for integrating disparate simulation model inputs and outputs, including GIS-based locational data.

The RTI is a distributed run-time interface that permits objects in one simulation to exchange data with objects in another simulation for large-scale simulations that may involve thousands of models, implemented optimally to strike the balance amongst performance, functionality and compatibility trade-offs.

PlanIT OS-WISDOM, with the appropriate data feeds will enable rapid creation and updates of multi-dimensional search spaces, making it possible to manage a dynamic situation. Combining dynamic short timeframe search spaces with EMOO and MCDM will enable the decision makers to steer an event to a desirable attractor in real-time, via short-term intervention strategies (from the multi-objective optimisation) that may be changed as the situation evolves. This will simultaneously influence operational and tactical planning during a disaster event. The raft of simulation models that define the system will also mean flexibility to design for-purpose search spaces that can represent different phase regimes, so that the visualisation of the combined Pareto frontiers will include three sets of non-dominated intervention strategies that mimic the "solid", "liquid", and "gaseous" phases—hence antifragility in the quality of the intervention strategies. These phase regimes will be based on the failures rates of the connected infrastructures such as water supply, transportation, fuel, power stations, communications and so on. Therefore, each phase will have a behaviour optimised for with a set of non-dominated intervention strategies. The nature of the unfolding event will help determine the choice of the intervention strategy from the combined set of strategies via MCDM from the different decision-makers.

The simulation models for disaster management are mainly based on Multi-Agent Systems (MAS), for predictive, scenario and statistical modeling in real-time, such as:

(a) DEFACTO [47] for 3D situation awareness and appropriate response;
(b) ALADDIN [1] for managing interactions between multiple actors for collective behavior;
(c) ORCHID [52] for crowd sourcing map data in evacuation planning, and coordinating UAVs for situation awareness;
(d) FireGrid [31] for modeling evolution of fire, its impact, and establishing intervention alternatives and evacuation strategies;
(e) RoboCup Rescue Kleiner et al. [43] for simulating coordination of physical robotic agents for search and rescue; and
(f) DrillSim [6] for simulating different response activities at micro and macro levels.

Jain and McLean [37] suggested an interoperable framework for these kinds of simulation models in order to achieve effective disaster management, and PlanIT OS-WISDOM is ideal. The information each model generates may be either used independently or combined with other outputs from the other simulation models to create multi-dimensional optimization search spaces for determining a Pareto of intervention strategies.

These models require real-time sensor (weather, seismographic data, GPS), web (social network), and text (unstructured content for sentiment analysis) data from Ensembles 3 and 4. GIS locational data spread out among all the levels of government (local, regional, state and central) are critical and include pipeline locations, building layouts, electrical distribution, powerlines, sewer systems, streets, residential areas, and storage facilities. We are assuming a scenario here where the disparate levels of government agencies have given way to "Government 2.0", i.e. a one-stop service for data access. That means a new system of information management, which will, among other service deliveries, underpin the delivery and availability of these data via the cloud (or Ensemble 3.0).

Combine this with streaming (high velocity) data, or "data-in-motion" used to analyse events as they happen and you have event stream processing which is vital for everyday operational decisions. In such situations any recurring patterns in the data, which may mean problems or opportunities, will drive tactical and strategic decisions.

3.2.2 Ensemble 2: Cloud Computing

The cloud infrastructure is an essential component for all data acquisition, storage, analysis and visualization that will meet antifragility requirements when combined with the appropriate software on a cloud. All of Ensemble 1 will be cloud-based and currently the Living PlanIT-BEACON partnership is undertaking the generic PlanIT OS-WISDOM implementation on Amazon Elastic Compute (EC2) and Microsoft Windows Azure. This will mean running Hadoop on both platforms, which provide a MapReduce [21] framework that enables parallel processing, i.e. the distribution of computational work load across disparate clusters of machines for long duration jobs. Plan IT OS™ has its own API that will deliver similar capability to Hadoop/MapReduce, and WISDOM will directly benefit from Hadoop/MapReduce architecture for parallel processing. Software-level and hardware-level failures are common during such runs, and MapReduce is fault-tolerant in this regard, increasing the antifragility of computation in Ensemble 1. In the classic disaster recovery rule book a primary datacenter is built designed for failover in a remote datacenter. In this model emergency drills are carried out once every so often to try and predict how to recover from catastrophic failures, including failing over to the remote datacenter. Such drills are based on a perception of what failure might look like. However, when extreme events result in catastrophic failures such as the attack on the World Trade Center or the recent massive flooding caused by the storm Sandy—the turn of events is often much more unpredictable and recovery is much more challenging than a well rehearsed practice run [32, 39].

However, real-time applications place demands on processing and storage of data produced by streaming applications with data rates and processing demands that vary with time. Although this favours the on-demand cloud paradigm, current commercial cloud computing platforms are only accessible over the public Internet, therefore, lack the low latency or bandwidth requirements for real-time applications [35]. As such there are no guarantees for a network and storage bandwidth for a real-time application on current commercial cloud platforms, which would compromise the operation of Ensemble 1. Also with the evolution from low bandwidth, "off-the-grid" sensors to networked high bandwidth sensors capable of actuation (for instance, in wind estimation to track tornadoes or rainfall estimation to predict flooding storm), the energy and bandwidth demands necessitate connection to the power grid and wired network links. That will mean that in the future the likes of Amazon and Microsoft will have to offer as well non-traditional resources on their cloud computing platforms such as high bandwidth network resources and steerable sensors that multiple clients can share [35].

However, a huge improvement on cloud platforms is making real-time processing of streaming big data possible. For example, Amazon Kinesis takes in large streams of data records that can then be consumed in real-time by multiple data-processing applications that can be run on Amazon EC2 instances [40]. This is a huge improvement from 2 years ago when Hadoop's MapReduce on Amazon EC2 performed poorly in terms of meeting deadlines and response time for real-time applications [55], although latency imposed by the Internet will remain as the bottleneck for some time. 3D situation awareness will also benefit from NVIDIA GRID GPU instance, G2, via Amazon EC2 cloud, which enables graphical applications to be rendered in Amazon cloud and streamed, enabling antifragility calculations of 3D situation awareness information.

3.2.3 Ensemble 3: Earth Observing Satellites

Hazard response can be greatly enhanced with coordinated monitoring for emerging disaster situations between space borne assets (Ensemble 3) and ground-based sensor networks (Ensemble 4). Monitoring information is sent to Ensemble 1 via the ground station(s) for analysis, or combined with other data and/or simulations for determining intervention strategies. Redundancy by replicating the ground stations at different localities will support antifragility of monitoring data delivery to Ensemble 1. The Iceland Met Office is a very good example of sophisticated network of sensors to monitor volcanic activity, which triggers space observations from seismic signatures (such as earthquake intensity, location, trending intensity and shallowing depth). However, the triggering of space observations is still manual [14], which means slower responses to urgent events such as an avalanche of snow or volcanic eruptions.

Making the ground station the controller that autonomously coordinates monitoring tasks between Ensembles 3 and 4 for emerging disaster events, which involves concurrently negotiating with a multiple of earth observing satellites is the ideal situation advocated by Chakraborty et al. [13]. Getting Ensemble 3 to operate autonomously without human-in-the-loop opens opportunities for antifragility designs [39]. It is non-trivial because many earth orbiting satellites are subject to competing objectives, i.e. many clients compete for satellite resources among a multiple of interacting satellites where each is constrained on power, temperature, and committed schedules.

Therefore, clients negotiate activities weeks or months in advance for earth orbiters, making it impossible to respond to emerging disaster events in less than a week—automation will mean the ability to respond in minutes [13]. NASA deployed a peer-to-peer negotiating process (which is a distributed scheduling model) among all users who utilize the Deep Space Network (DSN) for mid-range scheduling system for the antennas of the DSN—a step in the right direction for antifragility. The key innovation of the deployed software is that the schedule is determined by scheduling requests, requirements, and constraints that represent a service-oriented approach to scheduling, i.e. users are allocated services that can flexibly provided by the network [38]. However, the process still has human-in-the-loop, the schedulers who provide the scheduling requirements to the users to start the collaborative scheduling on a weekly basis [38].

Antifragility is a work in progress for satellite applications, which is very useful in monitoring disasters such as floods, volcanic eruptions, forest fires, etc. and will involve efficiently and autonomously allocating monitoring tasks among satellites.

3.2.4 Ensemble 4: Wireless Sensor Networks and Mobile Communication Services

Ensemble 4 consists of the Wireless Sensor Networks (WSNs), cellular network and the Mobile Emergency Response and Communications Services (MERCs), a concept adopted from the Samsung Solar Integrated Digital Village (as in Fig. 4)—a complete solar digital solution for offering an education Internet school, power generation for small business enablement, a tele-medical centre (providing remote medical assistance) for quick and accurate diagnoses, a health centre for basic illnesses (providing professional, qualified medical care), and basic LED lightning [18].

The idea of the MERCS is to provide mobile services just like the Samsung Solar Integrated Digital Village and instead of the Internet school, provide mobile banking and a temporary cellular network for taking the overload of calls made during emergency situations, or providing the sole network in an area where the original network has been damaged. MERCS will also provide local compute and storage (rather than sole reliance on cloud hosting) and contribute to antifragility through redundancy by reducing dependence on the uplink bandwidth—UOS™ architecture enables this scenario. By facilitating access to MERCS communications for users via Be-Bound® app for Android smartphones makes it possible

Fig. 4 A samsung solar integrated digital village in South Africa [18] that can easily be adapted as a mobile emergency response and communication services (MERCS) unit and also a base for reconnaissance survey UAVs

to handle a large volume of calls since Be-Bound® uses 2G network and allows users to the web without data connectivity. That means Wi-Fi signal, 3G or 4G network is not needed for operation. Instead data from the web is compressed on cloud servers then sent to smartphones via very low bandwidth text messages. Be-Bound® includes built-in applications for e-mail, weather report, news, geolocation services and Twitter [28]. The company is so confident of their product that they offered the free use of its services for reconstruction efforts to the Philippines following the devastating November 2013 Typhoon that left thousands dead and many more homeless.

MERCS can also be used as a base for UAVs for situation awareness and control can come from ORCHID in Ensemble 1. Living PlanIT and Cisco Systems, Inc. have been working on deployment of UAVs for the last couple of years and now PlanIT OS™ has the ability to interface with UAVs including negotiated flight paths. Also Professor Kumar (University of Pennsylvania) has developed UAVs for civilian search and rescue operations, which he calls “aerial robots”, designed to be the first responders in emergencies such as earthquakes and fires [14]. They range in sizes of 20–75 cm in diameter so that they can fly indoors and outdoors. They are equipped with sensors, which enables them to create a situation awareness map of a given space. They fly using swarm technology, which allows a human controller to command one robot and the rest figure out how to cooperate together to accomplish a task.

WSNs are a group of sensors, or nodes, that are linked by a wireless medium to perform distributed sensing tasks such as surveillance, widespread environmental sampling, security, monitoring and in harsh conditions such as forest fire detection, seismic monitoring, flood detection, and nuclear, biological and chemical attack detection. Via the ground station they can be coordinated with Ensemble 3 for monitoring tasks. WSNs are extremely flexible in that they can be used in harsh terrains where physical placement is difficult and they embody antifragility in their operation in that they are self-organising (i.e. network discovery and multi-hop broadcasting), overcome node failures (by using other routing paths), can be relocated and they can carry different sensors in one network [62]. Their Achilles’ heel include, limited power and memory size, lower data rates, security issues and high error rates since they transmit packets as electronic waves that can be affected by reflection, refraction, diffraction or scattering [51]. Research is targeted at minimizing most of these weaknesses.

3.2.5 Ensemble 5: Scheduling and Timetabling Negotiators

The scheduling and timetabling negotiators will be trained staff that can quickly understand the intervention strategies and information on situation awareness and intervention strategies, coming from Ensemble 1 (which will be constantly updated as an event continues to unfold). The negotiators will then contact the appropriate respondents for mission assignment. Communication is two-way and constant for each assigned mission for backup or time needed to complete a task for reassignment. A public web-based timetable will show these assignments with constantly changing duration times as the respondents update the negotiators. Visibility to the public is important for media and also for volunteers who might want to be assigned to jobs they can do in their area. These negotiators may not be full-time staff but remain on call if a situation would arise and would also report for intermittent training and drills.

3.2.6 Ensemble 6: Emergency Respondents

The emergency respondents normally operate under different objectives because of directives coming from their headquarters. Decentralized operations make it difficult to achieve coordinated responses without doubling up on resources. In the model in Fig. 2, all communications are coming from Ensemble 5, which in a way centralizes rescue mission assignments appropriately to the police, fire services, ambulance services, refuge services for the displaced, Red Cross, and volunteers. The emergency respondents (such as the police, ambulance service and fire brigade) will also have access to continuous information flow coordinated via Ensemble 1 through to Ensemble 5, for allowing real-time manipulation of traffic in emergency circumstances. The way can be cleared for a fire truck or ambulance not just by coordinating traffic lights (if they exist) to turn green, but also by thinning traffic in that area ahead of the vehicle by routing other traffic to alternative routes. This may require regulation changes in order to present instructions as opposed to advice via the navigation system—PlanIT OS™ capability has been demonstrated in this regard, including situation awareness to assist the respondents [45].

3.2.7 Summary

The speed at which such a process as depicted in Fig. 2 can make new discoveries and translate interoperable data and simulations into effective and cost-saving rescue missions, will ultimately be realized in more lives being saved. There is no doubt that public and private sectors depend on information and communication technology (ICT) in critical situations that affect cities or any other geographic region and resources:

(a) An antifragile ICT to support rapid recovery during a phase transition. The more antifragile a system is the more it must rely on automation [39]. Also to handle shocks in the system, software must not be tightly coupled to hardware;
(b) Analytics and modeling to prepare for and adapt to acute and chronic threats as depicted in Fig. 1;
(c) The ability to work with the decentralized nature of provisioning of services and management of resources for better coordination of the emergency respondents;
(d) ICT that can be used to allow citizens and other stakeholders to have a direct view of a situation across their city/region and can have a direct voice in the development of recovery plans;

The proposed system will manage:

(a) Reconnaissance survey;
(b) Monitoring;
(c) Collection and analyses of disparate and incommensurable data; determining real-time information from analyses of the data;
(d) Disseminating the information to centralised, scheduling and timetabling negotiators, who will be responsible for assignment of rescue missions to appropriate emergency respondents, follow up of rescue missions in real-time for additional resources or job completion time for reassignment; and
(e) Initiating and updating a web-based real-time rescue mission timetable, visible 24/7 on the Internet to the public, making it possible for volunteers to make themselves available where it appropriate (through the negotiators).

The system in Fig. 2 will address the important concerns raised by Massaguer et al. [48] and Ramchurn et al. [58], and that is capturing disaster response as a process of four intertwined areas, irrespective of scale and nature [4, 7]:

(a) Damage assessment (i.e. the magnitude of disaster-related losses being identified);
(b) Needs assessment (i.e. identifying incidents requiring response);
(c) Prioritisation of response measures (i.e. prioritising a 'matched-required-response' to available resources); and
(d) Organisational response (i.e. decision making behind the logistics of the deployment of emergency resources).

If you think of Fig. 2 as a system, it will only work if it feeds on data during a phase transition between pre- and post disaster event. Starve it of the data (as in failure of cellular networks because of calls overload, or destroyed wireless sensors destroyed and so on) then it will not function. Therefore, the key is to develop an antifragile software and hardware platform that will ensure data flow, and will continue to function even in extreme situations. If the antifragility of data flow is guaranteed, then processing of these data to determine relevant information for the negotiators will be guaranteed. In a disaster situation, data and derived information filter through appropriately to the emergency responders with situation awareness across a city/region that will make it possible to efficiently allocate available resources, and with the ability to track missing persons. In a city/region of resource stress, the same framework in Fig. 2 can equally provide situation awareness in space and time.

4 Conclusion

There is no shortage of technologies that may be adapted or used for improving emergency response times. However, it is the connectedness that causes concern because it creates fragilities that have to be managed for by spiraling complexity. Good designs will find the balance between function and fragility and therefore, designers need to be aware whether they are designing for robust-yet-fragile, or robust-yet-flexible (as in resilience), or antifragile systems. For mission critical applications that have to continue functioning in a wider range of environments, antifragile designs are ideal where failures do not stand for a breakdown or malfunctioning of normal system functions, but rather represent the converse of the adaptations necessary to cope with the real world complexity [61]. Antifragility will mean programming for the different phase regimes with connectivity configurations (of both protocols/software and hardware) that metaphorically represent the solid, liquid, and gaseous states, as multiple interacting feedback loops. As more research tries to unravel connectivity for the supercritical state (i.e. neither liquid nor gas but exhibiting properties of both), it will just mean in the future, antifragility will imply system functioning over a much wider range of environments. The Internet of Things will benefit more from antifragility designs with direct impacts to emergency response systems.

Therefore we conclude that an antifragile delivery mechanism built on Internet of Things that includes a tight integration/interoperability of the different kinds of data and simulations, real-time monitoring and situation awareness, and coordination of different respondent agents on the ground during an emergency, will most likely move us towards shorter response times, with a higher probability of saving more lives and protecting property.

Antifragility design from ground up might seem a tall order, but benefits will far out weigh not going down that path. PlanIT OS™ developed by Living PlanIT, is already being utilised in new smart cities being constructed around the world. The advantages of PlanIT OS™ are its ability to handle, reconcile, and align big data that are disparate, and use them in real-time for decision making for functioning of a city. With smart buildings and traffic logistics controlled by systems such as PlanIT OS™, there are certain kinds of emergencies that can be taken care of. However, for extreme disasters, the concept captured in Fig. 2 with PlanIT OS-WISDOM as the core technology will be vital. The technology will not only be viable for emergency response systems but for many other applications such as smart cities management, climate change monitoring and land use management, value/supply chain optimisation, patient stratification and so on, which makes a compelling case for government and private sector investment.

Acknowledgments The original ideas of this work were fleshed out under the FRENZ (Facilitating Research co-operation between Europe and NZ) Sandpit 2011, on "The Use of ICT Tools for Governance and Policy Modelling" dubbed RESPITE (RESilient, raPid response management and Instantaneous disasTEr communiqué systems) by, Hugh Canard (NZ), Tony Norris (NZ), Paul Chippendale (Italy), Julian Padget (UK), Naktarious Chrysoulakis (Greece), Dine Giuli (Italy), and Oliver Chikumbo (USA). Since then the RESPITE ideas have rapidly evolved with the inclusion of UOS-WISDOM developments and antifragility concepts for the IoT under BEACON, Center for Study of Evolution in Action (Michigan State University), and Living PlanIT SA. We are thankful for their feedback and final comments on this chapter.

References

1. Adams NM, Field M, Gelenbe E, Hand DJ, Jennings NR, Leslie DS, Nicholson D, Ramchurn SD, Roberts SJ, Rogers A (2008) The aladdin project: intelligent agents for disaster management. In: Proceedings of the EURON/IARP international workshop on robotics for risky interventions and surveillance of the environment, Benicassim, Spain
2. Alighieri D (1977) La divina commedia, Canto III, Inferno, 7–9, La Nuova, Italia
3. Anand K, Kühn R (2007) Phase transitions in operational risk. Phys Rev E 75(1):12p. doi:10.1103/PhysRevE.75.016111
4. Ashish N, Hegde R, Huyck C, Kalashnikov DV, Mehrotra S, Smyth P, Venkatasubramanian N (2008) Awareness technologies for disaster response. In: Terrorism informatics: knowledge management and data mining for homeland security (Eds) Chen H, Reid E, Sinai J, Silke A, Ganor B, Springer, Berlin, pp 517–547
5. Bahora AS, Collins TC, Davis SC, Goknur SC, Kearns JC, Lieu TN, Nguyen TP, Zeng JS, Horowitz BM, Patek SD (2003) Integrated peer-to-peer applications for advanced emergency response systems, Part 1: Concept of operations. In: Proceedings of the systems and information engineering design symposium (Eds) Jones MH, Tawney BE, Preston White Jr K, pp 261–268
6. Balasubramanian V, Massaguer D, Mehrotra S, Venkatasubramanian V (2006) DrillSim: a simulation framework for emergency response drills, In: Proceedings of the international systems for crisis response and management
7. Basak S, Modanwal N, Mazumdar BD (2011) Multi-agent based disaster management system: a review. Int J Comput Sci Technol 2(2):343–348
8. Batty M (2012) Smart cities & big data: how we can make cities more resilient, CASA, UCL, 90 Tottenham Court Road, London WC1E 6BT
9. Bossomaier T, Barnett L, Harré M (2013) Information and phase transitions in socio-economic systems, Complex adaptive systems modeling 1:9. http://www.casmodeling.com/content/1/1/9
10. Buldyrev SV, Parshani R, Paul G, Stanley HE, Havlin S (2010) Catastrophic cascade of failures in interdependent networks. Nature 464:1025–1028
11. Carlson JM, Doyle J (2002) Complexity and robustness. In: Proceedings for the national academy of science USA, 1(99): 2538–2545, www.pnas.org/cgi/doi/10.1073/pnas.012582499
12. Cavalcante HLD de S, Oriá M, Sornette D, Ott ED, Gauthier J (2013) Predictability and suppression of extreme events in a chaotic system. Phys Rev Lett 111:198701
13. Chakraborty D, Saha S, Clement B (2006) Negotiating assignment of disaster monitoring tasks, In: Joint conference on autonomous agents and multi-agent systems, Agent Technology and Disaster Management Workshop, pp 10–17
14. Chiaet J (2013) Civilian drones to change how we respond to emergencies, http://blogs.scientificamerican.com/observations/2013/11/25/civilian–drones-to-change-how-we-respond-to-emergencies/
15. Chikumbo O, Goodman E, Deb K (2014) The triple bottomline, hyper-radial-visualisation-based, ‘decision making by shopping’ for a land use management problem using evolutionary multi-objective optimisation. J Multi-Criteria Decis Anal (accepted)
16. Chikumbo O, Goodman E, Deb K (2012) Approximating a multi-dimensional Pareto front for a land use management problem: a modified MOEA with an epigenetic metaphor, IEEE Congress on Evolutionary Computation (CEC). doi:10.1109/CEC.2012.6256170, pp 1–9
17. Chu L-H, Chen B-S (2008) Comparisons of robustness and sensitivity between cancer and normal cells by micoarray data, Cancer Informatics, 6:165–81
18. Citizenship News (2013) Samsung showcases first ever digital Village. http://www.samsung.com/za/news/localnews/2013/samsung-showcases-first-ever-digital-village
19. Csete ME, Doyle JC (2002) Reverse engineering of biological complexity. Science 295:1664–1669
20. Dai L, Vorselen D, Korolev KS, Gore J (2013) Generic indicators for loss of resilience before a tipping point leading to population collapse. Science 336:1175–1177

21. Dean J, Ghemawat S (2008) Mapreduce: simplified data processing on large clusters. Commun ACM 51(1):107–113
22. Deb K, Sundar J, Udaya Bhaskara Rao N, Chaudhuri S (2006) Reference point based multi-objective optimization using evolutionary algorithms. Int J Comput Intell Res 2(3):273–286
23. Deb K, Thiele L, Laumanns M, Zitzler E (2002) Scalable multi-objective optimization test problems. In: Proceedings of the congress on evolutionary computation, pp 825–830
24. Demirbas M (2013) Antifragility from an engineering perspective, University at Buffalo. http://muratbuffalo.blogspot.co.nz/2013/06/antifragility-from-engineering.html
25. Dorogovtsev SN, Goltsev AV, Mendes JFF (2008) Critical phenomena in complex networks. Rev Mod Phys 80:1275–1335
26. Freeman W (1992) Tutorial on neurobiology: from single neurons to brain chaos. Int J Bifurcat Chaos 2(3):451–482
27. Goodman E, Deb K (2014) Personal communication. Center for the Study of Evolution, Michigan State University, Beacon
28. Google play (2014) Be-Bound: stay connected. https://play.google.com/store/apps/details?id=com.altheia.android.bebound&hl=en
29. Green DG, Newth D, Kirley M (2000) Connectivity and catastrophe –towards a general theory of evolution. In: (Eds) Bedau M. et al Proceedings of artificial life VII
30. Gutterman S (2013) The rise of the internet of things. Environ Leader: Environ Energy Manage News, Jan 8
31. Han L, Potter S, Beckett G, Pringle G, Welch S, Koo S-H, Wickler G, Usmani A, Torero JL, Tate A (2010) FireGrid: an e-infrastructure for next-generation emergency response support. J Parallel Distributed Computing 70(2010):1128–1141
32. Harrison C (2013) Building a resilient planet, IBM Redbooks, Point-of-View Publication, IBM Academy of Technology, p 6
33. Hengherr S, Worland MR, Reuner A, Brummer F, Schill RO (2009) High-temperature tolerance in anhydrobiotic tardigrades is limited by glass transition. Physiol Biochem Zool 82:749–755
34. Holling CS (2001) Understanding the complexity of economic, ecological and social systems. Ecosystems 4:390–405. doi:10.1007/s10021-001-0101-5
35. Irwin D, Shenoy P, Cecchet E, Zink M (2010) Resource management in data-intensive clouds: opportunities and challenges. In: Proceeding of the 17th IEEE workshop on local and metropolitan area networks
36. Jain S, McLean CR (2004) An architecture for integrated modeling and simulation of emergency response. In: Proceedings of the institute of industrial engineers annual conference, pp 1503–1508
37. Jain S, McLean CR (2003) An integrating framework for modeling and simulation of emergency response. In: Proceedings of the winter simulation conference, (Eds) Chick S, Snchez PJ, Ferrin D, Morrice DJ, New Orleans, Louisiana, pp 1068–1076
38. Johnston MD, Tran D, Arroyo B, Sorensen S,Tay P, Carruth B, Coffman A, Wallace M (2012) Automating Mid- and Long-Range Scheduling for NASA's Deep Space Network, SpaceOps 2012, Stockholm, Sweden. http://hdl.handle.net/2014/42582
39. Kavis M (2013) Antifragile systems: designing for agility vs stability, The virtualisation practice: virtualisation cloud computing news, resources, and analysis. http://www.virtualizationpractice.com/antifragile-systems-designing-for-agility-vs-stability-22536/
40. King R (2013) Amazon's big data service Kinesis now available, ZDNet. http://www.zdnet.com/amazons-big-data-service-kinesis-now-available-7000024430/
41. Kitano H (2007a) Towards a theory of biological robustness. Mol Syst Biol 3:137
42. Kitano H (2007b) A robustness-based approach to system-oriented drug design. Nat Rev Drug Discovery 6(3):202–210
43. Kleiner A., Brenner M, Bräuer T, Dornhege C, Göbelbecker M, Luber M, Prediger J, Stückler J, Nebel B (2005) Successful Search and Rescue in Simulated Disaster Areas, RoboCup 2005, Osaka, Japan. pp 323-334

44. Levin K, Cashore B, Bernstein S, Auld G (2009) Playing it forward: path dependency, progressive incrementalism, and the "Super Wicked" problem of global climate change, Earth Environ Sci 6:doi:10.1088/1755-1307/6/0/502002
45. Living PlanIT SA (2011) Living PlanIT SA MS cloud center: fire demo only video. (Video can be obtained by request from www.living-planit.com)
46. Lynch C (2009) Jim Gray's fourth paradigm and the construction of the scientific record, In: the fourth paradigm: data-intensive scientific discovery (Eds) Hey T, Tansley S, Tolle K, Microsoft Research, pp 177–183
47. Marecki J, Schurr N, Tambe M (2005) Agent-based simulations for disaster rescue using the DEFACTO coordination system, Emergent information technologies and enabling policies for counter terrorism
48. Massaguer D, Balasubramanian V, Mehrotra S, Venkatasubramanian N (2006) Multi-agent simulation of disaster response, International Conference on Autonomous Agents and Multi-Agent Systems, Hakodate, Hokkaido, Japan, pp 124–130
49. Motter AE (2013) How to control your dragons. Phys 6:120. doi: 10.1103/Physics.6.120
50. Mushegian AR, Koonin EV (1996) A minimal gene set for cellular life derived by comparison of complete bacterial genomes. Proc Nat Acad Sci USA 93(19):268–273
51. Nack F (2009) An overview on wireless sensor networks, institute of computer science (ICS). Freie Universität, Berlin
52. Nicholson D (2012) ORCHID: the science and application of human agent collectives, Open Informatics. http://slideslive.com/38889039/orchid-the-science-and-application-of-human-agent-collectives
53. Norris F, Stevens S, Pfefferbaum B, Wyche K, Pfefferbaum R (2008) Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness. Am J Community Psychol 41(1):127–150
54. OnScale Solutions (2014) Scalaris. http://www.onscale.de/scalarix.html
55. Phan LTX, Zhang Z, Zheng Q, Loo BT, Lee I (2008) An empirical analysis of scheduling techniques for real-time cloud-based data processing. In: IEEE international conference on service-oriented computing and applications, pp 1–8
56. Radicchi F, Arenas A (2013) Abrupt transition in the structural formation of interconnected networks. Nat Phys 9:717–720
57. Radicchi F (2013) Driving interconnected networks to supercriticality, *arXiv*: 1311.7031v2
58. Ramchurn SD, Rogers A, Macarthur K, Farinelli A, Vytelingum P, Vetsikas L, Jennings NR (2008) Agent-based coordination technologies in disaster management (demo paper). In: Proceedings of 7th conference on autonomous agents and multi-agent systems (Eds) Padgham, Parkes, Müller, Parsons. Estoril, Portugal, pp 1651–1652
59. Resilience engineering association (2014) http://www.resilience-engineering-association.org/
60. Scheffer M, Carpenter SR (2003) Catastrophic regime shifts in ecosystems: linking theory to observation. Trends Ecol Evol 18(12):648–656
61. Schulze H, Mochalski K (2009) Internet study 2008/2009, Leipzig. ipoque, Germany
62. Sohrabi K, Gao J, Ailawadhi V, Pottie GJ (1999) Protocols for self-organisastion of a wireless sensor network. In: 37th Allerton conference on communication, computing and control, p 24
63. Sornette D (2009) Dragon kings, black swans and the prediction of crises. J Terraspace Sci Eng 2(1):1–18
64. Taleb N (2012) Antifragile: things that gain from disorder. Random House, New York
65. UN-Habitat (2013) State of the world cities 2012/2013: prosperity of cities, Routledge Taylor and Francis Group, New York
66. United Nations (2008) Disaster preparedness for effective response: guidance and indicator package for implementing priority five of the hyogo framework 2005-2015. UN/ISDR, United Nations, Geneva
67. Van Roy P (2009) The Self-managing, 'Unbreakable' Internet?, ScienceDaily. ScienceDaily, 14 October 2009. http://www.sciencedaily.com/releases/2009/10/091006104053.htm

68. Vassev E, Hinchey M (2011) Towards the formal language for knowledge representation in autonomic service-component ensembles, In: Proceedings of the 3rd international conference on data mining and intelligent information technology applications (ICMIA2011), AICIT, IEEE Xplore
69. Wagner A (2007) Robustness and evolvability in living systems. Princeton University Press, Princeton
70. Williams P (2012) Smart thinking solutions, session: emergencies and security, Smart City Expo—World Congress, Barcelona, Spain. http://www.youtube.com/watch?v=M_QWhqKv6pA#t=205
71. Wirsing M, Hölzl M, Tribastone M, Zambonelli F (2013) ASCENS: engineering automatic service-component ensembles. Formal Meth Compon Objects, Lect Notes Comput Sci 7542:1–24
72. Zhou K, Dolye J (1997) Essentials of robust control. Prentice Hall, New Jersey

Building in Resilience: Long-term Considerations in the Design and Production of Residential Buildings in Israel

M. Sever, Y. Garb and D. Pearlmutter

Abstract Threats to national security, such as that against critical infrastructures not only stem from man-made acts but also from natural hazards. Hurricane Katrina (2005), Blackout Canada-US (2003), Fukushima (2011), Hurricane Sandy (2012), and Alberta floods (2013) are examples that highlight the vulnerability of critical infrastructures and buildings to different kinds of disasters. In this chapter we describe the need for an integrated approach to building design which considers the possible synergies between structural durability and energy efficiency. Developing ideas from previous work regarding architectural awareness of earthquake resistance, we introduce three levels of integration needed when designing for resilience: (1) integration in multi-disciplinary design teams; (2) integration in the design process, i.e. integrated design or co-design, and (3) integration of long-term and short-term considerations. The aim of this chapter is to examine barriers to the integrated design of resilient buildings by looking at disincentives for non-linear co-design processes along the extended building supply chain.

Keywords Building resilience · Co-design · Integrated design · Long-term considerations

1 Introduction

In recent years the concept of 'resilience' has become increasingly prominent in disaster research. The concept of 'resilience' has largely supplanted the concept of 'resistance' with its focus on pre-disaster mitigation. As opposed to resistance, the term resilience implies that we cannot prevent the disruption caused by the next disaster; we can just prepare ourselves to different scenarios and improve our ability to

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A. Masys (ed.), *Disaster Management: Enabling Resilience*,
Lecture Notes in Social Networks, DOI 10.1007/978-3-319-08819-8_4

recover from them [28]. In the U.S., disaster resilience appears to have emerged as a research and policy priority in the aftermath of the terrorist attacks of September 11, 2001. Interest in the concept expanded further following Hurricane Katrina [38].

The concept of disaster resilience is mentioned in the U.S volume Disasters by Design [29, 38]. According to Mileti [29], the White and Haas report from 1975 was a pioneering report on the USA ability to withstand and respond to natural disasters. This report paved out the way for an interdisciplinary approach to research and management, giving birth to a 'hazards community'; professionals have continued to investigate how engineering projects, warnings, land use management, planning for response and recovery, insurance and building codes can help individuals and groups adapt to natural hazards, as well as reduce the resulting deaths, injuries, costs and social, environmental and economic disruption.

Most strategies for managing hazards have followed a traditional planning model: Study the problem, implement one solution and move to the next problem. This approach casts hazards as static and mitigation as an upward, positive, linear trend. The reality is, events during the past quarter-century have shown natural disasters and the technological hazards that may accompany them are not linear problems that can be solved in isolation [29, 38].

According to Bosher and Dainty [8] design, engineering and construction are the most influential disciplines that affect the resilience of the built environment. However, little research has been undertaken globally on how to mainstream disaster risk reduction considerations into planning procedures for major construction projects [8].

Perelman [32], quoted by [12] argues that the design of resilient buildings has to be driven by two 'independent policy movements' both of which focus upon disaster risk management. They are the homeland and national security movement, which respond to the threats of attacks or disasters, and the sustainability movement, which is particularly concerned with green practices that meet the multiple requirements of the people and society in an optimized way during the life cycle of the built facility [33].

Uncertainty and risk generated by the threat of natural hazards are key features involved in shaping the built environment. According to Coaffee [12], concern for environmental sustainability, linked to climate change and the related threats of natural disasters, is as important as possible terrorist risk as an influence on city and building design. Furthermore, the potential complementarities between security and environmental agendas may encourage a fruitful discussion between professionals involved in the design of resilient buildings (see Fig. 1).

According to Liu [27] large scale catastrophic earthquakes are the greatest challenges in achieving resilience of built environments; earthquakes have no warnings

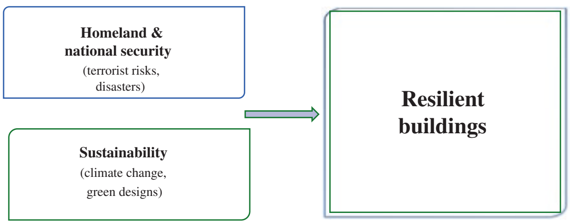


Fig. 1 Designing for resilience

and can cause massive destruction in a very short time period. Unfortunately, as has been experienced in September 11, 2001, terrorist attacks have no warnings either and can similarly cause devastating results. Therefore, taking into account terrorist attacks and natural disasters together is essential when designing for resilience.

Mileti [29] noted how disaster policy could overlap with sustainability; adopting a long-term perspective through improved engineering, safer urban development, and cautious environmental management would not only reduce greenhouse gas emissions that cause global warming, but would also help to save lives, reduce injuries, and limit property losses in a case of a disaster.

Risk management and homeland security are two of the current paradigms being discussed in academic and policy circles. Therefore, the contemporary focus has shifted to ensuring the capability of the built environment to both resist and recover rapidly following a disaster event [8].

According to McEntire [28], a disaster is a complex event and therefore a comprehensive approach to disaster reduction is needed. Moreover, the emerging emphasis on disaster risk reduction has broadened the range of experts whose knowledge is relevant and necessary for disaster mitigation [8].

Located in a politically, environmentally and seismically prone area, Israel—an immigrant state—presented a great challenge over the years in producing different housing solutions for its massively growing population. These special circumstances bring to light the need for an integrated approach to the design and production of buildings in Israel, which considers the possible synergies between structural durability and energy efficiency.

Many disaster losses are the results of interactions of three major systems: the physical environment, the social and demographic characteristics of the communities that experience them and the built environment. In this chapter we will focus on the built environment: we first introduce the Israeli regulatory framework and unique characteristics of the building construction industry. These characteristics include, for example, the low level of standardization in the industry and the fragmentation of supply chains.

Secondly, we review different levels of barriers to integrated design processes of resilient buildings. We refer to three levels of barriers known in the literature—the institutional level, the organizational level and the individual level. Each level may explain different aspects of the difficulty to implement long-term considerations through the design and production of buildings. Finally, by relating to design criteria that may contribute to resilience from two complimentary angles—structural durability and energy efficiency—we will try to add a new dimension to the study of risk management and sustainability.

2 The Israeli Regulatory Framework

The design of buildings, in general, has traditionally been regulated in order to protect occupants from threats such as structural failure and fire. Since the 1970s, regulation has been applied to energy and emissions as well, and according to a report by the OECD [30], a regulatory approach is one of the most reliable ways to achieve a given goal of energy efficiency.

The Israeli regulatory framework includes a national Planning and Building Law from 1966, and a broad array of planning regulations [5]. These regulations refer, among other matters of concern, to design criteria that may contribute to the building's survivability under different threats.

2.1 Urgency in the Construction of the New State of Israel

According to Brechia and Hasson [9], the need to give quick housing solutions in Israel during the 1950s–1960s, when a mass influx of immigrants entered the country, was so urgent, that environmental matters were neglected by the Israeli Government.

It took the country two more decades and another mass influx of immigrants to develop a national plan (plan 31) that integrated, for the first time, land-use, environmental, transportation, economic, and social policies.

The state of Israel had been caught unprepared for a major crisis that was not a product of a war or a natural disaster [1]. During the large wave of immigration from the USSR and Ethiopia in the early nineties, the state of Israel absorbed approximately one million immigrants. Israel's private sector, which accounted for almost 90 % of housing starts at the beginning of the 1990s, was unable to handle the sudden need for new apartments. Moreover, the uncertainty in the scale of the immigration made it difficult for entrepreneurs to invest largely without knowing if the flow of immigrants would continue [15].

Speed was the main reason for direct government-financed construction. A major part of the strategy for providing housing to the thousands of new immigrants was the use of prefabrication as a means to control costs and regulate production. Two general types of lightweight housing were included in plans: various lightweight systems which were intended to last 30–50 years and temporary housing (caravans) which were intended to provide shelter for a period of up to 5 years.

2.1.1 Mobile Homes During the 1990s

Authorities turned in many cases to foreign suppliers to install thousands of factory-built lightweight mobile homes. Mobile units were ordered on August and December 1990 and were sited in urban areas with inadequate public services and climate protection. By its nature, lightweight building is characterized by a low thermal inertia. Moreover, the low durability of light weight housing may have lead to the formation of slums [31]. These sites were the least successful element of the direct government-financed construction in the eyes of all stakeholders—the immigrants, local authorities, and government planners. By 1993, many units were unoccupied, and only the very poor immigrants remained there [1].

2.1.2 Permanent Low Rise Emergency Housing

This part of the program included low-rise housing: the size and quality of construction were intended to be very basic (45–60 m^2, single-story) but allowed for future expansion either laterally or through a second floor [1]. This quality of the design met the needs of many young families that could improve their living conditions later on by expanding their original unit.

2.1.3 The Public Program (Privately Constructed) Apartment Housing

Many architects were involved in the architectural design of the buildings—the result was a great variety of designs. In order to speed up the construction, developers were encouraged to use innovative construction methods. Generally, the quality of construction was good. However, there were complaints regarding the "finish" of some of the buildings and developers were required to fix the deficiencies [1].

2.2 Towards an Integrated Building Code

In 1997 a building regulations coordination unit was established in the Ministry of the Interior, with its main objective being the formulation of a comprehensive building code. This process progressed slowly until 2001, when the Zailer Commission was appointed in the wake of the tragic collapse of the Versailles wedding hall in Jerusalem [40]. As a result of the Zailer report, a governmental decision was issued mandating the preparation of an integrated building code, privatization of oversight and licensing in order to improve the stringency of quality and safety in construction, and the completion of all building standards.

Another activity aimed to improve the quality of construction and long-term performance of buildings in Israel was a 1999 proposal for a national energy code. The purpose of the code was to promote energy conservation in buildings based on a nationwide standard, and to contribute to Israel's greenhouse gas abatement efforts [4]. To date, the energy code proposal has been transformed to a new standard for energy in buildings (SI 5280). As a part of the reforms recommended by the Zailer Commission, it will be included in the newly revised building code.[1]

While this comprehensive regulatory process is still in progress, a number of relevant policies have already been established to ensure the long-term safety and efficiency of buildings in Israel. The following section will present briefly the development of regulations in three main topics: civil defense, earthquake resistance, and energy efficiency since the establishment of Israel until today.

[1] According to a meeting report regarding regulations for energy efficiency, took place in February 2011 as part of the code preparation: given by prof. Erel from Ben Gurion University.

2.3 Civil Defence

From a disaster management perspective, it is interesting to explore the civil defence concept through the development of residential buildings in Israel. The first law of civil defence in Israel was issued in 1951. According to that law, all residential buildings were required to have a bomb shelter either on their ground level or below the ground. However, several homes or residential buildings could make use of a single shelter jointly. The shelter was designed to resist the damage made by the blast and the impact of shell fragments [39].

Following the First Gulf War (in the 1990s) when the warning time was shortened, and there was a need for fast access to shelter, the old concept of a bomb shelter serving all the apartments could not give an appropriate answer to that need. Therefore, there was a paradigm shift from the bomb shelter towards the "protected space". The "protected space" serves individual apartment units, building floors, or other public areas. It consists of a reinforced concrete sealed room[2] with access from the building's individual apartment.

Recently, the standard of the "protected space" was improved[3] by requiring not only the preparation for filters but also the installation of them, for allowing a long stay in the room in a case of a chemical/biological attack. All protected spaces are located in a reinforced concrete vertical shaft. Provided that the shafts are well connected to each other, this type of vertical shaft may also provide increased resistance to strong shaking (as shown in Fig. 2).

2.4 Earthquakes

The first Israeli code dealing with earthquakes was issued in 1975. However, most Israeli buildings were built before 1975 and therefore have not been designed for seismic resistance. The Israeli ministry of construction and housing had built thousands of apartments in Israel for low income households before the year 1980. For example, a seven-story building that was built in 1972 has concrete bearing walls only along the X axis of the building. There are no elements to resist the force along the Y axis except for the staircase shafts that were constructed of reinforced concrete and therefore may be considered as stiffening elements (Fig. 3).

Research in the field of earthquake engineering has provided tools that have been implemented in regulations, with a comprehensive code for seismic resistance in building design approved in 1995.[4] This code, which is based on a

[2] In order to prevent the penetration of toxic gases.

[3] The association of contractors and builders in Israel estimated an additional cost of 34,000 shekels for each apartment because of this requirement in their document from 25/10/11.

[4] Taken from Sever [34].

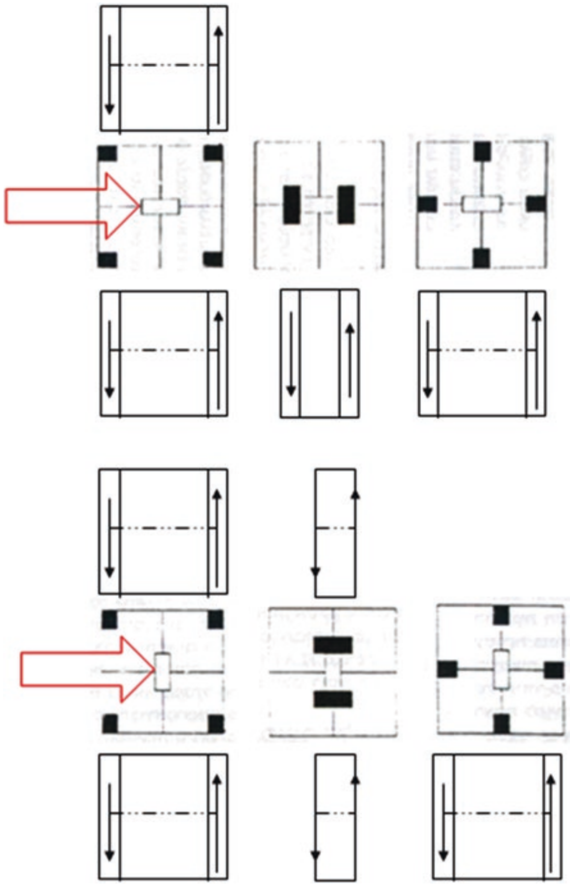


Fig. 2 Different locations for shafts and their contribution to the building's resistance to seismic forces from each direction [34]

Californian code, includes detailed instructions for designing structural systems for storey buildings to withstand an earthquake [22].

As a result of a devastating earthquake in Turkey in 1999, the Israeli Government decided on August 1999 on a preparedness program for potential earthquake events in Israel. The steering committee that was established in order to implement the program assessed the damages to people and to structures due to a strong earthquake centered in Israel (as shown in Table 1). In addition to the preparation and enforcement of codes, preparedness measures that have been taken include assessing the durability of particular facilities and spatially mapping the risks of natural hazards [34].

Later on, in 2005, the government of Israel has encouraged citizens to strengthen inadequately reinforced buildings under National Master Plan (NMP) 38 for the reinforcement of existing buildings against earthquake damage [22]. The plan encourages the reinforcement of residential buildings by allowing entrepreneurs to construct extra floors as part of the reinforcement project.

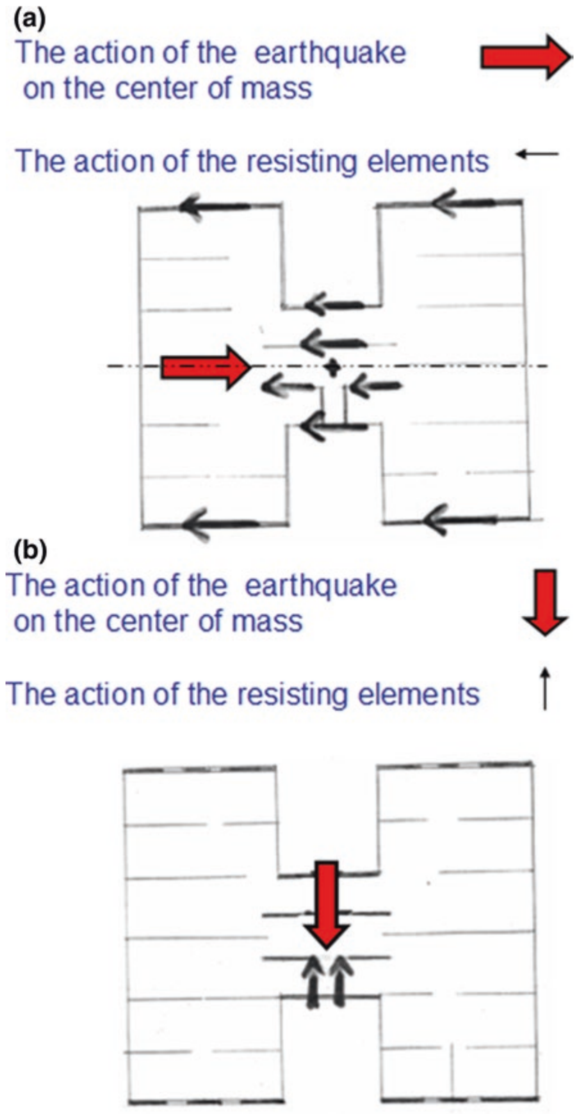


Fig. 3 A type "H" building: **a** there are elements to resist a force on the X axis, and **b** there are not enough elements to resist a force on the Y axis

Table 1 Assessed damages due to a strong earthquake centered in Israel

The damage	Quantity
Victims	16,000
Severely injured	6,000
Lightly injured	83,000
Evacuated people	377,000
Demolished buildings	10,000
Heavily damaged buildings	20,000
Lightly damaged buildings	104,000

However, this incentive hardly exists in the periphery of Israel, where the seismic risk is high but implementation of the plan would not be cost-effective. Moreover, by the year 2010 the government of Israel did not allocate the needed budget for the reinforcement of ten thousands government-owned apartments that would not be safe in a case of an earthquake.

2.5 Energy-Efficient Buildings

Every building that has been built in Israel after 1980, which is not higher than 27 m (9 stories) is required to have a solar water heating system. The standard for thermal insulation in residential buildings in Israel is compulsory since 1986.[5] An update from 2011 requires higher standards of insulation. There is a governmental activity requiring the instillation of solar systems also in higher buildings (up to 15 stories).

A high-profile milestone towards the achievement of energy-efficient buildings in Israel has been the adoption and recent revision of a voluntary standard for labeling buildings with reduced environmental impact, or "green" building (SI 5281). The standard was approved by the Standard Israeli Institution in 2005 for residential and office buildings [5], and has been expanded to cover other building types as well.

For example, the long facades of the building that is shown in Fig. 4a are oriented to the north and south where the building can gain solar heating in the winter and avoid it by shadings in the summer. Moreover, each apartment in the "H" configuration can have access to natural light and natural ventilation. However, from a seismic perspective, this configuration must be treated carefully. In a case of an earthquake, the wing which is parallel to the movement of the earth is stiffer than the other wing which is perpendicular to the movement. Therefore, the junction is exposed to opposing forces that may cause a separation between the wings (as shown in Fig. 4b).

Recently, the big Israeli municipalities ("The Forum 15") decided to give permits only for buildings that comply with the green standard. The contractors protest against that decision. According to them, it would add costs to the construction, complicate the permit process which is slow anyway and as a result the clients would have to pay more for their apartment.

[5] Taken from the Ministry of National Infrastructures, Energy and Water Resources' site: a PDF document in Hebrew: Energy consumption in buildings (2012).

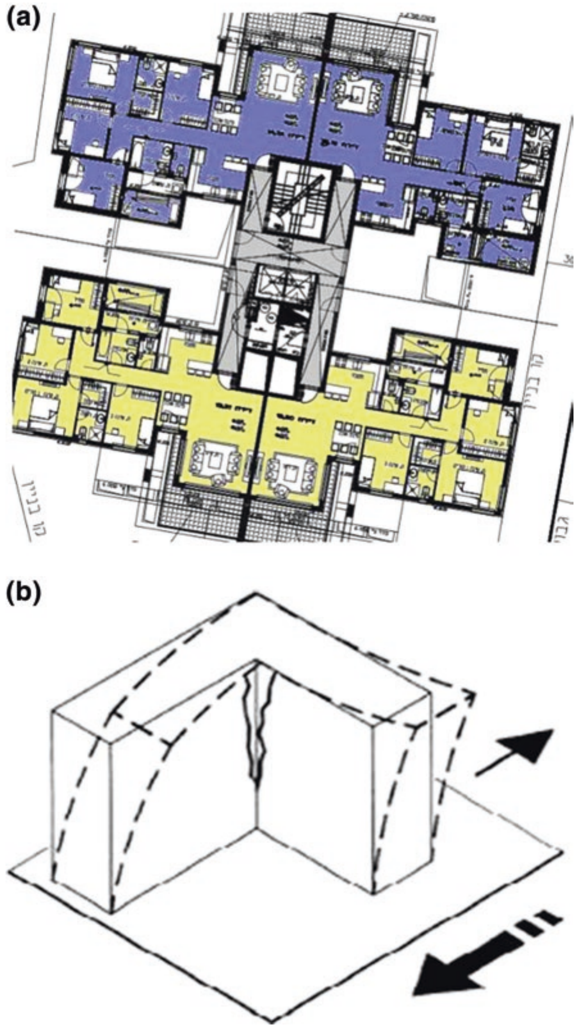


Fig. 4 **a** A type "H" building of an Israeli new building; each apartment is enjoying from three directions of light and air [21] **b** a complex configuration "L" shaped plan [3, 34]

2.6 Possible Synergies Between Green Building Improvements and Structural Reinforcement

In order to reinforce a residential building according to NMP 38, the entrepreneur needs to get an approval from most of the building's residents.[6] Some of them are afraid of the possible disturbance caused by construction works. However, when

[6] This was the subject of a professional day (2.7.13) that included lectures by an engineer specializing in seismic design, a leading Israeli project manager specializing in green projects, a head of the engineering branch of one of the municipalities, and entrepreneurs.

green improvements are included in the structural reinforcement there is a potential of upgrading the value of the building. Therefore, if considering a combination between green improvements and structural reinforcement it is important to include only works that can be done from the outside of the building without entering the apartments.

These improvements may include, for example, the following works: adding dynamic shading openings, adding external insulation to the building's envelope, coloring the building's envelope with reflective and low heat absorbing finish materials, creating large openings and thus allowing the penetration of natural light, and using condensed water from air conditioners for flushing toilet bowls. However, one of the barriers to including green improvements which comply with the Israeli standard for green building as part of the reinforcement works is there is a need to enter the apartments [20].

Moreover, small contractors who are involved in reinforcement of existing buildings already face difficulties with the conventional process and are not experienced with green improvements. Therefore, the requirement to include green improvements in their project would make it almost impossible for them to get a permit. To date, only a handful of buildings have been accredited with a green building label. The actual success of this incentive for energy-efficiency improvements is limited by a complex set of constraints, which appear to overlap with those inhibiting the uptake of the incentive for strengthening structures according to NMP 38. In both cases, the inherent conflicts between short-term investment considerations and long-term considerations regarding the resilience and efficiency of the housing stock remain unresolved.

3 Unique Characteristics of the Building Construction Industry

3.1 Unique Characteristics of the Building Sector and Key Influences on Resilience/Long Term Considerations

3.1.1 Fragmented Supply Chains

Currently, housing *supply* chains are fragmented and underpinned by poor communication, adversarial relationships and a lack of trust and commitment. Partnering-a long term commitment between organizations-can address this phenomenon. Specific business objectives may be achieved by maximizing the effectiveness of each participant's resources. Furthermore, in order to improve the performance of buildings, each organization should adopt a business process orientation, focused on the client's needs and establish open channels of communication within and outside its own boundaries [18].

A few Israeli entrepreneurs, promoting a green agenda, decided voluntarily to adopt the Israeli green standard, even though it may raise construction costs.[7] They explain their potential customers that their buildings are better in different aspects, for example: the building's orientation, saving energy elements, and healthier materials. However, they all complain on the bureaucracy involved in executing a residential project in Israel. Therefore, they need high skills and experience in communicating with regulators in order to get a valid approved plan.[8]

More specific barriers have been identified which tend to impede improvement in the environmental performance of buildings [30]. We assume these barriers impede not only the environmental performance of the building but also its survivability in disasters. These barriers are related to a number of characteristics that are unique to the building sector in terms of its product, production process, and the way the product is used as will be explained in the next paragraphs:

3.1.2 Long Lived Nature of Products

The useful lifespan of a building is typically longer than that of any other manufactured product, usually extending over several decades. The long-lived nature of buildings results in a low turnover rate within the overall building stock, and therefore technical innovation cannot be quickly or easily incorporated through replacement of the "product" (i.e. the building).

3.1.3 Spatially Fixed Nature of Products and Production Process

The building sector is distinguished by the physical nature of its production process and its products, with a large proportion of the work involved in conventional construction taking place at the site. Although other industrial production processes are site-based, few combine a spatial fixity of production and product such as occurs in construction. This has led to a low level of standardization in the design and production of buildings, and to a relative failure to exploit the economies of scale that exist in industries with more extensive repetition [30].

Another consequence of poor standardization is that standard quality control methods that are widely used in the manufacturing sector are not easily applied in the construction industry. Therefore the effective enforcement of building standards, such as those regulating environmental performance, requires customized checking of design documents and on-site inspection of buildings by technical experts—which incurs significant administrative costs. In the UK it has even

[7] It is interesting to notice that one of the leading contractors in Israel explained in a public panel that he could build a green building which would cost less than a conventional one.

[8] These skills are needed in order to get any permit not only for green building.

been suggested that private firms enter the building inspection market in order to reduce these costs [30]. According to Bennet [6], growing diversity in the industry is likely to amplify heterogeneity in building designs even further, accelerating the costs of enforcement.

3.1.4 Dominance by a Large Number of Small Firms

Furthermore, the construction industry is characterized by the dominance of a large number of small scale builders. The proportion of firms in this sector employing fewer than 10 persons was 81 % in the US, 93 % in EU countries, 92 % in Israel [10] and 75 % in Japan. The dominance of small-scale firms can be explained by the poorly standardized production process in the building sector, which makes it difficult to exploit economies of scale. Small firms generally do not have specialized staff for research and development and are slow to adapt to new technologies [30].

4 Barriers to Incorporating Long Term Considerations into the Design and Production of Resilient Buildings

Investors in building construction are typically focused on minimizing capital costs, rather than considering future potential savings by energy-efficiency improvements.

Recent studies have investigated stakeholders' interests in energy efficient building in Israel, and concluded that the knowledge held by homeowners regarding energy-saving potential through appropriate design is limited, as is their ability to affect housing developers' construction decisions [5, 16].

In fact, a host of factors contribute to the accumulation of uncertainty and to the ultimate discouragement of investment in energy efficiency and other sustainable practices associated with long-term considerations, even if such investments are beneficial in a life cycle cost analysis. As a result, there is a gap between the availability of practices associated with long-term considerations and their actual uptake in the construction industry [30].

Various explanations have been given for this "efficiency gap". They include the lack of information on the demand side, lack of expertise on the supply side, and principal-agent problems—i.e. the conflict of interests between those shouldering short-term costs and those benefiting from long term savings [5, 16]. Hoffman and Henn [17] explored the sociological and psychological dimensions of the green building world, analyzing barriers on the individual, organizational and institutional levels. Their observations will add another dimension to the study of risk management as will be described in the following paragraphs:

4.1 Barriers on the Individual and Organizational Level

On the individual level they refer, for example, to consumers who are not necessarily amenable to added costs that are not associated with tangible and immediate added value [17].[9]

The organizational level of barriers deals with the unique form of the construction project team-the temporary organization. The members of the team come together, on a temporary basis, to design and build the required project. The organizational structure of the temporary organization and the competing interests of its members often limit their ability to identify and internalize the long-term costs and benefits that are implicit in the design decisions made [17].

4.2 Barriers on the Institutional Level

On the institutional level, [17] refer, for example, to regulative institutions and standards such as the LEED system. Critics charge that LEED has become a point chasing game with participants losing sight of the objectives of green building—to minimize the impact on the environment—and instead focusing on getting more points with the least effort.

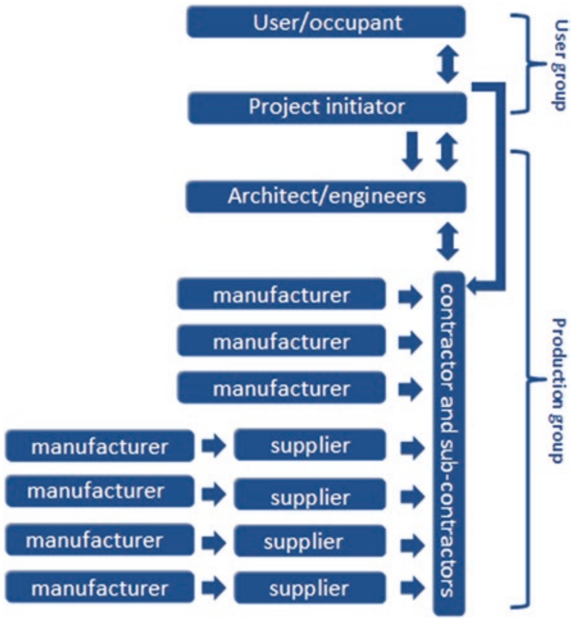
Moreover, it has been observed that government regulations and industry standards may hamper innovation [7]. This is particularly the case with prescriptive approaches, which specify the materials, configurations and processes required to achieve a desired regulatory goal, and which are distinguished from performance approaches which leave many of these factors open. In the latter case, only the final regulatory goal is specified, rather than how the goal should be met [7].

5 Designing for Resilience

Many actors are involved in the design and production of buildings (see Fig. 5). Therefore, there is a need for integration of processes within the construction industry in general and in the construction of resilient buildings in particular. Developing ideas from previous work regarding architectural awareness of earthquake resistance, we introduce three levels of integration needed when designing buildings for resilience: (1) integration in multi-disciplinary design teams; (2) integration in the design process, and (3) integration of long-term and short-term considerations [35].

[9] One of the Israeli entrepreneurs who lead the market of green building related to convincing the clients of the added value as the real challenge. He was speaking in the Israel Engineers Association for Construction and Infrastructure's panel discussing: "Do entrepreneurs like green building?" in 2011.

Fig. 5 The actors in the construction industry [14]



5.1 Integration in Multi-disciplinary Design Teams

A high degree of specialization characterizes the contemporary design profession, and contrasts sharply with the image of pre-modern architects like Vitruvius (in the first century BC) or the renaissance scholar Leonardo Da Vinci, who were knowledgeable in a wide spectrum of related fields [34].

According to Davidson [14] the success of post-disaster reconstruction depends to a large extent on the complex relationships between the multiple actors involved. These actors include the affected people, community based organizations, local and central government, NGOs, designers and builders. The building industry is composed of different categories of participants, each with its own set of behavioral rules and customs within a national context. A relatively limited number of professional firms are selected from a range of available professions as project participants (as shown in Fig. 6). This group of team members is called a "temporary multi-organization".

The members of this unique form of the construction project team—the "temporary multi-organization"—come together, on a temporary basis, to design and build the required project. According to Davidson [14], the major challenge of any construction project team is to "translate" satisfyingly verbal expression of needs to actual design and construction. Unlike the purchase of a car or an existing house, the decision to procure a new building "on the paper" is based on trust in the competence of the relevant professionals to design and produce the building.

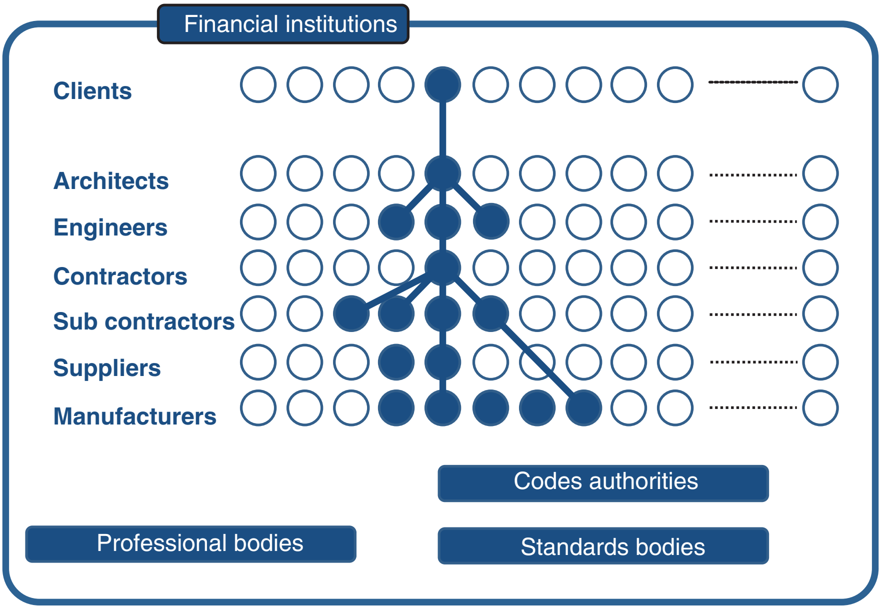


Fig. 6 The building industry and its principal participants, within their respective environments [14]

5.1.1 Architect/Engineer Relationships

Results from a survey of Wellington structural engineers and architects [11] indicate that an underlying positive attitude exists between the professions. However, there are areas where each profession is critical of the other regarding both the design process and the design content. Structural engineers are critical of architects' lack of structural understanding (design content), and the late stage in which they usually seek for structural advice (design process)—making it almost impossible for the engineer to reach optimal structural solutions.

However, according to that survey, at the early stages of the design, architects require design flexibility and freedom. That is why they are concerned that if a structural engineer is involved too early in the process (design process), he or she can prematurely stifle their design explorations. According to that survey, architects are disappointed by engineers' lack of innovation and poor engagement with architectural design ideas (design content). Therefore, exemplary collaboration requires the meeting of the minds of experienced professionals who possess high levels of technical and design skills and with well-developed personal qualities and communication skills.

5.2 Integration in the Design Process (Co-design)

The actors involved in the design process in general, and in the preliminary design process in particular, share and create knowledge through design communication. This collaborative part of the design process, is a process in which experts from different disciplines share their knowledge about both the design process and the design content [25].

However, creating shared understanding between design professionals is difficult because these actors have different backgrounds, interests and perspectives on the new design. For instance, the architect uses a visual language to examine ideas and the engineer uses mainly mathematical tools; while the architect explores alternative solutions using imagination and intuition, the engineer's thinking is characterized by rational processes that lead to a single and accurate solution [11]. It has been found that a lack of shared understanding between these diverse types of actors tends not only to hinder the design process but also to reduce the quality of the final product [25].

Traditionally, relationships within the design and construction team have followed a linear chronological sequence: the client presents requirements to the architect; the architect prepares a design; the design is handed to the engineers; and the detailed plan is sent out for a bid and built by a contractor [17], as shown in Fig. 7. Such a linear scheme may fit the design process of a simple structure, when merely basic needs have to be met by the design: for example, every building has to resist gravitational loads, which can be easily predicted according to the building's function.

According to IEA [19], linear design processes usually result in poor performance, high operating costs, and the creation of an interior environment that is sub-standard. The following are examples of these results:

Limited exploitation of the potential advantages offered by solar gain during the heating season (for example, in Israel—by locating proper openings in the south), resulting in a greater heating demand.

Possible exposure of the building to high cooling loads during the summer due to excessive exposure of glazing to summer sun (it would be difficult to plan effective shading devices in the east and west because of the low position of the sun).

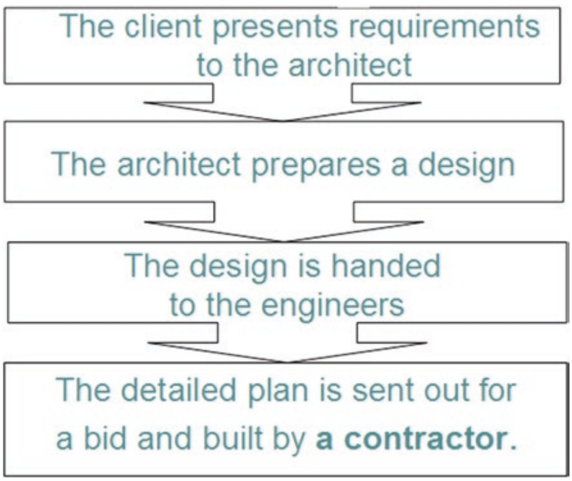


Fig. 7 A linear chronological sequence of a building production process

Non-utilization of a building's day lighting potential, due to a lack of appropriately located openings, or a lack of devices to channel the day light further into the interior of the building.

Exposures of occupants to severe discomfort, due to excessive local over heating or glare in areas lacking adequate shading.

5.2.1 Integrated Design Process

Integrated design process is a procedure considering and optimizing the building as an entire system for its whole life span. This can be achieved when all actors of the project cooperate across disciplines. The integrated design process is characterized by a circular sequence and emphasizes the iteration of design concepts early in the process (see Fig. 8a, b), by a coordinated team of specialists.

According to Larsson [26] it is important to ensure that the proposed design team is aware, from the beginning, of the project's high-performance goals. In seismically prone areas we would recommend that the design team would prepare a statement on seismic goals and expectations as a part of the high performance goals.[10] Moreover, in an integrated design process the designers are expected to allow future changes and confirm client's commitment to supporting high performance targets from the very first step of design. According to Kincaid [24] buildings should have a special quality which allows for adaptation to different uses in the future through their geometry, fabric and structure. Learning from previous research, architectural decisions dealing with the geometry of the building and the location of different elements in the plan (walls, piers of staircases, pillars, and so on) have a significant impact on the building's stiffness and on major characteristics of its dynamic response as shown in Fig. 9 [35].

Changes to existing buildings can be an alternative to traditional demolition and reconstruction. Building adaptive reuse is defined as a significant change to an existing building function when the former function has become obsolete [13]. Conejos et al. [13] refer to planning for reuse as a key design criterion when designing new buildings. Based on successful reuse projects, they developed a list of design strategies that lead to future successful adaptive reuse of buildings. These strategies belong to different groups of categories: physical, economic, functional, technological, social, legal, and political categories (see Fig. 10).

From a functional perspective, the design of the functional space and the service space of a new building must be flexible and allow changes according to newly required needs (a single easily defined use for a building should be avoided in order to allow for future unexpected needs), service ducts must allow for future additions and modifications.

[10] This statement can help designers and owners to agree on goals that are reasonably in line with resources available, as suggested in design checklist to facilitate architect/engineer interaction [37].

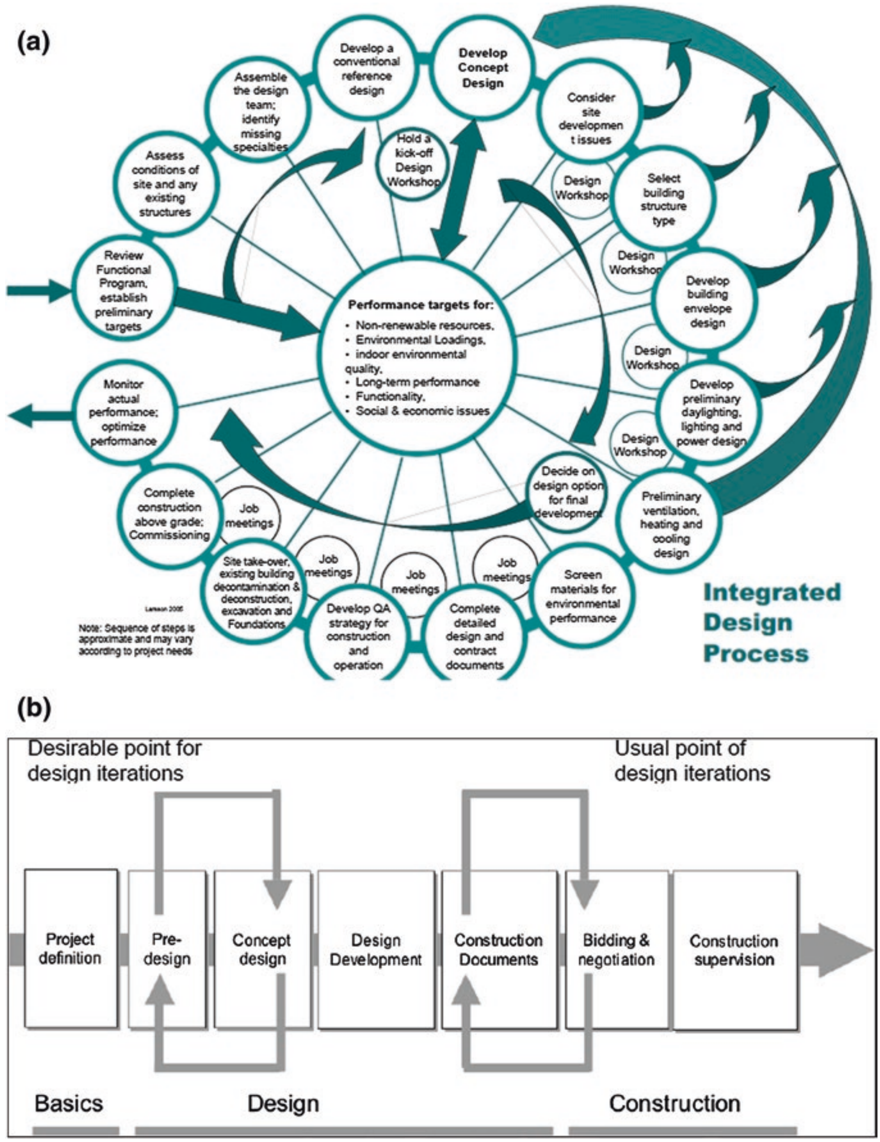


Fig. 8 **a**, **b** Integrated design process [26]

From a physical perspective, the structural design of the building must support the functional new requirements and allow for different uses and loads in the future. When designing for earthquake resistance both the direction and magnitude of the seismic force is unknown. A regular and symmetric configuration, can resist forces from any direction and therefore, may encourage structural solutions which rely, for example, on less reinforcing steel [34].

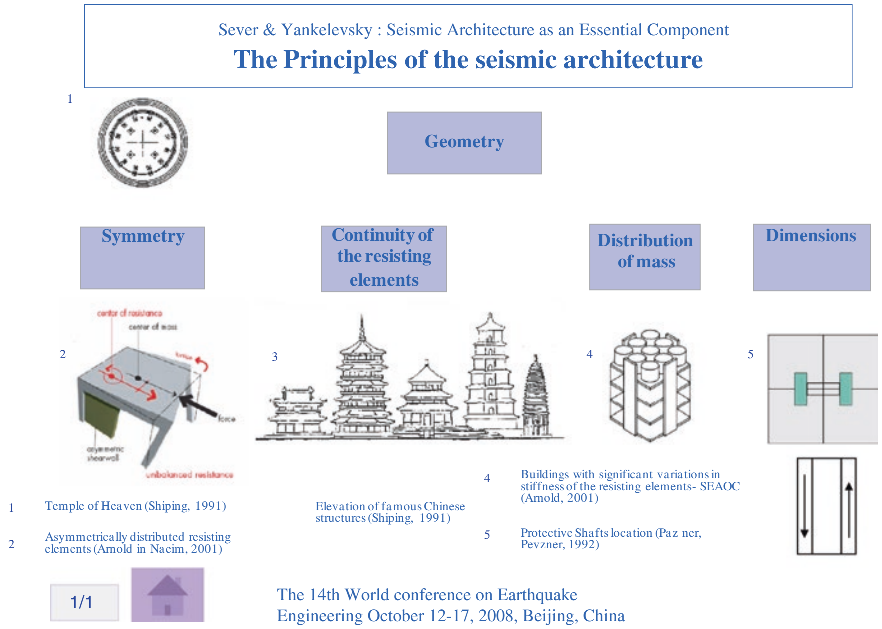


Fig. 9 The principles of the seismic architecture [34]

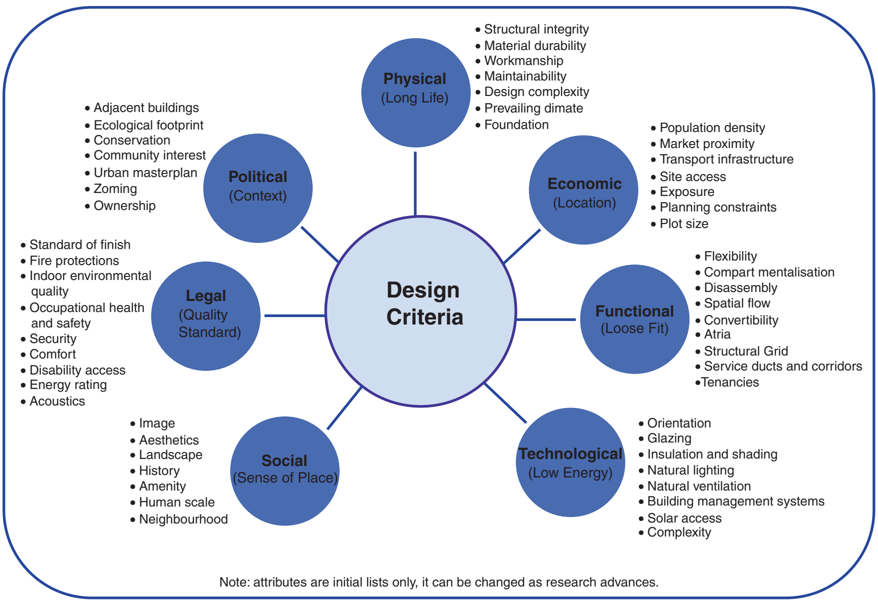


Fig. 10 “Planning for reuse” design criteria

From an economic perspective, the location of a building has a crucial impact on its suitability for different users and their changing needs: middle/under—class families need access to work place, old people need easy access to health services and public green spaces, and students need a place to live while having their studies in the center.

From a social perspective, the esthetics of the building and the organization of the built environment has an impact on the “sense of a place”. It is interesting to learn from the experience of Israel as an immigration state, and the special circumstances in which the government of Israel had to provide housing solution for its growing population: from May 1948 until the end of 1951, 687,000 Jews immigrated to the country, doubling the Jewish population [36]. One of Israel’s main goals in those years was the establishment of sovereignty over territories that it acquired.

By designing space according to national considerations, the country wished to establish control, power, and authority mainly in the periphery of the country, far from the center-where there were no work places available [23]. The housing unit itself was designed as a ‘machine for living’ which was supposed to fulfill all the new immigrants’ housing needs without referring to their habits and culture [23].

From a legal perspective, the standard of finishes and indoor environment quality, have an impact on the durability of materials and as a result on the level of the building’s maintenance. Based on precise calculations of cost and benefit, public housing buildings in Israel were smaller and were usually inferior to those built by the private sector. As a result, most of the neighborhoods in which they had been built were included in Project Renewal because of their low level of physical maintenance [1].

From a political perspective, the ecological footprint of the building and its relationships with the natural and built environment surrounding it are determined through an urban master plan. In order to make an efficient use of the site, building elements need to be placed in a way that will maximize the potential of natural light; minimize impacts on subsurface ecology and aquifers; minimize water demand; preserve site ecosystems, and maximize outdoor space for building users.

In seismically prone areas it is required to check the characteristics of the building in accordance to the site and analyzing soil profile (periods, amplification, duration); accessibility to lifelines, and adjacency to existing buildings; up-slope or down-slope conditions, and collapse-hazard.

From a technological perspective, the configuration of the building has a role in balancing day lighting and thermal performance; a regular and symmetric configuration might be inferior to a complex one from a bio-climatic perspective. Furthermore, the decision to use natural ventilation instead of hybrid or mechanical systems is dependant, among other parameters, on cost and benefit calculations; the orientation of the building may maximize the benefit from using natural ventilation.

Therefore, the architect should be aware of the great effect the orientation and the configuration of the building which are decided very early in the process have on the behavior of the building in case of an earthquake and on technological possibilities that would be considered in the next stages of the design.

5.3 Integration of Long-term and Short-term Considerations

We stipulate that short-term together with long-term considerations may encourage integrative solutions which could not emerge in a design process, focused only on immediate needs of the client. However, due to the high-risk nature of the building industry, the decisions of developers are most directly driven by initial costs and short-term profitability, rather than by theoretical future returns—especially if such benefits are reaped by customers who have shown unwillingness to pay for them in the form of an up-front premium. Therefore, one of the greatest challenges of the construction industry is to balance between short-term and long-term considerations.

5.3.1 Can Affordable Housing in Israel Be Resilient?

Alterman et al. [2] refer to affordable housing programs as multi dimensional programs. These programs differ one from another according to their goals—social or economic—and according to the question of ownership—housing units for rent or for purchase. Furthermore, four categories of tools are discussed; each would fit different goals and circumstances: overcoming statutory barriers to supplying affordable housing units, keeping affordable housing units in the existing stock, supplying new affordable housing units, and enlarging the general housing stock [2].

The new standards that have been issued by the government of Israel over the last decade include harsher requirements in a whole spectrum of subjects, such as: modifications in buildings in order to make them suitable for disabled people, fire safety, physical protection and seismic resistance, façade covering, and thermal insulation. Moreover, municipalities may include in statutory local plans additional requirements, such as, for example: complying with the voluntary green standard, including under-ground parking places, and covering façades with stone. As a result, such requirements may cause increase in building costs.

On the one hand, a regulatory approach is used by the government as a means to fit occupants' needs and protect them from different threats.[11] On the other hand, the contractors claim that the benefit from some of the requirements is marginal (if exists at all), but the increase in the cost of the apartment is substantial—about 14.6 % from an average apartment's price [4].

Unfortunately, some of the requirements that aimed to guarantee resilience in the long-term may damage the effort to supply affordable housing in the short-term. Since the mass immigration to Israel in the nineties, Israel's housing industry has been characterized by less and less involvement of the government in construction. Given the global economic crisis of 2011 together with Israel's location

[11] However, according to the contractors, the procedure for professionally approving regulations is handled separately by each ministry, without considering the implication of all of these requirements together on the apartment's price.

Table 2 The responsibility of each actor for developing affordable resilient housing in Israel—an initial analysis

Producers	Regulators		Consumers
Entrepreneurs, designers	Government	Municipalities	Consumers
Supplying an efficient design small apartments	Avoiding "over regulation"		Demanding smaller apartments
Supplying "basic standard" apartments	Marketing lands for residential use; allowing foreign workers	Requiring entrepreneurs to include small apartments in new residential complexes	Demanding a basic standard of finishes, without compromising the quality of design and construction
Industrialization	Reinforcing government-owned old buildings	Facilitating processes: Building permits Population permits	Strengthening old buildings

in a politically and seismically prone area, there is a growing need for supplying affordable housing units which will be resilient. The responsibility for developing affordable (and resilient) housing units in Israel is divided between different actors who belong to three main groups: producers, regulators, and consumers (the responsibilities are shown in Table 2).

Entrepreneurs, together with their designers and suppliers (producers) are responsible for managing an integrated design process, using industrialization in construction and assuring durability of materials. The government, represented by different ministries, (regulators) is responsible for considering holistically the total implication of regulation in a cost/effective manner in order to avoid "over regulation", and encouraging the industry by releasing lands for construction.

The local municipalities (regulators) have statutory tools that can be used not only in order to reduce housing prices but also to guarantee the resilience of the built environment. In addition to facilitating and shortening bureaucrat processes wherever under their jurisdictions, they should require entrepreneurs to include small apartments in new residential complexes, as suggested by Alterman et al. [2]. The consumers are responsible for demanding the government and the private sector to supply affordable housing solutions which consist of a basic standard of finishes without compromising the quality of design and construction.

6 Conclusion

The common goal of all actors involved in designing and producing residential buildings in vulnerable areas is to achieve resilience. Israel's geopolitical location, together with its seismic sensitivity and bio-climatic characteristics bring to light the need for an integrated approach to the design and production of buildings which would consider the possible synergies between structural durability and energy efficiency.

Developing ideas from previous work regarding architectural awareness of earthquake resistance, we introduced three levels of integration needed when designing for resilience: (1) integration in multi-disciplinary design teams; (2) integration in the design process, i.e. integrated design or co-design, and (3) integration of long-term and short-term considerations.

We examined barriers to the integrated design of resilient buildings by looking at disincentives for non-linear co-design processes along the extended building supply chain. Traditionally, relationships within the design and construction team have followed a linear sequence. However, linear design processes usually result in poor performance, high operating costs, and the creation of a sub-standard environment. Therefore, integration in the design team and in the design process is necessary in order to achieve resilience.

One of the barriers to identifying and internalizing the long-term costs and benefits of a housing project is the organizational structure of the temporary design and construction project team; competing interests of its members and a lack of understanding between them may impede the incorporation of long-term considerations in the design and production of buildings.

The unwillingness of consumers to invest in components which do not give an immediate added value is a barrier to incorporating long-term considerations in the design and construction of buildings. Although regulation has a critical role in ensuring survivability of residential buildings and their users, it might impede innovation and the development of cheaper solutions which would improve the affordability of housing solutions. Therefore, integration of short-term together with long-term considerations is needed when regulating, designing and producing residential buildings.

References

1. Alterman R (2002) Planning in the face of crisis: land use, housing and mass immigration in Israel. Routledge, London
2. Alterman R, Silverman E, Pialkof H, Mualem N (2011) Affordable housing: statutory tools and local policy (a draft for distribution). Center for Urban and Regional Studies, Ministry of the Interior (Hebrew), Technion, Haifa
3. Arnold CH (2001) Architectural considerations. In: Naeim F (ed) The seismic design Handbook. Kluwer Academic Publisher, Boston Mass, pp 275–326
4. Association of contractors and builders in Israel (2011) A rise in construction costs caused by regulation. http://www.landvalue.org.il/index2.php?id=3532&lang=HEB
5. Bar Ilan Y, Pearlmutter D, Tal A (2010) Building green, promoting energy efficiency in Israel. Center for Urban and Regional Studies, Technion, Haifa
6. Bennet J (2000) Construction—the third way. Butterworth-Heinemann, Oxford
7. Blayse AM, Manley K (2004) Key influences on construction innovation. Construction Innovation (Sage Publications, Ltd.), vol 4(3), pp 143–154
8. Bosher L, Dainty A (2011) Disaster risk reduction and 'built in' resilience: towards overarching principles for construction practice. Disasters 35(1):1–18
9. Brechia V, Hasson SH (2012) Environmental policy in Israel 1948–2011: processes and trends that led to a "business as usual" scenario, sustainability outlook for Israel 2030. http://www.kayamut2030.org/

10. CBS, Central Bureau of Statistics (2010) Statistical abstract of Israel, survey of industries in the economy-construction No. 22.3
11. Charleson AW, Pirie S (2009) An investigation of structural engineer-architect collaboration. SESOC J 22(1):97–104
12. Coaffee J (2008) Risk, resilience, and environmentally sustainable cities. Energy Policy 36(12):4633–4638
13. Conejos S, Langston C, Smith J (2013) AdaptSTAR model: a climate friendly strategy to promote built environment sustainability. Habitat Int 37:95–103
14. Davidson C (2010). Multi-actor arrangements and project management. In: Gonzalo L, Cassidy J, Davidson C (eds) Rebuilding after disasters: from emergency to sustainability. Spon Press, Oxon, pp 89–109
15. Evans M (2011) Population dispersal policy and the 1990s immigration wave. Isr Stud 16(1):104–128
16. Fundaminsky S (2007) Stakeholder attitudes toward energy-efficient building, a neighborhood case study. Ben-Gurion University of the Negev, Jacob Blaustien Institutes for Desert Research, MA
17. Hoffman AJ, Henn R (2008) Overcoming the social and psychological barriers to green building. Organ Environ 21(4):390
18. Hong-Minh SM, Barker R, Naim MM (2001) Identifying supply chain solutions in the UK house building sector. Eur J Purchasing Supply Manage 7:49–59
19. IEA (2003) Task 23, optimization of solar energy use in large buildings. Integrated Design Process Guidelines, Berlin, Zug
20. ILGBC (2012) Including green building in NMP 38 projects. http://www.ilgbc.org/template/default.aspx?PageId=26
21. ILGBC (2013) Green building costs of residential buildings in Israel. http://www.ilgbc.org/template/default.aspx?PageId=26
22. Isareli State Comptroller (2011) The durability of structures and infrastructures in earthquakes—a situation report. Jeruaslem (Hebrew). www.mevaker.gov.il
23. Kallus R, Yone HL (2002) National home, personal home: public housing and the shaping of national space in Israel. Eur Plann Stud 10(6):765–779
24. Kincaid D (2000) Adaptability potentials for buildings and infrastructure in sustainable cities. Facilities 18:155–161
25. Kleinsmann M, Valkenburg R (2008) Barriers and enablers for creating shared understanding in co-design projects. Des Stud 29(4):369–386
26. Larsson N (2009) The integrated design process; history and analysis. International initiative for a sustainable built environment
27. Liu A (2012) Integrated design for achieving building seismic resilience. In: 15th world conference of earthquake engineering, Lisbon
28. McEntire DA (2005) Why vulnerability matters: exploring the merit of an inclusive disaster reduction concept. Disaster Prev Manage 14(2):206–222
29. Mileti D (1999) Disasters by design: a reassessment of natural hazards in the United States. Joseph Henry Press, Washington, D.C
30. OECD (2003) Environmentally sustainable buildings: challenges and policies. OECD Publications Service, Paris
31. Pearlmutter D, Meir I (1995) Assessing the climatic implications of lightweight housing in a peripheral arid region. Build Environ 30(3):441–451
32. Perelman L (2008) Infrastructure risk and renewal: the clash of blue and green-Symposium introduction. pp 1–9. http://www.riskinstitute.org/PERI/
33. Sarja A (2000) Integrated life cycle design of materials and structures. In: 8th international conference on durability of building materials RILEM Publications, Helsinki, Finland
34. Sever M (2007) A seismic architecture as an essential component of the structural integrity of Israeli apartment buildings in earthquakes. M.Sc. Technion, Hebrew
35. Sever M, Garb Y, Pearlmutter D (2012) Exploring barriers to the integrated design and production of resilient buildings in Israel. In: 15th world conference of earthquake engineering, Lisbon

36. Shadar H (2004) Between east and west: immigrants, critical regionalism and public housing. J Archit 9(1):23–48
37. State of California (1991) Committee on the architect's role in earthquake hazard mitigation. Architectural practice and earthquake hazards. State seismic safety Commission, California
38. Tierney KJ (2008) Structure and process in the study of disaster resilience. In: 14th world conference on earthquake engineering, Beijing, China
39. Yankelevsky D, Sever M, Schwarz S, Zerubavel U (2011) Architectural principles for seismic design. The Israel Ministry of Construction and Housing and the Technion Research and Development Foundation Limited, Haifa
40. Zailer V (2003) Israel state committee of inquiry for the safety of publicly used buildings and facilities, final report. Summary of the report: http://elyon1.court.gov.il/heb/veadot/versay_full/eng.htm

Urban Resilience and Sustainability: The Role of a Local Resilience Forum in England

Julie Fisher, Ksenia Chmutina and Lee Bosher

Abstract Whilst being a large contributor of greenhouse gas emissions, the urban environment is prone to impacts of hazards, threats and major accidents. It is crucial to plan, design, build, manage and operate urban environments in a resilient and sustainable manner. The compatibility and conflict between resilience and sustainability has received increasing attention in recent years in academic literature, however its application at local and national levels has not yet been widely attempted. The Local Resilience Forum (LRF) is an important mechanism for facilitating the complex multi-stakeholder interactions required to deliver urban resilience in England, however sustainability does not appear to be a priority. This study explores how emergency planning and the design of the built environment can further both agendas. A range of promising practices have been found that potentially could not only increase the resilience of, but that are also integral to the sustainability of, the built environment.

Keywords Resilience · Local level · Sustainability · Built environment

1 Introduction

Pertinent to this chapter is the array of hazards, threats and major accidents that can pose risks to the built environment and those who use them, particularly as the potentially profound impacts of these can nullify years of development and investment [1].

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A. Masys (ed.), *Disaster Management: Enabling Resilience*,
Lecture Notes in Social Networks, DOI 10.1007/978-3-319-08819-8_5

It is also argued [e.g. 2] that since the built environment is one of the major contributors of greenhouse gas emissions, it is critical to ensure its sustainability. Urban built environments must therefore be planned, designed, built, managed and operated so that they are suitably resilient as well as sustainable, and supporting of governance and social systems. It has been suggested by Bosher et al. [3] that emergency managers and planners have a key role to play in increasing this resilience, however, this view has so far not been widely recognised outside the United Kingdom (UK) [4]. It is therefore reasserted here that the Local Resilience Forum (LRF) plays an important role in facilitating the complex multi-stakeholder interactions required for this. Sustainability however is not seen as a priority in LRF practice. This research is part of a large pan-European project (funded under the European Union's FP7 Security Programme) that aims to better understand the integrated nature of the built environment and how its users and assets can be protected from the range of hazards, threats and major accidents that pose a risk to them. This chapter examines the relationship between urban resilience and sustainability, exploring its development through urban and building design, and emergency planning.

2 (Urban) Sustainability and Resilience

Urban sustainability is defined based on the concepts of social, economic and environmental responsibilities [5]. Its implementation often focuses on achieving stability, practising effective management, and the control of change and growth [6]. However, due to the changing climate, an increase in the number of recent disasters caused by natural hazards and social instabilities, urban environments have been forced to focus on the ideas of change, disturbance, uncertainly and adaptability—which are within the scope of the emerging science of urban resilience. It is therefore crucial that the urban environment embraces both resilience and sustainability [7].

In order to understand what constitutes a resilient built environment, the origins of the term 'resilience' must first be explored. Bosher and Dainty [1] suggest that the concept of resilience primarily emerged in relation to how ecological systems cope with stresses or disturbances caused by external factors see [8, 9]. Holling [10, p. 14] asserts that resilience is the "*measure of the persistence of systems and their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables*". More recently, the term has been applied to human social systems [11], economic recovery [12], engineering [13] and urban planning and recovery [14].

Sapountzaki [15] and Klein et al. [16] highlight that the Latin root of the word '*resilio*' means to 'jump back' or return to a previous state, however, it has been argued that it is not sufficient for systems to simply return to a previous state (as it is this that contributed to the scale of the disruption), and that there should be progression to a more robust version [17, 18]. Alexander [19] argues that the modern conception of resilience is derived from a rich history of meanings and applications but that it is dangerous to rely too much on this term; he suggests that resilience is being used as a buzz-word that has started to lose meaning and pertinence. However, the term is widely used in both policy and literature relevant to Disaster Risk Reduction, and is seen as the ability of a system to cope with disruption, maintain essential operations, return to normal operations after the disruption has ended, and elevate to a more informed state. It is suggested that "'*built-in resilience' can be a quality, a process and an end-state goal that can intuitively and proactively cope with dynamic changes* (*in their various natural and man-made guises*)*"* [20, p. 242]. Therefore, Bosher [20] argues that built-in resilience is a quality of a built environment's capability (in physical, institutional, economic and social terms) to keep adapting to a range of existing and emergent threats.

The inter-connected nature of resilience and sustainability has been evident in literature for a number of years, with notions of 'turquoise design theories' to denote the typical associations of resilience/security with the colour blue, and those of sustainability/environment with the colour green [21]. The developments in resilience, emergency planning, and urban and building design, as previously outlined [1, 22], have arisen most notably through the emergence of resilience as the key discourse in relation to security. Perelman [21] states that this is the very essence of 'turquoise design' and the true meaning of resilience; resilience is the merging of security and safety concerns with the broader goals of sustainability and sustainable development. Coaffee [23, p. 4636] notices that "*in future decades it is most likely that the sustainability agenda will provide the most appropriate policy vehicle for the achievement of resilience, with security seen as an essential element of corporate and organisational responsibility alongside economic, environmental and social concerns*". Such assertions are also evident in a range of governmental and non-governmental literature [24, 25].

2.1 Sustainability in the UK

The notion of sustainability and sustainable development in the UK is addressed in the Vision for Mainstreaming Sustainable Development, a policy document that shapes government responsibility in relation to this. According to this vision, sustainability means: "*Making the necessary decisions now to realise our vision of stimulating economic growth and tackling the deficit, maximising wellbeing and protecting our environment, without negatively impacting on the ability of future generations to do the same*" [26]. This definition is based on the National Planning Policy Framework, established in the 2005 UK Sustainable Development Strategy, which defines sustainability as "*living within the planet's environmental limits; ensuring a strong, healthy and just society; achieving a sustainable economy; promoting governance; and using sound science responsibly*" [27]. Representations of sustainability put forward in these documents are largely influenced by the Inter-Governmental Panel on Climate Change (IPCC), international standards, and European Union policies (notably the Directives 2002/91/EC and 2006/32/EC).

Lizarralde et al. [7] however argue that the term 'sustainability' has been 'instrumentalised' to provide a disproportionate focus on energy consumption and on carbon emission reductions. This is naturally at odds with more theoretical approaches to the sustainability paradigm which go beyond the consideration of emissions.

2.2 Resilience in the UK

Within the UK, the resilience of the built environment has received increasing attention over the past decade, with a range of obligations and incentives being present to reduce its vulnerability to the plethora of hazards, threats and major accidents that pose a risk to it [28]. Cabinet Office [29] defines resilience as "the ability of the community, services, and of infrastructure to detect, prevent, and, if necessary, to withstand, handle and recover from disruptive challenges". This definition underpins the development of all subsequent resilience-related work, including the Local Resilience Forum (LRF) framework, the National Risk Register and National Security Strategy, the identification of people who might be vulnerable in a crisis, data protection protocols, cyber-security programmes, and plans for the protection of critical infrastructure and the prevention of violent extremism.

Advancements in implementing 'resilience' have occurred particularly in relation to the two areas of urban and building design, and emergency planning. The UK has an established system for emergency planning and engagement between required stakeholders (see Fig. 1) [30] ('the act') but the same cannot be said in terms of risk mitigation through urban and building design [28].

Whilst the act stipulates local arrangements for stakeholders to engage through the (non-statutory) LRF framework, no such formal provision exists for the integration of physical interventions into the built environment, although guidance has been produced on which stakeholders should be consulted when dealing with, for example, terrorism [31]. Interestingly, the act describes the duties of appropriate stakeholders to cooperate in LRFs (formal meetings and allocations of work to responsible stakeholders). The LRFs are based on police areas [32] and provide a forum for the formal integration of a broad range of relevant stakeholders (see Table 1).

Implicit within this framework are a number of stakeholders that might contribute to the design, construction and operation of the built environment; particularly in relation to how the creation and development of the urban environment can reduce the likelihood and mitigate the potential impacts of a disaster or emergency. Some of these stakeholders include civil and structural engineers involved in the LRFs through the inputs of government agencies, local authorities, utilities and transport companies, as well as urban planners.

The incorporation of physical measures into urban and building design has been used to increase resilience for decades, and has arguably been seen as a 'universal remedy' to an ever-increasing array of socio-economic problems, policy

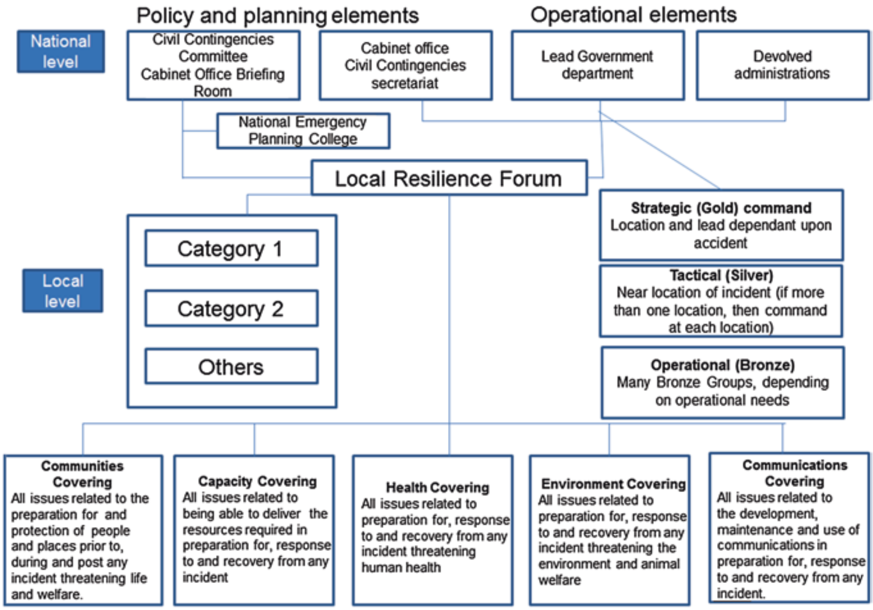

Fig. 1 Emergency response arrangements in the UK (authors' illustration)

Table 1 The range of key 'responders' that should be involved in LRFs in England

Category 1 organisations	
Local authorities	All principal local authorities
Government agencies	Environment Agency, DEFRA, Maritime and Coastguard Agency
Emergency services	Police forces, British Transport Police, fire authorities, ambulance services
Health services	Primary care trusts, Health Protection Agency, National Health Service Acute Trusts (hospitals), foundation trusts, port health authorities
Category 2 organisations	
Utilities	Electricity, gas, water and sewerage, public communications providers (landlines and mobiles)
Transport	Network Rail, train operating companies (passenger and freight), Transport for London, London Underground, airports, harbours and ports, Highways Agency
Government	Health and Safety Executive
Other	Chamber of commerce, non-governmental organisations and social care charities

priorities, and risks and threats that contemporary society faces [33]. The use of such design has traditionally been associated with territorial control (for instance in the face of terrorist threats) through the regulation, restriction and control of access, and ensuring surveillance coverage [22]. Rogers and Coaffee [34] assert that government policy has been concerned with making the environment of cities more attractive as a whole, whilst also improving safety and security, particularly in relation to dealing with terrorist activities. HM Government [31] states that the incorporation of counter terrorism into the built environment is to be achieved within the overall aim of creating high quality public places. Whilst Harre-Young [28] highlights that the protection of places can occur through the use of organisational measures such as business continuity management, concern regarding the modification of the built environment remains a constant presence, as highlighted by Coaffee [35, p. 940]: "*We need to consider the 'physical' changes brought about through counterterrorism measures being embedded in the urban landscape as a result of heightened terror threat levels*".

Nonetheless, at a time when England has experienced an increase in flooding-related events it is arguably most pertinent to consider the multi-hazard/threat approaches to increasing the resilience of urban spaces, rather than risks on an individual and case-by-case basis. For instance research by Harre-Young [28] has highlighted that physical (and managerial) mitigation measures have been proven to do more than their intended outcome, and commercial and fiscal gains can be accrued by doing so, all of which furthers the resilience of the built environment and its longevity (and arguably sustainability).

3 Methodology

The information has been derived from one LRF based in England, which is anonymous in order to protect the identity of respondents involved in the research. The case study LRF is viewed as being representative of other LRFs within England, and comprises all the nominal structures found in such forums. The methodology comprised a literature review using a web-based search of documentation, legislation and organisational information, most of which is readily available online, through local authority and UK government websites. In addition, fifteen key informant stakeholders involved in emergency planning and resilience, and having involvement with the specific Local Resilience Forum were identified using snowball sampling and semi-structured interviews conducted; these include:

- The Flood Management Officer in a city council
- Three Emergency Planning Officers in a city council
- Two Architectural Liaison Officers in local police constabularies
- A Fire and Rescue Service officer, regional emergency services
- A Counter-Terrorism Security Advisor, in a local police constabulary
- An officer of the Civil Contingencies Research Office, in a local police constabulary
- Crime Prevention Officer, local police constabulary
- Two representatives of UK Environment Agency

- Emergency Planning Officer, Fire Service
- Emergency Planning Officer, Mental Health Trust
- Emergency Planning Officer, Health Trust
- Emergency Planning Officer, Care Trust

All interviews were fully transcribed and annotated. A grounded theory approach was taken to their analysis, with initial higher level coding based on the key interview themes such as agency roles and responsibilities, effectiveness, and constraints. Further lower level coding was developed and refined as data analysis progressed. Subsequently, thematic analysis allowed identification of a variety of drivers and barriers. Thematic analysis was chosen due to the complexity of the dataset and the need for a flexible analytical process to provide structure. In this way, key concepts were identified which had wider application, beyond the specific LRF under investigation, to the broader context of LRF stakeholder involvement in urban resilience.

4 Promising Practice in Resilience

One of the aims of this research was to explore the means through which organisations, and urban and building design, can improve resilience, and incentives for doing so. The specific focus on an LRF allowed the key factors in the development of safer and more secure spaces to be determined. Findings were then analysed against those from recent research into urban and building design, which shows how this can increase the resilience of the built environment. Importantly, this research has found that there is not only evidence of promising practice, but that increases in resilience can be an integral part of the sustainability of the built environment. These interventions are more likely to be self-sustaining by adopting approaches that highlight the importance of local level involvement in solutions to local level problems. Feedback from interviewees strongly suggests that the LRF is an effective mechanism that facilitates an integrated multi-agency response. A number of reasons are suggested for this, including effective debriefing practices, the testing and exercising of plans, effective business continuity planning, communicating with the public, engagement with the voluntary services, and the development of community resilience. The three most significant aspects that are discussed below are the relationships between key actors, emergency multi-agency response, and the input of stakeholders into urban design itself, ideally at the earliest planning stages.

Relationships

The LRF encompasses a wide range of organisations, many of which are not considered to be ‘core responders’ (category one) or ‘coordinating responders’ (category two), but are still deemed to be essential ‘other responders’. This broad brush approach appears to offer great benefits, as exemplified by the support offered by organisations such as the Mental Health Trust and the St John Ambulance service. This allows the main responding agencies to be 'back filled' in times of pressure. In order for this system to work, there needs to be a lack of perceived hierarchical status between the agencies. The interviews provided by the various respondents demonstrate a high level of mutual respect and understanding which allows this to succeed.

At an organisational level, the success of the LRF is perceived to be due to "*the fact that they look at every single department, every single group that should be there, it is not just the Police, Fire,* (*city*) *council*" (Senior Manager, Voluntary Service).

This inclusive approach allows the creation of different sub-groups as issues arise, which offer a wide range of expertise. The importance of involving the voluntary services such as the Red Cross, St John Ambulance and the Salvation Army, was noted particularly by several respondents, as "*an integral part of the response*" (Senior Officer—Police). Other LRFs have reportedly disbanded their sub groups but here they are generally seen to be an effective way of working, as "*if you want to produce some meaningful work which is done with cooperation, which is a requirement of the Act, then you really need those sub-groups in place"* (Senior Manager—Planning Organisation).

Good governance and management of those involved is stated as being essential to the effective working of the LRF (Emergency Planner—Local Authority). The Secretariat to the LRF is applauded; it alternates every 2 years between the Town/City and County Councils that, as has been suggested, results in a slight competitive aspect that typically has positive impacts (Emergency Planner—Fire and Rescue Service).Individual personalities are also emphasised as an important factor in the effective working of the LRF: "*I think the partners work well as a group. I think it is personality. And the chairs of most of the standing groups all work well together*" (Manager—Care Trust).

Personal relationships and friendship were also acknowledged as contributing to the success of the LRF: "*There are people there we've known for many, many years, so when you get that it's not complacency. There's a lot of camaraderie and there's a lot of friendship in terms of the will is there to actually do a good job and to help each other. I see that an awful lot and that's very good considering we come from a variety of different organisations with lots of different sort of skill sets and reasons for being*" (Emergency Planner—Local Authority).

This was confirmed by members of many different agencies including the Fire and Rescue Service, the Town/City Council, the Police Force, and the St. John Ambulance. The fact that key stakeholders know each other and the way they work together strengthens the resilience of relationships within the group and ultimately, their effectiveness in planning for and responding to emergencies: *"There's a good willingness to get the work done and do a good job. There's none of this 'Well, we're not going to do that because…' or whatever. Even if it comes to where there're problems* […] *we have to accept that at times and just move on. So there's nothing sort of held against some of the organisations that at times can't help or whatever, but we as a group in the main all work together*" (Emergency Planner—Local Authority).

The LRF also expands its outreach and improves its relationship with private stakeholders such as security companies that work in crowded spaces, the Pub

Watch, the Club Watch etc. While admitting that the inclusion of the private sector is not extensive enough yet, it has been improving, and a number of initiatives, such as collaborative emergency planning development, have taken place.

Despite the fact that LRFs do not have statutory rights, professional and personal relationships allow effective and efficient operations based on mutual support and trust.

Emergency Response—'Planning to Respond'

All the LRF partners can activate command and control procedures when a situation that cannot be managed using normal management structures occurs (Manager—Health Trust). In this case, a Gold (strategic) Commander is identified from the lead agency, followed by lower levels of Silver (tactical) and Bronze (operational). These roles can be subject to change, as for example, a fire might result in the Fire Service leading Gold, however if the site subsequently becomes a crime scene, the Police will take over. The protocols for response are well known and rehearsed among stakeholders and can be operationalized extremely quickly; for example, the Health Protection and Environment Agencies have agreed protocols with the emergency services. Therefore, in a major incident, everyone is familiar with the different roles and who to communicate with, for instance: *"a big factory going up in smoke, they [the Fire Service] would let us know… So then we would deploy people to site, we'd open our incident room up at our office, … and we've got a hierarchy of roles that we would send out and they're trained to go to the right place at the rendezvous point and speak to the right people and respond in a professional way*" (Senior Manager—Planning Organisation).

It is vital to adopt an integrated response at the scene of operation: *"…when everyone just surges to the scene, if we don't understand each other's roles, if our procedures aren't integrated and dovetailed then we're going to tread on each other's toes and be less effective"* (Emergency Planner—Fire and Rescue Service).

In situations which exceed the capacities of the local agencies, mutual aid is invoked with agencies from other regions, with these arrangements also undergoing periodic testing and exercising.

Finally, following any actual incident or training exercise, debriefing is a standard procedure to "*identify the lessons of things that went well or things that you know you could improve on*" (Emergency planner—NHS). These lessons are then used to review and revise existing plans and future responses, resulting in improvements to the previous state of emergency planning.

Input into Urban Design

The Police, the Fire Service and the Environment Agency have input into the design and planning of urban buildings and environments. Specifically in relation to counter terrorism and hazardous sites and substances, the National Counter Terrorism Security Office (NaCTSO) co-ordinates trained Counter Terrorism Security Advisers (CTSAs). These are Police staff embedded within each Police Force to undertake threat and risk assessments and provide advice to a range of stakeholders. The Police also have a number of Architectural Liaison Officers (ALOs), who provide advice to those planning new builds on matters relating to general (non-terrorism related) crime: "*Something we have seen built on is having a very good relationships with* *planners are architects. Certainly with* [*pre-applications*]*, getting involved at grass root stage and be able to influence concepts* […]. *We can give quite direct advice. That's how we influence. We have a different type of hat, a policing hat as opposed to just an architectural hat. And you need to get away from being a police person, to become a hybrid between a police person and a planning person to understand how planners work, and it's not always easy*" (ALO—police).

However, there is no legal obligation for organisations to adhere to any advice provided to them on these matters; therefore these types of initiatives tend to be couched in terms of developing and increasing business continuity [28]. In contrast, fire regulations exist for all buildings and the Fire and Rescue Service has legal responsibility for their enforcement. However, the Fire and Rescue Service only has statutory rights over enforcement of legislation from '*the point at which the building is finished and then occupied*' (Emergency Planner—Fire and Rescue Service).

The Civil Contingencies Act (CCA) also places a legal duty on local authorities and other key agencies through the LRFs to maintain local risk assessments through a Community Risk Register [36] that becomes the basis for supporting the preparation of emergency plans and, in theory but not necessarily in practice, for supporting appropriate decisions regarding urban planning. For instance in the case of attempting to avoid building housing developments in flood prone areas, the publication of "Planning Policy Statement 25: Development and Flood Risk" (PPS25) intended to ensure that flood risk was more rigorously incorporated into the urban planning process. However, recent Government figures (quoted in [20]) suggest that this planning policy has had a negligible impact in reducing the proportion of houses being built in flood prone areas; with on average nearly one in every ten new houses being built in highly flood prone locations in England. As one of the emergency managers noticed: "*I think there is a certain barrier there when you want to work with people that have never considered resilience or emergencies and you suddenly knock on the door and say 'Have you considered this?' And I think planning is one of those areas that they haven't had the wake-up call yet but they might well get the wake-up call"*.

This is arguably not a resilient or sustainable situation, and this indicates, possibly due to the complex format of planning in England, that not all key natural hazards are being suitably addressed through the work of the LRFs.

4.1 Barriers to Promising Practice

While LRFs can be viewed as very successful mechanisms for implementing resilience on a local level, a number of barriers were identified that could impede their success.

Fiscal Constraints

The LRF is not a legal entity and there is no budget for its activities; associated costs are met by the relevant agency or sector involved. However, due to the recent budget cuts, financing LRF projects becomes harder: "*Police say we put* *a thousand* [*pounds*] *in, fire say we will too, and then local authority says well we don't have a thousand. And then what happens? Does the project fail? Or do we go along regardless and you get the thing for free? Anything major, anything significant—really really struggles. The LRF shies away from financial matters because they are too difficult to resolve and you have to rely on best intentions*" (Emergency Planner—Local Authority).

All respondents expressed concerns about the current economic situation, and in particular, the impact of the UK Government's spending cutbacks to public services such as emergency planning. This has resulted in prioritising resources to the groups that have the '*biggest impact*' (Emergency Planner—Fire and Rescue Service) and staff cut-backs have resulted in some issues being left until a later date (Emergency Planner—Local Authority), which ultimately affects resilience (Manager—Primary Care Trust). The full impact of budget cuts is yet to be quantified or qualified, but the fear is it will result in a lack of insurance against incidents, "*because if you want that insurance policy, you need that resilience*" (Emergency Planner—Police Force]. Training and exercise have also decreased as a result of the cuts. Without these, progress that has been made in relation to resilience and emergency planning could be lost. Within these constraints, there is a need to identify long-term incentives and cost-effective solutions for the protection of the built environment.

Harre-Young [28] has identified such incentives and solutions in the context of counter-terrorism design features which include: reductions in risk and damage, competitive gains for engaged stakeholders (particularly construction companies/consultants), etc.

Strategic Sign-Up

Getting senior management to engage with the LRF process was noted as being difficult, as those in senior positions prioritised issues as they saw fit, rather than according to those defined by the LRF. An example is the need for key decision makers to attend meetings: "*you need people there who have got the authority to make decisions that could spend millions if they needed to*" (Manager—Ambulance Service). This is particularly important due to the lack of statutory rights of the LRF: "*It's got no legal powers, it has no budget, so it does depend on goodwill. In the Act it's suggested good practice, but you have to have some kind of senior group that sanctions even if it's not a legislative group. It's got to have somebody… you know, a group that sort of like says "Yeah, we'll do this and we'll go in that direction*" (Emergency Management Office—Local Authority).

There were also concerns about the quality of the multi-agency plans as these are difficult to achieve without high level support*:"…it's about getting people's buy-in for something that you might perceive as important but actually they think it's somebody else's job to do*" (Emergency Planner—Local Authority).

Authorising the mainstreaming of resilience issues within organisations is an area for improvement, and a lack of awareness of agency involvement in the LRF prevents personnel from engaging with the process; the example was given of a community safety department not being involved in a 'warning and informing' sub-group, despite the potential benefit of their involvement. The fact that an

LRF is not a legal entity impacts many areas of operation, including decision making, budget allocation, training and exercise, and engagement with other non-LRF stakeholders. As a civil contingencies officer notes: *"If the LRF had some statutory support, particularly financially, say if you are member of LRF you put in 500 pounds a year just to be a member, then that would give the LRF some way to, well if we have something identified to just do it rather than go cap in hand to EA or whoever it might be"*.

Communicating with the Public

The UK Government's Community Resilience Programme [37] aims to '*increase individual, family and community resilience against all threats and hazards*' (p.5). An important aspect of this aim is the requirement to facilitate discussion between all stakeholders, including central government, emergency services, the voluntary sector and communities on good practice.

Central to the Community Resilience Framework is effective risk communication at local level to increase awareness and enhance public response, and arguably to make community resilience initiatives self-sustaining. The LRF has made concerted efforts towards effective information sharing with the public, with communication experts represented from each agency at sub group level. State of the art methods of communication are increasingly used such as Twitter, which allows the emergency services to more easily see where problems might arise, and to respond to public concerns. Further interventions that would increase resilience require legislation, in order to, for example, allow mobile phone broadcasts to be made: *"…and just blast everybody's mobile phone to say there's been an incident in the city centre, please make your way to wherever, and that technology exists"* (Emergency Planner—Police Force).

A flood warning system used by the Environment Agency to warn the public of flood risk operates, however take up of this is low, as homeowners "*don't want to know because it potentially affects their insurance*" (Senior Manager—Planning Organisation). Consequently, the Environment Agency is considering how to make membership of this list the default position.

These challenges can be attributed to a lack of awareness among the general population. Most of the respondents agreed that there is a need to increase education at school level in order to increase overall resilience. Some also argue that increasing awareness will lead to improvements in overall urban resilience: "*In my opinion it all boils down to education, it's about what we teach our children* […] *it's about educating our youngsters to be more resilient. And then the built environment follows. If you've got a more aware population, they understand how to behave in the urban environment"* (Civil Contingencies Officer—Police).

Increased awareness would also address the over-reliance on local authorities: "*People expect a lot from the government—it's like that explosion last week* (*talking about a house which exploded because of the gas leak*)*, so what's the council going to do for me, where are they going to put me?*" (Civil Contingencies Officer—Police). Emergency management officers agree that the general public has a passive attitude and signs of 'dependency' when it comes to experiencing a natural hazard related emergency: "*Their property floods and their first response is not how do I sort this, but 'I phone the council and the council will sort it*" [Local Authority].

Use of Tools and Hardware
While different agencies use various tools and hardware, there is no common information management system, although all stakeholders can subscribe to the secure National Resilience Extranet (NRE) which was developed by the Civil Contingencies Secretariat to provide access to restricted documents. Although agencies have been encouraged to do this, not all have done so, as it can cost between £15 and 20,000 per organisation: "*…I feel very reluctant to spend public money on tools that I don't think are necessarily going to be of benefit to the trust, patients or staff*" (Resilience Manager—NHS).

Atlas Incident Management System (AIMS) is used by several responders including the Ambulance service, the Police, the Fire and Rescue Service, and the County and Town/City Councils. This system works through logging information and the actions that are required, the allocation of responsibility to achieve those actions, and whether this has been completed or not.

5 Integrating Resilience and Sustainability Approaches

While the implementation of resilience on a local level is straightforward, the issue is not as clear when it comes to sustainability. A number of synergies between sustainability and resilience have been recognised. For example, Harre-Young [28] identified that the incorporation of counter terrorism measures mitigated the impacts of a range of other threats, hazards and major accidents, prolonging the longevity of buildings and urban space, and also highlighted a range of environmental benefits. It is still however unclear how these can be incorporated into the practice of entities such as a LRF.

Synergies between resilience and sustainability might, as argued by Coaffee and Bosher [25] include developing landscapes that are both 'green' and can conform to Crime Prevention Through Environmental Design (CPTED) principles. For example, rather than using traditional and security-explicit barriers such as bollards and concrete blockers, ponds and trees can be strategically placed and used as physical barriers instead, mitigating vehicle-borne crime such as 'car bombs' and 'ram-raiders'. The likelihood and impact of flooding in urban areas could also be reduced, through the use of landscaping and ponds as part of sustainable urban drainage systems (SUDS) [25]. Energy use could be reduced through the integration of security systems with others and embracing 'whole building design', and through the use of thick thermal walls or window films, which can insulate buildings better whilst providing blast resistance and fire protection [25].

While the LRF is seen as a very successful mechanism for implementing resilience on a local level, a number of barriers were identified that would undoubtedly impede their success in incorporating resilience and sustainability. Currently, these are two agendas that are seen as separate issues: "*I think they're two totally different things. For resilience I would think of an engineer that would be working out if one panel falls off a building and then the entire building falls down. So buildings have got an element of robustness against accidental damage which actually also transfers to intended damage. So yeah, I think straightaway I put them in two totally different camps. One is more about structures and the other one is more about integrating efficient usage and trying to get that to a point that you're using a minimum amount of energy. The two don't naturally seem to fit*" (Planner—Local Authority).

One of the main barriers is the wrong perception of sustainability—as it has already been discussed, many respondents define sustainability as 'green' and 'efficient' neglecting the aspects of social well-being and economic development. For example, one of the respondents emphasised that during the application process local authorities and other involved parties (such as police) are '*trying to make a robust micro-economic, social bit of city*', i.e. to improve the overall well-being of the city and their citizens. This fits into a wider definition of sustainability, however this does not come across as sustainability is looked at through the lens of 'green developments' only. In addition, the LRF is concerned about the weather events caused by climate change and thus is starting to talk about resilience to climate change, however again any activities relevant to this are grouped as an 'adaptation' and are not seen as part of sustainability.

It is believed that sustainability should mainly be implemented by construction stakeholders, mainly architects. As noted by one of the respondents, "*there is an expectation that everything that goes out of this practice is as sustainable as it can possibly be.*" (Architect—Private Sector). This leads to the second barrier: whilst the LRF has been trying to engage with a wide set of stakeholders, its communication with construction stakeholders does not go beyond the remits of the LRF (which is often focused on emergency response, whereas sustainability fits better with prevention and preparedness). Whilst interviewees suggested that planning process allows communication among various stakeholders and that the construction stakeholders do actually contribute a lot to it, it does not however appear that sustainability is an important part of that process. In addition, all of the respondents involved in the LRF admitted that sustainability is not considered or even thought of as a part of LRF activities.

However the major barrier for the integration of resilience and sustainability into the LRF practice is the lack of clear messages and incentives from national government. As emphasised by Lizarralde et al. [7], UK policy creates tensions between the two perspective; these include: *achievement vs. capacity* (sustainability focuses on what can be obtained, e.g. in terms of CO_2 emission reductions, whereas resilience puts emphasis on what is available in order to cope with risks and threats); *incremental performances vs. trial and error performances* (sustainability calls for a maximisation of resource efficiency leading to the minimisation of resource consumption, whereas resilience focuses on testing performances based on anticipated scenarios); and *efficiency vs. redundancy* (sustainability suggests a lean approach to development and streamlining process consumption reduction, whereas resilience assumes the consideration of overdesign in order to avoid damages). These two perspectives emphasise diverging priorities and relationships; and such tensions create increased complexity in policy and decision-making, potentially undermining both agendas and making their integration on practice complex and mutually-exclusive.

Lizarralde et al. [7] suggest that the '*built environment will increasingly reveal elements of green, blue and turquoise, and for that matter bluey-turquoise, turquoisey-green, turquoise with a hint of green, or green with a blue veneer, or blue with a green veneer*'. Therefore in the future a more inclusive and joined-up approach to integrating resilience and environmental sustainability should be advanced through the greater collaboration of a wide range of stakeholders—architects, engineers, planners, the police, insurers, surveyors and the public, who should be involved with the planning, design, construction, operation and management of urban spaces.

6 Conclusion

This chapter has explored the interconnectivities between resilience and sustainability in relation to emergency planning and urban design, based on the operations of a specific LRF in England. Ideally, the design, construction and operation of urban space should be based on principles that are both sustainable and resilient. The results of the interviews however show that emergency managers and planners encounter several difficulties in incorporating these principles, notably due to different (and often wrong) perception of the sustainability. Confronted with this difficulty, they tend to emphasise the blue (security/resilience) agenda over the green (sustainability) agenda, leaving the latter to the construction stakeholders.

The case study LRF highlights a range of promising practice in England that increases the resilience of urban space to a number of hazards, threats and major accidents. Central to their successful practice has been effective individual and organisational relationships, familiar structures for command and control, and a level of input into the design of urban space. These examples demonstrate that resilience is actually an integral part of the sustainability of urban space, and not simply compatible with it.

However, such progress is threatened by the potential impact of fiscal constraints and in particular public sector spending cuts, the difficulty in securing senior management engagement with the LRF, and communication and engagement with the public and local communities. These factors are inevitably linked as increased prioritisation is demanded by restricted budgets. Research has already shown that incorporating resilient measures can also lead to environmental benefits and increased sustainability, so there is a need to identify cost-effective solutions for stakeholders so that they continue to prioritise the protection of urban space in this way. Without addressing these broader issues, the success and long-term sustainability of the multi-agency response enshrined in the LRF may not be guaranteed, despite the great skills and efforts of the individuals and organisations involved.

Acknowledgments The authors are grateful for funding that was received for components this research from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 261652.

References

1. Bosher LS, Dainty ARJ (2011) Disaster risk reduction and 'built-in' resilience: towards over-arching principles for construction practice. Disasters: J Disaster Stud, Policy Manage 35 (1):1–18
2. Kibert CJ (2007) The next generation of sustainable construction. Build Res Inf 35(6):595–601
3. Bosher LS, Carrillo PM, Dainty ARJ, Glass J, Price ADF (2007) Integrating disaster risk management into construction: A UK perspective. Build Res Inf 35(2):163–177
4. Tveiten CK, Albrechtsen E, Wærø I, Wahl AM (2012) Building resilience into emergency management. Saf Sci 50:1960–1966
5. Brundtland GH (1987) Our common future. Report of the World Commission on environment and development, United Nations
6. Ahern J (2011) From fail-safe to safe-to-fail: sustainability and resilience in the new urban world. Landscape Urban Plan 100(4):341–343
7. Lizarralde G, Chmutina K, Dainty A, Bosher L (Forthcoming) Tensions and complexities in creating a sustainable and resilient built environment: achieving a turquoise agenda in the UK. Environmental Science and Policy (under review)
8. Errington PL (1953) Reviewed work(s): natural communities by Lee R. Dice. Sci, New Ser 117 (3028):43
9. Blum JL (1968) Salt Marsh Spartinas and Associated Algae. Ecol Monogr 38(3):199–221
10. Holling CS (1973) Resilience and stability in ecological systems. Ann Rev Ecol Syst 4:2–23
11. Manyena SB (2006) The concept of resilience revisited. Disasters 30(4):433–450
12. Rose A (2004) Defining and measuring economic resilience to disasters. Disaster Preven Manage 13(4):307–314
13. Hollnagel E, Woods DD Leveson N (eds) (2006) Resilience engineering: concepts and precepts. Aldershot, Ashgate Publishing, UK
14. Vale LJ, Campanella TJ (eds) (2005) The resilient city: how modern cities recover from disaster. Oxford University Press, Oxford
15. Sapountzaki K (2007) Social resilience to environmental risks. Manage Environ Q: Int J 18(3):274–297
16. Klein R, Nicholls RJ, Thomalla F (2003) Resilience to natural hazards: how useful is this concept? Environ Haz 5(1–2):35–45
17. Clinton WJ (2006) Lessons learned from Tsunami recovery: key propositions for building back better. Office of the UN Secretary-General's Special Envoy for Tsunami Recovery
18. Bosher L (ed) Hazards and the built environment: attaining built-in resilience. Taylor and Francis. ISBN: 978-0-415-42730-2
19. Alexander D (2013) Resilience and disaster risk reduction: an etymological journey. Nat Haz Earth Syst Sci Discuss 1:1257–1284
20. Bosher LS (2014) 'Built-in resilience' through disaster risk reduction: operational issues. Build Res Inf 42(2): 240–254
21. Perelman LJ (2008) Infrastructure risk and renewal: the clash of blue and green. In: Public entity risk institute symposium, 4–18 Jan Faifax, Virginia, USA
22. Coaffee J, O'Hare P, Hawkesworth M (2009) The visibility of (In)security: the aesthetics of planning urban defences against terrorism. Sec Dialogue 40(4–5):489–510
23. Coaffee J (2008) Risk, resilience and environmentally sustainable cities. Energy Policy 36(12):4633–4638
24. Fussey P, Coaffee J, Armstrong G, Hobbs R (2011) Sustaining and securing the olympic city: reconfiguring London for 2012 and beyond. Ashgate, Farnham

25. Coaffee J, Bosher LS (2008) Integrating counter-terrorism resilience into sustainable urbanism. Proc Instit Civil Eng: Urban Des Plan 161(2):75–83
26. DEFRA: adapting to climate change. https://www.gov.uk/government/policies/adapting-to-climate-change (2013)
27. DEFRA: guiding principles for sustainable development. http://sd.defra.gov.uk/what/principles/
28. Harre-Young SN (2012) The relative performance and consequences of protecting crowded places from vehicle-borne improvised explosive devices. Unpublished Ph.D. Thesis, Loughborough University, UK
29. Cabinet Office: Glossary: revision to emergency preparedness (2012) https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/61046/EP_Glossary_amends_18042012_0.pdf
30. Civil Contingencies Secretariat (2004) Civil contingencies act 2004: a short guide. Cabinet Office, London
31. HM Government (2012) Crowded places: the planning system and counter-terrorism. Home Office, London
32. HM Government (2004) Emergency preparedness. Her Majesty's Stationery Office, London
33. Bretherton J, Coaffee J (2009) Urban design and planning challenges and opportunities. Proc Instit Civil Eng: Urban Des Plan 162(1):35–36
34. Rogers P, Coaffee J (2005) Moral panics and urban renaissance: policy, tactics and youth in public space. City 9(3):321–340
35. Coaffee J (2010) Protecting vulnerable cities: The UK's resilience response to defending everyday urban infrastructure. Int Aff 86(4):939–954
36. Cabinet Office: The National Risk register (2013). https://www.gov.uk/risk-assessment-how-the-risk-of-emergencies-in-the-uk-is-assessed
37. HM Government (2011) Strategic national framework on community resilience. Cabinet Office, London

Wicked Problems Framework: Architectural Lessons from Recent Urban Disasters

Alexandra JaYeun Lee

Abstract This chapter extends the design framework of Horst Rittel (1930–1990), who argued that complex societal problems that cannot be addressed using linear systematic processes, namely, 'tame' problems, may need alternative approaches, since they are 'wicked' in nature. Urban issues such as informal settlements, poverty, and overcrowding, are merely the physical symptoms of deep systemic issues beyond the control of planners and architects alone, and hence, are 'wicked'. Rittel, a thought leader of design thinking, coined the expression "Wicked Problems" in 1973 to describe the complex issues of society situated in the real world that cannot be solved using rationality alone. In fact, such issues need transdisciplinary understanding and action to optimise decision-making based on multiple viewpoints and methods of inquiry.

Keywords Horst Rittel · Wicked problems · Disaster recovery · Community development · Democratic design

1 Introduction

1.1 Resurgence of Democratic Design

Societal progress through scientific innovation and architectural design has long been a central endeavour for the architectural profession, mandated through institutional code of practice, and rewarded through peer recognition and professional awards. By and large, however, the architects' service to society is demonstrated through practice. For instance, the community architecture movement of the 1960s remains an

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A. Masys (ed.), *Disaster Management: Enabling Resilience*,
Lecture Notes in Social Networks, DOI 10.1007/978-3-319-08819-8_6

emphatic example of the design profession's commitment to and a concern for social justice. Such practices were motivated in part due to the rapid urbanisation of industrial cities and the proliferation of government-funded mass housing developments [33], p. 69), most notably in the UK and the U.S. In the UK the self-build champions such as Turner [62] and Habraken [31] mobilised a new generation of builders and steered the government authorities to make the state-led developments more inclusive and democratic. In the U.S. a similar movement came to be known as the Community Design Centres. In the last decade, the community design movement is experiencing a rapid resurgence under familiar expressions such as, "participatory design", "community-led design", "co-design", "human centred design" and "public interest design". The concept of community-centred, democratic design methods has also become widespread in other disciplines, credit to Horst Rittel, a UC Berkeley professor of architecture who coined the expression "wicked problems" in 1973.

2 Background

2.1 Theories of Horst Rittel (1930–1990) and the Wicked Problems

Rittel's concept of "wickedness" describes a class of problems that are ill-defined, complex, and for which there are no straightforward solutions, in contrast to "tame" problems that can be rationalised, and relatively simple to solve. Tame problems Rittel argued that most societal issues are *wicked*, because most real world problems have multiple facets and considerations that cannot be solved using rationality alone. As such, wicked problems require transdisciplinary response. The concept of sustainability, for instance, cannot be considered from a single perspective, but requires knowledge and experience of multi-scale, multi-generational, multi-disciplinary methods of inquiry [38]. Wicked problems require industries to work together, rather than in their siloes. Wicked problems form an integral part of the society that generated them, thus their resolution requires change at societal level. Brown et al. [11] argued that "transdisciplinary imagination" is essential in approaching wicked problems for "just and sustainable decision-making" (Brown et al. [11] pp 4–5).

2.2 Wicked Problems and Disasters

Many of the *wicked* attributes of society are amplified in a state of chaos, and nowhere is this more evident than in the early days of a natural disaster in cities. In the past decade, the community architecture movement has extended to disaster recovery, with the emergence of non-profit organisations such as Architecture for Humanity (U.S.), Emergency Architects (FR), Article 25 (UK), and Architects Without Frontiers (AUS) specialising in disaster recovery architectural service and consultancy. By and large, however, architectural contributions to disaster recovery are few and far between, existing as part of a humanitarian agency sponsored technical manuals for emergency/transitional shelters, or brought in towards the end of the critical recovery period to rebuild infrastructure and housing. Architects are generally considered in public as the last responders to disasters [15]; Lee [39]; Sanderson [52]; Boano and Hunter [8]. Charlesworth [16] noted that architects are seldom party to the critical political decisions that determine the reconstruction vision of post-conflict cities, and suggested "architects should adopt an interventionist stance by taking a professional stand against the violation of human rights… [using] their design expertise" (p. 16). In finding that architects have little political influence in post-conflict cities, Charlesworth sets out a challenge for architectural researchers: "How can architects engage in… the problem-sharing processes needed in urban centres… broken by systemic urban conflict? Is it our role to provide the definitive solution, or rather to provoke… collective action in rebuilding civil society after the disaster…?" (p. 132) While Charlesworth does not situate her research in terms of *wicked problems*, the evidence of the wickedness is ubiquitous in her characterisation of urban disaster problems as needing to be "[shared]", and in the inherent challenge of providing a "definitive solution" in a place of systemic conflict. This paper re-evaluates these issues by employing the Rittelian strategy of design inquiry to evaluate the *wicked* aspects of urban disaster recovery process.

This paper argues that reconstruction strategies in many post-disaster sites have failed largely because the *wicked* issues of architectural design have been approached as *tame* problems. Wicked problems require an open systems approach that embraces multiple methods of constructing knowledge, that is, from the collective knowledge of both professionals and civil society, and from the "humble position of uncertainty and provisionality" (Brown et al. [11], p. 39) rather than that of linear, positivist rationality that have, thus far, dominated post-disaster management. So how is the architectural notion of "wicked problems" relevant to democratic design decisions in urban disasters?

2.3 Reflection on Systems Thinking

In the first instance, it is useful to look back on what prompted Rittel to distinguish the tame problems versus the wicked problems, in which he classified the former as the first generation systems approach and the latter as the second generation systems approach. According to Rittel [48, 49, 50], the systems thinking of the first generation pertains to "attacking problems of planning in a rational, straightforward, systemic way" (1973, [48, 50], p. 390) which has enabled revolutionary progress in aeronautics and led to improvements in health systems and the environment. However, Rittel observed that such early successes in the systems thinking were short-lived, because "most research about creativity and problem-solving behaviour is about 'tame' problems… (yet) all essential planning problems are wicked" (p. 392). Where the problem is insufficiently understood, and where the consequences of an action taken in response to such problems are unknown, the classical systems approach can lead to catastrophic failures. Herbert Simon described such problems "ill-structured problems" [55], and Donald Schön called them the "swampy lowlands" of reality [53]. Urban issues such as informal settlements, poverty, and overcrowding, are the physical symptoms of more complex, interdependent systemic issues beyond the control of planners and architects alone, and hence, are 'wicked'.

3 Methods

3.1 *Ethnographic Research*

A critical study on architecture's relationship to urban disasters seeks a broad understanding of the attitudes and intentions of architectural professionals. The author has opted to undertake an ethnographic study of such architects rather than electing to study the specific buildings designed by them. Yet because architecture is a discipline grounded in practice, case studies are a common research method in architectural research [57] and this research has undertaken to study three of the recent events in Haiti, the United States, and New Zealand, and interviewed some 50 experts who have experience in at least one of the three disasters at those locations in the last decade. In lieu of undertaking longitudinal research of how professionals responded to disasters at different phases of recovery, the research took a snapshot of their activities across three case studies at different phases of recovery. The most profound observation to emerge out of undertaking research across the three countries was not only the extent to which the research informants were previously acquainted with one another within each case site, but also the fact that these relationships were found to be common across multiple disasters (Fig. 1). The complex interrelationship of experts within the field revealed the close-knit nature of the expert community at such sites, as well as amplifying the importance of a sense of community in establishing an effective practice.

3.2 *Ontological Rationale*

In terms of the methodology employed, the author followed a mixed methods research that resonates strongly with the ontological position of Rittel. This study combines an empirical approach of theory elaboration as developed by Diane Vaughan [63] and a constructivist grounded theory method as developed by Kathy Charmaz [17–19]. Constructivist grounded theory methods combine the reflexive nature (i.e. construction) of semi-structured interviews with the analytical methods of grounded theory. Theory elaboration methods set out a robust criteria for validating a theory, whereby the theory to be tested is triangulated from multiple perspectives, academic rigour, transparency, and at multiple scales (or 'units of analysis'). At the centre of both these methods is the recognition of self, and ways

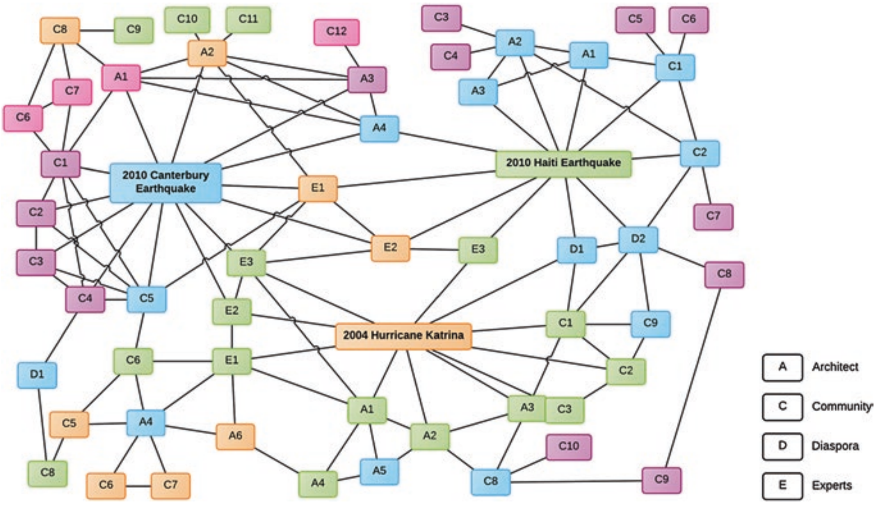

Fig. 1 Social network diagram of interview participants

of relating to others. This means that in order to undertake a research about democratic design, and in order to make a fair representation of views about a particular architecture (whether whole or in part), the research must draw on the experience of the insider (the designer) as well as the outsider (the intended occupant or user). In other words, both grounded theory and the theory elaboration method can make *explicit* what has been made *implicit* by the researcher.

3.3 The Rittelian Framework

How these methods are relevant in testing the Rittelian framework is straightforward. This paper argues that the constructivist approach can help to untangle some of the design problems of *wicked* situations, based on the following observations. First, the *wicked* problems framework shares the philosophical position of theory elaboration in their acknowledgement of multiple realities and the value of transparency. Second, the grounded theory research is recognised as one of the first ways in which humanities researchers were able to quantitatively evaluate qualitative data [25]. By employing a set of robust, tried-and-tested analytical tools developed by sociologists and ethnographers since the 1960s, it is possible to deduct useful insights from interviews, using analytic strategies such as ‘coding’, ‘theory generation’, and ‘constant comparison’. Third, the method enables a cross-sectional comparison between disparate units of analysis and distillation of large quantity of data through the process of ‘abductive’ reasoning. The research has yielded three key themes as follows.

4 Top-Down Strategies

4.1 Build Back Faster

Rittel's characterised design as an activity, which is "intended to bring about a situation with specific desired characteristics without creating unforeseen and undesired side and after effects" (Rittel 1978, as cited in [46]). However, whether the aims of 'build back better' are fulfilled on the ground is debatable. Since the establishment of the United Nations in 1945, the humanitarian aid sector has progressively increased its influence by partnering with first-responder government agents and other specialised NGOs in response to humanitarian crises, whether natural or human-induced. Though considered "natural" disasters, cyclones and earthquakes are increasingly associated with human activities, as a product of how we design, manage, and live in our cities, using the resources available around us. International aid agencies and governments often rush in their policy decisions in an attempt to demonstrate resilience after a major disaster.

Nevertheless, systemic approaches that fail to consider the long-term effects can backfire, sometimes exacerbating the effects of the disaster itself. The agenda for building back better changes according to how a given disaster agency interprets its physical manifestation. In Haiti, it became 'Build Back Better Communities' (BBBC); in New Orleans, it became 'Bring New Orleans Back'; and in Christchurch, 'Restore Christchurch Cathedral'. A case in point, Haiti's international design competition, BBBC, was an abysmal failure. Spearheaded by the former U.S. President Bill Clinton and the Republic of Haiti's Prime Minister Michel Martelly who jointly presided over the Interim Haitian Recovery Commission, launched the initiative in the hopes of developing new low-cost permanent housing solution for Haitians. The initial Request for Proposal (RFP) had four criteria: (1) to use durable local building materials, (2) to be buildable using local Haitian labour, (3) to be affordable and earthquake resistant, (4) to use green technologies where possible [42]. The RFP drew over 350 submissions from around the world, out of which some 140 entries were shortlisted and invited to present their full-scale prototype at the housing expo and some 60 eventually delivered.

Unfortunately, there are some major oversights that turned this ambitious endeavour into a failure. The amount of financial resources that could have been used for more urgent, systemic housing problems in Haiti pales in comparison to billions of dollars in aid that was pledged but has yet to be delivered. In fact, the campaign was illustrative of the reason why Haiti is often referred to as the 'Republic of NGOs' [37]. The housing for Haitian citizens were wholly outsourced to foreign design professionals, not many of whom adequately understood the social, cultural, political, environmental realities of Haiti. The outcome of BBBC led to an alienation of its own citizens, castigating the survivors under a veil of political 'tokenism' [5] where one maybe seen (populations in crowded areas are assigned limited housing aid) but not heard (their minimal housing needs are not met). What resulted was a cluster of militarised transitional housing compounds fabricated overseas—symbolically reminiscent of Western ideologies.

In the temptation to *tame* the *wicked* nature of Haiti's crisis, some experts have resorted to dismissing this earthquake as just another Haitian tragedy [54].

4.2 Yearning for the Past

A German philosopher, Friedrich Hegel popularised the notion that, "all we learn from history is that we learn nothing from history". Perpetuation of Hegel's adage is still evident today not only in urban planning decisions and policies but also in behaviours of disaster survivors that reinforce this phenomenon. An urge to return home has been a defining behaviour of displaced survivors, irrespective of the expert advice given [13], Potangaroa and Kipa [45, 56]. There is a high probability of a disaster becoming a recurrent event, even though the specific intervals of its recurrence are not always predictable (particularly earthquakes). Yet rebuilding over the likely path of *future* disasters is a commonplace amongst the survivors of disasters. People's sense of attachment to the land—whether personal, social, commercial, historical—is only heightened by the stark absence of place that had forged their identity pre-disaster [12]. The devastation of the February 2011 earthquake—which was essentially an aftershock of the September 2010 earthquake—muted the discourse on architecture and heritage at large, but the Christchurch Cathedral remained a contentious topic for all. Some supported its demolition, while others wanted to see it reinstated. Architecture became a battleground for earthquake-battered Christchurch citizens who saw it as a symbolic opportunity to reassert their 'right to the city'. The cathedral became a media poster-child for the earthquake, and also a symbol of Christchurch residents' identity, and perhaps, the last vestige of resilience and hope amid the lack of certainty.

4.3 Discord Between Knowledge and Action

Rittel characterised wicked problems as having no immediate and ultimate test of a solution (1973, p. 392), which is also applicable to how people assess disaster risk. The main hindrance to understanding disasters remains to be the perception that natural disasters are high impact events with low probability occurrence (HILP), which some would dismiss as having zero probability [23]. Dunlap and Michelson [28] argued that the society-wide underestimation of disaster risk is a direct result of the reactive nature of social response to disaster. For instance, disaster risk mitigation measures can be difficult to enforce as the needs are not immediate, and consequently, the potentially devastating impact of a disaster is left unaddressed. In the cases of both Hurricane Katrina and Canterbury earthquake, risk assessment for potential disasters was undertaken within a couple of years prior to both events, but in neither cases had these reports resulted in any changes in policy or mitigation measures. Furthermore, Alexander [4] argued that, while building codes can regulate the design, construction and maintenance of structures within its jurisdiction to protect its users and occupants from the forces of disasters, the technological protection measure have not kept pace with the growing vulnerability of places with high risk to disasters (2006: 6).

Lessons in 'building back better' from the case studies thus far converge on the fact that *how* one might build back following a disaster hinges on *what* the appropriate definition of building back better is. Too often, post-disaster cities are 'built back' into a 'worse' state than before, making itself vulnerable to future events of similar magnitude. Authorities in underdeveloped nations governed by policies that prioritise short-term gains and populist agendas are unlikely to invest in disaster planning and management because their payoffs are uncertain. Building back entails an impossible task of replicating a pre-disaster city in a post-disaster context. While disasters often result in short-term exodus of survivors, many of those displaced by the event display remarkable persistence in their resolve to return to original sites of destruction despite the risks of doing so. Public denouncement of Mayor Nagin's 'Bring Back New Orleans' plan, which sought to replace entire neighbourhoods with green fields, illustrates the extent to which communities can mobilise together to reinforce a sense of belonging and the importance of *home* versus a *house*. Development of 'Unified New Orleans Plan' forced dozens of independent planning initiatives to reconcile their differences but also to expose blind spots, identifying new perspectives that made people's needs more transparent as a result. This further reinforces that most people are not resistant to change; they fear change when they lack transparency; they fear change when they perceive what they might lose as a result of change outweighs the benefits of change. The key issue here, however, is *for whom* rebuilding can be considered 'better'. Top-down architectural and planning interventions have limited success without strong engagement with the community throughout the recovery process, from inception through to completion.

In exploring the various nuances of 'build back better', the author learned that those accustomed to operating in an autocratic manner see the objectives of 'building back better' as simply an invitation to 'build back faster' under the mantle of 'progressive' design and 'avant-garde' concepts, but the social reality of post-disaster complexities suggests they can undermine the *wicked* problems of *building back better*. This observation does not contradict the need to restore key physical urban infrastructure as a first-response. Rather, it serves to highlight the importance of having mechanisms in place to help rebuild *communities* as an equally important consideration for improving the overall resilience of a place. But how this may be achieved in practice is another wicked problem, which is discussed in the next section.

5 Bottom-Up Tactics

5.1 Design as Power

In his 1987 essay, *The Reasoning of Designers*, Horst Rittel stated, "everybody designs sometimes; nobody designs always. Design is not the monopoly of those who call themselves 'designers'." (p. 1). Yet, Rittel proposed that design is associated with power, but moreover that designers are actors in the application of power (p. 6). The recognition that every person affected by a decision being made has at least some power to influence lies at the core of an argument for democratic decision-making. Participation of disaster victims in rebuilding projects remains a major challenge for disaster recovery [24]; Kendra and Wachtendorf [34] because community engagement is a resource-intensive activity, monetarily and in terms of time. Incidentally, money and time are two resources that are always in short supply [47], which lead many field practitioners, however reluctant they may be, to rely on improvisation to solve most of the challenges they encounter on the ground. Seasoned professionals have some advantage in that they are more nimble and familiar with this state of post-disaster chaos, are thus able to navigate through the complex reality by cutting through bureaucracy to arrive at solutions that no technical manuals can provide. But another wicked problem that emerges in post-disaster context is that in many cases, there are no manuals or 'how-to' guides to start with. In Haiti, where there has not been any state level enforcement of national building code to speak of prior to the 2010 earthquake, the proliferation of *bidonville* (urban informal settlements) in the decade leading up to the event was the primary contributor to the loss of lives, and illustrates that such urban disasters are exacerbated through human actions. But the absence of national building code in Haiti is a symptom of larger, systemic problem, which many scholars argue has been compounding since their independence in 1805 [21, 26, 27], and some claim to go back as early as 500 years [44].

5.2 Wicked Problems of Social Cohesion

The extent to which citizen participation leads to project success or failure is often determined by whether the agents of power are working *with* people or exerting power *over* people [29]. A key challenge that remains is that while there is a considerable difference between the design outcomes of the two approaches, the engagement processes of these approaches are, on the surface, seldom discernible from one another, and are thus difficult to measure.

Following a major urban disaster, disaster recovery agencies operate under constant pressure to expedite through the early emergency phase continuing through to recovery, often leading to early burnouts and high staff turnover. Coupled with the fact that disasters catch most of its victims off-guard, each disaster is often the incumbent political leader's first [51]. This does not mean that the institutional structure for disaster management has little impact in the processes of recovery. In the U.S., for instance, emergency response to natural disasters remains the responsibility of local government, wherein the incumbent mayoralty has statutory authority as well as accountability over civil military activities within his or her jurisdiction [20]. So then at least in theory, having the direct means to call upon local professionals and to direct first responders where the needs are most dire gives the regional network of disaster responders, which includes the local members of community, power to effect change. By contrast, in New Zealand, civil defence remains the responsibility of central government [9], which is conducive to a top-down disaster response and reconstruction process. The political actions employed by the local authorities since the 2011 Christchurch earthquake were described by the local media as ‘scapegoating’, ‘hiding’, ‘excluding’, and ‘not communicating’, which reflects the way authorities have managed uncertainties and the recurrent aftershocks. Such reactionary tactics, in turn, can obstruct community’s ability to contribute in early design decisions. After all, the Haiti earthquake illustrates that systemic interventions, be they building codes or regulatory frameworks around deforestation or arbitrary tariffs on local produce to make imported goods more competitive, are what Rittel calls, *constraints* (1987, p. 6), which in the end are self-imposed and negotiable, rather than absolute or necessities in the eyes of power brokers.

But when the central governing authority is no longer able to keep pace with the changing demands of disaster recovery, or in the case of Haiti, physically falls apart, disaster opens up opportunities for new leadership to emerge. In Foucauldian sense, disaster creates an opportunity to create an alternative space, or “places of deviation” that falls outside the established norm within society (Foucault 1986). Boano and Hunter [8] characterised post-disaster sites as offering a depoliticised arena for reproduction of space (p. 1). Post-disaster sites can lead to production of new space—to be contested by community in the absence of a clear authority. So how might communities harness this newfound opportunity towards stronger social cohesion and resilience?

Disaster scholars argue that communities with strong networks affect the ability of individuals to activate informal ties in disaster (Hurlbert et al. [32], as was demonstrated in New Orleans after Hurricane Katrina [3], where “higher levels of social capital facilitate recovery and help survivors coordinate for more effective reconstruction” [2]. Neighbourhoods that were well-connected had a better chance of survival than those who were not. Knowing one’s neighbours, Aldrich argued, exceeded the benefits of governmental support and economic resources. Not surprisingly, those without access to private vehicles were from lower socioeconomic neighbourhoods, in low-lying lands of the Mississippi Delta are those who suffered the most flood damage.

5.3 *Design as Choice*

In reality, equitable citizen participation requires leadership and responsibility from all sides—not just politicians, policy makers, and technical experts—but also from the community whose constituents are diverse and knowledgeable. Design equity is as much about making professional services available to communities in need as much as it is about democratizing the process of rebuilding generally. Where equity is not sufficiently present, however, the study found that the local community finds empowerment through tackling the wicked problems themselves.

A Latin adage, *nihil de nobis, sine nobis*, ('nothing about us, without us, [is for us])' which is often employed by post-disaster community organisations reinforces an understanding that empowerment is obtained not by having problems solved by others on their behalf, but by being supported to tackle many of the *wicked* problems themselves. The Christchurch earthquakes became a catalyst for galvanizing communities, and the overall improvement in social resilience has been a valuable outcome of the disaster. Suburban communities like the Port Hills, Sumner and Lyttelton, that were initially 'forgotten' by council authorities in the early days of the earthquake implemented innovative resilience strategies such as 'time banking', which enabled local communities to share their resources through exchanges of time credits, and established community-led urban design groups to positive effect. These communities demonstrated a strong sense of local identity and solidarity, enabling them to bounce back more quickly compared to those who waited for actions by the powers-that-be. In the case of the latter, such external interventions tend to resemble a stopgap rather than a long-term solution.

Disaster can serve as a catalyst for renewing community spirit and resilience against future disasters, and, in many cases, creates an even stronger sense of community than before [1, 36, 58]. Solving problems according to the community's values—irrespective of whether they align with expert advice—is an ethical consideration for professionals engaged in disaster recovery projects, and also an opportunity to challenge the existing mores of professional practice. Design is an equalizer that has the potential to re-empower communities struggling to restore their sense of belonging and identity.

5.4 Overcoming Disaster Capitalism

At the other extreme, architects can become inadvertent instruments of what Klein [35] calls, "disaster capitalism". As multiple agencies jockey for control in a state of disarray, politicians and professionals who work for them can just as easily be turned into public scapegoats. As people search for answers amid a climate of uncertainty and trauma, misunderstandings often exaggerated through the media can breed public contempt for even the most well-meaning professionals. In the early days following the September 2010 earthquake in Christchurch, where no human casualty occurred, the primary concern for the nation was to determine the fate of unreinforced masonry structures, many of which were heritage and character buildings. The New Zealand Institute of Architects (NZIA) responded by appointing an Architectural Ambassador to serve as the expert liaison for architects in the public arena. The selected architect, Ian Athfield, was known for a number of successful public works around the country but the fact that he was born in Christchurch was a lesser-known fact. So when the incumbent Mayor Bob Parker made a public endorsement of Athfield's appointment the next day, the media interpreted as part of Parker's political bid for reappointment of his term [22]. While professionals can and often do intervene, any suspicion of agendas that serve personal rather than public interest can backfire on their efforts to assist in disaster recovery efforts. In New Zealand, architects were much more successful outside of the media limelight. At the national level, the NZIA worked with the government's Department of Building and Housing to develop strategies for mass housing; Athfield proceeded to give over 50 public talks in his first year of his formal appointment as the ambassador, helping to improve the public's understanding of architecture; but most importantly, many local architects offered pro bono service to the public, and worked as building assessors to salvage historic buildings that were erroneously marked for demolition.

Despite such efforts, the 2010 and the 2011 earthquakes in Christchurch remains the most economically devastating event in New Zealand's history. In a 2012 Swiss Re report, the Christchurch earthquake ranked third in economic losses resulting a major earthquake as a percentage of its GDP, following Haiti (121 %) and Chile (18.6 %). The 2011 Tohoku earthquake in Japan, while it tragically took over 220,000 lives, its economic impact stood at 5.4 % [7]. However, the state-owned asset sales as a default economic strategy by the central government, apart from being unpopular to residents, reinforces familiar tactics of disaster capitalism as seen in New Orleans and Haiti. Even though scholars argue that government-led asset sales is a valid route of recovery strategy from lost economic productivity [30, 59] argued that New Zealanders are opposed to free-market capitalism. The free-market policy is intended to foster innovation, but the lack of design controls or establishment of standards meant that overall quality is lowered rather than pushed up. Disaster can equally pave the way for heroic grassroots movements and community leaders to flourish, but in the absence of architectural anchors, such as the aforementioned Christchurch Cathedral, that defined the community, neo-liberal forces and hegemonic political-interest-groups can equally hijack the opportunity to advance radical changes at the expense of disaster victims. Political proponents argue that the expert-centred reconstruction is less time-consuming and more straightforward in decision-making and policy implementation, but short-term advantages gained by such methods are lost in the longer term compared with the community-centred approach. There is no illusion that architects, even those who aspire towards the common good, are necessarily political. Rittel (1973) contended, "no plan has ever been beneficial to everybody", because decisions are "usually compromises resulting from negotiation and the application of power." That architects are party to such a process, Rittel argues, is what makes the very act of design a "political commitment".

Inasmuch as the socio-aesthetic convergence of architecture as an end product and as a process can create tensions around architectural identity and empowerment, the concept of community design warrants further reflection in terms of what it means (and for whom) in the post-disaster context. While the involvement of architects in times of disaster offers no singular panacea to the complex environment of disasters, architects involved in disaster recovery have the moral obligation to consider the consequences of the professional service rendered as the legacy of their work will outlive those of most other experts, including the first responders to disasters.

6 Conclusion: Beyond the Wicked Problems, an Argument for the Design Democracy of the Third Generation

6.1 Future of Democratic Design

The Rittelian framework, while not explicitly employed by the agents of disaster recovery as a formal strategy, its relevance is unequivocal for those who seek to establish community cohesion and empowerment. Additionally, by framing post-disaster decision-making processes in terms of *wicked* problems design-enablers in each community can better navigate the complex environment of disasters. To build societal resilience, public design education—more specifically, training in democratic design process—is invaluable in societies where the only constant is change. Democratic design can foster creative capacities in our communities and increase resilience by reducing societal vulnerabilities. Since 2011, Christchurch has embraced change by hosting dozens of innovative events and projects. A case in point is the annual Festival of Transitional Architects (FESTA), a weekend dedicated to exhibiting new architectural ideas and celebration of Christchurch's transition into a new city. It has spurred the global travel publication Lonely Planet to place Christchurch 6th in the "Top 10 Cities for 2013" for "rising from the rubble with a breathtaking mix of spirit, determination and flair"[41], and projects such as FESTA illustrate that architecture can serve as a powerful medium for expressing a community's resilience and solidarity.

Some critics of humanitarian designers argue that architects are the last responders to disaster [43, 52], but this paper demonstrates that architects should work alongside the first responders, and particularly with affected communities, because the groundwork for last responders cannot wait until after the decision-makers and key stakeholders have left the room. This research began with the question of how the 'wicked problems' framework is relevant to urban disasters, and has found that wicked problems are, in fact, everywhere. Design leadership in the context of urban disasters often implies physical transformation of post-disaster environments, but this paper demonstrates while the symbolic impact of architecture through its lifecycle of construction, destruction, and reconstruction, remains a powerful force for those it serves; architecture is an equally powerful agent in giving communities voice in the process of disaster recovery.

Tim Brown, the founder of global design consultancy IDEO, defended that society needs T-shaped professionals—people who not only have deep specialisation in his or her field, but also ability to empathise with others [10]. In other words, we need more architects. Yet an ethical pathway for architects cannot be pre-defined [39, 40], as the reality of the working environment tends to be swamped with *wicked* problems that require a series of improvised decisions and choices rather than those based on proven solutions from the last century. The experiences of disaster professionals interviewed reaffirm that creativity is an essential skill to have on stand-by, because design, ultimately, is a renewable resource and a source of community empowerment.

References

1. Aguirre B et al (2005) Institutional resilience and disaster planning for new hazards: insights from hospitals. J Homel Secur Emerg Manage 2(2): p. Article 1
2. Aldrich DP (2012) Building resilience: social capital in post-disaster recovery. University of Chicago Press, Chicago, IL
3. Aldrich DP, Crook K (2008) Strong civil society as a double-edged sword: siting trailers in post-Katrina new Orleans. Polit Res Q 61(3):379–389
4. Alexander DE (2006) Symbolic and practical interpretations of the hurricane Katrina disaster in New Orleans (Online). Social Science Research Council, Brooklyn, NY. (cited on October 11, 2012) Available from: http://forums.ssrc.org/understandingkatrina/symbolic-and-practical-interpretations-of-the-hurricane-katrina-disaster-in-new-orleans/
5. Arnstein SR (1969) A ladder of citizen participation. J Am Instit Plan 35(4):216–224
6. Bell B (ed) (2004) Good deeds, good design: community service through architecture. In: 1st edn. Princeton Architectural Press, New York, NY. 239
7. Bevere L, Gorollimund B (2012) Lessons from recent major earthquakes. In: Villat J (ed) Economic research and consulting. Zurich, Switzerland, Swiss Reinsurance Company Ltd
8. Boano C, Hunter W (2012) Architecture at risk ? The ambivalent nature of post-disaster practice. Architectoni.ca 1(1): 1–13
9. Britton N (2007) National planning and response: national systems, in handbook of disaster research. In: Rodriguez H, Quarantelli EL, Dynes RR (eds). Springer, New York, NY. 347–367
10. Brown T (2005) Strategy by design, in fast company June 1, 2005, fast company: Harlan, IA. Available from http://www.fastcompany.com/52795/strategy-design
11. Brown VA, Harris JA, Russell JY (eds) (2010) Tackling wicked problems through the transdisciplinary imagination. Earthscan, London, UK
12. Brunsma DL, Overfelt D, Picou JS (eds) (2007) The sociology of Katrina: perspectives on a modern catastrophe. Rowman and Littlefield Publishers, Lanham, MD
13. Campanella R (2010) Delta urbanism. American Planning Association, Chicago, IL, New Orleans
14. Cary J (2012) Public interest design: from idealism to realism. (cited Oct 14, 2012); History of Public Interest Design. Available from http://www.publicinterestdesign.org/infographic/
15. Cesal E (2010) Down detour road : an architect in search of practice/Eric J. Cesal. MIT Press, Cambridge, MA. p. ix, 227
16. Charlesworth ER (2006) Architects without frontiers: war, reconstruction and design responsibility. Architectural Press, Oxford, UK
17. Charmaz K (2000) Grounded theory: objectivist and constructivist methods. In: Denzin NK, Lincoln YS (eds) Handbook of qualitative research. Sage Publications, Thousand Oaks, CA. 509–535
18. Charmaz K (2006) Constructing grounded theory. Sage Publications, London, UK
19. Charmaz K (2011) Grounded theory in the 21st century. In: Denzin NK, Lincoln YS (eds) The sage handbook of qualitative research. Sage, Thousand Oaks, CA. 507–535
20. Col J-M (2007) Managing disasters: the role of local government. Public Admin Rev (Special Issue): 114–124
21. Concannon BJ, Lindstrom B (2012) Cheaper, better, longer-lasting: a rights-based approach to disaster response in haiti. Emory Int Law Rev 25:1145–2011
22. Conway G, Greenhill M (2010) Row grows over rebuilding. In: The Press, Fairfax New Zealand News Limited, Christchurch
23. Daniels RJ, Kettl DF, Kunreuther HH (eds) (2006) On risk and disaster : lessons from Hurricane Katrina. University of Pennsylvania Press, Philadelphia, PA
24. Davidson CH et al (2007) Truths and myths about community participation in post-disaster housing projects. Habitat Int 31(1):100–116
25. Denzin NK, Lincoln YS (eds) (2011) In: Denzin NK, Lincoln YS The sage handbook of qualitative research (eds). Sage, Thousand Oaks, CA

26. Diamond J (2005) Collapse: how societies choose to fail or succeed. NY, Penguin Group, New York
27. Dolisca F, McDaniel JM, Teeter LD, Jolly CM (2007) Land tenure, population pressure, and deforestation in haiti: the case of foret des pins Reserve. J Forest Econ 13:277–289
28. Dunlap RE, Michelson W (2002) Natural hazards and disasters. In: Dunlap RE, Michelson W (eds) Handbook of environmental sociology. Greenwood Press, Westport, CT
29. Dupuy A (2010) Disaster capitalism to the rescue: the international community and Haiti after the earthquake. NACLA Rep on the Am 43(4):14–19
30. Farrell F (2011) 'Free-market quake' turns citizens into assets. In: The press, fairfax New Zealand News Limited, Christchurch
31. Habraken NJ (1972) Supports, an alternative to mass housing. Architectural Press, London
32. Hurlbert JS, Haines VA, Beggs JJ (2000) Core networks and tie activation: what kind of routine networks allocate resources in nonroutine situations? Am Socio Assoc 65(4):598–618
33. Jenkins P, Forsyth L (2010) Architecture, participation and society. New York, NY, Routledge
34. Kendra JM, Wachtendorf T (2007) Community innovation and disasters. In: Rodriguez H, Quarantelli EL, Dynes RR (eds) Handbook of disaster research. Springer, New York, NY. 316–334
35. Klein N (2007) The shock doctrine : the rise of disaster capitalism. Allen Lane, London
36. Kreps GA, Drabek TE (1996) Disasters are nonroutine social problems. Int J Mass Emer Disasters 14(2):129–153
37. Kristoff M, Panarelli L (2010) Haiti: A republic of NGOs? Peace brief. (cited on April 26, 2010) Available from United States Institute of Peace Brief website: http://www.usip.org/sites/default/files/PB 23 Haiti a Republic of NGOs.pdf
38. Lee AJY (2010) Bridging the urban divide: towards a transdisciplinary design of the built environment. In: Tankel Y, Underhill Y (eds) The right to the city: research and engagement at the World Urban Forum 5, 2010, 2011, The University of Auckland: Auckland, NZ. 52–57
39. Lee AJY (2012) Design ethics in disasters. Culvahouse T (ed) Ethics and etiquettes issue, ArcCA, AIA California Architects Journal, Oct 23, 2012, Available from http://aiacc.org/2012/10/23/design-ethics-in-disasters
40. Lee AJY (2013) Casting an architectural lens on disaster reconstruction. Disaster Preven Manage 22(5):480–490
41. Lonely Planet (2012) Top 10 cities for 2013 (Online). Lonely Planet, London, UK. (cited April 27, 2014); Available from http://www.lonelyplanet.com/themes/best-in-travel/top-10-cities/
42. Malcolm Reading Consultants (2010) Building back better communities Port-au-Prince, Haiti: request for proposal on behalf of the Government of the Republic of Haiti. June 16, 2010. Malcolm Reading Consultants, London, UK
43. Nussbaum B (2007) Are designers the enemy of design*?* Business week March 18, 2007 (cited June 21, 2011); Available from http://blogs.businessweek.com/mt/mt-tb.cgi/5969.1362014642
44. Oliver-Smith A (2010) Haiti and the historical construction of disasters. NACLA Rep Am 43:32–36
45. Potangaroa R, Kipa M (2011) The response to the February 2011 earthquake in the Eastern suburbs of Christchurch, New Zealand. In: Proceedings from The 8th annual international conference of the international institute for infrastructure, renewal and reconstruction (IIIRR) Kumamoto, Japan, August 24–26, 2012
46. Protzen J-P, Harris DJ (eds) (2010) The universe of design: Horst Rittel's theories of design and planning. Routledge, Abingdon, Oxon
47. Quarantelli EL (ed) (1978) Disasters: theory and research. Sage Publications, Beverly Hills, CA
48. Rittel H (1973) On the planning crisis. In: Protzen J-P, Harris DJ (eds) (2010) The universe of design: Horst Rittel's theories of design and planning. Routledge, Abingdon, Oxon. 150–165
49. Rittel H, Webber WJ (1973) Dilemmas in a general theory of planning. Policy Sciences 4:155–182
50. Rittel H (1988) The reasoning of designers. In: Protzen J-P, Harris DJ (eds) (2010) The universe of design: Horst Rittel's theories of design and planning. Routledge: Abingdon, Oxon. 150–165
51. Rodriguez H, Quarantelli EL, Dynes RR (eds) (2007) Handbook of disaster research. Springer, New York, NY

52. Sanderson D (2010) Architects are often the last people needed in disaster reconstruction. The Guardian, March 3, 2010 (cited June 21, 2011), Available from http://www.guardian.co.uk/commentisfree/2010/mar/03/architects-disaster-reconstruction-haiti-chile
53. Schon D (1983) The reflective practitioner: how professionals think in action. Basic Books, New York, NY
54. Schuller M, Morales P (eds) (2012) Tectonic shifts: Haiti since the earthquake. Kumarian Press, Sterling, VA
55. Simon H (1969) The sciences of the artificial. MIT Press, Cambridge MA
56. Smith GP, Wenger D (2005) Sustainable disaster recovery: operationalizing an existing agenda. In Perry RW, Quarantelli EL (eds) What is a disaster? New answers to old questions. International Research Committee on Disasters: Bloomington, IN. 234–257
57. Snyder JC (ed) (1984) Architectural research. Van Nostrand Reinhold Company, New York, NY
58. Stallings RA (2003) Methods of disaster research. Xlibris Publishing, Bloomington, IN
59. Stevenson JR et al (2011) Preliminary observations of the impacts the 22 February Christchurch earthquake on organisations and the economy: a report from the field (22 February–22 March 2011). In: Bulletin for the New Zealand society for earthquake engineers 2011, New Zealand Society for Earthquake Engineering Inc. Wellington, New Zealand. 65–77
60. Thorpe A (2012) Architecture and design versus Consumerism: how design activism confronts growth. Earthscan, Abingdon, Oxon
61. Till J (2009) Architecture depends. MIT Press, Cambridge, MA
62. Turner J (1972) Freedom to build: dweller control of the housing process. Macmillan, New York, NY
63. Vaughan D (1992) Theory elaboration: the heuristics of case analysis. In: Ragin CC, Becker HS (eds) Exploring the foundations of social inquiry. Cambridge University Press, Cambridge, UK. 173–202

Part III
Cyber Domain

Architectures for Cyber-Security Incident Reporting in Safety-Critical Systems

Chris W. Johnson

Abstract Cyber-attacks can have a devastating impact on safety-critical systems. The increasing reliance on mass market Commercial Off-The Shelf (COTS) infrastructures, including Linux and the IP stack, have created vulnerabilities in applications ranging from Air Traffic Management through to Railway signalling and Maritime surveillance. Once a system has been attacked, it is impossible to demonstrate that malware has been completely eradicated from a safety-related network. For instance, recent generations of malware use zero day exploits and process injection with command and control server architectures to circumvent existing firewalls and monitoring software. This creates enormous problems for regulators who must determine whether or not it is acceptably safe to resume operations. It is, therefore, important that we learn as much as possible from previous cyber-attacks without disclosing information that might encourage future attacks. This chapter describes different architectures for encouraging the exchange of lessons learned from security incidents in safety-critical applications.

Keywords Incident reporting · Cyberattacks · Cyber-Security · Causal analysis

1 Introduction

Incident reporting has been widely recognised as a key component in many safety management systems [1]. Information about adverse events helps to warn others of potential hazards. Incident reports can also be used to disseminate the recommendations that help prevent any recurrence of previous mishaps. They also help to promote the mitigation and recovery techniques that increase our resilience to hazards that cannot be avoided. In other words, as shown in Fig. 1, incident

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A. Masys (ed.), *Disaster Management: Enabling Resilience*,
Lecture Notes in Social Networks, DOI 10.1007/978-3-319-08819-8_7

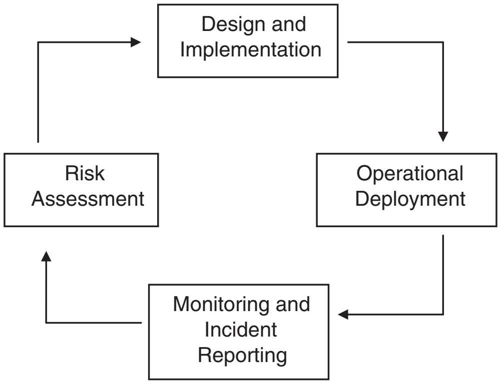

Fig. 1 Incident reporting within the safety management lifecycle

reports help to validate the likelihood and consequence assessments that drive risk analysis.

International bodies have, therefore, advocated the use of incident reporting in safety-critical applications:

> (The assembly) urges all Contracting States to ensure that their aircraft operators, providers of air navigation services and equipment, and maintenance organisations have the necessary procedures and policies for voluntary reporting of events that could affect aviation safety (ICAO Resolution A32-15: ICAO Global Aviation Safety Plan).

International support for voluntary incident reporting systems includes near-misses. Systems that only exchange information about previous adverse events are reactive, whereas near-miss reporting schemes help to identify potential hazards before they occur:

> Companies should investigate near-misses as a regulatory requirement under the Hazardous Occurrences… Aside from the fact that near-miss reporting is a requirement, it also makes good business and economic sense because it can improve vessel and crew performance and, in many cases, reduce costs. Investigating near-misses is an integral component of continuous improvement in safety management systems. (International Maritime Organisation, Guidance on Near-Miss Reporting MSC-MEPC.7/Circ.7).

These initiatives have resulted in a proliferation of safety-related incident reporting tools and techniques, including but not limited to, the Australian Incident Monitoring System and Confidential Safety Reporting Information Scheme, the Canadian National Defence General Accident Information System, the European Space Agency Alert System and European Major Hazard Incidents Data Service (MHIDAS), the Japanese Maritime Incident Reporting System and Rail Accident Method, the US NTSB Aviation Safety Reporting System, FDA Adverse Event Reporting System and Manufacturer and User Facility Device Experience database (MAUDE), FRA Confidential Close Call Reporting System (C3RS), the UK Confidential Incident Reporting System (CIRS), Confidential Human Factors Incident Reporting Programme (CHIRP) and Confidential Incident Reporting and Analysis System (CIRAS). There are also generic reporting tools including Data Reporting Analysis and Corrective Action Systems (DRACAS), Failure Reporting,

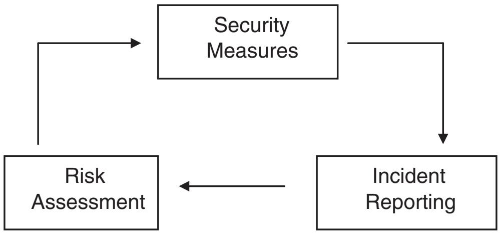

Fig. 2 Incident reporting within the ENISA key security governance processes [2]

Analysis and Corrective Actions systems (FRACAS), Prevention and Recovery Information System for Monitoring and Analysis (PRISMA) and PRISMA-Rail, Rail-Program for Risk Informed Safety Managements, Safety Management Information System, Technique for the Retrospective and Predictive Analysis of Cognitive Errors etc.

Given the proliferation of incident reporting within safety-critical applications, it is no surprise that organisations, including the US Department of Homeland Security as well as the European Network and Information Security Agency (ENISA) have promoted similar schemes to track cyber-security concerns. For example, Fig. 2 shows how ENISA include incident reporting within their key processes for the governance of security concerns. Risk assessments help to identify the potential targets of an attack and to determine whether there are known vulnerabilities. Security measures are then taken to protect those targets and to ensure that measures continue to be implemented over time. Collecting incident reports helps to understand “weaknesses in security measures and to evaluate and validate the risk assessment”. This triangle is, typically, supervised by a government agency, such as a regulator, or by an industry association, including groups of professional auditors [2]. As mentioned, the US DHS advocates similar arrangements through the National Cyber security and Communications Integration Center (NCCIC). The NCCIC coordinates the information collected through incident reporting to improve situation awareness for cyber communities across government and the private sector. Similarly, the US Computer Emergency Response Team (US-CERT) provides direct operational advice on the reporting of security incidents, based on the NIST guidelines for incident reporting [3]. These initiatives have been supported by a growing number of tools and techniques that provide means of reporting security incidents. These include commercial and open source tools such as AbuseHelper; Application for Incident Response Teams (AIRT); Assuria Auditor and Request Tracker for Incident Response (RTIR). Most national Computer Emergency Response Teams have reporting applications, including those of the US and UK CERTs. Professional and industry groups have also coordinated security incident reporting, these include the Forum of Incident Response and Security Teams (FIRST) as well as the industry bodies supported within the UK Centre for the Protection of National Infrastructures Warning, Advice and Reporting Points (WARPs) programme. There are semi-automated security incident reporting tools, such as the US Air Force Automated Security Incident Measurement (ASIM) infrastructure and the new Einstein programme for collecting, analysing, and sharing computer security information across the US Federal Civilian Government. Other reporting systems support particular sectors, such as the US Federal Communications Commission's Disaster Information Reporting System (DIRS) and Network Outage Reporting System (NORS).

Unfortunately, there have been very few attempts to integrate the reporting of safety and security incidents even though it is clear that cyber-attacks can have a profound impact on the safety of most complex systems [4, 5]. The increasing reliance on mass market Commercial Off-The Shelf (COTS) infrastructures, including Linux and the IP stack, have created vulnerabilities in applications ranging from Air Traffic Management through to Railway signalling and Maritime surveillance. Once malware has infected a complex system, it is impossible to predict the potential impact on safety requirements. We cannot assume that the development techniques used in creating a virus or Trojan would meet the strict requirements of an industry regulator within safety-critical industries! Although many papers have been written about the impact that COTS software might have on meeting Safety Integrity Levels or Software Assurance Levels, very few have considered the implications of malware. It would be difficult to guarantee that critical processes continue to receive necessary network or processing resources without a sustained forensic analysis of the malware. This creates further problems given the length of time required to conduct such studies. In the short term, we cannot keep aircraft circling while we determine whether or not an Air Traffic system can safely be used to guide their descent. Beyond that, it is difficult to contemplate the business consequences of closing air space for the length of time it might take to convince a regulator that an infrastructure is safe to resume operations. It is impossible to demonstrate that malware has been completely eradicated from a safety-related network. For instance, recent generations of attack use zero day exploits and process injection with command and control server architectures to circumvent existing firewalls and monitoring software. This creates enormous problems for regulators. It is, therefore, important that we learn as much as possible from previous cyber-attacks without disclosing information that might encourage future attacks. The following pages describe integrated architectures for encouraging the exchange of lessons learned from security incidents in safety-critical applications.

1.1 Internal Reporting Architectures

Figure 3 represents one of the simplest architectures for an incident reporting system; in this case the focus is on a safety-related application. A contributor submits a report based on the occurrence that they have witnessed or are concerned about. This submission process can be implemented using printed forms, by telephone calls, or increasingly using computer-based techniques. In some cases, automated systems can detect adverse or near miss events that may subsequently prompt further investigation—for instance, a Short Term Conflict Alert (STCA) in Air Traffic Management. An investigator is then required to gather

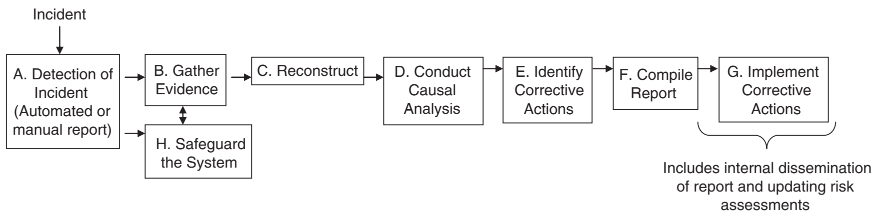

Fig. 3 An internal incident reporting architecture

further evidence, including system logs and witness statements. These are then used to map out the events leading to an incident. The reconstruction supports more detailed studies of the causal and contributory factors. From there it is possible to identify those actions, which are intended to reduce the likelihood or mitigate the consequences of any recurrence. The previous stages of the analysis are then documented and distributed to stakeholders so that corrective actions can be implemented.

This process is a simplification because it assumes that all incidents will be analysed to the same level of detail. In practice, there is typically a preliminary risk assessment after initial evidence has been obtained. Most reporting systems lack the resources to conduct detailed causal analyses for all adverse events and near miss incidents. In consequence, only those events with a higher risk of recurrence will go through all of the stages illustrated in Fig. 3.

The architecture illustrated in Fig. 3 can also provide a template for security incident reporting systems. Many of the concerns in the implementation of such architectures are the same as they would be in safety-related industries. For instance, if the definition of a reportable incident is set too low then scarce resources will be wasted as analysts investigate thousands of false positives. For example, supervisors' time can be wasted by STCA alerts if the system is configured to generate alarms that are within the bounds of normal, safe operation. Similarly, automated network monitoring systems will detect adverse events even when there is no threat to security if they have not been correctly configured for normal traffic patterns.

A number of problems complicate the use of this simplified safety incident reporting architecture for cyber-security concerns. Firstly, it is often more difficult to detect cyber-attacks than it is to identify safety-related incidents. Many security threats take elaborate measures to hide within a network. This is another reason for the integration of security and safety reporting systems, given that malware will often show the same symptoms as more routine bugs or system failures. For example, engineering teams often become suspicious when network monitoring tools identify unexpected transmissions or when memory/processing resources seem to be compromised. These concerns could be triggered by malware or by routine configuration problems and it is often impossible to know the cause without more sustained analysis.

Thirdly, stages B to E are characterised as ‘forensic analyses within security management systems [6, 7]. This raises a host of concerns that are not, typically, considered within safety-related incident reporting systems. For example, the systems and networks that are affected by a suspected cyber-attack can be considered a crime scene and evidence must be preserved according to legal principles and guidelines. It will be necessary to uncover normal, hidden, deleted, encrypted and password-protected files to gain as much information as possible about the nature and scope of any attack. Further problems arise because the tools and techniques that support the causal analysis of cyber-attacks lags many years behind those available to accident and incident investigators in other domains. Further work is required to determine whether the existing application of root cause analysis techniques, including those using counter-factual reason and systemic models, can be extended to support the reporting of cyber-attacks [1].

Further differences arise at the end of the reporting chain with the drafting and dissemination of lessons learned. In safety-related systems there is usually a presumption that as many stakeholders as possible should be informed of any lessons learned; even if the presentation of those lessons may be tailored to particular audiences using newsletters, technical reports, daily briefing documents etc. In the aftermath of security related incidents, there is a concern that any subsequent dissemination should not undermine the future security of an application process. In some cases, disclosing that an attack has been identified will itself provide adversaries with important information on ways to refine future cyber threats.

There are a number of limitations with the simple reporting architecture shown in Fig. 3. In particular, there are no guarantees that a company will take any corrective actions or that the actions implemented in stage G will address the underlying causes of an incident. Similarly, there is a danger that different organisations will respond in different ways to similar incidents across the same industry. This inconsistency creates the opportunity for future failures if an organisation fails to correctly safeguard the system. Similarly, in security reporting systems there is a concern that a known vulnerability would only be patched by the company suffering an attack and that any other critical infrastructures would remain exposed. A further problem is that there is no external validation of an incident report. This creates concerns that a lack of technical expertise or problems of political bias might undermine the response to previous incidents. These limitations are addressed by an increasing role for external agencies, including professional bodies and industry associations, in the following reporting architectures.

2 Gatekeeper Architecture

Figure 4 illustrates a more elaborate architecture for reporting adverse events. This model explicitly represents different agents within the scheme. As can be seen, reports are generated by a host of sources from both inside or outside an organization. These are forwarded to a supervisor or 'Gatekeeper' who gathers the initial evidence in the aftermath of an adverse event. They will then conduct an initial risk assessment to determine whether the mishap warrants a full investigation. The term 'gatekeeper' is used because this individual plays a key role in determining the focus of subsequent investigations. If an incident is identified as a high risk for any recurrence then stages F through to J follow those in the simplified architecture of Fig. 3. Otherwise, only a summary report is developed, however, the supervisor may also be required to explicitly document the reasons why it was NOT investigated. Several of these low risk incident summaries can be compiled, for instance every 6 months. The collated documents can then be analysed for underlying safety or security trends. In other words, several low risk or near miss incidents might collectively justify a more sustained analysis than any individual incident.

Figure 4 further extends the simplified architecture of Fig. 3 by considering the reporting chain for adverse events within an organisation. The supervisor or gatekeeper controls the day to day running of the system. However, an internal security or safety management group provides strategic and tactical oversight. In the case of a high-risk incident, they are immediately informed and may, in turn, choose to notify external agencies of a significant threat to safety or security. In addition, they are responsible for monitoring the implementation of corrective actions taken both in the aftermath of high risk incidents and also to resolve common concerns amongst the periodic reviews of low risk or near miss events. In other systems, the management group may have a more direct role in approving or rejecting recommendations—when, for instance, recommendations require major

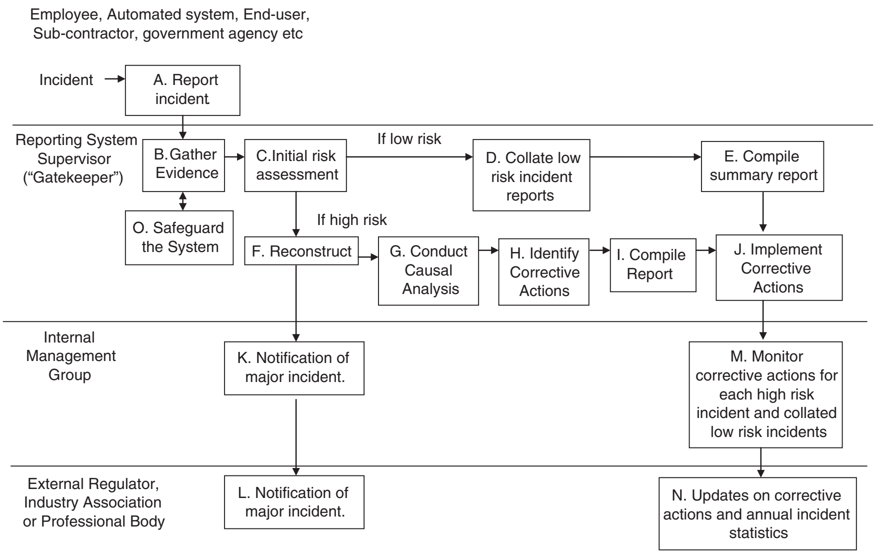

Fig. 4 Gatekeeper reporting architecture

sustained investments or management commitment at more senior levels than the supervisor/gatekeeper.

This revised architecture also shows how safety or security management groups provide an interface with external agencies including regulators, professional bodies or industry associations. In safety-critical applications, this provides important mechanisms for ensuring that incidents are not repeated across an industry. Even in safety-related areas, this raises a host of concerns. Some companies are reluctant to provide their competitors with a commercial advantage by providing information about lessons learned; even though this is indicative of a poor safety culture. Other organisations can be more worried about a potential loss of reputation or of market confidence. There are also concerns that information about previous failures, for instance involving management decisions or employee actions, might provide the basis for subsequent litigation. In consequence, many reporting systems support the submission of confidential and anonymous reports. This can reduce the utility of the lessons that are provided when readers cannot obtain details about the context in which an incident or near miss occurred. These concerns are exacerbated when incidents relate to the security of complex systems. There is often a reluctance to provide information outside of the immediate organisation suffering the attack. Concerns focus on the third party release of details that might further undermine security or public confidence in the aftermath of a cyber-incident. Without legal guarantees, most commercial organisations will only provide anonymous summaries of minor adverse events to these agencies—in some cases; even this would be refused unless there are reciprocal benefits from the further exchange of security information by competitors.

Further problems affect the extension of this approach to capture both safety and security related incidents. In particular, the success or failure of the system depends on the skills and expertise of the supervisor or gatekeeper. If they decide that an incident does not merit further analysis then the management committee will only see a summary report. Even if the committee then decided that the adverse event/near miss required further investigation, many organisations would only be able to retrieve part of the necessary forensic evidence. The focus on the gatekeeper is even more critical because there is little practical guidance about how best to assess the risks of potential cyber-threats. To illustrate the dilemmas, a European Air Traffic Management service provider recently detected a problem with the local area network that integrated radar and flight plan data. The problem caused an intermittent degradation in quality of service. The systems engineering supervisor took the decision to investigate the incident further but could not find the cause. The symptoms then disappeared. At this stage, the supervisor has to make a decision—it might have been a non-malicious bug in the network management system or an intermittent hardware fault or a result of interactions between the thousands of applications that exchanged data over the infrastructures. Alternatively, the loss of service might have been the first symptom of a cyber-attack. The supervisor had limited resources and was in the middle of a periodic software upgrade on another application and decided not to investigate any further. Some weeks later, the symptoms recurred and the causes were traced to a keystroke logger running on a Linux installation that was not specifically focussed on the ATM service provider. It is possible to criticise the supervisor's decision, however, the site had no specialist expertise in cyber-security and they had never before experience malware in an operational system. As mentioned before, they also lacked any formal tools to help them decide whether or not the initial symptoms should have triggered a deeper investigation, given that the malware had several weeks to operate without being detected inside the organisation's firewalls.

The gatekeeper architecture also suffers from increased complexity. Individuals and teams will only remain motivated to contribute information about safety or security incidents if they feel that they concerns are being addressed. It can be hard to them to follow the progress of a particular incident report through the various stages of causal and forensic analysis. Similarly, they may be frustrated if and their concerns are classified as 'low risk' and do not trigger more detailed investigations. Some companies have addressed these issues through the introduction of incident tracking systems so that reporters can trace each action being taken in response to the safety or security issues that they raise. This also enables the internal management to review any open corrective actions that have still to be implemented following a major incident. Several of these systems were listed in the opening sections of this paper. Very few of them have been extended to support security management, hence when individuals do report concerns over violations of security policy they often report that little seems to have changed [8]. This undermines both the long term future of the reporting system and the utility of any immediate lessons that might have been drawn from a particular concern.

3 Active External Monitoring Architectures

The reporting architectures illustrated in this paper are deliberately intended to reflect different levels of safety or security maturity. The simple system in Fig. 3 focuses on the internal dissemination of information. The more elaborate gatekeeper architecture assumes that the reporting organisation has sufficient confidence and legal protection to share lessons learned with external regulators, industry associations or other professional bodies. However, Fig. 4 assumes a relatively passive role for external oversight. In contrast, active monitoring architectures provide for additional support from external agencies in the investigation of adverse events. As can be seen in Fig. 5, external bodies are notified after a high risk incident has been detected. However, in contrast to the earlier models regulators, industry associations or other professional bodies offer assistance both in safeguarding the system and in investigating the incident. As can be seen, it is assumed that this more active support would only be appropriate for high risk incidents or in special circumstances, for example where a company lacked specialist expertise in forensic analysis. As might be expected, it takes a higher level of trust and safety/security maturity to encourage this level of participation from external agencies—or in other cases, this level of involvement may be the consequence of

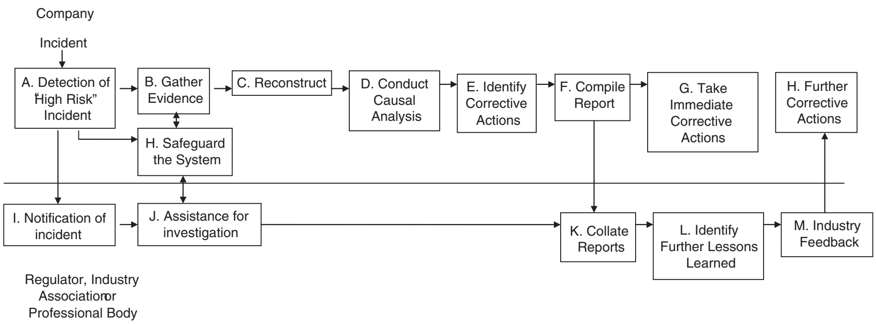

Fig. 5 Active external monitoring architecture

specific legislation to ensure the protection of critical infrastructures. As before, there may be considerable concern to ensure that any industry feedback in stage M does not compromise commercially sensitive information or the public reputation of a company participating in the scheme. Great care must also be taken to ensure that other companies can use any lessons learned in a report while at the time protecting the future security of safety-related applications.

As with previous architectures for incident reporting, a number of factors complicate the use of active external monitoring as an integrated approach to safety and security management. At present, many industries suffer from artificial barriers or silos between the different external agencies that address the problems of safety and security. In the United States, the Government Accountability Office has issued a series of reports over the last 12 months with titles that include: "A Better Defined and Implemented National Strategy Is Needed to Address Persistent Challenges" [9] and "Cyber security: National Strategy, Roles, and Responsibilities Need to Be Better Defined and More Effectively Implemented" [10]. Part of the confusion arises because safety has, traditionally, been devolved to organisations with a specific focus on particular safety-critical industries—these include the FDA, FRA, FAA with cross-sector organisations looking after more general forms of occupational health and safety, through OSHA. However, cyber-security has been seen as a cross-cutting concern that requires specific expertise. Governments have, therefore, created distinct agencies to deal with these threats. In particular, the US Federal Information Security Management Act (2002) provides the wider context for this paper. FISMA requires that Federal agencies have "procedures for detecting, reporting, and responding to security incidents". The US National Institute of Standards and Technology (NIST) coordinate the technical implementation of FISMA, with operational leadership from the Department of Homeland Security and the US CERT, mentioned in previous sections. These divisions create a dangerous situation where cyber-security agencies have almost no understanding of the impact that malware could have on the technical operation of safety-critical systems. Conversely, the regulatory agencies established to monitor the implementation of safety standards have almost no expertise in cyber-security; many suffer from a long legacy of physical security specialists whose talents provide little help in mitigating new generations of advanced persistent threats.

In Europe, the legislative context is set by EU Directive 2009/140/EC. A key element within the directive has become known as 'Article 13a' on the security and integrity of public communication networks. Paragraphs 1 and 2 of Article 13a require service providers to ensure the security and integrity of their networks and to ensure continuity of service. Paragraph 3 requires that service providers report significant security breaches and losses of integrity to national regulatory agencies. They must then forward summaries to the European Network and Information Security Agency (ENISA). EU Directive 2009/140/EC focuses on the resilience of operators irrespective of whether their services are being used in safety-critical infrastructures or in mass market applications. However, the European Commission has recently proposed the extension of obligatory reporting requirements as part of the European Union's 2013 Cyber-Security Strategy. Again significant work remains to be done before common incident reporting structures can be established for safety concerns. For example, the European Aviation Safety Agency has traditionally avoided any consideration of cyber-threats, even though they can have a considerable impact on the operation of complex, critical infrastructures. ENISA lacks specific expertise in the aviation domain. This creates a situation where companies lack clear guidance—for example on how best to respond using remaining airborne and ground systems when malware is detected within the Flight Data Processing or Surveillance systems of an Air Navigation Service Provider [4].

One partial solution is to draft letters of agreement between safety and security regulators to clarify responsibilities and establish an agenda for future cooperation within national and international programmes for critical infrastructure protection. Alternatively, professional bodies and industry associated can support the integrated reporting of safety and security concerns. This raises questions about whether regulatory agencies would interpret the use of these systems as acceptable means of compliance with legal reporting requirements across different industries. Other questions relate to the funding of incident reporting systems through professional organisations. In some of the smaller European member states, one or two companies compete in a limited market. In can be difficult to justify funding more complex monitoring mechanisms. In other countries, existing industry associations lack the organisational and technical expertise to support such an enterprise.

It seems likely that these organisational barriers will be resolved through political and organisational changes over the next decade. It remains to be seen whether the necessary changes can be completed before lives are lost across national critical infrastructures. In the meantime companies face a host of practical challenges in integrating a unified approach to incident reporting using the active monitoring architectures illustrated in Fig. 5. Previous sections have described an incident in which Air Traffic Management engineers were initially alerted to potential malware through intermittent delays in data passed across a local area network. It took several days to determine whether this was due to a conventional safety-related concern, covered by reporting infrastructures under EASA, or whether there was a potential cyber-attack, reportable under the separate extensions to Article 13a cited above. Without a more unified approach, it is very difficult for companies to know how to obtain the "assistance for investigation" envisaged in stage J of the active monitoring architecture.

4 Joint Public-Private Architecture for Cyber-Safety

Figure 6 illustrates an integrated architecture for the reporting of potential cyber-incidents in safety-critical infrastructures. It focuses on a joint public–private approach based on cooperation between industry and government with implicit mechanisms for cost sharing. As can be seen, it builds on the previous architectures. However, it also assumes the creation of a Joint Monitoring Group for cyber-security incidents. This is intended to represent a wide range of stakeholders but, in particular, safety regulators from a range of different industries as well as various government security agencies, including national CERTs. The Joint Monitoring Group should also include companies with the technical expertise required to both provide advice and help disseminate the lessons learned from cyber-incidents in national critical infrastructures. Given the increasing range of novel threats to the security of complex systems, the monitoring group would help to focus the more general assistance that is available through CERTs and other government bodies, which today have little experience or knowledge of safety-critical software engineering standards. This is reflected in the active role that the monitoring group plays in stage Q 'Safeguarding the System'. It is

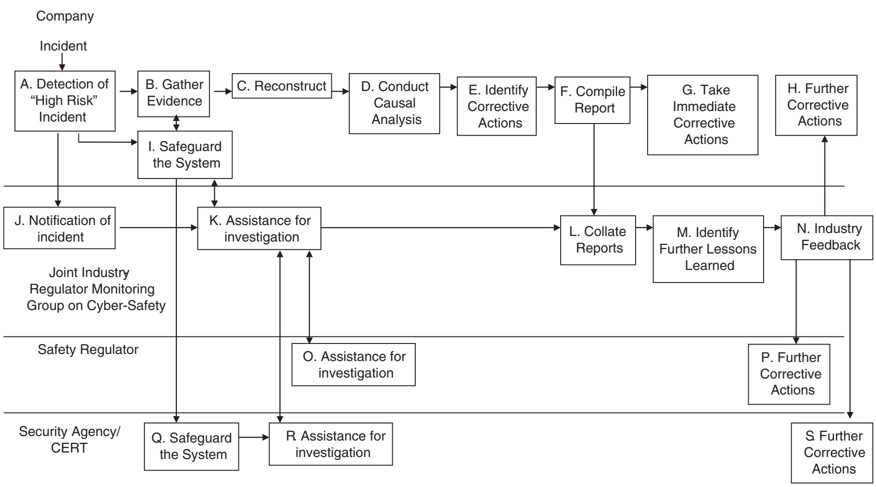

Fig. 6 Joint public–private coordination of cyber-safety reporting systems

intended that a company would only notify the joint monitoring group if they had initial evidence that a safety-related application might have been the target of a cyber-attack.

All of the reporting architectures illustrated in this paper represent compromises. Internal reporting systems based on the Fig. 3 architecture provide simple, low cost approaches to ensure that lessons are disseminated inside a company. However, they provide limited support across an industry or in alerting other critical infrastructures to the potential threat from future cyber-attacks. At the other end of the complexity spectrum, Fig. 6 represents an elaborate approach in which multiple public bodies and private companies work together to increase resilience by sharing investigatory resources and lessons learned across critical infrastructures. They assume significant input from safety regulators and a continuing commitment from commercial participants to invest resources of time and expertise to support other companies when attacks occur.

5 Conclusions and Further Work

This paper presents a number of architectures that can be used to support the development of incident reporting systems in safety-critical industries. The aim has been to identify ways of integrating the response to both safety hazards and cyber-attacks. For example, we have identified the stages that are typically involved in the development of simply internal reporting systems used within an individual organisation. It is necessary to secure sufficient evidence to reconstruct an adverse event, conduct a causal analysis, identify corrective actions etc. Many of these stages that were originally identified within safety-critical systems have their parallels in the forensic investigations of cyber-incident reporting applications. However, malware also poses unique challenges—in particular, how to safeguard an application and the public in the immediate aftermath of an attack. For instance, how do we land the aircraft in flight when we fear that an Air Traffic Management infrastructure is compromised?

Subsequent sections presented a more elaborate Gatekeeper architecture involving cooperation with internal company management and with external organisations, including regulators, industry associations or professional bodies. The intention was to extend a purely internal reporting system so that other companies in the same industry or across other critical infrastructures might be alerted to potential future attacks. The system supervisor or gatekeeper must determine which events are passed onto the company management; hence they play a key role in filtering the information that is eventually passed to external organisations. A key recommendation is that these individuals urgently require tools that help them to assess the safety consequences of potential cyber-incidents to ensure the coherence and consistency of their decision making.

Active external monitoring architectures build on the gatekeeper approaches but also assume that regulators, industry associations and professional bodies will become more closely involved in assisting cyber-incident investigations. This is important when most safety-critical companies lack any in-house forensic expertise. These systems also assume a greater degree of both safety and security maturity given that companies must be willing to accept support and guidance from external organisations. It seems unlikely that these approaches will succeed without additional legislative and regulatory protection for the companies that participate in the programme. However, they may be necessary to ensure adequate protection for national critical infrastructures; without resource pooling we can have little confidence in the investigation of more complex cyber-attacks across many of our industries.

The closing sections presented a more complex approach based on the creation of public–private partnerships. Joint working groups consist of companies across safety-critical industries, of national safety regulators and of existing security agencies. The intention is to eliminate the silos that have arisen when each industry has its own safety regulator which are separate from state cyber-security agencies. In consequence, very few safety regulators have any cyber-security expertise. Conversely, most CERTs lack any specific understanding of safety-related development practices. Companies are encouraged to share incident information through their representatives on the joint working group and to seek support when needed.

The architectures in this paper are drawn from a number of international projects to establish incident reporting systems across Europe and North America. Previous work has shown that there is no 'ideal approach'. In the past, reporting systems have failed because their proponents over-estimated the maturity of the host organisation. Elaborate reporting architectures seldom succeed if industry employees are worried about retribution or prosecution when they report an incident. Many European reporting systems have died as soon as public funding is reduced. In such circumstances, it may be better to encourage simplified systems with the exchange of anonymous summaries each year. This helps to establish the reporting culture that is a prerequisite for more elaborate schemes [1]. Irrespective of the architecture that is used, the underlying argument behind this paper is that we must act now to integrate reporting mechanisms for cyber-attacks on safety-critical, national infrastructures. At present, companies do not know where to report their concerns in consequence many attacks are treated as isolated incidents. There is a reluctance to tell safety-regulators because of the consequences for the certification and approval of underlying software/hardware infrastructures. There is also a clear lack of regulatory guidance on the tools and techniques that can be used to assess and mitigate the safety hazards of cyber-attacks. All of these concerns create an urgent need to coordinate government and commercial action before public safety is placed at greater risk.

References

1. Johnson CW (2003) Failure in safety-critical systems: a handbook of accident and incident reporting. University of Glasgow Press, Glasgow, Scotland
2. European Network and Information Security Agency (2012) Critical cloud computing: a critical information infrastructure protection perspective on cloud computing services, version 1.0, Heraklion, Greece, Dec 2012
3. NIST (2012) Computer security incident handling guide: recommendations of the National Institute of Standards and Technology. NIST special publication 800-61 revision 2, Aug 2012
4. Johnson CW (2012) CyberSafety: on the interactions between cybersecurity and the software engineering of safety-critical systems. In: Dale C, Anderson T (eds) Achieving System Safety. Springer, London, UK, pp 85–96. Paper to acompany a keynote address, 20th annual conference of the UK safety-critical systems club. ISBN: 978-1-4471-2493-1
5. Johnson CW (2013) The telecoms inclusion principle: the missing link between critical infrastructure protection and critical information infrastructure protection. In: Theron P, Bologna S (eds) Critical information infrastructure protection and resilience in the ICT sector. IGI Global, Pennsylvania, USA
6. U.S. National Institute of Standards and Technology (NIST) (2006) Guide to integrating forensic techniques into incident response. Special publication 800-86, Gaithersburg, Maryland. http://csrc.nist.gov/publications/nistpubs/800-86/SP800-86.pdf
7. U.S. National Institute of Standards and Technology (NIST) (2012) Computer security incident handling guide (draft). Special publication 800-61 revision 2 (draft), Gaithersburg, Maryland. http://csrc.nist.gov/publications/drafts/800-61-rev2/draft-sp800-61rev2.pdf
8. Wiik J, Gonzalez JJ, Kossakowski K-P (2005) Limits to effectiveness in computer security incident response teams. In: Twenty third international conference of the system dynamics society. The system dynamics society, Boston, MA, July 17–21 2005. http://www.cert.org/archive/pdf/Limits-to-CSIRT-Effectiveness.pdf
9. US Government Accountability Office (2013) A better defined and implemented national strategy is needed to address persistent challenges, GAO-13-462T, Washington, DC, USA, 7 Mar 2013
10. US Government Accountability Office (2013) Cybersecurity: national strategy, roles, and responsibilities need to be better defined and more effectively implemented, GAO-13-187, Washington, DC, USA, 14 Feb 2013

The Cyber-Ecosystem Enabling Resilience Through the Comprehensive Approach

Anthony J. Masys

Abstract According to Helbing (Nature 497:51–59, 2013) [14] we are increasingly living in a world which creates 'hyper-risks' because of numerous networks and interdependencies. In this 'hyper-connected world' with interconnected social/technical/political/economic domains, shocks to regional, national and global systems can have significant security implications. This 'hyper-connectivity' characterized by the global pervasiveness of internet and cyber usage has also provided a conduit for threats to national security as described in the United Nations Office on Drugs and Crime (UNODC in Comprehensive study on cybercrime, 2013) [34]. Robinson et al. (Cyber-security threat characterization A rapid comparative analysis, 2013: 5) [28] of RAND defines Cyber threats as '…those actors or adversaries exhibiting the strategic behaviour and capability to exploit cyberspace in order to harm life, information, operations, the environment and/or property'. The pervasiveness and impact of cyber-security threats has made it a top tier security issue in national risk assessments in the last five years (Robinson et al. in Cyber-security threat characterization A rapid comparative analysis, 2013: viii) [28]. Resilience thereby becomes a key property in the face of such threats. Resilience does not reside purely in cyber security patches and technical solutions but requires a more comprehensive and collaborative approach that embraces the social, organizational, economic, political and technical domains.

Keywords Cyber threat · Comprehensive approach · Systems thinking · Resilience

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A. Masys (ed.), *Disaster Management: Enabling Resilience*,
Lecture Notes in Social Networks, DOI 10.1007/978-3-319-08819-8_8

1 Introduction

The scope, nature and number of cyber attacks on governmental and private sector networks have raised the profile on cyber security. As noted in the [34: xvii]:

> In 2011, at least 2.3 billion people, the equivalent of more than one third of the world's total population, had access to the internet. By the year 2017, it is estimated that mobile broadband subscriptions will approach 70 per cent of the world's total population. By the year 2020, the number of networked devices (the 'internet of things') will outnumber people by six to one, transforming current conceptions of the internet. In the hyperconnected world of tomorrow, it will become hard to imagine a 'computer crime', and perhaps any crime, that does not involve electronic evidence linked with internet protocol (IP) connectivity.

The pervasiveness of this global cyber infrastructure is instrumental for economic prosperity and national security. Helbing [14: 51] poignantly argues that 'Globalization and technological revolutions are changing our planet. Today we have a worldwide exchange of people, goods, money, information, and ideas, which has produced many new opportunities, services and benefits for humanity. At the same time, however, the underlying networks have created pathways along which dangerous and damaging events can spread rapidly and globally'. With this in mind comes the realization that '…most cyber infrastructure is not secure and is vulnerable to attacks from malicious actors potentially leading to failure of critical infrastructure, exploitation of sensitive information, and loss of intellectual property' [15: 544]. Linkov et al. [18: 471] support this noting that '…the increasing reliance of US citizens, businesses, and governments on cyber infrastructure has put national security at considerable risk to unforeseen and unknown threats'.

As a National Security issue, Robinson et al. [28: 5] defines Cyber threats to states '… as those actors or adversaries exhibiting the strategic behaviour and capability to exploit cyberspace in order to harm life, information, operations, the environment and/or property'. The challenge in dealing with such cyber threats stems from the fragmented and disconnected approaches and solutions which as noted by Pawlak and Wendling [27: 542] '…are driven by policy, legal or technological considerations and as such rarely include all stakeholders: public administration, businesses, citizens, the research community or relevant international players'. To address the pervasiveness and severity of the cyber threats requires an approach that recognizes the cyber security risks from a 'systems perspective' recognizing the complex interdependencies between the physical, human and informational domains [4, 22, 23].

This chapter approaches this 'complexity' dilemma through the application of systems thinking enacted by the comprehensive approach [22, 23].

2 Cyber Domain

The complex threat landscape associated with cyber-security is rooted in the growing adoption of the internet within a digitally connected cyber-ecosystem. Analogous to natural ecosystems, this cyber ecosystem [17] is characterised by the inherent interdependencies and interconnections that emerge as a complex dynamic system. The ecosystem lens in which to view the cybercrime domain is essential in understanding and implementing the strategic vision of the comprehensive approach [8, 19, 23, 25]. It affords the analysis of interdependencies and interconnectivity in processes, roles, responsibilities, governance and decision making.

Along with the benefits of the cyberspace come challenges. The UK Cyber Security Strategy highlights some of the challenges [33: 18].

- Cyberspace is largely commercially owned and driven, and global in nature.
- The systems that form cyberspace contain a vast array of components, sourced from a global and diverse range of suppliers. Multiple sub-contractors produce, test, package and assemble these components.
- Predicting and understanding how cyberspace will be used in future is difficult given the rate of innovation and change.
- New vulnerabilities and risks will emerge suddenly.
- The pace of events can make existing defences and responses look slow and inadequate. Along with the complexity of cyberspace, this makes attributing hostile actions difficult.
- The covert nature of the threat means that the public and businesses can underestimate the risks.

Such criminal behavior as drug trafficking, money laundering, terrorism now leverage cyberspace for criminal purposes. The threats associated with cyber space are well articulated in Chap. 7 of this book whereby Chris Johnson describes in detail some examples of cyber vulnerabilities to safety critical systems. Recently as described in the Guardian [13] cyber attacks on Target department stores show how hackers 'stole about 40 m debit and credit card numbers and the personal information, including names, email addresses, phone numbers and home addresses of as many as 70 million customers. The chain has nearly 1,800 stores….Banks, credit unions and other entities that issued debit and credit cards have had to cancel and reissue cards, close transactions or accounts, and refund or credit card holders for transactions made with the stolen data'. In another cyber incursion, NATO websites were recently the target of significant DDoS attack. Such a distributed denial-of-service (or DDoS) attack emerges as an attempt to flood or overload a server with huge volumes of traffic from multiple systems. Often coincident with such an attack is the incorporation of malware or Trojans with the intent to crash the server completely. The 'Heartbleed' bug had significant impact affecting networking devices including servers, routers, switches, phones and video cameras used by small and large businesses everywhere. As noted by CNN [2] 'someone could have been able to tap your phone calls and voicemails at work, all your emails and entire sessions at your computer or iPhone. You also could have been compromised if you logged into work from home remotely. And you'll probably never know if you were hacked'. As described by UNODC [34: 35] '…during one single 10 day period, a botnet of around 183,000 zombie devices was found to harvest almost 310,000 items of victim bank account, credit card, and webmail and social networking credentials'.

The impact of cybercrime on society has both personal and national security implications. Building resilience in the face of such cyber threats is key to national and global prosperity.

3 Systems Thinking and the Comprehensive Approach

The features of systems thinking that shape the methodological lens in which we view the cyber domain stem from the notion that a system is not simply an aggregation of objects but is rather a set of interrelated, interconnecting parts creating through their interaction new system properties. In this sense, the cyber ecosystem can be conceptualized as a complex dynamic system in which Ottino [26: 293] argues '… cannot be understood by studying parts in isolation. The very essence of the system lies in the interaction between parts and the overall behaviour that emerges from the interactions'. Systems thinking thereby becomes both a worldview and a process in the sense that it informs ones understanding regarding a system and can be used as an approach in problem solving [10: 5]. As a process, systems thinking recognizes the requirement to assess the system within its environment and context [31]. In terms of the cyber ecosystem, the systems perspective provides a holistic view. As described in Masys [22, 23] policies, rules, regulations all play a role in how systems are operated. Hence resilience must also take into consideration elements beyond just technical concerns and solutions.

The comprehensive approach concept as it pertains to the cyber ecosystem should be understood in the context of an increasingly complex and interdependent system. The impact and pervasiveness of cybercrime faced by local and global communities is often of such a scale that management of the problem space is problematic. In response, stakeholders both private and public must develop capabilities and capacities to manage such cyber threats. As described by Diebert [9: 4] '*The international* dimensions of cyberspace security has led to the *securitization* of cyberspace—a transformation of the domain into a matter of national security. A comprehensive approach is thereby a necessity and not an option.

4 Discussion

Worldwide Threat Assessment of the US Intelligence Community [39] highlights cyber threats as significant alongside terrorism, transnational organized crime, weapons of mass destruction proliferation, counter-intelligence, counter-space, natural resources insecurity and competition, health and pandemic threats and mass atrocities. Resilience thereby becomes an important property of the cyber ecosystem. Chapter 1 of this volume presents a matrix that captures the complexity associated with resilience [16]. The framework highlights four concepts in terms of resilience goals:

1. Capacity to rebound and recover
2. Capability to maintain desirable state
3. Capacity to withstand stress
4. Capability to adapt and thrive.

These resilience goals help to frame the cyber ecosystem strategy in the face of cyber threats highlighting key capacity and capability requirements. Reliance on the digital domain and networked infrastructure makes us more interdependent, hence:

1. Cyber resilience is not an isolated issue. It is a much broader transformation across society driven by information and communication technologies.
2. Cyber resilience is not a single issue. In many cases, even the underlying values and concepts cannot be depended upon- the digital era has re-constituted ideas such as privacy, ownership and security.
3. Cyber resilience is a socio-economic issue [38: 5].

Like the 'heartbleed' bug, 'Unexpected events often audit our resilience' [36: 1]. How do we then map and enable resilience? Within the risk, crisis and disaster management domain, lessons learned from Hurricane Katrina highlight '…serious failures in policy, planning, and practice at all four levels of government—municipal, parish, state, and federal—in reference to a city exposed to known hazards' Comfort [5: 7]. This suggests that resilience is a property of the system that emerges from the interdependencies and interconnectivity resident within the system. With consideration of the socio-technical landscape associated with the cyber ecosystem, systems thinking emerges as a key lens. It recognizes as described by Coakes [3: 2], 'Socio-technical thinking is holistic in its essence; it is not the dichotomy implied by the name; it is an intertwining of human, organizational, technical and other facets'. Senge [30] argues that since the world exhibits qualities of wholeness, the relevance of systemic thinking is captured within its paradigm of interdependency, complexity and wholeness. Discrete occurrences in time and space are seen as entangled. Flood [12: 13] argues that '…they are all interconnected. Events can be understood only by contemplating the whole'. Hence the systemic property of resilience within the cyber ecosystem requires an holistic strategy such as that articulated in Masys [22] pertaining to Actor Network Theory and critical infrastructure.

Linkov et al. [18: 472] argue that discussions of resilience found in the literature are 'often focused on one operational domain (e.g., physical, information, cognitive, or social) and do not represent interconnections among system components to inform across these domains'. The systems lens of actor network theory [22] highlights the interconnectivity and interdependencies that characterize the complexity space associated with network thinking [35]. Within this conceptualization, resilience becomes an emergent property of the system, one that can be shaped through heterogeneous engineering [20, 21]. The paradigm of systems thinking permits a view of the cyber ecosystem as a complex system in which as noted by Sterman [32: 10] we come to the understanding that 'you can't do just one thing' and that 'everything is connected to everything else'. This is supported by Senge [30: 73] who is of the opinion that the discipline of the systems approach lies in a shift of mind: in seeing interrelationships rather than linear cause-effect chains and seeing processes of change rather than snapshots. System thinking paradigm that is realized through the 'network mindset' [1, 35] thereby is an appropriate approach for unearthing and communicating the complexities and interdependencies resident within the cyber ecosystem. Given that the threat is often not recognized until it manifests in a cyber system, enabling resilience becomes a key strategic capability.

The effect of cyber threats as discussed is felt at local, regional and global levels thereby resulting in '…organizations struggling to solidify a security vision supported by an effective strategy' [29]. This suggests the requirement for an integrated cyber strategy that is 'glocal' (locally enabled and globally supported). The solution space for such a strategy draws upon the findings of the [34] and point towards a comprehensive approach. To date, national, regional and global efforts to embrace a comprehensive approach to cyber security strategies have been somewhat slow and fragmented.

Findings derived from the UNODC [34: xi] regarding cyber security highlight key concerns:

- the impact of fragmentation at international level and diversity of national cybercrime laws on international cooperation
- a reliance on traditional means of formal international cooperation in criminal matters involving cybercrime and electronic evidence for all crimes
- the role of evidence 'location'
- harmonization of national legal frameworks
- law enforcement and criminal justice capacity
- cybercrime prevention activities

As described by the World Economic Forum [38: 5] a fragmentation of the cyber ecosystem could precipitate 'a loss of trust which leads to explicitly isolationist policies.,…or uncoordinated policy developments in different jurisdictions result in a disparate set of requirements to operate globally'. To address this fragmentation, inclusivity rather than exclusivity becomes the mantra realizing multi stakeholders issues. Cyber resilience becomes the successful mitigation of the strategic and economic impacts of cyberattacks, and is based on cybersecurity capabilities which move beyond audit and compliance models.

These findings speak to the requirement for a more coherent cyber strategy. As described by de Coning and Friis [7: 2]

> The comprehensive approach concept should be understood in the context of an increasingly complex and interdependent international conflict management system. The scope of the crises faced by the international community is often of such a scale that no single agency, government or international organization can manage them alone. In response, a wide range of agencies, governmental and non-governmental, and regional and international organizations have each developed specialized capacities to manage various aspects of these complex crisis systems, and together they have been able to respond with a broad range of interlinked activities.

The requirement for a comprehensive approach is further supported by the transnational dimension of cybercrime. UNODC [34: xxiv] argue that '30 and 70 % of cybercrime acts involve a transnational dimension, engaging issues of transnational investigations, sovereignty, jurisdiction, extraterritorial evidence, and a requirement for international cooperation. A 1996 UN Report asserted that transnational crime had become the 'new form of geopolitics'. A case in point, the proliferation of cyber crimes in particular for example within the financial domain, poses serious concerns. As noted in Menon and Siew [24: 243] economic crime '…can distort trade and investment flows, undermines the integrity and proper functioning of financial markets, and even threatens regional and global security through its financing of terrorism. Due to their scale and reach, economic crimes if left unchecked could have systemic consequences, retarding growth in countries and eroding confidence and support for the global economy'. Addressing these financial cyber crimes requires a critical understanding of their nature and unique characteristics in order to shape and enable resilience: a systems perspective such as heterogeneous engineering [20, 21] figures prominently in this solution space.

The comprehensive approach is not new.

> As global challenges continue to rise in number and increase in complexity (effects of climate change and degradation of natural resources, population pressures and migratory flows, illicit trafficking, energy security, natural disasters, cyber security, maritime security, regional conflicts, radicalisation and terrorism, et cetera) and as economic and financial resources remain under pressure, the case for a comprehensive approach, making optimal use of all relevant instruments - be they external or internal policy instruments - is now stronger than ever. EU [11: 3]

Such an approach has been successfully deployed recently as an organizing principle for EU action. As noted in EU [11: 3], 'comprehensiveness refers not only to the joined-up deployment of EU instruments and resources, but also to the shared responsibility of EU-level actors and Member States'. As a distributed networked of capabilities the EU brings together the ' European Commission and the 28 Member States, to work in a joined-up and strategic manner, the EU can better define and defend its fundamental interests and values, promote its key political objectives and prevent crises or help to restore stability' [11]. It is argued that the 'EU is stronger, more coherent, more visible and more effective in its external relations when all EU institutions and the Member States work together on the basis of a common strategic analysis and vision'. This is what the comprehensive approach is about [11: 3].

The EU [11] articulate 8 key areas of action that resonate with the cyber comprehensive approach. These areas are:

1. Develop shared analysis
2. Define a common strategic vision
3. Focus on prevention
4. Mobilize different strengths and capacities
5. Commit to the long term.
6. Linking policies and internal/external action
7. Make better use of delegation (partners and stakeholders)
8. Work in partnerships

Complex issues pertaining to such cyber security risks described are not amenable to detailed forecasting. Given the cyber interdependencies and interconnectivity, there is an inherent level of uncertainty in the understanding regarding the cyber vulnerabilities and the next threat vector. Therefore the resilience strategy needs the flexibility to adapt to emerging insights. This necessitates the effective implementation of a comprehensive approach such that all actors contribute in a concerted effort, based on a shared sense of responsibility, openness and determination, taking into account their respective strengths, mandates and roles, as well as their decision-making autonomy. A global cyber security strategy is managed more effectively when the interdependency and interconnectedness of the political, security, governance and development dimensions of these operations are recognized. Such an approach can facilitate enhanced situation awareness on emergent threats and risks and support over-the-horizon awareness and targeting.

Addressing the unique challenges associated with the transnational nature of cyber threats requires collaborative efforts among key security stakeholders as well as leveraging 'glocal' partnerships between public-private entities that facilitate questioning judgments and underlying assumptions, and employing critical and creative thinking in order to explore the resilience space of the cyber ecosystem. Figure 1 presents 3 foundational principles of the proposed comprehensive cyber strategy.

The figure highlights key interdependent elements of the political/economic/social/technical domains. The notion of dynamic harmonization focuses on developing and aligning capabilities and capacities along the lines of: legal frameworks, law enforcement, cyber forensics analysis, public/private partnerships, cyber security awareness and capacity building. The 'dynamic' nature arises from the requirement for foresight and proactive planning and interventions to enable a cyber ecosystem resilience.

New ways of thinking about cyber security that address the complexity and multidimensionality is required (if not essential) to manage the complex problems associated with the disruptive implications of transnational cybercrime. To achieve this Major and Schöndorf [19] argue that '…successful outcomes, governments and other actors involved need to coordinate their aims, activities and instruments at the earliest possible stage and ensure these are tailored to need. This is what comprehensive approaches are all about. New concepts and structures should be introduced to guarantee the coordination and cooperation of those involved at national and international levels'. The concept of a comprehensive approach is based on the assumption and requirement for some level of coherence amongst the actors/stakeholders regarding shared goals and objective and to create a dialogue to address the various dimensions of the problem space (cyber, political, security, safety, socio-economic) Masys [23]. This is supported by Menon and Siew [24: 244] who argue that 'we need a paradigmatic game change, from a hitherto territorially oriented approach, to one where investigations, prosecutions and law enforcement efforts are coordinated internationally. Legal and enforcement regimes must also be sufficiently responsive, and adapt to the changing nature and complexities of this area of crime' (See Fig. 1).

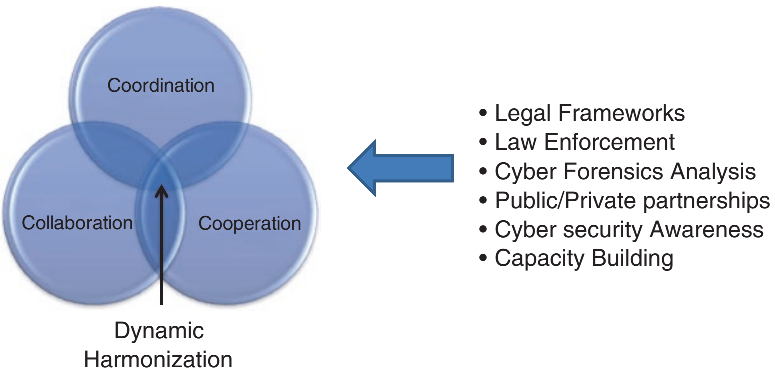
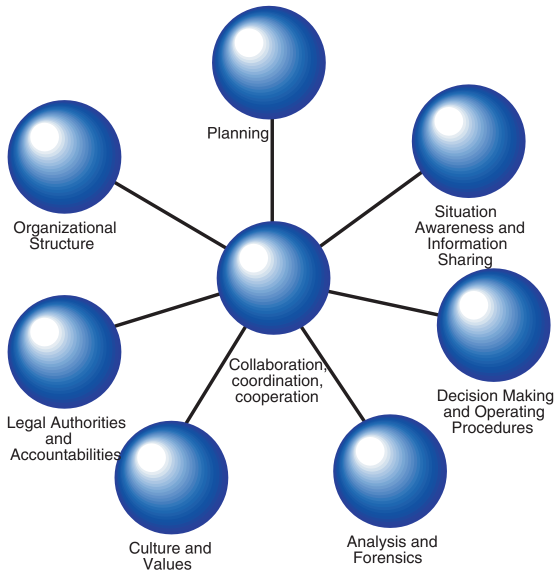


Fig. 1 Principles of a cyber comprehensive approach

Fig. 2 Activity focus network of comprehensive approach Masys [23] leveraging [37: 11–12]



As described in Masys [23], through the advent of an Activity Focus Network (AFN) model Corman [6: 35] the interdependencies resident within the comprehensive approach pertaining to a cyber strategy (Fig. 2) can be shown. The macro representation afforded by the AFN is built from higher-order groupings of activities/concepts about how activities are organized [6: 38]. Within the cyber domain it recognizes the ‘glocal’ strategic necessity to address cybercrime.

Figure 2 illustrates that collective endeavors are therefore borne out of a realization that an organization cannot achieve all its goals without cooperation with other organizations operating in the same domain [37: 7]. Mapping complex tactical and strategic interoperabilities across the ‘glocal’ landscape supports more inclusivity and coherence. Scenario planning and foresight [20, 21] are growing areas of interest that support strategic thinking by developing a range of possible ways in which the future could unfold, anticipating trends and identifying optimal policy responses to address each possible scenario. This is a key capability that adds context and supports the co-evolution of the organizational governance and strategy that is both local and global in which collaborative partnerships and risk management figure prominently.

The cyber ecosystem analogy emphasises the interdependence of all actors in the cyber environment who "co-evolve their capabilities and roles" to support glocal resilience. As described by Kraemer-Mbula et al. [17] in the absence of coordinated global governance and leadership, criminal networks are likely to proliferate or consolidate in order to pursue convergent goals and interests.

The comprehensive approach facilitates proactive measures to address complex, uncertain and globally interconnected issues and as such is inherently dynamic to proactively deal with emerging cyber threats.

5 Conclusion

As discussed by Chris Johnson (Chap. 7) and UNODC [34], cyberattacks are both growing in number, transnational footprint and becoming more sophisticated. Events such as the Estonian cyber infrastructure in 2007, '…the use of spyware and malware—such as with Stuxnet, DuQu or Flames—to disrupt critical infrastructure has made headlines, questioning the ability of governments and private actors to respond to cyber threats' Pawlak and Wendling [27: 536]. Our increasing dependence on cyberspace has brought new risks. With our reliance on cyberspace connectivity across systems, vulnerabilities emerge resulting in compromised or damaged systems.

A broad array of potential threats, like the heartbleed bug, poses a substantial challenge to existing 'glocal' governance structures. The borderless and transnational nature of cyber ecosystem with the complexity, pervasiveness and dynamic qualities characterize challenges associated with cyber threats. As the internet becomes ubiquitous, tremendous opportunities for criminal acts enabled by cyberspace emerge exploiting the interconnectedness, accessibility and anonymity properties.

As described by Collier et al. [4: 469], 'while significant advances in the field of cybersecurity have been achieved, solutions have focused more on the technical issues at component levels such as threat detection, encryption, and other mitigation procedures and technologies and less on how to address overall cyber-influenced risk and to support decisions at level of large-scale systems'. Cybersecurity 'glocal' capacity building emerges as a key enabler for resilience and is a foundation element of the comprehensive approach. Moving beyond the existing organizational, institutional or conceptual dividing lines is key. Collective endeavors are therefore borne out of a realization that an organization cannot achieve all its goals without cooperation with other organizations operating in the same domain [37: 7]. Systems thinking affords the opportunity to map complex tactical and strategic interoperabilities. In this way it becomes a thinking tool and 'worldview' facilitating tool that can be applied to all phases of conflict and crisis to all the actors involved and at all operational levels. The comprehensive approach emerges from such a worldview that roots the cyber strategy in the three principles of coordination, cooperation and collaboration.

References

1. Barabasi A-L (2003) Linked. Plume, Penguin Group, New York
2. CNN (2014) Heartbleed bug affects gadgets everywhere. http://money.cnn.com/2014/04/11/technology/security/heartbleed-gear/
3. Coakes E (2003) Socio-technical thinking—an holistic viewpoint. In: Clarke S, Coakes E, Hunter MG, Wenn A (eds) Socio-technical and human cognition elements of information systems. Information Science Publishing, Hershey, pp 1–4
4. Collier ZA, Linkov I, Lambert JH (2013) Four domains of cybersecurity: a risk-based systems approach to cyber decisions. Environ Syst Decisions 33:469–470
5. Comfort LK (2006) Cities at risk: hurricane Katrina and the drowning of New Orleans. Urban Aff Rev 41:501–516
6. Corman SR (2006) Using activity focus networks to pressure terrorist organizations. Comput Math Organ Theor 12:35–49
7. De Coning C, Friis K (2008) Introduction: how to conceptualise 'comprehensive approach'? In: Friis K, Jarmyr P (eds) Comprehensive approach challenges and opportunities in complex crisis management. NUPI report
8. De Coning C, Lurås N, Schia NN, Ulriksen S (2009) Norway's whole-of-government approach and its engagement with Afghanistan. NUPI report security in practice-8. Available at http://www.oecd.org/development/evaluation/dcdndep/47107380.pdf. Accessed 1 Nov 2013
9. Deibert R (2012) Distributed cyber security as cyber strategy: outlining a comprehensive approach for Canada in cyberspace. Canadian Defence and Foreign Affairs Institute. https://citizenlab.org/wp-content/uploads/2012/08/CDFAI-Distributed-Security-as-Cyber-Strategy_-outlining-a-comprehensive-approach-for-Canada-in-Cyber.pdf
10. Edson R (2008) Systems thinking. Applied: A primer. ASysT Institute. http://www.anser.org/docs/systems_thinking_applied.pdf
11. EU (2013) Joint communication to the European parliament and the council: the EU's comprehensive approach to external conflict and crises. Brussels, 11 Dec 2013 Join (2013) 30 final. http://www.eeas.europa.eu/statements/docs/2013/131211_03_en.pdf
12. Flood RL (1999) Rethinking the fifth discipline: learning within the unknowable. Routledge Publishing, London
13. Guardian (2014) Cyber-attack on Pennsylvania company possibly linked to target data breach, 7 Feb 2014. http://www.theguardian.com/business/2014/feb/07/target-data-breach-pennsylvania-cyberattack
14. Helbing D (2013) Globally networked risks and how to respond. Nature 497:51–59
15. Kelic A, Collier ZA, Brown C, Beyeler WE, Outkin AV, Vargas VN, Ehlen MA, Judson C, Zaidi A, Leung B, Linkov I (2013) Decision framework for evaluating the macroeconomic risks and policy impacts of cyber attacks. Environ Syst Decisions 33:544–560
16. Koslowski TG, Longstaff PH (2014) Resilience Undefined: A framework for interdisciplinary communication and application to real-world problems. In Masys AJ (ed) Disaster management- enabling resilience. Springer Publishing

17. Kraemer-Mbula E, Tang P, Rush H (2013) The cybercrime ecosystem: online innovation in the shadows? Technol Forecast Soc Change 80:541–555
18. Linkov I, Eisenberg DA, Plourde K, Seager TP, Allen J, Kott A (2013) Resilience metrics for cyber systems. Environ Syst Decisions 33:471–476
19. Major C, Schondorf E (2011) Comprehensive approaches to crisis management. SWP comments, 23 Sept 2011
20. Masys AJ (2012) The emergent nature of risk as a product of 'heterogeneous engineering': a relational analysis of oil and gas industry safety culture. In: Bennett S (ed) Innovative thinking in risk, crisis, and disaster management. Gower Publishing Limited, England, pp 59–85
21. Masys AJ (2012) Black swans to Grey swans—revealing the uncertainty. Int J Disaster Prev Manag 21(3):320–335
22. Masys AJ (2014) Critical infrastructure and vulnerability: a relational analysis through actor network theory. In: Masys AJ (ed) Networks and network analysis for defence and security. Springer Publishing, Berlin
23. Masys AJ (2014) Dealing with complexity: thinking about networks and the comprehensive approach. In: Masys AJ (ed) Networks and network analysis for defence and security. Springer Publishing, Berlin
24. Menon S, Siew TG (2012) Key challenges in tackling economic and cyber crimes Creating a multilateral platform for international co-operation. J Money Laundering Control 15(3):243–256
25. NATO (2012) A comprehensive approach to crisis management. Available at http://www.nato.int/cps/en/natolive/topics_51633.htm. Accessed 14 Nov 2013
26. Ottino J (2003) Complex systems. AIChE J 49(2):292–299
27. Pawlak P, Wendling C (2013) Trends in cyberspace: can governments keep up? Environ Syst Decisions 33:536–543
28. Robinson N, Gribbon L, Horvath V, Robertson K (2013) Cyber-security threat characterization A rapid comparative analysis. RAND report. http://www.rand.org/content/dam/rand/pubs/research_reports/RR200/RR235/RAND_RR235.pdf
29. Rudner M (2013) Cyber-threats to critical national infrastructure: an intelligence challenge. Int J Intell Counter Intell 26:453–481
30. Senge P (1990) The fifth discipline: the art and practice of the learning organization. Doubleday Currency, New York
31. Senge P (2006) The fifth discipline: the art and practice of the learning organization. Doubleday Currency, New York
32. Sterman JD (2000) Business dynamics: systems thinking and modeling for a complex world. McGraw-Hill Publishing, Boston
33. UK Cyber Security Strategy (2012) https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/60961/uk-cyber-security-strategy-final.pdf
34. UNODC (2013) Comprehensive study on cybercrime draft, Feb 2013 http://www.unodc.org/documents/organized-crime/UNODC_CCPCJ_EG.4_2013/CYBERCRIME_STUDY_210213.pdf
35. Vespignani A (2009) Predicting the behavior of techno-social systems. Science 325:425–428
36. Weick KE, Sutcliffe KM (2007) Managing the unexpected: resilient performance in an age of uncertainty, 2nd edn. Wiley, San Francisco, CA
37. Williams AP (2010) Implications of operationalizing a comprehensive approach: defining what interagency interoperability really means. Int C2 J 4(1):1–30
38. World Economic Forum (2014) Risk and responsibility in a hyper-connected world. http://www3.weforum.org/docs/WEF_RiskResponsibility_HyperconnectedWorld_Report_2014.pdf
39. Worldwide Threat Assessment of the US Intelligence Community (2013) Statement for the record—senate select committee on intelligence James R. Clapper. Available at www.intelligence.senate.gov/130312/clapper.pdf

Part IV
Organizational/Social Domain

Enabling Resilience: An Examination of High Reliability Organizations and Safety Culture Through the Lens of Appreciative Inquiry

Jerson Wattie and Anthony J. Masys

Abstract Dulac (A framework for dynamic safety and risk management modelling in complex engineering systems. MIT, Cambridge, 2007) argues that complex socio-technical systems have a tendency to slowly drift from a safe state toward a higher risk state, where they are highly vulnerable to small disturbances whereby seemingly inconsequential events can precipitate an accident. Recent socio-technical disasters such as the 2011 Fukushima Nuclear accident, 2010 Deepwater Horizon accident and 2005 refinery explosions at BP's Texas City all highlight major disasters in which a safety culture was not working. Many industries around the world are showing an increasing interest in the concept of 'safety culture' as a means of reducing the potential for large-scale disasters, and accidents associated with routine tasks (Cooper Saf Sci 36:111–136, 2008). Traditional root cause methods of analysis examining safety culture apply a deficiency model in which problems are identified to support corrective action and transformational change. Within this paradigm one asks: "What are the problems?", "What's wrong?" or "What needs to be fixed?" Here we introduce a paradigm shift from a deficiency based approach to a strength based approach through the advent of "Appreciative Inquiry" (AI). The Appreciative Inquiry model is based on the assumption that the questions we ask will tend to focus our attention in a particular direction. Appreciative Inquiry stands out as a methodology that can facilitate examination and 'construction' of safety culture. As a high engagement, strength-based approach to organizational change, AI focuses on aligning strengths of the organization with opportunities, aspirations and desired results and transforming goals into action fostering organizational learning at its core. Drawing upon the literature on AI, High Reliability Organizations and safety culture, this chapter presents appreciative inquiry as a tool-set to facilitate structured analysis and construction of the qualities of a safety culture of excellence to support a High Reliability.

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A. Masys (ed.), *Disaster Management: Enabling Resilience*,
Lecture Notes in Social Networks, DOI 10.1007/978-3-319-08819-8_9

Keywords Safety culture · High reliability · Organization · Socio-technical system · Appreciative inquiry

1 Introduction

The complex socio-technical domain is replete with 'hyper-risk' [17, 26] characterized by inherent interdependencies and interconnectivity of the human, physical and informational domain. By virtue of the inherent complexity, safety culture emerges as a product of heterogeneous engineering [25]. Masys [25: 72] argues that 'safety culture is not something abstract that resides within the minds of people but rather is:

> …an emerging property of a socio-technical system, the final result of a collective process of construction, a "doing" that involves people, technologies and textual and symbolic forms assembled within a system of material relations (Gherardi and Nicolini 2000).

As noted in [16], events like the Deepwater Horizon accident, which killed 11 rig workers, the 2005 refinery explosions at BP's Texas City, Texas, facility that killed 15 employees, the near capsizing of BP and ExxonMobil's Thunder Horse rig off Louisiana coast in 2005 and two near-blowouts of shallow-water wells in 2002 show a pattern of safety culture that is not working. Stemming from a history of accidents involving complex socio-technical systems, (Chernobyl, Challenger and Columbia Space Shuttles, Deepwater Horizon, Fukushima) the interest in safety culture has garnered much interest [14]. A strong safety culture positions the organization for resilience in the face of accidents and disasters through adherence to the qualities of an HRO [45]. As noted by Woods [47] 'the common thread in the work on proactive safety was the idea that *resilience* is a critical systems property when organizations are under pressure both to be highly productive and to achieve ultra-high levels of safety. Resilience refers to the art of managing the unexpected, or how a team or organization becomes prepared to cope with surprises'.

As described in [5: 116], a goal-directed [35] approach to safety culture stands out as a way to shape characteristics of the organization to create change and enhance safety. This suggests that because goals (ideas of future, ideas of a desired end-state) play a strong causal role in action, the application of a forward-thinking strength-based paradigm may serve to provide the requisite perspective to building a safety culture of excellence.

To facilitate this paradigm shift from a deficit model to a strength-based model, Appreciative Inquiry (AI) is introduced. AI is an approach that facilitates transformational change within an organization. It is based on the assumption that the questions we ask will tend to focus our attention in a particular direction. Whereas a *deficiency* based approach focuses on "What are the problems?" and "What's wrong?" Appreciative Inquiry takes an alternative asset-based approach. It asks questions like "What's working well?", "What's good about what you are currently doing?"

The widespread engagement with stakeholders, the focus on opportunities, and the creation of a shared vision, make AI a powerful approach for transformational change. An AI survey on building a safety culture was initiated with a sample group from The Trinidad and Tobago Emergency Mutual Aid Scheme (TTEMAS). Coupled with this, an analysis of safety culture, through the contextual examination of deepwater horizon was conducted focusing on a deficit-based approach and contrasting that with the AI strength-based approach. What emerged from the deployment of AI within TTEMAS is a 'rich description' of the facilitating root causes of success associated with an exceptional safety culture.

2 Appreciative Inquiry

As described in Busche [3], AI emerged as a strength-based movement from Case Western Reserve University through the efforts of various researchers (e.g., Barrett, Bright, Bushe, Carter, Cooperrider, Johnson, Ludema, Powley, Sekerka, Stavros, Thatchenkery). Three primary observations supported the development of AI [8]: the view that the traditional deficit based problem solving approach did not achieve the results; the view that social construction shaped organizational realities; and the view that the lack of new ideas was a function of the method of inquiry (Busche 2010).

The fundamental assumption of AI is that:

> Every organization has something that works right- things that give it life when it is most alive, effective, successful, and connected in healthy ways to its stakeholders and communities. AI begins by identifying what is positive and connecting to it in ways that heighten energy, vision, and action for change [7]: xx).

As a philosophy/methodology, AI is operationalized through a 5D process cycle of definition, discovery, dream, design and destiny (Fig. 1). Table 1 details the process descriptions as described in [27].

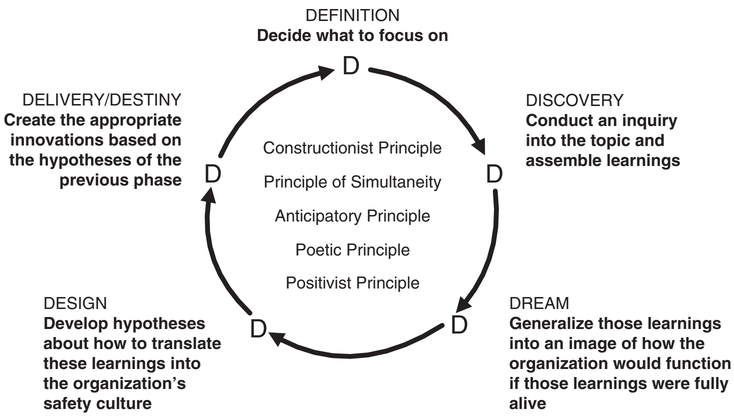

Fig. 1 Appreciative inquiry "5D" cycle with core principles (modified from [27])

Table 1 5D process descriptions [27]

Definition. During this phase the initial focus and scope of the inquiry is established. Since organizations move in the direction of the questions they ask, the choice of questions is vital. In the Definition phase, the organization's focus shifts from describing the problem to determining what its members want to achieve and what they need to know to get there
Discovery. It is through this phase of dialogue that the organization identifies "best practices,""life-giving forces," or "root causes of success." AI operates on the premise that the act of asking positive questions is as important as the data it elicits
Dream. During this phase, people throughout the business create images of what life in the organization and its relationships with key constituents would look like if the company's very best practices became the norm rather than the exception
Design. During the Design phase, participants identify the high-leverage changes in the organization's systems, processes, roles, measures, and structures necessary for achieving the dream. It is about enacting the essence of the vision in the policies, core processes and practices, and systems—all of the formal and informal structures that sustain the corporation's essence
Delivery/Destiny. In the Delivery/Destiny phase, the organization fleshes out and redesigns yet again the innovations that it identified during the Design phase. The hallmarks of this phase are creativity, innovation, and iteration—buttressed by ongoing inquiries into the progress being made and the effectiveness of the changes

The five core principles of AI, shown in Fig. 1, anchor the 5D process. The Constructionist Principle alludes to the observation that an organizations culture is socially constructed defined by the inherent belief systems and mental models of the organization. As described in [28], organizations will evolve in the direction of the images they create. The principle of simultaneity argues that inquiry and change are connected. Through the process of inquiry a change agenda has been formed at the same time. The anticipatory principle reflects how our impressions of the future shape our behaviour in the present. The poetic principle highlights how our inquiry is not bounded and is without constraint. The positivist principle reinforces the observation of the effect of framing issues management in a positive light. So doing will help guide change for more long-lasting and effective results [28].

What is important to recognize from Appreciative Inquiry is that it not only focuses on the best of what is, but engages all stakeholders in a processes of re-imagining what could be and thereby facilitating the creation of a shared vision. These qualities make AI well suited as a method of inquiry regarding safety culture.

3 Case Study

The 2010 oil spill in the Gulf of Mexico is now considered the largest offshore spill in U.S. history. The spill stems from a sea floor oil gusher that resulted from the April 20, 2010 Deepwater Horizon drilling rig explosion. The explosion killed 11 platform workers and injured 17 others. Members of a federal investigative panel into the Deepwater incident blasted BP for apparently failing to improve its safety culture after a string of accidents over the last decade [16].

Drawing upon the findings of deepwater horizon accident as a backdrop for identifying the dysfunctionalities pertaining to safety culture qualities, a positive strength-based approach to defining safety culture qualities is developed through a sample group survey of The Trinidad and Tobago Emergency Mutual Aid Scheme (TTEMAS). TTEMAS is a volunteer group of safety and process operations specialists who are employed with companies that reside on a local petrochemical estate. These companies have pooled their emergency resources into a mutual aid response unit for the benefit of more effective coordination and support in the event of failure. As an organization, TTEMAS is indoctrinated by legislation as an extensive network of private and public officials. The majority of their private membership embodies heavy petrochemical and small manufacturing businesses. The organizational structure that governs TTEMAS is tall and is represented at the policymaking level by each private member's CEO who in turn volunteers that member to council. Periodically are general elections among members to appoint an operational steering committee for the daily affairs of the organization. That steering committee is represented by the roles of President, Treasurer, Secretary and Public Relations Officer. There is a lower tier of ordinary general members who support the functions of the steering committee. Attending national officials are represented by independent public officers who support TTEMAS's objectives with state resources. Generally TTEMAS is a private volunteer organization that is supported by majority private funds with some national resources. It is a unique hybrid response organization.

An explicit requirement is that TTEMAS members should have some form of public safety and process industry experience. TTEMAS meets and trains regularly because they are officially responsible for annual emergency drills in the petrochemical estate. All members are well trained, highly respected subject matter experts that evaluate other similar exercises. During their long history TTEMAS has conducted several drills both land and marine. They respond actively to fire, explosions, chemical releases, mass causalities and natural disasters. TTEMAS has very close connections to government response agencies and in the past have engaged practicing officials as executive members. TTEMAS's long history of involvement in the national emergency grid has made them an attractive organization for young professionals who wish to support public safety. The community surrounding the petrochemical estate has considerable experience with TTEMAS's operations via education and outreach campaigns. Presently community members are not represented on the TTEMAS administrative council but they are consulted on operations occasionally. TTMEAS has their main operational presence on the petrochemical estate; but have recently activated other branches throughout heavy industry areas of the country.

Given the role and function of TTEMAS in the management of emergencies within the domain of the oil and gas sector, they are well positioned for the application of the strength-based AI inquiry into safety culture.

4 Discussion

As described in [25, 41] argues that many accidents result from 'failure of foresight'. He describes this as the 'accumulation of an unnoticed set of events which are at odds with the accepted beliefs about hazards and the norms of their avoidance'. As described in the Deepwater Accident report, preceding the deepwater accident were a string of events that suggest a dysfunctional safety culture. The Safety Board's report on Texas City noted that 'while most attention was focused on the injury rate, the overall safety culture and process safety management program had serious deficiencies' [30: 221]. The organizational causes included:

> BP Texas City lacked a reporting and learning culture. Reporting bad news was not encouraged, and often Texas City managers did not effectively investigate incidents or take appropriate corrective action.
>
> BP Group lacked focus on controlling major hazard risk. BP management paid attention to, measured, and rewarded personal safety rather than process safety.
>
> BP Group and Texas City managers provided ineffective leadership and oversight. BP management did not implement adequate safety oversight, provide needed human and economic resources, or consistently model adherence to safety rules and procedures.
>
> BP Group and Texas City did not effectively evaluate the safety implications of major organizational, personnel, and policy changes [30: 221].

A culture of complacency characterizes the oil and gas industry leading up to the Deepwater accident [30]. The report highlights issues pertaining to the inadequacy of risk management, poor communications and decision making. For example, '… officials made a series of decisions that saved BP, Halliburton, and Transocean time and money—but without full appreciation of the associated risks' [30: 223]. The Deepwater Horizon accident highlights the key areas of safety culture, organizational failure, organizational learning, and reliability. It was noted in the final report that 'the immediate causes of the Macondo well blowout can be traced to a series of identifiable mistakes made by BP, Halliburton, and Transocean that reveal such systematic failures in risk management that they place in doubt the safety culture of the entire industry' [30].

4.1 Theoretical Framing of Safety Culture

The early works of disaster researchers have uncovered important human factors that have altered the historical routine nature of operational failure i.e. poor organizational safety culture. Today's safety professionals may confidently assert that safety culture is essentially "the way we see and do things around here that could reduce the chance of danger". However it is worth the extra effort to reflect on the social undertones, the duality of culture inclusive of feeling safe in order to understand why the concept remains a distant feature of most organizations. Safety culture therefore requires extra scrutiny in light of the current spate modern disasters. Recently the worst example of modern failure, the Gulf of Mexico Blowout has stimulated fresh interest in the paradox of organizational safety and modern technologies.

Consider the early work of [41] work postindustrial revolution into the age of striking industrial mishaps e.g. Bopal, Piper Alpha. The fresh public uproar inspired social scientists to produce some of this century's most definitive work on human factors and disaster inception. Their theories form the first sinews of cultural logic where authors like Turner, Reason et al. advanced their theories to form the base of modern investigative methods for failure models. With original interest, Turner noted that organizations are generally suspect when searching their historic mental models. It is an innate human predisposition that suggests an internal contradiction that comes with discovery. To protect the time-honored public respect of scientific discovery denial of certain danger appears comforting. Turner notes that the genesis of most accidents is mental blindness, an artificial atmosphere, a bounded rationality [1]; paralysis of the mind, unable to reliably decode the complexity of reality. Again this is part of the human condition where fixed symbols, artifacts and prestige somehow awaken productivity. This is critical to our evolution. While business as usual, routine underpins mortal confidence. To survive this extreme world it must be possible for humans to decode if only a fraction of infinite environmental signals. Rules and routine often appease risk taking. However the presence of routine and status while it increases efficiency and confidence it inversely affects our attention to defects. Turner refers to this accumulation of abnormalities in a known system as the seeds of future catastrophe. Turner suggests that humans initially represent their reality as pride in successful tactics. Gradually failure is subsequently removed from memory. Humans then downplay defects in order to defend the integrity of existing scientific models. A sudden discharge of awareness appears soon after defects begin to exceed controls. As traditional measures fail under the weight of abnormality there is a wave of fresh astonishment that represents disaster onset. There is an immediate acknowledgment of despair, a vacuum of ideas and a cry for assistance. The final phase establishes sobering memories of failure and a pledge of fresh solutions. This rebuilds public confidence and inspires future plans for corrective technologies. Albeit the momentum for Turner's disaster cycle is driven by the intrinsic struggles between science and politics. Early on individual prejudices come from strong competing executive guarantees that resonate as organizational policies. Operational confidence in these select groups is communicated to others as solutions. These specific solutions dilute external signals. The result creates an aversion to outsiders with their critical and time consuming ideas. Similarly through the inclusion of too many strangers with their noisy ideas also amplifies fear and can create additional dangers. Logically in industrial life there are numerous challenges involving authority, dishonesty and ignorance.

4.1.1 Informed Culture or Safety Culture

Organizational safety culture has mostly been a corporate expression used to explain the complex human preconditions present at work. However the problem is perhaps the term attempts to represent powerful human emotions in social groupings i.e. an organization with textbook accuracy. Safety culture is much more complex and travels across time and space. It accumulates as byzantine learnt lessons and with egotism that outstrip technological defenses. Learning and culture is mostly abstract [44], while being the catalysts for scientific advancement. But intellect can also encourage hubris and this quickly turns into destruction [23].

The term safe culture conceivably gained more importance with the British Health and Safety Commission (HSC) (1993). It was considered to explain misconduct in a series of industrial disasters that included Chernobyl. Since then it has been a standard argument in many academic failure modes.

> Safety culture is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organization's health and safety management" [19].

Evidently the HSC's early account represents elements of Turner's early work although it does not exactly clarify how human factors become so powerful. Cultural disaster seeding is still evasive concept despite the plethora of modern debates on safe culture. Moreover it was [33] who brought the term into modernity by describing the abstract process of human behavior as accident seeding or latent error faults within tangible safety plans. He noted that silently, errors of ignorance formed in the spaces where information on complex risk was missing. Reason noted that organizational knowledge was categorically a safe culture, one where reliable information on difficult problems was continuously available throughout the folds of a company. Notably once risk information is circulated it builds as critical organizational memory. Event details produce confidence and resilience; it reminds operators to fear. Information involves the senses in critical thinking and affirmative actions. Reason suggests that safety culture is symbolic of an engine that works precaution into a constant frenzy which produces a high respect for the environment's signals i.e. active foresight. Reason moves further to explain that available information allows operators to shape appropriate protective barriers. Except Reason's vigilance as an engine metaphor still is a complex interpretation i.e. with every passing pulse of his engine personal prejudices silently grow because humans are proud creatures. While Reason's explanation offer good insight, his model remains short of life in commercial plays. We cannot accurately measure how deep personal business choices modify safety and encourage disasters but one should ponder using history wisely. Reason argues that in time while bureaucratic failure is rare it offers overwhelming evidence of neglect. Notwithstanding more assessable individual accidents, bureaucratic messes are more significant in heavy industry accidents. Accordingly systemic barriers in industry operate with the defense in depth concepts to protect against technical and executive slips i.e. hard engineered barriers and soft administrative barriers working in unison. Juxtapose Turner's earlier model and we can see that Reason's suggestions use the fortifications from Turner's earlier foresight failure sequence to build understanding.

Except with real events, human perceptions only recognize direct failure lessons and form corresponding rigid barriers. Principal assurance in these barriers are often represented as the dominant or expert opinion which this builds as organizational/industry memory. Reason anticipates that these concepts are the contrivances associated with pseudo organizational memory, overconfidence and later hubris [40]. Reason mentions the danger of pseudo confidence in his famous “Swiss Cheese Model”, the standard model for organizational failure. Hard defenses are often weakened when humans under appreciate systemic risks. Regulated strategies and opinions create gaps in organizational memory. This fragility is represented in Reasons theory as illusive and dynamic human factors that silently build when the organizations negligently chase business agendas. Accordingly safety culture is primarily a social issue that attacks any measure of hard science. Organizational resilience is therefore firmly based on humans prudently observing their active environment and making necessary changes with lessons gleaned from rare events. There must be honest willingness to treat with internal fragility, albeit humans have become fearless because of advanced technological defenses based on strict scientific concepts [33, 40]. Nevertheless safety culture can be preserved in an organization practicing healthy respect for systematic hazards under harsh modern circumstances [33].

4.1.2 How to Prevent Organizational Failure

Toft and Rynolds [40] outlined this systematic principle for preventing failure based on perception filtering. The model is a formalized modern adaptation of the earlier socio technical arguments presented by Turner [41] and later [33]. An organization is theoretically a closed loop processing unit. It is a box where lessons are uploaded, stored and analyzed. Firstly direct foresight develops when corrective instruments i.e. logic always recognizes and stabilizes external signals so that they meet an expected degree of control i.e. foresight is equal to hindsight. Comparatively indirect foresight can also be developed when unusual signals enter the organization/system gaze. Initially these abnormal signals can be ignored; these signals can grow silently into future problems i.e. seeding complex failures. The system’s active foresight can reduce the problems of ambiguity through a continuous comparison with borrowed logic. When internal lessons are absent, active foresight can select isomorphic features to fashion correctors that stabilize abnormal, silent errors in their embryonic stages. This is the organizational loading of lessons to shape better organizational knowledge.

Organizational memory and so foresight grows with a mental obsession with abnormalities, though some requirements are critical for the Toft and Reynolds model to work reality. This includes a set of suitable and sufficient correctors, constructive supervision for correctors and a sizable lesson database with clear objectives [40]. Although the Toft and Reynolds model is very principled and does lengthen the organizational cognizance with mindfulness, this is vulnerable to the duality of culture. Pidgeon [32] argues that simulations such as this, germane to the early work of Turner et al. are good but do not adequately consider the latent convolutions of politics and emotion. Hubris exists in obscure folds as shades of authority. High pressure industrial life is inherently troublesome and its commercial importance to living causes unpredictable outcomes. Toft and Reynolds admit that their model is inescapably vulnerable to political distortion, choices that corrupt reliability. These are those latent failures, Reason’s dynamic gaps in his Swiss Cheese Model.

Pigeon and Reason both agree that at the governance with emotional undercurrents are at most very powerful. Both suggest that personnel safety is actually less critical to disaster formation because they are confined to expected human errors. Deviant leadership behaviors are more potent because they penetrate the organization's sense making i.e. sloppy management [42]. Turner suggests that the real danger of sloppy management dwells in the behaviors of senior managers when they use their authority to protect personal deviance. Anthropologically a leader's role is especially trustworthy with groups, arguably it is the source of major social disturbances [23]. These theories are quite specific to real modern world troubles. One only has to look at the combination of politics and defense in depth technologies during the Gulf of Mexico Blowout to understand organizational failure as a result of latent disaster seeding by executives.

4.1.3 Disastrous Decision Making in the Gulf

The Gulf of Mexico Blowout killed 11 people and leaked millions of gallons of oil into the surrounding pristine environment. The primary accident was caused by a series of failed endeavors including, poor onsite engineering precaution. Nevertheless the central disaster developed from a web of underlying administrative failures that developed into a highly complex multi agent controversy. The ensuing chaos wreaked havoc on administrators as they struggled to maintain their integrity in the face of cascading failures. Equally the magnitude of this disaster has been investigated and described periodically by experts. Correspondingly the causes of this event and other petrochemical disasters theoretically remain the same, poor organizational safety cultures. Public inquiries have revealed that the revelation of poor organizational safety cultures is an indicator of deviant leadership subcultures. The social significance of leadership means that people will always express deviant behaviors in spite of most highly reliable controls. Deviance is the dark side of an organization's obsession with commercial survival [43].

We often view administrative deviance within restricted imagination and time. Deviation is silently stored within organization strategic decisions over time, usually present within select individuals. Yet when many disaster inquiries are convened they suffer from scope restricted to recent memory and the accessible facts. In medical post mortems those under public scrutiny usually close ranks to protect their peers; they control professional risks [20]. Generally unrestrained, blame free individual recollections are more important when positively describing the formation of disastrous events [20, 23]. Mason suggests that causes of past events avoid tunnel vision and cultural blindness to deviance. While long causal chains are often difficult and indistinct they contain vast amounts of information on the systemic root causes of poor safety culture. In the case of the Gulf of Mexico disaster two highly respected reports drew reference to the historic, systemic pathogens that existed in the BP's organizational culture long before the Gulf of Mexico accident. The National Commission on the BP Deepwater

Horizon Oil Spill and Offshore Drilling Report [11] notes that complex systems fail in complex ways. The oil well blowout was avoidable but a long history of misguided risk management approaches among stakeholders saw the widespread erosion of safe attitudes in the entire offshore drilling industry. The Deepwater Horizon Study Group [10] suggested that there were multiple opportunities for drillers to develop sound protective measures however competition and productivity outweighed the importance of critical thinking and regulation. Both reports suggest that the liable parties over time forgot to be afraid. This statement reestablishes Reason's principle of conviction in pseudo knowledge. Corruption runs deep and once established it becomes normal. Unethical culture and restricted leadership erodes confidence in operating safely [23]. Disasters are primarily the result of early flaws sometimes indifferent decisions at project design. As confidence grows with engineered trimmings it downplays other systemic risks [40]. Operational invincibility is typical of early gains as it convinces leaders that their strategies are noble. The [30] recounts that during the BP's history former leaders grew braver as early gains in first to deep water plays turned into lucrative profits and political respect. This confidence became part of the company's bold exploration philosophy and saw BP elevated to pioneering status. Mason notes that this elevated status changes an executive strategy from cautious to daring, observed in NASA before their space shuttle Challenger disaster.

Culture is therefore invisible, intoxicating, and persistent. Successful past strategies are unquestionably fatal to others under changing circumstances. Yet post disaster, our instinctive memory is edited by deeply rooted personal wishes. Our memory of tragic events will always fail us growing forward because we are unable to value multiple opinions of the same event. The cause of an incident is usually attributed to one-dimensional versions of the facts. Many current one dimensional explanations entertain equipment malfunctions, operator error and unpredictability etc. Systemic errors must be reliably considered to reduce the chances of catastrophic failure [40]. The diverse properties of a failed system must be viewed in fullness [42]. Tragically comprehending the full lesson is not an easy characteristic of humanity so perhaps poor safety cultures are inevitably normal. Perrow [31] normal accident theory suggests that linear or procedural disorders are well studied in operational failure. It is potentially what brings great pleasure to operators because it is suited to available engineering controls. However multidimensional lapses are more devastating through their incalculability. They are not sought after accounts because the inability of operators to readily explain vast feedback loops. In the aftermath of the Gulf of Mexico blowout BP's experts reconstructed the event using Reason's failure model, unfortunately the scope of their explanation downplayed BPs encouragement of failed strategic decisions. This is the practice of making accidents normal through organized irresponsibility. It is a manner of reducing fear and improving engineering composure through ignorance. It encourages the anticipation of acceptable risks whereas more organic, backstage practices take root [1]. The limited appreciation for all hazard information creates the seeds for gross negligence. Good safety culture takes an intense, sensible look at the cultural folds of the organization [32].

4.1.4 BP'S Swiss Cheese Analysis

Hopkins [18] accepts the strategic value of Reason's Swiss Cheese Model for explaining BPs oil spill. He suggested that Reason's model aids in hindsight by distinguishing the progress of failure and relative consequences because of gaps in operational foresight. However Hopkins noted that BP's use of Reason's model was not insufficient so as to appropriately explain the progress of a multi agent calamity. BPs effort could not describe its honest obligation for events before, during and after the accident. The fear caused by mass hysteria limits individual prudence [2]. In this way Hopkins relates that when BP produced its explanation of the event, it appeared to be devoid of direct culpability. This act is in conflict with the intent of Reason's original intent, safety culture is an honest and informed one. Notably when blame is involved, Reason's model becomes compromised by sanitized data. Ideally it is self-preservation that drives humans to continually kill one another [2]. Weir [46] suggest that our self-taught ability to distill failure into acceptable levels of blame is the fuel that drives future disasters which are our naked fears.

Masys [25] Actor Network Theory (ANT) notes that safety culture emerges from a relational view between physical, human and informational actors. True safety culture embraces foresight through collective sense making of all activities in business. It should not be restricted to linear transactions. Hopkins expands Reason's model of the Gulf of Mexico accident to include the complex relationship of multiple actors. Notably Reason's general model is removed as the central feature previously defined by BP. Reason's model becomes the consequence of closed, ill-advised management decisions and multiple error pathways. Expediency through groupthink is a pervasive; real pathogen found in a range of human decisions pre-disaster and post-disaster conditions, seen in the BP event. It perhaps has been historically underestimated because it carries along quietly in deeds and thoughts long after the central failure has been controlled. Disasters belong to restrictive, idealistic, executive worldviews [42]. To improve safety culture and restrict disaster; organizations must learn from openness and embrace critical thinking among is various interests. They must also connect to safety culture at the holistic level through instruction. Organizational learning builds an informed culture by tapping into the complexity of multiple actor networks that contain physical, human and informational intelligence [24].

4.1.5 Effective Learning from Crisis

Toft and Rynolds [40] suggest that personal communication can potentially repair deviance. Learning is connected to the deep multiple beliefs and experiences of culture within the system's actor network. Learning inspires culture and vice versa, a natural dynamism that positively influences the organization's individual thoughts. Schein [37] suggests that learning is used to teach individuals of an organization how to cope with their environment by affecting their thoughts. Correspondingly Smith and Elliot (2007) note that changing the culture within an organization can decide its destiny. Amongst these arguments envisage learning through [29] functional and interpretive philosophy of organizational actuality. Learning is the abstract process of an individual decoding life messages through functional and interpretive windows. It is a deep, nonphysical manifestation refined by regulation and personal understanding. This correspondingly epitomizes the duality of cultural learning either passively or actively [40]. The first simply involves a process of observing the facts of an experience while the second involves the creation of an internal awareness using the facts as gauges. Both forms of learning affect the different aspects of socialization. The former is the weaker since it connects to only direct signals e.g. rules, regulations, politics etc. It is less effective according to Toft and Reynolds because its descriptions are more superficial. Similarly Smith and Elliot agree that vulnerability to future crisis lies in formality i.e. regulations, structures and plans or direct signals. A paradigm shift in thinking towards the personal qualities of belief, customs and behaviour increases reliability in crisis. Research has found that targeting attitude actually uncovers more information for assimilation and loosens complex environmental signals. Schein [37] psychological judgment suggests that to acquire these personal qualities an observer must spend time in an organization probing past the obvious which focuses on company policy and general arrangements. The greater, more rewarding aspect of culture lies with behavioural indicators. Schein's agrees with Smith and Elliot's earlier position that organizational learning consists of tiers of understanding. The first order learning is concerned with material articles and second order learning involves the relevant personal idiosyncrasies. Kim [21] agrees with this theory of levels i.e. functional learning is skill based while abstract learning understands why there is skill and this creates the difference between general action and intelligence.

4.1.6 Organizational Learning Is Predominantly Abstract

Organizational learning is a cultural process whereby individuals are always decoding and storing information to understand their environment. As a result culture and learning are analogous since culture is learnt and learning is forming culture [37]. Learning is knowledge of the connection between an organization's actions and its environment. Ultimately this becomes stored as knowledge which is used to create an appropriate response to the environment [21]. De Long [12] suggests that culture plays a key role in shaping knowledge because culture is important in determining the relationship between organizational structure and information flow. It is a process that influences the formation and adoption of extra knowledge. While this explanation is helpful in the classic sense, the complexity of culture remains and it limits the role of complete knowledge. Because culture is blurry the exact science of organizational learning and knowledge is open to speculation. Consequently the visible artifacts of culture in an organization are stored as the active organization's memory [21]. Active memory is important to organizational knowledge and confidence because it determines the future response of the group through what the group has experienced. Ideally these memories are the experiences that go on to reshape individual culture and to confirm Schein's earlier assumptions. Memory therefore is as complex as culture and can be seen as artifacts, traditional policies and procedures but also create their latent flaws.

A lot of emphasis has been placed on individual knowledge because without it there is no memory of success or failure. There is no appropriate response by the organization and it soon fails because it has no foresight. This leaves room for individuals to improvise to deal with external changes [21]. Culture then creates the memories that are critical to full learning and that later builds knowledge and this is what makes learning effective. Alternatively there are several reasons why learning cannot be effective in creating knowledge and in the next section we discuss these as the barriers to learning. The important message here though is that once culture remains complex, broken memories are expected and learning is sporadic, failure is soon close as people begin to invent new realties. Smith and Elliot [38] suggest that a secure organization must have knowledge transfer that is open and reliable between individuals to prevent this. Hence better knowledge transfer shapes healthier future safe subcultures and vice versa therefore this makes groups more effective in the real world [12]. But as always in prudent theoretical takeaway must be the need for critical thinking with ubiquitous cultural imagery. Knowledge is a useful tool in early analysis and it keeps an organization safe but it also plays a key role in simultaneously blinding an organization [38].

4.1.7 Problems with Organizational Learning

Organizational culture and its associated beliefs, values and attitudes are facilitators and or barriers to the successful knowledge management initiatives and commitments to knowledge sharing practices [15]. Culture's unpredictable nature is the cause of many problems with organizations and is simply beyond understanding the features general operation. Theoretically better crisis management involves a need to improve safety cultures whilst safety culture has to do with open and relevant knowledge transfer. Most local high-risk organizations have guiding safety cultures well framed in their archetypes and freely request their staff promote these principles. However richer study reveals that this proud exterior of functional ability is filled with deep-seated cultural conflicts that are often underestimated. De Long and Fahey [12] suggest these problems occur when knowledge grows in separate sections of an organization and gradually cause units to silently advance their own sub-cultural biases within work. Mostly leaders miss these deep lying cultural traits in favour of more popular operational information, often traded as misguided memories of good performance. Turner [42] indicates that this is administrative inattentiveness and it lies at the heart of unsafe cultures. While technical data about risk is critical there is a need to be more sensitive to opinions. Humans usually avoid attitude complexity in favour of more direct resolutions.

Robbins and Judge [34] suggests that a strong inclusive culture increases the efficiency of an organization's overall performance by encouraging better quality work through the harmony of ideas. Culture as suggested earlier is the bond that holds an organization and defends its standard beliefs. In contrast culture also has the latency of dysfunction with all its value. Turner [42] agrees that industry specialization actually inhibits the flow of information. Unseen vulnerability in trusting expert climates creates serious limitations for realistic response measures in the face of cascading failure. This represents the weakness in organizational sophistication (Smith and Elliot 2007). Additionally culture creates more delineation in the value of knowledge when experts decide who special knowledge is disseminated to [12]. Generally Reason's informed culture i.e. safety culture concept is potentially utopian. In reality information sharing is too human. An informed culture or safe culture is frustrated by the myriad of individual preferences. Inspiring a safe culture must always be a thoughtful, managed exchange. Culture and its offspring disasters are capricious.

4.1.8 The Hallmark of Reliability

Although culture and disasters are unpredictable, selected research suggests that potential blunders can be stabilized by a Highly Reliable Organization (HRO). Personal error provoking within HROs is alleviated and reliability guaranteed by an elevated level of human sensitivity through a well-informed culture. The ability to realize a high reliability culture is not mysterious; it is formed by a preoccupation with human performance [33]. Weir [46] agrees that the major opportunities for improving on failure lies with improving individual culture. Reliability thus lies in an intense and honest examination of failure history with honesty about deviance. This is no easy task and requires professionals within an organization to reboot most of their mental models and eject biases or suffer more problems with safety culture. Dekker [9] explains that the idea of safety is always compromised if professionals continue to spend time learning in traditional incomplete ways. Resilience does not belong to popular safety and dogmatic concepts. Professionals must revolutionize their mental models by deep critical analysis and second-guessing expediency. However while these arguments are credible they lightly consider that individuals in reality are bombarded by numerous troubles. It is only natural for business to be convenient and loose interest in intrinsic personal opinions Dekker suggests. Nevertheless, [40] suggests that for an organization to be highly reliable interconnected failure lessons must impact at the individual level of the organization and resonate psychologically through the hierarchy with steady force. Isomorphic learning should build personal concern which travels along the lines of authority raising more concerns within units. New levels of interest and higher order feelings are later produced. The culmination of this social wave grows managerial hindsight because these intimate concerns negatively affect production and capital. Accordingly hindsight creates a predictable growing interest in managerial contact with failure which creates superior foresight. Managers attempt to take these early overwhelming aspects of operational failure seriously and develop policies to improve areas of likely weaknesses. This new high-level managerial purpose should be actively associated with changing the organization's destiny with failure or actively learning. In theory if an organization's hierarchy openly discusses awful experiences, a resultant sensitivity to adversity generates active foresight and increases reliability, an informed or safe culture [33]. Therefore organizational mindfulness inevitably returns to the anticipatory analysis associated with Dekker's earlier argument on constructive management. Creative lessons advances higher order thinking and becomes the organization's way to advance into a HRO [45]. Hopkins [18] notes that dictatorships have little success with disasters, resilience is found in personal experiences i.e. regular interactive debates and open simulations highlight personal encounters.

The theoretical framing of the Deepwater horizon accident illustrates a deficit view of safety culture (focusing on what is wrong). Such a deficit view addresses the root cause of failure but fails to capture the root causes of success. To explore the strength-based approach to safety culture, TTEMAS was solicited to conduct an AI examination of safety culture. Leveraging the 5D process of AI (Fig. 1), stakeholders within TTEMAS were asked the following:

1. Describe a time when you were part of TTEMAS and produced some great results pertaining to safety culture.
2. What behaviors and attitudes were present to create this safety culture?
3. What factors were present?
4. HROs are organizations with systems in place that are exceptionally consistent in accomplishing their goals and avoiding potentially catastrophic errors. Describe the qualities of your ideal HRO and its essential safety culture features.
5. What are three things you could do now to contribute to an exceptional (world-class) safety culture?

To create conditions for a safety culture of excellence to flourish depends on identifying leverage points within the organization. Through the AI survey, foundational success criteria were articulated and linked to measures of success. In this sense, as described in [5] such leveraging must be goal-directed [22, 35]. As a goal-directed effort, AI can shape the ensuing discourse in a positive perspective to build a safety culture rooted in excellence. The opportunity tree is a tool in AI to help visually identify the features, characteristics and factors that describe a goal such as 'an exceptional safety culture'. The characteristics of the 'exceptional safety culture' can be viewed both as sub-goals that help an organization to attain its super-ordinate goal. The trunk (Fig. 2) represents the root causes of success and the branches represent the outcomes of success, the salient outcomes that result from achieving the directed goal.

From the survey emerged some key characteristics that define safety culture within TTEMAS. The results are captured in an 'opportunity tree'

The AI approach recognizes and acknowledges the problems that exist but rather than approaching the issue through a deficit 'problem fixing' paradigm, AI focuses on engaging stakeholders from a 'positive perspective' whereby excellence is embraced to formulate solutions that stem from optimum performance. Within

Fig. 2 Opportunity Tree derived from TTEMAS AI survey

the context of safety culture, it is about looking at the system's strengths and what the organization looks like at its best as a foundation for directed action to achieve the desired future. Shendell-Falik [39: 96] argues that what emerges from such an inquiry is '…innovated structures, processes and ways of working together differently and an increased sense of commitment and enthusiasm to the organization. These benefits come about because of the inclusive, inquiry-based positive nature of the AI approach and because human systems move in the direction of that which they most frequently ask about.' The TTEMAS AI safety culture survey provides an alternative lens to the analysis of safety culture through a strength-based approach. This strength-based approach for achieving new levels of safety excellence within complex organizations has been documented in the medical domain. The Institute of Medicine reports estimated that up to 98,000 individuals die each year as a result of medical errors such as that resulting from a lack of information sharing [39: 95]. It has been recognized that every time a patient moves from one environment to another, there is a risk that essential information regarding care will not be communicated. In this case study, an AI intervention revealed an opportunity to increase patient safety in cases when nurses work amidst competing priorities to achieve safe, timely, effective and efficient patient care was seen as significant [39: 95].

Critical to the development of a safety culture is the development of a Learning Organization that embraces the 5 disciplines [36: 96]. AI works in creating a climate and method of inquiry that builds upon the positive addressing the 5 disciplines of: shared vision, team learning, mental models, personal mastery and systems thinking. In terms of safety culture, as described by Shendell-Falik [39], AI shifts '…peoples focus from problems to possibilities, from what cannot be done to what can be done, from blaming others for their failures to appreciating others for their contributions, and from getting back to previously identified levels of functioning to going beyond what was thought possible. It is highly inclusive'. An AI strategy becomes an occasion to identify and discuss issues, to encourage new insights, and to explore possibilities for change and their consequences. The traditional approach of causal focus all too often results in new 'fixes'; that apply limited solutions with disappointing results. AI on the other hand seeks to encourage broader participation and discussion from stakeholders to highlight new conceptual approaches that can facilitate communication and illuminate and organize dynamic interdependencies. Stakeholders from all levels and in all specialties of the organization are recognized as critical resources for identifying opportunities, understanding operations, and improving performance. We move therefore from a '…fixing orientation to a collaborative learning orientation' [4: 191]. As described in [6: 31] '….developing a safety culture is dependent on the deliberate manipulation of various organizational characteristics thought to affect safety. The very act of doing so means that such manipulations must be goal-directed'.

5 Conclusion

> First we shape our structures, then our structures shape us.
> (Winston Churchill)

These words encapsulate the essence of safety culture and the socio-technical notion of interdependencies and interconnectedness. From AI it is recognized that 'We create what we imagine'. The AI methodology is rooted on a set of fundamental principles and it is grounded in extensive research on the connection of human behaviour to images that people hold in their minds, the language and words they use, and the emotions they experience [39]. Through this strength-based approach, AI facilitates an organization to become more reflexive and aware of their own strengths and abilities in ways that increase their effectiveness in support of safety culture.

References

1. Beck U (2006) Living in the risk society. A Hobhouse memorial lecture given at old theatre. London School of Economics, Houghton Street, London, Wed 15th February 2006 at 6:30 pm
2. Bourke J (2005) Fear: cultural history. Virago Press, Time Warner Group UK, Brettenham House, Lancaster Place, London, WC2E7EN
3. Bushe GR (2010) Appreciative inquiry: theory and critique. www.gervasebushe.ca/AITC.pdf. Accessed 15 Dec 2010

4. Carroll JS (1995) Incident reviews in high-hazard industries: sense making and learning under ambiguity and accountability. Organ Env 9(2):175–197
5. Cooper MD (2000) Towards a model of safety culture. Saf Sci 36:111–136
6. Cooper D (2002) Safety culture: a model for understanding and qualifying a difficult concept. Professional Safety
7. Cooperrider DL, Whitney D, Stavros JM (2008) Appreciative Inquiry handbook: for leaders of change, 2 ed. Crown Custom Publishing Inc.
8. Cooperrider DL, Srivastva S (1987) Appreciative inquiry in organizational life. In: Woodman RW, Pasmore WA (eds) Research In organizational change and development, vol 1. JAI Press, Stamford, pp 129–169
9. Dekker SWA (2002) The re-invention of human error. Technical report 2002-1, Lund University School of Aviation, pp 1–16
10. Deepwater Horizon Study Group (2011) Final report on the investigation of the Macondo Well Blowout. Center for Catastrophic Risk Management (CCRM), The University of California Berkley
11. Deepwater Horizon Study Group (2011) Final report on the investigation of the Macondo well blowout. Center for Catastrophic Risk Management (CCRM), The University of California Berkley
12. De Long DW, Fahey L (2000) Diagnosing cultural barriers to knowledge management. Acad. Manage. Executive 14(4):113–127
13. Dulac N (2007) A framework for dynamic safety and risk management modelling in complex engineering systems. PhD dissertation, MIT, Cambridge, MA
14. Fernandez-Muniz B, Montes-peon JM, Vazquez-Orda CJ (2007) Safety culture: analysis of the causal relationships between its key dimensions. Saf Cult 38:627–641
15. Gupta A, Govindarajan V (2000) Knowledge flows within multinational corporations. Strateg Manag J 21(4):473–496
16. Hammer D (2010) Federal investigators blast BP over 'safety culture' at oil spill hearings. The Times-Picayune. Thursday August 26 2010. www.nola.com/news/gulf-oil-spill/index.ssf/2010/08/federal_investigators_blast_bp.html. Accessed 1 Nov 2010
17. Helbing D (2013) Globally networked risks and how to respond. Nature 497:51–59
18. Hopkins A (2012) Disastrous decisions: the human and organizational causes of the gulf of Mexico Blowout. CCH Australia Limited, Australia
19. HSC (1993) Organising for safety: third report of the ACSNI (Advisory committee on the safety of nuclear installations) study group on human factors. Health and safety commission (of Great Britain). HSE Books, Sudbury
20. Johnston AN (1996) Blame, punishment and risk management. In: Hood C, Jones DKC (eds) Accident and design: contemporary debates in risk management. UCL Press, Park Square, Milton Park, Abingdon, Oxon, pp 72–82
21. Kim DH (1993) The link between individual and organizational learning. Sloan Manage Rev Fall 37–49
22. Locke EA, Latham GP (1990) A theory of goal setting and task performance. Prentice-Hall, Englewood Cliffs
23. Mason RO (2004) Lessons in organizational ethics from the columbia disaster: can culture be lethal? Organ Dyn 33(2):128–142
24. Masys AJ (2010) Opening the black box of human error: revealing the complex aetiology of fratricide. VDM Publishing
25. Masys AJ (2012) The emergent nature of risk as a product of 'Heterogeneous Engineering': a relational analysis of oil and gas industry safety culture. In: Bennett S (ed) Innovative thinking in risk, crisis, and disaster management, Wey court east union road farnham, surrey, GU97PT. Gower Publishing Limited, England, pp 59–85
26. Masys AJ (2014) Critical infrastructure and vulnerability: a relational analysis through actor network theory. In: Masys AJ (ed) Networks and network analysis for defence and security. Springer, Berlin

27. Mohr BJ (2001) Appreciative inquiry: igniting transformative action. Syst Thinker 12(1):1–5
28. Mohr BJ, Watkins JM (2002) The essentials of appreciative inquiry: a roadmap for creating positive futures. Innovation in Management Series, Pegasus Communications, Inc. Waltham, Mass
29. Morgan G (1980) Paradigms metaphors, and puzzle solving. Adm Sci Q 25(4):1–17
30. National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling (2011) Deep water the gulf oil disaster and the future of offshore drilling. Report to the President
31. Perrow C (1999) Normal accidents: living with high-risk technologies. Princeton University Press, New Jersey
32. Pidgeon N (1997) The limits to safety? Culture, politics, learning and man-made disasters. J Contingencies Crisis Manag 5(1):1–14
33. Reason J (1998) Achieving a safe culture: theory and practice. Work Stress 12(3):293–306
34. Robbins SP, Judge TA (2011) Organizational behaviour, 14th ed. Prentice Hall Publishers, Upper Saddle River, New Jersey
35. Ryan TA (1970) Intentional behaviour. Ronald Press, New York
36. Senge P (2006) The fifth discipline: the art and practice of the learning organization, 2nd edn. Doubleday Currency, New York
37. Schein E (1990) Organizational culture. Am Psychol 45(2):109–119
38. Smith D, Eliot D (2007) Exploring the barriers to learning from crisis: organizational leaning and crisis. Manage Learn 38(5):519–538
39. Shendell-Falik N, Feinson M, Mohr BJ (2007) Enhancing patient safety improving the patient handoff process through appreciative inquiry. J Nurs Adm 37(2):95–104
40. Toft B, Reynolds S (2005) Learning form disasters: a management approach, 3rd ed. Palgrave Macmillan Publishers, Hampshire
41. Turner BA (1976) The organizational and interorgnaizational development of disasters. Adm Sci Q 21(3):378–397
42. Turner BA (1994) Causes of disaster: sloppy management. Br J Manag 5:210–215
43. Vaughan D (1999) The dark side of organizations: mistake misconduct, and disaster. Ann Rev Sociol 25:271–305
44. Wattie J (2013) A study of the effects of organization culture on the reliability of the Trinidad & Tobago Emergency Mutual Aid Scheme (TTEMAS) as the only emergency response group on the Point Lisas Industrial Estate (PLIE). University of Leicester, Civil Safety and Security Unit, Leicester, UK
45. Weick KE, Sutcliffe KM (2007) Managing the unexpected: resilient performance in an age of uncertainty 2nd ed. Jossey-Bass, San Francisco
46. Weir DTH (1996) Risk and disaster: the role of communications breakdown in plane crashes and business failure. In: Hood C, Jones DKC (eds) Accident and design: contemporary debates in risk management, 2Park Square. UCL Press, Milton Park, Abingdon, Oxon, pp 114–125
47. Woods DD (2006) Resilience engineering: redefining the culture of safety and risk management. HFES BULLETIN 49(12):1–3

Unintended Consequences. What Lessons Can Risk-Managers Learn from the Use of Armed Remotely Piloted Vehicles for Counter-Insurgency in Pakistan?

Simon Bennett

You look at a thing, and it changes in the looking.

Adam Forrest, journalist [22]

[L]ike any tactical decision … [drone attacks] should be continuously and closely monitored … with sensitivity to facts on the ground.

Barnidge [6]

Abstract According to sociologist Robert Merton, actions have intended and unintended consequences, some of which are functional, some not. The CIA's drones-first Pakistan counterterrorism strategy is used to illustrate how a well-intentioned policy may generate adverse outcomes sufficient to undermine that policy. The adverse outcomes (in Merton's argot 'latent dysfunctions') generated by the CIA's counterterrorism strategy may be so numerous and grave as to undermine the War on Terror. Adverse outcomes include collateral damage, radicalisation, destabilisation and diplomatic schism. Several lessons are drawn. For example, that latent dysfunctions can undermine, if not fatally compromise, purposive action. It is far from certain that the CIA's drones-first counterterrorism strategy is making a net contribution to the War on Terror. Latent dysfunctions could render the War on Terror a zero-sum game. The author concludes that a timely response to contra-indications (Langer's 'mindfulness' and Toft's 'active learning') makes policy success more likely. Inhibitors to mindfulness include ignorance, prejudice, dogma, groupthink and collective amnesia.

Keywords War on terror · CIA · RPVs · Pakistan · Merton · Dysfunctions

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A. Masys (ed.), *Disaster Management: Enabling Resilience*,
Lecture Notes in Social Networks, DOI 10.1007/978-3-319-08819-8_10

1 Introduction

In an increasingly risk-conscious world [7, 8] politicians determined to retain power attempt to manage risks down to a level deemed acceptable by electors. This dynamic obtains in every sphere of human activity, from energy generation and health-care provision to war-fighting. In a Risk Society, legitimation lies more in the support of the electorate than in that of a technocratic elite:

> [T]he more science and technology permeate and transform life on a global scale, the less this expert authority is taken as a given. In discourses concerning risk… the mass media, parliaments, *social movements*, governments, philosophers, lawyers, writers, etc. … are winning the right to a say in decisions [my emphasis]. [8]

As evidenced by the western powers' reluctance to intervene in the long-running Syrian conflict, popular support is increasingly seen by politicians as a precondition for military operations—especially those undertaken not in defence of the homeland, but to promote a sometimes intangible or obtuse foreign policy objective. Existential threats legitimate military action and other serious measures and help shape the public mood. Non-existential threats have less impact and agency. The prospect of defeat to Nazi Germany legitimated the creation of a war economy, the exertions of Operation Dynamo, the Battle of Britain and Battle of the Atlantic, and helped sustain British morale during the Blitz. The American public's perception that the intermediate-range nuclear missiles deployed to Cuba by the Soviet Union posed an existential threat to the continental United States helped legitimate President Kennedy's 1962 blockade of the island. The issue was less clear-cut in the case of the communist insurgency in South East Asia during the 1950s and 1960s. The growing belief that the spread of communism in that region did *not* pose an existential threat to the continental United States gradually undermined the American public's support for military action against the Viet Cong and North Vietnamese Army. Public support, then, is one of the preconditions for foreign military operations. Certainly, it is one of the preconditions for sustained foreign military operations.

According to Osgood [47] the concept of limited war gained traction during the second half of the Twentieth Century, partly because both the USA and USSR came to accept that a major conflict might spark Armageddon. The majority of the wars that did occur during the second half of the Twentieth Century were spatially, temporally and politically constrained:

> The great majority of these [more than fifty] wars … did not directly involve a nuclear or even a major power; most of them were insurgency or civil wars, none of them (except the Hungarian intervention in 1956) was fought between advanced industrial states …. [47]

Despite its policy of containment, the United States was never entirely comfortable with foreign military adventures: "The whole history of the expansion of American commitments … is pervaded with the longing to avoid new commitments and involvements" [47].[1] The sea-change in public opinion that followed

[1] Had it not been for the attack on Pearl Harbour it is possible that America would not have entered the Second World War. Isolationism was a feature of America's post Great War zeitgeist.

America's humiliation in South East Asia provided the rationale for a reappraisal of its war-fighting technique. Vietnam was the first war to be fought in the media spotlight. Images of dead and dying US soldiers and of body-bags being loaded onto, or unloaded from United States Air Force transports were regularly beamed into American homes. It became difficult to avoid seeing still or moving images of the carnage caused by large-scale foreign military interventions. Vietnam has been dubbed 'the first television war'.

Later humiliations, like the Carter Administration's 1980 failure to rescue the fifty-two American citizens taken hostage by Iranian students[2] and the Clinton Administration's failed Somalia intervention (that saw dead soldiers from some of the United States Army's most capable units dragged through the streets of Mogadishu)[3] strengthened the case for a root-and-branch reform of America's war-fighting technique and reinvention of its war-fighting technologies. Perceived reversals like Vietnam, Iran and Somalia helped lay the foundations for a revolution in tactics and equipment. Until the shock of the terrorist attacks of September 11, 2001, America was wary of involving itself in, or instigating conflict. This is why America did not intervene in the Rwandan genocide (that saw the deaths of at least 500,000 Rwandans) and confined its involvement in the 1998–1999 Kosovo War to air-strikes. While Prime Minister Tony Blair committed British troops to the conflict, President Clinton viewed Kosovo through the prism of his failed Somalian intervention. Instead of troops he committed B-52s, B-1s, B-2s, F-117s, A-10s, F-16s and AV8Bs and lent diplomatic support.

Deri [21] draws attention to: "Americans' increasing reluctance to risk lives in war". According to Deri [21], since the deprivations and exertions of the Second World War,[4] America's political class has found it increasingly difficult to win popular support for foreign military adventures:

> In World War II, Americans endured rationing, war taxes and the draft with relatively little protest. In the Vietnam War, in which the American death toll was seven times less than in World War II, less than half of Americans agreed with the war just two years after it began …. In the 21st century, it took only a year before more than half of Americans thought the Iraq War was a mistake. In both of these conflicts, negative public opinion tended to focus on the war imposing a human and monetary cost upon the nation.

Given the public's increasing aversion to risk [7, 8], the escalating cost of conventional war-fighting and the post-2007 economic downturn, governments unwilling to eschew foreign campaigns have adopted technologies that offer relatively risk-free and cost-effective offensive capabilities. The age of the Remotely Piloted Vehicle (RPV) has arrived. In his book *The New Western Way of War*, Professor Martin Shaw [53] says that today's wars must be fought in such a way that they deliver both military success and public approval. To this end war-fighting risks are,

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[2] Eight US soldiers were killed during Operation Eagle Claw.

[3] Soldiers were drawn from the US Army Rangers, Delta Force and the 160th Special Operations Aviation Regiment. The fact that these elite units had been driven back by Muhammad Farah Aideed's irregulars compounded the shock.

[4] Following the sneak-attack on Pearl Harbour, the American public supported the global war on fascism with gusto.

where possible, transferred to other states (for example, many of the risks associated with fighting the War on Terror have been transferred to states like Iraq, Afghanistan, Pakistan, Somalia and the Yemen). Shaw refers to the premeditated displacement of risk to foreign soil as ‘risk-transfer war’. New technologies like RPVs are an important component of the new war-fighting paradigm. Although vulnerable to conventional weapons, RPVs all but eliminate ‘home’ casualties. By minimising home casualties, RPV-centric operations make it less likely that the public will turn on the political class, as it did in the United States towards the end of the Vietnam War.

Unfortunately for those who live in countries where RPVs are deployed it seems that the era of the surgical strike that avoids collateral damage has not yet arrived. While the accuracy of drone strikes has improved, innocent civilians are still being killed or injured:

> While there are reasons to suspect that drone strikes are becoming more accurate and causing fewer civilian casualties than they did between 2004 and 2008, there is no reason to believe that the civilian death toll hovers in the single digits [as claimed by the Obama administration], and the estimates from the best-sourced database (TBIJ) [The Bureau of Investigative Journalism] suggest that the tallies of civilian deaths are much higher. [15]

In Pakistan several factors conspire to boost the level of collateral damage. These factors include CIA-directed strikes encouraged by unreliable or untrustworthy informants (what is to stop someone with a grudge against an individual or family from using the CIA to do her/his dirty work?), the fact that insurgents often live amongst innocent civilians, the fact that some are married with children, the CIA’s use of ‘signature strikes’ that involve the profiling of behaviour, and the quality and reliability of UAV sensor data (like video pictures) [21, 15]. Because they are guided by an often unsophisticated and culturally unaware profiling of behaviour, signature strikes could be said to exemplify a general disregard amongst US personnel for the lives of non-combatants:

> In these cases, strikes are authorized without knowledge of the identity of the target, solely on the basis of behaviour—such as gathering at a known Al-Qaeda compound, loading a truck with what appears to be bomb-making material or even crossing a border multiple times in a short period—that appears suspicious. The obvious risk is that more innocent civilians will be killed on the basis of a misinterpretation of their behaviour by drone operators, or that the standards by which a ‘pattern of life’ is identified might be too lax …. The dangers of a false positive—that is, a strike which kills only civilians by mistaking them for combatants—with signature strikes is much greater than with those strikes in which the target is identified, however imperfectly, in advance [by, for example, a paid informant]. At a more fundamental level, the adoption of signature strikes … reflects an underlying indifference to the combatant status of potential victims that is at odds with much of the legal and ethical foundation of modern warfare [15].

Speaking to the moral dimension of the CIA’s campaign in Pakistan, Boyle [15] concludes: “[S]tandards of proportionality have been eroded with drone warfare”. Proportionality is an important moral principle in a State’s application of force, whether through a civilian police service or the military. In authoritarian states (like Hitler’s Germany, Stalin’s Soviet Union or Pol Pot’s Cambodia) there is little or no sense of proportionality in the use of force. Even democratic states can flirt with authoritarianism. Witness the robust police response to the protests that followed the August, 2014 killing by a police officer of an unarmed youth in Ferguson, Missouri. The President commented on what he termed 'police paramilitarism'.

It is claimed that RPV-incurred collateral damage[5] has several consequences, including the alienation of host nation civilians from the War on Terror,[6] recasting of terrorists as freedom-fighters, instigation of terrorist attacks on home territory (like the attempted 2010 Times Square bombing), de-legitimation of host nations' local and national democratic institutions (because of their apparent inability to influence RPV policy),[7] disruption of host nation cultural activities like weddings, tribal gatherings, elders' meetings and burial ceremonies (because locals fear that any gathering is a potential RPV strike target),[8] psychological distress (both acute and chronic) amongst those who live or work in the theatre of operation[9] and even hostility to western-style preventive medicine initiatives like vaccination programmes [21, 15, 23, 30, 13, 2]. Seen through the lens of Merton's [41] theory of unintended consequences, RPV operations in places like Afghanistan, Pakistan, Somalia and the Yemen have several latent dysfunctions (unintended negative consequences). The question for policy-makers is whether these unintended negative consequences are so great that they negate the benefits that accrue from RPV operations (like reducing the number of soldiers who return home in body-bags)?

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5 According to Deri [21], the Committee on Government Oversight and Reform says the central tenet of counter-insurgency operations is 'do no harm'.

6 Foust [23] refers to "… the decrease … in Pakistanis' perceptions of the U.S.: 19 % favourable under President Bush in 2008, but only 12 % favourable under President Obama in 2012. Whatever the cause, the U.S. is losing the war of perception in Pakistan". Ahmed (cited in [3]) claims that "drones act as a hated symbol of America and its war on terror". Drone strikes are amenable to a range of interpretations or constructions. These range from 'surgical strikes' to 'extrajudicial killings' [66]. Deri [21] notes of RPV operations in Pakistan: "[The] American political and popular response has been largely positive …. However, U.S. policymakers have failed to recognize the Pakistani reaction to drone warfare, which has been overwhelmingly hostile". A Pew Research Centre [49] poll found that 61 % of Pakistanis polled believed drone strikes were unnecessary, while 89 % believed drones killed too many innocent people.

7 The de-legitimation and destabilisation of the government of a nuclear state like Pakistan could have serious consequences for regional and global security. Instability may lead to proliferation and conflict. Deri [21] notes: "In 2002, 72 % of Pakistanis believed that their national government had a good influence on the country; in 2007, 59 % agreed. Not long after the drone program escalated, this number dropped to a minority at 40 %. In 2011, a mere 20 % believed that the government was a good influence". The National Intelligence Council [44] observes: "A conflict-ridden East Asia would constitute a key global threat and cause large-scale damage to the global economy". Boyle [15] talks about the "untold consequences for the future of a nuclear-armed country seething with anti-American sentiment". In recent years there has been talk of Pakistan as a failed or failing state. Somalia shows what can happen when a state collapses (lawlessness, feuding, piracy, social and economic regression, regional instability, etc.). Had Somalia been a nuclear-armed state, the consequences could have been much worse.

8 Deri [21] says: "[T]errorist cells are often seamlessly embedded with civilian communities".

9 Deri [21] talks about "… the extreme psychological distress … of rural villagers". According to the International Human Rights and Conflict Resolution Clinic at Stanford Law School and the Global Justice Clinic at NYU School of Law [30], the 'uncontrollability' of drone activity heightened villagers' emotional stress: "Interviewees indicated that their own powerlessness to minimise their exposure to strikes compounded their emotional and psychological stress".

1.1 Merton's Hypothesis

Sociologist Robert K. Merton claimed that purposive social action ("action which involves motives") could have both intended (expected) and unintended (unexpected) consequences (which Merton termed 'functions') [41]. 'Manifest functions' are the consequences we expect. 'Latent functions' are those we do not expect.

There are two types of latent function: those that support the original intent, and those that work against it ('latent dysfunctions'). Because they undermine the intent, latent dysfunctions are the worst type of unanticipated consequence. They are corrosive of success. Examples of Merton's 'law of unintended consequences' abound. For example.

1. Healthy Eating

Exhortations to eat sensibly, watch your weight and exercise have both manifest and latent functions. For some they improve health, self-esteem and longevity (manifest functions). For others they undermine health by causing eating disorders like anorexia nervosa. Seen through the lens of Merton's theory, anorexia is a latent dysfunction of well-intentioned advice. It is an undesirable unintended consequence.

2. Disability Access

In recent years more attention has been paid to the perceived access needs of wheelchair-users. To this end, kerbs have been ramped to enable wheelchair-users to cross the road more easily (the manifest function). Seen through the lens of Merton's theory, the ramping of kerbs has also produced latent functions and latent dysfunctions. An example of a latent function would be that ramping benefits not only wheelchair users but also those unsteady on their feet. An example of a latent dysfunction would be that ramping makes it easier for cyclists to use pavements to make progress (because the barrier-effect of the kerb has been eliminated). For safety's sake cyclists should be segregated from pedestrians. Pavements should be reserved for pedestrians.

3. Re-allocating Housing

Under the United Kingdom's 2012 Welfare Reform Act, local authority or housing association tenants deemed to have a bedroom that is not used can have their state benefits cut [45]. Designed to ease the problem of overcrowding by releasing under-occupied properties to larger families (the manifest function), the so-called 'bedroom tax' has several latent dysfunctions, including the fact that vacated larger properties are remaining empty because there are no large families seeking more suitable accommodation. Empty local authority or housing association properties are a latent dysfunction of the bedroom tax. Empty properties may be squatted or vandalised.

According to Merton, five factors influence the chances of an action having unintended consequences:

1. Ignorance

The more imperfect the foreknowledge, the greater the chance of an action having unintended consequences.

2. Error

The more wayward the initial assumptions, the greater the chance of an action having unintended consequences.

3. Imperviousness

The more myopic the actors (the more closed to contra-indications), the greater the chance of an action having unintended consequences.

4. Dogma

The more value-driven and zealous the actors, the greater the chance of an action having unintended consequences.

5. Baggage

The greater the baggage, the greater the chance of an action having unintended consequences. Sveiby et al. [55] offer this example of how preconceptions and/or predispositions can produce unintended consequences: "[B]ecause organisational change initiatives have failed in the past, [subsequent] change initiatives are met with cynicism by employees, thereby further increasing the risk of failure". Precedent or baggage may render actions ineffectual (the unintended consequence). This is Merton's [42] 'self-fulfilling prophecy'. Defeatism is a self-fulfilling prophecy.

Examples taken from the realm of social policy (health campaigns, disabled access initiatives and housing policy) appear to support Merton's hypothesis that purposive social action can have both intended and unintended consequences (some of which are functional, others not). But what of the military domain? Does Merton's hypothesis hold for military innovations like remotely piloted vehicles? Do RVP operations have both intended and unintended consequences (functional and dysfunctional)? If so, what lessons can risk managers learn from the military?

2 Case Study: The CIA-Directed Remotely Piloted Vehicle Counter-Insurgency Campaign in Pakistan

2.1 Introduction

Like air-launched cruise missiles or submarine-launched ballistic missiles, remotely-piloted vehicles (RPVs) are 'stand-off' or 'arms-length' weapons systems that mitigate the risks inherent in armed conflict. The development of RPVs like Predator and Reaper[10] symbolised a shift in American public opinion.

[10] Reaper is a more capable and lethal system than Predator. Such systems are considered cost-effective weapons platforms. Predator costs $3.5 million per unit. A Fighting Falcon multi-role fighter costs $14.6 million and a B-2 stealth bomber $1.16 billion [21, 61, 62].

America's post-Somalia doubts about 'boots on the ground' military expeditions were reified in armed RPVs. With reference to the social construction of technology (SCOT) [36, 14, 50] proposition, armed RPVs like Predator and Reaper express a desire to sanitise conflict for the aggressor nation. As Latour [35] puts it: "Technology is society made durable".

According to Democratic politician David Obey (cited in [26]), after the Somalia embarrassment the American public wanted "zero degree of involvement and zero degree of risk and zero degree of pain and confusion".[11] The United States, Britain and Israel use armed drones. The number of nations possessing some type of RPV numbers seventy-five. It is estimated that over the next decade the annual value of the RPV market will hit $11.3 billion. The North Atlantic Treaty Organisation considers drones a force multiplier [13].

2.2 Current Position

While RPVs are popular with the major powers and alliances like NATO, they have their limitations and issues:

1. Because they are slow-flying, RPVs are vulnerable to interception and basic air defence. Imran Khan promised that if elected Prime Minister of Pakistan, he would order the air force to intercept CIA-operated drones [15].
2. RPVs have a high attrition rate. While manned aircraft suffer two crashes per 100,000 flying hours, RPVs suffer forty-three. A ten year cross-sectional study of US RPV operations attributed 60.2 % of 221 mishaps to human factors [60].
3. While RPVs are suited to low-intensity conflicts like that being fought by the Central Intelligence Agency in the tribal areas of Pakistan or Israel's policing of the Gaza Strip, they are less suited to high-intensity conflicts.
4. Even with high-fidelity sensors it can be difficult to identify individuals from above. Cultural events (like weddings or meetings of elders) are amenable to multiple interpretations, especially by those unfamiliar with local custom. Consequently it has been claimed that RPV operations cause significant collateral damage. Unfortunately, because of the nature of the conflict and killing-grounds, it is difficult to ascertain exactly how many innocent civilians have been killed. Further, estimates are subject to political spin on all sides: "Islamist groups inflate the number of people killed in US strikes and aggressively push their higher casualty totals to local and international media outlets. Similarly, the US often underestimates the number of casualties from drone strikes, even when the available evidence suggests that some civilian deaths have occurred" [15]. Deri [21] notes of the situation in Pakistan: "[S]tatistics yield a civilian fatality rate that ranges from 15 % to more than twice that, at 33 %". It has been claimed that civilian deaths cause resentment

[11] In regard to SCOT, Jameson [31] talks about "the ultimately determining instance"—the spur to action. The Somalia misadventure could be described as that for the armed RPV.

and act as a recruiting sergeant for terrorist organisations. Deaths can also provoke retaliation. The Taliban said its 2009 attack on the Manawan (Lahore) Police Academy (that killed two instructors and five trainees) was in retaliation for CIA-directed RPV operations [21].

5. Because the only choice available to a RPV crew is whether or not to engage, potential intelligence-gathering opportunities are lost. Callam [17] writes: "Hunter-killer operations can only eliminate the target and thus forfeit potential intelligence that could be gained through capture". The Government of Pakistan forbids US ground operations but just about tolerates RPV surveillance and hunter-killer missions. There is a lethal irony to this policy: were the Pakistanis to allow US ground operations the volume and quality of intelligence would increase,[12] thereby reducing the insurgent threat to both US and Pakistani interests (and, perhaps, the global terror threat). Of course, there would be significant political fallout from allowing Americans to wage war on sovereign Pakistani territory. Witness the reaction to the assassination by US special forces of Osama bin Laden in the Pakistani town of Abbottabad: "The official reaction of Pakistan was betrayal, infringement of its sovereignty, the threat of retaliation, severe condemnation of the raid, and the curtailment of American involvement in Pakistan" [43].
6. Because RPV strikes eliminate the visible costs of war (news-footage of body-bags or coffins being offloaded from transports) it is possible to form the view that wars can be fought with impunity. Sanitisation may accelerate the militarisation of foreign policy. As George Orwell [46] envisioned in *Nineteen Eighty-Four*, conflict may become the norm rather than the exception. As natural resources dwindle, a war mentality could lead the world into a dark place with nations fighting over supplies of oil, gas, water, wheat, coal, iron ore, etc. Deri [21] says of the American mindset vis-à-vis drones: "[D]rones are fast becoming America's new weapon of choice for counter-terrorism, *and perhaps war itself* (my emphasis)". The US military is now training more armchair UAV pilots than fast-jet pilots [21]. Deri [21] suggests that American society has normalised drone warfare to the point where it is a 'background' activity: "The … impact of drone warfare on the American political conversation is palpable. Drone strikes in Pakistan, conducted secretly by the C.I.A. outside of a war zone, are laden with questions about international law, constitutional balance of powers, and ethical warfare. Yet, *the issue has never been debated on the floor of Congress or put to a vote* …. Instead, drones seem to have become the political answer to quelling public condemnation of a conflict …. Thanks to UAV technology, America's reaction to costly wars appears to consist of engaging in 'costless' drone warfare, *rather than attempting to find an exit strategy*" (my emphasis). Technologies that reduce the costs of war (psychological, financial and human) to the belligerent to the point where negatives are no longer debated in public or

[12] It is claimed that intelligence provided by the CIA's paid informants is sometimes of poor quality.

private make a state of permanent war more likely. When the mothers and fathers of US service personnel no longer face the prospect of a Department of Defence telegram, why should they concern themselves with the strategic ambitions of their government and military? “In America … UAV technology …does away with the greatest emotional burden of being at war: the condolence letter” explains Deri [21].

7. There is the question of operators’ willingness to pull the trigger. How can commanders be sure that RPV pilots and sensor operators will seek out and eliminate threats? RPV operations create psychological pressures. According to Otto and Webber [48], RPV pilots have similar mental health risk profiles to fast-jet pilots. To counter the possibility that two-person RPV crews might feel disconnected from the battle-space, in 2009–2010 the United States Air Force revamped its training to instill more of a ‘warrior culture’ [5]. The life of an RPV operator is very different to that of a soldier or airman who serves in-theatre. After their shift, RPV operators return to a familiar world. If they are in a relationship they might return to their wife/husband and children in a domestic setting. They would be aware of issues connected to collateral damage. Indeed, friends, family, neighbours and even persons in the street might make them aware of the moral and humanitarian dimensions of RPV operations. It is possible that adverse comments and admonitions might play on an RPV operator’s mind. During training, soldiers go through a process of desensitisation. Seeing comrades killed or wounded generally reinforces a soldier, sailor or airman’s resolve. Because they are removed from the front-line, RPV operators do not experience the reinforcement that results from witnessing a comrade being killed or wounded. They do, however, experience at first-hand the discourses and debates current in civilian life. Towards the end of the Vietnam conflict, service personnel home on leave were sometimes challenged by those who disagreed with the war. Some soldiers became defensive. As one veteran of the 2nd Battalion, 4th Marines told *New York Sun* journalist Seth Gitell: “I didn’t reveal I was a Vietnam veteran because they labelled us ‘baby killers’. Even at parties nobody knew I was a Vietnam veteran” (cited in [25]). Those connected with CIA-directed RPV operations in Pakistan could find themselves facing the same ‘court of public opinion’ as that faced by soldiers returning from Vietnam. Having said this, the CIA-directed campaign enjoys considerable support amongst the American people: “Since 2004, the CIA has conducted approximately 290 known strikes in Pakistan’s remote Waziristan region …. [D]rone technology eliminates all risk to American military personnel. As a result the American political and popular response has been largely positive” [21].
8. There is the possibility that RPV operators will eliminate not only innocent locals but also, via so-called ‘double-tap’ strikes, those who attend the dead, dying and injured [21, 15, 30]. The killing of humanitarian workers creates ill-feeling.
9. There is the question of how RPV crews react to the considerable psychological pressure induced by flying a drone for long periods, while trying to make

sense of often confusing or ambiguous images and/or signals. Troops on the ground have more opportunity to dissipate combat stress than RPV operators housed in air-conditioned rooms. According to the USAF, 46 % of Reaper and Predator pilots and 48 % of Global Hawk sensor operators experience 'high operational stress' [18]. A number of RPV operators also exhibit 'clinical distress'.[13] According to Dao [18] stressors associated with RPV operations include: overwork due to crew shortages; switching between the military and civilian sphere on a daily basis; working in isolation; and "witnessing combat violence on live video feeds". As epidemiologist Dr Jean Lin Otto (cited in [18]) explains: "[RPV pilots] witness the carnage. Manned aircraft pilots don't do that. They get out of there as soon as possible". Sifton [54] challenges the view that by distancing the warrior from her/his target, RPVs take the pain and distress out of killing: "Drones make the nasty business of killing a little easier. Or do they? There are … studies showing that those who conduct strikes or watch videos of strikes suffer from 'operational stress', which officials believe is the result of operators' long hours and extended viewing of video feeds showing the results of military operations after they have occurred—i.e., dead bodies …. [T]here is no public information about stress among those ordering the strikes—the CIA strike operators or the decision-makers at Langley". An unidentified USAF physiologist and psychologist has noted how factors like prolonged periods of conscious attention while operating RPVs (operators are denied the motion cues available to fast-jet pilots), being tied to a shift-pattern of 5–6 days on with 2–3 days off, and having to transition between domestic life and a demanding military role on a daily basis conspire to induce stress in RPV operators: "Every day is a small-scale reintegration, requiring the operator to find a balance between supporting the war effort … and domestic responsibilities" [4]. Crews can experience RPV duties as interminable and all-consuming: "There are little to no down days … Every day the mission is job number one. From this standpoint it's very similar to being deployed, except there's no finish line" [4]. Some RPV operators are crushed. In her investigation into the lives of American RPV crews, journalist Nicola Abé interviewed ex-crewmember Brandon Bryant. Bryant, an intelligent young man who was a good sensor operator, left the military with post-traumatic stress disorder (PTSD). Unable to sleep, he began to re-live the death and destruction he helped deliver. He wrote in his diary: "Total war. Every horror witnessed. I wish my eyes would rot". After his first kill he said he "… felt disconnected from humanity for almost a week". As his trauma grew he was less able to communicate with his girlfriend. He told her: "I can't just switch and go back to normal life". He knew he had a serious problem when he heard himself say to fellow crewmembers: "What motherfucker is going to die today?" (Bryant cited in [1]). Abé [1] notes: "One of the paradoxes of drones is that, even as they increase the distance to the target,

[13] Birch, Lee and Pierscionek [13] define clinical distress as "anxiety, depression or stress severe enough to affect an operator's job performance or family life".

they also create proximity”. Colonel William Tart (cited in [1]), Director of the USAF Remotely Piloted Aircraft Task Force, says of drone operations: “War somehow becomes personal”. Perhaps there is little difference between the emotions experienced by a Marine who terminates an insurgent on a street in a war-zone and those experienced by an RPV pilot who terminates an insurgent with a Hellfire missile? A stressed, anxious or depressed RPV operator may not perform as expected: S/he might launch an unwarranted strike or fail to execute a warranted strike. Abé [1] likens RPV pilots’ mental dysfunction to “a short-circuit in the brain of the drones”.

10. There is the matter of the truth in regard to drone operations. The CIA-directed programme in Pakistan is not open to scrutiny. Indeed, one of its defining characteristics is its secrecy. According to Deri [21], the programme’s opacity creates a situation where exaggeration or attenuation is almost inevitable. Vested interests exploit the secrecy for their own ends: “[E]stimates of casualties vary considerably, often depending upon the political and social loyalties of the estimator. A 2009 Pakistani study put the civilian fatality rate at over 98 %—at the other end of the spectrum, a University of Massachusetts professor estimated that only 3.5 % of total fatalities were civilians”. If the first casualty of war is truth, the first casualty of a secret war is the public’s ability to assess costs and benefits.
11. Finally there is the possibility that CIA-directed RPV operations over sovereign territory will so de-legitimise and de-stabilise the elected government of Pakistan that it is less able to withstand the threat posed by home-grown terrorist organisations like the 35,000-strong Tehrik-i-Taliban Pakistan (TTP) [15]. Boyle suggests that the US military’s ‘drones-first’ policy undermines the State Department’s efforts to build stable and secure nations able to repel both home-grown and insurgent terrorist organisations. The incoherence of the US-sponsored War on Terror may exacerbate the problem of international terrorism. America’s anti-terror policy is riddled with (and, possibly, fatally undermined by) contradictions: “The long-term goal of building strong and legitimate governments that can police their territory and work as reliable partners with the United States is undermined by a drones-first policy that sidelines these governments or treats them as subservient accomplices to the brute exercise of American power” [15]. Ironically, in light of the destabilising effect of CIA-directed drone strikes, Washington’s own National Intelligence Council [44] has made reference to Pakistan’s “faltering governance institutions”. It is not clear whether the NIC acknowledges the potential impact of drone strikes on the credibility and legitimacy of Pakistan’s political institutions. In 2005 *The Times of India* claimed the National Intelligence Council and Central Intelligence Agency were forecasting a ‘Yugoslavia-type fate’ for Pakistan: “[I]n a jointly prepared Global Futures Assessment Report [the NIC and CIA] said: ‘By the year 2015 Pakistan would be a failed state, ripe with civil war, bloodshed, inter-provincial rivalries and a struggle for control of its nuclear weapons and complete Talibanisation’” [56]. In its 2013 Failed States Index (compiled from a wide variety of reports), the Fund For

Peace[14] ranked Pakistan the thirteenth most unstable state (Somalia was ranked the world's most unstable state). The CIA engages in targeted killing in both Pakistan and Somalia [15].[15]

3 Analysis

Seen through the lens of Merton's theory of the expected and unexpected consequences of purposive social action, the USA's CIA-directed RPV counter-insurgency campaign in Pakistan has manifest functions, latent functions and, most worryingly for the Pakistanis and global security, latent dysfunctions.

3.1 Manifest Functions

1. Elimination of high-value targets (HVTs) and lower-ranked combatants

Several HVTs have been killed, including "infamous terrorist" Baitullah Mehsud in 2009 [21]. Interestingly, and somewhat against trend, Osama bin Laden was assassinated not by an armed drone but by Special Forces delivered to Pakistan by helicopter.

2. Sanitisation of war for aggressor nation

The elimination of 'home' casualties and avoidance of adverse publicity (like images of body-bags) helps politicians, civil servants and the military 'sell' foreign interventions. Lacking the ability to fight his Somalia campaign at a distance, President Clinton and the troops he commanded paid a heavy price. By reducing the human and financial cost of warfare, the RPV-led sanitisation of war probably makes armed conflict more likely.

[14] The Fund for Peace is a non-partisan and independent research and educational organization "that works to prevent violent conflict and promote sustainable security" [24].

[15] The CIA's counter-terrorism policy of targeted killing has attracted a good deal of criticism. However, the United States may not be the only western country to have organised targeted kills. It has been alleged that during the early 1970s the British Army engaged in targeted killing in Ulster. Specifically, it has been alleged that a short-lived British Army Unit [the Military Reaction Force (MRF)] operating in west Belfast assassinated persons it believed to be connected with Republican terrorism. Some of these persons were unarmed. According to the *Belfast Telegraph* [10] "there was no independent evidence any were paramilitaries". One soldier claiming to have been a member of the MRF told a BBC reporter: "We were not there to act like an Army unit, we were there to act like a terror group. We were there in a position to go after IRA and kill them when we found them". Another said: "If you had a player who was a well-known shooter who carried out quite a lot of assassinations … it would have been very simple, he had to be taken out" (cited in [10]).

3. Reduction of the political risks inherent in foreign actions

Failed military expeditions undermine political leaderships. The bloody and corrupting Vietnam War that provoked schism and unrest at home effectively ended the presidency of Lyndon Johnson. Jimmy Carter's failure to rescue the Iranian hostages handed the presidency to Ronald Reagan.[16] The failed Somalia campaign that saw the humiliation of some of the US military's most capable units rebounded on Bill Clinton. Foreign actions that risk significant numbers of friendly casualties are politically risky. Actions that risk no friendly casualties are politically less risky.

4. Reducing the cost of war-fighting in a time of hardship

Although the United States' 2007–2009 recession was the longest since World War II, the government sought to maintain the country's global military posture. RPVs have provided a cost-effective means of projecting lethal power: "The top-of-the line Predator or Reaper model costs approximately US$10.5 million each, compared to the US$150 million price tag of a single F-22 fighter jet" [15].

3.2 Latent Functions

1. Helping to sustain US global scientific and technological leadership

According to Boyle [15] global spending on RPVs is likely to be more than $90 billion by 2021. Many nations will look to the US to supply their drones. Boyle [15] notes: "According to a study by the Teal Group, the US will account for 62 % of research and development spending, and 55 % of procurement spending on drones by 2022 …. It is likely that the US will retain a substantial qualitative advantage in drone technology for some time". Some believe the future of the US economy rests with high-technology, high value-added products like RPVs.

2. Helping to maintain the military-industrial complex

Determined to capture as much of the drone market as possible the Pentagon has authorised RPV sales to sixty-six countries. Weapons sales underwrite the USA's military-industrial complex, a political and economic phenomenon highlighted by Dwight D. Eisenhower in his Farewell Address to the Nation on 17 January, 1961. The military-industrial complex aligns the power of the Commander-in-Chief and Pentagon with one of the world's most innovative and dynamic research and manufacturing sectors. The US remains the world's biggest economy.

3. Helping to sustain a post-downturn Keynesian economic policy

In an effort to cushion the effects of the post-2007 economic downturn, President Obama injected money into the US economy. For example, he provided a significant

[16] The crisis hung like a putrefying albatross around Carter's neck. It ran from 1979–1981.

amount of money to the country's ailing car industry. While it was not enough to prevent the financial ruin of the City of Detroit [19], Obama's policy helped save Chrysler and General Motors: "Detroit has come back to life. The city, to the visitor, is still a landscape of … smashed-up Art Deco buildings. But it's still the place where the big names of US auto-making work. And after the US government spent $89 billion on keeping the two iconic auto giants alive, Detroit is getting back to work" [37]. Military spending on items like RPVs provides a further much-needed injection of cash into a sluggish US economy. The state of the US economy will help determine whether the Democrats retain the Presidency.

3.3 Latent Dysfunctions

1. Assassination of non-combatants

The killing of non-combatants in CIA-directed RPV operations has proved a public-relations disaster in Pakistan, although the American public seems less concerned about collateral damage. Collateral damage results from, amongst other things, terrorists' habit of operating from residential areas, the fact that some live with their families, reliance on potentially unreliable paid informants for targeting information, RPV-operator errors of judgment (induced by, for example, fatigue), signature and double-tap strikes. It has been claimed that drone warfare is less wasteful of innocent lives than more conventional forms of warfighting that might involve, for example, the laying of minefields, carpet-bombing of enemy formations or use of chemical, biological, radiological or even nuclear weapons (CBRN). However, given the nature of the opposition this argument is specious. No commander would use overwhelming force against a widely scattered and lightly-armed opposition. The only sensible military options are RPV hunter-killer missions or intelligence-led operations by special forces. Evidence suggests the former lack the finesse of the latter.[17] Unfortunately, there is little prospect that the government of Pakistan will allow US special forces free range on its territory.

2. Acting as a recruiting sergeant for terrorist groups

The killing of innocent people has outraged many in Pakistan. Swearing revenge on the United States some Pakistanis have joined terrorist organisations. Others voice support or sympathy for terrorists who are sometimes portrayed as freedom fighters. Writing before the escalation of the drone campaign, Hersh [28] said:

> Pakistan … is a nuclear power that harbours some of the most dedicated and potentially destabilising anti-American Islamic activists in the world.

[17] Boyle [15] says: "It is hard to argue … that drone strikes will … kill fewer civilians than carefully constructed covert operations against HVTs".

Successful drone campaigns have provoked some terrorists to migrate to other global flash-points like Syria:

> [T]he evidence that drones inhibit the operational latitude of terrorist groups and push them towards collapse is … ambiguous …. Hundreds of Al-Qaeda members have fled to battlefields in Yemen, Somalia, Iraq, Syria and elsewhere. These operatives bring with them the skills, experience and weapons needed to turn these wars into fiercer, and perhaps longer-lasting, conflicts …. Many Al-Qaeda members have joined forces with local insurgent groups in Syria, Mali and elsewhere, thus deepening the conflicts in these states [15].

Ironically, drone warfare seems to have helped create a thriving terrorist diaspora.

3. Destabilisation and delegitimation of a friendly democratic government

In the eyes of many Pakistanis, the government's apparent inability to reign in the United States and its agents has undermined its credibility and legitimacy. Pakistan's tribal areas have always been unruly. The drone campaign has made a long-standing governance problem worse. Terrorist organisations are willing and able to fill the political vacuum. Undermining a key actor in the War on Terror [28] may rebound on the United States and its allies.

4. Destabilisation of a nuclear power in a volatile region

Unstable nuclear powers pose a threat to regional and global security (as demonstrated by events on the Korean Peninsula). There are tensions between Pakistan and India (for example, in regard to the future of Kashmir [28]).[18] The world does not want to see nuclear weapons in the hands of a failing or failed state. The sometimes violent 1990s break-up of the superpower Soviet Union and its empire proved an unnerving chapter in world affairs. It has been argued that the world was in greater danger at that point than it had been at the height of the Cold War when the potential for mutual assured destruction (MAD) acted to stabilise international politics [40].

5. Undermining the State Department's policy of improving the resilience of friendly states

The USA's stance on Pakistan is Janus-faced. On the one hand it seeks to create a strong and stable state able to police its borders and develop its potential, while on the other it pursues a drones-first counter-terrorism policy that both undermines the credibility and authority of the government of Pakistan and gives succour to terrorists and their supporters. As Boyle [15] explains: "[T]he US has offered Pakistan more aid—some US$4.3 billion in 2010 alone, second only to the sum offered to Afghanistan in amounts of US aid given worldwide—in part to build its 'counterinsurgency capability', even while continuing drone strikes signal a lack of faith in the country's capacity and will to tackle terrorism. Seen in this light, the

[18] On December 13, 2001, Kashmiri terrorists launched an armed assault on the Indian Parliament. The terrorists "were believed to be heavily supported by [Pakistan's Inter Services Intelligence organisation]" [28].

US–Pakistani relationship is riddled with hypocrisy: the US sidelines the Pakistani government with drones, while 'building its capacity' with aid and military equipment transfers". The US government is either oblivious to, or is unable or unwilling to address the strategic, diplomatic, political and economic contradictions at the heart of its Pakistan strategy.[19]

6. Undermining the USA's efforts to occupy the moral high ground in the War on Terror

According to a report in the *New York Times* [9], all males of military age killed in CIA-directed RPV strikes are classified as militants unless categorically proven otherwise by whatever post-strike investigation takes place. Put another way, in the CIA campaign, anyone touched by a drone strike is guilty until proven innocent. This is the reverse of the way suspects are treated by the US judicial system. In the US, a party is innocent until proven guilty in a court of law where an adversarial system provokes argument and debate. The US judicial system invites different interpretations of an event. Because of the paucity and superficiality of post-strike investigations and same-day burials, the CIA's reverse burden of proof risks criminalising innocent Pakistanis. The USA's policy on victim classification is ethically and morally dubious. Other factors, like the secrecy surrounding the CIA-led initiative, deaths of non-combatants and rescue workers, and the imposition of the campaign on the government of Pakistan further undermine the reputation of the United States as a beacon of justice, transparency and accountability. Put simply, the United States seems to value the lives of foreign nationals less than it does the lives of its own citizens.

7. Creating a schism in the military

It is fair to say that some military personnel do not hold those who fly RPV hunter-killer missions in the highest regard. Some front-line troops (the 'grunts') and veterans do not regard RPV operations as genuine soldiering—as demonstrated by the furore over the Pentagon's proposal to award a medal to RPV operators. The Distinguished Warfare Medal (DWM) would have recognised 'non-valorous combat impact'. According to Tilghman [57], the Pentagon's announcement that the DWM would outrank awards like the Bronze Star with Valour "sparked uproar among troops and veterans". The Obama administration responded by abandoning the DWM. The backlash suggests that RPV operators are not universally admired. Episodes like this could impact RPV operators' self-image and morale, possibly making them less reliable in the performance of their duties. The amount of collateral damage could increase [12].

[19] The Carter and Reagan administrations' support for Afghanistan's anti-Soviet elements helped create the Taliban: "CIA Director, William Casey, a religious man, believed that Christianity and Islam could combine against the godless Soviets" [16]. However, in helping drive the Soviet Union out of Afghanistan the USA facilitated the current global terror campaign. The USA's posture on communist Afghanistan has proved a boomerang policy *par excellence* [28, 16].

8. Eroding self-esteem

Because front-line troops overcome existential risks they experience high self-esteem and earn the respect of others. Drone operators can struggle to build self-esteem: “All the aspects of battle, which normally enhance self-esteem and engender the esteem of others are absent, and there is the potential for this work to erode the self-image of the drone operator as well as the image of the war hero in the public mind” [13]. The success with which a person performs his/her duties is influenced by self-esteem (because self-esteem impacts morale). A demoralised operator may not perform as expected. S/he may terminate non-legitimate targets or fail to terminate legitimate targets. A war-fighting system that operates unpredictably is a liability [12].

4 Why the Unintended Consequences/Latent Dysfunctions of the USA’s Purposeful Action Against Terror?

According to Merton [41, 42] five factors determine the number and severity of unintended consequences/latent dysfunctions: Ignorance; Error; Imperviousness; Dogma; Baggage. The alienation of many Pakistanis from the War on Terror reflects US ignorance, error, imperviousness and dogma in the matter of its approach to counter-terrorism. By measuring the success of its Pakistan operation solely in terms of numbers of terrorists killed, the United States overlooks the possibility that its drones-first strategy may be strengthening rather than weakening the ranks of organisations like al-Qaeda and Pakistan’s home-grown TTP. Wedded to the CIA’s secretive campaign, and content to measure success by counting corpses, the Obama administration has blinded itself to the possibility that its *modus operandi* may fatally undermine the War on Terror.

Obama has made the same mistake as Johnson did over Vietnam. Content to measure success by counting NVA and Viet Cong dead, Johnson and his generals failed to notice that they were losing the war of hearts and minds to the enemy. The Administration’s ignorance, error, imperviousness and dogma blinded it to a major latent dysfunction of the Vietnam War—specifically that it was increasingly seen as a war of imperial conquest rather than a war of liberation.

In Vietnam, events like the My Lai massacre served to alienate people from the American cause. In Pakistan (and Afghanistan) the killing of civilians in drone strikes serves to alienate locals from the War on Terror. The US has no understanding of (or chooses to ignore?) the cultural dimension of warfighting in a country like Pakistan. Specifically, it has no understanding of the tribal and other bonds that unite the people of Pakistan’s border regions, and no comprehension of what happens when close-knit communities are attacked by a foreign power. As demonstrated by the swelling ranks of organisations like the TTP, such willful ignorance of cultural norms is counter-productive. In failing to re-appraise its drones-first counter-terrorism policy in Pakistan the US demonstrates imperviousness and dogma—according to Merton [41, 42] conditions likely to produce unintended consequences/latent dysfunctions. In his analysis of the drones-first counterterrorism policy, Boyle [15] mentions a number of latent dysfunctions (which he calls ‘second-order political effects’):

> The use of drones… has a series of second-order political effects that must be weighed against advantages accrued through the killing of terrorist operatives. Drones can subject governments to high levels of political pressure…. They can multiply the ranks of enemies in insurgencies and undermine the social fabric that allows many of these societies to function. Many of these consequences are systematically discounted in analyses of drones that focus exclusively on how many terrorists are killed relative to civilians…. [T]hese costs illustrate a central inconsistency of American policy…

Perhaps the most interesting question is why the Obama administration has signally failed to learn the lessons of Vietnam. The parallels between Obama’s dysfunctional drones-first policy and Johnson’s equally dysfunctional attritional war are there for all to see. Like Obama, Johnson sought to kill as many of the enemy as possible regardless of the wider social, economic and political costs. And, like Obama, he continued the policy despite there being contra-indications (like the 1968 Tet offensive that sowed panic throughout South Vietnam and disillusion across the United States).[20] What was the result of Johnson’s dogged attachment to simplistic attritional war? He undermined the South Vietnamese government’s show-case pacification programme that sought to bring security and development to impoverished rural communities. By preventing the needs of rural communities from being met, Johnson’s war let the Viet Cong in by the back door:

> The US strategy of attrition … was at odds with the tactics and philosophy of South Vietnam’s pacification programme …. Attrition offered a convenient way to measure success in the short run …. Attrition was not designed to … resolve the political issues of the war …. The focus on attrition … meant the underlying political issues of the war were overlooked …. Viewed from the perspective of the village and the province, the attrition strategy of the United States was not the most effective or appropriate response to the insurgency rending South Vietnam in the 1960s [29].

The flaws in Obama’s Pakistan counter-insurgency strategy are in many ways identical to those in Johnson’s Vietnam counter-insurgency strategy. With reference to Toft’s [58, 59] theory of isomorphic learning, Obama and his generals could have learned valuable lessons from Johnson and Westmoreland’s failure. Perhaps because of imperviousness and dogma, those lessons seem not to have been learned.

4.1 Lessons for Risk-Managers

By using armed RPVs to reduce the human, political and financial risks of warfare, the United States has incurred significant diplomatic and security costs. Specifically, the CIA-directed campaign has undermined the government of

[20] Karnow [32] observes of Tet: “[S]ome 70,000 Communist soldiers attacked South Vietnam's cities …. The televised scenes shocked the American public, which was already souring on the war. His ratings plummeting as antiwar sentiment spread, Johnson abandoned the race for re-election. Vietnam … threw America into turmoil”.

Pakistan, radicalised many of that country's citizens and harmed relations between Pakistan and the United States. The USA's new warfighting paradigm has created a set of unintended consequences or latent dysfunctions that are undermining the War on Terror. Failure to manage the latent dysfunctions of drone operations could render the War on Terror an exercise in futility.

The case study offers the following lessons for risk managers:

1. That latent dysfunctions can undermine, if not fatally compromise, purposive action. The net effect of the drones-first policy may be to increase rather than reduce the risk of terrorism.
2. That ignorance and dogma can blind actors to latent dysfunctions. Contra-indications (signs that the strategy is not working as intended) are either missed or ignored. The CIA seems impervious to the outrage felt by many Pakistanis when non-combatants are killed in drone strikes.
3. Latent dysfunctions can be avoided—but only with effort. Specifically, those in charge must scan for and, where possible, act upon contra-indications. Had Johnson and Westmoreland heeded reports that their attritional war was alienating South Vietnam's rural population they might have been able to reduce the ideological appeal of the Viet Cong. They might have been able to change the course of history.

Theories of collective mindfulness [63, 34, 64, 65] and high-reliability (HRT) [51, 33, 52, 39, 38, 27] teach that reflective practice (awareness, constructive critique and recalibration) helps improve system reliability. Mason [38] offers this definition of high reliability organisations (HROs):

> Successful cultures become susceptible to hubris and carelessness. One antidote for organizational hubris is the highly reliable organization (HRO) model, based on the concept of mindfulness. *These organizations are constantly aware of the possibility of failure, appreciate the complexity of the world they face*, concentrate on day-to-day operations and the little things, *respond quickly to incipient problems* and accord deep respect to the expertise of their members. They value knowledge and expertise highly, communicate openly and transparently, and avoid concentrations of power or corruption by setting up independent units with countervailing powers (my emphasis).

Where military operations are concerned, a willingness to reflect upon and, where appropriate, modify one's tactics can help improve the chances of success. Because Major Orde Wingate heeded the contra-indications of the British Army's conventional war in Burma he was able to formulate a strategy (reified in a volunteer guerilla force called the Chindits) that gradually pushed the Japanese back [11]. Wingate was an unconventional soldier—a maverick—who prided himself on his open-mindedness, rejection of convention and plain speaking (sometimes to the point of being accused of insubordination). Despite his toughness and determination (the Chindits were driven hard), the Major was respected by his men. Not unsurprisingly, given his own roller-coaster career and liking for the unconventional, Prime Minister Winston Churchill was drawn to Wingate and his Chindits.

Wingate was the personification of mindfulness: "Wingate was a lateral thinker who questioned everything and everyone—especially his superiors" [11]. According to the Health and Safety Laboratory [27], mindful leadership involves:

> Proactive … audits to identify problems in the system (often in response to incidents that occur in other similar industries), 'Bottom-up' communication of 'bad news' [and] engagement with front line staff through site visits.

Latent dysfunctions can only be remedied if those directing the purposeful action are willing to listen and act. Regarding the latent dysfunctions inherent in the US Government's drones-first military strategy, it would appear that the Obama administration believes the negatives (collateral damage, vengefulness, de-legitimation of the government of Pakistan, diplomatic rifts, regional instability, etc.) to be outweighed by the positives (the saving of US soldiers' lives and currying of electoral support, for example). As of August, 2014 there was no sign that President Obama would act to remedy the latent dysfunctions inherent in the CIA's drones-first counter-insurgency strategy.[21]

References

1. Abé N (2012) The woes of an American drone operator. Spiegel Online. 14 December
2. Ahmed AS (2013) The Thistle and the Drone: How America's war on terror became a global war on tribal Islam. Brookings Institution Press, Washington DC
3. Ali W (2013) The cost of our drone war in Pakistan. http://bostonreview.net. Accessed 10 October 2013
4. Anonymous (2013) Virtual adrenaline revisited. Remotely-piloted combat and one of its potential risks. The Combat Edge. June–August:8–13
5. Barnes JE (2010) Air Force works to instil 'warrior culture' in drone crews. Los Angeles Times. 29 March
6. Barnidge RP (2011) A Qualified Defence of American Drone Attacks in Northwest Pakistan Under International Humanitarian Law. Boston Univ Int Law J 30:409–447
7. Beck U (1992) Risk Society: Towards a new modernity. Sage, London
8. Beck U (2009) World at Risk. Polity Press, Cambridge
9. Becker J, Shane S (2012) Secret 'kill list' proves a test of Obama's principles and will. New York Times, 29 May
10. Belfast Telegraph (2013) Probe urged into secret Army unit. http://www.belfasttelegraph.co.uk/news/local-national/northern-ireland/probe-urged-into-secret-army-unit-29772008.html. Accessed 25 November 2013
11. Bennett SA (2010) Human factors for maintenance engineers and others—A prerequisite for success. In: Blockley R, Shyy W (eds) Encyclopedia of aerospace engineering. Wiley, Chichester
12. Bennett SA (2013) Killing them softly. Will drone operators pull the trigger? Air International. Oct:8–13

[21] There is an irony in the Obama Administration's apparent unwillingness to reflect upon the flaws in its drones-first counter-insurgency strategy, namely that it was the safety-enhancing mindfulness of US Navy carrier operations that helped inspire HRO theory. The Administration seems unwilling or unable to learn from a branch of its own military.

13. Birch M, Lee G, Pierscionek T (2012) Drones: The physical and psychological implications of a global theatre of war. Medact, London
14. Bjiker W (1994) Of bicycles, bakelites and bulbs: Toward a theory of sociotechnical change. Massachusetts Institute of Technology Press, Cambridge MA
15. Boyle MJ (2013) The costs and consequences of drone warfare. Int Aff 89(1):1–29
16. Braithwaite R (2011) Afgansty. The Russians in Afghanistan 1979–89. Profile Books, London
17. Callam A (2010) Drone wars: Armed unmanned aerial vehicles. Int Aff Rev 18(3)
18. Dao J (2013) Drone pilots are found to get stress disorders much as those in combat do. The New York Times. 22 February
19. Davey M (2013) A private boom amid Detroit's public blight. http://www.nytimes.com. Accessed 27 November 2013
21. Deri AR (2012) 'Costless' war: American and Pakistani reactions to the U.S. Drone War. Intersect. 5
22. Forrest A (2013) JFK—follow the facts. The Big Issue. 11–17 November 1077:16–22
23. Foust J (2013) U.S. Drones make peace with Pakistan less likely. http://www.theatlantic.com. Accessed 10 October 2013
24. Fund for Peace (2013) The failed states index 2013. http://ffp.statesindex.org/rankings-2013-sortable. Accessed 24 November 2013
25. Gitell S (2007) Spitting on Veterans. New York Sun. 6 February
26. Hamilton N (2012) Bill clinton: mastering the presidency. Random House, London
27. Health and Safety Laboratory (2011) High reliability organisations: a review of the literature. Health and Safety Laboratory, Buxton
28. Hersh SM (2004) Chain of command. The road from 9/11 to Abu Ghraib. Allen Lane, London
29. Hunt RA (1994) Pacification and attrition in Vietnam. In: Freedman L (ed) War. Oxford Readers, Oxford
30. International Human Rights and Conflict Resolution Clinic at Stanford Law School, Global Justice Clinic at NYU School of Law (2012) Living Under Drones. Death, Injury and Trauma to Civilians from US Drone Practices in Pakistan. http://livingunderdrones.org. Accessed 17 November 2013
31. Jameson F (1995) Postmodernism, or, the cultural logic of late capitalism. Duke University Press, Durham
32. Karnow S (1994) General Giap on Dien Bien Phu and Tet. In: Freedman L (ed) War. Oxford Readers, Oxford
33. LaPorte TR, Consolini P (1991) Working in practice but not in theory: theoretical challenges of high-reliability organisations. J Public Adm Res Theor 1:19–47
34. Langer EJ (1989) Mindfulness. Addison-Wesley, Reading MA
35. Latour B (1991) Technology is society made durable. In: Law J (ed) A Sociology of Monsters. Essays on Power, Technology and Domination. Sociological Review Monograph. 38
36. MacKenzie D, Wajcman J (eds) (1985) The social shaping of technology. Open University Press, Milton Keynes
37. Mason P (2012) US auto industry: The road to recovery? http://www.bbc.co.uk/news/17842000. Accessed 27 November 2013
38. Mason RO (2004) Lessons in organizational ethics from the Columbia disaster: can a culture be lethal? Org Dyn 33(2):128–142
39. McIntyre GR (2000) Patterns in safety thinking. Ashgate, Aldershot
40. Mearsheimer J (1994) Instability in Europe after the cold war. In: Freedman L (ed) War. Oxford Readers, Oxford
41. Merton RK (1936) The unanticipated consequences of purposive social action. Am Sociol Rev 1(6):894–904
42. Merton RK (1968) Social theory and social structure. Collier-Macmillan, London
43. Mohanty N (2013) America, Pakistan and the India Factor. Palgrave-Macmillan, Basingstoke

44. National Intelligence Council (2012) Global Trends 2030: Alternative Worlds. Office of the Director of National Intelligence, Washington DC
45. National Housing Federation (2013) Bedroom tax. http://www.housing.org.uk/policy/welfare-reform/bedroom-tax. Accessed 16 November 2013
46. Orwell G (1949) Nineteen eighty-four. Secker and Warburg, London
47. Osgood RE (1994) The reappraisal of limited war. In: Freedman L (ed) War. Oxford Readers, Oxford
48. Otto JL, Webber BJ (2013) Mental health diagnoses and counselling among pilots of remotely piloted aircraft in the United States Air Force. Med Surveill Mon Rep 20(3):3–8
49. Pew Research Center (2011) U.S. image in Pakistan falls no further following Bin Laden killing. http://pewresearch.org/pubs/2032/pakistan-public-opinion-osama-bin-laden-india-terrorism-alqaeda-american-image.. Accessed 20 November 2013
50. Pinch T (1996) The social construction of technology: A review. In: Fox R (ed) Technological change: Methods and themes in the history of technology. Harwood Academic Publishers, Newark NJ
51. Roberts KH (1990) Some characteristics of one type of high reliability organisation. Organ Sci 1(2):160–176
52. Roberts KH (1993) Cultural characteristics of reliability-enhancing organisations. J Manage Issues 5(2):165–181
53. Shaw M (2005) The New Western Way of War: Risk-transfer war and its crisis in Iraq. Polity, Cambridge
54. Sifton J (2012) A brief history of drones. The Nation. 7 February
55. Sveiby KE, Gripenberg P, Segercrantz B, Eriksson A, Aminoff A (2009) Unintended and undesirable consequences of innovation. Conference paper, XX ISPIM conference, The Future of Innovation. Vienna, 21–24 June 2009
56. The Times of India (2005) Pak will be failed state by 2015: CIA. http://articles.timesofindia.indiatimes.com/2005-02-13/us. Accessed 22 November 2013
57. Tilghman A (2013) Pentagon's new high-tech warfare medal draws backlash. http://www.usatoday.com. Accessed 28 November 2013
58. Toft B (1992) The failure of hindsight. Disaster Prev Manage Int J 1(3):48–63
59. Toft B, Reynolds S (1997) Learning from disasters. Perpetuity Press, Leicester
60. Tvaryanas AP, Thompson WT, Constable SH (2006) Human factors in remotely piloted aircraft operations: HFACS analysis of 221 mishaps over 10 Years. Aviat Space Environ Med 77(7):724–732
61. United States Air Force (2013a) Fact sheets. http://www.af.mil/AboutUs/FactSheets/Display/tabid/224/Article/104482/b-2-spirit.aspx. Accessed 20 November 2013
62. United States Air Force (2013b) Fact sheets. http://www.af.mil/AboutUs/FactSheets/Display/tabid/224/Article/104505/f-16-fighting-falcon.aspx. Accessed 20 November 2013
63. Weick KE (1987) Organisational culture as a source of high reliability. Calif Manag Rev 29:112–127
64. Weick KE, Sutcliffe KM (2001) Managing the unexpected: assuring high performance in an age of complexity. Jossey-Bass, San Francisco
65. Weick KE, Sutcliffe KM, Obstfield D (1999) Organising for high reliability: processes of collective mindfulness. Res Organ Behav 21:81–123
66. Woods C (2012) Drones: Barack Obama's secret war. http://www.newstatesman.com/politics/politics/2012/06/drones-barack-obamas-secret-war. Accessed 17 November 2013

Extra-Fragile in Disaster: People with Disabilities in a Bombarded Zone

Rita Sever

Abstract Although some guidelines and manuals support the specific inclusion of people with disabilities in emergency considerations, most programs focus on disability as a cross cutting issue, or on protecting people with disabilities as a vulnerable group, rather than on the specifics of inclusion and overcoming barriers. There is little evidence that these guidelines are used to any effect with people with disabilities. In emergencies, handicapped people may encounter particular difficulties that make the general facilities and assistance inaccessible to them. At the same time, services that usually cater to their special needs also suffer damage and become less effective or even unavailable. The social and personal supports that surround people with disabilities are fragile and appear to be particularly susceptible to the type of disruption that disasters incur. This is what was happening in Israel in summer 2006. The existing public services were inadequate for people with disabilities living in the bombarded North which became a disaster zone, and 3rd sector organizations stepped into fill the void. A program was created by NGOs to respond to a deluge of requests for assistance from people with disabilities living in their communities within the disaster zone. The research presented in this chapter is a mixed-methods case-study that studied this program. It is based on documentary material, program records, in-depth interviews with the partners and staff members of the program, and a survey of a representative sample of people with disabilities who requested assistance from the project. In addition to complementing findings of other researches, this study has unveiled some of the problems and dilemmas encountered by the project and has highlighted several issues that have not gained ample consideration, if at all, in the existing literature on disaster management and planning for resilience: unintended consequences of the participatory approach; managing and coordinating volunteers; and the double jeopardy of people with physical or mental disabilities who are also culturally and/or linguistically different from the mainstream population.

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A. Masys (ed.), *Disaster Management: Enabling Resilience*,
Lecture Notes in Social Networks, DOI 10.1007/978-3-319-08819-8_11

Keywords People with disabilities · Disaster management · Special needs in emergency · Linguistic minorities · Immigrants

1 Introduction

> When the world was attentive to the shocking reports and images out of Haiti in the aftermath of the January 2010 earthquake, nothing was heard about what was happening to people with disabilities [15].

The whole question of what actually happens to disabled people in emergencies is still quite neglected. The body of academic literature on this subject is small and the subject is seldom a theme at emergency management conferences [1].

Disasters tend to discriminate against disabled people [22]. People in wheelchairs, for example, cannot take refuge under desks and tables in earthquakes, neither can they rapidly exit a building down stairs [16]. People who are deaf or have defects of vision may fail to recognize danger or to hear verbal orders to evacuate. People who depend on electrical apparatus (dialysis machines, ventilators etc.) may find themselves in difficulty when there are power cuts during emergencies [1].

People with disabilities (PwD) living in seismically active areas often have additional situational characteristics that could increase their vulnerability to harm and loss in a natural disaster and its aftermath, such as living in unreinforced masonry buildings, in older buildings with low-rent units near urban centers [31].

In the great east Japan earthquake of 2011, people with hearing, intellectual, and mental disabilities were slower to access information on the surging tsunami, and even though information reached people with visual disabilities and physically disabled bedridden persons, it was difficult for them to evacuate on their own. *Everybody is placed in a dreadful situation in a time of emergency, and the disabled who had difficulty protecting themselves ended up left out*" [6]. PwD were stuck, sometimes for 3 weeks, in coastal high-rise apartments after Hurricane Sandy 2013 [10].

The UN Convention on the Rights of Persons with Disabilities outlined the obligation of States to protect and ensure the safety of PwD in situations of risk, including armed conflict. But -*…in practice, disability is rarely considered in humanitarian programmes, even when a growing body of evidence* […] *shows that people with disabilities in such situations are at particular risk* [9: 1801].

In short, "*Those with disabilities have been historically underserved in times of disaster*" [11].

Practical guidelines for preparing for and/or assisting the disabled in emergencies are however being published gradually by various organizations and emerging in various states.

One of a number of examples is a guide published in Istanbul, focusing on preparedness for disaster. (http://www.guvenliyasam.org/en/publications/first-72-hours-for-disabled-people-in-an-earthquake). Its target population consists not only of disabled people, but also of their families, relatives, friends and the personnel in the corporations from which they get service—who should all have information about disaster preparation. The guide predicts that getting the necessary aid would be impossible at the first 72 “golden hours” during a disaster or emergency. Getting through this period with the minimum loss, the guide states, depends on being prepared. The guide includes general information for all disabled groups and basic information that is distinctively prepared for each disabled group, for earthquake preparedness.

Another example is the NFPA *Emergency Evacuation Planning Guide for People with Disabilities,* which was developed in response to the emphasis that had been placed on the need to properly address the emergency procedure needs of the disability community and is available to everyone in a free, downloadable format from the websites of several organizations (e.g. www.nfpa.org). This Guide addresses the needs, criteria, and minimum information necessary to integrate the proper planning components for the disabled community into a comprehensive evacuation planning strategy. It provides information on five general categories of disabilities: mobility impairments, visual impairments, hearing impairments, speech impairments, and cognitive impairments.

Although some of the guidelines and manuals support the specific inclusion of PwD in emergency considerations, most programmes focus on disability as a cross cutting issue, or on protecting PwD as a vulnerable group, rather than on the specifics of inclusion and overcoming barriers. There is little evidence that these guidelines are used to any effect with PwD, in part because of lack of standards and indicators to monitor inclusion; but also because of the lack of awareness and training at field level. Local disabled people’s organizations are rarely included in planning and coordination meetings, particularly in crises. Thus the opportunity is missed to improve coordination and inclusion of PwD in humanitarian aid. Kett and van Ommeren [9] claim that many staff working in humanitarian agencies share common misperceptions about individuals with disabilities, and that many current delivery structures for humanitarian aid perpetuate these assumptions: that PwD either require expensive specialist care or their needs will be covered by general aid distributions; that they are unable to help others; and that they are unable to participate in most education, work, or community activities. In situations such as earthquakes or flooding, there is often the perception that PwD will simply not survive [9].

1.1 Mortality Rates

In disasters the mortality rate of people with pre-existing disabilities is considerably higher than the mortality rate in the general population [3, 17].

> The reality[…] is that there’s a higher mortality rate in natural disasters among people with disabilities compared with the non-disabled[…]. The specific needs of people with disabilities are often overlooked and underserved during the processes of decision making that accompany disaster management and recovery [3: 76].

According to a study conducted after the 1995 Great Hanshin-Awaji earthquake in Japan, the odds ratio (OR) of death for people with pre-existing physical disabilities nearly doubled; a similar study after the Taiwanese earthquake in 1999 found that the OR was 1.7 for deaths of people with pre-existing moderate physical disability and doubled for persons with pre-existing mental conditions [17].

A research conducted in the major disaster-stricken region after the great earthquake and tsunami in Japan 2011, found that the mortality rate was 1.03 % in the total population whereas that of disabled people was 2.06 %. An administrative report released by the Miyagi Prefectural authorities on March 29, 2012, stated that the mortality rate in the total population of the coastal area of Miyagi was 0.8 % while that of registered disabled persons was 3.5 % [4]. These figures may reflect an underestimation of the actual gap, because they rest on a somewhat limited definition of "disabled persons"—referring only to those who are officially registered by the government as people with physical or mental disabilities. However, not all those with mental disabilities are officially registered, nor are those who have disabilities caused by intractable diseases, developmental disabilities, and higher-brain dysfunctions (op.cit).

Why are mortality rates for disabled persons especially high?

In the case of the great earthquake and tsunami in Japan 2011, Fujii [4] offered two explanations. One—that little consideration had been given to the needs of PwD in various counter-disaster measures and policies in the region affected by the Earthquake. The second explanation links the mortality rate among PwD in disasters to the quality of the local support policy that exists for them in "normal" times. Most of the disaster stricken areas had scarce social resources (workplace, housing, personal support system including consultation services, etc.) for PwD. This is even more apparent in recovery and reconstruction efforts: the more social resources are available, the more recovery and reconstruction efforts invested in the disability sector have progressed.

Moreover, the concentrated and accumulated impact of the disaster on disabled people is seen not only in the death rate but also in various stages of their life after the disaster, such as living under disrupted lifelines (the first 1 week immediately after the disaster is particularly crucial), and their stays at the evacuation centers and temporary housing [4].

1.2 Who Are People with Disabilities (PwD)?

Most people will, at some time during their lives, have a disability, either temporary or permanent, that will limit their ability to move around and to easily use the built environment or to function effectively in other aspects. One person may have multiple disabilities, while another may have a disability whose symptoms fluctuate. Disabilities manifest themselves in varying degrees, and their functional implications are important not only for emergency evacuation, but also for adaptation of special shelters for evacuated PwD.

Many forms of disability exist, such as paraplegia, quadriplegia, deafness, blindness and defects of vision, mental illness and retardation, cerebral damage, stroke, senility and dementia, Alzheimer's disease, and numerous forms of dependence on care-givers, equipment and supplies for support to the vital functions that sustain life. There are various classifications of the great variety of disabilities. Alexander [1], for example, suggests the following categories: difficulties of personal mobility, inability to see (with possible use of guide-dogs), deafness, problems of communication and articulation of words (as with stroke victims), cognitive disorders, various medical problems, use of life-support systems, people who suffer from intolerance of chemical or environmental substances, psychiatric disorders and panic attacks, and infirmity associated with old age. The variety of disabilities requires a varied catalogue of provisions during emergencies, such as transport for people with reduced mobility, specialized means of communication for those with cognitive or speech difficulties, provision of portable or substitute equipment for those who depend on life-support systems, and psychiatric support for those with mental health problems [1].

1.3 What Happens in Disasters to People with Disabilities (PwD)?

The body of research on what actually happens to PwD during and after emergencies is still small. Some of the few papers published in the last two decades, are Rahimi's [16] study of the behavior of 33 physically disabled people during the Loma Prieta earthquake that shook the greater San Francisco and Monterey Bay areas in 1989; Takahashi et al. [26] study of the effects of the 1995 Hanshin earthquake in Japan on people with cognitive disabilities; Fu et al. [3] study of the role of communications before, during and after the 2008 earthquake in Sichuan province in China, among PwD; and Iwasaki's [6] report on the added difficulties of PwD at evacuation shelters which they reached after escaping the Great East Japan Earthquake of 2011.

Takahashi et al. [26] described the vulnerability of (adult) people with intellectual disability when services were disrupted by a major earthquake. "Before the earthquake, many people with intellectual disability lived at home with their family (mostly parents) and attended a workshop or day centre. Most of them travelled to the workshop or day center using public transport." But people with these disabilities who survived the earthquake had difficulty in adapting themselves to refuge life and maintaining their lives under very strict circumstances. "There were no private spaces in the refuges, and people with intellectual disability were rejected and segregated by their neighbors in the refuges because of their strange behavior and noisy utterances. This was another severe stress for these people" (op.cit.: 194). Furthermore, they had a hard time getting food and other necessities that were brought to the shelters by volunteers, "Food and daily necessaries were brought in and distributed by volunteers. However, the distribution was not always completely impartial. Those who had the power to assert themselves used to come to the front of the queues to make their demand and get preferential treatment" (op.cit.:194). People who could get through to the volunteers and express their demand, had a better chance of getting what they needed than those who didn't know how to do this. Thus people with cognitive disabilities had difficulties in functioning in these shelters.

The researchers emphasized the value of an accessible register of people with cognitive disabilities and of multiple networks of support at the time of a major disaster [26].

Fu et al. [3] found that in the first few days after the Sichuan earthquake, PwD relied on battery-powered radios and face-to-face communication to receive disaster-related information. Many listened to the radio in groups, as some people's radio sets were lost when their houses collapsed. One example of an application of wireless communication for PwD was a 'virtual network' service—a communication package that stimulated peer-support among PwD before and after the earthquake. After the earthquake, power for communication devices became a key issue as people in the affected areas struggled to maintain communications with the world outside. This brought the researchers to suggest further research that would explore the feasibility of developing and marketing low cost solar or hand-generated chargers for mobile phones or radios. They also found that the content of media coverage was making a big difference—both informational support and providing emotional support by the media were very important. PwD depended heavily on the face-to-face communication with local officers for information about the details of social welfare policies and post-disaster subsidies. Information on the subject was received in piecemeal fashion through the mass media or personal conversations, but sometimes the information received did not seem to be completely consistent with the messages received from the officers, particularly with regard to the exact amount of the subsidies they were supposed to receive ([3]: 83–84).

Iwasaki [6] reported that even at evacuation shelters which they reached after escaping the disaster of The Great East Japan Earthquake of 2011, PwD were facing many hardships due to difficulties moving in wheelchairs and lack of medical equipment, medications, and nursing care products, as well as difficulties communicating with others. Loss of essential utilities, including electricity supply, threatens the lives of those who depend daily on medical devices such as ventilators and suction devices, or who remain on dialysis. The physical and mental states of those in need of therapies and medications for intractable diseases, internal diseases and mental disorders become unstable, and those who are physically disabled using powered wheelchairs have difficulty moving around. At an early stage, there was a severe shortage of equipment and supplies necessary to sustain life such as supplies for home medical care, beds, and diapers. Also, survivors had little access to information from the mass media, so the TV audience had more information than the afflicted.

People with communication difficulties end up isolated in evacuation shelters packed with a large number of sufferers. Among those who are barely able to go to a restroom because of difficulties moving around, and those who are not considered disabled because their internal, hearing, language, or mental disorders are indiscernible to the eye, there are people who can seldom say what is bothering them in surroundings without familiar faces. Changes in the environment may worsen the condition of a disease for mental reasons, and throw those with a tendency for autism into a panic. Considering that even healthy people feel intense stress, one can only imagine how much anxiety and conflict did disabled persons and their families have at that time.

In addition to the support necessary and common to all survivors, PwD also need the support necessary for disabilities, which should be guaranteed as their right in principle. During the emergency, however, support necessary and common to all survivors was given priority, and there were many cases in which PwD did not express themselves out of concern that "they would place a heavy burden on others" [6].

In these works, the PwD were caught in emergencies created by a natural disaster. What happens to people with disabilities under conditions of war is still an unchartered territory in academic literature, as it is in actual programs.

> Many programmes allocate separate funding to victim assistance programmes whereby only those injured or impaired by conflict are given priority funding, medical care, or assistive devices, while **those disabled before the conflict are overlooked**…. [9: p. 1801]; emphases added)

1.4 Services in Emergencies/Disasters

Disaster/emergency services involve "rapid assignment and temporary deployment of staff who must meet multiple demands and work in marginal conditions and in unfamiliar settings such as shelters, recovery service centers, and mass care facilities" (SRA [25]: 20)

In emergencies, PwD may encounter particular difficulties that make the general facilities and assistance inaccessible to them.

The social and personal supports that surround them appear to be particularly susceptible to the type of disruption that disasters incur [12]. Services that usually cater to their special needs, such as Centers for Independent Living (CILs) for example, may also suffer damage and become less effective or even unavailable.

> Damage to CILs' facilities and equipment during the [Katrina] storms hampered their efforts to respond to consumers and others who requested assistance. The ability of CILs to function internally was also significantly disrupted, including an inability to process payrolls, recover files on computers, pay vendors, and maintain other essential services [30: 13].

Despite the growing availability of preparation guides for PwD, the reality in actual emergencies is often lack of integration and co-operation between the various organizations that work with the disabled and the civil protection community which must plan for and manage emergencies [1].

This reality was highlighted by a research [30] which identified major barriers faced during Hurricane Katrina by CILs and emergency managers in responding to the needs of PwD. The researchers found significant gaps in three key areas: (a) *pre-disaster planning* by CILs, by individuals with disabilities, and by local emergency management agencies; (b) pre- and post-disaster *communication and* *information sharing* within CILs, between CILs and consumers, and between local emergency management agencies; and (c) pre- and post-disaster *coordination* between CILs and other disability agencies, local and regional emergency management organizations, and community supports.

The research found that little pre-disaster planning took place in the CILs and they were caught unprepared. There was also little interaction between the CILs and emergency management personnel before the hurricane. Some of the CILs did have a plan in place to protect data stored on computers, but the planning in other areas, including equipment, vehicles, supplies, and staffing, was either incomplete or non-existent. CILs did not have anyone on staff with disaster preparedness training and did not have a plan or procedures to provide services in the event of a disaster. The one CIL that did report having procedures in place also reported that they were not written down.

Some CILs reported having a formal or informal relationship with local emergency managers before the storm, but none had a formal plan in place with the local emergency management agency. In the same way, local emergency managers had little contact with disability organizations before the storm.

1.5 Special Evacuation Shelters

In Japan until 2004 counter-disaster measures for *people with functional needs in disaster* (PFND) focused mainly on warning and neighborhood-based evacuation assistance activities. The concept of a specially designated post-disaster shelter for PFND started to emerge in 2004, following the recognition that general evacuation shelters were not capable of responding to the functional needs of PwD and the frail elderly. Sheltering needs were however perceived to be short-term and less life-threatening than evacuation needs, since most hazards that the PFND Japanese committees had been studying were meteorological [27].

Then came the March 2011 earthquake, and very large numbers of people rushed to general shelters, where they had to stay for a long time. In these shelters most PwD did not ask for help because they felt that these shelters were unresponsive to their functional needs.

The situation apparently required alternative shelters for PFND. At one of the large general shelters, a medical doctor strongly demanded that the city administration provide an alternative shelter for the frail elderly, PWD and those outpatients who did not require intensive medical care in the Hospital. Yugakukan gym eventually accepted about 130 PFND and their family members.

Disaster-hit municipalities responded in a variety of ways to the needs for shelters and temporary housing units that were specially designated for PFND. The Sendai city administration had already made pre-planned arrangements/compacts for an *alternative sheltering service* with 52 local social service providers prior to the March event. Some of those shelters had conducted study seminars and practice drills in the previous year. Thanks to these preparations, some responded to the city administration's request quickly and others voluntarily initiated sheltering operations. In total, 26 shelters operated in the City.

Specially designated shelters operated in Ishinomaki City but the operation lacked a formal logistic support foundation for a prolonged period of time. In another city the frail elderly, PwD and small children were all mixed with other evacuees who looked after those in need at general shelters. In some shelters, cardboard partitions were used to separate PFND from general evacuees in order to provide some privacy [27].

1.6 Special Support Centers

Emergency services for PwD are expected to locate and assist them in disaster; to meet their independent living needs including medication and durable medical equipment, accessible housing and transportation; to accommodate caregivers and service animals; to provide for assistive technologies; etc. [30].

In 2011, the Japan Disability Forum (JDF) established "Headquarters for the Comprehensive Support of Persons with Disabilities Affected by the Great East Japan Earthquake" immediately after the great earthquake & tsunami. They provided support mainly through Support Centers which operated in the three prefectures that sustained major damage, collaborating with related organizations and coordinating with municipalities. Their major activities were: (1) safety confirmation at the earliest stage, (2) support provision at the evacuation center (including delivery of necessary goods), (3) reopening of the cleaning and repair related workshops for PwD, (4) move from evacuation centers to temporary housing and checking the places to be restored, and (5) transportation support from temporary housing (to hospitals and stores). The JDF also conducted a complete survey of registered PwD in two of the cities [4].

1.7 Top-Down Versus Participatory Approaches

In cases where planning and providing special services and arrangements for PwD does exist, it is mostly done 'top down', namely for—but not with—the potential beneficiaries. For example, the U.S. Federal Emergency Management Agency (FEMA), based on a biomedical model that sees disability as an individual 'condition', not a social situation, has valuable information on its web site under the heading "Assisting People With Disabilities in a Disaster", but it is aimed at care-givers, not the disabled people themselves. There is no reference to the life circumstances or situation of the disabled person. For example, PwD often need more time than others to make necessary preparations in an emergency; some people who are blind or visually-impaired, especially older people, may be extremely reluctant to leave familiar surroundings when the request for evacuation comes from a stranger; some people with cognitive or mental difficulties may be unable to understand the emergency and could become disoriented or confused about the proper way to react; and many respiratory illnesses can be aggravated by stress in an emergency, while oxygen and respiratory equipment may not be readily available. Most resources presume the dependence of the disabled person upon a care-giver and disregard situations in which there may not be anyone to assist the person in question, who may well have to 'cope' on his/her own. Advice could be provided about how a person with a disability could go about developing her/his own support system and could—for that matter—be in a position to provide assistance and support to someone else [31].

A different approach calls for partnership with and participation of PwD in planning and in providing assistance in disasters. For example—after the events of September 11th 2001 in the U.S, the National Organization on Disability (NOD) strongly emphasized the importance of tapping the knowledge, experience, and opinions of PwD and the need to ensure that PwD are included at all levels of preparedness planning for all emergencies. Furthermore, it referred to the inclusion of people with *all* types of disabilities: "deaf/hard of hearing, blind, mental illness, physical, and non-apparent disabilities (i.e. cognitive, multiple chemical sensitivity)" [31: 16].

2 The Present Research

This is a mixed-methods research that studied a project which operated in Israel during a period of armed confrontations along its northern border in summer 2006. The case-study [32] is based on documentary material, project's records, 16 in-depth interviews with the partners and staff members of the project, and a survey of a representative sample (N = 207) of people with disabilities who requested assistance from the project [19].

It contributes to the accumulating knowledge about services for PwD in disasters, from somewhat unique perspectives. Firstly, it addresses an emergency created not by a natural disaster but by conditions of war. Secondly, it studies an ad hoc project rather than a pre-prepared special emergency service or a special evacuation shelter.

It analyses what happened when a project constructed ad hoc to assist PwD during an on-going emergency created by conditions of war, and operated by an organization of and for PwD, struggled to cope with the diversified needs of people with a vast variety of disabilities.

2.1 Context

As already said, the social and personal supports that surround people with disabilities are fragile and particularly susceptible to the type of disruption that disasters yield. So in emergencies PwD may encounter particular difficulties that make the general facilities and assistance inaccessible to them.

This is what was happening in Israel in the summer of 2006. The local welfare and health systems were disrupted in the bombarded North which became a disaster zone, and a number of problems and needs of PwD living in their community in the disaster zone emerged—lack of a nearby bomb shelter and difficulties in accessing available shelters being just one of them. PwD, who'd lived independently until then, were left without their security networks when many of their neighbors, and even welfare officials, moved temporarily to safer areas of the country together with their own personal families. People with serious disabilities, who depended on 24/7 nursing at home, were abandoned by their hired personal caregivers, who fled the warzone leaving them without treatment, assistance, sometimes even without medication and/or food.

Although no official call for evacuation was issued and no evacuation centers were established by the authorities, many people sought to leave the war zone and had to find accommodation in safer areas. Among them were numerous PwD, who needed help in finding an accessible/suitable place to stay. This was especially difficult in cases of a disabled couple, or a family of children with a disabled parent, or people with communication disabilities. Even when a place to stay was found, many PwD were unable to get there without suitable transportation.

In short, PwD living in their communities within the bombarded region needed an address to turn to for help, a body that could respond to their needs. The existing public emergency services were inadequate for them, and 3rd sector organizations stepped into fill the void. Improvising was essential, because everybody was caught unprepared for the emergency; and a dynamic framework was necessary, one that could evolve while in motion.

So a program was initiated by NGOs aiming to respond to a deluge of requests for assistance from PwD in the disaster zone.

The program was named *MAGEN*—a Hebrew word meaning "shield"—also kind of an acronym of the program's full name in Hebrew: ***Ma****'ane* ***G****amish l****e****N****echim beherum*, (i.e. "flexible response for PwD in time of emergency").

High performance in response to disasters requires an ability to utilize uncharacteristically flexible decision making and expand coordination and trust of emergency response organisations. These requirements are often superimposed on conventional bureaucratic systems that rely on relatively rigid plans, exact decision protocols and formal relationships [7, 8]. *MAGEN* evolved as an ad hoc partnership between 3rd sector and governmental organizations. It was initiated by the Unit for Disabilities and Rehabilitation at JDC Israel and an advocacy NGO called *The Israeli Human Rights Organization of People with Disabilities* (IHROPD), which became the operating body of the project. Other major partners were the Association for Planning and Development of Services for Children and Youth at Risk, and the Rehabilitation Department of the Ministry of Welfare.

The program's major activities were three fold: (a) emergency response via a telephone hotline; (b) direct services for PwD who remained in the North; and (c) temporary accommodations for PwD and their family members who sought to evacuate the northern region during the crisis period.

The project was in operation for 5 weeks, starting a week after the bombarding began and closing 3 weeks after the cease fire was declared. During that period

MAGEN handled approximately 2,500 requests on behalf of 6,000 PwD and their families. Most of the requests came from people who sought to evacuate the confrontation areas. *MAGEN* provided a respite package of five days in central Israel (mainly in rooms that were rented in hotels) for 1,820 PwD and their families. In addition to providing accommodation for these people, *MAGEN* offered emotional support and organized leisure activities. The program also assisted PwD who remained in their homes in the northern region, by providing food, medications, and transportation, and also by contacting other institutions and organizations that could assist them.

Who Applied for Help and how did they know about *MAGEN*?

The program received requests from people living in the community with a large variety of disabilities: physical (varying degrees of limb disabilities), medical (organ transplants, artificial ventilation, oncological treatment), sensory (blindness and deafness), mental and cognitive, and cerebral disabilities. Most requests came from PwD who lived with family members, some came from singles. Almost half (46 %) of those who contacted *MAGEN* had no “safe room” or a bomb-shelter at home. About one third (32 %) did have a public shelter in or nearby their building, but most of these shelters were not accessible to wheelchairs, and PwD faced many difficulties entering and exiting the shelters as well as functioning inside them. 70 % of the people who approached *MAGEN*, had learned about its existence through the media, especially through TV texted messages (44 %) or through their social networks—family members, friends, neighbors (29 %).

Many people who requested assistance from the program were registered as PwD; 52 % had been in contact with welfare authorities prior to this emergency, mostly families with disabled children. There were also requests from PwD who had lived completely independently until then but the arrangements that had enabled their independence were not resilient enough to sustain the emergency conditions.

2.2 Dilemmas in Designing the Program’s Scope and Action-Plan

During the emergency, *MAGEN*’s partners had to cope with a number of professional and financial dilemmas. Among them: home hospitality (at volunteer families’ homes) versus accommodation at hotels; evacuation until the crisis is over, versus a respite approach aimed at mitigating stress for residents whose homes were along the confrontation line; short-term versus longer-term respite; and maximal inclusion versus prioritization of assistance [19].

2.2.1 The Home Hospitality Solution

During the emergency in the North, families in other (safer) areas of the country opened their homes and offered accommodation for people who wished to evacuate from the bombarded zone. Initially, *MAGEN* intended to rely on this hospitality and to evacuate PwD from the bombarded area to homes of volunteer families in other areas. But finding and enlisting such families proved to be a difficult task, since stigmas were hard to overcome: many families who had volunteered to host evacuees from the North, refused to accept PwD.

But even when such families were found and PwD were sent to their homes, very soon this proved to be a problematic solution both for the hosts and for the guests. The hosts were overwhelmed by the unfamiliar implications of living with PwD, such as the constant noise of an artificial respiration machine, for example. The PwD felt embarrassed to be guests in strange (often rich and luxurious) homes; and were uncomfortable in houses which were not suited to accommodate their special needs (e.g. toilets, bathrooms, doors, stairs etc.). In short, prolonged hosting of families with disabilities at volunteers' homes yielded strains and required help not only with stress-relief but also solutions to physical and other problems, sometimes even help with the costs of hosting.

So the program turned to renting accommodations (i.e. rooms) at hotels in safe areas.

2.2.2 Maximal Versus Restricted Inclusion?

The original target population of IHROPD—the advocacy NGO that became the operating body of *MAGEN*—included **all** disabilities [20]. They wanted *MAGEN* to adopt their inclusive definition of: (a) *who's a person with disabilities*? Answer: anyone who copes with any condition that impairs one or more of his/her major functioning. (b) *who's eligible for assistance, especially for respite*? Answer: the disabled person together with his/her family and/or caregiver.

While this view was supported by the JDC partner, another partner of *MAGEN* held a different approach: The Welfare Ministry's representative opted for criteria-based prioritization (e.g. geographic proximity to the border), a more restricted definition of the target population (e.g. those registered as PwD in welfare services' records), recommended that only the disabled persons themselves be eligible for respite, and warned that inclusion of families and lack of prioritization would result in a gap between the willingness to acknowledge everybody's needs and the project's capability and limited resources to actually cater to all of them. If the project is unable to provide respite for all, he argued, it would be unreasonable that the family members of one person with disabilities get respite instead of three other individuals with disabilities.

The partners resolved the dilemmas by taking the following decisions: (1) the project's target population was defined broadly and not restricted to people who were already registered as disabled in welfare records. Thus it included also mental and cognitive disabilities, people with medically-induced disabilities such as cancer patients, patients with artificial respiration, etc. (2) Nuclear families (i.e. parents and minor children of the disabled) were accepted as eligible for respite.

These decisions yielded some *unintended consequences,*[1] and had serious implications for the nature of the project activities and the project's overall effectiveness.

[1] sf. Simon Bennett's chapter in this book.

2.3 Respite for PwD Together with Their Families

The decision to accept for respite not only disabled individuals but also their (nuclear) family members reflected the project's community-based perception of its target population. It also reflected a gross overestimation of the scope of suitable accommodations that the project would be able to provide at that time. The reality was that the project provided respite for some 1,820 PwD with their families, and most of them (84 %) were happy with what they got, according to the survey's findings. The main reasons for satisfaction indicated in the survey were that they were able to leave their homes and that arrangements were made for them to have a place to stay; that the project's response was prompt, that they were treated well, and the project's staff were attentive and understanding. However, these people constituted only some 30 % of the body of people who registered requests, while many others were left behind, bitter and frustrated. One of the main reasons indicated for dissatisfaction with *MAGEN* in the survey was the complaint that no one enabled them to leave their homes.

2.4 Diversity of Disabilities—The Scope, the Meaning and Some Illustrations

In order to grasp the scope of the potential diversity and understand its implications, it would be enlightening to take a look at NFPA guide's (op.cit.: 9–13) description of the main categories of disabilities, and at some illustrative examples from the reality of the project.

2.4.1 People with Mobility Impairments

Wheelchair Users

People with mobility disabilities may use one or more devices, such as canes, crutches, a power-driven or manually operated wheelchair, or a three-wheeled cart or scooter, to maneuver through the environment. People who use such devices have some of the most obvious access/egress problems. Typical problems include maneuvering through narrow spaces, going up or down steep paths, moving over rough or uneven surfaces, using toilet and bathing facilities, reaching and seeing items placed at conventional heights, and negotiating steps or changes in level at the entrance/exit point of a building.

Ambulatory Mobility Disabilities

This subcategory includes people who can walk but with difficulty or who have a disability that affects gait. It also includes people who do not have full use of their arms or hands or who lack coordination. People who use crutches, canes, walkers, braces, artificial limbs, or orthopedic shoes are included in this category.

Activities that may be difficult for people with mobility disabilities include walking, climbing steps or slopes, standing for extended periods of time, reaching, and fine finger manipulation.

Generally speaking, if a person cannot physically negotiate, use, or operate some part or element of a standard building egress system, like stairs or the door locks or latches, then that person has a mobility impairment that affects his or her ability to evacuate in an emergency unless alternatives are provided.

Respiratory Impairments

People with a respiratory impairments can generally use the components of the egress system but may have difficulty safely evacuating due to dizziness, nausea, breathing difficulties, tightening of the throat, or difficulty concentrating. Such people may require rest breaks while evacuating.

Illustrations from the project:

> The accessibility needs of people in wheelchairs created a complex issue for the hosting hotels: allocating them rooms that are not far from the elevator and the dining room (since moving on rugs is difficult in a wheelchair); providing higher legged tables at the dining room for the wheelchairs to get under them; wide doors at the entrance to the room and inside it (entrance to bathroom); showers (not baths), toilet adjustments, facilities inside bathrooms etc.
> *Incident*: a woman in a wheelchair couldn’t enter through the narrow bathroom door in her hotel room. She improvised a solution: Every morning she took her towel and toothbrush and wheeled herself to the dining-room’s accessible toilets. Until she was told by the dining-room’s attendant that this practice was discomforting the “regular” guests.

2.5 People with Visual Impairments

This category includes people with partial or total vision loss. Some people with a visual disability can distinguish light and dark, sharply contrasting colors, or large print but cannot read small print, negotiate dimly lit spaces, or tolerate high glare. Many people who are blind depend on their sense of touch and hearing to perceive their environment. For assistance while in transit, walking, or riding, many people with visual impairments use a white cane or have a service animal. There is a risk that a person with a visual impairment would miss a visual cue, such as a new obstruction that occurred during the emergency event, that could affect egress.

Generally speaking, if a person cannot use or operate some part or element of a standard building egress system or access displayed information, like signage, because that element or information requires vision in order to be used or understood, then that person has a visual impairment that could affect his or her ability to evacuate in an emergency unless alternatives are provided.

Illustrations from the project:

- Blind people needed to be accompanied to places in unfamiliar surroundings.
- In a self-service dining room a blind person needed to be led to the buffet, but the volunteer assigned to help him was a religious woman who refused to lead him by his elbow because she wouldn't touch him.
- A blind person who had ear pains needed to go to a clinic, but no volunteer was available to accompany him.

2.6 People with Hearing Impairments

People with partial hearing often use a combination of speech reading and hearing aids, which amplify and clarify available sounds. Echo, reverberation, and extraneous background noise can distort hearing aid transmission. People who are deaf or hard of hearing and who rely on lip reading for information must be able to clearly see the face of the person who is speaking. Those who use sign language to communicate may be adversely affected by poor lighting. People who are hard of hearing or deaf may have difficulty understanding oral communication and receiving notification by equipment that is exclusively auditory, such as telephones, fire alarms, and public address systems. There is a risk that a person with a hearing loss or deafness would miss an auditory cue to the location of a dangerous situation, affecting his or her ability to find safe egress.

Generally speaking, if a person cannot receive some or all of the information emitted by a standard building egress system, like a fire alarm horn or voice instructions, then that person has a hearing impairment that could affect his or her ability to evacuate in an emergency unless alternatives are provided.

Illustrations from the project:

> A sign-language translator was not always available at the respites. This was especially problematic for immigrant deaf people who couldn't communicate by written communication in Hebrew.

2.7 People with Speech Impairments

Speech impairments prevent a person from using or accessing information or building features that require the ability to speak. Speech impairments can be caused by a wide range of conditions, but all result in some level of loss of the ability to speak or to verbally communicate clearly.

The only "standard" building egress systems that may require a person to have the ability to speak in order to evacuate a building are the emergency phone systems in areas of refuge, elevators, or similar locations.

2.8 People with Mental and/or Cognitive Impairments

Mental and cognitive impairments may prevent a person from using or accessing building features due to an inability to process or understand the information necessary to use those features.

Cognitive impairments can be caused by a wide range of conditions, including but not limited to developmental disabilities, multiple sclerosis, depression, alcoholism, Alzheimer's disease, Parkinson disease, traumatic brain injury, chronic fatigue syndrome, stroke, and some psychiatric conditions, but all result in some decreased or impaired level in the ability to process or understand the information received by the senses.

Illustrations from the project:

Mental Impairments

People struggling with mental-health disabilities created dramatic scenes and acute problems in the hotels, thus draining the limited time resources of the projects' tiny staff. The need for a steady and permanent presence of mental health professional was only recognized gradually and not fully answered.

> …a woman - a single mother with an autistic child together with his grandmother - entered the hotel lobby (she herself seemed to be mentally impaired). All three were extremely anxious. Mother and son were hitting the grandmother, the woman hit herself, and all three were screaming in the lobby at the top of their voices.

The hotel manager demanded that they be expelled from the hotel immediately. It was 3 pm, and they already had a key to a room. The project's representative/coordinator promised to have them leave the hotel, but suggested to get them into their room first, where they can be calmed (although an acquaintance from their hometown said to her that inside the room they'd kill each other). The manager refused to allow it and almost pushed her down the stairs insisting that she gets them out immediately. So she called a taxi and put the grandmother in it; the acquaintance took the child to one side of the lobby and the coordinator took the women to the opposite side and tried to calm her. She promised the woman that they'd be transferred to another hotel, but asked that there be no more outbursts there. No psychiatrist was present at the hotel nor available by phone, and the project's representative spent the better part of one and a half hour trying to cope with the situation, instead of catering to new arrivals at the hotel. When she called the project's headquarters, she was told to explain to the hotel manager that they're trying to find a solution but this might take some time. She felt that nobody understood her situation, felt that she was completely alone there and had to do everything by herself.

Cognitive Impairments
Parents of children with deep retardation couldn't cope with them by themselves 24/7 at the respite. Volunteers were needed for keeping these children busy for 4-6 h a day, but this task required volunteers who'd training in special education.

2.9 People with Temporary Impairments and Multiple Impairments

In addition to people with permanent or long-term disabilities, there are others who have temporary conditions that affect their usual abilities. Broken bones, illness, trauma, or surgery can affect a person's use of the built environment for a short time. Diseases of the heart or lungs, neurological diseases with a resulting lack of coordination, arthritis, and rheumatism can reduce a person's physical stamina or cause pain. Other disabilities include multiple chemical sensitivities and seizure disorders. Reduction in overall ability is also experienced by many people as they age. People of extreme size or weight often need accommodation as well.

It is not uncommon for people to have multiple disabilities. For example, someone could have a combination of visual, speech, and hearing disabilities.

Illustrations from the project:

Medical conditions

- Supply of medical equipment was needed for people depending on artificial respiration or on other appliances, instruments, devices, utensils, tools, etc.
- PwD who had been injured before arriving at the respite needed medical care, and volunteers to escort them to the doctor/clinic
- Mental patients who arrived without their medication needed a volunteer to escort them to the pharmacy

Multiple disabilities

- An elderly man in a wheelchair, who suffered from incontinence, was urinating while moving about in his wheelchair in the public spaces (which caused great discomfort for the surrounding people).

2.10 People with Service Animals

Service animals assist PwD in their day-to-day activities. While most people are familiar with guide dogs trained to assist people with visual impairments, service animals can be trained for a variety of tasks, including alerting a person to sounds in the home and workplace, pulling a wheelchair, picking up items, or assisting with balance. The ADA defines a service animal as "any guide dog, signal dog, or other animal individually trained to provide assistance to a person with a disability." Service animals are permitted in private facilities that serve the public, including shelters, hospitals, and emergency vehicles.

Service animals need special food and might become hesitant or disoriented during the emergency situation.

Illustrations from the project:

- Blind people arrived at the hotels with their service dogs, who needed to be walked outside three times a day. People (including the staff at the hotel) didn't know that for service dogs to be able to focus on their job they shouldn't be handled or fed while on duty. These dogs are very likeable, and people used to pet and/or feed them.
- An injured blind person came in with his service dog who was also injured and became hesitant and disoriented, unable to respond correctly to orders (instead of "right" went forward etc)

2.11 Implications

PwD left their homes in a hurry. Some came alone, unaccompanied by a much needed caregiver; lacking any personal equipment: no extra clothing (thus a problem of washing emerged, while no launderettes were to be found in the hotel or nearby); no money, no vital medication, no prescriptions and no magnetic healthcare cards; etc.

Beside obvious humane merits, the acceptance of all kinds of disabilities for respite in hotels created a semi-chaotic reality in the respites.

The hotels were caught completely unprepared for hosting a multitude of PwD, all at the same time. "*Wow!—So many wheelchairs in the lobby*!!"; "*One wheelchair in the hotel (in regular times) stresses the staff; now* 12–13 *wheelchairs!…"* They were even less prepared for the diversity of difficulties and disabilities of these special guests, who were added to the regular clientele of the hotels. *"It's unnerving to see such harsh sights, like little children with muscular dystrophy in wheelchairs*" were some of the staff's responses.

The hosting hotels had to cater to PwD while simultaneously catering to "regular" (i.e. not disabled) guests. Some of the latter were apprehended by the interface with PwD, some were even disgusted, and complained to the hotel managers that they had come to relax, not to be exposed to harsh sights.

The various disabilities yielded needs and problems that were not anticipated in advance and almost overwhelmed the very dedicated but very few representatives of the project at the hotels.

2.12 Administrative and Logistic Difficulties

> some people think that a 20 years old son is still a child

The program operated on two levels: one at the IHRPD headquarters and the other at the location of the respites—the hotels.

A MAGEN coordinator was posted at each hotel. She was getting from headquarters lists of people who were due to arrive at the hotel, and was responsible (among other duties) for their reception upon arrival and for allocating them rooms.

The lists arrived (by fax) at the last minute (sometimes concomitantly with the people's arrival at the hotel), were handwritten (not digital), lacked essential details and were unclear or even inaccurate in many cases.

Examples:

- Inconsistency of name order in the lists: sometimes a person's last name was written first (e.g. Cohen Tal), sometimes it came last (e.g. Tal Cohen). This made it difficult for the coordinator to identify at glance all members of the same family.
- Missing essential information relevant for technical requirements, such as: kind of disability and difficulties, is an accessible room needed, is a special toilet-chair needed, etc.
- Composition of the arriving family: this has implications on the room/s that must be allocated. For example, a family with children needs adjacent rooms with a combining door.
- Number of family members: sometimes a disabled person arrived with more family members than allowed (especially children over the age of 18 which was the allowed age).
- …sometimes four people arrived, instead of three; or a 4th adult instead of a child. A [hotel] room can contain no more than 3 adults, so two rooms were needed for this family—but no vacant rooms were available. The hotel was packed with other people (not disabled) who fled from the bombarded area.

All this made it very difficult to prepare for the arrival of people and efficiently allocate them suitable rooms.

Problems were solved by changing allocation of rooms, "like a puzzle", but this required moving people who'd already settled in a room, to another room—sometimes in the middle of the night ("people arrived at all hours, including at night").

Still—as one interviewee said—*"we must remember that the program's headquarters relied on information that was given on phone (by the person requesting help) – and some people think that a 20 years old son is still a child…"*

The project's dedicated staff did their best and even more. "Magen's representatives at the hotel were wonderful, totally gave of themselves…"

They were however too few and too inexperienced in this field.

Illustration:

> People were sitting in the lobby for hours, waiting to get a room. MAGEN 's representatives at the hotel wanted to handle by themselves the reception of the program's arrivals. They both sat together at a small table and all the people were crowded around them. The

> lists they were faxed from the project's headquarters were neither full nor accurate. So they asked for the people's identity cards, completed missing or incorrect details in the list, and then they allocated rooms and gave out the keys. This took a very long time.

Unable to cope efficiently with many of the problems and supply adequate solutions, they were overwhelmed by the flood of problems. At some point "*the project's coordinator telephoned from the hotel that she's falling apart and wanted to leave*". (..but she didn't.)

2.12.1 And There Were the Volunteers

> …ultimately, disasters are characterized by many people trying to do quickly what they do not ordinarily do, in an environment with which they are not familiar" (Chan et al. [2] in SRA [25]).

This is true for professionals, and even more so for non-professional volunteers.

Many people were offering to volunteer during the emergency; and a great need for volunteers who'd assist people with such a vast variety of impairments, did indeed exist in MAGEN. The problem was to match the characteristics of the demand (i.e. people with a vast variety of disabilities) with those of the supply (i.e. the available volunteers). The program lacked the organizational and logistic tools needed for constructing the necessary infrastructure, such as: (a) a data base of volunteers—their abilities, availability (days, hours) and limitations (e.g. a religious woman who wouldn't touch a blind male person); (b) matching it with a data-base of the "clientele"; and (c) properly assigning volunteers to the various roles.

In addition, lack of prior training contributed to emotional overload and burnout, resulted in turnover and dropout of volunteers, and made the project's investment in their instruction fruitless.

3 Discussion

The present research studied a unique enterprise that was different in several aspects from those described in the disaster management literature: (a) The emergency: the program operated not after a disaster created by forces of nature but during an ongoing armed conflict. (b) The *shelter*—PwD were not evacuated to a shelter specially designed for them; neither were they evacuated to a general shelter to be left there to get the services offered to all. The program attempted to cater to their special needs by creating designated "islands" within existing hotels, which were catering simultaneously to "non-disabled" guests too. (c) The *purpose*—the program was not providing evacuation to safety for as long as the crisis existed. It was offering a few days of respite in a safe facility, aimed at mitigating stress for PwD whose homes were along the confrontation line. After that, the PwD had to return to their homes in the bombarded zone.

Still, some of the findings of this case study resemble those of researches based in other emergencies. Clearly, the bombarded communities in the Israeli North were caught unprepared. The collapse of services for—and support networks of—PwD, echoes White et al. [30] findings that damage to CILs' facilities and equipment during the Katrina storms hampered their efforts to respond to people who requested assistance. So are also the findings about the difficulties in meeting the independent living needs of people with a vast diversity of disabilities, including medication and durable medical equipment, accessible housing and transportation, accommodating caregivers and service animals, etc. The finding, that hosting PwD at volunteer families' homes proved to be problematic, is similar to White et al. [30] finding that "… the significant amount of time which persons with disabilities displaced by the disaster stayed with extended families, [resulted in] physical, emotional, and financial stress placed on them and their families." (op.cit.: 12). Other findings of the present research align with Takahashi et al. [26] description of the vulnerability of people with cognitive (here also mental) disabilities when services are disrupted by a major emergency, and their findings about the rejection of these people by "normal" evacuees at the refuge.

In addition, the case-study highlights several issues that have not yet gained ample consideration in the existing literature: (1) some unintended consequences of the application of a participatory approach; (2) challenges of managing and coordinating "occasional" volunteers; and (3) the double jeopardy of disabled people who belong to minority groups.

3.1 Unintended Consequences

Reflecting Wisner's [31] recommended "participatory and inclusive approach" (op.cit.: p. 13) that actively involves disabled people and their organizations in the emergency services, an NGO of- and for- disabled people (IHROPD) was a central participant in the planning of *MAGEN* and became its operating body.

As expected, one of the major strengths of the project was its empathy with the target population. In the survey, many PwD reported that they had been treated well, and that the project's staff had been attentive and understanding. "*When a person telephoned to ask for assistance he was answered by one of his own, not by a commercial company's telephone receptionist*" said one of the interviewees.

The findings, however, also call attention to some **unintended consequences** of this participatory approach.

Firstly, as an advocacy NGO for PwD, the mission of IHROPD was to protect and serve the interests not only of the registered ones but of all people with *every* kind of disability. Prior to the emergency, IHROPD—as an advocacy agent—often fought against the "restricting approaches" of the establishment. In *MAGEN* the establishment was an important member of the planning and leading partnership, represented by a senior officer of the Welfare Ministry. This member opted for prioritization in face of limited resources. IHROPD's all-inclusive ideology made it difficult for them to accept this approach, and—as already mentioned above—their benevolent approach prevailed.

The findings show that one of the unintended consequences of this prevalence was that many of the PwD who asked for help remained not only unassisted but also disappointed, because of the great expectations aroused by this benevolence and the modest ability to fulfill them.

Secondly, as an advocacy agent, IHROPD had no experience in providing actual services to a highly diversified body of PwD that required a vast variety of provisions; let alone experience in doing so in a non-specified context of ordinary hotels while professional as well as financial resources are limited. IHROPD also lacked the comprehensive professional logistic and organizational tools that were vital under these circumstances.

So another unintended consequence was the creation of semi-chaotic, circumstances in the respites.

3.2 Managing and Coordinating Volunteers

Disaster services involve “rapid assignment and temporary deployment of staff who must meet multiple demands and work in marginal conditions and in unfamiliar settings such as shelters, recovery service centers, and mass care facilities” (RSA 2008:20).

When referring to disaster responders, the literature rarely addresses “ordinary”, occasional volunteers specifically. It usually speaks about the professional groups that provide a variety of services to populations affected by disasters:

> … These groups may include emergency managers who provide logistical support for emergency relief operations, individuals who work for state, local, or federal governmental organizations, mass care providers who help with housing and social services (including social workers, disaster mental health professionals, and the Red Cross), public health and medical services providers (including emergency medical services personnel who may be the first to arrive at the scene), and the military [25: 20].

Some research about volunteers in emergencies does exist, mainly about their own vulnerability, stress and trauma. For example, the physical and mental health symptoms suffered by the volunteers deployed in an emergency relief task during the Wenchuan earthquake in China, addressed by Zhang et al. [33]; or the emotional trauma of volunteer interpreters after interpreting in disaster situations (Valero-Garcés 2005, in [25]).

The present study, however, draws attention to the challenges of managing and coordinating occasional volunteers in face of a highly diversified target population of disabled people; and even more so if some of the disabled people belong to a linguistic and/or other minority group.

Consequently policy makers planning for resilience might be advised to establish a “*Reserve System of Volunteers for PwD in Emergency*”[2] that would complement

[2] This is inspired by an idea raised several decades ago by Sever et al. (1975) who suggested to construct “Reserve Groups for Workplaces in war time”.

existing military and civil emergency frameworks by specializing in meeting the divergent needs of PwD. The system should include the construction of an updated data base of volunteers (their abilities, availability—days, hours, limitations etc.) as well as organized training and practice sessions focused on PwD's needs, according to a program developed together with people with *all* types of disabilities.

3.3 The Double Jeopardy

One of the serendipitous findings of this research was that the project seems to have been more successful in providing solutions for PwD who belonged to the (Hebrew speaking) Israeli majority than to those who belonged to the (Arabic speaking) Israeli minority: 66 % percent of the former were given respite in hosting facilities, versus only 16 % of the latter. Furthermore, 42 % of the former versus 28 % of the latter were satisfied with the prompt response of the project; and a similar difference was found in the general satisfaction of the clients from their connections with the project: 45 versus 20 % [19].

These findings suggest that disabled people who belong to a cultural and/or linguistic minority group may be caught in double jeopardy: the existence of language and/or of cultural barriers, in addition to the personal disabilities, might impede proper assistance to these people during and after the emergency—as long as most professional rescuers and assisting volunteers come from the cultural mainstream.

Literature about cultural, linguistic, ethnic and other minorities in disasters does exist. Siddiqui et al. [24], for example, state that groups differing from the majority population by race, culture or language are often more vulnerable in times of disaster, yet are frequently not included in disaster plans and suffer disproportionately from adverse outcomes. Cultural and linguistic barriers, and distrust of government authorities are among the factors that contribute to vulnerability in disaster. They largely hinder the ability of minorities to prevent, protect against, quickly respond to and recover from disasters.

Another example is a comprehensive report addressing the need for cultural competence in disasters, (SRA [25]) which concludes that "*Disaster response poses specific challenges in the provision of culturally competent services to minority populations*" (op.cit.: 20).

The findings of the present research imply that planners for resilience should be aware of the exacerbated challenges that emerge when attempting to provide emergency services for PwD who are also culturally and/or linguistically different from the mainstream population.

This calls for some mutual integration of the special recommendations for adequate provisions for the vast variety of personal disabilities, and those for culturally competent provisions.

For example, efforts to develop culturally competent services should also include acquaintance with and awareness of the special provisions needed for people with personal disabilities.

At the same time, organizations that cater to PwD should also build their cultural and linguistic capacity through expanded workforce diversity, cultural competence training for responders and training of bilingual interpreters. The special guides for the disabled should be available in various languages, tailored for cultural and linguistic appropriateness. Their dissemination should utilize preferred and trusted messengers, as well as multiple channels of communication, such as ethnic media, bilingual community volunteers, and print materials with pictograms, appropriate translations etc.

References

1. Alexander D (2008) Helping disabled people in emergencies. http://emergency-planning.blogspot.com/2008/07/helping-disabled-people-in-emergencies.html. Retrieved 10.5.12
2. Chan TC, Killeen J, Griswold W, Lenert L (2004) Information technology and emergency medical care during disasters. Acad Emerg Med 11(11):1229–1236
3. Fu K, White J, Chan Y, Zhou L, Zhang Q, Lu Q (2010) Enabling the disabled: media use and communication needs of people with disabilities during and after the Sichuan earthquake in China. Int J Emerg Manag 7(1):75–87
4. Fujii K (2012) The Great East Japan earthquake and disabled persons—background to their high mortality rate . DINF—Disability INFormation Resources. The Japanese Society for Rehabilitation of Persons with Disabilities (JSRPD). http://www.dinf.ne.jp/doc/english/index_e.html. Retrieved 11.10.13
6. Iwasaki K (2011) The Great East Japan earthquake and the disabled. The Japan News, Waseda Online. http://www.yomiuri.co.jp/adv/wol/dy/opinion/earthquake_111024.htm. Retrieved 11.9.13
7. Kapucu N (2007) Non-profit response to catastrophic disasters. Disaster Prev Manag 16(4):551–561
8. Kapucu N (2008) Planning for disasters and responding to catastrophes: error of the third type in disaster policy and planning. Int J Publ Policy 3(5/6):313–327
9. Kett M, van Ommeren M (2009) Disability, conflict, and emergencies. Lancet 374(9704):1801–1803. doi:10.1016/S0140-6736(09)62024-9
10. Lewis T (2013) Hurricane Sandy Impacts: how the superstorm changed the public's view of weather threats. Original article on LiveScience.com Posted: 08/12/2013. http://www.huffingtonpost.com/2013/08/12/hurricane-sandy-impacts_n_3743902.html, Aug 2013
11. Masters J (2013) Portlight receives $250,000 grant for Hurricane Sandy relief efforts. http://www.wunderground.com/blog/JeffMasters/hurricane-sandys-name-retired-isaac-snubbed, 11 Apr 2013
12. Neria Y, Galea S, Norris FH (2009) Mental health and disasters. Cambridge university press, Cambridge
13. NFPA (2012) Emergency evacuation planning guide for people with disabilities. www.nfpa.org. Retrieved 10.7.12
15. Phillips C, Estey S, Ennis M (2010) Still invisible: persons with disabilities in post-quake Haiti. Reliefweb, 7.4.2010: http://reliefweb.int/node/350699. Retrieved 10.7.12
16. Rahimi M (1993) An examination of behavior and hazards faced by physically disabled people during the loma prieta earthquake. Nat Hazards 7(1):59–82
17. Reinhardt JD, Li J, Gosney J, Rathore FA, Haig AJ, Marx M, Delisa JA (2011) Disability and health-related rehabilitation in international disaster relief. Global Health Action 4: 7191. doi: 10.3402/gha.v4i0.7191. Published online 2011 Aug 16
19. Sever R (2007) MAGEN project—flexible response for people with disabilities in time of emergency: research report (Hebrew). Jerusalem: JDC Israel, the Unit for Disabilities and Rehabilitation; Israeli Human Rights Organization of People with disabilities; ASHALIM; United Jewish Communities, Apr 2007

20. Sever R (2008) Temporary double essentiality? A case study of an advocacy NGO operating a service during a period of emergency (Hebrew). Paper presented at the 11th spring conference of the Israeli Center for Research of the 3rd Sector, Ben Gurion University, Be'er Sheba: 12.3.2008
22. Sever R (2012) Discriminated against: people with disabilities in emergencies. Paper presented at the 14th Biennial conference of the International Society for Justice Research (ISJR), on 'social justice in a complex reality', at the College of Management, Rishon LeZion, Israel, 9–12 Sept 2012
24. Siddiqui NJ, Purtle JP, Andrulis DP (2011) Ethnicity and minority status effects on preparedness. In: Penuel KB, Statler M (eds) Encyclopedia of disaster relief. Sage Publication, Thousand Oaks
25. SRA International, Inc (2008) Cultural competency in disaster response: a review of current concepts, policies, and practices. Report prepared for the office of minority health. SRA International, Inc, Rockville. https://www.thinkculturalhealth.hhs.gov/pdfs/DisasterPersonneEnvironmentalScan.pdf. Retrieved 17.7.13
26. Takahashi A, Watanabe K, Oshima M, Shimada H, Ozawa A (1997) The effect of the disaster caused by the great Hanshin earthquake on people with intellectual disability. J Intellect Disabil Res 41(2):193–196
27. Tatsuki S (2012) Challenges in counter-disaster measures for people with functional needs in times of disaster following the Great East Japan Earthquake. Int J Japan Sociol 21:12–20. doi:10.1111/j.1475-6781.2012.01158.x
30. White GW, Fox MH, Rooney C, Cahill A (2007) Assessing the impact of Hurricane Katrina on persons with disabilities. Lawrence: The University of Kansas, The Research and Training Center on Independent Living
31. Wisner B (2002) Disability and disaster: victimhood and agency in earthquake risk reduction. Radical interpretations of disaster (RADIX), 28 p. http://www.radixonline.org/resources/disability_and_disaster_wisner.doc
32. Yin R (1994) Case study research: design, methods, 2nd edn. Sage Publication, Thousand Oaks
33. Zhang WQ, Liu C, Sun TS, Zhao J, Han JQ, Yang YH, Li SJ, Ma YQ (2011) Physical and mental health status of soldiers responding to the 2008 Wenchuan earthquake. Aust N Z J Public Health 35(3): 207–211

Disaster Management: Enabling Resilience

The Application of Quality of Life Metrics

Regan Potangaroa, Happy Santosa and Suzanne Wilkinson

Abstract The current "resilience gap" is how it can be enabled in reality from its apparent idealistic grounding? This chapter accepts that a first step should be the establishment of a suitable metric for resilience measurement. It then describes the theoretical construct for using Quality of Life Models and develops one particular model, namely the DASS42. It does this with 7 case studies that cover a decade of work in various post disaster situations. The case studies seek to highlight the operational contexts and issues encountered to reach this "reality" of enabling resilience; and the lessons learnt trying.

Keywords Post disaster reconstruction · Resilience · Quality of Life · DASS42

1 Introduction

The aim of this book is how can we "design and enable resilience in systems and communities" and what are "the underlying fragilities that turn shocks and stresses into crises"? Moreover, how does one "enable resilience to support risk, crises and disaster management"?

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A. Masys (ed.), *Disaster Management: Enabling Resilience*,
Lecture Notes in Social Networks, DOI 10.1007/978-3-319-08819-8_12

This chapter looks at one way to possibly measure resilience as a first step towards perhaps managing it. This issue of metrics seems to be at the core of the resilience discussion. The approach discussed uses a Quality of Life (QoL) Tool but does not set out to validate or justify how they are constructed; which is explained elsewhere [10]. It does however consider how the selected QoL tool was theoretically adapted and its application in the field to address the above aim of the book.

The stumbling block or "problem" experienced in the field (and that sparked the work described in this chapter) was with the provision of interim shelter in a post disaster reconstruction context. It was observed that while people were being supplied with a "house"… what they really wanted was a "home". The difference between the two can be intuitively felt but essentially was the difference between something that only provided protection from the outside elements against something that also allowed the resumption of family life. Programmatically, it was the difference between focusing on the outputs rather than the outcomes. Moreover, any metric tends to move that focus to what is being measured and thereby possibly miss the point. And this is what was happening in the shelter sector where an emphasis was placed on building houses (hence output) rather than ensuring they supported the resumption of family life (and hence an outcome). Therefore the "problem" was how to measure and thereby promote positive "outcomes" for those affected rather than maintain the existing and largely irrelevant measurement of outputs?

What was not realised at the start of this work was that the metric that emerged would link into resilience and provide potential insights into the relationship between individual and community resilience. And that this would lead to a better understanding of how to effectively and efficiently target and support communities. Resilience was seemingly woven into the process as opposed to being a stand alone product.

2 The Resilience Background

The understanding of individual resilience is largely based upon studies of trauma exposed people who subsequently developed symptoms and sought treatment [2]. And it was only later longitudinal studies that pointed to the human capacity for resilience [3]. A community on the other hand has been defined in different ways depending on the perspective of the discipline. It can be a group of people coming together in physical, environmental, economic, relational, political or social ways [17]. A resilient community is able to cope with disturbances or changes and to maintain adaptive behaviour but it's resilience is not the sum of individual resilience as might be expected [23] who commented that "…discussions of community resilience often note that the ''whole is more than the sum of its parts,'' meaning that a collection of resilient individuals does not guarantee a resilient community" but for measuring community resilience they "recommend that community-level adaptation be understood as ''population wellness,'' a high prevalence of wellness in the community, defined as high and non-disparate levels of mental and behavioural health, role functioning, and quality of life in constituent populations."

This wellness and QoL are linked and this is explained by the World Health Organisation when describing their QoL instrument [35] as follows "The Constitution of the World Health Organization (WHO) defines health as "A state of complete physical, mental, and social well-being not merely the absence of disease…". It follows that the measurement of health and the effects of health care must include not only an indication of changes in the frequency and severity of diseases but also an estimation of well being and this can be assessed by measuring the improvement in the quality of life related to health care. Although there are generally satisfactory ways of measuring the frequency and severity of diseases this is not the case in so far as the measurement of well being and quality of life are concerned". And hence why WHO developed their QoL tool. However the point that while wellness maybe the condition, its measurement should be in terms of QoL is both interesting and key to the following discussion.

But how is QoL then linked to resilience… this will be addressed later when we review QoL tools but for now let us assume that such a linkage exists.

One important aspect of a resilient community (sometimes referred to as social resilience) is the capacity for individuals to learn from their experiences and to then incorporate this into their community interactions so that they are able to shape the 'trajectory of change' [13] and play a central role in the degree and type of impact caused by the change [20]. Thus, while individual resilience can influence community resilience; the reverse is apparently not the case.

The current thinking therefore is that building resilience requires an integrated approach and a long term commitment to improving three critical capacities: namely absorptive capacity, adaptive capacity, and transformative capacity [1]. Each of these capacities is not mutually exclusive and apparently exists at individual, household, community, state, and ecosystem levels.

Nonetheless, operational and programming questions about how to do this and what it might entail remain [24]. Resilience is seemingly portrayed on one hand as self evident and common sense; but on the other as conceptually and programmatically elusive". And while a lack of resilience is readily evident in the field… on the other hand when it is there, is not.

For example study and reflect on the two photographs in Fig. 1a. The first is of a portable toilet set up in the Eastern suburbs of Christchurch following the 22 February 2011 earthquake. The resulting liquefaction meant that sewerage pipe networks were inoperative and instead portable toilets were quickly set up by the Civil Defence and Emergency Management team coordinating the disaster response. This was one of hundreds and was set up in a "less than desirable" area and the photograph taken on 12 March 2011, 20 days after earthquake. The second is from a fishing village in Punta (which is near Estancia), on Panay Island in the Philippines and was after Typhoon Haiyan on 8 November 2013 (also referred to as Typhoon Yolanda in the Philippines). It is a mock up village playfully built by children living nearby and was taken on 16 January 2014 some 2 months after the typhoon.

Study these two photographs and try to answer the question whether these two communities are resilient and why? Do not read beyond this paragraph till you have formed your opinion and do not look at the next set of photographs.

Fig. 1 **a** Is resilience evident in these two photographs and why?. **b** Is resilience more evident when it is not there?

Imagine that you are in the field in what was essentially the emergency phase for Christchurch and early recovery in the Philippines (though it felt like an emergency one nonetheless). You have been working in and around the area and happen to come upon these situations. What do you make of them? Once you have formed your opinion, then read on….

Is there resilience in these two communities… well before we answer that have a look at the two same photographs in Fig. 1b. They are the same but this time certain elements have been "digitally" removed. Does this make it "easier"? Hopefully it does… and hence why resilience is often more evident when it is not there rather than when it is. This is one of the field issues of identifying evidence based material on resilience because it can go un-noticed. And yes both seem to suggest aspects of a resilient response.

Thus, picking up the earlier theoretical thread there remain questions about what really does constitute resilience, and whether it should be thought of at an individual, community or societal level? What are it's scales and timeframes, is resilience specific to particular risks or more generic and is it the same for a fast onset natural disaster as a slow or protracted one? All of these were possibly touched on when reflecting on Fig. 1a.

But more importantly, the three critical capacities of absorptive capacity, adaptive capacity, and transformative capacity seem to focus on the systems rather than the individual (or household) and as such resilience is consequently seen as a property of the system or perhaps community rather than the individual. Those in the field question whether this is correct? It was not the "system" or the "community" that placed the pictures and the gnomes outside the portable toilet or playfully constructed a new village in the sand.

3 The Objective of This Chapter

Given this background, the objective of the remaining chapter, in addition to proposing a method of resilience measurement using a QoL instrument as a first step to managing it (as indicated at the start), will also be to show how it can assist in understanding the ambiguities described by Adam Pain and Simon Levine. Such an understanding may go further than just managing it. There will be several operational field case studies from which will be drawn out relevant experiences, lessons and research findings. It will set out to expand the theoretic resilience basis above, discuss the reasons for the selection of the DASS42 QoL model [5], discuss the linkages of it that have been used such as the with the Disaster Life Continuum Model and consequently how the QoL can be used as a resilience metric. It will develop the ideas from the field of the value of linking into existing data sets with an example of the "Talk-to-the-Buildings" Approach which has suggested an interesting convergence of individual and community resilience.

But before we do that we probably need to define how the chapter views resilience. Thus, resilience is considered: "as the capacity of individuals to navigate their way to resources that sustain their well-being and their capacity both individually and collectively to negotiate for these resources" [7] to which is added "in a timely manner".

The definition of resilience has been extensively discussed elsewhere [4]. So rather than repeat that process the above definition has been selected to firstly reflect the 3 identified capacities namely absorptive, adaptive and transformative and secondly the ability of people to learn from the disaster. But more importantly provides for the exploration of linkages between resilience and well being/QoL.

4 QoL Models/Instruments

According to Sharpe there are 38 QoL models [30] that seem to fall into the 3 following categories (adapted from [10]):

- Type 1: The most common, usually says little about the possible components of QoL because they are usually based on semi objective data such as GDP, health statistics, cost of living or employment data.
- Type 2: Break down QoL into a series of components, dimensions or domains, or identify characteristics deemed essential to any evaluation of QoL. Alternatively, they identify a number of dimensions of general QoL, but may not necessarily claim to cover every possible dimension.
- Type 3: Explicitly tailored to meet the objectives of a specific piece of research or sector. May therefore overlook or exclude certain dimensions of QoL considered less relevant to the research aims. Alternatively, may refer only to one or a small number of the dimensions of QoL commonly in the health-related QoL They can also be a "hybrid" of types 1 and 2.

Selected examples from the literature are tabulated in Table 1.

The original work sought to measure the outcomes for beneficiaries of providing housing using a QoL tool. Hence, it seemed that it would be a Type 2, rather than a Type 1 or 3. Two Type 2 models were selected: the WHO QoL tool and the DASS42.

The WHO QoL tool is the most widely known. It has had extensive use in examining the QOL aspects of health related interventions and while it is suitable for architectural and physical engineering and planning interventions its predominant use remains in the health sector [12]. It consists of 100 questions in the standard version (25 questions in a brief version) and is a comprehensive self assessment of the individual's QOL. This is defined as "an individual's perception of his/her position in life in the context of the culture and value systems in which he/she lives, and in relation to his/her goals, expectations, standards and concerns. It is a broad-ranging concept, incorporating in a complex way the person's physical health, psychological state, level of independence, social relationships, and their relationship to salient features of their environment" [34].

The DASS42 was developed at the University of New South Wales, in Sydney Australia [19]. And is a "set of three self-report scales designed to measure the negative emotional states of depression, anxiety and stress" and was "constructed not merely as another set of scales to measure conventionally defined emotional states, but to further the process of defining, understanding, and measuring the ubiquitous and clinically significant emotional states usually described as depression, anxiety and stress" [5]. The characteristics of high scorers on each DASS scale are as follows:

- Depression scale: self-disparaging, dispirited, gloomy, blue, convinced that life has no meaning or value, pessimistic about the future, unable to experience enjoyment or satisfaction, unable to become interested or involved, slow, lacking in initiative.
- Anxiety scale: apprehensive, panicky, trembly, shaky, aware of dryness of the mouth, breathing difficulties, pounding of the heart, sweatiness of the palms, worried about performance and possible loss of control.
- Stress scale: over-aroused, tense, unable to relax, touchy, easily upset, irritable, easily startled, nervy, jumpy, fidgety, and intolerant of interruption or delay.

5 Why Select the DASS42?

The Depression Anxiety Stress Survey DASS42 (consisting of 42 questions) was selected because it has the following advantages over other QoL tools:

- It does not need a before and after survey to draw relative comparisons. This meant that the QoL could be characterized from one survey. On the other hand the WHO QoL tool requires a before and after survey.

Table 1 Selected Examples of available QoL tools/models

	Tool/model	Model example and comments (adapted from Galloway [10] and Foster and Keller [9]
TYPE 1	Life satisfaction and religion by Mookerjee and Beron	Survey done in 60 industrialized and developing nations studying the role of gender and religion on levels of happiness using two sources of information: (1) The World Database of Happiness. (2) QoL measuring tools including the Human Development Index, the Gastil Index of Civil Liberty, the Index of Economic Freedom, the Gini Coeffcient of Income Inequality and the Corruption Perception Index [22]
	Quality of life report, New Zealand	The "Big Cities" group comprises 12 major metropolitan territorial local authorities: Auckland, Rodney, North Shore, Waitakere, Manukau, Tauranga, Hamilton, Wellington, Porirua, Hutt, Christchurch and Dunedin. The group jointly commissions the Quality of Life in New Zealand's Largest Cities Survey which collects comparable information on social, economic and environmental outcomes within each of the urban areas
	Social report New Zealand	Available at http://www.socialreport.msd.govt.nz/Ministry of Social Development provides a lot of information from indicators of social well-being for all New Zealanders. These reports tend to focus on population or universal indicators of well-being
TYPE 2	WHO QoL tool	Available as the 100 item WHOQOL 100 or the shorter 26 WHOQOL BREF questionnaire; intended for the health sector. This is a well known and well used tool that is available in 20 different languages [35]
	DASS42	Questionnaire of either 42 or 21 items. The tool adopted for the work described in this chapter [5]
	Universal quality of life model	Generic Framework. Identifies 4 spheres with 3 dimensions in each. The spheres are Global, External, Interpersonal and Personal Life as a whole combined with relevant life domains [31]
	Life assessment questionnaire (LAQ)	National Wellness Institute, 1983 developed to measure the six wellness dimensions outlined by Hettler [14]
	The Quality of well-being (QWB) scale	Developed by Kaplan and colleagues, differs from other approaches because it defines quality on twenty-four functional states on a scale ranging from 0 for death to 1 for perfect health. The scoring weights were developed based on preferences that individuals assign to the various states [16]

(continued)

Table 1 (continued)

	Tool/model	Model example and comments (adapted from Galloway [10] and Foster and Keller [9]
TYPE 3	MIA	The best known approach specifically for elderly people is the Multi-level Assessment Instrument (MIA), developed by Lawton and colleagues; this is a 152-item battery that generates scores in seven areas: physical health, cognition, activities of daily living, time use, social relations and interactions, personal adjustment, and perceived environment. More recently, Kane and colleagues have been conducting research to develop a self-report measure of the psychosocial aspects of quality of life for nursing home residents: Their eleven domains include comfort, functional competence, autonomy, dignity, individuality, privacy, relationships, meaningful activity, sense of security and safety, enjoyment, and spiritual well-being [18]
	PRECEDE-PROCEED	The model is a tool for designing, implementing, and evaluating health behaviour change programs. It starts with desired outcomes and then works backwards in the causal chain to identify a mix of strategies for achieving those objectives. In this framework, health behavior is regarded as being influenced by both individual and environmental factors, and hence has two distinct parts. First is an "educational diagnosis"—*PRECEDE*, an acronym for Predisposing, Reinforcing and Enabling Constructs in Educational Diagnosis and Evaluation. Second is an "ecological diagnosis"—*PROCEED*, for Policy, Regulatory, and Organizational Constructs in Educational and Environmental Development Designed for the Health sector [11]

- It has been designed for use by non psycho-social professionals and so could be readily used by building professionals. It is readily available from the internet. Access to the WHO tool usually is through an "accredited" centre.
- It deals with the "ubiquitous" situation rather than the clinic situation and hence would apply to the majority of people facing post disaster reconstruction and seeking houses and ultimately homes.
- The questions are phenomena-logically based and are largely trans-cultural. This makes them easier to ask, generally easier to understand and allows direct answers.
- And importantly in disaster situations, does not generate expectations amongst the surveyed population. Any survey work carried out post disaster can carry "unintended expectations". For example, the need to know what percentage of people could build their own houses could be ascertained by simply asking "would you be able to rebuild your own house?" However, the "expectation" is if they are not then someone might help them and so people are encouraged to answer "no" even if they can. Moreover, changing the question to "how would you rebuild your house?" suggests there could be various assistance packages and instead encourages people to say they are worse off than they might be in the expectation they might get something regardless. However, asking respondents to grade from 0 to 3, with 0 meaning "Did not apply to me at all" to 3 meaning "Applied to me very much, or most of the time" a question like "I found myself getting upset by quite trivial things" does not raise any similar expectations.

6 The DASS42 and Its Severity Table

One significant advantage (mentioned above) was not requiring a before and after survey. This is because of what the DASS42 developers call a Severity Table, shown in Table 2 below. This table can directly "characterise" the DASS42 scores [19]. It can also allow 'step" comparisons between different demographics within the database such as age and gender. In addition, it has been suggested that despite the non clinical nature of the DASS42 that those with Extremely Severe might need or should be referred for professional assessment.

Table 2 The DASS42 severity table[a]

	Normal	Mild	Moderate	Severe	Extremely severe
Depression	0–9	10–13	14–20	21–27	28+
Anxiety	0–7	8–9	10–14	15–19	20+
Stress	0–14	15–18	19–25	26–33	34+

aDownloaded from: http://www.swin.edu.au/victims/resources/assessment/affect/dass42.html

7 The DASS42 and the Disaster Life Continuum Model

The three self-report scales provide a useful link into the Disaster Life Continuum disaster model [6]. The most commonly used disaster model is the 4R model which can also come in a 3R and a 5R form [21]. The "R"s represent the different disaster phases such as Reduction, Readiness, Response and Recovery with a sometimes a 5th R for Reconstruction. It is a linear model with one phase linking into the next but is often depicted as a circle linking back on itself or as a spiral suggesting a new reduced vulnerability for future disasters. However, operational staff dealing with affected families find it limiting and almost irrelevant than other models such as the Disaster Life Continuum. Moreover, such a model seems more relevant to an "outcomes" discussion.

In the Disaster Life Continuum Model decisions and planning prior to the disaster are made in the context of the family and the community and society that support the family as shown in Fig. 2a. When the disaster occurs, the community and social context together with the family context is shattered as shown in Fig. 2b. Consequently, those affected experience two general forms of reaction: firstly depression and then anxiety. The model suggests that depression indices will be higher in the immediate aftermath of a disaster due to a preoccupation and fixation of how things were before the disaster. With time, this reduces

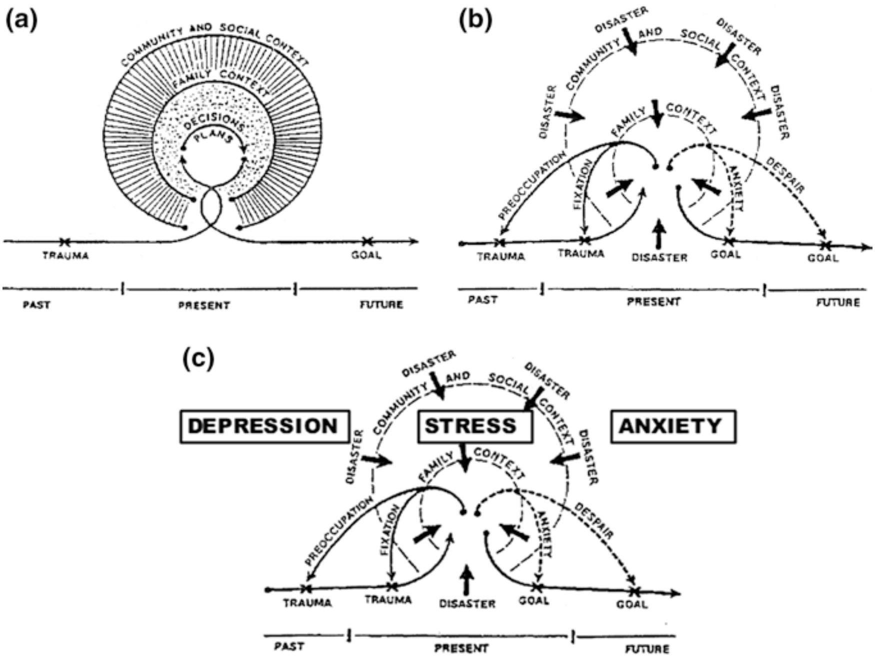

Fig. 2 The Disaster life continuum model and the DASS42 [6]. **a** Before a disaster. **b** After a disaster. **c** The links to the DASS42 self reporting scales

and is replaced increasingly by higher levels of anxiety (and despair) as the focus shifts to the future and getting back to normal such as sorting out somewhere to live, reconnecting with people, finding work and getting children back to school. "Stress" seems to be a contextual measure against which these other changes occur. They are heighted in Fig. 2c. Thus, there seems to be a link between what the DASS42 measures and what is happening in the disaster.

This is crucial for the measurement of outcomes because of the following:

(1) Disasters affect people differently and the measurement of the QoL is able to assess those that are the most vulnerable.
(2) The change over from a high Depression indication to an increasing and ultimately high Anxiety indication is the point at which affected people are seeking longer term solutions such as housing.
(3) The time taken to do that is also the first resilience measure and this is the link between QoL and resilience mentioned earlier [25].
(4) Finally, the time taken to subsequently move from that elevated anxiety level to a "normal" one is a second resilience measure.

What is also interesting is that people would not be expected to be in an "extremely severe" state of anxiety and depression (as defined by the severity Table 2) at the same time. This has been used as a data test of the DASS42 data. From field observations this is usually less than 5 %.

8 DASS42 Translations

The DASS42, as mentioned earlier, is a standard set of 42 questions. When necessary it is translated into other languages and this has been done for Udu, Hindi, Tamil, Bahasa, Mandarin, French, Ceole, Tagalog and Samoan. The translation process follows a standard method of getting one person to translate it into the language and a second to translate it back. An 85 % accuracy is the pass criteria. From experience translations are fairly straight forward except for questions 5, 8, 12, 14, 22, 26, 33 and 38 listed in Table 3. Some are culturally sensitive and for example Sri Lankan women would be reluctant to accept that they could not "get going".

Table 3 Questions in the DASS42 requiring careful cultural translation

DASS42 question numbers	5	I just couldn't seem to get going
	8	I found it difficult to relax
	12	I felt that I was using a lot of nervous energy
	14	I found myself getting impatient when I was delayed in any way.
	22	I found it hard to wind down
	26	I felt down-hearted and blue
	33	I was in a state of nervous tension
	38	I felt that life was meaningless

9 Final Methodology

From experience it has been learnt that:

- The survey takes about 15 min to complete.
- It is best done separately and not as family unit or even as a married couple.
- Where others will be doing the interviewers, usually all of those interviewing will do the first few together to standardize the method and approach by a review immediately after the first shared interviews.
- The tool is robust and does “crash” if one question has been missed. It is also stable and from experience 30 responses per demographic category seems to be sufficient. Beyond that number usually do not change.

Those interviewed are asked to select based on a Likert scale of 0 (Did not apply to me at all) to 3 (Applied to me very much, or most of the time) for their daily life over the past week.

10 Case Studies

The “resilience” gap as noted by Pain and Levine seems to be on the operational side rather than the policy. Hence, seven case studies using the QoL Approach have been included to study issues of “operationisation”. These include the following:

- Banda Aceh, Indonesia in 2005 (Asian Tsunami 2004)
- Manshera, Pakistan in 2005 (The Kashmir Earthquake 2005)
- Sichuan, China in 2008 (The Sichuan or Wenchuan Earthquake 2008).
- Port au Prince, Haiti in 2011 (The Haitian Earthquake 2010)
- The Eastern Suburbs of Christchurch in 2011 (The Christchurch Earthquake 2011)
- Tacloban, Philippines in 2013 (Typhoon Haiyan or Yolanda 2013)
- Informal settlements in Surabaya, Indonesia in 2008 and 2013 (no disaster as such).

They are presented in chronological order for no particular reason nonetheless contrasts and comparisons will be drawn across this order as appropriate and as required. All are from significant disasters or catastrophes except for the last one in Surabaya, and usually were part of an assistance programme with the study addressing some specific Agency issue. Those that weren’t (Sichuan and Surabaya) were part of an existing research programme by a partner University. Interestingly, most were completed without “direct” funding that probably allowed a rapid response sufficient to measure what are time-sensitive transitions.

10.1 Case Study 1: Banda Aceh, Indonesia in 2005 (Asian Tsunami 26 December 2004)

This was the first time that the QoL Approach outlined above was operationally applied and was the most extensive of the case studies presented.

The tsunami disaster was a vision of complete devastation, the death toll exceeded 100,000 caused by a 10–13 m high tsunami sweeping in land by up to 3 km. The most affected area was along the West Coast of Aceh from the provincial capital of Banda Aceh to the 2nd largest town of Meulaboh, a distance of approximately 250 km. There was no warning as it swept away 147 bridges and 80 % of the coastal highway. Typically, only ground floor slabs of buildings were left and in many places even those had been sucked off their foundations. The tsunami had a relatively minor impact south of Meulaboh due to the proximity and orientation of the fault movement that generated it [35].

The United Nations High Commissioner for Refugees UNHCR took on the role of working along this coast as the focus for its planned aid package of 35,000 permanent houses. But it was clear from the outset that there was going to be a lack of “hard” base line data from which to work and moreover, demonstrate that such a package was effective and well spent. Hence, a survey of the West Coast of Aceh was undertaken using two QoL Tools.

The two survey tools selected were the WHO QoL and the DASS42 QoL Tools. And while both were administered only the results from the DASS42 were eventually used.

Surveys were completed at each of UNHCR’s field offices along the West Coast with 100 people interviewed in the towns of Lamno, Calang, Krueng Sabe and Tenoum. In Meulaboh 200 people were surveyed because it was a larger city, thus 600 per QoL Tool. These were completed over the 16 February to 13 March 2005 period, approximately 8–10 weeks after the tsunami.

That was completed by Mapala a local NGO using teams of 5 people that included at least two women team members. This gender balance was to ensure that women would be able to talk candidly, which may not have been possible with a male.

A pilot of the survey was trialed in Banda Aceh and this brought out that many of those completing the survey would not be able to read and that most would converse in Acehanese instead of the national language of Bahasa Indonesia. This meant that the survey had to be translated and that survey team members were relied on for reading out the questions and taking down notes (Fig. 3).

Specific training of team members was undertaken so that there was a level of uniformity of survey process, inquiry and data taking across the 3 separate teams involved. Due to the logistics and the lack of a telephone network at that time, communication would be minimal once they were air lifted into the field. Hence, any issues needed to be identified before leaving. In addition, field living conditions were basic and the work was physically demanding (not forgetting emotionally draining) with each team having to carry in all their equipment together with food and water

Fig. 3 Survey teams interviewing on the west coast of Aceh between 16 February and 13 March 2005

for 5 days. Facilities were also basic in the field offices and there was limited electrical supply from on site generators. Hence, the training was also used to prepare the Jakarta based team members for the "survival" conditions in the field.

The question for the aid community was whether it was too early for a permanent shelter programme? The affected area was still in the emergency phase and moreover no one had experience of going directly to permanent shelter and omitting any interim shelter. Some care was required.

The QoL numbers were individually calculated and aggregated with the results tabulated below. The overall numbers suggested that people had already made the transition from a high depression through to a high anxiety in the 10 weeks since the tsunami and consequently were looking for long term solutions such as permanent housing. All of the local towns recorded a "Severe" rating with Meulaboh recording a slightly lower "Moderate". Moreover, not only were people ready for a permanent housing shelter but that seemed to be the result over the full 250 km of the West Coast. The message seemed definite and clear to proceed with the shelter programne immediately.

Still further, this was 10 weeks after a disaster of unprecedented scale in an area that was a military zone (from which foreigners were stopped from entering) but nonetheless the entire coast was seemingly able to respond in resilient way.

It is interesting to also position this perspective against the planning timetable associated with the 4R model which was the kind of thinking that Aid Agencies on the ground were working against. This suggested that the response phase would be of the order of 3–6 months, the recovery period a further 15 months to 2 years and the rehabilitation (where permanent housing could be expected to start) being 2–2½ years out extending out for 15 years from the date of the disaster. However, these results suggest quite the opposite. This appeared to be the first time that the concerns of any beneficiary group had been quantitatively factored into what had been accepted as a de facto planning standard [32]. There is more that can be developed from this but the need to accelerate the implementation of permanent shelter was now central for the well being of those affected (Table 4).

Table 4 DASS42 overall results

	Towns and villages along the west coast of Aceh						
	Lamno	Calang	Krueng Sabe	Tenoum	Meulaboh 1	Meulaboh 2	Overall
Depression	9.2 Mild	8.2 Normal	9.0 Normal	12.0 Mild	8.8 Normal	10.4 Mild	Normal
Anxiety	15.0 Severe	14.8 Severe	15.2 Severe	17.0 Severe	13.8 Moderate	15.6 Severe	Severe
Stress	14.8 Mild	10.7 Normal	11.4 Normal	16.1 Mild	11.1 Normal	13.5 Normal	Normal

10.1.1 What Is the Impact of Age?

The UNHCR Handbook list "vulnerable people" as those that are sick, mentally incapacitated, the elderly, children and women head of households [33]. And no real differences were expected from that list for the situation in Aceh. However, Table 5 suggests that the QoL impact was possibly felt more by the young than the old. In all areas and for all the DASS42 indicators (except for Tenoum) the "young" (those under 30 years of age) had seemingly lower "wellness" (or QoL) than the "old" (those over 50 years of age). Moreover, the impact gradually decreased moving from the "young" to the "old".

Thus, there seemed to be some further pattern working inside the affected communities. Whether this related to its previous military status or not wasn't clear. Moreover, the usually concerns of livelihood may not have been the case given 10 years of military law prior to the tsunami, it was intriguing. Still further, it was also not clear whether those under 30 years of age had a lower QoL before the tsunami. Nevertheless, there was reason to consider those under 30 years of age as potentially "vulnerable" and ascertain why as part of future community engagement. This would not have otherwise been evident.

10.1.2 What Is the Impact of Gender?

This was significant. There had been discussion amongst the UNHCR team as to whether the tsunami impacted more on females rather than males? This was based on observations and "feeling" but the survey figures quantify this difference. Females were more impacted than men, with females being typically one level higher on the Severity Table. This was the same finding throughout the West Coast. Thus, the wellness/QoL of females was consistently lower. Again it is not known whether this was the case before the disaster but this survey appears to establish that disasters are not "gender free" and quantitatively demonstrate, perhaps for the first time, that the QoL of females are more impacted than males. But it remains debatable whether their resilience, namely "their capacity as individuals

Table 5 DASS42 results for age

	Age (years)	Lamno	Calang	Krueng Sabe	Tenoum	Meulaboh 1	Meulaboh 2	Overall
Depression	Less than 30	9.8 Mild	10.4 Mild	11.3 Mild	11.3 Mild	11.4 Mild	10.5 Mild	Mild
	30–39	9.3 Mild	8.6 Normal	8.8 Normal	12.4 Mild	10.5 Mild	11.2 Mild	Mild
	40–49	9.6 Mild	7.4 Normal	8.5 Normal	12.5 Mild	8.0 Normal	11.3 Mild	Normal
	50+ years	10.7 Mild	7.1 Normal	8.1 Normal	8.8 Normal	8.4 Normal	9.1 Mild	Normal
Anxiety	Less than 30	15.7 Severe	17.2 Severe	18.7 Severe	20.3 X Severe	18.4 Severe	17.9 Severe	Severe
	30–39	16.2 Severe	15.5 Severe	15.4 Severe	17.3 Severe	14.3 Severe	15.7 Severe	Severe
	40–49	13.8 Mod.	13.7 Mod.	13.8 Mod.	16.4 Severe	16.0 Severe	14.6 Severe	Mod.
	50+ years	20.8 X Severe	13.4 Mod.	13.9 Mod.	12.4 Mod.	12.6 Mod.	16.4 Severe	Mod.
Stress	Less than 30	16.0 Mild	12.4 Normal	13.9 Normal	18.4 Mod.	14.4 Normal	14.9 Normal	Normal
	30–39	16.3 Mild	10.9 Normal	11.1 Normal	16.0 Mild	11.9 Normal	13.9 Normal	Normal
	40–49	14.2 Normal	9.8 Normal	10.5 Normal	16.4 Mild	11.7 Normal	14.3 Normal	Normal
	50+ years	13.0 Normal	10.3 Normal	11.4 Normal	10.9 Normal	10.7 Normal	12.6 Normal	Normal

to navigate their way to resources that sustain their well being" is any less? This perhaps needs to be kept in mind for later case studies.

Overall, it seems significant that these patterns were the same at all the locations surveyed along the West Coast. And again perhaps this needs to be kept in mind for later case studies (Table 6).

10.1.3 What Did This Mean for the Housing Program?

The QoL survey painted a more conclusive picture of what needed to be done, filled in several of the details, expanded the "sense making" of the team's present and previous disaster experience than what would have been otherwise possible or that could be taken from the UNHCR Emergency Handbook. It indicated the following:

- The need for shelter was critical and moreover the need was for permanent shelter options so that people started to address the issues of an unknown future.
- This need was immediate and should not be held over.
- The shelter program should target "expected" vulnerable groups but also ascertain the apparent new vulnerabilities of those under 30 years of age and also understand how the resilience mechanism of females allows them to better navigate to resources that sustain their well being.

Hence, the QoL Approach seemed to have operational value, did enable and allowed for the design and enhancement of resilience within the shelter response in Banda Aceh following the 2004 Asian Tsunami. The condition of the affected

Table 6 DASS42 results for gender

		Lamno	Calang	Krueng Sabe	Tenoum	Meulab. 1	Meulab. 2	Overall
Female	Depression	9.2 mild	10.8 mild	10.3 mild	14.1 mod.	12.3 mild	12.8 mild	Mild
	Anxiety	16.1 severe	17.9 severe	18.2 severe	21.7 X severe	18.8 severe	17.7 severe	Severe
	Stress	16.5 mild	13.2 normal	13.6 normal	19.3 mod.	15.3 mild	15.4 mild	Mild
Male	Depression	9.1 mild	5.7 normal	7.8 normal	9.3 mild	7.0 normal	6.6 normal	Normal
	Anxiety	12.9 mod.	12.0 mod.	12.4 mod.	11.1 mod.	11.2 mod.	12.8 mod.	Mod.
	Stress	12.2 normal	8.2 normal	9.4 normal	12.1 normal	8.8 normal	10.9 normal	Normal

community before the disaster was not clear, which will probably be the situation for most disaster responses. However, that should lessen as it moves into the Recovery and Reconstruction Phases. Finally, the scale of this survey and the comparative results across the West Coast should be noted. The following case studies will be more localised and possibly levering from but extending the findings from this case study on the role of a QoL Approach.

10.2 Case Study 2: Manshera, Pakistan in 2005 (The Kashmir Earthquake 8 October 2005)

This case study is from a displaced rural situation in a camp setting in Pakistan following the Kashmir Earthquake. Banda Siah Khan Camp was just outside Havelian and 13 km south of Abbottabad.

The earthquake resulted in around 75,000 deaths and displaced an estimated 3.5 million people. Approximately 1,000 of them were in Banda Siah Khan Camp which had a planned capacity of between 12,000 and 20,000 people. The objective of this UNHCR study was to better understand the needs of those in the camp and thereby advise the Civil Authorities who had set it up on what they needed to review relative to camp management and site planning. Part of that study included a QoL assessment which was carried out by a team of local post graduate students organised by Ms Sonia Shamrose from the Civil Authority. It was completed on 10–11 November 2005 approximately 4–5 weeks after the disaster (Fig. 4).

The immediate findings were the higher Anxiety and lower Depression levels suggesting that those affected were seriously considering what the future may hold. This seems to align with the camp's "reputation" of being essentially a staging area for people moving from the affected largely rural area to urban areas such as Karachi or Lahore (Table 7).

The effects of the earthquake had more impact on the QoL of females than males, which the Civil Authorities would need to be mindful about so that

Fig. 4 Banda Siah Khan Camp, South of Abbottabad, Pakistan

Table 7 DASS42 overall results

DASS42 factor	Survey result	
Depression	19.3	Moderate
Anxiety	18.7	Severe
Stress	23.3	Moderate

Table 8 DASS42 results for gender

Females			Males		
		Severity			Severity
Depression	20.4	Severe	Depression	18.5	Moderate
Anxiety	19.6	X Severe	Anxiety	18.1	Severe
Stress	25.4	Severe	Stress	21.6	Moderate

Table 9 DASS42 results for age

Years	Depress.	Severity	Anxiety	Severity	Stress	Severity
Less than 25	22.1	Severe	21.6	X Severe	24.4	Mod.
26–35	16.8	Mod.	17.2	Severe	21.7	Mod.
36–45	19.7	Mod.	18.2	Severe	24.9	Mod.
46+	18.9	Mod.	17.6	Severe	22.2	Mod.

appropriate planning can be implemented. It was not possible to suggest any specific recommendations other than to highlight the difference and the usual aspects around sanitation, latrines, water source points, washing areas and family care. It would be beneficial to check whether the camp actually was being used as a staging area as the move from the mountains to these urban centres would not be straightforward. And instead of investing heavily in the camp infrastructure alone, urban based reception areas may have more value (Table 8).

Age is not as critical as gender but there could be issues for those under 25 years of age. Again, it would be difficult to pin point specific actions given that a "Severe" Anxiety rating covers all age grouping outside those under 25 years. Nevertheless, the future issues could be expected to be around employment, housing, moving from the "country to the city" or just surviving. This needs to be discussed with the camp committee groups. Clearly, this time is one of great change for these affected families that seems to go beyond any seismic impacts (Table 9).

While this case study is "brief", it has been retained to demonstrate a degree of diversity in the application of the QoL Approach. Additional value could have been gained if there had been other data on the camp population. Nonetheless, the QoL Approach did seem to assist in "navigating their way towards to resources that sustain their well being" and hence to enabling resilience.

10.3 Case Study 3: Sichuan, China in 2008 (The Sichuan or Wenchuan Earthquake 12 May 2008).

This was the first time that foreigners were allowed into a disaster in China. The Sichuan Earthquake caused 69,197 deaths and made approximately 4.8 million people homeless.

The camps in an around Mianzhu were selected for this survey as they were close to Chengdu, were accessible by bus, they were large and there appeared to be open access both to and inside the various camps. But perhaps most importantly, those affected seemed comfortable talking with members of the survey team. There was apprehension about talking to foreigners which was understandable and sensitivity by Government Officials not only because this was the first time that foreigners were allowed in but also because of the Olympic Games due to start in August that year. Moreover, overseas media reports were not positive about the earthquake response. This was not backed up by the survey data, interviews with those affected, disaster officials, fellow academics and what was observed in the field. The speed and the scale of the Chinese response made it one of the best if not the best response measured since 2005.

A team of 5 volunteers from Nanjing University who were already on site completed 138 surveys from 8–11 July 2008 (8 weeks after the disaster) supervised by Alice Chang, who was one of our Ph.D students at that time. These were at the location around the Mianzhu City Stadium Resettlement Camp. These people were from the 4 townships of Qingping, Hanwang, Tianchi and Jiannan (Fig. 5).

The results from those surveys showed the following:

- Overall: Those surveyed have moved on from the disaster are looking to their future. Note that after only 8 weeks, DASS42 Depression indicators are normal which was astonishingly fast as can be seen in later comparisons.
- Gender: The QoL of females were again seemingly more affected by the disaster than males.
- Age: There appears to be a spike in the data for those in the 40–49 years old. That aside, the elevated levels for anxiety are across all the age groups which adds weight to the "overall" conclusion above. It seems that people have "settled in" to solving the issues from the disaster (Table 10).

Fig. 5 Surveying people staying in the camps around Mianzhu

Table 10 DASS42 overall results

DASS42 Factor	Survey result	
Depression	8.2	Normal
Anxiety	9.4	Moderate
Stress	11.1	Normal

Table 11 (A) A China 8 weeks after the May 12 2008 earthquake (DASS42 results), (B) China 8 weeks after the May 12 2008 earthquake (severity table)

(A)							
		Gender		Age (years)			
	Overall	Female	Male	>30	30–39	40–49	50+
D	8.2	11.5	5.2	8.6	10.6	12.9	11.9
A	9.4	13.6	5.7	12.7	11.0	14.3	11.5
S	11.1	15.2	7.3	13.5	13.6	15.2	15.4
(B)							
D	Normal	Mild	Normal	Normal	Mild	Mild	Mild
A	Mod.	Mod.	Normal	Mod.	Mod.	Severe	Mod.
S	Normal	Mild	Normal	Normal	Normal	Mild	Mild

D = depression, *A* = Anxiety, *S* = Stress

Thus, based on these results it seems that the disaster was handled well and moreover because those surveyed seem typical of other neighbouring camps where access was not so readily available, that it maybe representative of the people in Mianzhu… and perhaps beyond (Table 11).

How "well" can also be seen when the results for the Sichuan Earthquake are compared to other disasters. Firstly, the Sichuan outcomes are better than those in Aceh Indonesia (after the 2004 SE Asian Tsunami) and Pakistan (for those affected by the October 8, 2005 Kashmir Earthquake). Both of these instances were surveyed at a similar time after the disaster and were in a similar disaster situation (people displaced from their homes and living in a temporary camp situation). Moreover, the Sichuan outcomes while being higher than those for Tamil Nadu and Sri Lanka, which were taken 234 and 238 weeks respectively after the disaster, were surprisingly lower than those for the Andaman Nicobar Islands ANI (235 weeks after their disaster) (Table 12).

Thus, the conclusion seems to be that the people in Mianzhu are highly resilient. Why that is and what are the qualities that one group possess that will help them "navigate their way to resources that sustain their well being and their capacity both individually and collectively to negotiate for these resources; in a timely manner?

The Partnering Approach and the speed at which interim housing was achieved have been suggested as two "resources". And while it was conceivably possible for the Government to impose price controls this did not seem to happen during the 4 field trips made by one of the authors and several others made by Ph.D students

Table 12 Aceh 9–10 weeks after the 26 Dec 2004 tsunami/earthquake

		Gender		Age (years)			
	Overall	Female	Male	>30	30–39	40–49	50+
D	9.6	11.6	7.5	10.7	10.2	9.6	8.4
A	15.2	18.3	12.0	17.8	15.8	14.7	14.3
S	13.0	15.7	10.1	15.0	13.5	12.9	11.3
Pakistan 4–5 weeks after the Oct 8 2005 earthquake							
D	19.3	20.4	18.5	22.1	16.8	19.7	18.9
A	18.7	19.6	18.1	21.6	17.2	18.2	17.6
S	23.3	25.4	21.6	24.4	21.7	24.9	22.2
Tamil Nadu, India 234 weeks after the Dec 26 2004 tsunami/earthquake							
D	9.4	20.4	18.5				
A	9.2	19.6	18.1				
S	9.2	25.4	21.6				
ANI, India 235 weeks after the Dec 26 2004 Tsunami/Earthquake							
D	13.1	12.4	14.8	11.5	12.6	10.2	18.9
A	10.0	10.3	9.4	12.4	7.9	7.7	12.3
S	16.3	16.0	16.9	14.6	17.5	12.0	19.9
Sri Lanka 238 weeks after the Dec 26 2004 tsunami/earthquake							
D	8.0	8.4	7.5	5.4	7.0	8.1	11.4
A	7.5	7.7	7.3	6.4	6.4	5.7	13.0
S	7.4	7.5	7.3	6.4	4.2	6.8	12.6

studying aspects outside their resilient response. Moreover, the use of loans and other seemingly market instruments to manage the response perhaps suggested a sophistication beyond simply government structures [26].

But what the QoL Approach was able to do was to identify where a "comparative" resilient response occurred and having done that looked at some of the specific reasons why that occurred. This would seem to be the first step towards enabling resilience and operationalising a resilient capacity into assistance programmes. Finally, it did seem that the Chinese Government received some unfair criticism of their overall earthquake response following the Sichuan Earthquake. And while the survey was limited it did seem typical and consistent with what was found elsewhere.

10.4 Case Study 4: Port au Prince, Haiti in 2011 (The Haitian Earthquake 12 January 2010)

This was a displaced urban camp context in contrast to the earlier rural one.

The Haiti Earthquake happened just as night fell. The death toll was of the order of 220,000 though numbers remain sketchy. The extensive building damage meant that people lived nearby in tents and over time camps emerged throughout the capital city of Port au Prince.

The International Federation of the Red Cross Red Crescent Societies (IFRC) was responsible for one part of Caradeux Camp. That included planning for the constructing of interim shelter so that people could return home. That required understanding how people went about getting something built prior to the earthquake and as part of that study a QoL component was included to understand what selection protocol could/should be used.

In all 108 surveys were collected over the week of 20–24 September 2010, just over 36 weeks after the disaster.

As with previous results those surveyed had made the transition from to an elevated Anxiety and lowered Depression situation. One would probably expect this after 36 weeks but the results did support in principle the proposed interim shelter that was being planned. That was beneficial for IFRC (Table 13).

Further analysis suggested that the QoL of females were more affected by the earthquake than males. By now this was expected; and females were typical at least one Severity Table level higher than males as had been the case in Indonesia (12 locations), India (6 locations), Sri Lanka (3 locations) and in Pakistan (6 locations). Samoa (4 locations) was the only post disaster survey where the QoL of males were more affected than females; but after 9 months that difference had all but disappeared (Table 14).

In terms of age it is evident that those over 50 years of age had significantly affected QoL's than other age groups. They were typically one severity level above others and hence this group needed a particular focus to understand what was happening in the camp in addition to prioritization of the interim shelter (Table 15).

What did this mean for the interim shelter programme? The results suggest the following considerations:

(1) Priority should be given to female head of households and to households with family members 50 years or over. The 50 years is not a definitive age and perhaps those in the 45 years and above should be included.

Table 13 DASS42 overall results

DASS42 factor	Survey result	
Depression	14.6	Moderate
Anxiety	15.6	Severe
Stress	14.5	Mild

Table 14 DASS42 results for gender

	Females (61)	Males (29)
Depression	15.7 moderate	12.6 mild
Anxiety	16.3 severe	14.0 moderate
Stress	14.9 mild	13.6 normal

Table 15 DASS42 results for age

Age (in years)	Number	Depression	Anxiety	Stress
Less than 30	47	11.0 mild	11.9 moderate	11.2 normal
30–39	22	9.5 normal	10.1 moderate	9.3 normal
40–49	13	10.3 mild	11.5 moderate	10.7 normal
50+	8	17.6 moderate	18.0 severe	17.3 mild
Total =	90			

(2) It would appear that those affected are focused on the future and consequently the shelter programme would need to demonstrate how it addressed "future" issues. It may need to show how it was "enabling" by say facilitating work from home and "adaptive" in terms of subsequent changes to achieve a better family fit rather than a "one-size-fits-all" and in the long term "sustainable" in terms of say material selection. All of these would seem to enable resilience.
(3) Training is becoming another possibility with local providers available to link into existing professional level 1, 2 or 3 qualifications. This would provide a qualification that could further address this overall "Anxiety" issue; additionally if this were possible for females.
(4) Measure the impact on females (rather than males) as an effectiveness indicator. And possibly link QoL metrics into the programme's Logframe considerations for monitoring and evaluation.

10.5 Case Study 5: The Eastern Suburbs of Christchurch, New Zealand in 2011 (the Christchurch Earthquake 22 February 2011)

This was a specific operational application of the QoL Approach. The Christchurch Earthquake caused 185 deaths and caused damage totaling around $NZD15 billion.

The CCWC Church in Aranui (one of the poorer Eastern suburbs of Christchurch) had set up a Food Bank run out of their Church. But now other local agencies who had established Food Banks prior to the earthquake were suggesting that it might be time to close it. And the question they had was whether that was correct.

The response/emergency phase of the earthquake was seemingly finishing and programmes such as theirs were wondering what they should do to assist their community as they moved into this recovery phase. It was confusing even for a locally based Church and its parish.

Consequently, a QoL Approach was used to survey those using the Food Bank and this was completed around the 6 May 2011, approximately 6 weeks after the disaster. In all 57 surveys were completed and while a larger number was planned the sense at the time and the practicalities of surveying 100 households was to use what was readily obtainable.

The results followed the pattern of previous case studies with an elevated Anxiety (Table 16).

The analysis continued to follow a pattern with the QoL of females being more impacted than for males but from there was quite different (Table 17).

The age data suggested the QoL of those in the 40–49 years old had been significantly impacted and moreover, this age bracket may have been "carrying" the load of the disaster for households in and around Aranui (Table 18).

Moreover, review of individual surveys showed that there were extreme levels of both anxiety and depression for approximately 25 % of people. As discussed earlier it would not be plausible to be simultaneously extremely preoccupied with the past while extreme concerned about the future. Previous surveys such as in Samoa had picked up similar but smaller instances but that was 2 weeks after their tsunami and not 9–10 weeks as this case. The field sheets were reviewed and they appear to be thoughtful and not rushed which suggested two things. Firstly, that many families are still in emergency mode and perhaps that families-on-the-edge may have actually gone over it. The Church needed to check their community to see if that was happening but was unseen. And secondly, there was probably a need for professional counselors to be attached to the Food Bank. This is

Table 16 DASS42 overall results

DASS42 factor	Survey result	
Depression	15.3	Moderate
Anxiety	14.7	Severe
Stress	20.2	Moderate

Table 17 DASS42 results for gender

	Females	Men
Depression	16.8 moderate	14.4 moderate
Anxiety	16.3 severe	13.4 moderate
Stress	22.6 moderate	19.6 moderate

Table 18 DASS42 results for age

Years	Depression	Anxiety	Stress
Less than 30	11.6 mild	11.3 mild	15.5 mild
30–39	16.3 moderate	13.5 moderate	23.1 moderate
40–49	21.3 severe	22.7 X severe	26.4 severe
50+	16.5 moderate	15.8 severe	20.9 moderate

particularly worrying and should be a concern to other social agencies working in the area of Aranui and also the Eastern suburbs. The concern being whether these "acute" short term conditions would then become "chronic" longer term ones.

Other questions asking respondents to rank issues were included. The priority issues for those with a high Anxiety scale were 1st family, 2nd food, 3rd equal housing and health and 4th employment. (It is perhaps not so surprising that food is ranked number 2 given that the people surveyed were from a Food Bank).

Thus, the most effective future use of resources for the Church to consider should follow a similar ranking. As a rule-of thumb humanitarian aid programmes try to address at least 3 of these issues simultaneously to be seen as effective as assistance in one area invariably flows into the others; invariably issues are connected. Hence, the way forward can be found by talking to women in the 40–49 age group and asking them about family, food, housing, health and employment and then noting the specific and common factors from those discussions/interviews. In addition, assistance and monitoring should be skewed towards women and in particular those in the 40–49 years age bracket.

Hence, should the Church curtail the food programme based on the changed disaster response status from Response to a Recovery Phase? The answer would have to be a definite "No". Aranui and its neighbouring Eastern Suburbs seem unaffected by this changeover and for them it was still an "emergency". And while there were existing Food Banks before the disaster the present scale and demand seems to have over loaded existing services; and one is left wondering why the suggestion for the Church to close down there one was made in the first place? To put the Eastern Suburb situation into some context, the measured QoL was lowered than camps of displaced people in Port au Prince, Haiti (one of the poorest countries in the Western Hemisphere), and displaced rural-mountain people in Pakistan. Moreover, this was in a "developed" economy with a Civil Defence Emergency Management Act that was apparently a world leader. Nevertheless, the clear goal of a disaster response must be "not to leave anyone behind".

So how was resilience enabled in this context of apparent systemic "failure" in the Eastern Suburbs? Measuring it did suggest a resilient way forward for the Church and their Food Bank. It produced a ranking list based on those with the elevated Anxiety about what the future held for them and their families (as indicated by the ranking). And was able to point the way so that "individuals could navigate to resources that sustain their well-being and their capacity both individually and collectively to negotiate for these resources". However, it should be noted that resilience was not a stand-alone, but a woven part of the process. This seems to be important in the operationalisation of resilience.

10.6 Case Study 6: Tacloban, Philippines in 2013 (Typhoon Haiyan 8 November 2013)

This was another specific operational application of the QoL Approach that underlines how it can be applied in the field and how that may "enable" resilience.

Typhoon Haiyan (locally called Yolanda) caused over 5,000 deaths and made 3.5–4 million people homeless. The city of Tacloban on the Island of Leyte became the unofficial "ground zero" for the typhoon and was where many Aid Agencies concentrated their assistance.

As that Response Phase developed, coordinated by the Emergency Shelter Cluster, they reported adequate coverage of shelter materials (such as tents and tarpaulins) in some areas but that significant gaps still existed. And the question rose whether it was the right time to ramp up the shelter materials provided by including "corrugate galvanised iron" (CGI) roofing. This was moving the Response into the Early Recovery Phase but given the gaps that still remained was it appropriate? For example, were those affected ready for more permanent shelter that CGI would require? And while the risk of supplying tents and tarpaulins was low if they were poorly constructed or if there was another storm that was not the case for CGI. There needed to be training that would go with its distribution. Certainly those affected were asking for CGI and were recycling damaged sheets where ever possible. For them CGI was the obvious next step. Another concern for Aid Agencies was its cost, the impacts of supplying it on the local markets and whether it would be more appropriate to put in place a cash or voucher system. Such a system provides cash or vouchers to affected families and they then procure it through the local markets. And if all of that was not enough the guidelines on the thickness and nailing of CGI sheets put out by the Emergency Shelter Cluster were both confused and questionable. For example, the stipulated minimum roofing thickness by the IFRC in Geneva (who lead the Emergency Shelter Cluster for "natural" disasters) is 26 gauge or 0.46 mm thickness [15]. That was mis-understood by the Emergency Shelter Cluster in the Philippines as 26 gauge but as an American Wire Gauge size (and not British Wire Gauge) which is 0.40 mm. However, neither size was readily available in the Philippines that made inclusion of CGI logistically problematic. Moreover, the basis for the thickness was questioned as it was largely based on overseas structural codes that stipulate that roofing needs to be able to carry a 1 kN load person load (or 100 kg or 16 stone). Otherwise the thickness according to the Philippine Code under typhoon loads would be 0.30 mm; which was readily available in the Philippines. Thus, the decision on whether to supply CGI was complicated but the first question was whether it was appropriate regardless?

The QoL Approach was applied by a local NGO working for an INGO in Manaybanay, Pastrana, Leyte on 12 December 2013, just over 4 weeks after the disaster. The NGO/INGO were already active in this community and the plan was to roll out any CGI shelter programme through this and other locations in Leyte.

But was it the appropriate time to distribute CGI? Should one listen to the feedback from those affected or would overcoming the organizational inertia prevent that? Moreover, was it premature to introduce CGI given the number of planning issues that seemed unresolved? In addition, there was a need for "due diligence" by the INGO. The opportunity was also taken to check the vulnerability criteria being discussed, firstly to see if they were correct, and secondly to check whether any had perhaps been missed. The aim was to use those criteria for any prioritization of assistance including shelter.

Altogether, 121 DASS42 surveys were completed. These suggest that even by the 12 December just over 4 weeks since the disaster distribution of CGI would have been more than appropriate and as was evidenced in the field was desperately required, regardless of the organizational constraints. This was seemingly a resilient response, but there was also a cautionary note that engagement with affected communities needed to support that capability, but exactly how? (Table 19).

The analysis of the DASS42 survey further suggested that the QoL of women were more affected than men, as in previous case studies (Table 20).

Interestingly the "pain" of loss of QoL appears to be spread across age groupings for all 3 DASS42 factors. This has not always been the case and it could be the 4 week period since the disaster and that with time this may change. But at the moment it appears spread through the affected community (Table 21).

The data was then split into two groups and those with a lower QoL re-analysed against those with a "higher" QoL. The lower QoL cut off point was those with a "Severe" or higher rating for the Anxiety scale. The sensitivity of this cut off was checked. The objective of this split was to verify the 5 vulnerability grouping that were used by the local NGO that were as follows:

- Number of Household members (HH).
- Number of children under 5 years of age.
- Female head of Household (FHH)

Table 19 DASS42 overall results

DASS42 factor	Survey result	
Depression	18.4	Moderate
Anxiety	20.7	X severe
Stress	21.0	Moderate

Table 20 DASS42 results for gender

	Women	Men
Depression	18.4 moderate	13.8 moderate
Anxiety	21.3 X severe	14.8 severe
Stress	21.6 moderate	14.9 mild

Table 21 DASS42 results for age

Years	Depression	Anxiety	Stress
Less than 30	18.3 moderate	21.4 X severe	21.4 moderate
30–39	17.1 moderate	18.3 X severe	20.3 moderate
40–49	18.1 moderate	19.9 X severe	20.3 moderate
50+	19.7 moderate	22.6 X severe	21.9 moderate

- People with disabilities (PWD)
- Elderly
- Pregnant and Lactating Mother (PLM)

They are commonly used vulnerability criteria but the lack of an income one did seem to be a gap. It is common for multiple families to be part of an extended family or household in the typhoon affected area. The 5 vulnerability data were already known to the NGO and hence were simply linked to the QoL Approach to produce an extended DASS42 Spreadsheet.

The criteria were then ranked based on the averaged Anxiety figures for those with a "Lowered" QoL. That was then compared to the same ranking for the "Non Lowered" QoL which should be the "opposite", all things being equal. This is a useful technique (Table 22).

PWD was the key criteria for determining QoL but this should be tempered by there being only 2 cases within the "Lowered QoL" data above. Certainly, being disabled was problematic before the typhoon and certainly would not have improved after it. Hence this should be reviewed once more data was available beyond the 121 surveys for this study.

Table 22 Ranking of vulnerability criteria and suggested weighting factors

NGO criteria	Number	"Lowered" ranking	"Non lowered" ranking	Calculated weighting factor	Suggested weighting factors
No. of HH members	84	5	1	2.4	2.4[a]
No. of children under 5 years of Age	54	2	2	2.6	2.6[b]
FHH Female head of Household	27	4	3	2.5	2.5
PWD People with disabilities[c]	2	1	4	3.2	2.0[c]
Elderly[c]	15	3	5	2.3	2.3[c]
PLW Pregnant and Lactating Mother	11	6	6	2.1	2.1
Income	Not included in the NGO's Criteria.				2.0[d]

[a]Pro rata basis for family sizes from 1 to 5 and then 2.4 for family sizes 6 and above
[b]1.3 for 1 child under 5 and the 2.6 for 2 and above
[c]The same definitions of disabilities and elderly were used for this analyse as defined by the local NGO and used in their database
[d]Suggested value at this stage with a sliding scale based on an agreed definitions of both a "minimum" income point and a poverty income point. Perhaps 200 and 100 pesos/person/day so that there would be a sliding scale from 200 to 100 pesos from 1 to 2 and then 2 for values below 100 pesos/person/day. This figure should be reviewed once data is at hand as it could be as high as 3

The next important criteria was the “Number of Children under 5 years of Age” followed by the “Elderly” which was defined as being over 65 years of age. FHH ranked 4th which intuitively seems low and finally the Number of House Hold Members. Interestingly this is rank 1st for the Non-Lowered QoL which seems to be correct.

But what happens when there is more than one of these criteria in a Household? To assist with this situation with a view to a rapid setting up of a “targeting” spreadsheet, the analysis went one step further and derived weighting factors. These were based on dividing the Anxiety factors for Lowered and Non Lowered and are listed in “Calculated Weighting Factors”. The PWD factor was arbitrarily amended to produce the suggested factors and ranges given in “Suggested Weighting Factors”. The importance of these is that they could be automatically incorporated into the NGO’s existing data bases and consequent prioritization of affected households readily derived.

The DASS42 data and spreadsheet above is set up so that it does not include family names or addresses. This was deliberate done for privacy of the family data and information. However, that being said the survey analysis suggests a level of concern beyond a characterization by the DASS42 Severity Table and it was suggested that follow up should be done with the following Households:

1st Households 28, 42, 69,103
2nd Households 35, 55,102
3rd Households 38, 70, 6, 94, 98 and 101.

The key message from this QoL survey was that communities despite the apparent end of the Emergency Phase remain in deep Anxiety and probably “pain”. The survey strongly supported the field observations to supply CGI immediately. And as a result a “CGI for Christmas” initiative was put in place to resolve those organizational and planning barriers.

The enabling of resilience from this case study is evident at several levels. At an organisational level it was the setting up priority criteria, the verification of vulnerability criteria and the push to deliver CGI. At an individual level it was an early and rapid adoption of a resilient mind set. But again, resilience is not a standalone quality but one that is woven into the situation.

It was gratifying to see the extent that the QoL Approach can be grafted into other data and in particular the technique of splitting data between a Lowered and a Non Lowered QoL. This seemingly simple method opened up information that was not otherwise accessible.

10.7 Case Study 7: Informal Settlement in Surabaya, Indonesia in 2008 and 2013 no Disaster as Such

The previous case study looked at the grafting of the QoL Approach to other data and splitting it between Lowered and Non Lowered QoL. This case study uses a similar split but with a “coupling” of two tools namely the DASS42 and the Talk-to-the-Buildings Approach [28]. The case study is of 85 households in Kampong Tunjungan, an informal settlement located in the CBD of Surabaya, Indonesia. It does not involve a post disaster context as previous case studies. The results suggest the existence of a resilience "tipping" point between individual and community resilience. This is still preliminary but the possibility of a tipping point, its operational possibilities and its relevance to the resilience discussion was intriguing. Despite that, the methodology used and its potential to "enable resilience" seems to be justification.

The Talk-to-the-Buildings Approach essentially maps spatial patterns within houses. These Patterns are tabulated in the table below and Russell et al. documents an example of its use in Tamil Nadu, India [8, 29] (Table 23).

This approach has several advantages as follows:

- Buildings don't by necessity tell "lies".
- Such tools could be trans-cultural and therefore usable in other geographic areas.
- There is no direct need for language translators in the field.
- It has a certain appeal and seems reasonable to those in the "architectural stream".
- It fills a gap and allows validation and potential triangulation of research findings
- It enhances discussion within the teams.
- Can rapidly produce base conclusions for critical reflection.

Table 23 The 10 essential patterns that form the talk-to-the-buildings approach

Pattern	Definition
1. Inhabiting the site	If the form of the house doesn't begin by responding to the site, house and site may well end up in conflict with each other
2. Creating rooms, outside and in	a lively balance of indoor and outdoor rooms
3. Places in between	Places that allow you to inhabit the edge, that offer enough exposure to make you aware of your surroundings, and that provide just enough protection to make that awareness comfortable
4. Refuge and outlook	At its simplest we are inside looking out
5. Private edges, common core	A good home balances private and communal space throughout
6. The flow through rooms	Movement through a room affects the room itself
7. Composing with materials	Choosing its materials – to support, frame, fill, cover, colour and texture space – is the act of composing the home
8. Sheltering roof	More than any other single element, the form of the roof – as experienced both outside and in – carries the look and meaning of shelter, of home
9. Parts in proportion	A home is a hierarchy of parts in proportion
10. Capturing light	Good homes capture light – filter it, reflect it – in ways that, no matter the season or time of day, delight their inhabitants

Kampung Tunjungan Pada is an informal settlement located in the CBD of Surabaya, Indonesia and is bounded by major roads and office buildings. Its location means that residents have been able to find employment in those offices or by operating small businesses often home based such as fast food, barbers or tailors. The site was selected because of the previous contacts and work that ITS University had completed in the Kampung. But also because Surabaya has positively supported the improvement of its informal settlements since the early 1920s. Hence they have a special character and exhibit probably the “best” of informal settlements.

There are no parks or open public areas within the Kampung though residents often grow potted plants and flowers; lanes are narrow typically 2.5 m overall; and children by necessity play in the lanes. Houses built in the 1930s seem to be better quality than those built later in the 1970s and the pressure to build has resulted in some houses not actually facing a lane. Some houses have a city supply water system, most do not and hence water purchase from shops or cartage from nearby wells is a constant requirement. Drainage is by gutters built in response to annual flooding of the Kampung and is usually maintained by each resident. Waste water is via these drains. House plots vary from 2.5×5 to 10×20 m and some residents have constructed 2 storey homes. It is made up of 4 separate areas as shown in the map (Fig. 6).

Training with both tools was given to the members of the 4 ITS survey teams prior to their work in the field, one team for RW1 through RW4 (Fig. 7).

The DASS42 survey tool had previously been translated into Bahasa by the Legal Department of Sykat Kuala University in Banda Aceh and checked by the

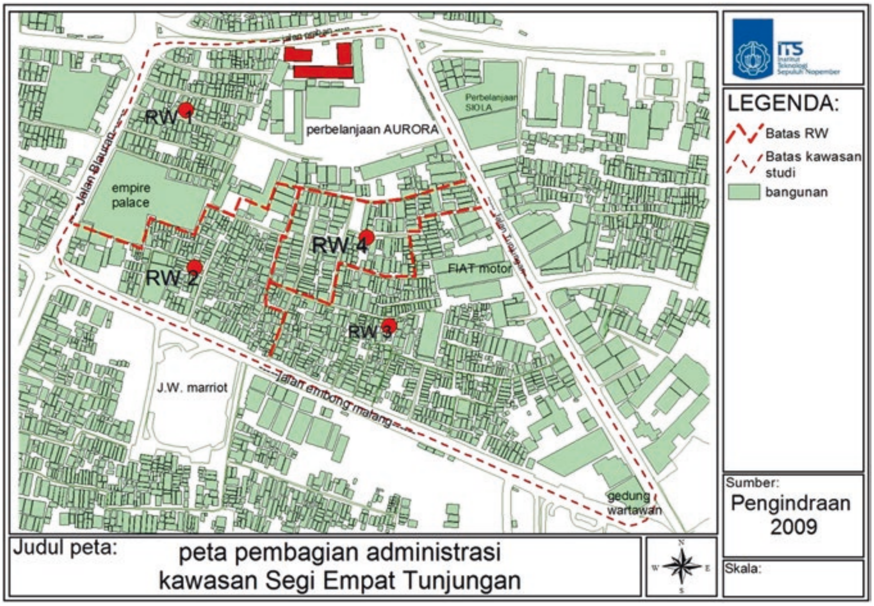

Fig. 6 The map of Kampung Tunjungan Pada

Fig. 7 A high density of patterns in this porch

Table 24 DASS42 overall results

DASS42 factor	Survey result	
Depression	3.5	Normal
Anxiety	4.1	Normal
Stress	5.3	Normal

Jesuit Brothers in Yojarkarta and used in over 10 different locations in Indonesia. Nonetheless, the version was review by the ITS team and some minor modifications made. The teams were then taken through the survey to ensure there was an agreement on what the questions meant and the process to be used.

Approximately 20 families were surveyed from each of the 4 districts 17 from RW1, 20 from RW2, 25 from RW3, 23 from RW4 hence 85 in total during May 2011 and the same spreadsheet analysis as used for the other case studies was applied. Perhaps not surprisingly the results were “Normal”, there was no “disaster” (Table 24).

Instead, the occurrences of lowered Depression, Anxiety or Stress were counted against households and this was used as the QoL indicator for each of the areas of RW1 to RW4. These were as follows:

- RW1: 4 lowered QoL factors involving 2 households out of 17.
- RW2: 13 lowered QoL factors involving 7 households out of 20.
- RW3: 0 lowered QoL factors out of 25.
- RW4: 24 lowered QoL factors involving 16 households out of 23.

Hence, RW3 would seem to have the best QoL followed by RW1, RW2 and finally RW4. The least QoL ranking for RW4 was consistent with the feeling within the survey teams and while it was not unexpected, it was somehow still surprising.

The results from the Talk-to-the-Buildings Approach identified which Patterns were predominantly found in the houses in each of the 4 areas. That suggested that more Patterns were associated with an increasing QoL (and opened the discussion of the role of the built environment and resilience) [27].

Certainly, the results from each tool were useful and provided insights that would have otherwise not been realised. But for both, the small differences in their numbers made it too "delicate" to go further. However, if the QoL was again split into Lowered and Non Lowered and the difference between the Patterns numbers used, than an interesting picture started to appear. This is tabulated and plotted in Table 25.

Figure 8a is a plot of the results with the data arranged from lowest to highest. RW3 would mathematically be ∞ (division by zero) and instead the number of houses surveyed was used. This seemed justified based on the "physics" of the process. Firstly both curves seemed similar despite coming from different tools. One measured QoL while the other measured architectural design and quality. At face value it seemed to suggest a relationship between the built environment and architecture, and the QoL (and thereby the resilience) of the building's occupants. That was stunning and despite the preliminary nature of the work published on it because nothing similar seemed to be in the literature.

Table 25 DASS42 and talk-to-the-buildings

	DASS42 ratio of non lowered to lowered QoL	Talk-to-the-buildings difference in patterns
RW4	0.4	0.2
RW2	1.9	4.5
RW1	7.5	6.7
RW3	25.0 (actually ∞)	28.4
	Series 1 below	Series 2 below

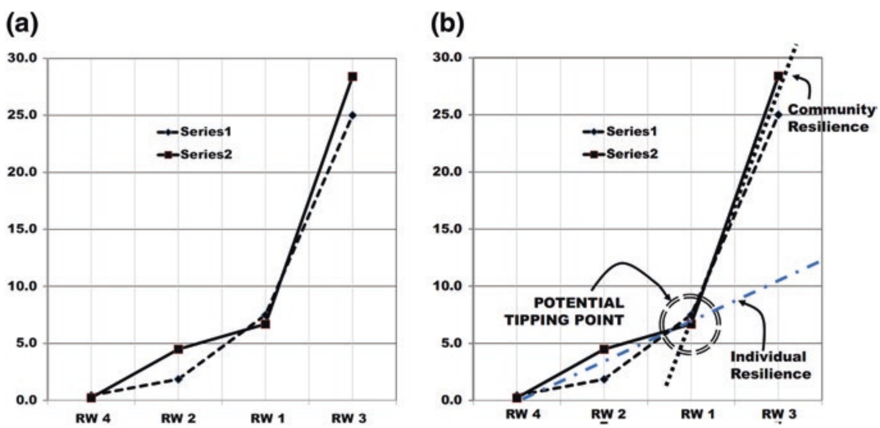

Fig. 8 **a** Plot of the results. **b** Plot with overlay

However, on further reflection, discussion and feedback there could be more in the plot as shown in Fig. 8b. It seemed to be pointing to a "Tipping Point" with the areas RW4 and RW2 being below it, RW3 above it and RW1 on it. The suggestion was that those above the tipping enjoyed additional seeming free QoL and Design. In this region "the whole was greater than the sum of the individuals" while for RW4 and RW2 the whole was the sum of the individuals. Thus, the area below the tipping point represented Individual QoL (or resilience) while above was the "community" QoL or resilience.

This would have immediate operational implications. For example, in the Kampung it would suggest that assistance should be provided to RW1 first; this would then put them over the tipping point and mean the emergence of community resilience with it that could be "self sustaining" and "durable". The discussion would be whether area RW4 or RW2 should be assisted and while that would be more involved the discussion could take place against a measurable framework.

Thus, it seems that a QoL Approach enables resilience by providing a metric to measure it. And in this case to discern potential relationships between individual and community resilience but also the possibility of a tipping point that has direct operational applications.

11 Conclusion

This work on the use of QoL tools has been compiled over a decade of persistence, largely in the field in post disaster situations where resilience is at times all that people had. Thus, the authors must acknowledge the many that helped over that time.

There are many "sub" conclusions that can be drawn that include that disasters have greater impact on the QoL of females compared to males, that the Sichuan Earthquake response was perhaps one of the "best" and that developed economies with seemingly advanced procedures won't necessarily ensure a better outcome than developing ones as apparently occurred in the Eastern Suburbs of Christchurch. And that there is potentially "hidden" information that differentiating by using a "Lowered" and "Non Lowered" split can reveal.

But what does this mean for how we "design and enable resilience in systems and communities?" Moreover, does resilience remain as pointed out by Pain and Levine as being on "one hand as self evident and common sense; but on the other as conceptually and programmatically elusive". Does a QoL Approach seemingly address such issues?

It is probably evident from the case studies that resilience is not stand alone. It is inter-connected and at times is the contextual background to what is happening; and perhaps why it is elusive? Unlike hazards and vulnerabilities it defies any "mapping", but exists nonetheless. It operates at differing levels and the crucial question is what are "the resources that those affected need to sustain their well being", and how can they obtain access to them? Did the QoL Approach identify these resources; and the answer would probably be a qualified "yes" because while it could identify those groups with a lower QoL, it could not suggest what to do. Moreover, it worked better when there was other data that it could re-interpret to identify them. On the other hand, it would provide a workable platform for operationalising resilient programmes; as it has done in the 7 case studies.

But "access to resources" is not new to humanitarians, and often it is a lack of access prior to the disaster that is at the core of their vulnerability in the first place. Unfortunately, for the same reasons before the disaster such access is not forth coming after the disaster. So the fear is even when we are able to identify them that they will nevertheless remain unattainable.

Putting that aside, one big advantage of the QoL Approach is that it puts the affected community as the central issue, rather than the many others that can potential crowd it out as seen in the Tacloban case study. That has to be "good", doesn't it?

Acknowledgements The author would like to acknowledge the following people that have made this work possible:

DASS42: Professor Peter Lovibond from the University of New South Wales, Australia as the developer of the DASS42 used in this work.

Banda Aceh: Ms Cut Yasmin (UNHCR) and Bambang Wijiatmoko and his teams from Mapala.

Pakistan: Ms Sonia Shamrose from Abbottabad and her team of post graduate students from her local University that completed interviews.

Sichuan: Dr Alice Chang and her team of researcher volunteers Zheng Jing, He Wei, Tan Meng, Mao Anran, Xu Danping.

Port au Prince Haiti: Ascension Martinez and her Socialisation team from IFRC (Haiti).

Surabaya: Students from ITS Universiti Surabaya Fetty Bahar, Harfa Ishandaria, Bagus Brotodiwirjo, Siti Mafruchan, Adinda Siti Pinasti, Retno Utami, Tanti Satriana, Tara Saraswati, Satya Santosa, Sigit Hariyoso and Andarita Rolalisasi.

Appendix 1: DASS42 Questions

Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applied to you over the past week. There is no right or wrong answers. Do not spend too much time on any statement.

The rating scale is as follows:

0 Did not apply to me at all
1 Applied to me to some degree, or some of the time
2 Applied to me to a considerable degree, or a good part of time
3 Applied to me very much, or most of the time

1	I found myself getting upset by quite trivial things	0	1	2	3
2	I was aware of dryness of my mouth	0	1	2	3
3	I couldn't seem to experience any positive feeling at all	0	1	2	3
4	I experienced breathing difficulty e.g., excessively rapid breathing, breathlessness in the absence of physical exertion	0	1	2	3
5	I just couldn't seem to get going	0	1	2	3
6	I tended to over-react to situations	0	1	2	3
7	I had a feeling of shakiness e.g., legs going to give way	0	1	2	3
8	I found it difficult to relax	0	1	2	3
9	I found myself in situations that made me so anxious I was most relieved when they ended	0	1	2	3
10	I felt that I had nothing to look forward to	0	1	2	3
11	I found myself getting upset rather easily	0	1	2	3
12	I felt that I was using a lot of nervous energy	0	1	2	3
13	I felt sad and depressed	0	1	2	3
14	I found myself getting impatient when I was delayed in any way e.g., lifts, traffic lights, being kept waiting	0	1	2	3
15	I had a feeling of faintness	0	1	2	3
16	I felt that I had lost interest in just about everything	0	1	2	3
17	I felt I wasn't worth much as a person	0	1	2	3
18	I felt that I was rather touchy	0	1	2	3
19	I perspired noticeably e.g., hands sweaty in the absence of high temperatures or physical exertion	0	1	2	3
20	I felt scared without any good reason	0	1	2	3
21	I felt that life wasn't worthwhile	0	1	2	3
22	I found it hard to wind down	0	1	2	3
23	I had difficulty in swallowing	0	1	2	3
24	I couldn't seem to get any enjoyment out of the things I did	0	1	2	3
25	I was aware of the action of my heart in the absence of physical exertion e.g., sense of heart rate increase, heart missing a beat	0	1	2	3
26	I felt down-hearted and blue	0	1	2	3
27	I found that I was very irritable	0	1	2	3
28	I felt I was close to panic	0	1	2	3
29	I found it hard to calm down after something upset me	0	1	2	3
30	I feared that I would be "thrown" by some trivial but unfamiliar task	0	1	2	3
31	I was unable to become enthusiastic about anything	0	1	2	3
32	I found it difficult to tolerate interruptions to what I was doing	0	1	2	3
33	I was in a state of nervous tension	0	1	2	3
34	I felt I was pretty worthless	0	1	2	3
35	I was intolerant of anything that kept me from getting on with what I was doing	0	1	2	3
36	I felt terrified	0	1	2	3
37	I could see nothing in the future to be hopeful about	0	1	2	3
38	I felt that life was meaningless	0	1	2	3

39	I found myself getting agitated	0	1	2	3
40	I was worried about situations in which I might panic and make a fool of myself	0	1	2	3
41	I experienced trembling e.g., in the hands	0	1	2	3
42	I found it difficult to work up the initiative to do things	0	1	2	3

References

1. Béné C, Wood RG, Newsham A, Davies M (2012) Resilience: New Utopia or new tyranny? Reflection about the potentials and limits of the concept of resilience in relation to vulnerability reduction programmes IDS Working Papers. Institute of Development Studies, 2012405, pp 1–61. Retrieved from http://www.ids.ac.uk/files/dmfile/Wp405.pdf
2. Bonanno GA (2004) Loss, trauma, and human resilience: Have we underestimated the human capacity to thrive after extremely aversive events? Am Psychol 59:20–28
3. Bonanno GA, Mancini AD (2008) The human capacity to thrive in the face of potential trauma. Pediatrics 121:369–375
4. Comfort L, Boin A, Demchak C (2010) Designing resilience: preparing for extreme events. University of Pittsburgh Press, Pittsburgh. ISBN 13;978.0.8229.6061 4
5. DASS (2006) Depression anxiety stress scales DASS Psychology Foundation of Australia http://www.psy.unsw.edu.au/Groups/Dass
6. Emergency Management Australia EMA (2003) Recovery management: context of recovery; EMA Institute, Mt Macedon Aug 2003, pp 51
7. Exenberger S, Juen B (2014) Well being, resilience and quality of life from childrens perspectives. Springer, Berlin. ISBN 978-94-007-7518-3
8. Feng V, Russell A, Potangaroa R (2008) Can houses learn? In: The 4th international post disaster reconstruction conference i –Rec2008 30 April–2 May 2008, Christchurch. New Zealand
9. Foster L, Keller P (2007) Defining wellness and its determinants. In: British Columbia atlas of wellness. Western Geographical Press, pp 721–762
10. Galloway S (2005) Well-being and quality of life: measuring the benefits of culture and sport: a literature review and thinkpiece section 1: a literature review. Scottish Executive Social Research 2005, p 13
11. Green L, Kreuter M, Deeds S, Partridge K (1980) Health education planning: a diagnostic approach, 1st edn. Mayfield, Mountain View
12. Hawthorne G, Richardson J, Day N (2002). Using the assessment of quality of life AQoL instrument version 1. Centre for Health Program Evaluation Monash University in collaboration with Melbourne University, p 80
13. Herreria E, Byron I, Kancans R, Stenekes N (2006) Assessing dependence on water for agriculture and social resilience. Bur Rural Sci, Canberra
14. Hettler B (1980) Wellness promotion on a university campus: family and community health. J Health Promot Maintain 3:77–95
15. IFRC (2014) Corrugated galvanised iron (CGI) sheets last updated: 2011/01/01 and accessed in May 2014 http://procurement.ifrc.org/catalogue/detail.aspx?volume=1&groupcode=111&familycode=111003&categorycode=BSHE&productcode=EBUIBSHE
16. Kaplan R, Bush J, Berry C (1976).Health status: types of validity for an index of well-being. Health Serv Res 1976:478–507 cited in Seiber W, Groessl E, David K, Ganiats T, Kaplan R (2008) Quality of well being self-administered (QWB-SA) Scale. User's Manual, Health Services Research Center, University of California, San Diego
17. Kumar C, (2005) Revisiting "community" in community based natural resource management. Community Dev J 40:275–285

18. Lawton M, Brody E (1969). Assessment of older people: self-maintaining and instrumental activities of daily living. Gerontologist 9:179–186 cited in McDowell I (2006) Measuring health: a guide to rating scales and questionnaires, 3rd edn. Oxford University Press
19. Lovibond S, Lovibond P (1995) Manual for the depression anxiety stress scales, 2nd edn. Psychology Foundation, Sydney
20. Maguire B, Cartwright S (2008) Assessing a community's capacity to manage change: a resilience approach to social assessment, May 2008, Aust Govt
21. Ministry of Civil Defence Emergency Management MCDEM (2004) National CDEM strategy 2003–2006. Pub. by the NZ Govt, pp 14–16
22. Mookerjee R, Beron K (2005) Gender, religion and happiness. J Socio-Econ 34:674–685
23. Norris FH, Stevens SP, Pfefferbaum B, Wyche KF, Pfefferbaum RL (2008) Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness. Am J Community Psychol 41(1–2):127–150
24. Pain A, Levine S, (2012). A conceptual analysis of livelihoods and resilience: addressing the 'insecurity of agency'. HPG Working Paper, November 2012
25. Potangaroa R (2005) The development of a permanent shelter program for Aceh, North Sumatra. Scientific forum on tsunami, its impact and recovery, AIT, Thailand
26. Potangaroa R (2014) Interim housing provision following an earthquake disaster. In: Beer M, Patelli E, Kougioumtzoglou I, Au S (eds) Encyclopedia of earthquake engineering. Springer, Berlin
27. Potangaroa R, Santosa H, Siregar H (2011) Architecture and well being in informal settlements in Surabaya, Indonesia. In: Keynote address International conference on the human dimension in the development of eco-housing and human settlement, ITS Universiti, Surabaya, 18 Oct 2011
28. Potangaroa R, Santosa H, Siregar H (2013). The proposition of the convergence of individual and community resilience. In: International conference on urban and regional planning department (CITIES 2013), Institut Teknologi Sepuluh Nopember (ITS), Surabaya
29. Russell A, Potangaroa R, Feng V (2008) Houses or Homes? The patterns of design. In: The 4th international post disaster reconstruction conference i –Rec2008 30 April–2 May 2008, Christchurch, New Zealand
30. Sharpe A, Smith J (2005). Measuring the impact of research on well-being: a survey of indicators of well-being. Centre for the Study of Living Standards, CSLS Research Report Number 2005-02, February 2005, p 119
31. Susniene D, Jurkauskas A (2009) The concepts of quality of life and happiness—correlation and differences. ISSN 1392—2785 Inzinerine Ekonomika-Engineering Economics (3). 2009 WORK HUMANISM
32. UNDP (2004) Reducing disaster risk: a challenge for development. United Nations Development Program UNDP chapter 1, pp 13–15, UNHCR Geneva, pp 11–23
33. UNHCR (1998) United nations high commissioner for refugees. UNHCR 1998 handbook for emergencies
34. WHO (1994) The development of the World Health Organization quality of life assessment instrument the WHOQoL. In: Orley J, Kuyken W (eds) Quality of life assessment: international perspectives. Springer, Heidleberg, p 43
35. WHO (1997) WHO QOL measuring quality of life. Division of Mental Health and Prevention of Substance Abuse, World Health Organization, p 1
36. Wilkinson F, (2005) Report on coastal design and tsunami mitigation for shelter/ housing reconstruction along west coast Aceh Province, UNHCR report

Defining and Negotiating a Shared Responsibility for Disaster Resilience

Bede Wilson

Abstract The introduction of the National Strategy for Disaster Resilience in Australia heralded a significant change in disaster management policy. In particular, the strategy emphasises the need to share responsibility between governments, businesses, non-government organisations and individuals. Exactly how this responsibility should be shared, however, is open to interpretation. This chapter uses Cultural Theory to examine how the community of Springbrook, Australia, defines and negotiates a shared responsibility for disaster resilience. The influence of this process on the community's disaster management plan is also assessed. The Springbrook example shows that initiatives that promote mutual understanding of world views are an effective way to develop disaster resilience. Through deliberation these world views may form alliances that address the limitations of any single approach. Such alliances are both exclusive and temporary however, suggesting that a broader range of initiatives, rather that broader participation itself, is required to support widespread and sustained resilience.

Keywords Shared responsibility · Cultural theory · Disaster planning

1 Introduction

In 2011 the Australian Government released the National Strategy for Disaster Resilience. Underpinning this strategy is the concept of "shared responsibility", the idea that government, businesses, individuals and non-government organisations are collectively responsible for the resilience of a community [9]. Despite the emphasis placed on developing a shared responsibility, this dimension of the strategy has gone relatively unexamined to date. For instance, the strategy gives little

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A. Masys (ed.), *Disaster Management: Enabling Resilience*,
Lecture Notes in Social Networks, DOI 10.1007/978-3-319-08819-8_13

consideration to the fact that exactly how responsibilities for disaster resilience should be shared is, of course, open for debate. The National Strategy for Disaster Resilience presents a vision of a more engaged community, where all parties work in a coordinated manner to improve resilience to disasters [9]. If community members can agree on what a shared responsibility should look like then a degree of coordination may be possible. If they cannot however, the prospects of meeting this goal seem bleak.

The intense focus on the National Strategy for Disaster Resilience by Australian governments highlights the importance of research in this area. For example, Federal Government funding provided for National Emergency Management Projects and via the National Partnership Agreement on Disaster Resilience totalled approximately $30 million in 2012–2013. Much of this funding is also supported by co-contributions from state and local governments. Crucially, the awarding of funds under these schemes is contingent on projects directly addressing the objectives of the strategy [8]. Despite this the ambiguity of the concept of “a shared responsibility” limits its relevance when considering applications for such funding.

This chapter examines the topic of a shared responsibility for disaster resilience in detail. In particular, it describes research conducted in the community of Springbrook, Australia. This study followed developments within the community following Ex-Tropical Cyclone Oswald. In the wake of the event, community members set about developing a new community disaster management plan to address the perceived problems they had experienced during the disaster. This provided an opportunity to observe the responsibility sharing process in action, and to assess the impact this had on the effectiveness of the planning process and other resilience building initiatives.

2 Resilience and Responsibility in Disaster Policy

Whilst there are a number of definitions for the term resilience, it is most commonly used to refer to a process of adaptation in response to disasters and changing risks. Norris et al. [29] reviewed the term resilience as it is used in a range of disciplines including engineering, ecology, social sciences and psychology. Across the range of definitions they found two commonalities: that resilience is a process, rather than an outcome, and that the outcome of this process is adaptability, rather that stability.

Moving beyond definitions, exactly how the concept of resilience should inform disaster management initiatives is less than straightforward. There is some consensus that resilience should be built through localised or community based initiatives [19, 34, 43], although this is not to the exclusion of action by central government. As Prior and Roth [34: 68] state, “… most resilience activities involve facilitation or targeted intervention of some form.” As such there is a particular focus on forming partnerships with communities [30] and organisations such as businesses [7]. The promotion of resilience is also strongly tied to developing mutual understanding through effective communication [27]. In this sense the approach is complementary to risk communication as presented by Wynne [44]. Moving beyond general principles, the literature on resilience is conflicted. For example, Paton and Johnston [30: 275] argue that a "… sense of community [facilitates] resilience to adversity." Norris et al. [29: 145] argue the opposite can be true, noting that a strong sense of community can result in strong "insider-outsider dynamics". Norris et al. [29] also identify place-attachment as a double-edged sword, having positive impacts in communities that are rebuilding and negative impacts in communities that are relocating. Skertich et al. [36] argue for greater inter-agency resource sharing as a means of decreasing coupling in emergency response systems. They justify this assertion using [32] Normal Accident Theory, which suggests that loose coupling can reduce the risk of system accidents. However, Normal Accident Theory also states that increased complexity results in a greater likelihood of system accidents [32], suggesting that inter-agency resource sharing does not necessarily improve disaster resilience. Finally, Prior and Roth [34] argue for improved risk assessment and prediction to enhance resilience. In contrast, Hood et al. [17] suggest that the resilience approach opposes a reliance on risk assessments on the basis that disasters cannot be reliably predicted. It is even argued that a focus on risk assessment may increase risks by fostering the erroneous belief that risks that have not been identified cannot occur [17] and by favouring "specific resilience" over "general resilience" [43: 4]. In all, these contradictions can be seen to reinforce the concept of resilience as a process rather than a quantity or outcome; the process of adaptation is necessarily dependent on the nature of the community, the risk of disasters and the nature of disaster management interventions. It does also suggest that generic resilience building measures implemented by governments are likely to be ineffective.

2.1 Resilience Policy

Resilience is a theme that has recently found prominence in the disaster management policy landscape. In international policy, the United Nation's Hyogo Framework for Action signalled a clear commitment to promoting resilience. A review of the earlier Yokahama Strategy found that "… building resilience through enhanced national and local capabilities to manage and reduce risk" was one of the major challenges for disaster management globally [42: 2]. The framework also directly links resilience to "… knowledge and information on hazards, vulnerabilities and capacities" [42: 9]. Within Australia this triggered the development of a National Disaster Resilience Framework and ultimately, the National Strategy for Disaster Resilience [35]. This strategy is wide-ranging, identifying seven areas for action. These are "leading change and coordinating effort, understanding risks, communicating with and educating people about risks, partnering with those who effect change, empowering individuals and communities to exercise choice and take responsibility, reducing risks in the built environment, and supporting capabilities for disaster resilience" [9: 6–13].

The National Strategy for Disaster Resilience has been referred to as a "significant shift in national policy" [35: 9] and even "the single most significant policy initiative in the field of disaster management in Australia's history" [22: 1]. Despite this enthusiasm, McArdle and Archer's reasons for making such a statement are primarily related to the strategy being the first such national guidance. In this sense the commentary may be a reaction to increased federal government involvement in what has traditionally been a state government responsibility. Some aspects of the strategy have been criticised however. Eburn and Dovers [12] argue that not defining resilience within the strategy makes the approach somewhat ambiguous. They also suggest that a resilient community does not necessarily follow the direction of emergency services, leaving open the possibility of confusion and conflict during a disaster response. Jones [20] acknowledges the change in focus promoted by the strategy but suggests that it is yet to produce any genuine shift in disaster management industry thinking. McLennan and Handmer [25: 71] agree that the strategy represents "[a]n important shift", but argue that its significance lies in the concept of shared responsibility, rather than resilience per se.

2.2 The Emergence of Shared Responsibility

Debate about a shared responsibility for disaster management came to the fore in Australia following the Victorian Bushfires Royal Commission in 2009. The commission identified a preference for community self-reliance within the State's bushfire safety policy, and found that this preference had been justified under the banner of "shared responsibility" [39]. In particular, the commission viewed the State's "Prepare, Stay and Defend or Leave Early" policy, otherwise known as "stay or go", as an example of this. The basis of the policy was that residents who had made the recommended preparations could stay and defend their homes if it was safe to do so, and those who hadn't should leave well before their homes came under threat. The Commission criticised the policy, and argued for an "… increased responsibility for all concerned, albeit at different levels" [39: 352]. In doing so the commission sought to highlight that the fire agencies' level of capability compelled them to adopt a greater responsibility than other members of the community. McLennan and Handmer [26: 2] characterise this as a shift from self-reliance "… and towards a greater degree of responsibility for 'those in authority' …." The National Strategy for Disaster Resilience subsequently enshrined this shift in policy, by adopting the Commission's definition of shared responsibility. Importantly, McLennan and Handmer [25] point out that the strategy also expanded on this by stating that "[t]he fundamental change is that achieving increased disaster resilience is not solely the domain of emergency management agencies; rather it is a shared responsibility across the whole of society" [9: 3].

The debate about shared responsibility for disaster management is in some ways tied to broader changes in government-individual relationships. A shift in responsibility away from governments has been explained as a product of neo-liberalism. For example, Ilcan [18: 208] describes the process of "privatizing responsibility", the transfer of traditional government roles to individuals, non-government organisations and businesses, with the potential drain on public resources often provided as a justification. This was certainly considered in the development of the National Strategy. It states, "[g]overnments' desire to help communities in need, and pressure to help those affected may be creating unrealistic expectations and unsustainable dependencies" [9: 1]. Nickel and Eikenberry [28] warn that this argument fails to recognise the structural causes of the need and that, far from promoting resilience, the removal of government services necessitates action from supposedly voluntary partners. Brown [6] argues that promoting individual responsibility can be positive, but that removing assistance from those in need prevents individuals from making positive choices in the future. Accordingly, whilst the goal of a greater responsibility for all may be admirable, it is also plagued by conflicting goals and questions of fairness.

In *Risk Society*, Beck [4] explains the trend towards individual responsibility through the process of "individualisation". He argues that the dilution of traditional class structures means that individuals are increasingly expected to define their own "biographies". Giddens [14: 26] terms this the "end of tradition" and identifies it as one of the defining characteristics of the risk society. Beck [4: 131] cautions that this does not equate to a genuine emancipation but rather exchanging the constraints of tradition "… for the constraints of existence in the labor market and as a consumer, with the standardizations and controls they contain." Such a process foments conflict between individuals and the institutions that constrain them. In this context, responsibility for disaster resilience can be characterised as a tension between individuals and institutions (including governments), rather than a collaboration.

Beck [5: 18] also introduces "organised irresponsibility", the idea that increased environmental degradation is accompanied by decreased accountability. This is brought about by a mismatch between the nature of late-modern hazards and the tools that society has to comprehend them. Applied to disasters, the complexity surrounding planning schemes, legal obligations, mitigation cost-benefits and other considerations, makes disaster aetiology incomprehensible [31] in contrast to the binary "stay or go" decisions that are expected of individuals. In such an environment, individuals emerge as the focal point for future preparedness initiatives [15].

2.3 Recent Research

There are a number of recent studies related to disaster management that examine the concepts outlined so far. Frandsen et al. [13] evaluated a pilot program run by the Tasmanian Fire Service in which a series of community engagement activities were progressively tailored for the local community, based on feedback from prior events. This feedback led Frandsen et al. [13] to conclude that the use of trusted voices and organisations within the community was crucial to the success of such programs. Bajracharya et al. [3: 27] examined the role of public-private partnerships in "… achieving sustainable, disaster-resilient communities." They use the example of two such partnerships in the Gold Coast, Australia to illustrate that community groups do not require "authorisation" from governments to take on a disaster resilience responsibility [3: 32]. On the topic of communication, Nicholls [27] studied the 2003 Canberra Bushfires to identify how resilience is best supported by governments. She found that effective two-way communication promoted mutual understanding that improved resilience and hence assisted the community to recovery. Dufty's [11] review of social media in disasters suggests that the decentralised nature of this technology allows communities to form around commonalities of interest and responsibility, making it a particularly effective tool in promoting disaster resilience. Despite all of these studies addressing a number of similar themes however, none of them examined the concept of shared responsibility in detail.

The study most relevant to the issue of shared responsibility is that conducted by McLennan and Handmer [23]. Their research included a number of components including a literature review, the conduct of industry workshops, a review of emergency management policy and the development of an Australian case study from accounts presented at the Victorian Bushfires Royal Commission. A key outcome of the study was the identification of ten "master frames" through which the topic of shared responsibility could be viewed. McLennan and Handmer [23] argue that analysing shared responsibility through a number of frames aids in the generation of new ideas. The study also identified a number of mechanisms for sharing responsibility from establishing legislation through to influencing social norms [24]. Through their work McLennan and Handmer [25: 72] hint at the nebulous character of shared responsibility by asking, "Who shares responsibility? How? and For what?" Whilst their work examines archetypal responses to these questions based on various policy positions, it does not answer one key question; that is, how does the community answer these questions for themselves. It also leaves open the question of how the goal conflicts that so often characterise debates about resilience are resolved. These questions are ones that are consistently absent from much disaster resilience research.

3 Cultural Theory

Whilst there are many theoretical frameworks that may be used to examine disaster resilience, it is suggested that Cultural Theory provides a model that successfully integrates concerns about both risk and the sharing of responsibility. Based on the work of Douglas and Wildavsky [10] and further developed by others [1, 2, 40], it views risks as the product of cultural biases and conflicts between world views. Embodied within each world view is a perspective on how risks should be managed and responsibilities allocated.

The concept of world views is central to Cultural Theory. Slovic [37: 693] describes world views as "general social, cultural, and political attitudes that appear to have an influence over people's judgements about complex issues." Cultural Theory categorises world views based on two dimensions, "grid" and "group". These dimensions are summarised by Thompson et al. [40: 5], who state:

> *Group* refers to the extent to which an individual is incorporated into bounded units. The greater the incorporation, the more individual choice is subject to group determination. *Grid* denotes the degree to which an individual's life is circumscribed by externally imposed prescriptions. The more binding and extensive the scope of the prescriptions, the less of life that is open to individual negotiation.
>
> Thompson et al. [40: 5] [original emphasis]

These dimensions then describe four world views [40: 5–7]. "Hierarchy" is defined by high grid and group dimensions. As such it is a world view that promotes "strong group boundaries and binding prescriptions" [1]. Hierarchical organisations such as governments would typically belong in this category. Conversely, "individualism" is defined by low grid and group dimensions. With a rejection of both group determination and prescribed inequality, this world view is firmly within the purview of free marketeers. "Egalitarianism", defined by high group and low grid, preferences a greater good over individual advancement, and seeks consensus over majority or laissez-faire environments. Communards and environmentalists are commonly cited examples of egalitarians [1, 40]. "Fatalism" occupies the last quadrant in the grid-group typology. Fatalists do not invest in groups and experience inequality out of resignation, rather than preference. As such fatalists are left to cope; as Thompson et al. [40: 9] put it, "[the fatalist's] strategy is one of personal survival." The definition of these world views forms the basis for a range of further analyses. For example, each world view brings with it a perspective on the nature of society and the environment that influences perceptions of risk. Thompson et al. [40] also highlight that hierarchists, individualists and egalitarians will actively seek out alliances in order to compensate for the weaknesses of their own world view. By accounting for the way risks are perceived, as well as preferences for managing them, Cultural Theory is uniquely placed to provide insight into the way the responsibility for disaster resilience is shared.

With regard to resilience in particular, Cultural Theory also has something to offer. Thompson et al. [40] describe a fifth world view; that of the hermit. As a largely autonomous way of life this part of the theory is often excluded from studies of the management of risk (see, for example, Lodge [21]). The autonomous world view sees the others as unnecessarily dualistic and hence it rejects them all. This leads Thompson et al. [40] to conclude that "… in withdrawing from this fourfold system, in which each of the engaged ways of life is endlessly chewing bits off the others, the hermit is sustained not by the unalloyed truth but by his own distinctive myth: Nature Resilient." In other words, the hermit is engaged in a constant process of adaptation in order to maintain autonomy.

4 The Springbrook Initiative

The small community of Springbrook in the Gold Coast hinterland is just one that is grappling with the task of enhancing resilience. Springbrook is known for its natural beauty, being perched atop the Great Dividing Range and home to spectacular world heritage listed rainforest [41]. With this environment comes a downside in that the community, more than most, is vulnerable to the impacts of bushfires and severe weather. In January 2013 Springbrook was impacted by Ex-Tropical Cyclone Oswald. During this event parts of the community were isolated, and many households lost power, water, sanitation and telecommunications for a number of days. In the months following the disaster, community members approached the City of Gold Coast with a view to developing a disaster management plan that was tailored to the Springbrook community. A key consideration for this initiative was that the plan should be based around the organisations, individuals, and resources located within Springbrook, so that it could function even when the community was isolated. In essence, this plan provided a means of improving the resilience of the Springbrook community. This brought with it a need to determine how responsibility should be shared across the community, providing an ideal opportunity to explore the responsibility sharing process in detail.

Three research objectives were identified as the basis of a study in Springbrook. The first was to examine how community members define a shared responsibility for disaster resilience. This required an understanding not only of how community members believe responsibility should be shared, but also the rationale for this belief. Understanding the rationale was critical to locating community members' perspectives on disaster resilience in the context of their world views. The second objective was to discover how divergent perspectives were reconciled whilst conducting community based disaster resilience initiatives. Understanding this element required an examination not just of explicit negotiations, but also of how the nature of the group implicitly included or excluded certain topics for discussion. The final objective was to evaluate what influence the negotiation process had on the nature and effectiveness of the community planning initiative. Findings related to this objective formed the basis of a series of recommendations that may be used to improve future disaster resilience initiatives.

The research adopted a qualitative case study design. A purposive approach to sampling was adopted, with the objective to maximise the diversity of perspectives that would be encountered. This was critical to ensuring that all of the world views of Cultural Theory were represented throughout the study. Accordingly, not all of the research participants were directly involved in the development of the Springbrook Community Disaster Management Plan. Representatives from government departments, emergency services, community and environmental groups and local businesses participated in the study, as well as some residents who were not affiliated with any group.

Data was collected through a combination of semi-structured interviews, documentary analysis and participant observation. In total fifteen participants were interviewed, all being from the aforementioned groups. Documents included the various drafts of the Springbrook Community Disaster Management Plan, as well as other artefacts from the planning process, local community newsletters, handouts provided at community meetings and more general disaster preparedness leaflets. Participant observation was used to gain data during a community meeting which was held to discuss the contents of the plan and seek feedback from residents. All of the data that was collected throughout the study was analysed using the coding approach from grounded theory, as outlined by Glaser and Strauss [16] and further developed by Strauss [38]. This involved three stages of coding. The first was open coding, where all of the data was reviewed and coded based on the themes or issues that it related to. The second was axial coding, where these original codes were grouped to identify the most important themes. The final stage was selective coding, where the theories identified in the literature review were used as frames to organise the codes from the first two stages. The results of this process are presented in the following sections.

5 Defining Shared Responsibility

In the case of Springbrook, community members defined a shared responsibility for disaster resilience in terms of the impacts of both disasters and disaster preparedness on their own way of life. Debate about fire hazard reduction measures within the community illustrates this phenomenon. For example, residents who did not clear their properties of flammable material were identified by emergency services and some residents as a threat to the community's resilience. It was stated that their lack of preparation put emergency services and other residents at a greater risk of harm. As one participant put it, "… you knock on the door to have a chat to them and they've got their firewood up against the house, they've got roof and guttering overflowing with leaves, they've got trees over the house itself. I mean, they don't help themselves." Conversely there were residents who felt that the impacts of such clearing threatened the environmental and aesthetic qualities that, for them, defined life on Springbrook. As it was put, living on properties thick with vegetation is a "lifestyle choice", and many people are "willing to take the risk".

Such a debate illustrates how different conceptions of shared responsibility emerge. This pattern is predicted by Cultural Theory, which suggests that "… people select certain risks for attention to defend their preferred lifestyles and as a forensic resource to place blame on other groups" [33: 112]. In this sense seemingly simple issues can bear significant social baggage. Residents who did not clear their properties were used as evidence of a broader disregard for the authority of governments and emergency services. Conversely, the need for clearing fire breaks was used as evidence of development having already exceeded the carrying capacity of Springbrook. Clearly definitions of shared responsibility are inseparable from the world view of those who define them.

The patterns in community members' definitions of shared responsibility reflect the link between ways of life and myths of nature described in Cultural Theory. For example, the view that governments should adopt primary responsibility for disaster resilience by centralising management functions was expressed in tandem with the view that only governments had sufficient understanding of the science of disasters and the ways to manage them. This viewpoint exhibits the hierarchist's preference for prescribed roles and group determination as well as the belief that, with sufficient knowledge, the environment can be safely managed. Participants who highlighted the impacts of climate change and more intensive development on Springbrook viewed broad community involvement as the most effective means of preventing the exploitation of the Springbrook community by third parties. This perspective rejects the imposition of external interests and clearly delineated roles, whilst also highlighting the fragility of the natural environment; a clear nod to the egalitarian way of life. Those who supported more extensive clearing and controlled burning in order to protect existing areas of development made no reference to the potential downsides of doing so, demonstrating a distaste for government regulation of property owners and an optimistic attitude to the environment that could be expected of individualists. Finally, those residents who had not made preparations for disasters expressed a view that they would simply follow directions during a disaster and evacuate whenever they were told to do so; an essentially fatalistic approach. Autonomy, the world view of Cultural Theory's hermit, was referred to by almost all of the research participants. It is perhaps unsurprising however that those who advocated a withdrawal from society were not heard first hand. As such it is difficult to say definitively how the autonomous way of life influences definitions of a shared responsibility for disaster resilience within Springbrook.

It is important to highlight that whilst all of Cultural Theory's world views and myths of nature were evident within the Springbrook community, the proponents of those world views did not necessarily match the vignettes of Thompson et al. [40] that describe such individuals. In fact, elements of all four world views could be encountered in a discussion with just one participant. Accordingly, whilst Cultural Theory is able to explain how community members define a shared responsibility for disaster resilience, it cannot necessarily be used to predict specifically who defines these responsibilities so.

Whilst Cultural Theory helps to explain patterns in the way responsibility is shared, elements of other theories were also evident in the results of the research. For example, the tension between individuals and institutions that Beck's [4] concept of individualisation predicts was observed. Individualisation itself, however, refers to a "categorical shift in the relation between individual and society" [4: 127]. Such a shift could not be observed over such a short time within the Springbrook community. Similarly the reliance on local community organisations that was observed within Springbrook could be viewed as a privatisation of responsibility in the sense that Ilcan [18] referred. This does not help to explain the desire of such organisations to eschew government intervention however. Based on the evidence that was collected, Cultural Theory was best able to explain the perspectives of all elements of the community as they defined a shared responsibility for disaster resilience.

6 Resilience as Interactions Between World Views

In examining how the Springbrook community defined a shared responsibility for disaster resilience, six distinct types of interaction were observed. Deliberation was seen throughout the development of the Springbrook Community Disaster Management Plan. Whilst this was an effective means of addressing differences of opinion, its use tended to be limited to negotiation between similar groups. Persuasion emerged as a common means of dealing with divergent perspectives within Springbrook. This approach is in fact the basis of the existing community education programs run by emergency services. Persuasion was also observed in the lobbying of politicians, particularly in relation to the environmental concerns surrounding hazard reduction burning, land clearing and development. Prescription of roles, typically through emergency plans, was an approach used almost solely by governments. These plans focussed on establishing clear roles and responsibilities to establish consistency of approach. This was not the only purpose of emergency plans however. There was evidence that plans were used to minimise or delay changes, by precluding changes outside review schedules and by discounting concerns that were not raised in the initial consultation period. Direct opposition to differing perspectives emerged frequently throughout the course of the research. In particular this was seen in a "war of facts" over the environmental consequences of hazard reduction burning. As with lobbying, direct opposition was primarily seen in debates involving environmental concerns. Exclusion was evident within Springbrook disaster resilience initiatives, both as a deliberate strategy and a structural by-product. There were some cases where residents recounted stories of being actively excluded because of their perspectives. More common however were examples of residents who excluded themselves because they did not agree with the perspectives of some local community organisations. Finally, resignation was most commonly encountered where residents were forced to accept decisions of government that they did not agree with.

Disaster resilience initiatives that encouraged deliberation were able to reconcile divergent perspectives in a way that enhanced resilience within the community. The development of the Springbrook Community Disaster Management Plan provides an example of such an approach. Following Ex-Tropical Cyclone Oswald, some community members felt that they had been forgotten by government agencies, and that they were left to respond to the disaster themselves. From an egalitarian perspective this demonstrated that external support could not be relied on and that residents would have to self-organise in order to cope with disasters. Ex-Tropical Cyclone Oswald also highlighted the limitations of this approach; that the community did not have sufficient local capacity to completely rely on such a strategy. From a hierarchical perspective, the prevailing doctrine of disaster management, Ex-Tropical Cyclone highlighted another limitation; that the vulnerability of Springbrook's communication and transport infrastructure limited the effectiveness of existing command and control arrangements. By providing a means of deliberating between world views, the development of the Springbrook Community Disaster Management Plan converted two related conundrums into a starting point for improving community resilience. Practical measures such as the provision of a cache of resources for use by residents, and providing a more robust means of communication between Springbrook and the Gold Coast Local Disaster Coordination Centre, provide increased local capacity as well as a greater level of integration between community and emergency service actions. Crucially, they do so without requiring any significant change in the way in which responsibilities are shared or any significant adjustment in world views. The Springbrook Community Disaster Management Plan has provided a forum through which the limitations of two world views can be both identified and compensated for.

Aside from deliberation, there were no examples of the observed social processes contributing to a reconciliation of divergent perspectives. In fact many of these processes appear to have led to the exact opposite, reinforcing existing world views and increasing conflict within the community. For example, attempts to persuade individuals to prepare an emergency kit containing essential supplies such as food and water were a regular feature on Springbrook. Those conducting community education programs used the persistent failure of residents to make such preparations as evidence of a continuing need for the education programs themselves. Conversely, residents who felt that the community had been abandoned by governments responsible for maintaining robust infrastructure used the need for such preparations as evidence that Springbrook had indeed been neglected. Whilst some individuals may have adopted the advice, it is clear that it also had the effect of galvanising the positions of other members of the community. A similar reaction was seen where prescription, opposition, exclusion and resignation were observed.

7 Enhancing Disaster Resilience Initiatives

The development of the Springbrook Community Disaster Management Plan shows that initiatives that promote alliances between world views can enhance resilience, but that these alliances are both exclusive and temporary. For example, the development of the plan has helped to reconcile a desire for community self-determination with the hierarchical nature of the disaster management system, but it has only achieved this for those parties that participated in its development. The nature of this initiative, determined by the world views that were represented in it, had the effect of excluding other community members. It is not clear from the observations that were made what influence broader involvement may have on the effectiveness of such an initiative. Despite this, Thompson et al. [40] state that alliances between all three active ways of life (hierarchy, egalitarian and individualist) are both rare and unstable. This suggests that a wider range of initiatives, rather than initiatives involving a wider range of views, could be more effective in improving resilience. Even alliances between two world views are destined to erode, with Thompson et al. [40] noting that the more that is invested in an alliance, the more likely it is to fail under pressure due to differences of opinion. This suggests that the effectiveness of disaster resilience initiatives such as the Springbrook Community Disaster Management Plan is time limited.

Regarding other disaster resilience initiatives on Springbrook, it is not axiomatic that activities that polarise community opinion are ineffective at promoting resilience. The conflict between world views that was evident within the Springbrook community did have the effect of limiting participation in a number of groups and activities. Whilst this could be prima facie evidence of a threat to resilience, Cultural Theory suggests otherwise. In fact an absence of conflict between world views would suggest that there is insufficient diversity to balance the failings of one against the strengths of another. Thompson et al. [40: 87] argue that a "permanent dynamic imbalance" is required to maintain any functioning social system. There is a strong parallel between this and resilience, "a process that leads to adaptation … not stability" [29: 144]. In short, the conflict that was observed within Springbrook is an inevitable feature of a resilient community and should not necessarily be viewed as undesirable.

7.1 Relationship to Existing Literature

The way community members defined a shared responsibility for disaster resilience within Springbrook lends weight to the argument that resilience should be characterised as a process of adaptation rather than a set of definite qualities. Through the lens of Cultural Theory this process of adaptation occurs when alliances between world views change. Accordingly, processes which facilitate such alliances are likely to enhance the community's resilience. There are myriad ways in which this may be achieved, although some commonalities can be identified. For example, the assertion that resilience should be built through community based initiatives [19, 34, 43] is supported by the evidence from Springbrook; an appreciation of the world views of community members sufficient to enable effective deliberation can only be developed through meaningful engagement within the community. The approaches of Nicholls [27] and Wynne [44] with a focus on developing mutual understanding may also be effective, as is the approach of Lodge [21: 395] who advocates for "deliberating among world views". Viewing resilience as a product of forming alliances also helps to explain why much of the resilience literature is conflicted regarding the effectiveness of specific interventions; each disaster resilience initiative must take into account the existing balance of world views within a community, meaning that it may not be possible to transplant approaches from one community to another. Other communities may of course provide ideas and sources of inspiration, however attention must be paid to the potential unintended consequences of adopting approaches that were developed elsewhere.

The analysis of responsibility sharing within Springbrook provides a slightly different perspective to some of the existing literature on the topic. The mechanisms for shaping expectations of responsibility that were observed within Springbrook are related to those identified by McLennan and Handmer [26]. They are not, however, equivalent. The mechanisms observed within Springbrook (deliberation, persuasion, prescription, opposition, exclusion and resignation) describe types of social interaction that are used to influence the way responsibility is shared within a community. They have also been defined so as to indicate the intended outcome of the process. To elaborate, the function of deliberation is to harmonise world views. Persuasion, on the other hand, seeks to adjust world views. Prescription is used to constrain world views, whereas opposition seeks to erode them. The purpose of exclusion is to isolate world views and the function of resignation is to cope with them. All of these approaches, ultimately, are employed in order to strengthen the relative position of the world view within which their adopter resides. The mechanisms identified by McLennan and Handmer [26] may perform a number of functions simultaneously. For example "vision statements", they suggest, may be used to "steer or mobilise", may be "linked to social sanctions" or may, when not adhered to, "be grounds for a person being removed from a professional position" [26: 13]. Thus a vision statement is better characterised as an instrument which may be used to perform a number of functions (in the examples given: persuasion, exclusion and prescription). The same applies to the other mechanisms they identified: "hard laws and regulations", "soft interventions", "contracts and agreements", "collective inquiry and decision making", "organisations and associations" and "social norms" [26: 18]. This distinction highlights how important it is to understand the context within which such instruments are employed to ensure that their function and significance are understood.

7.2 Policy Implications

The findings of this research have three key implications for disaster management policy. Firstly there is a need to take a broader view of risk in order to account for the way community members define a shared responsibility for disaster resilience. Each world view provides a different way of viewing and managing risks, and seeking these perspectives can help to identify new options or policy directions. The National Strategy for Disaster Resilience states that "[w]e all share a responsibility to understand [local disaster] risks, and how they might affect us" [9: 6]. The findings from Springbrook suggest that understanding how others understand risks is just as important, and may be more helpful when trying to enhance resilience within a community. Secondly, where disaster resilience initiatives involve parties that hold differing perspectives, deliberative decision making processes can be an effective means of establishing shared ground and improving resilience.

In the case of the Springbrook Community Disaster Management Plan, acknowledging the limitations of each world was a crucial part of facilitating this process. Finally, if effective alliances cannot be forged, initiatives that encourage community debate about disasters can be another way to enhance community resilience. In the absence of any such debate, one world view may be allowed to dominate. Whilst this may reduce conflict in the short term, it is also likely to foster weaknesses that will become apparent when a disaster finally occurs.

8 Conclusion

In conclusion, this chapter has examined how communities define and negotiate a shared responsibility for disaster resilience. The study in Springbrook has shown that community members define shared responsibility in terms of the impacts of both disasters and disaster preparedness on their own way of life. Accordingly it has illustrated the value in seeking to understand issues of disaster resilience from a wide range of viewpoints. Doing so provides a means of reflecting on the limitations of existing approaches to disaster management, and can also help to identify opportunities for new, more effective disaster resilience initiatives. In particular, forming alliances between world views can provide an effective means of improving disaster resilience. Such alliances are both exclusive and temporary however, meaning a broad range of initiatives is required in order to ensure that widespread and sustained resilience can be achieved. Above all else this research highlights that, not only is agreement on the sharing of responsibility unlikely, it should be treated with abject suspicion. All of Cultural Theory's world views are flawed, and sufficient diversity must be maintained to ensure that the flaws of any single approach are not allowed to dominate. Whilst this may be more haphazard than the vision presented in the National Strategy for Disaster Resilience, it is most likely to deliver the desired outcomes.

References

1. Adams J (1995) Risk, 2nd edn. UCL Press, London
2. Adams J (1999) Risky business: the management of risk and uncertainty. Adam Smith Institute, London
3. Bajracharya B, Hastings P, Childs I, McNamee P (2012) Public-private partnership in disaster management: a case study of the Gold Coast. Aust J Emerg Manage 27(3):27–33
4. Beck U (1992) Risk society: towards a new modernity. SAGE Publications, London
5. Beck U (1998) Politics of risk society. In: Franklin J (ed) The politics of risk society. Polity Press, Cambridge
6. Brown A (2005) If we value individual responsibility, which policies should we favour? J Appl Philos 22(1):23–44
7. Busch NE, Givens AD (2013) Achieving resilience in disaster management: the role of public-private partnerships. J Strateg Secur 6(2):1–19

8. Commonwealth of Australia (undated) funding initiatives. Available online at http://www.em.gov.au/Fundinginitiatives/Pages/default.aspx. Accessed 3 Aug 2013
9. Council of Australian Governments (2011) National Strategy for Disaster Resilience. Commonwealth of Australia, Canberra
10. Douglas M, Wildavsky AB (1983) Risk and culture: an essay on the selection of technological and environmental dangers. University of California Press, Berkeley
11. Dufty N (2012) Using social media to build community resilience. Aust J Emerg Manage 27(1):40–45
12. Eburn M, Dovers S (2012) Sharing responsibility with governments and their agencies. In: Proceedings of the 3rd human dimensions of wildland fire. International Association of Wildland Fire, Montana
13. Frandsen M, Paton D, Sakariassen K (2011) Fostering community bushfire preparedness through engagement and empowerment. Aust J Emerg Manage 26(2):23–30
14. Giddens A (1998) Risk society: the context of British politics. In: Franklin J (ed) The politics of risk society. Polity Press, Cambridge
15. Giddens A (1999) Risk and responsibility. Mod Law Rev 62(1):1–10
16. Glaser B, Strauss A (1967) The discovery of grounded theory. Aldine Publishing Co., Chicago
17. Hood CC, Jones DKC, Pidgeon NF, Turner BA, Gibson R (1992) Risk management. In: Risk: analysis, perception and management. Royal Society, London
18. Ilcan S (2009) Privatizing responsibility: public sector reform under neoliberal government. Can Rev Sociol 46(3):207–234
19. Ireni-Saban L (2013) Challenging disaster administration: toward community-based disaster resilience. Adm Soc 45(6):651–673
20. Jones R (2013) In search of the ‘prepared community’: the way ahead for Australia? Aust J Emerg Manage 28(1):15–19
21. Lodge M (2009) The public management of risk: the case for deliberating among worldviews. Rev Pub Policy Res 26(4):395–408
22. McArdle D, Archer F (2011) Is this the holy grail we have been waiting for in disaster management. J Emerg Prim Health Care 9(1):1–6
23. McLennan B, Handmer J (2011) Framing challenges for sharing responsibility: a report of the sharing responsibility project. Bushfire CRC, Melbourne
24. McLennan B, Handmer J (2011) Mechanisms for sharing responsibility: a report of the sharing responsibility project. Bushfire CRC, Melbourne
25. McLennan B, Handmer J (2012a) From risk to resilience? Reframing shared responsibility in Australian disaster policy. In: Proceedings of the 3rd human dimensions of wildland fire. International Association of Wildland Fire, Montana
26. McLennan B, Handmer J (2012) Reframing responsibility-sharing for bushfire risk management in Australia after black saturday. Environ Hazards 11(1):1–15
27. Nicholls S (2012) The resilient community and communication practice. Aust J Emerg Manage 27(1):46–51
28. Nickel PM, Eikenberry AM (2007) Responding to “natural” disasters: the ethical implications of the voluntary state. Adm Theor Prax 29(4):534–545
29. Norris FH, Stevens SP, Pfefferbaum B, Wyche KF, Pfefferbaum RL (2008) Community resilience as a metaphor, theory, set of capacities and strategy for disaster readiness. Am J Community Psychol 41(1–2):127–150
30. Paton D, Johnston D (2001) Disasters and communities: vulnerability, resilience and preparedness. Disaster Prev Manage 10(4):270–277
31. Pawson E (2011) Environmental hazards and natural disasters. NZ Geogr 67(3):143–147
32. Perrow C (1999) Normal accidents: living with high-risk technologies, 2nd edn. Princeton University Press, Princeton
33. Pidgeon N, Hood C, Jones D, Turner B, Gibson R (1992) Risk perception. In: Risk: analysis, perception and management. Royal Society, London

34. Prior T, Roth F (2013) Disaster, resilience and security in global cities. J Strateg Secur 6(2):59–69
35. Prosser B, Peters C (2010) Directions in disaster resilience policy. Aust J Emerg Manage 25(3):8–11
36. Skertich RL, Johnson DEA, Comfort LK (2013) A bad time for disaster: economic stress and disaster resilience. Adm Soc 45(2):145–166
37. Slovic P (1999) Trust, emotion, sex, politics, and science: surveying the risk-assessment battlefield. Risk Anal 19(4):689–701
38. Strauss AL (1987) Qualitative analysis for social scientists. Cambridge University Press, California
39. Teague B, McLeod R, Pascoe S (2010) 2009 Victorian Bushfires Royal Commission: final report—volume II—fire preparation, response and recovery. Government Printer for the State of Victoria, Melbourne
40. Thompson M, Ellis R, Wildavsky A (1990) Cultural theory. Westview Press, Colorado
41. United Nations (1994) Convention concerning the protection of the world cultural and natural heritage: world heritage committee eighteenth session. United Nations Educational, Scientific and Cultural Organisation, Geneva
42. United Nations (2005) Hyogo framework for action 2005–2015: building the resilience of nations and communities to disasters. United Nations Inter-Agency Secretariat of the International Strategy for Disaster Reduction, Geneva
43. Walker B, Westley F (2011) Perspectives on resilience to disasters across sectors and cultures. Ecol Soc 16(2):4
44. Wynne B (1983) Redefining the issues of risk and public acceptance. Futures 15(1):13–32

Part V
Socio-Ecological Domain

Wildland Fire Management: Movement Towards Enabling Resiliency?

Michael R. Czaja

Abstract Wildfires in the western US are changing. Research suggests they are expanding in size and duration. The results include civilian and firefighter fatalities, record destruction and damage to homes and infrastructure, and increasing costs to agencies responsible for fire management. Two developments within the framework of wildland fire management suggest potential movement towards enabling resiliency. One of these is development of the National Cohesive Wildland Fire Management Strategy. The other is a state-level initiative, Colorado's Task Force on Wildfire Insurance and Forest Health. A goal of both processes is to seek methods which allow human populations and infrastructure to withstand a wildfire without loss of life and property. One implication will be how these initiatives enable resiliency within the larger subject of disaster management. Another will be to potentially apply this type of strategy development and working group methodology to other appropriate fields of disaster management.

Keywords Wildland fire management · Cohesive strategy · Resilience · Fire-adapted communities · Wildland-urban interface

1 Introduction

Wildland fire management across all landscapes and jurisdictions in the United States (US) involves a complex matrix of fuel types, climate considerations, mission goals, polices, land and resource values, social concerns, and costs [23]. In the western US, wildland fire activity increased markedly over the past two

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A. Masys (ed.), *Disaster Management: Enabling Resilience*,
Lecture Notes in Social Networks, DOI 10.1007/978-3-319-08819-8_14

decades, with a higher frequency of fires larger than 121 ha (or approximately 300 acres), longer incident durations, and longer fire seasons driven by both land use history and climate change [3, 79]. This increase in fire behavior results in increased risk to responders, home and property losses, higher costs, and increased threats to communities and landscapes [23].

Collectively, these trends lead the US Congress, the fire community, and the public to call for a new wildland fire management strategy. The Federal Land Assistance, Management, and Enhancement Act of 2009 (FLAME Act) required the Secretary of Agriculture and the Secretary of the Interior to submit a report to Congress which contained a cohesive wildfire management strategy [14, 15, 20, 29]. It must be noted that the FLAME Act, while containing the requirement for development of a cohesive strategy, was enacted due to the financial strains placed upon Federal agencies with wildland fire responsibilities. The cohesive strategy is a collaborative process involving all levels of government and non-governmental organizations, as well as the public, to seek national, all-lands solutions to wildland fire management issues. The cohesive strategy focuses on three areas: restore and maintain resilient landscapes, fire-adapted communities, and response to wildland fire. It is being implemented in three phases to allow the development of a systematic approach to plan for, respond to, and recover from wildland fire incidents [20]. Developed as a result of a changing landscape, the cohesive strategy has the potential to provide a significant contribution to the enabling of resilience in communities and landscapes. While the collaborative community continues to implement the cohesive strategy, other parallel actions are occurring at different scales. Several of these are at the state level. One example includes actions currently taking place within the State of Colorado.

During the 2012 wildfire season, Colorado experienced several significant wildfire events. All took place within the wildland-urban interface and resulted in the loss of lives, structures, and significant acreage burned. In January, 2013, Colorado's Governor, John Hickenlooper, used an executive order to establish the Wildland and Prescribed Fire Advisory Committee. This body will advise the Director of the Division of Fire Prevention and Control on all matters pertaining to wildfire preparedness, response, suppression, coordination, or management, as well as prescribed fire-related issues. The Governor also established a Task Force on Wildfire Insurance and Forest Health. Members included the Colorado State Forest Service (CSFS), US Forest Service (USFS), representatives from the insurance industry, non-profit groups, and others. The task force was charged to examine how to protect residents of the wildland-urban interface and the state's landscape [9, 69, 84]. In light of the implementation of the cohesive strategy, one area to examine is how will the state's initiatives contribute to meeting the cohesive strategy's goals and objectives?

The scope of this chapter is to introduce the current wildfire situation in the western US and in Colorado and examine the tools and processes available to enable resiliency found within the cohesive strategy and identified by Colorado's task force. The analytical flow will define the key terms, including disaster, wildfire, wildland fire management, and resiliency, review the larger issue of wildfires in the western US and in Colorado, and discuss the cohesive strategy and task force. In this discussion, programs, capabilities, and objectives will be examined. This includes the status and any identifiable policy and action outcome. Further, the relationship, if any, between the cohesive strategy and Colorado's initiative will be explored. The increasing risk of wildfire to lives, infrastructure, communities, and the landscape makes this an appropriate, and timely, subject to address. One implication will be to examine how these programs, recommendations, and policies enable resiliency within the larger framework of disaster management. Another will be to potentially apply this type of strategy development and working group methodology to other appropriate fields of disaster management.

2 Definition of Key Terms

Within the US, wildland fire management incorporates numerous participants, with various responsibilities and interests, responding to a complex natural process. The following section provides a foundation for the following examination of the cohesive strategy and associated actions within Colorado.

2.1 Disaster and Wildfire

The new wildfire reality can lead to disaster on several scales. Disasters are those events, concentrated in time and space, in which a society faces danger and incurs such losses that the social structure is disrupted and the delivery of essential services may be prevented [16, 32]. The social, economic, and political effects of wildfires can be seen at various levels. A wildfire which necessitates evacuations, damages or destroys homes and infrastructure, disrupts essential services, and potentially impacts watersheds providing municipal water can be overwhelming. In many cases, insurance coverage is lacking or insufficient for those living within a wildfire's burn zone. Often, residents are unable, or choose not, to rebuild. This can disrupt a locale's social fabric and can impact a community's ability to rebuild and gather tax revenue.

The goal of disaster policy is to reduce vulnerability and increase resilience to all types of events, whether natural or man-made. This includes a political component, with the appropriate societal institutions and policy development [32]. In examining resilience within the context of wildfires, it is appropriate to frame the issue within a coupled human-environment, or social-ecological system (SES), context. As Walker et al. [78] observe, resilience within a SES can be defined as the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain the same function, structure, identity, and feedbacks. Within the context of this chapter, landscapes are complex intersections of natural, built, and human components [8]. For wildfires, the objective is to withstand fire without the loss of life or property and to recover without significant impact on the infrastructure or the landscape. When assessing the size and frequency of wildfires, one key area to consider is fire severity. This is the landscape's response to fire and can be used to describe the effects of fire on the soil and water system, flora and fauna, the atmosphere, and society [62]. While a wildfire can be successfully suppressed with minimal or no damage to homes and infrastructure, a severe wildfire can have far-reaching effects on watersheds and the communities that depend on them. Fire management includes those activities required for the protection of lives, homes, infrastructure, and other values from fire and the use of certain practices, such as prescribed fire, to meet land management objectives. One common objective of prescribed fire is the reduction of fuels, seeking to lessen the risk of future catastrophic fires [56].

2.2 Wildland Fire Management

Regarding the actual implementation of wildland fire management, a variety of participants are found at various scales, both within and outside of government. This includes, but is not limited to, the US Congress, the interagency community, state, and local resources. The Congressional committees with oversight are the Committee on Appropriations, the Committee on Natural Resources, and the Committee on Agriculture in the House of Representatives (House) and the Committee on Appropriations, the Committee on Energy and Natural Resources, and the Committee on Indian Affairs in the Senate, including their respective staffs [76, 77].

The Wildland Fire Leadership Council (WFLC) provides strategic leadership and oversight to implement national fire planning [86]. The council is an intergovernmental council of Federal, state, tribal, county, and local government officials. The council is convened by the Secretaries of Agriculture and the Interior to consistently implement wildland fire policies, goals, and management activities. The Wildland Fire Executive Council (WFEC), a sub-component of the WFLC, coordinates policy and strategic direction. It is the focal point for the accomplishment of the WFLC's strategic direction. A subcomponent of the WFEC, the National Wildfire Coordinating Group (NWCG) coordinates policy and program implementation. It responds to WFEC taskings [86].

The respective national agencies primarily concerned with wildland fire policy are the USFS (Department of Agriculture); the Department of the Interior (DOI), including the Bureau of Indian Affairs, National Park Service, Bureau of Land Management, and the US Fish and Wildlife Service; US Fire Administration (Federal Emergency Management Agency); Intertribal Timber Council; and the National Association of State Foresters [51, 55, 88]. Each of these agencies has specific offices with wildland fire management responsibilities. In turn, these agencies also have state, local, and tribal partners [38].

Other non-governmental organizations and professional groups also participate in wildland fire management processes. These include the International Association of Fire Chiefs (IAFC), with its "Ready, Set, Go!" program and the National Fire Protection Association (NFPA), proponent for the "Firewise Communities" and "Fire Adapted Communities" programs [36, 37, 46]. The Western Forestry Leadership Coalition (WFC in this chapter), Western Governors Association (WGA), and Insurance Institute for Business and Home Safety (IIBHS), among others, can also be included. Individual participants are also found throughout the interest group community. Some are research specialists with the Federal Government Accountability Office (GAO), others are members of research organizations, such as Headwaters Economics, or the academic community. Stephen Pyne, a noted academic researcher at Northern Arizona University, is a recognized and influential member of this community.

2.3 Wildfire, Mitigation, and Landscape Disturbance

Wildfires occur in the wildland, an area in which development is essentially nonexistent, except for roads, railroads, powerlines, and similar transportation facilities. Structures, if any, are widely scattered or found in the wildland-urban interface. This is the area where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels [56, 70]. The International Association of Wildland Fire [39] expands this to specifically include the merging of structures and vegetation in a wildfire-prone environment. Wildland fire is now a general term describing any non-structure fire that occurs in the vegetation and/or natural fuels. There are three types of wildland fire. They are wildfire, wildland fire use, and prescribed fire. The revised NWCG definitions define a wildfire as an unplanned, unwanted wildland fire including unauthorized human-caused fires, escaped wildland fire use events, escaped prescribed fire projects, and all other wildland fires where the objective is to put the fire out. Wildland fire use includes the management of a naturally-ignited wildfire to meet management objectives. Prescribed fire will be discussed as one of the following mitigation strategies [56, 57].

Mitigation strategies are an important component of wildland fire management and enabling resilience. Four common mitigation strategies can be implemented to reduce wildfire risk. Two individual actions are establishing defensible space around a home or structure and using fire-resistant, or "Firewise," materials in construction. Defensible space includes a fuel-free area immediately around a home, with a buffer zone outside of this that has thinned vegetation and the removal of dead vegetation. It also includes landscaping with fire-resistant plants and pruning branches back off of roofs and up off of the ground. Firewise construction includes fire-resistant roofs, walls, windows, and attachments (such as decks, porches, and fences) [48, 49]. These are important components of the "Firewise Communities" and "Fire Adapted Communities" programs, addressed later in the chapter.

There are two fuels treatment actions which are commonly conducted by land management agencies. Fuels treatments reduce the quantity, depth, and continuity, both vertical and horizontal, of fuels to mitigate potential fire behavior and severity. These agency actions include prescribed fires and mechanical thinning [1, 31]. As previously introduced, prescribed fire is any fire intentionally ignited by management, under an approved plan, to meet specific objectives, often fuel reduction [56, 57]. These fires can replicate the benefits of wildfires on the landscape, maintaining biodiversity, assisting with the restoration of ecosystem health, and reducing the risk to people and property [62, 73]. Properly managed, they also cause far less damage to ecological processes than uncontrolled, severe wildfires [42, 74]. Mechanical thinning removes excess trees and ladder fuels to reduce the likelihood that a surface fire will move into the tree crowns. Ladder fuels are those that allow fire to move from the surface into the crowns of trees and shrubs. This method of thinning also reduces the connectivity of tree crowns, making it more difficult for fire to spread through the canopy [18].

In general, forest and other landscape disturbances have profound economic, social, political, and ecological implications for people living, working, and recreating in and near these landscapes. Because of this, the values, interests, and concerns of local stakeholders should be incorporated into management strategies. This avoids costly conflicts and reduces the long-term impacts of disturbances [25]. Natural, or ecological, disturbances are the dominant factor in defining composition and structure of forest ecosystems. Fires, insects, and pathogens are the primary agents of disturbance and, under certain circumstances, can cause extensive tree mortality [30].

Even when wildfire suppression efforts are successful, the cost in lives and money, and the impact on communities and the landscape, can be staggering. The following section introduces the nature of wildfires on the landscapes of the western US. This provides background on why the cohesive strategy and other actions have been considered necessary.

3 Wildfires in the Western United States

The dynamics of wildfires on the landscape of the western US are changing. Different ecosystem types and geographic areas in the western US are naturally characterized by different fire regimes. In some places, fire activity is greatly exceeding the normal range. In others, it is not [43]. In general, the fire season is lengthening and observers note that we are entering a period of megafires, which have not been seen in decades. These fires have a high combustion intensity, are inherently complex to manage, and are dangerous to firefighters [63]. Ecosystems and human populations are becoming more vulnerable. This situation has been described as a complex mix of physical, ecological, economic, and social developments [6].

3.1 Changing Nature of Wildfires

Research by Westerling et al. [79] focused on 1166 large [>400 ha (approximately 988 acres)] forest wildfires between 1970 and 2003 on western, Federal land-management areas. Their findings suggest that the incidence of large wildfires significantly increased in the 1980s. They also found that at the end of their research period, wildfire frequency was nearly four times the average of 1970–1986, and the total area burned was more than six and half times its previous level. In addition, their research indicates that the length of the wildfire season increased by 78 days when comparing 1970 –1986 with 1987–2003. These findings have been supported by other research. Gebert [26] observes that 1987 was the year when statistical tests indicate that a structural change occurred with increased acres burned and suppression costs.

A quick review of wildfire statistics is necessary when examining the objectives of the cohesive strategy and related state-level initiatives. Across the nation in 2012, 67,744 wildfires burned 9,326,238 acres. The 10-year average for 2003–2012 was 63,162 fires and 6,670,780 acres burned. The number of fires in 2012 was below the 5- and 10-year national averages, while the acreage was above the national average [50]. This follows a recent trend, where there are fewer wildfires, but the acreage is growing. Regionally, a review of recent fire seasons found increasing figures for both categories. In the geographic breakdown for wildland fire management, Colorado is located within the Rocky Mountain coordination region, along with Kansas, Nebraska, and the majority of South Dakota and Wyoming [27]. As an example of 2012 fire behavior, compared to the 10-year average, the Rocky Mountain region experienced 149 % of fires and 367 % of acres burned. In Colorado alone, there were 1,498 wildfires and 246,445 acres burned in 2012 [50]. The 10-year average for the state is 1,433 fires annually, with 82,062 acres burned.

3.2 Wildland-Urban Interface

There is a direct correlation between the expansion of the wildland-urban interface (subsequently identified as the WUI) into fire-prone landscapes and lives lost, plus destroyed and damaged property. As previously defined, the WUI is an area where humans and their development meet or intermix with wildland fuel [56, 70]. The continuing population growth within the WUI results in increased risks to human safety and higher potential costs for destroyed or damaged property. Nationally, a 2006 estimate by the Federal GAO found 44 million homes in the contiguous 48 states were located within the WUI [61]. A 2013 analysis conducted by the data analytics firm CoreLogic found that in the years between 1990 and 2008, close to 17 million homes were constructed in the US. Of these, approximately 10 million (58 %) were built in the WUI and potentially located near high wildfire risk zones.

Within 13 western states, the same analysis found approximately 740,000 homes to be at high or very high risk for wildfire damage [5].

In Colorado, the CSFS estimates that 1 million Colorado residents live in proximity to 6 million acres of forests at high risk to wildfires [13]. With the presence of 117,472 homes, approximately 20 % of Colorado's WUI is developed [34]. With a regional average of 16 % WUI development, Colorado is second only to Washington State's 29 % level of development. From 2004 to 2012, primary structure losses due to wildfires were over 13,000 [47]. In 2012, 4,244 structures were destroyed by wildfires, including 2,216 residences, 1,961 outbuildings and 67 commercial structures. This is above the annual average of 1,416 residences, 1,253 outbuildings, and 46 commercial structures (data from 1999 to the present). Colorado accounted for the majority of 2012's structural loss, with 656 residences and 162 outbuildings destroyed [50]. Colorado's 2013 wildfire season also left its mark. The season's most significant wildfire was the Black Forest Fire. The fire claimed two lives, destroyed over 450 homes, and burned 14,280 acres before being contained [72]. The fire is the most costly, in terms of homes destroyed, in Colorado history.

As suggested by the Black Forest Fire, humans are often put at risk by wildfires. Within Colorado, eight civilians died in wildfires during 2012 and 2013 [7, 12, 40, 72]. While no wildland firefighters died in Colorado during those 2 years, an average of 17 wildland firefighters die each year in the line of duty (2003–2012 statistics). These deaths result from various causes, such as entrapment (five in California during 2006), helicopter crashes (nine in California during 2008), and vehicular accidents (eight in Oregon during 2003). In some instances, these firefighters perish during suppression operations in WUI environments [53]. Initial statistics indicate that 37 wildland firefighters died in 2013. Nineteen of these belonged to a single crew, the Granite Mountain Hotshots (Prescott, AZ), who were killed June 30 in an entrapment during a WUI fire near the community of Yarnell, AZ [87].

Solving the problem of fire within the WUI may never be complete because of continual changes in social and biophysical systems associated with population growth, cultural change, fuel, and climatic shifts [28]. This results in civilian and firefighter fatalities, record destruction and damage to homes and infrastructure, and increasing costs to agencies responsible for fire management. When considering the expansion of the WUI into fire-prone areas, the potential for disaster becomes far too real.

3.3 *Wildland Fire Costs*

Along with the expansion in fire size and severity, costs are also rising. This is an important consideration. As Pyne [64] observes, what you propose as a solution depends on how you define the problem. Fire suppression costs, due to lengthening fire seasons and increasing severity, has been identified as a problem. It is important to note that while the FLAME Act legislation required the development of a national cohesive strategy, addressing resilience, the impetus for the legislation was cost. The rising cost of wildland fire suppression precludes the expenditure of funds on other programs, such as fuels mitigation, which can potentially support community and landscape resiliency.

Concerns about costs have been growing for over a decade. Stephens and Ruth [71], citing the US Departments of Agriculture and the Interior, plus other organizations, observed that even with large expenditures and substantial infrastructure dedicated to fire suppression, the annual area burned by wildfire has increased in the previous decade. Cost has also been a significant factor for agencies with wildland fire-fighting responsibilities. The NWCG stated that the high costs of wildland fire suppression, particularly large and complex incidents, are of considerable concern to Congress, the Office of Management and Budget (OMB), the GAO, the public, and the agencies themselves [58].

The cost for wildland fire suppression in the western US is significant for Federal agencies. In 2013, the National Association of State Foresters (NASF) reported that the USFS and the DOI's agencies ran out of money to suppress emergency wildfires eight times between 2000 and 2013 [68]. This often requires an emergency supplement, generally coming at the expense of other programs. For example, between 1999 and 2006, more than $3 billion was transferred from other DOI or USFS accounts to support fire suppression, placing strains on other agency programs [45]. In 2010, citing several former Chiefs of the USFS, the WFC stated that suppression funding accounts for an increasing amount of the total USFS budget each year. From 2000 to 2008, this funding increased from 25 to 44 percent of the service's budget [17]. Federal fire suppression costs have been over $1 billion annually since 2006. In 2012, the total Federal expenditure for fire suppression was $1.90 billion, with the bulk of that, $1.44 billion, expended by the USFS [54]. Since 1985, that is the second-highest cost, only behind 2006's $1.93 billion, and does not include state and local costs. Of note, 2012 Federal wildfire-related appropriations to the USFS and DOI totaled $2.76 billion. Combined with fire protection activities, such as fuel reduction and preparedness, the total Federal costs for the period 2002–2012 exceed $3 billion annually [29, 35].

An analysis of wildland fire costs by the WFC found fire suppression costs are only a portion of the true costs associated with a wildfire. Total costs can range from 2 to 30 times the reported suppression costs. These include not only fire-fighting costs, but damage to homes and natural resources, and other costs, such as lost tax revenue and payments to families of a fire fighter killed during a wildfire [17]. For the years 2012–2013 in Colorado, a recent estimate of insurance costs for the 2012 High Park and Waldo Canyon Fires are $113.7 million and $453.7 million, respectively. The estimated insurance costs for the 2013 Black Forest Fire are $292.8 million [66].

Using Birkland's [2, p. 147] definition, one can argue that wildfires have become "common events under uncommon circumstances." In his view, these are generally common events that gain greater attention due to some unique and unusual feature of the event that makes them newsworthy and, not coincidentally, worthy of greater government attention and potential policy change. Historically speaking, the occurrence of wildland fires is common. What has made them recently "uncommon," however, is the combination of factors previously discussed, requiring a new strategy to deal with the increasing complexity and costs.

4 Cohesive Strategy and Colorado Task Force

To this point, the chapter introduced an extremely complex socio-environmental dynamic, wildland fire, which is found on landscapes within the US. While wildfires are found across the nation, this chapter is focused on the western region and, in particular, Colorado. It is outside the scope of the chapter to explore other factors, such as climate change, drought, and previous forest management techniques, which research suggests are contributing to the new wildfire reality. One objective of this book is to examine the underlying fragilities that can potentially turn shocks and stresses into crises and how to enable resilience to support risk, crisis, and disaster management. As we have seen, wildfires can potentially be extremely disruptive to both communities and the landscape. This is not only true for loss of life and physical damage or destruction to homes or infrastructure, but also the impact on the landscape when a severe wildfire occurs, potentially affecting the landscape's ability to act as a watershed or to undergo regeneration. The financial impact is another critical component. This can make recovery challenging for individuals and communities, and agencies may see disrupted funding priorities or the need to transfer needed funding out of certain programs to cover wildfire suppression costs.

This section of the chapter will address how the national cohesive strategy and actions within one state seek to address wildfire-related fragilities and, potentially, enable individual, community, and landscape resilience. Any linkages between the cohesive strategy and the state actions will be identified, as will specific legislative or policy initiatives within Colorado. It is no accident that wildfire costs served as one of the major catalysts to develop the national cohesive strategy and initiatives within Colorado.

4.1 Federal Legislation

During Senate testimony in 2007, Robin M. Nazzaro, the GAO's Director for Natural Resources and the Environment, stated that if the responsible agencies and Congress are to make informed decisions about an effective and affordable long-term approach to wildland fire issues, there should be a cohesive strategy that identifies long-term options and necessary funding [60]. While it should be noted that the GAO also explored other aspects of Federal wildland fire management, such as fuels reduction and use of firefighting assets, the identification of a cohesive strategy and necessary budgetary options reinforced that the development of solutions was taking place within the wildland fire management and policy communities.

Specific solutions to the overall funding problem, components of which were subsequently incorporated into the subsequent FLAME Act, were developed within the policy community. Stephens and Ruth [71] observed that Congress should provide an improved budgetary process for fire and fuels management, with a larger annual Federal fire-suppression budget. They suggested that the President and Congress develop more realistic and multiyear funding, such as a trust fund or reserve account. In 2010, the WFC recommended the development of a new funding mechanism for emergency fire suppression activities, including a separate account for wildland fire suppression costs. A key component to this proposal was that the funding for this account must not come from the agency budgets, nor factored into the 10-year rolling average of suppression costs used to develop agency budgets [17].

The responsible Federal agencies also noted the need for restructuring budgets. In its fiscal year 2010 (FY 2010) budget proposal to Congress, the USFS identified the need for a separate reserve in order to provide funding for firefighting when its 10-year average funding amount was exhausted. The service indicated that the President's administration was taking a new approach to the complexities associated with managing wildland fire [75].

In response to the increasing cost of wildland fire suppression, the US Congress enacted the Federal Land Assistance, Management, and Enhancement (FLAME) Act of 2009, contained within Public Law 111-88 (October 30, 2009), Interior Department and Further Continuing Appropriations, Fiscal Year 2010. The act establishes, within the US Treasury, separate FLAME Wildfire Suppression Reserve Funds for the Departments of Agriculture and the Interior. These are available to cover the costs of large or complex wildfires and act as a reserve when amounts for wildfire suppression and Federal emergency response in the Wildland Fire Management appropriation accounts are exhausted. The act also required the Secretaries of Agriculture and the Interior to submit a report to Congress which contained a cohesive wildland fire management strategy [14, 15, 21, 29].

The act was the direct result of a recognized need for increased funding to meet fire suppression costs and was a significant success at a time of competing budgetary priorities. The enactment of the FLAME Act makes funds available for catastrophic, emergency wildland fire suppression activities. Funds will also be made available for activities on state and private land, in accordance with existing agreements, and on Native American Lands. Two components of the act also satisfied suggested recommendations made by members of the wildland fire management and policy communities. First, FLAME funds made available to the appropriate Federal agencies to pay wildfire suppression costs are separate from amounts annually appropriated for this purpose. Second, the act required the USFS and DOI to submit a report to Congress, as previously recommended by the GAO, which contains a cohesive wildfire management strategy. As envisioned by Congress, the cohesive strategy would include cost-effective allocation of fire management budgets, the allocation of hazardous fuels reduction funds, an assessment of climate change on the frequency and severity of wildfire, and other subjects.

4.2 National Cohesive Strategy

In response to the requirements of the FLAME Act, the WFLC directed the development of the National Cohesive Wildland Fire Management Strategy [20, 85]. The WFLC stresses that through the active participation in the development of the cohesive strategy, attention can be brought to the policies and actions necessary to strategically approach the issue of effective wildland fire mitigation and response.

The strategy development was a collaborative process involving all levels of government and non-governmental organizations, as well as the public, to seek national, all-lands solutions to wildland fire management issues. The strategy focuses on three areas: restore and maintain resilient landscapes, fire-adapted communities, and response to wildland fire. It is being implemented in three phases to allow the development of a systematic approach to plan for, respond to, and recover from wildland fire incidents [20]. In development of the cohesive strategy's guiding principles and core values, the WFLC incorporated components of the current Federal wildland fire policy.

4.3 Federal Wildland Fire Policy

Pyne [65] made the observation that fire policy and fire sociology are the study of how, granted fire's physical properties, people should apply and withdraw fire and how they should protect themselves from its threats. Stephens and Ruth [71] observe that the wildland fire policies of Federal agencies have evolved from the use of small patrols in the newly created National Parks to diverse policy initiatives and institutional arrangements that affect millions of hectares of forests. This is clearly reflected in the current Federal policy. The 1995 Federal Wildland Fire Policy was updated in 2001, with implementation policy issued in 2003 and 2009 [52, 59].

Several elements of the Federal wildland fire management policy were incorporated into the cohesive strategy's guiding principles. Most important, firefighter and public safety is foremost and must be reflected in all plans and activities. Plans and programs will be based upon the best available science. The full range of fire management activities will be used to achieve ecosystem sustainability, including interrelated ecological, economic, and social components. Response to wildland fire will be based on ecological, social, and legal consequences of the fire. Rehabilitation and restoration efforts will be undertaken to protect and sustain ecosystems, public health, safety, and to help communities to protect infrastructure.

Finally, setting priorities among protecting public communities and community infrastructure, other property and improvements, and natural and cultural resources will be done based on the values to be protected, public health and safety, and the costs of protection [51]. Values are defined as property, structures, physical improvements, natural and cultural resources, community infrastructure, and environmental, economic, and social values [56].

4.4 Cohesive Strategy Governance

Governance of the cohesive strategy is the responsibility of several previously established councils and new organizations created to support this effort. The WFLC provides executive leadership and broad oversight for the effort. In turn, the WFLC appointed the WFEC to provide oversight over the implementation of the cohesive strategy. The Cohesive Strategy Subcommittee (CSSC) was appointed by the WFEC to advise the WFEC on implementation of the cohesive strategy. The CSSC's membership mirrors that of the WFEC and WFLC, with several members having long-term continuity with development of the cohesive strategy. The National Science and Analysis Team (NSAT), reporting to the CSSC, is comprised of experts who conduct data collection, synthesis, analysis, and modeling in support of the cohesive strategy. Finally, the WFEC chartered three Regional Strategy Committees (RSC), West, Northeast, and Southeast, to coordinate regional assessments. The regional committees appointed working groups to develop and update the regional assessments [19].

4.5 Cohesive Strategy Implementation Phases

As previously mentioned, the cohesive strategy is being implemented in three phases. This allows the development of a systematic approach to plan for, respond to, and recover from wildland fire incidents. The phased approach was designed to promote dialogue at the national, regional, and local levels [20]. The following discussion will highlight pertinent aspects that relate to resiliency, focused on the western US.

Phase I. Development of the cohesive strategy and the report to Congress, mandated by the 2009 FLAME Act, were the objectives of this phase. These serve as the two foundation documents for the strategy's development. The two documents were approved and released to the public in March, 2011 [24]. Several partner organizations in the development of the cohesive strategy sent letters to the Secretaries of Agriculture and the Interior, expressing support for the effort. These included the International Association of Fire Chiefs (IAFC), National Association of Counties (NAC), National Association of State Foresters (NASF), National League of Cities (NLC), and the Western Governors Association (WGA) [20].

The cohesive strategy recognizes that wildfire is not just a fire management, fire operations, or a wildland-urban interface problem. It is a larger, more complex land management and societal issue [23]. The strategy's vision for the following century:

> Safely and effectively extinguish fire, when needed; use fire where allowable; manage our natural resources; and, as a Nation, live with wildland fire (p. 1).

To achieve this vision, three primary factors have been identified as presenting the greatest challenges and opportunities to make a positive difference in addressing the wildland fire problem. These are the national goals for wildland fire management. They are restoring and maintaining resilient landscapes, creating fire-adapted communities, and responding to wildfires. Goals and outcome-based performance measures for each factor will serve as the foundation for the regional tasks, actions, and performance measures that were developed in Phase II.

Restoring and Maintaining Resilient Landscapes. The strategy recognizes the lack of ecosystem health and variability from geographic area to geographic area. Landscape conditions and needs vary, based on local climate, fuel conditions, and other factors. Because of this, the strategy will address landscapes at a regional and sub-regional scale.

Goal: Landscapes across all jurisdictions are resilient to fire-related disturbance in accordance with management objectives

Outcome-based performance measure: Risk to landscapes is diminished. Outcome-based metrics will center on risk to ecosystems at landscape scales

Creating Fire-Adapted Communities. The strategy will offer options and opportunities to engage communities and work with them to become more resistant to wildfire threats.

Goal: Human populations and infrastructure can withstand a wildfire without loss of life and property.

Outcome-based performance measures: Risk of wildfire impacts to communities is diminished; individuals and communities accept and act upon their responsibility to prepare their properties for wildfire; jurisdictions assess level of risk and establish roles and responsibilities for mitigating both the threat and consequences of wildfire; and the effectiveness of mitigation activities is monitored, collected, and shared. Output-based metrics will include indicators relevant to communities with mitigation plans and planned or completed treatments.

Responding to Wildfires. This component recognizes the full spectrum of fire management activities. It recognizes the differences in missions among local, state, tribal, and Federal agencies. The strategy will offer collaboratively methodologies to move forward.

Goal: All jurisdictions participate in making and implementing safe, effective, and efficient risk-based wildfire management decisions.

Outcome-based performance measures: injuries and loss of life to the public and firefighters are diminished; response to shared-jurisdiction wildfire is efficient and effective; and pre-fire, multi-jurisdictional planning occurs. Output-based metrics will reflect trends in changing risk to support the national measure.

Indicators include pre-season agreements and annual operating plans, integrated wildfire response scenarios, and shared training. Risk exposure to firefighters will be based on a balanced consideration of values to be protected and the probability of success.

Phase II. There were two main components to this phase. The first was to bring together stakeholders and communities to look for synergies and ways to work together to improve land management, reduce wildfire risk, improve suppression capability. The second was to gather information describing conditions in the three regions pertaining to the threat of wildfire, values at risk and objectives. During this phase, three regional assessments and action plans were developed and used to inform the final cohesive strategy. This phase implemented a collaborative planning and analytical process and the regions identified alternative management strategies. These, in turn, were used in the Phase III report and actions plan.

In June, 2012, the Departments of Agriculture and the Interior released the cohesive strategy's Phase II national report [67]. During this phase, the regional assessments were completed to link the national goals to the need and challenges found at regional and local levels. The regional committees examined the processes by which wildland fire, or its absence, threatens areas and issues of value to the American public, including local economies, watershed quality, wildlife habitat, and others [22]. The regions also explored the social and economic implications of landscape and wildland fire management. The western region encompassed 17 states in the western US, including Alaska and Hawaii, plus the affiliated Pacific Islands.

Each region identified numerous national laws, regulations, and policies which impact the accomplishment of wildland fire management goals. These included the National Environmental Policy Act, Endangered Species Act, National Forest Management Act, the Clean Air Act, and the US Forest Service's National Forest System Land Management Planning Rule. State laws and policies also guide management activities and impact wildland fire and resource management goals. Examples include mandates to suppress wildland fire on state and private lands and laws or policies limiting, or preventing, the use of prescribed fire or fire for resource benefit.

Values. Values were identified by each regional committee, stakeholders, working group member's professional observations, peer-reviewed literature, and previous analyses. Values common to all three regional groups included the safety of firefighters and the public, protection of private property, water conservation and quality, air quality, maintenance and enhancement of local economies, and restoration of healthy and resilient landscapes. The following values were specifically identified by the western regional committee: valuing people for who they are, not what they have in the bank; living or respecting the Western or frontier culture; enjoying vast, wild, open landscapes; and using, and stewarding, public lands.

In development of the cohesive strategy, it was necessary to identify trends and uncertainties. As with values, all regions identified a common core group: population growth; increasing WUI development; changing climate; invasive species spread; changing public expectations regarding wildland fire response; economic fluctuations; land parcellation; and the increasing role of wildland fire equipment and personnel in other disaster and all-hazard response. The western regional committee also identified certain unique trends and uncertainties, including the increased incidence and spread of uncharacteristically large wildfires and degradation of drinking water and watersheds.

Objectives and Actions. The aim of the cohesive strategy is to produce a blueprint for achieving the national goals and reducing risks posed by wildland fire, incorporating objectives and actions at the national, regional, and local levels [22]. Several objectives were found in all three regions. Collaboration and communication were recognized as being the keys to success. Other common objectives: develop and conduct effective education and outreach to empower public engagement in, and support for, wildland fire management activities; proactively use a variety of vegetation management techniques, such as prescribed fire, to achieve local and large landscape objectives; support working forest, wildlands, and local economies; and collaborate to create jobs and diverse products and markets.

Western regional objectives included: the protection of landscapes and multiple values from the effects of unwanted fire; continue to develop, support, and maintain community wildfire protection plans as one of the primary means to achieve the goals of the cohesive strategy; and develop community-based strategies to deal with the impact of post-fire hazards on natural and cultural resources, emergency responders, communities, and planned activities. In turn, the regional committees developed potential actions and activities to support the objectives. Over 300 actions were included in the three regional assessments during Phase II. The actions and their potential to reduce risk were evaluated during Phase III.

Alternative management strategies were developed at the regional level, based on the three national goals and incorporating specific regional needs and constraints [22]. Each regional committee began developing their alternatives using management scenarios and areas to explore for reducing risk. For example, the western regional committee developed one scenario emphasizing landscape resilience, placing a greater emphasis on restoring the landscape with fuels treatments through prescribed fire, mechanical thinning, and wildland fire. Another scenario emphasized the creation of fire-adapted communities through collaboration and self-sufficiency. The three regional committees' management concepts laid the foundation for the Phase III analysis [22].

Finally, the National Science and Analysis Team (NSAT) provided active support during this phase. The NSAT was created for two purposes. First, provide analytical support to the regional committees and Cohesive Strategy Subcommittee. Second, support the development and implementation of the cohesive strategy through the application of proven scientific processes and analysis. Individuals from Federal, state, and tribal agencies, plus universities and the non-profit community, participated in NSAT activities. Research areas included such topics as fuels management, wildfire extent and intensity, landscape resilience, firefighter safety, fire-adapted human communities, public acceptance, and policy effectiveness. Many topics overlap and intersect. Team researchers developed conceptual models which were used to build more rigorous models in the next phase.

Phase III. This phase, which continues at the time of publication, involves taking the qualitative information gathered in Phase II and translating it into quantitative models which can inform management actions on the ground [20]. It will build and test analytical tools, based on science, incorporating the results of the previous two phases. The models which are developed will assess risks to values and inform decision makers. These analyses will help stakeholders understand how their decisions, actions, and policies are likely to influence wildland fire risks. They will also help identify where scientific research should be directed to support stakeholders, decision makers, and policy development.

Regional Risk Analysis Reports. During the initial stage of Phase III, NSAT researchers worked with each regional committee to develop data to assess the wildfire situation. Using this data, each region developed Regional Risk Analysis Reports containing recommendations to achieve the three cohesive strategy goals. These reports were designed as a practical decision support tool for wildland fire management organizations, Federal, state, and local governments, and non-governmental organizations and local communities. The regional reports suggest how key elements can be integrated into strategy, provide examples of how to connect Federal, state, and local interests, provide ideas of how projects and funds can be better aligned and leveraged, and profile organizations which have blended these lessons to build stronger collaborations [20].

The western regional report was framed within the context of the regional landscape. One component was the significant wildfire risk from overstocked fuels, drought, insects and disease, invasive species, and urban development in WUI areas. The unhealthy forest and rangeland conditions in the West are widespread and increasing, providing conditions for uncharacteristically large, severe, and costly wildfires, with increasing threats to human life and property. These environmental conditions, along with the spread of the WUI, underlie four broad areas of risk: risk to firefighters and civilian safety, plus ecological, social, and economic risks. The report also noted that with a variety of landscapes and land ownership in the region, one key weakness was the availability of data. The region has a large amount of land administered by various Federal agencies, often interspersed with private property or property owned by local or state governments. This poses a management and response challenge for wildfires or other incidents at landscape scale. Fires that start on Federal land move into private land, threatening homes and communities.

As outlined in the regional report [81], the region's risk analysis data provides a generalized picture of the entire region, while identifying existing biophysical and social conditions. Its analysis identifies where wildfires are burning, where future wildfires are likely to occur, and where mitigation may reduce the severity of future wildfires. The analysis also summarizes the three previously discussed alternatives in relation to the cohesive strategy's goals and social, economic, and ecological conditions. Similar to the strategy's goals, the three alternatives are not exclusive. There is no one preferred option to be applied across the region. The alternatives are considered investment options that are thought to offer the greatest possible impact.

The western regional committee oversaw the development of recommendations that applied to the cohesive strategy's goals, either collectively or individually. The following are examples of the various recommendations. Two recommendations were for the collective goals. The first was providing resources to support local government officials, including fire chiefs, in the integration of the cohesive strategy into their communities and operations. The second was addressing identified barriers and promoting critical success factors across the region and at all levels. For the goal of landscape resiliency, one recommendation was to encourage agencies to use existing legislation and contracting tools to expedite fuels treatments. Criteria could include projects that reduce the risk to landscapes and communities by focusing on areas with a high burn probability. Regarding fire-adapted communities, recommendations included: facilitating shared learning among communities for adaptation, review and modifying requirements for technical and financial support of communities, and develop and promote local collaborative capacities to implement fuels treatments and response to fires. Finally, for fire response, one recommendation is to integrate Federal, state, local, and tribal response capability. This would be done by identifying where the greatest opportunities exist in communication, training, qualification, and mobilization.

Regional Action Plans. Each region's risk analysis, combined with the Phase II assessment and strategy, was further refined into the Regional Action Plan, describing the actions and tasks identified to implement the recommendations for landscapes, communities at risk, and fire response [80]. Planning included agencies and other stakeholders involved in each specific action. As with the other regional plans, the Western Region Action Plan is a dynamic document that will be updated continually and modified on a 5-year basis to best focus on the issues surrounding wildland fire in the West. It is a science-based guide to direct a regionally-focused approach to wildland fire that holistically addresses the needs of the landscape, communities, and emergency responders. The plan builds upon the previously developed recommendations to identify specific actions and tasks, suggests lead and collaborating agencies, and establishes timeframes in which the actions and tasks should take place.

The recommendations fell into four broad categories: overarching actions, actions to restore and maintain landscapes, actions to promote fire-adapted communities, and actions to promote fire response. Using fire-adapted communities as an example of enabling resilience, the western region intends to promote the development of community capacity and link them into a sub-regional communication and learning network. Fire adaptation is viewed as a continuum, with communities moving toward adaptation through a collaborative process involving the development and refinement of community wildfire protection plans, fuels treatments, the "Firewise Communities," "Fire Adapted Communities," and "Ready, Set, Go!" programs, and other community-level activities. This is a continuous process requiring periodic reviews and a renewal of commitment to be successful. Communities will also need technical and financial support to move toward fire adaptation [8]. There are additional recommendations for monitoring and accountability. The action plan serves as a guide for moving forward to recognize the benefits of fire on the landscape, where and when it is appropriate, and to reduce the negative impacts of wildfire on natural resources, humans, and values at risk [80].

National Strategy. The WFEC accepted the regional plans in April, 2013. Regional contributions inform the national-level analysis, which includes not only an analysis of wildland fire issues, but also interrelationships between biophysical and socio-economic drivers and the development of policy options [8]. The draft Phase III report, National Wildland Fire Management Strategy and Risk Analysis Report (National Strategy), was released in August of 2013, with the final report and national action plan released in April, 2014. The national strategy and companion national action plan represent the completion of the cohesive strategy effort. The national strategy is comprehensive and science-based. It is being implemented across the country and overseen by the WFEC, which will establish a 5-year review cycle to provide updates to Congress.

The risk analysis report identified eleven barriers and critical success factors (CSF). The barriers have to be removed, and critical success factors met, for the national strategy to be successful. Each was selected by the regional committees as being the highest priority barriers and CSFs to be addressed in order to contribute to a successful strategy implementation. Continuing with the discussion of resilient communities, one barrier and CSF was growth management, land development, and zoning laws. Reducing the risk to firefighters and homeowners, reduced suppression costs, and lowered insurance rates were identified as top priorities. There is a need for growth management, land development, and zoning laws that require defensible space and wildfire risk reduction actions as communities develop. These include creation of defensible space, fire-resistant construction, hazard reduction, and other actions, plus the continued maintenance of these actions. Another barrier and CSF was the implementation of enforceable fire prevention ordinances at the state and local levels [8].

Policy Options. In its Phase III report, the CSSC stated that the key to strategy success and building national policy options is to understand the underlying relationships between biophysical landscapes, the people who inhabit them, and wildland fire. In 2012, the NSAT was tasked to explore potential options for achieving the goals of the national strategy and to identify the challenges, opportunities, and trade-offs inherent in each option [8]. These options are presented in the final report. The purpose was to conduct a broad, strategic overview that could inform subsequent decision making at both the regional and national levels. The policy options support intergovernmental decisions about maintaining, emphasizing, or de-emphasizing, management actions in different contexts and locations. A wide range of environmental, socioeconomic, and wildfire data has been collected to support the development of the strategy and its components. This data was consolidated and summarized at the county level (3,109 nationwide) to provide a comparable unit of analysis across data sets. This allowed the data to identify relationships among key factors and variables. It also allowed the development of maps that highlighted intra- or inter-regional or state similarities and differences.

As previously discussed, a central goal of the national strategy is promoting fire-adapted communities. The plan views the wildfire risk to communities and values as the intersection of three principal elements. They are wildfire occurrence and extent, homes and communities, and socioeconomic resources. The values threatened include homes, buildings, infrastructure, firefighter and public safety, public health, and the benefits communities derive from the landscape around them. Analysis and development of the report's policy options considered this community framework, plus landscape resiliency (fire frequency, forested area, etc.), WUI area, home density, demographic measures, and other factors. In developing the policy options, factors were grouped into the two principal themes of landscape resiliency and risk to communities [8].

One conceptual view of the national strategy is that of a collection of policies and management actions that collectively influence vegetation composition and structure, wildfire extent and intensity, response to wildfire, and community preparedness and resiliency. These then influence the goods and services received from forests and rangelands, firefighter and public safety, and homes and property affected by fire. This conceptual framework can be applied at any scale. For the purpose of the national risk analysis, the WFEC considered a series of options that might be considered from a national perspective. They are grouped into the four management themes of broad scale fuels management, managing human ignitions, home and community actions, and response to wildfire [8].

Moving Toward the Future. The national strategy recognizes that while wildfire is a national challenge, each fire is a local event, impacting people, landscapes, and resources. The national plan compliments regional plans in addressing wildfire issues with both national and local perspectives. Several steps remain to be taken. Issues of national scope are addressed in the national action plan. The plan identifies actions, tasks, and lead agencies. It also identifies priorities and a methodology for monitoring and accountability. Stakeholders and collaborative partners will continue to be involved as the plan is implemented. Finally, working groups will address recommendations to improve barriers and CSF's and examine efficient governance and oversight [8].

In summary, the national strategy identifies several outcomes. Foremost, responsibility for actions resides with all stakeholders at various scales. The strategy is designed to be developed and implemented in a collaborative environment, where all stakeholders engaged and effected by wildfire work toward common goals, are aware of wildland fire risks and opportunities to address risks, and make decisions with compatible and cohesive information. The strategy also creates a policy environment recognizing opportunities to reduce risk, rewarding successful efforts at reducing risk, recognizing barriers that prevent the achievement of common goals, and attempting to reduce barriers through an iterative process using adaptive learning. The strategy also creates a science environment that enhances multi-scale understanding of wildfire risks to important values, opportunities to reduce risk, and trade-offs among options intended to reduce risk. A final outcome is that of a decision-making environment where complimentary decisions are possible among agencies, organizations, and stakeholders at all scales, risks are reduced and managed, and the three strategy goals of healthy and resilient landscapes, fire-adapted communities, and fire response influence outcomes [21].

The regional or local component of the national strategy development was a common theme in the chapter's previous sections. The remaining section explores this relationship further. Recent wildfire incidents in Colorado necessitated action on the part of the state's Governor. How the national strategy's formulation informed analysis and policy implementation in Colorado is the subject of the following section.

4.6 Task Force on Wildfire Insurance and Forest Health

While the national strategy involves multiple scales, linked initiatives are taking place within Colorado. In response to the catastrophic wildfires of 2012, the state's governor, John Hickenlooper, issued executive orders to establish two entities in January, 2013. One was the Task Force on Wildfire Insurance and Forest Health (Task Force), created by Executive Order B 2013-002. The Governor charged the task force to identify and reach agreement on ways to encourage activities, practices, and policies that would reduce the risk of loss in WUI areas and provide greater customer choice and knowledge of insurance options. The other was the Advisory Committee to the Director of the Division of Fire Protection and Control on Wildland Fire and Prescribed Fire Matters (Executive Order B 2013-001). Governor Hickenlooper tasked the advisory committee to work to improve the state's approach to forest health and develop a long-term strategy for sustaining vital resources [69]. As identified in the national strategy, linkages between the national, regional, and local levels are critical for successful implementation. This section provides an overview of the task force's activities and how recommendations are nested with the national strategy. Task Force-related legislative proposals, currently progressing through the state's legislative process, are also discussed. The Advisory Committee's activities are not being addressed in this chapter and would be an appropriate subject for further analysis.

Members of the Task Force represented a variety of public and private entities. Public agency membership included the state's Department of Natural Resources, Division of Fire Protection and Control, Division of Homeland Security and Emergency Management, Forest Service, local government representatives, and other agencies. Private sector representatives came from the insurance and banking industries, and a non-governmental conservation organization, among others. The chair was Barbara Kelley, Executive Director of the Colorado Department of Regulatory Agencies [83].

To successfully complete its mandate, the Task Force stated that it had to first, identify the scope of the problem in Colorado and determine how to quantify the magnitude of the wildfire risks in the WUI and second, then identify and consider a variety of ways to address the problems. Recognizing that there is no single solution to wildfires in the WUI, the Task Force developed a series of findings and recommendations which can make a "significant and sustainable difference" in reducing the risk of loss of life and property in future WUI wildfires. The Task

Force also recognized that the recommendations would be “debated, developed, adapted, and implemented” through legislation, rulemaking, and public discourse at all levels of government [84, cover letter].

Convening in February, 2013, the Task Force conducted hearings and working group meetings throughout the year, often at locations within the WUI. While the executive order didn’t specifically reference the parallel national strategy development as a guide, the Task Force used it as a foundation document [9]. In accordance with the national strategy’s philosophy, the Task Force placed an emphasis on a science-based approach to carrying out its mandate. To provide a common baseline for members, the Task Force established an extensive reference set of peer-reviewed, professional, and technical publications. This also included the use of lessons-learned reports from previous wildfire incidents which impacted infrastructure or the landscape. Subject matter experts from a variety of relevant fields presented information to the Task Force in hearing rooms and on the ground. The Task Force presented its findings and recommendations to the Governor on September 30, 2013, and met for the last time on October 22 [9, 84].

Identified in the Task Force mandate, and similar to the cohesive strategy goal, one key focus area was reducing the risk of loss within the WUI. The Task Force examined the condition of Colorado’s forests, noting the challenges resulting from the increase of fuels, drought, pests, and the effects of recent, severe wildfires in the state. This analysis then considered the values at risk from wildfire. Those identified by the Task Force were recreation, wildlife habitat, air and water quality, and homes and infrastructure. In examining the risk to homes and infrastructure, the Task Force framed the subject identical to that used in the cohesive strategy process. To increase safety in fire-adapted communities, the goal would be to withstand a wildfire without the loss of life and property [82]. The Task Force examined four general areas. These were: defensible space, including the adoption of building codes and participation in the “Firewise Communities” and “Fire Adapted Communities” programs; land use zoning and planning at the county, municipal, and homeowner association level; implementation of community wildfire protection plans; and emergency management, such as residential egress and the use of reverse emergency notification (telephone and texts) for residents. The Task Force also looked to other regional states, such as California, Montana, Oregon, and Washington, to gain a better understanding of how these states addressed issues such as WUI development and the implementation of specific building codes and fire protection fees [4, 82].

Task Force Recommendations and Resulting Legislation. Task Force recommendations covered a number of key themes, including risk assessment mapping, improving forest health, building codes and zoning activities, and insurance. The following recommendations were submitted to the Governor and legislative leaders:

1. In coordination with stakeholders, further develop the on-line Colorado Wildfire Risk Assessment Portal (CO-WRAP) to create a mapping tool with the capability to identify and quantify wildfire risks to specific WUI properties. The state forest service developed the CO-WRAP in 2012.

2. Disclose CO-WRAP results to relevant stakeholders.
3. Create a process to handle appeals and updates for CO-WRAP scores.
4. Continue and enhance state-supported grant funding for wildfire risk mitigation.
5. Create a pilot program for prescribed fire and more flexible air quality permitting options from the appropriate state regulatory agencies.
6. Work with stakeholders to identify and disseminate consistent information about WUI best management practices (BMPs) and watershed impacts.
7. Adopt a state-wide model ordinance for WUI properties.
8. Assess a fee on WUI properties to help fund mitigation activities.
9. Prohibit community building or land-use requirements that are inconsistent with science-based, "Firewise" principles.
10. Amend the standard real estate contract to include a WUI disclosure, including the CO-WRAP score.
11. Increase homeowner and stakeholder awareness of financial and technical assistance in Colorado to support wildfire risk mitigation.
12. Develop and require a Wildfire Mitigation Audit for WUI high-risk properties.
13. Disseminate information about pending legislative changes dealing with homeowner's insurance laws. In essence, reinforce the need to for homeowners to protect themselves with adequate insurance.

Release of the Task Force recommendations resulted in an immediate discussion among the public, agencies, and elected officials. Several of the recommendations were viewed as being a radical departure from the status quo. This was especially true of recommendations seen as putting restrictions on building in the WUI or establishing risk-based fees. The Task Force's chair noted that the recommendations were holistic and that she expected homeowners, firefighters, governments, and insurance companies to work together to ensure beneficial changes are made [33]. Senior elected officials have prominently joined the discussion. Governor Hickenlooper doesn't support the recommendations concerning building codes or fees. He observes that these are delegated to counties and municipalities, with state-level mandates not appropriate. While supported by firefighters and agency wildland fire managers, these recommendations were also opposed by housing developers, the real estate industry, and local governments [41, 44].

Legislation resulting from the recommendations and associated discussion was quickly proposed. To date, this has been the sole method for Task Force recommendations to enter the policy process. The Second Regular Session of the Sixty-Ninth General Assembly (state legislature) convened on January 8, 2014. A proposed bill for mandating building codes in the WUI, based on a Task Force recommendation, didn't advance out of legislative committee [11]. As previously mentioned, there is no overarching political support for this initiative at this time. While it is possible that related legislation may still be proposed, it is not seen as being probable at this point. Variations of less contentious Task Force recommendations were introduced as proposed bills and advanced from committee. Currently making their way through the legislative process, these bills will establish a wildfire information and resource center (Senate Bill 14-008), create a wildfire mitigation tax credit (House Bill 14-009), and create a local firefighter safety grant program (Senate Bill 14-046) [10].

The Task Force dealt with a complex subject and made some far-reaching and innovative recommendations. There was general recognition that Colorado must address wildfire-related issues. At this time, however, the political process is focusing on actions which are not seen as being contentious or politically risky. The extent to which further non-legislative rules and management actions are introduced remains to be seen.

5 Conclusion

To use a colloquial term, there are a lot of moving pieces when it comes to wildland fire management in the western US. Governments and agencies at various scales, private sector entities, individuals, management plans, funding priorities, the level of community preparedness, and the landscape, itself, are just a few pieces that fit into this puzzle. The mix of an ever-increasing WUI and the changing nature of fire on the landscape can result in loss of life and damage or destruction to infrastructure, often with significant social and economic implications. Recent wildfire incidents in Colorado have reinforced this only too well.

This chapter examined how the recently-developed National Cohesive Wildfire Management Strategy could enable resilience in light of the severity of the various challenges associated with wildfires. It also explored how a recent initiative by Colorado's governor, nested with the national strategy, attempted to deal with forest health, wildfires, and communities within the state. It is too soon to determine whether the national strategy or Colorado's emerging legislation will be successful. The national strategy was just implemented within the pastyear. Based on its goals and methodology, however, the strategy offers the potential to meet its objectives and enable resiliency.

The national strategy is a collaborative process seeking a national, all-lands solution to wildland fire management issues. The goals of restoring and maintaining resilient landscapes, fire-adapted communities, and responding to wildland fire provide a guide to plan for, respond to, and recover from wildland fire incidents. In this age of scare resources and funding, a collaborative strategy is essential. The incorporation of a science-based process will prove critical when dealing with wildfire's complex biophysical, social, and economic components.

Colorado has seen significant impacts from wildland fire, in both lives and property, over the past several years. This chapter summarized a recent review and analysis process which resulted in recommendations seeking to minimize the impacts of wildfires on individuals, communities, and infrastructure. The link to enabling resilience was clearly established by the Task Force's reference to the national strategy and its goal of communities withstanding a wildfire without the loss of life or property. The major factor within the state shaping pending legislation and potential management initiatives is political will. The Governor would not publicly support certain recommendations that changed the status quo in WUI development. Similar legislative efforts also failed. Only time will tell whether perspectives change and a new thought process develops regarding how to prepare for, and manage, wildfires in the state.

This is truly a dynamic time for wildland fire management. In the short term, national, regional and local initiatives will be implemented. Further research is appropriate to determine how successful they will be in the accomplishment of their goals. Potential application of this methodology to other fields of disaster management is also a potential area to be examined. Anecdotally, the author has spoken with fire managers and incident commanders in his hometown of Fort Collins, Colorado. One county-level manager said that in his 20 years in wildland fire management, current fires have a much higher level of intensity than those on the past. He has never seen anything like their rate of spread and impact on the landscape and communities. Time will tell whether the national strategy and nested regional and local planning are robust and agile enough to deal with this new reality in the American West.

References

1. Absher J, Vaske J (2005) An analysis of homeowner and agency wildland fire mitigation strategies. In: Peden JG, Schuster RM (eds.) Proceedings of the 2005 Northeastern Recreation Research Symposium, April 10–12, Bolton Landing, NY. General Technical Report NE-341, pp 231−236. US Department of Agriculture, Forest Service, Northeastern Research Station, Newtown Square, PA
2. Birkland T (1997) After disaster: agenda setting, public policy, and focusing events. Georgetown University Press, Washington DC
3. Black AE, McBride BB (2013) Safety climate in the US Federal Wildland Fire Management Community: influences of organizational, environmental, group and individual characteristics. Int J Wildland Fire 22(6):850–861
4. Burton L (2013) Wildfire mitigation law in the Mountain States of the American West: a comparative assessment, http://www.ucdenver.edu/academics/colleges/SPA/Research/EAWG/Research/wildfires/Documents/WhtPprIntrstStdy15jul13.pdf
5. California Environmental Associates (2013) EcoWest: counting homes in the Western WUI, http://www.ecowest.org/2013/07/05/counting-homes-in-the-western-wui/
6. Carroll M, Blatner K, Cohn P, Morgan T (2007) Managing fire danger in the forests of the US Inland Northwest: a classic, "wicked problem" in public land policy. J Forest 105:239–244
7. City of Colorado Springs (2013) Waldo Canyon Fire: Final After Action Report, http://www.springsgov.com/units/communications/ColoradoSpringsFinalWaldoAAR_3April2013.pdf
8. Cohesive Strategy Subcommittee (2013) The national cohesive wildland fire management strategy and risk analysis-phase III report (draft, 2013)
9. Colorado Department of Regulatory Agencies (2013) Informational website for the task force on wildfire insurance and forest health, http://www.dora.state.co.us/taskforce/
10. Colorado General Assembly (2014) Bill folders, http://www.leg.state.co.us/CLICS/CLICS2014A/csl.nsf/MainBills?openFrameset
11. Colorado Legislative Council (2014) Wildfire Matters Review Committee: bills not recommended to legislative council, http://www.colorado.gov/cs/Satellite/CGA-LegislativeCouncil/CLC/1251642784983

12. Colorado State Forest Service (2012) Lower north fork fire, http://csfs.colostate.edu/pages/lnf-fire-information.html
13. Colorado State Forest Service (n.d) Agency overview (Brochure). Author, Fort Collins, CO
14. Congressional Research Service (2010a) H.R. 2996-Department of the interior, environment, and related agencies appropriations act, 2010, 111th Congress (2009–2010), http://beta.congress.gov/bill/111th-congress/house-bill/2996
15. Congressional Research Service (2010b) Summary S.561–111th Congress (2009–2010), http://beta.congress.gov/bill/111th/senate-bill/561
16. Coppola D (2007) Introduction to international disaster management. Butterworth-Heinemann, Burlington
17. Dale L (2010) The true cost of wildfire in the Western U.S. Western Forestry Leadership Coalition, Lakewood, CO
18. Dennis F, Sturtevant R (2007) Forest restoration guidelines in ponderosa pine on the front range of Colorado. Colorado State Forest Service, Fort Collins
19. Departments of Agriculture and the Interior (2013a) Cohesive strategy governance and engagement, http://www.forestsandrangelands.gov/strategy/governance.shtml
20. Departments of Agriculture and the Interior (2013b) Overview: national cohesive wildland fire management strategy, http://www.forestsandrangelands.gov/strategy/overview.shtml
21. Departments of Agriculture and the Interior (2013c) The cohesive strategy, http://www.forestsandrangelands.gov/strategy/communicators.shtml
22. Departments of Agriculture and the Interior (2012) A national cohesive wildland fire management strategy phaseii national report, http://www.forestsandrangelands.gov/strategy/documents/reports/phase2/CSPhaseIIReport_FINAL20120524.pdf
23. Departments of Agriculture and the Interior: A National Cohesive Wildland Fire Management Strategy. Authors, Washington, DC (2011a)
24. Departments of Agriculture and the Interior (2011b) The federal land assistance, management and enhancement act of 2009 report to congress. Authors, Washington, DC, http://www.forestsandrangelands.gov/strategy/documents/reports/2_ReportToCongress03172011.pdf
25. Flint C, McFarlane B, Müller M (2009) Human dimensions of forest disturbance by insects: an international synthesis. Environ Manage 43(6):1174–1186
26. Gebert K (2008) Venture capital. Wildfire, March/April, pp 24–29 (2008)
27. Geographic Area Coordination Center (2014) Rocky mountain area coordination center, http://gacc.nifc.gov/rmcc/ (2014)
28. Gill M, Stephens S (2009) Scientific and social challenges for the management of fire-prone wildland-urban interfaces. Environ Res Lett 4:1–10
29. Gorte W (2011) Federal funding for wildfire control and management. Congressional Research Service Report RL33990 (2011)
30. Goyer R, Wagner MR, Schowalter TC (1998) Current and proposed technologies for bark beetle management. J Forest 96(12):29–33
31. Graham R, McCaffrey S, Jain T (2004) Science basis for changing forest structure to modify wildfire behavior and severity. General Technical Report RMRS-GTR-120. US Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, UT (2004)
32. Handmer J, Dovers S (2013) Handbook of Disaster Policies and Institutions: Improving Emergency Management and Climate Change Adaptation, 2nd edn. Routledge, NY
33. Handy M (2013) Group's suggestions spur mixed feelings. Fort Collins Coloradoan, 13 October 2013
34. Headwaters Economics (2013a) As wildland-urban interface (WUI) develops: firefighting costs will soar, http://headwaterseconomics.org/interactive/wui-development-and-wildfire-costs
35. Headwaters Economics (2013b) The rising costs of wildfire protection, http://headwaterseconomics.org/wildfire/fire-cost-background
36. International Association of Fire Chiefs (2014) Ready, set, go! http://www.wildlandfirersg.org/ (2014)
37. International Association of Fire Chiefs (2012) Wildland fire programs: ready, set, go! [Pamphlet] (2012)

38. International Association of Fire Chiefs (2009) Quadrennial fire review, http://www.iafc.org/displayindustryarticle.cfm?articlenbr=38303 (2009)
39. International Association of Wildland Fire (2013) WUI fact sheet, http://www.iawfonline.org/pdf/WUI_Fact_Sheet_08012013.pdf
40. Larimer County Sheriff (2012) High park fire, http://larimersheriff.org/press-release/high-park-fire-3 (2012)
41. Lee K (2014) Worsening wildfires spark modest fixes. The Denver Post, 24 January 2014
42. McLoughlin D (2011) Prescribing fire: a hot Australian topic. Wildfire 20(5):14–19
43. Miller JD, Safford HD, Crimmins M, Thode AE (2009) Quantitative evidence for increasing forest fire severity in the Sierra Nevada and Southern Cascade Mountains, California and Nevada. USA Ecosystems 12:16–32. doi:10.1007/s10021-008-9201-9
44. Moreno I (2014) Governor supports bills to combat wildfires. The Fort Collins Coloradoan, 24 January 2014
45. National Association of State Foresters (2009) Quadrennial fire review 2009. Author, Washington, DC (2009)
46. National Fire Protection Association (2014a) Our initiatives, http://www.nfpa.org/about-nfpa/our-initiatives
47. National Fire Protection Association (2014b) Wildland fires, http://www.nfpa.org/safety-information/for-consumers/outdoors/wildland-fires
48. National Fire Protection Association (2013) Fire Adapted Communities (Pamphlet)
49. National Fire Protection Association (2012) How to Have a Firewise Home (Pamphlet)
50. National Interagency Coordination Center (2013) Wildland fire summary and statistics 2012 annual report, http://www.predictiveservices.nifc.gov/intelligence/2012_statssumm/intro _summary.pdf
51. National Interagency Fire Center (2014a) Interagency standards for fire and fire aviation operations: chapter 1, federal fire program policy and guidance overview, http://www.nifc.gov/PUBLICATIONS/redbook/2014/Chapter01.pdf
52. National Interagency Fire Center (2014b) Policies, http://www.nifc.gov/policies/policies_main.html
53. National Interagency Fire Center (2014c) Safety: historical wildland firefighter fatality reports, http://www.nifc.gov/safety/safety_HistFatality_report.html
54. National Interagency Fire Center (2014d) Statistics: suppression costs (1985–2012), http://www.nifc.gov/fireInfo/fireInfo_documents/SuppCosts.pdf
55. National Wildfire Coordinating Group (2013) NWCG Members, http://www.nwcg.gov/nwcg_admin/members.htm
56. National Wildfire Coordinating Group (2012) PMS 205: glossary of wildland fire terminology, http://www.nwcg.gov/pms/pubs/glossary/p.htm
57. National Wildfire Coordinating Group (2010) NWCG #24-2010: Terminology updates resulting from release of the guidance for the implementation of federal Wildland fire management policy
58. National Wildfire Coordinating Group (2009a) Interagency large fire cost reviews-process and guidance (NWCG Memorandum #003-2009). National interagency fire center, boise, ID, http://www.nwcg.gov/var/of-interest-1/nwcg-excutive-board/eb-historical-documents/memos/2009/nwcg-003-2009-interagency-large-fire-cost-reviews-process-and-guidance/view
59. National Wildfire Coordinating Group (2009b) Update on the modifications to the interagency strategy for the implementation of federal Wildland fire management policy (NWCG Memorandum #001-2009). National Interagency Fire Center, Boise, ID, http://www.nwcg.gov/general/memos/nwcg-001-2009
60. Nazzaro R (2007) Wildland Fire management: lack of a cohesive strategy hinders agencies' cost-containment efforts. Testimony before the Committee on Natural Resources, US Senate. United States Government Accountability Office (GAO) Publication GAO-07-427T. US Government Printing Office, Washington, DC
61. Nazzaro R (2006) Wildland fire suppression: lack of clear guidance raises concerns about cost sharing between federal and nonfederal entities. Report to the chairman, subcommittee on public lands and forests, Committee on Natural Resources, US Senate. United States Government Accountability Office (GAO) Publication GAO-06-570. US Government Printing Office, Washington, DC

62. Neary D, Ryan K, DeBano L (2004) Summary and research needs. In: Neary D, Ryan K, DeBano L (eds.) Wildland fire in ecosystems: effects of fire on soil and water. General Technical Report RMRS-GTR-42-vol. 4, pp 207–212. US Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, UT
63. Pyne S (2010) America's fires: a historical context for policy and practice. Forest Historical Society, Durham
64. Pyne S (2009) Fire on the fringe. Environ Res Lett 4:1–3
65. Pyne S (2007) Problems, paradoxes, paradigms: triangulating fire research. Int J Wildland Fire 16(3):271–276
66. Rocky Mountain Insurance Information Association (2012) Wildfire, http://www.rmiia.org/Catastrophes_and_Statistics/Wildfire.asp
67. Salazar K, Vilsack T (2012) Cohesive strategy phase II transmittal letter, http://www.forestsandrangelands.gov/strategy/documents/reports/phase2/CSPhaseIIReportTransmittalLetter052212.pdf
68. Schwedler J (2013) Forest coalition lauds new emergency fire funding bill in senate. National Association of State Foresters Press Release
69. State of Colorado (2013) Gov. Hickenlooper announces wildfire insurance and forest health task force, Wildland Fire Advisory Committee, http://www.colorado.gov/cs/Satellite=Pagechildpagename=GovHickenlooper2FCBONLayoutcid=1251639076858pagename=CBONWrapper
70. Stein S, Menakis J, Carr M, Comas S, Stewart S, Cleveland H, Bramwell L, Radeloff V (2013) Wildfire, wildlands, and people: understanding and preparing for wildfire in the wildland-urban interface. General Technical Report RMRS-GTR-299. US Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR
71. Stephens S, Ruth L (2005) Federal forest-fire policy in the United States. Ecol Appl 15(2):532–542
72. United State Forest Service (2013) InciWeb: black forest fire, http://inciweb.nwcg.gov/incident/3424/
73. United States Forest Service (2012a) Managing wildland fires through ecosystem restoration, http://www.fs.fed.us/fire/management/ecosystem_restoration.html
74. United States Forest Service: Managing Wildland Fires: Prescribed Fire, http://www.fs.fed.us/fire/management/rx.html (2012b)
75. United States Forest Service (n.d.) US forest service FY 2010 president's budget overview, http://www.fs.fed.us/publications/budget-2010/overview-fy-2010-budget-request.pdf
76. United States House of Representatives (2014) Committees, http://www.house.gov/committees/
77. United States Senate (2014) Committees, http://www.senate.gov/pagelayout committees/d_three_sections_with_teasers/committees_home.htm
78. Walker B, Holling CS, Carpenter SR, Kinzig A (2004) Resilience, adaptability, and transformability in social-ecological systems. Ecol Soc, 9(5), http://www.ecologyandsociety.org/vol9/iss2/art5
79. Westerling AL, Hidalgo HG, Cayan DR, Swetnam TW (2006) Warming and earlier spring increase western us forest wildfire activity. Science 313(5798):940–943. doi:10.1126/science.1128834
80. Western Regional Strategy Committee (2013a) The national cohesive wildland fire management strategy: phase III western regional action plan, http://www.forestsandrangelands.gov/strategy/documents/rsc/west/WestRAP_Final20130416.pdf
81. Western Regional Strategy Committee (2013b) The national cohesive wildland fire management strategy: phase III western regional science based risk analysis report, http://www.forestsandrangelands.gov/strategy/documents/reports/phase3/WesternRegionalRiskAnalysisReportExecSummary11162012.pdf
82. Wildfire Insurance and Forest Health Task Force (2013a) Forest health and the wildland-urban interface, http://www.dora.state.co.us/taskforce/

83. Wildfire Insurance and Forest Health Task Force (2013b) Membership and contact information, http://www.dora.state.co.us/taskforce/Membership2.html
84. Wildfire Insurance and Forest Health Task Force (2013c) Report to the governor of Colorado, the speaker of the house of representatives, and the president of the senate. Colorado Department of Regulatory Agencies, Denver, CO
85. Wildland Fire Leadership Council (2012a) Implementation of the national cohesive wildland fire management strategy
86. Wildland Fire Leadership Council (2012b) Wildland fire governance
87. Wildland Firefighter Foundation (2013) Fallen wildland firefighters, http://www.wffoundation.org/Page.asp?NavID=22
88. Wilfong T (2004) Fire programs. In: Oldham C (ed) Forest service centennial: a new century of service, 1905–2005. Fairmont Publications, Tampa, pp 48–61

Vulnerabilities and Co-evolutionary Dynamics in Morelia Michoacan, Mexico: A Case Study

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Abstract This chapter suggests that human populations' vulnerability to environmental hazards relates to sustainability and complexity sciences, given the global, multi-disciplinary and dynamic nature of the issues currently faced by humanity. Among the human population affected by environmental disasters (being of hydrometeorological, geological, biological, technological, and even socioeconomic nature), the poor are usually the most affected [14, 79]. According to The Munich Re group (2012), even though from 2007–2010 the losses due to climatological disasters were greater on first world countries, the insurance payments were also greater than in third world countries, where insurance rarely exists. Not only the lack of basic infrastructure, education, goods and services make the human poor more vulnerable to disasters, poverty issues also hinder the response of governments after each event. Human populations' vulnerability to environmental hazards can be understood as a non-linear dynamical process among physical, economic, ecologic, and sociocultural factors. Depending on the dynamic outcome among them, these factors either contribute or hinder human societies' sustainability. The case study for this chapter is Morelia, which is the capital city of Michoacan State, Mexico. The city had 729,279 residents in 2010, and it is vulnerable to extreme rainfall events, which result in flooding of given areas of the city every raining season. There are also geological fault lines where inhabited sections of the city have been constructed. This study considers social, economic and ecological variables, using metadata from the National Institute of Geography and Statistics (INEGI, [51, 53, 54]) and the National Council for the Assessment of Social Development Policies [26] of Mexico. This information is used to develop a

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A. Masys (ed.), *Disaster Management: Enabling Resilience*,
Lecture Notes in Social Networks, DOI 10.1007/978-3-319-08819-8_15

complex co-evolutionary model to understand the relationships that lead to an increase or mitigate the vulnerability of the case-study population to extreme environmental hazards. The modeling process focuses on developing behavior algorithms to understand the dynamics of four coevolving subsystems: economic, government (local, state and national), the ecosystems, and the human society, the former three treated as black boxes, and the later subdivided as poor, and no poor. From the dynamics of this co-evolutionary process emerges either a stronger or a more vulnerable society. Co-evolution is understood as a circular adaptation process in which the agents learn from their relationships with their environment, being also able to influence the environment willfully or not. The co-evolutionary dynamics are defined by two meta-attributes: *Fitness* and *Flexibility*, as conditions for a sustainable co-evolutionary complex system [62]. *Fitness* refers to the ability of the system-agent to accomplish the goals and purposes for which it was created, while flexibility denotes the capacity of the agent to generate options to continue achieving such purposes and goals [61]. As fitness and flexibility values increase among the agents modeled, the co-evolutionary capacity of these agents needed to cope with environmental hazards increases as well, reducing their vulnerability to such hazards. The attributes used for describing the agents' inner meta-attribute *Fitness* are: health, dwelling, education, income, and disability. The external factors affecting *Fitness* are represented by: access to credit and insurance, information on hazards, and peace and security conditions. To describe the meta-attribute *Flexibility* the attributes studied are education, income diversification, and family of the agents. The external variables affecting *Flexibility* are income distribution and educational services diversification and quality. The agents coevolve with each other and with governmental entities that provide educational and health services, and are responsible for obtaining and spreading information related to hazards. The subsystem economy, while treated as a black box, explains the income dynamics, including the income inequality among the population. All these interactions are framed in the ecosystem subsystem which provides ecological services to the population. The more the population grows the more pressure the ecosystem suffers in order to supply services, becoming more susceptible to possible external shocks. The behavior algorithms have been developed according to the attributes described above. The modeled process has so far shown the importance of education in both meta-attributes and the big role that government plays on the decrease or increase of vulnerability levels.

Keywords Vulnerability · Complexity · Sustainability · Coevolution · Agent-based modelling · Simulation

1 Introduction

This chapter describes the application of the complex co-evolutionary systems approach [60, 62] to study human populations' vulnerability to environmental hazards, taken the human poor of Morelia city, Michoacan State, Mexico, as a case study. First, the operational definition of vulnerability to extreme ecological events, its relation with sustainability and complexity sciences, and the concepts of fitness and flexibility as meta-attributes to measure both vulnerability and sustainability are discussed. Second, the case-study is described, with emphasis on the vulnerability of Morelia's human poor population. Third, the behavior algorithms used to model the system of interest are described. Finally, there is a discussion about the outcomes of this study and future lines of research.

1.1 Vulnerability to Extreme Ecological Events

Hinkel [48] proposed that, given the numerous definitions of vulnerability and of ways to measure it, every study that attempts to assess it should draw upon its own field and the questions that are tried to be answered. For this work, vulnerability can be described as a process in which an individual or a population is susceptible of suffering harm. Vulnerability can be used as an assessment tool that can help understand some underlying factors that contribute to disasters. Vulnerability to extreme environmental hazards can be defined as the emergent outcome of a dynamical process among physical, economic, ecologic, and sociocultural factors. Depending on the dynamics among them, these factors either contribute or hinder human societies' vulnerability. Hence, vulnerability implies that some individuals are more vulnerable than others due to differences in their socioeconomic context.

The way the elements of a community interact with each other and with the environment can either increase or mitigate vulnerability patterns. Reducing vulnerability, therefore, implies a reduction of the risk and uncertainty a given community faces against environmental hazards [74]. Hence, the main purpose of this study is to study the social characteristics that define the vulnerability of a given community and to suggest points of intervention to diminish such vulnerability.

1.2 Vulnerability and Development

Considering recent extreme environmental events (i.e. Honduras 1998; Sri Lanka 2004; Chile 2010; Japan 2011) it is easy to infer the tight relationship between vulnerability and development. Extreme events resulted in deaths and material losses among the affected population. However, those living in marginalized conditions suffered the most due not only to the disaster by itself, but to the lack or poor implementation of recovery protocols [8, 18]. Those who have struggled their whole life to build a house only to lose it overnight may not find it easy to rebuild it.

Vulnerability can be understood as an emergent outcome of processes among physical, economic, social and ecological factors. Depending on such process' dynamics, these factors can either increase or reduce vulnerability. Picturing a society completely vulnerable to an extreme environmental hazard without any preparation for a disaster, it could be easily inferred that if such a hazard happened, this particular society is most likely to disappear. Therefore, vulnerability to extreme ecological events should be considered in an inverse relationship with development.

There will always be unforeseen extreme events to which no society could be prepared for. However, many phenomena that have caused disasters in the last decades have been the result of a lack of planning and/or the alteration of ecological resources. For example, it was estimated that after hurricane Mitch hit, between 50 and 75 % of the economic losses were due to poor design and allocation of dwells, bridges, roads, and infrastructure (IADB 1999).

2 Complexity Co-evolutionary Systems

The general systems theory suggests that a system should be studied not only through the parts that integrate it, but also through the relationships among them [11]. In turn, complex systems are difficult to understand, design and control because of the nature of the interactions among their components, implying the need for new methodologies (Functowitz et al. 1999). While there is not a universally accepted definition of the concept of complexity, for this work, complexity is the property of complex systems emerging from non-linear relationships among their components [19]. Human-made systems are complex [40] because of their non-linear processes at all hierarchical levels and within their phase spaces, being the latter the set of possible states of a given dynamical system [61].

In turn, human-made complex co-evolutionary systems (CCeSs) show emergent behavior, resulting from the non-linear interactions among systems' components and with their environment; such a behavior cannot be explained isolating such components' behavior [62]. From non-linear (co-evolutionary) interactions, emerge the individual-agent and the group behavior. Hence, non-linearity-co-evolution means circular processes, in which systems' components change their environment and in turn are changed by the latter [60, 62]. CCeSs emerge from the purposes, perceptions, beliefs, attitudes, values, mental models, and background of their creator-owner-decision-maker and its co-evolution with the resources at their hand in trying to achieve their own multiple, dynamic, and semi-structured purposes [61].

CCeSs achieve sustainability via the enhancement of their capacity to explore and exploit their co-evolutionary phase space—defined as the set of all possible states of a given dynamical system [61]. Hence, Martínez-García [62] defines sustainability as the dynamic, emergent property of CCeSs to co-evolve with their environments, satisfying a diverse array of dynamic purposes bounded by trade-offs, constraints, and different measures of success. Specifically, sustainable CCeSs exhibit enough fitness to achieve their multiple, dynamic, constrained, semi-structured, incommensurable and conflicting purposes while performing above threshold values for failure, and enough flexibility to co-evolve with their environment. Fitness means that the system has the dynamic ability to achieve its purposes and objectives in an effective and efficient way, and flexibility is the systems' ability to dynamically generate, at any given time, sets of feasible, optimal options to achieve such purposes and goals. Fitness and flexibility are dynamic concepts emerging within a dynamic contextual environment, implying that CCeSs do not exists in isolation, but co-evolve with other, lower, higher and equal hierarchy systems, including their creator-owner-observers. Hence, sustainable CCeSs are sets of dynamic, co-evolutionary processes [61]. The definitions above emphasize the essential role of cognition to enhance the agents' capacities and skills for harnessing the complexity of their own systems [68]. Therefore, as self-generated, cognitive systems with humans at their core, the main technical problem for achieving sustainable CCeSs is how to enhance the decision-makers skills for choosing appropriate courses of action, in real time, in response to their own internal, dynamic purposes, while increasing their number of choices to face complex environmental conditions [62]. Furthermore, CCeSs complexity implies irreducibility [65], meaning that their complexity cannot be reduced in trying to understand-design-control them.

When studying vulnerability, co-evolution plays an important role in trying to understand learning processes and responses resulting from unexpected environmental events and the perception of risk and uncertainty. Such a perception is highly linked to social factors such as poverty, education and availability of information on hazards. Unlike adaptation, the concept of co-evolution implies the agent's reason to cope with external changes; hence, adaptation is a process forced by the circumstances and in which human's wit is not a necessary condition. In turn, the concept of co-evolution gives a special relevance to information emerging from systems and its influence on systems components and their interactions. Co-evolution is, therefore, a key element when trying to cope with vulnerability patterns since it provides the agents with inner elements to make better choices that helps them to face hazards. Hence, co-evolution (where cause is effect and effect is cause) imply that a given agent-system modifies and it's modified by the same, lower or higher hierarchy systems [19, 62]. Furthermore, co-evolution implies contextuality, meaning that a complex system share elements with other systems, having such elements a causal role in processes different from those within the original systems [19], meaning that the systems' behavior depends on their context-environment.

Human-made CCeSs generate and apply information and knowledge, as well as new and improved decision-rules, while discovering thresholds and lever points [5]. Lever points refer to relatively small quantities of energy-materials-information which, applied to any given CCeS, result in large behavioral changes [49]. Thresholds serve to measure the cost of achieving a given objective [61]. In turn, bifurcation points emerge when the phase space of a given dynamical system contracts to a single point, in which either the system disappears or transforms itself into an essentially different one [62]. CCeSs non-linearity results in emergent, dynamic, non-linear and unpredictable behaviours [62].

The complex co-evolutionary systems approach [62] underlines the importance of processes and of knowing-leading-to-action versus the rectification of concepts. The information is generated from within; the practice of the system consists on the design of cognitive processes to obtain systemic perceptions, recognizing that the perspective and the personal experience is unique; and that communication is the base of collaborative action.

Martínez-García [62, 63] adds the concept of sustainability to the study of CCeSs in which two conditions are needed: *Fitness* and *Flexibility*. *Fitness* refers to the ability to reach the purposes and objectives for which the system was created, below failure thresholds. *Flexibility* is the capacity of a system for co-evolving with its environment.

For this study, Martinez-Garcia's operational definition of sustainable complex co-evolutionary systems is applied. Therefore, sustainability, as the opposite to vulnerability, is defined by two meta-attributes: *Fitnes*s and *Flexibility.* The assessment of system sustainability would also give the levels of vulnerability in an inverse relationship, this is, the higher the sustainability the lower the level of vulnerability of an agent-system.

3 Case Study: Vulnerability of Poor Population of Morelia Michoacán, México

Morelia is the capital city of Michoacan State, Mexico, located in the Midwest part of the country; its territorial extension covers 1,196.95 km^2. By 2010 the city's population was 729,279 habitants [51]. Within Morelia are the headquarters of the state and some federal government offices, as well as some industrial activities and businesses exchanges, along with the supply of educational services that attract students from neighbor states every year. The city rests on the Guayangareo Valley, which sits in a fold of the Transversal Neovolcanic Belt, north of the Michoacan state. The climate is temperate with summer rains. The municipality belongs to the Lerma-Chapala (93 %) and Balsas (7 %) hydrological regions [52]. Most of the population (70.4 %) works on the tertiary sector. The rest works at the secondary (23.3 %) and primary (3.49 %) economic sectors and there is a 2.81 not specified [51].

3.1 Environmental Hazards Faced in Morelia

The city faces two main types of environmental hazards: fault lines and floods.

3.1.1 Fault Lines

Garduño et al. [37] suggested that fault lines are associated to the overexploitation of aquifers and the presence of potentially seismic systems in the city, adding that Morelia is settled on a region where intense earthquakes have happened in the past. The authors determined five fault lines that resulted from the overexploitation of aquifers, soils' mechanics, and technics of water extraction. These lines are not seismic, but can produce damages on the infrastructure of dwells and on civil works. Moreover, Morelia sits on three potentially seismic faults: La Paloma, La Colina and Cointzio. On the La Paloma line there have been observed three types of hazard: earthquakes, falling blocks and rotational and translational mass movements [37]. Further, it has been suggested that the damages are the result of the lack of enforcement of the legislation designed to protect such areas from urban development [6, 35].

3.1.2 Floods

Morelia faces a three-month long raining season that in several occasions has provoked flooding on specific sections of the city. Historically, the population had endured with these events without major damages. However, these phenomena have become recurrent in the past decade, with greater harm resulting from the rapid growth of the urban area without proper planning, which is linked to the inappropriate building of dwells on risky lands, and of authorities granting permissions without the proper knowledge or disregard of the hazards involved. Further, several new dwells and irregular settlements have been developed in areas prone to floods; even some water sources have been dried to develop urban settlements. The population on these vicinities becomes highly susceptible to total or partial loss of their assets on every raining season [2, 4, 46].

Arreygue-Rocha [4] also points out that the rectification of the flow of the rivers that cross the city (the Chiquito and Grande rivers) has also contributed to increase the dangerousness that the neighborhoods adjacent face. According to official information, there are 27 neighborhoods in the city with high affectations, 4 more with affectations ranging from moderate to high, 12 with moderate affectations and two with affectations ranging from moderate to low [25].

4 Agent-Based Modelling and Simulation (ABMS)

For this work, the focus is on modelling the data and information available for the future development of an agent-based simulation tool. Agent-based modelling and simulation techniques (ABMS) are tools designed for complex systems simulation [12, 41], and could be based on the object-oriented programming (OOP) paradigm [30], where agents can be treated as objects. ABMS tools are very powerful for the study of socioeconomic-ecological systems, dealing with the complexity of such systems from the interactions at the lower hierarchical level, meaning that such a complexity is studied emphasizing bottom-up processes, since higher hierarchy behaviors emerge from lower hierarchy ones [40, 58]. The emergent behavior observed, modelled and simulated via ABMS, allows a better understanding of complex phenomena. Hence, ABMS could be used to predict, explain, and generate decision-rules (heuristics) [42]. ABMS allows answering questions such as: what kind of effect a given agent provokes on the system? What difference would make on the system a given agent's change of behavior?, being such questions formulated at different hierarchical levels [12, 40, 41, 59]. While ABMS are powerful tools, they are contextually limited [73], reflecting the impossibility of capturing the real-life system's complexity with models-simulation tools [19]. Other limits refer to the evaluation of the tool, which should be done against the purposes and objectives of its development [22]. Another is the lack of information and the limits of computational hardware, as well as irrational, subjective and dynamic human behavior, which makes the tool assessment and calibration difficult and the application of its outcomes cautious.

For modelling purposes, the individual members of the human population of interest are considered as agents. Agents are inserted in an environment where they coevolve with other agents, and could possess purposes, attributes, objectives and goals, which make them distinguishable from other agents. Further, agents could learn and coevolve with their environment (including other agents), resulting in changes in themselves, their behavior, and their environment [12, 59]. Hence, these modelling efforts focused on the co-evolutionary dynamics of the vulnerable poor population of Morelia, treating each individual member of such population as agents, aiming at a better understanding of the system of interest, and to finding possible lever points of intervention for decision-making purposes towards sustainability and vulnerability reduction. The agents' interact with other agents at the same hierarchical level, and at higher levels interact with the economy, government and the ecosystems.

4.1 Modelling the Complex Co-evolutionary Complex System of Interest

From non-linear (co-evolutionary) interactions emerge the individual-agent and the group behavior. Hence, non-linearity-co-evolution means a circular process, in which systems' components change their environment and in turn are changed by the latter [60, 62].

Human-made CCeSs generate and apply information and knowledge, generating new and improved decision-rules, while discovering thresholds and lever points [5]. Within this context, when a given human population is declared highly vulnerable, it can be said to be at a bifurcation point, in which such systems either disappear or transform themselves into something qualitatively different [62].

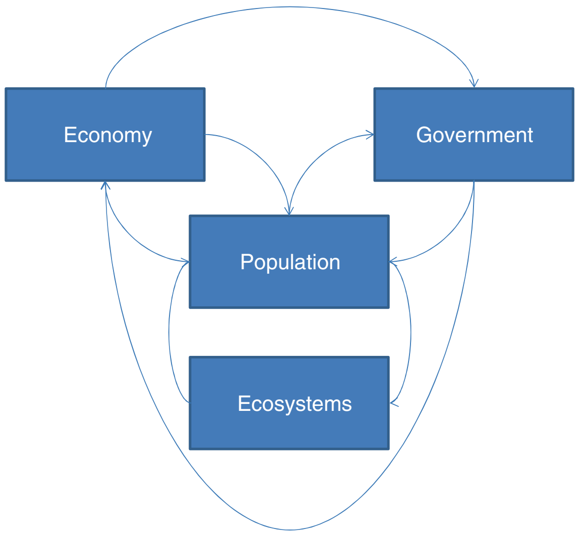

Fig. 1 Vulnerability dynamics

Modelling a complex co-evolutionary complex system starts by understanding the *steady-state*, which represents slow and stable changes in a dynamic system [33]. The *steady-state* is useful to forecast, with the inherent limitations of the complexity of the systems of interest, the future state of such systems, as well as to identify lever points to modify the behavior of the systems of interest making them less vulnerable.

The *steady-state* of Morelia's vulnerability to environmental hazards was modelled using metadata from the National Institute of Geography and Statistics [51, 53, 54] and the National Council for the Assessment of Social Development Policies [26] of Mexico. The modelling outcome resulting from the available meta-data is shown in Fig. 1.

Figure 1 shows how all the systems are connected to generate or reduce vulnerability patterns on the population. In turn, the system of interest was modelled using two types of agents:

- Poor
- No poor

The main focus of this study is the vulnerability dynamics emerging from poverty since people affected by it are already in a highly vulnerable state [8, 29], (UNDP 1994). To model the systems of interest, the agents' behavior is described using behavior algorithms, which capture the decision rules (heuristics) of the system *Population*. *Population* is divided into four subsystems: *occupation, dwelling, education* and *health*. All of them are evaluated according to variables/attributes that compose the meta-attributes *Fitness* and *Flexibility*.

The subsystem *Occupation* assesses the agent's livelihood; that is, the way an agent makes its living (see Fig. 2). *Fitness* is measured from two perspectives: the

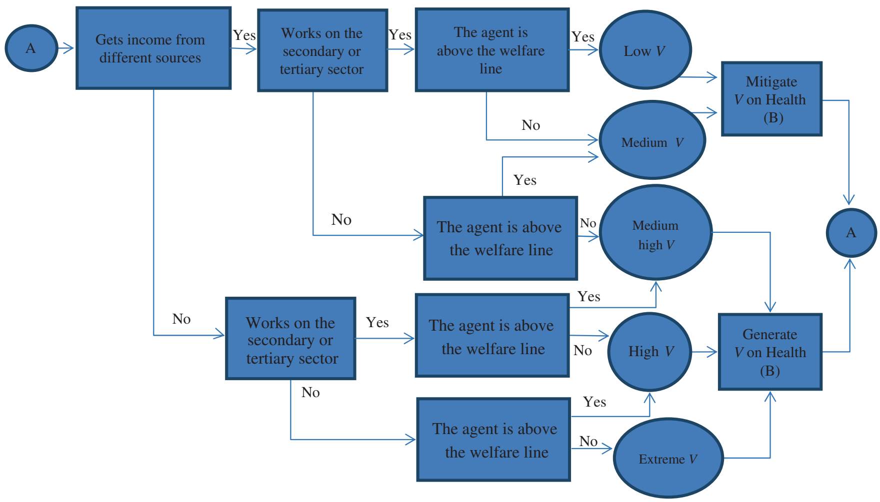

Fig. 2 Diagram of the behavior of the agents: occupation

sector where the agent works, and if the income it gets as result is above the minimum welfare line described by CONEVAL.[1] Some studies show that the population dedicated to the primary sector is more vulnerable to environmental hazards than those that work on the secondary or the tertiary sectors, mainly because of the susceptibility of the assets for the primary sector [29, 82]. In turn, *Flexibility* is assessed as the ability of the agents to obtain their income from different sources. The individual that obtains its income from different sources might be able to still have an active source of income after an extreme environmental event hits. The diagram starts and ends with a letter *A* showing the dynamics of the subsystem—every time a cycle ends an iteration occurs. An agent is in constant change and its vulnerability stage may change through time.

Agents who obtain their income from different sources are *flexible*. Those who do not or that do not work are not *flexible*. Agents who work at the secondary or tertiary sector and whose income is above the minimum welfare line get the full score of *fitness*. Differences in values of attributes that shape *Flexibility* result from agents lacking either one or the other.

Agents are classified into five levels of vulnerability (*V*): low, medium, medium-high, high, and extreme. Agents ranging from medium-high to extreme vulnerability levels generate vulnerability on the *Health* subsystem (B). Due to their low level of income, they would be expected to have a deficient nutrition and poor access to health services, which would make them more susceptible to

[1] Coneval [26] establishes the minimum welfare line as the minimum amount of income needed for people to be able to purchase goods and services to satisfy their dietary and non-dietary needs. People with income below this line are classified as poor.

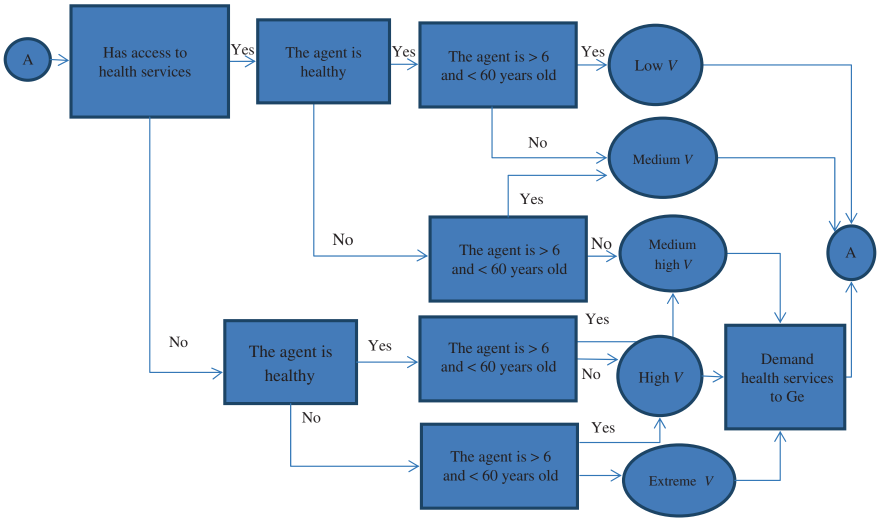

Fig. 3 Diagram of the behavior of the agents. Health (B)

sickness. On the contrary, agents with a level of vulnerability below medium-high mitigate vulnerability patterns on the *Health* subsystem.

For the *Health* (B) subsystem *Fitness* results from two attributes: *disability* and *age*. *Disability* refers to a handicap or disease condition that prevents the agent from having a normal life. The attribute *Age* is important due to the susceptibility of population 6 years or younger and of elders to disasters. These sectors of the population are prone to sickness and also have mobility difficulties; both characteristics are relevant when an extreme environmental event strikes. *Flexibility* is based on the access to health services. Agents who have access to health services may be able to cope with future illnesses better than those who don't (Fig. 3). From the combinations of the meta-attributes *Fitness* and *Flexibility* agents are classified into the same five levels of vulnerability than in the occupation subsystem. Those individuals ranging from medium-high to high vulnerability levels put pressure on the governmental entities demanding health services.

On the subsystem *Dwelling* (C) the meta-attribute *Fitness* is related to the access to public services: electricity, drainage and water; and to the quality of the materials of construction. Dwellings located in areas that can easily flood or in areas covered by fault lines are not flexible since they can suffer seriously damage after an extreme environmental event strikes. Those agents ranging from medium-high to extreme levels on vulnerability within this subsystem generate vulnerability dynamics on the *Health* subsystem, since people who live on houses lacking proper infrastructure are more prone to diseases, resulting in a higher demand to public health services. Agents ranging from medium to low levels of vulnerability on this subsystem mitigate vulnerability on the *Health* subsystem (see Fig. 4).

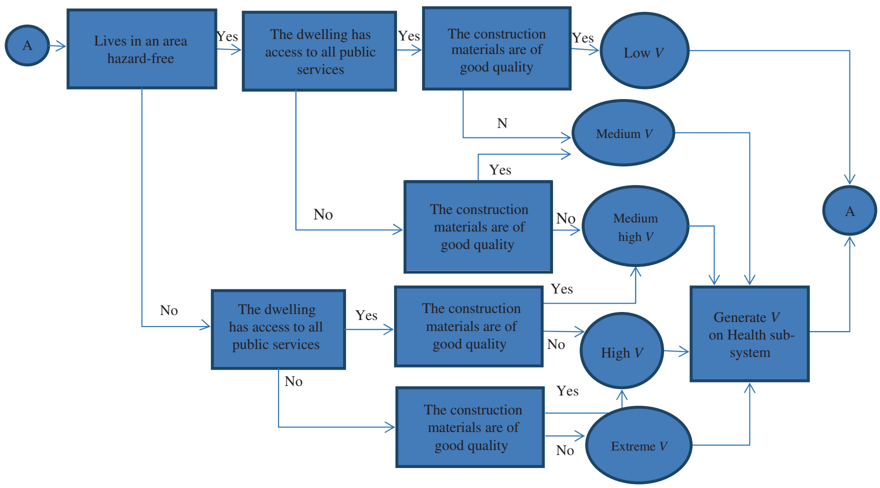

Fig. 4 Diagram of the behavior of the agents. Dwelling (C)

On the subsystem *Education* (D) the meta-attributes *Fitness* and *Flexibility* are assessed from the perspective of the level of education.[2] The higher the level of education of an agent the higher its *fitness*. *Flexibility* then means here the set of skills of an agent. Those agents who have a technical diploma and a professional degree are more likely to get a job in precarious circumstances, for instance, after an extreme environmental event. For instance, those individuals who have a degree and are able to do manual work after a disaster are more flexible. From the combinations of the two meta-attributes the agent is classified into the five levels of vulnerability mentioned above. This subsystem sends information to the *Occupation* (A) one (see Fig. 5). Individuals ranging from extreme to high vulnerability levels generate vulnerability in the *Occupation* subsystem since they may be more susceptible of getting low levels of income. These agents would also have less understanding and information about hazards and disasters. Agents with a level of vulnerability below medium-high could mitigate vulnerability on the *Occupation* subsystem because they are more likely to obtain a better income. These individuals would also have better understanding of the information available regarding hazards and disasters. The degree of vulnerability of an agent is then the average of the vulnerabilities obtained on each subsystem.

[2] It is used the International Standard Classification of Education ISCED developed by UNESCO. For the present study the following classifications are used: ISCED 2c, 3, 4 refers to lower secondary education for which some diplomas to enter the labor market could be obtained. ISCED 5A relates to the first stage of tertiary education not leading directly to an advanced research qualification. ISCED 6 relates to a second stage of tertiary education which leads to an advanced research qualification.

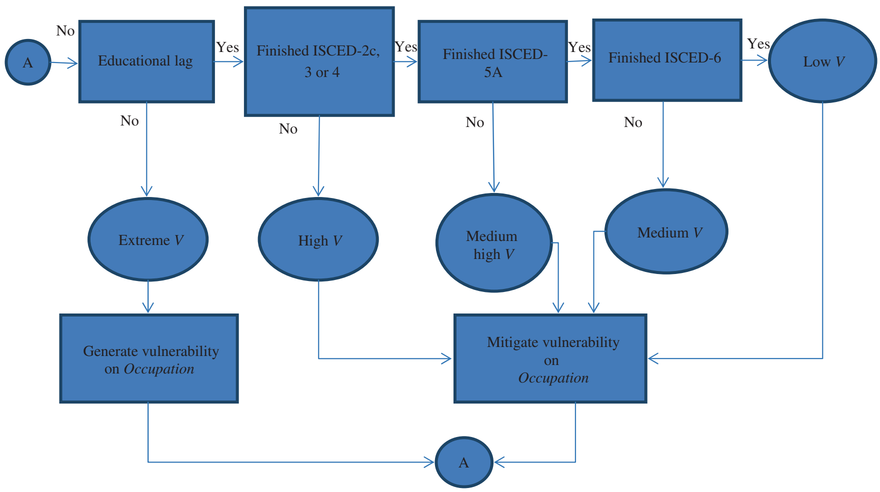

Fig. 5 Diagram of the behavior of the agents. Education

As previously mentioned, the governmental entities (Ge) are another system studied as a black box. In the present model, the governmental entities provide educational and health services, generate information about hazards, publish it massively, and regulate the location and the quality of housing developments and infrastructure. By doing this the governmental entities mitigate vulnerability patterns on the *Population* system. On the contrary, if they fail to provide such services to the population they contribute to vulnerability.

The *Ecosystem* system (Ec) is treated as vulnerable by itself and as generator of hazards as well. The *Ecosystem* get the full impact of the human activities; if such impact goes below its self-regenerating capacity, the ecosystem is declared *fit*. If the *Ecosystem* has the capacity to provide environmental services then it is *flexible*.

For each subsystem attributes that contribute to its *Fitness* and *Flexibility*. While each subsystem can provide important information on the agents' sustainability, the total will be calculated as an average of all of them:

$$Ft = \frac{Ft_A + Ft_B + Ft_C + Ft_D}{4}$$

$$Fl = \frac{Fl_A + Fl_B + Fl_C + Fl_D}{4}$$

where Ft is the meta-attribute *Fitness*, Ft_{A} is fitness in subsystem Occupation (A); Ft_{B} is fitness in subsystem Health (B); Ft_C is fitness in subsystem Dwelling (C); and Ft_D is fitness in subsystem Education (D).

Fl stands for the meta-attribute *Flexibility*, Fl_A is fitness in subsystem Occupation (A); Fl_B is fitness in subsystem Health (B); Fl_C is fitness in subsystem Dwelling (C); and Fl_D is fitness in subsystem Education (D).

Sustainability is, for modelling purposes, defined as

$$S = f(Fl,\ Ft)$$

$$S = \frac{Fl + Ft}{2}$$

As noted above, sustainability is understood as a circular process of knowledge that provides the agent with necessary tools to mitigate vulnerability patterns. This is why the higher the level of sustainability an agent has the lower its level of vulnerability. Vulnerability is then

$$V = 1 - S$$

being −V an asymptote of S.

5 Results

Preliminary results from the modelling effort show a level of sustainability of 0.40 and consequently a level of vulnerability of 0.60 that is classified as medium-high. The population of the city is highly vulnerable (0.80) on the subsystem *Occupation*, due to the small values for *Flexibility* individuals have on this subsystem and to the high number of people that have income below the welfare line. This result also generates vulnerability patterns on the subsystem *health* since poverty usually goes along with low levels of nutrition which, in turn, makes people prone to diseases.

On the subsystem *Health* it was determined a level of vulnerability of 0.65 which is classified as high. There are two important issues to note here, the first one is that only 48 % of the population has access to health services. The other one is that 77 % of the population shows health problems that can be either common diseases or handicaps. This reflects an uneven access of individuals who need medical attention to medical services.

The *Dwelling* subsystem (C) shows a low level (0.15) of vulnerability. It is important to note that only 14 % of the population lives in hazard-prone areas, this number may increase depending on the scale of the extreme event. Approximately 83 % of the population has access to all public services and 86 % lives in dwells built with good quality construction material.

On the *Education* subsystem (D) the level of vulnerability reaches 0.78. It is shown that 73 % of the population has finished basic education but only 15 % have a technical diploma or ISCED 2c, 3 or 4. Moreover, 16 % of the population has finished ISCED 5 and only 0.02 % has finished ISCED 6. These results are relevant since through education individuals are more capable to understand their surroundings and also can aspire to better living standards.

The overall level of vulnerability of Morelia was a 0.54 (medium–high). The city has an enormous potential to reduce its vulnerability to environmental hazards but for two main challenges: poverty and education. Even if access to good education services is available, people might decide to start working at young ages if there is the need. Moreover, it will be very difficult to obtain a wage above the welfare line if the level of education is low, which creates a negative circle of poverty.

All the attributes studied are necessary to improve the levels of sustainability of the individuals. A higher level of sustainability enhances individuals' capacity to make better decisions and reduce vulnerability to extreme events.

6 Conclusions

The city of Morelia faces social challenges to improve the level of sustainability of the population that could help mitigate vulnerability patterns to extreme environmental events. The occupation subsystem represents the main weakness of the population in the city mainly due to the low level of income and the little flexibility shown. Education is also an important matter in the city. Future lines of research refer to the identification of likely lever points of intervention, as well as the development of an ABMS tool for simulation, exploration and evaluation purposes.

References

1. Arreygue-Rocha E, Garduño V, Canuti P, Casagli N, Iotti A, Chiesa S (2001) Análisis geomecánico de la inestabilidad del escarpe La Paloma en la ciudad de Morelia, Michoacán, México. Revista Mexicana de Ciencias Geológicas 19:91–106
2. Arreygue-Rocha E, Garduño V (2004) Eventos excepcionales e inundaciones en la ciudad de Morelia, Michoacán. Ciencia Nicolaita 39:47–60
3. Arreygue-Rocha E, Garduño V, Canuti P, Casagli N, Iotti A (2005) Riesgos geológicos y geomorfológicos de la ciudad de Morelia, Michoacán, México. Geotermia 18:26–36
4. Arreygue-Rocha E (2007) Evaluación de las constantes inundaciones en la ciudad de Morelia, Michoacán, México. 8vo Congreso Iberoamericano de Ingeniería Mecánica. Perú
5. Axelrod R, Cohen MD (1999) Harnessing Complexity-Organizational Implications of a Scientific Frontier. The Free Press, USA
6. Avila A, Campos V, Tripp M, Marter T (2012) El papel del Estado en la gestión urbano-ambiental: el caso de la desregulación en la ciudad de Morelia, Michoacán. Revista Legislativa de Estudios Sociales y de Opinión Pública 5(9):145–179
7. Baker S, Kousis M, Richardson D, Young S (1997) The politics of sustainable development. Theory, policy and practice within the European Union. Routledge, London, UK
8. Beck U (2002) La sociedad del riesgo global. Siglo Veintiuno de España Editores Madrid
9. Beckerman W (1972) Economists, scientists and environmental Catastrophe. Oxford Econ Pap 24(3):327–344 (New Series)
10. Bell S, Morse S (2005) Holism and understanding sustainability. Syst Pract Action Res 18(4):409–426
11. von Bertalanffy L (1976) Teoría General de los Sistemas. Fondo de Cultura Económica, México
12. Bonabeau E (2002) Agent-based modeling: methods and techniques for simulating human systems. PNAS: Proc Natl Acad Sci USA 99(3):7280–7287. doi:10.1073/pnas.082080899

13. BID (2011) Estrategia social para la equidad y productividad América Latina y el Caribe. Washington: BID. Retrieved on Aug 2013 at http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=36706207
14. BID (1999) Reducción de la vulnerabilidad ante amenazas naturales: lecciones aprendidas del huracán Mitch. Documento estratégico sobre gestión ambiental. Taller sobre vulnerabilidad ecológica y social. Suecia. Retrieved on Aug 2013 at http://www.iadb.org/regions/re2/consultative_group/groups/ecology_workshop_1esp.htm
15. Birkmann J (2006a) Indicators and criteria for measuring vulnerability: theoretical bases and requirements. In: Birkmann J (ed) Measuring vulnerability to natural hazards, towards resilient societies. United Nations University Press, Hong Kong
16. Birkmann J (2006b) Measuring vulnerability to promote disaster-resilient societies: conceptual frameworks and definitions. In: Birkmann J (ed) Measuring vulnerability to natural hazards, towards resilient societies. United Nations University Press, Hong Kong
17. Bridger J, Luloff AE (2001) Building the sustainable community: is social capital the answer? Sociol Inq 71(4):458–472 (The University of Texas Press)
18. Chaus W (1993). Vulnerabilidad global. In: Maskrey A (ed) Los desastres no son naturales. Red de Estudios Sociales en Prevención de Desastres en América Latina. Octubre. La Red, Colombia. Retrieved on Jun 2013 at http://www.oei.es/decada/portadas/Desnat.pdf
19. Chu D, Strand R, Fjelland R (2003) Theories of complexity: common denominators of complex systems. Complexity 8(3):19–30
20. Cigna F, Osmanoglu B, Cabral-Cano E, Dixon T, Avila-Olivera J, Garduño V, DeMets C, Wdowinski S (2012) Monitoring land subsidence and its induced geological hazard with Synthethic Apertur radar interferometry: a case study in Morelia, Mexico. Remote Sens Environ 117:146–161
21. Clark W, Jaeger C, Corell R, Kasperson R, McCarthy J, Cash D, Cohen, Desanker P, Dickson N, Epstein P, Guston D, Hall J, Jaeger C, Janetos A, Leary N, Levy M (2000) Assessing vulnerability to global environmental risks. Discussion paper 2000–2012. Environment and Natural Resources Program, Belfer Center for Science and International Affairs, Harvard Kennedy School, Sept
22. Castle CJE, Crooks AT (2006) Principles and concepts of agent-based modelling for developing geospatial simulations, centre for advanced spatial analysis (University College London). Working paper 110, London. Clayton ARN (1997) Sustainability a systems approach. Earthscan, London, UK
23. Cohen J, Stewart I (2000) The collapse of chaos, discovering simplicity in a complex world. Penguin Books, London, Uk
24. Cohen M, Axelrod R (1984) The adaptive value of changing utility. Am Econ Rev 74(1):30–42
25. Corona N (2009) Vulnerabilidad de la ciudad de Morelia a Inundaciones. Unpublished Masters thesis. Centro de Investigaciones Geográfica Ambiental-Universidad Nacional Autónoma de México
26. CONEVAL (2010) Medición multidimensional de la pobreza en México. Consejo Nacional de Evaluación de la Política de Desarrollo Social. Retrieved on http://www.coneval.gob.mx/rw/resource/Metodologia_Medicion_Multidimensional.pdf
27. Cowan G (1999) Opening remarks. In: Cowan et al (ed) Complexity, metaphors, models and reality. Perseus Books Editorial, Cambridge, MA, USA
28. Cutter S (2003) The vulnerability of science and the science of vulnerability. Ann Assoc Am Geogr. 93(1):1–12
29. Cutter S, Boruff B, Shirley L (2003) Social vulnerability to environmental hazards. Soc Sci Q 84(2):242–260
30. Deitel HM, Deitel PJ (2003) Cómo Programar en Java (5ta ed.). Prentice, México Hall. De Jong K, Potter M (1995) Evolving complex structures via cooperative coevolution. Fourth annual conference on evolutionary programming, San Diego, CA
31. De Jong K, Potter M (1995) Evolving complex structures via cooperative coevolution. Fourth annual conference on evolutionary programming. San Diego, CA

32. Dirección Estatal de Protección Civil (2013) Plan de Fenómenos Hidrometeorológicos de Michoacán. Gobierno del Estado de Michoacán de Ocampo. Retrieved on May 2013 at http://www.proteccioncivil.gob.mx/work/models/ProteccionCivil/Resource/776/1/images/Plan%20Fenomenos%20Hidrometeorologicos%20Michoacan%202013(1).pdf
33. Durlaff S (1997) What should policy makers know about economic complexity? Santa Fe Institute working paper. 97-10-080, Santa Fe Institute, New Mexico, USA
34. Douglas M, Wildavsky A (1983) Risk and culture. University of California Press, California
35. Echeverría B, Ochoa L, Landa L, Rojas R (2008) A mexican city case study (Morelia, Michoacán) about buildings and infrastructure damages from active geological faults. Fourteenth world conference on earthquake engineering, Oct, Beijing China
36. Funtowicz SO, Ravetz JR (1994) The worth of a songbird; ecological economics as a post-normal science. Ecol Econ 10:197–207
37. Garduño V, Arreygue-Rocha E, Israde-Alcantara I, Rodrígez-Torres G (2001) Efectos de las fallas asociadas a la sobreexplotación de los acuíferos y la presencia de fallas potencialmente sísmicas en Morelia, Michoacán. Revista Mexicana de Ciencias Geológicas 18:37–54
38. Garza G (2007) Climatología histórica: las ciudades mexicanas ante la sequía (siglos XVII al XIX). Investigaciones Geográficas 63:77–92
39. Gell-Mann M (1999) Complex adaptive systems. In: Cowan K, Pines D, Meltzer D (eds) Complexity, metaphors, models and reality. Perseus Books Editorial, Cambridge, MA
40. Gilbert N (2004) Agent-based social simulation: dealing with complexity. Centre for Research on Social Simulation, University of Surrey, UK
41. Gilbert N, Troitzch K (1999) Simulation for the social scientist. Open University Press, Buckingham, Philadelphia
42. Gross D, Strand R (2000) Can agent-based models assist decisions on large-scale practical problems? A philosophical analysis. Complexity 5(6):26–33
43. Gunningham N (2002) Beyond compliance: next generation environmental regulation. In: Regulation: enforcement and compliance conference convened by the Australian institute of criminology in conjunction with the regulatory institutions network. RSSS, Australian National University and the Division of Business and Enterprise, University of South Australia and held in Melbourne, 2–3 Sept
44. Gunninham N, Kagan R, Thorthon D (2004) Social license and environmental protection: why businesses go beyond compliance. Law Soc Inq 29:307
45. Hare M, Deadman P, Kim L (2001) Towards a taxonomy of agent-based simulation models in environmental management. International congress on modeling and simulation proceedings. The Australian National University, Dec
46. Hernández-Guerrero J, Vieyra-Medrano A, Mendoza M (2012) Adaptation strategies in communities under precarious housing: flooding risk in the peri-urban sector of the city of Morelia, Michoacán, México. Appl Geogr 34:669–679
47. Heylighen F (1999) The growth of structural and functional complexity during evolution, chapter 2. In: Heylighen et al. (eds) The evolution of complexity–the violet book of einstein meets magritte. Kluwer Academic Publishers and VUB University Press, The Netherlands, pp 17–44
48. Hinkel J (2011) Indicators of vulnerability and adaptive capacity: towards a clarification of the science-policy interface. Glob Environ Change 21(1):198–208
49. Holland J (1996) Hidden order: how adaptations builds complexity. Addison-Wesley, Redwood City, CA
50. Holland J (2006) Studying complex adaptive systems (CAS). J Syst Sci Complexity 19:1–8
51. INEGI (2010) Censo de Población y Vivienda. Resultados definitivos. Instituto Nacional de Geografía y Estadística. México. Retrieved on Sep 2013 at http://www.inegi.org.mx/est/contenidos/proyectos/ccpv/cpv2010/Default.aspx
52. INEGI (2009) Prontuario de información geográfica municipal de los Estados Unidos Mexicanos. Morelia, Michoacán de Ocampo, Mexico. Clave geodésica 16053. Retrieved on Aug 2013 at http://mapserver.inegi.org.mx/dsist/prontuario/index2.cfm

53. INEGI (2005) Anuario Estadístico de Michoacán. Instituto Nacional de Geografía y Estadística. México. Retrieved on Aug 2013 at http://www.inegi.org.mx/est/contenidos/espanol/sistemas/aee05/estatal/mic/index.htm
54. INEGI (2000) Anuario Estadístico de Michoacán. Instituto Nacional de Geografía y Estadística, Mexico. Retrieved on Aug 2013 at http://www.inegi.org.mx/prod_serv/contenidos/espanol/bvinegi/productos/integracion/pais/aeeum/2000/aeeum2000.pdf
55. INEGI (1995) Anuario Estadístico de Michoacán. Instituto Nacional de Geografía y Estadística, México. Retrieved on Aug 2013 at http://www.inegi.org.mx/prod_serv/contenidos/espanol/bvinegi/productos/integracion/pais/aeeum/1995/AEEUM95I.pdf
56. INEGI (1990) Anuario Estadístico de Michoacán. Instituto Nacional de Geografía y Estadística, México. Retrieved on Aug 2013 at http://www.inegi.org.mx/prod_serv/contenidos/espanol/bvinegi/productos/integracion/pais/aeeum/1990/AEEUM95I.pdf
57. Kuznetz S (1955) Economic growth and income inequality. Am Econ Rev 45(1):2–28
58. Ma T, Nakamori Y (2004) Agent-based modeling on technological innovation as an evolutionary process. Eur J Oper Res 166(2005):741–755. Retrieved on Aug 2013 at http://dynamics.org/~altenber/PAPERS/EBR/CITED_BY/sdarticle-2.pdf
59. Macal CM, North MJ (2005) Tutorial on agent-based modeling and simulation (part 1). In: Kuhl ME, Steiger NM, Armstrong FB, Joines JA (eds) Proceedings on winter simulation conference 2005. Retrieved 17 Nov 2010. From University of Kentat http://www.kent.ac.uk/secl/philosophy/jw/reasoning/2009/Macal%20North%2005%20-%20Tutorial%20on%20agent-based%20modelling%20and%20simulation.pdf
60. Martínez-García AN (2005) A complex coevolutionary systems approach for the managements sustainable grasslands-A case study in Mexico. Unpublished Ph.D. thesis, Department of Mathematics-School of Physical Sciences—School of Natural and Rural Systems Management. The University of Queensland, Brisbane, Australia
61. Martínez-García ANY, Anderson J (2007) Cárnico-ICSPEA2—a metaheuristics co-evolutionary navigator for a complex co-evolutionary farming system. Eur J Oper Res. 179:634–655
62. Martínez-García A (2010) A complex co-evolutionary systems approach: a case study in Mexico—the management of sustainable grassland. Lambert Academic Publishing, Germany
63. Martínez-Garcia A (2012) Ingeniería de Sistemas Complejos Coevolutivos Sustentables. *C+ Te*c. Consejo Estatal de Ciencia 9:40–42
64. McIntyre L (1998) Complexity: a philosopher's reflexión. Complexity, 3(6):26–32. Mitchell M (2009) Complexity: a guided tour. Oxford University Press, USA
65. Nagamatsu S (2008) Measuring disaster coping capacity of local community for better risk governance. Global Risk Forum Davos. Presentación PPT. Retrieved on Aug 2013 at http://idrc.info/userfiles/image/presentations2008/Nagamatsu_Shingo_Measuring_Disaster_Coping_Capacity_of_Local_Communities_for_Better_Risk_Governance.pdf
66. Ocampo JA (2012) La historia y los retos del desarrollo latinoamericano. Naciones Unidas. Cepal. Retrived on Aug 2013 at http://www.eclac.org/publicaciones/xml/7/48677/Lahistoriaylosretos.pdf
67. Pretty JN (1996) Sustainability works. Our planet 8.4—Nov 1996
68. Putnam R (2001) The prosperous community, social capital and public life. The American prospect. Retrieved on Apr 2013 at http://prospect.org/article/prosperous-community-social-capital-and-public-life
69. Reyna A (2001) Algunas contribuciones de la demografía al estudio de los desastres. In: Garza M, Rodriguez D (eds) Los desastres en México, una perspectiva multidisciplinaria. UNAM, Universidad Iberoamericana AC, México
70. Rodriguez D (2001) Desastre y vulnerabilidad. Entre las ciencias naturales y las ciencias sociales. In: Garza M, Rodriguez D (eds) Los desastres en México, una perspectiva multidisciplinaria. UNAM, Universidad Iberoamericana AC, México
71. Ros J (2004) La teoría del desarrollo y la economía del crecimiento. Fondo de Cultura Económica, México

72. Torres GMA (2012) Modelación-simulación basada en agentes del uso de posibles puntos de palanca para hacer sustentables a los sistemas complejos coevolutivos agropecuarios periurbanos de Tarímbaro, Michoacán. Unpublished BEngSc thesis, Instituto Tecnológico de Morelia. Morelia, Michoacán, Mexico
73. Schneidenbauer S, Ehrlich D (2006) Social levels and hazard. In: Birkmann J (ed) Dependent in determining vulnerability (Chap. 3). Measuring vulnerability to natural hazards. United Nations University Press, New Delhi, India
74. Sterman J (2001) System dynamics modeling: tools for learning in a complex world. Calif Manag Rev 3:4
75. The South Comission (1990) The challenge to the south: The report of the South Commission. Oxford University Press, Oxford
76. Turner B (2010) Vulnerability and resilience: coalescing or paralleling approaches for sustainability science? Glob Environ Change 20:570–576
77. UNO (1968) Resolución 2398 de la XXIII período de sesiones. Retrieved on Feb 2013 at http://daccess-dds-ny.un.org/doc/RESOLUTION/GEN/NR0/247/12/IMG/NR024712.pdf?OpenElement
78. UNDP (1990) Human development report 1990. New York, USA. Retrieved on Sep 2012 at http://hdr.undp.org/en/reports/global/hdr1990/
79. UNDP (2004) Reducing disaster risk, a challenge for development. Bureau for crisis prevention and recovery. New York, USA. Retrieved on May 2011 at http://www.undp.org/cpr/whats_new/rdr_english.pdf
80. UNDP (2013) Human development report 2013. United Nations Development Programme, New York, USA. Retrieved on Feb 2013 at http://hdr.undp.org/en/reports/global/hdr2013/
81. UNISDR (2004) Living with risk: a global review of disaster reduction initiatives, 2004 version, New York, USA. Retrieved on Feb 2013 at http://www.unisdr.org/files/657_lwrsp.pdf
82. UNISDR (2009) Terminología sobre Reducción del Riesgo de Desastres. Naciones Unidas. Ginebra, Suiza. Retrieved on Feb 2013 at http://www.unisdr.org/files/7817_UNISDRTerminologySpanish.pdf
83. Vogel C, Moser S, Kasperson R, Dabelko G (2007) Linking vulnerability, adaptation and resilience science to practice: pathways, players and partnerships. Global environmental change 17:349–364 (Aug–Oct)

Glossary

Activity Focus Networks Represent the complex activity system of an organization. An activity focus is a conceptual or physical entity around which joint activity is organized

Antifragility Some things benefit from shocks; they thrive and grow when exposed to volatility, randomness, disorder, and stressors and love adventure, risk, and uncertainty. Yet, in spite of the ubiquity of the phenomenon, there is no word for the exact opposite of fragile. Let us call it antifragile. Antifragility is beyond resilience or robustness. The resilient resists shocks and stays the same; the antifragile gets better (Taleb, 2014: 4)

Appreciative Inquiry (AI) Is a theory and practice for approaching change from a holistic framework. AI leads systems to move toward the generative and creative images that reside in their most positive core—their values, visions, achievements, and best practices

As Low As Reasonably Practicable (ALARP) Refers to a level of risk that cannot be reduced further without an increase in cost that is disproportionate to the gain in safety

Comprehensive Approach Is based on the assumption and requirement for some level of coherence amongst the actors/stakeholders regarding shared goals and objective and to create a dialogue to address the various dimensions of the problem space (political, security, safety, socio-economic, humanitarian and human rights)

Dragon Kings An extreme outlier (Black swan). Dragon-kings emerge from such complex systems characterized by such mechanisms as ruptures, phase transitions, bifurcations, catastrophes, and tipping points. Sornette (2009) argues that Dragon Kings may have properties that make them not only identifiable in real time but also predictable

A. Masys (ed.), *Disaster Management: Enabling Resilience*,
Lecture Notes in Social Networks, DOI 10.1007/978-3-319-08819-8

Fundamental Surprise A kind of event that had not been imagined, or if it develops—spreads or propagates—in ways that have not been envisaged

High Reliability Organizations Is an organization that manages complexity, risk and uncertainty and in so doing has succeeded in avoiding catastrophes in an environment where normal accidents prevail

Resilience n. 1. The action or an act of rebounding or springing back; rebound, recoil. 2. a. Elasticity; the power of resuming an original shape or position after compression, bending, etc. b. The energy per unit volume absorbed by material when it is subjected to strain; the value of the elastic limit. …. 5. The quality or fact of being able to recover quickly or easily from, resist being affected by, a misfortune, shock, illness, etc.; robustness; adaptability (Oxford English Dictionary)

Safety Culture Is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organization's health and safety management (HSC, 1993)

Situational Surprise A kind of event that happens when it was not expected. It is not a surprise because of *what* it is—its nature—but because of *when* it occurs

TTEMAS The Trinidad and Tobago Emergency Mutual Aid Scheme

Wicked Problem Is a form of social or cultural problem that is difficult to solve because of incomplete, contradictory, and changing requirements. The defining characteristics are:

1. The problem is not understood until after the formulation of a solution.
2. Wicked problems have no stopping rule.
3. Solutions to wicked problems are not right or wrong.
4. Every wicked problem is essentially novel and unique.
5. Every solution to a wicked problem is a 'one shot operation.
6. Wicked problems have no given alternative solutions.[1]

[1] Conklin, Jeffrey (2006). *Dialogue mapping : building shared understanding of wicked problems*. Chichester, England: Wiley Publishing.